Original Research Article

Assessing the suitability of Tomato products as a functional ingredient in paneer

Abstract

This research involved the selection of suitable tomato ~~product~~ productsfrom amongst the puree, paste and powder for manufacture of tomato flavoured paneer.Paneer was prepared from milk standardized to 3% fat and 8.5% MSNF.The first part of the study was conducted to select the optimum level of tomato puree, paste and powder. From amongst different rate of addition(w/w of milk)of tomato products studied viz.7.5, 10, 12.5 and 15% in case of puree and paste and 4, 5, 6 and 7%in case of powder,~~it was found that samples containing puree, paste and powder @ 10, 10 and 5 % were liked the most. The overall acceptability scores of these samples was significantly (P<0.05) higher than the remaining experimental samples.~~ In the next part of the study three batches of paneer viz.T1, T2 and T3 were prepared in which tomato puree, paste and powder were incorporated at levels selected in the first part of the study. Control (C) paneer was prepared from standardized milk. It was found that the fat, FDM and pH of T1, T2 and T3 were significantly (P<0.05) lower than that of C, whereas moisture content of T1, T2 and T3 were significantly (P<0.05) higher than C. The recovery of fat, protein and TS in T1, T2 and T3 was significantly (P<0.05) lower than C, while no significant (P>0.05) difference was observed in yield of paneer. All the textural properties viz. hardness, springiness, cohesiveness, chewiness and gumminess of samples containing tomato products were significantly (P<0.05) lower compared to control. The overall acceptability score of T1 was significantly (P<0.05) higher than that of T2 and T3 but was significantly (P<0.05) lower compared to C. The Vitamin C, total dietary fiber and antioxidant capacity of T1 was significantly (P<0.05) higher compared to C.Hence, it was concluded that good quality tomato flavoured paneer can be prepared incorporating puree @ 10% w/w of milk with higher functional properties compared to control.

Key words: paneer, flavoured, tomato, functional, Vitamin C, total dietary fiber

Introduction

Paneer, a soft variety of unripened cheese is a traditional Indian dairy product which is obtained by heat and acid coagulation of milk. It is usually consumed fresh. Now-a-days consumers demand a variety in products. With advancing lifestyle and eating habits, there are constant demands of new varieties which suit the modern palate. Therefore, attempts have to be made in development and

introduction of novelty products which could be based on our classical and traditional dairy products, just so that the customers have more options to choose from.

Tomatoes (Solanum lycopersicum) are one of the most familiar vegetables in the global diet. It is the second most important vegetable in the world after potato (Dorais *et al*., 2008). The tomato has mild sweet and pronounced sour taste. Among various minerals present, potassium (by influencing the free acid content) and phosphate (due to its buffering capacity) indirectly affect the taste (Bhowmik *et al*., 2012). Solhi *et al.,* (2020)formulated a processed cheese containing various quantity of tomato powder and reported that iincorporation of tomato powder decreased the rigidity and increased the spreadability of the processed cheese progressively which are positive attributes for the processed cheese.In another study, dried tomato flavoured probiotic cream cheese containing *Lactobacillus paracasei* was developed (Santini*et al.,* 2012). Probiotic microorganism *L. paracasei* (LYO 50 DCU, Danisco) was added at the rate of 2 per cent of skim milk. Dried tomato powder (Variety *Speciale Limeira*) at the rate of 18.4 per cent w/w of curd were added and thoroughly mixed. It was found that it had very good acceptance, 82.6 per cent consumer that if available in market, they will certainly buy this product. However, scanty research is available in manufacture of tomato flavoured paneer. Hence, the objective of current research was to develop a technology for application of tomato as a functional ingredient in flavoured paneer.

Materials and methods

Fresh, raw mixed (cow and buffalo) whole milk, was procured from Anubhav Dairy, Anand.Citric acid, and calcium chloride of Loba-Chemical Pvt. Ltd. were used. Tomato variety Avinashwas used in this study.

Preparation and processing of tomato

Size, shape, weight, and colour were taken into consideration when choosing firm, tender tomatoes. Selection criteria included round or oval tomatoes with a uniform, dark crimson to brick red coloration. Selected tomatoes ranged in weight from 80 g to 95 g on average. Tomatoes that were overripe, underripe, or faulty were filtered out.The tomatoes were cleaned by being washed under a flowing tap of potable water. The tomatoes were then rinsed with reverse osmosis filtered water to eliminate chlorine residues after being immersed in water with 25 to 50 ppm chlorine for 10 minutes.Paste and puree were prepared according tothe method described in PM-FME training manual (IIFPT, 2020)except that during processing the skin was not removed as it contains the highest amount of dietary fibers and polyphenols amongst all parts of tomato.Tomato powder was prepared by tray drying tomato paste at 70-75 C for 6 to 8 h till a moisture content of 5 to 6% was obtained. The contents were scrapped off and finely ground to a powder. The composition of puree, paste and powder was: total solids: 12.19, 26.5, 94; protein: 1.61, 3.5, 12.42; total lipid: 0.97, 2.1,

7.45; ash: 0.713,1.55, 5.50; carbohydrates: 8.83,19.2, 68.11 and total dietary fiber:2.3,5.0, 17.74 % respectively.

