International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
www.chemijournal.com
IJCS 2020; 8(2): 2049-2058

Received: 21-01-2020
Accepted: 22-02-2020

Darji Kinjal
Department of Dairy Technology, SMC College of Dairy Science, Anand Agricultural University, Anand, Gujarat, India

Gokhale AJ
Department of Dairy Technology, SMC College of Dairy Science, Anand Agricultural University, Anand, Gujarat, India

Mallik JM
Department of Dairy Technology, SMC College of Dairy Science, Anand Agricultural University, Anand, Gujarat, India

Modha HM
Department of Dairy Technology, SMC College of Dairy Science, Anand Agricultural University, Anand, Gujarat, India

Patel HG
Department of Dairy Technology, SMC College of Dairy Science, Anand Agricultural University, Anand, Gujarat, India

Corresponding Author:
Gokhale AJ
Department of Dairy Technology, SMC College of Dairy Science, Anand Agricultural University, Anand, Gujarat, India

Impact of addition of salts on sensory, rheological properties and yield of *Paneer*

Darji Kinjal, Gokhale AJ, Mallik JM, Modha HM and Patel HG

DOI: https://doi.org/10.22271/chemi.2020.v8.i2ae.9057

Abstract
The objective of the present experiment was to arrive at a method of manufacture for *Paneer* by altering the process parameters such as coagulation temperature (°C), level of $CaCl_2$ (%, w/w) and level of NaCl (%, w/w) addition and its impact on sensory and yield of *paneer*. These parameters were standardized by using the Central Composite Rotatable Design (CCRD) of Response Surface Methodology (RSM), an advanced statistical software programme named Design Expert 9.0.3.1. Quadratic model fitted well to the sensory score for flavour, body and texture, colour and appearance score, moisture (%), yield (%) and Chewiness (Nmm) of *Paneer* manufactured and their R^2 values were 0.875, 0.811, 0.844, 0.855, 0.792, 0.817 respectively. A significant (P<0.01) negative effect of coagulation temperature for milk and non-significant positive effect of concentration of $CaCl_2$ addition and significant (P<0.01) positive effect of concentration of NaCl addition was observed. The values of moisture of *Paneer* ranged from 49.46 to 62.09 per cent. A significant (P<0.01) negative linear effect of coagulation temperature, non-significant positive effect of $CaCl_2$ addition and significant (<0.01) positive effect of concentration of NaCl addition on moisture of *Paneer* was observed. The values of yield of *Paneer* ranged from 15.46 to 20.55 per cent. At linear level, a significant (P<0.01) negative effect of coagulation temperature, non-significant (P<0.01) negative effect of $CaCl_2$ addition and significant (P<0.01) positive effect of concentration of NaCl addition on yield of *Paneer* was observed. The values of chewiness (Nmm) of *Paneer* ranged from 11.90 to 52.10 Nmm. At linear level a significant (P<0.01) positive effect of coagulation temperature, non-significant positive effect of concentration of $CaCl_2$ addition and significant (P<0.01) negative effect of concentration of NaCl addition on chewiness of *Paneer* was observed. The optimized process suggested by statistical package consisted of coagulation temperature of 77°C, 0.05 %, w/w of $CaCl_2$ and 0.5 %, w/w of NaCl addition. The yield of *Paneer* obtained employing this standardized process is 18.37 per cent. While that of control Paneer prepared by same procedure without addition of salt is 16.3 percent.

Keywords: Paneer, NaCl, $CaCl_2$, Yield, Rheology of Paneer, Coagulation temperature