Process of manufacture of TFP

Paneer was prepared frommilk standardized to 3% milk fat using method described by Aneja*et al*. (2002). The milk was heated to 90° and hold for 5 min. Following holding, the temperature of milk was brough down to 75 °C. At this temperature tomato puree, paste and powder heated to 70 °C was added at selected rate.The contents were the mixed for 1 min.Finally, coagulation of milk was done at 70 °C by addition of a 1 % citric acid solution heated to 70°C. Citric acid was gradually added to milk while stirring continuously and consistently to separate the clear whey. Milk was occasionally stirred while being heated to avoid the development of skin and charring of the milk solids at the bottom. Furthermore, excessive stirring was avoided. At each stage, the milk's temperature was noted. Following the completion of coagulation, stirring was halted, and the curd was given five minutes to settle before the whey was extracted using a muslin cloth. A hoop (15 cm x 10 cm x 9 cm) lined with a sturdy and clean muslin cloth was used to hold the curd once it had been collected. A weight of 2 kg/cm^2 was placed on top of the hoops and held there for 20 minutes to provide pressure. The paneer block was then cooled and submerged for two hours in pasteurized and chilled water that was between 4-6°C. The samples were taken out of the cold water and put on wooden boards so that water could drain off for ten minutes. Paneer was packed in 12 m polyester + 50 µ LD/LLDPE laminated pouches and stored at 7±1°C.

Selection of level of tomato products: Four batches of paneer were prepared in which tomato puree was added @ 7.5, 10, 12.5 and 15% (w/w of milk) for manufacture of A1, A2, A3 and A4. Similarly tomato paste was added @ 7.5, 10, 12.5 and 15% (w/w of milk) for manufacture of B1, B2, B3 and B4 respectively. Tomato powder @ 3,4, 5 and 6% (w/w of milk) was dissolved in equal quantity of water at 40 ºC followed by holding for 30 min. and added in the milk for manufacture of C1, C2, C3 and C4 respectively.

Selection of suitable tomato product: This part of study was carried out to select the most suitable tomato product from amongst tomato puree, paste and powder for manufacture of tomato flavoured paneer. Tomato puree, paste and powder were added at 10, 10and 5% (w/w of milk) for manufacture of T1, T2and T3 respectively. The effect on quantity of citric acid used, composition, and pH due to incorporation of different tomato products in paneer was assessed.

Analysis

Fat content in milk was estimated by Gerber's method (IS: 1479, Part I, 1960). The total solids of milk were determined by the standard procedure IS: 12333 (1997). The titratable acidity of milk was determined by the method described in the IS: 1479 (Part II) (1961).Moisture content in paneer was

determined by according to IS: 10484 (1983). The fat content of paneer samples was determined by the Mojonnier method as described in IS: 2785-1979 (Reaffirmed 1995). Protein content in paneer was determined by Kjeldahl method as per AOAC (1980), using Kjel-plus digestion system (Model-KPS 006L) and Kjel-plus semi-automatic distillation system (Model-Distil M) of M/s. Pelican Instruments, Chennai. Ash content of all the samples was determined by procedure described in BIS (1981). For analysis of Vitamin-C the procedure reported by Osborne and Voogt (1978) was followed. Total Dietary Fiber (TDF) was estimated by method reported by Madhu *et al*. (2017). DPPH radical scavenging activity of paneer samples was determined by the method described by Mc Cune and Johns (2002). Titratable acidity was determined by the procedure as described by Boghra and Rajorhia (1982). The pH of paneer was determined as described by O' Keeffee*et al*. (1976).

Sensory Evaluation : The paneer samples (~25 g rectangular pieces)were tempered to 10±2°C before judging. In a sensory evaluation laboratory of the Dairy Technology Department, sensory analysis was performed. The sensory panel (n=10) was composed of staff members and post graduate students working in the institution. The flavour, body and texture, colour and appearance and overall acceptability scores were evaluated using the 9-point hedonic scale.

Textural Analysis: Compression testing of paneer samples was done with Lloyd Instrument, Hampshire, UK (Model No. 01/2962) using 5 KN load-cells 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 10±1°C for h. All the textural measurements were conducted in a room maintained at 23±1°C temperature and 65±1 % RH. Cubic samples of the experimental paneer, with edges of 1.00±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 % of their initial size.Five cubic samples were used for each experimental paneer under study and the average value of these readings was reported.

Statistical analysis: Completely randomized design (CRD) was used for analysis of the data.

Results and discussion

Selection of level of tomato products

Effect of rate of addition of tomato puree on sensory attributes

The influence of rate of addition of tomato puree on sensory characteristics of paneer is depicted in Table-1. Amongst all the level of tomato puree studied, flavour score of A1and A2 was significantly higher ($P<0.05$) compared to A3 and A4. Flavour scores of A1 and A2 are at par ($P>0.05$) with each other. A3 and A4 had significantly lower flavor scores. This could be explained by soggy mouthfeel

prevailing in experimental samples containing higher concentration of tomato puree as remarked by judges. This can be due to increase in concentration of total dietary fiber resulting in high moisture retention in experimental samples with higher concentration of tomato puree. Similar observations were noted in case of body and texture and colour and appearance scores. A3 and A4 scored significantly lower body and texture scores due to occurrence of crumbly body defect in these samples. This can be due to increase in concentration of total dietary fiber in A3 and A4, as fibers prevents proper fusion of curd by providing a stearic hindrance to casein matrix.The overall acceptability score of A1 and A2 were at par (P>0.05) with each other. While overall acceptability score of A3 and A4 were significantly (P<0.05) lower compared to A1 and A2. Since the aim of the study was to utilize tomato puree as a functional ingredient in order to maximize the benefit of added tomato, a level of 10% puree was selected.

Table-1: Influence of rate of addition of tomato puree on sensory characteristics of flavoured paneer

Sample	Sensory score (9.0-point hedonic scale)			
	Flavour score	**Body and texture score**	**Colour and appearance score**	**Overall acceptability score**
A1	7.50^{a}±0.12	7.68^{a}± 0.20	7.75^{a}±0.20	7.50^{a}±0.11
A2	7.37^{a}±0.12	7.56^{a}± 0.12	7.50^{a}±0.12	7.56^{a}±0.23
A3	6.87^{b}±0.31	6.62^{b}±0.12	7.21^{b}± 0.20	6.88^{b}±0.20
A4	6.56^{b}±0.40	6.43^{b}± 0.31	7.12^{b}±0.11	6.56^{b}± 0.31
SEm	0.15	0.11	0.09	0.15
CD (0.05)	0.46	0.34	0.28	0.47
C V %	4.17	3.10	2.47	4.28

Each observation is a mean ± SD of four replicate experiments (n=4)

$^{a-b}$ Different superscript letters following numbers in the same column denote significant difference (*P<0.05*)

Effect of rate of addition of tomato paste on sensory attributes

The influence of rate of addition of tomato paste on sensory characteristics of paneer is depicted in Table 2. The flavor, body and texture,and colour and appearance scores of B1and B2 was significantly higher (P<0.05) compared to B3 and B4. Statistical analysis also revealed that the scores of B1 and B2 are at par (P>0.05) with each other. This could be explained by soggy mouthfeel prevailing in experimental samples containing higher concentration of tomato paste as remarked by judges. This can be due to increase in concentration of total dietary fiber resulting in high moisture

retention in experimental samples with higher concentration of tomato paste. The lower body and texture scores of B3 and B4 could be attributed to fragile body of these samples. Such effects could be explained by improper fusion of casein matrix due to stearic hinderance presented by tomato fibers. Crude fibers can come in between two casein floccules and thus prevent them from adhering to each other. And the lower colour and appearance scores B3 and B4 could be explained by occurrence of mottling effect on surface of B3 and B4 as higher concentration of tomato paste prevent proper mixing with milk.

The overall acceptability score of B1 and B2 were significantly (P>0.05) higher compared to B3 and B4. Since the aim of the study was to utilize tomato paste as a functional ingredient in order to maximize the benefit of added tomato, a level of 10% puree was selected.

Table-2: Influence of rate of addition of tomato paste on sensory characteristics of flavoured paneer

Sample	Sensory score (9.0-point hedonic scale)			
	Flavour score	**Body and texture score**	**Colour and appearance score**	**Overall acceptability score**
B1	6.75^{a}± 0.31	6.88^{a}± 0.20	6.75^{a}± 0.42	6.80^{a}± 0.30
B2	6.66^{a}±0.31	6.87^{a}±0.31	6.68^{a}± 0.20	6.81^{a}± 0.31
B3	6.18^{b}± 0.20	6.00^{b}± 0.42	6.18^{b}±0.23	6.06^{b}±0.20
B4	6.12^{b}± 0.12	5.87^{b}± 0.35	6.15^{b}±0.31	5.93^{b}±0.30
SEm	0.14	0.19	0.16	0.22
CD (0.05)	0.43	0.59	0.44	0.67
C V %	4.32	5.92	5.08	6.89

Each observation is a mean ± SD of four replicate experiments (n=4)

$^{a-b}$ Different superscript letters following numbers in the same column denote significant difference (*P<0.05*)

Effect of rate of addition of tomato powder on sensory attributes

The influence of rate of addition of tomato powder on sensory characteristics of paneer is depicted in Table 3.The flavour and body and texture scores of C1and C2 was significantly higher (P<0.05) compared to C3 and C4. C1 and C2were par (P>0.05) with each other with respect to flavor scores. This could be explained by gritty mouthfeel observed in experimental samples containing higher concentration of tomato powder. Such defect can be explained by improper hydration of dried tomato fibers. As C3 and C4 contain higher concentration of tomato powder, they have grittier mouthfeel

compared to C1 and C2. The lower body and texture scores of C3 and C4 could be due to occurrence of crumbly body defect in experimental samples containing higher concentration of tomato powder. This can be due to increase in concentration of total dietary fiber in C3 and C4, as fibers prevents proper fusion of curd by providing a stearic hindrance to casein matrix. No significant difference was observed in the colour and appearance score scores of experimental samples.Overall acceptability score of C1 and C2 were significantly higher compared to the remaining samples. Hence a level of 5% tomato powder was selected and used in the next part of the study.

Table-3: Influence of rate of addition of tomato powder on sensory characteristics of flavoured paneer

Sample	Sensory score (9.0-point hedonic scale)			
	Flavour score	**Body and texture score**	**Colour and appearance score**	**Overall acceptability score**
C1	6.37^{a}± 0.31	6.80^{a}±0.35	6.93^{a}± 0.31	6.65^{a}±0.62
C2	6.45^{a}± 0.21	6.75^{a}± 0.12	6.88^{a}± 0.30	6.57^{a}± 0.40
C3	5.87^{b}± 0.20	6.18^{b}± 0.31	6.56^{a}±0.31	5.87^{b}± 0.31
C4	5.37^{b}± 0.24	5.68^{b}± 0.20	5.68^{a}±0.20	5.56^{b}± 0.20
SEm	0.14	0.16	0.17	0.26
CD (0.05)	0.41	0.50	0.51	0.67
C V %	4.58	5.11	5.11	7.14

Each observation is a mean ± SD of four replicate experiments (n=4)

$^{a-b}$ Different superscript letters following numbers in the same column denote significant difference (*P<0.05*)

Selection of suitable tomato product

Effect of tomato product on quantity of citric acid used, composition, pH and acidity of paneer

A significant (P<0.05) reduction in quantity of citric used in experimental samples was observed compared to C. Due to higher concentration of soluble solids presents in tomato powder, especially organic acids, the sample T3 required traces of additional coagulant i.e., citric acid for coagulation. The fat content of C was significantly (P<0.05) higher than that of samples with tomato solids however there was no significant difference (P>0.05) in fat content of paneer containing different tomato product.

The moisture content of T1 and T2 was at par (P>0.05) with each other and was significantly (P<0.05) higher compared to all other samples i.e., C and T3. In accordance with above mentioned results for moisture, the FDM content of T1 and T2 were also at par (P>0.05) with each other while the T3 had a least FDM content from amongst all experimental samples which was found to be significant (P<0.05). This can be explained by non-significant change in fat content of T1, T2 and T3 while moisture content of T3 being significantly lesser than that of T1 and T2 which are statistically at par with each other. In all above aspects, it can be seen that T1 and T2 were found to be very similar. In the present study it was observed that tomato in concentrated liquid form i.e, puree and paste resulted in increase in moisture content of paneer compared to control. This could be attributed to higher moisture retention capacity due to presence of crude fiber in such products. The decrease in moisture content of sample containing tomato powder could be attributed to the higher total solids content in tomato power resulting in higher TS content in paneer with simultaneous decrease in moisture content. However, no data are reported in the literature for effect of incorporation of different tomato products on compositional attributes of paneer. According to FSSAI (2011), medium fat paneer shall not contain more than 60.0 % moisture and milk fat content shall not be less than 20.0 % of the dry matter and shall not be more than 50.0 % of dry matter. Therefore, the samples of paneer prepared in the present study fulfilled the FSSAI requirements with respect of fat and moisture content.

The pH of T1, T2 and T3 were statistically at par (P>0.05) with each other and lower than C. This decrease in pH due to Tomato solids could be related to the presence of organic acids in tomato (Petro- Turza, 1986). Similar results were observed by Mehanna*et al*. (2017) in processed cheese preparing using tomato juice as an ingredient. Mehanna and coworkers observed a significant decrease in pH of processed cheese containing tomato solids compared to control sample. They observed a slight decrease in pH of processed cheese upon increase in tomato juice from 10 to 30 % which was not found to be significant (P>0.05). In another study Solhi *et al*. (2020) prepared processed cheese containing tomato powder at levels ranging from 1 to 4 %. They reported that experimental samples containing tomato powder had lower pH compared to control sample i.e., a pH of 5.85 in control sample compared with 5.52 in experimental samples.

Table-4: Influence of tomato product on the quantity of citric acid used, composition and pH of tomato flavoured paneer

Type of Paneer	Quantity of citric acidused (g/kg milk)	Parameters (%)			pH
		Fat	FDM	Moisture	

C	2.02 ± 0.06[a]	24.90[a] ±0.220	51.60[a] ±0.47	51.74[a] ±0.71	5.50[a] ±0.05
T1	1.33 ± 0.06[b]	16.80[b]±0.27	42.73[b] ±1.18	60.67[b] ±0.44	5.33[b] ±0.02
T2	0.52 ± 0.06[c]	16.06[b] ±0.12	40.68[b] ±0.95	60.50[b] ±1.08	5.31[b] ±0.03
T3	0.03 ± 0.05[d]	17.25[b] ±1.17	33.24[c] ±1.83	51.50[a] ±1.32	5.36[b] ±0.05
SEm	0.04	0.43	0.85	0.47	0.03
CD (0.05)	0.14	1.41	2.76	1.46	0.09
C.V.%	7.40	4.00	3.42	1.69	0.91

Each observation is a mean ± SD of four replicate experiments (n=4)

[a-b] Different superscript letters following numbers in the same column denote significant difference (*P<0.05*)

Effect of for tomato product on % fat, protein, total solid recovery and yield of paneer

The mean value of fat recovery for T1, T2 and T3 were statistically at par with each other (P>0.05). However, the same value was significantly higher (P<0.05) in case of C. Similar results were obtained by Bajwa and Ahmed (2017) where paneer made using amla and lemon juice had significantly lower % fat recovery compared to control paneer made using citric acid only. According to Table-2 the ranges of mean values for protein recovery ranged from 83.64 % (T1) to 90.12 % (C). In case of paneer samples made using tomato solids, the mean value for protein recovery was highest for T3 (87.63 %) and lowest for T1(83.64 %). This could be due to higher protein content in tomato powder compared to puree. Bajwa and Ahmed (2017) reported that the paneer made using lemon juice had significantly lower % protein recovery compared to control sample made without adding any fruit juice.The recovery of total solids in T2 (44.81 %) and T3 (45. 28 %) are statistically at par with each (P<0.05) other but are significantly lower than that of T1 (47.12 %). TS recovery of C (6-34 %) was significantly (P<0.05) high compared to all experimental samples. The reason for least TS recovery observed in T2 and T3 could be due to high concentration of tomato solids in paste and powder, hindering coagulation. Similar results were observed by Bajwa and Ahmed (2017) in paneer made using various fruit juice as coagulant. It was reported that the paneer made using lemon juice had significantly lower (P<0.05) TS recovery (57.72 %) compared to control sample (61.92 %) made without adding any fruit juice.

The average yield of tomato flavoured paneers was 16.06 % (T2) to 17.31 % (T3) which were statistically at par (P>0.05)with each. Similar results were obtained by Bajwa and Ahmed (2017) reported that the there was no significant change in average % yield of paneer coagulated with sour fruit juices like lemon compared to that of control paneer. Similarly, Yashwantha *et al*. (2020) in his study on manufacture of lemon flavoured paneer, also reported that there was no significant change in pH of paneer made incorporating different forms of lemon rind i.e., shreds, paste and powder.

Table-5: Influence of tomato products on the recovery of fat, protein & total solids and yield of flavoured paneer

Type of paneer	% recovery of constituents			% Yield
	Fat	Protein	Total solids	
C	97.36[a] ± 2.06	90.13[a] ± 0.08	64.44[a] ± 0.66	17.31 ± 0.16
T1	88.10[b] ± 0.22	83.64[b] ± 0.33	47.12[b] ± 0.83	16.80 ± 0.27
T2	88.90[b] ± 0.36	85.96[c] ± 0.23	44.81[c] ± 0.65	16.06 ± 0.12
T3	90.62[b] ± 0.74	87.63[c] ± 0.31	45.28[c] ± 1.10	17.10 ± 0.97
SEm	0.79	0.34	0.42	0.36
CD (0.05)	2.57	1.02	1.29	NS
C V %	1.49	0.68	1.66	3.73

Each observation is a mean ± SD of four replicate experiments (n=4)

[a-b] Different superscript letters following numbers in the same column denote significant difference (*P<0.05*)

Effect of tomato product on texture profile

The data indicating hardness, springiness, chewiness, gumminess and cohesiveness of control as well as flavoured paneer due to incorporation of different forms of tomato rind viz. puree, paste and powder were presented in Table-6.

Hardness: There was significant difference (P<0.05) in hardness value among control and all experimental samples studied. Amongst all the experimental sample containing tomato products hardness of T2 was significantly lower (P<0.05) than T1 and T3. The decrease in hardness values of experimental samples could be attributed to higher moisture levels in experimental samples containing tomato solids compared to control sample. Higher moisture content could be attributed crude fiber present in tomato solids binding and retaining more water in paneer. The obtained results are in accordance with results obtained by Da silva *et al*. (2016) during a study done on Minas Frescal cheese made incorporating various fruit preparation. Results indicated that control Minas Frescal cheese showed significantly higher hardness value (P< 0.05) than the Minas Frescal cheeses made incorporating various fruits preparations like apple, guava, mango and banana. It was explained that decrease in hardness could be due to higher moisture content in experimental samples due to presence of fruit solids.

Springiness: The springiness value of control was significant higher (P<0.05) compared to all experimental samples studied. Amongst all the experimental sample containing tomato products springiness value of T2 was significantly lower (P<0.05) than T1 and T3. Statistical analysis also revealed that springiness values of T1 and T3 are at par (P>0.05) with each other.The decrease in springiness values of experimental samples could be attributed to poor fusion of casein matrix in experimental samples containing tomato solids resulting in shattering of product upon compression. Further, the poor fusion of casein matrix could be attributed to crude fibers present in tomato solids presenting a steric hindrance in between two curd particles.

Cohesiveness: Amongst all the experimental sample containing tomato products cohesiveness value of T2 was significantly lower (P<0.05) than T1 and T3 while cohesiveness values of T1 and T3 are at par (P>0.05) with each other.Similar to the decrease in springiness values, the decrease in cohesiveness values of experimental samples can be attributed to improper casein matrix fusion in samples that contain tomato solids due to presence of fibers as discussed earlier. Identical results were obtained by Da silva *et al*. (2016) during a study done on Minas Frescal cheese made incorporating various fruit preparation. Results indicated that control Minas Frescal cheese showed significantly (P< 0.05) higher cohesiveness value than the Minas Fresca cheeses made incorporating various fruits preparations like apple, guava, mango and banana.

Chewiness: The chewiness value of control samples was significant higher (P<0.05) compared to all experimental samples studied. Chewiness of T2 was significantly lower (P<0.05) than T1 and T3

Gumminess: The gumminess value of T2 among the experimental samples that contained tomato products was substantially lower (P<0.05) than that of T1 and T3. Jeong *et al*. (2020) reported an opposite result to our study where there was significant increase (P<0.05) observed in gumminess values of Queso blanco cheese upon progressive addition of micro encapsulated tomato extract powder from 0.5 to 2.0 %.

Table-6: Influence of type of tomato product on textural properties of flavoured paneer

Type of Paneer	TEXTURAL PROPERTIES				
	Hardness (N)	Springiness (mm)	Cohesiveness	Chewiness (N.mm)	Gumminess (N)
C	$18.98^{a} \pm 1.58$	$2.75^{a} \pm 0.03$	$0.17^{a} \pm 0.01$	$8.41^{a} \pm 0.07$	$3.12^{a} \pm 0.11$
T1	$17.04^{b} \pm 1.16$	$2.46^{b} \pm 0.13$	$0.14^{b} \pm 0.01$	$5.85^{b} \pm 0.84$	$2.36^{b} \pm 0.21$
T2	$14.26^{c} \pm 0.77$	$2.30^{c} \pm 0.15$	$0.11^{c} \pm 0.00$	$3.73^{c} \pm 0.54$	$1.61^{c} \pm 0.15$
T3	$16.97^{b} \pm 0.66$	$2.51^{b} \pm 0.16$	$0.13^{b} \pm 0.00$	$5.68^{b} \pm 0.43$	$2.26^{b} \pm 0.09$
SEm	0.55	0.06	0.0033	0.44	0.13
CD (0.05)	1.65	0.19	0.01	1.32	0.39

C V %	6.50	5.11	5.34	14.20	11.11

Each observation is a mean ± SD of four replicate experiments (n=4)

[a-b] Different superscript letters following numbers in the same column denote significant difference (*P<0.05*)

Effect of tomato product on sensory attributes

Amongst all the tomato products studied flavour score of T1 was significantly higher (P<0.05) compared to T2 and T3, although it was significantly (P<0.05) lower than control. Statistical analysis also revealed that flavour scores of T2 and T3 are at par (P>0.05) with each other.The decrease in flavour score of experimental samples T2 and T3 could be attributed to its harsh, coarse flavour which was explained by panel members as sour and with persistent after taste. This could be attributed to the higher concentration of organic acids in tomato puree and powder i.e., citric acid, malic acid and oxalic acid which are naturally present in tomato solids (Petro- Turza, 1986). The obtained results are in accordance with results obtained Jeong *et al*. (2020) who reported significant increase (P<0.05) in undesired flavors like sourness and astringency of Queso blanco cheese upon progressive increase in rate of addition of microencapsulated tomato extract powder from 0.5 to 2.0 % (w/w of cheese). Identical results were obtained by Da silva *et al*. (2016) who reported that that control Minas Frescal cheese showed significantly higher flavour score (P< 0.05) than the Minas Frescal cheeses made incorporating various fruits preparations like guava and mango.

The average body and texture score of C was significantly (P<0.05) higher than all experimental samples. Among experimental samples containing tomato solids, body and texture score of T1 was significantly (P<0.05) higher than T2 and T3 while body and texture scores of T2 and T3 were found to be par (P>0.05) with each other. Addition of tomato puree (T1) led to an acceptable body and texture with a firm, cohesive, slightly spongy body with a smooth texture however, the paneer had a moist surface. This effect could be attributed to presence of small particles of insoluble tomato solids on the surface of paneer. In contrast to T1, addition of tomato solids in the form of paste (T2) in paneer led to a product with very soft body, which was less cohesive and had an uneven coarse texture due to the formation of very fine curd as a result of improper casein micelles aggregation. This may be due to high concentration of insoluble tomato solids in tomato paste like fibres presenting steric hindrance to casein curd. Similarly, T3 had lower body and texture score compared to T1 due to coarse and gritty body as described by judges. Similar observations were obtained by Da silva *et al*. (2016) where control Minas Frescal cheese showed significant higher body and texture score (P< 0.05) than the Minas Frescal cheeses made incorporating various fruits preparations like guava and mango.

The colour and appearance scores for C was significantly (P<0.05) higher than all experimental samples containing tomato solids. While, the colour and appearance score of T2 was significantly (P<0.05) lower compared to other experimental paneer samples. This could be explained by higher concentration of tomato solids in T2 resulting into improper mixing with curd and producing uneven shade of red colour which was not liked by panelists. Similar results have been reported earlier by Da silva *et al*. (2016) where the traditional Minas Frescal cheese showed higher acceptance (P< 0.05) related to the appearance than the cheeses added with various fruits preparations like apple, guava and banana.

The overall preference of paneer was in the order C> T1 > T2 > T3. The overall acceptability of T1 was significantly higher compared to overall acceptability scores of T2 and T3 while T2 and T3 being statistically at par (P>0.05) with each other. Thus, from amongst puree, paste and powder, puree (T1) was found to the be the most suitable for manufacture of tomato flavoured paneer.

Table 7: Influence of type of tomato product on sensory characteristics of flavoured paneer

Type of Paneer	Sensory score (9.0-point hedonic scale)			
	Flavour score	**Body and texture score**	**Colour and appearance score**	**Overall acceptability score**
C	$8.43^{a} \pm 0.12$	$8.18^{a} \pm 0.23$	$8.25^{a} \pm 0.47$	$8.43^{a} \pm 0.16$
T1 (puree)	$7.38^{b} \pm 0.05$	$7.56^{b} \pm 0.40$	$7.50^{b} \pm 0.12$	$7.47^{b} \pm 0.12$
T2 (paste)	$6.65^{c} \pm 0.30$	$6.87^{c} \pm 0.24$	$6.68^{c} \pm 0.31$	$6.81^{c} \pm 0.51$
T3 (powder)	$6.50^{c} \pm 0.47$	$6.75^{c} \pm 0.23$	$6.87^{b} \pm 0.11$	$6.56^{c} \pm 0.20$
Sem	0.22	0.19	0.22	0.20
CD (0.05)	0.68	0.57	0.68	0.61
C V %	6.18	5.06	6.05	5.36

Each observation is a mean ± SD of four replicate experiments (n=4)

[a-b] Different superscript letters following numbers in the same column denote significant difference (*P<0.05*)

Comparison of vitamin-C, Total dietary fiber and antioxidant activity of T1 and Control

Vitamin-C and total dietary fiber content of T1 was 6 mg/100 g and 1.0 per cent of paneer respectively which was significantly higher in comparison with control i.e., 0.05 mg/100g and 0.03 per cent of paneer respectively. Antioxidant capacity of T1 expressed as per cent DPPH inhibition and trolox equivalent was 62.07 per cent and 45.81 µM/g of paneer respectively. While in case of control,

antioxidant capacity as per cent DPPH inhibition and trolox equivalent was 12.58 per cent and 11.35 µM/g of paneer respectively, which was significantly ($P<0.05$) lower than that of T1.

Conclusion:

From amongst puree, paste and powder, puree was found to the be the most suitable for manufacture of tomato flavoured paneer. It can be concluded from the study that good quality tomato flavoured paneer with can be prepared incorporating puree @ 10% w/w to standardized milk. It met the FSSAI standards for medium fat paneer with respect to moisture and FDM content. The Vitamin C and TDF content and antioxidant capacity of the product significantly ($P<0.05$) higher than control paneer prepared without addition of tomato solids. The overall acceptability of productwas 7.57 indicating that it was liked very much to liked moderately on a 9.0-point hedonic scale score card.

References

Ahmed, A., & Bajwa, U. (2019). Composition, texture and microstructure appraisal of paneer coagulated with sour fruit juices. *Journal of food science and technology*, *56*, 253-261.

Ahmed, A., & Bajwa, U. (2022). Effect of fruit acidulants on instrumental colour values and sensory qualities of paneer. *African Journal of Agriculture and Food Science*. *5*(2), 41-48.

Aneja, R. P., Mathur, B. N., Chandan, R. C., & Banerjee, A. K. (2002). Technology of indian milk products: handbook on process technology modernization for professionals, entrepreneurs and scientists. Dairy India Yearbook.

Da Silva, D. G. L., Da Silva, I. C. F., De Oliveira, J. F., Bellini, E. S. L., Klososki, S. J., & Pimentel, T. C. (2017). Effect of the addition of guava, apple, mango, or banana on the physical, chemical and microbiological characteristics and on the acceptance of Minas Frescal cheese during cold storage. *Journal of food processing and preservation*, *41*(6), e13296.

Dorais, M., Ehret, D. L., & Papadopoulos, A. P. (2008). Tomato (Solanum lycopersicum) health components: from the seed to the consumer. *Phytochemistry Reviews*, *7*, 231-250.

Indian Standard: 10484 (1983). Specification for *Paneer*. Bureau of Indian Standards,Manak Bhavan, New Delhi 1-11.

Indian standard: 12333 (1997). Milk, Cream and Evaporated Milk-Determination of total Solids Content (reference method). Bureau of Indian Standards, Manak Bhavan, New Delhi.

Indian Standard: 1479 (Part I) (1960). Methods of test for dairy industry-Rapid examination of milk. Bureau of Indian Standards, Manak Bhavan, New Delhi

Indian Standard: 2785-1979 (Reaffirmed 1995). Specification for Natural cheese (Hard Variety), Processed Cheese, Processed Cheese Spread and Soft Cheese. Bureau of Indian Standards, Manak Bhavan, New Delhi.

Indian standards (1969). IS 5162 Specification for paneer. Bureau of Indian Standards, Manak Bhavan, New Delhi.

Indian Standards. (1961). IS: 1479, (Part-II). Methods of testing for dairy industry Part-II. Rapid examination of milk. Indian Standards Institution, New Delhi.

Indian standards. (2003). IS 15346 Method for Sensory Evaluation of Paneer/Chhana [FAD 19: Dairy Products and Equipment] Indian Standard Institution, New Delhi

Jeong, H. J., Lee, Y. K., Ganesan, P., Kwak, H. S., & Chang, Y. H. (2017). Physicochemical, microbial, and sensory properties of queso blanco cheese supplemented with powdered microcapsules of tomato extracts. *Korean journal for food science of animal resources*, *37*(3), 342.

Kumar, K. S., Paswan, S., & Srivastava, S. (2012). Tomato-a natural medicine and its health benefits. *Journal of Pharmacognosy and Phytochemistry*, *1*(1), 33-43.

McCune, L. M., & Johns, T. (2002). Antioxidant activity in medicinal plants associated with the symptoms of diabetes mellitus used by the indigenous peoples of the North American boreal forest. *Journal of Ethnopharmacology*, *82*(2-3), 197-205.

Mehanna, N. S., Hassan, F. A., El-Messery, T. M., & Mohamed, A. G. (2017). Production of functional processed cheese by using tomato juice. *Int. J. Dairy Sci*, *12*, 155-160.

Olorunnisomo, O. A., &Adewumi, A. S. (2016). Lime and Mango juice as coagulants for soft cheese made from fresh or reconstituted milk. *Journal of Biology, Agriculture and Healthcare*, *6*(6), 37-40.

Osborne, D. R., &Voogt, P. I. (1978). The analysis of nutrients in foods. Academic Press Inc. (London) Ltd., 24/28 Oval Road, London NW1 7DX.

Petro-Turza, M. (1986). Flavor of tomato and tomato products. *Food Review International*, *2*(3), 309-351.

Santini, M.S., Koga, E.C., Aragon, D.C., Santana, E.H., Costa, M.R., Costa, G.N., Aragon-Alegro, L.C. (2012). Dried tomato-flavored probiotic cream cheese with Lactobacillus paracasei. Journal of food science. 77(11), M604-8.

Solhi, P., Azadmard-Damirchi, S., Hesari, J., &Hamishehkar, H. (2020). Production of the processed cheese containing tomato powder and evaluation of its rheological, chemical and sensory characteristics. Journal of food science and technology, 57, 2198-2205.

Yashavantha, R., Pinto, S., Patel, D., Paul, P., & Chaudhary, M. (2020). Development of lemon flavoured paneer. *Journal of Pharmacognosy and Phytochemistry*, *9*(5), 1320-1324.

Yashvantha, R., Pinto, S., Patel, D., & Paul, P. (2020). Manufacture and Evaluation of Paneer Using Lemon Rinds as a Value-Added Ingredient. *International Research Journal of Pure and Applied Chemistry*, *21*(19), 1-12.

Yashvantha, R., Pinto, S., Patel, D., & Paul, P. Evaluation of efficacy of lemon rind as a preservative in paneer. *The Pharma Innovation Journal*. 9(9), 41-48.