Introduction
Paneer is a South Asian variety of soft cheese obtained by acid and heat coagulation of milk. It is a non-fermentative, non-renneted, non-melting and unripened type of cheese. *Paneer* is having approximately 53-55 % moisture, 23-25 % milk fat, 17-18 % protein, 2.0-2.5 % lactose and 1.5-2.0 % minerals (Kanawjia and Singh, 1996) [16]. The yield of *Paneer* is dictated by the composition of milk used which changes with the seasons of the year had profound effect on the yield of *Paneer*. Milk obtained during winter season had highest yield (15.5 %) while rainy season had least yield of 14.79 %. Type of milk, standardization for fat or fat and SNF, heat treatment given to milk, type and strength of coagulant, losses incurred after coagulation (based on pH and temperature of coagulation) and moisture content of resultant *Paneer* after pressing decides the final yield of *Paneer* (Sharma *et al*., 2002; Chandan, 2007) [28, 3]. Addition of $CaCl_2$ or NaCl for increasing yield and shelf life of *Paneer* was carried out by several researchers. Chawla *et al*. (1987) [4] and Yadav *et al*. (1994) [31] reported incorporation of sodium chloride @ 0.5 % improved the yield of *Paneer*. Sanyal and Yadav (2000) [24] found that addition of 0.25 % common salt along with 2.5 % cultured skim milk increased the yield of reduced-fat *Paneer*. Sanyal *et al*. (2004) [26] observed that the addition of common salt @ 0.75 % to milk increased the yield of reduced-fat *Paneer* by 19.59 %. Addition of $CaCl_2$ alone alters flavour of *Paneer* and NaCl as only additive in milk for *Paneer* making have a tendency to give soft body that causes frying problem and also not liked by consumers.

Keeping the above facts an attempt is made to use combination of both $CaCl_2$ and NaCl for manufacturing of *Paneer* in order to get benefits of increasing yield without altering sensory and rheological properties of *Paneer*.

Materials and methods

Materials used

The milk used for manufacturing *Paneer* was procured from Department of Dairy Processing and Operations (Anubhav Dairy) of Anand Agricultural University, Anand. Citric acid as coagulant and calcium chloride, both Loba-chemical Pvt. Ltd., and good quality non iodized edible sodium chloride salt (Tata brand) was used for *Paneer* manufacture.

Basic process for *Paneer* preparation

20 kg milk was heated up to 90°C for 5 min. Thereafter, the temperature of milk was lowered to coagulation temperature (65 to 90°C). At this stage, $CaCl_2$ (0.00 to 0.15% by weight of milk) dissolved in 200 ml distilled water was added to milk. The milk was then coagulated with citric acid as a coagulant. After that NaCl (0.00 to 1%) was added in coagulated milk and kept for 10 min. The coagulated curd was strained and whey was separated. The curd was transferred in to the S.S. *Paneer* hoop for pressing by putting weight of about 2 kg on the hoop lid. The *Paneer* block was separated from the hoop and was dipped in chilled water (2-4°C) for 2 h. Thereafter, the *Paneer* block was weighed and cut into required size packed.

Experimental design

The central composite rotatable design was used for designing the experimental combinations (Modha and Pal, 2011) [20]. The experiment was designed using software Design Expert version 8.0.3. The variables used were coagulation temperature of milk, rate of $CaCl_2$ and NaCl addition level of these variables along with experimental plan consisting of three variables at five levels has been shown in Table 1. The variables were standardized to simplify computation and to deduce the relative effect of variables on response. The magnitude of the coefficients in second order polynomial shows the effect of that variable on the response.

Table 1: Coded and decoded levels of the experimental independent variables used in central composite rotatable design.

Independent variables (coded)	-1.68	-1	0	1	1.68
Temp. of Coagulation (°C)	65	70	78	85	90
Rate of addition of $CaCl_2$ (%, w/w)	0.00	0.03	0.08	0.12	0.15
Rate of addition of NaCl (%, w/w)	0.0	0.2	0.5	0.8	1.0

Compositional analysis

The moisture of the *Paneer* samples were determined as per the procedure described in Indian Standard: 2785 (1979) [15] using Mojonnier Milk Tester Model-D. Fat extraction of *Paneer* was determined as per the procedure described in Indian Standard: 2311 (1963) [14]. Total nitrogen/protein of *Paneer* was determined by semi-micro kjeldahl method (Indian Standard: 1479-Part-II, 1961) [11], using Kjel-plus Digestion System (Model-KPS 006 L, M/s. Pelican Instruments, Chennai) and Kjel-plus Semi-Automatic Distillation System (Model-Distil M, M/s. Pelican Instruments, Chennai). Ash content of the samples was determined by procedure described in Indian Standard: 1547 (1985) [13]. Salt content of *Paneer* was carried out by procedure described in Indian Standard SP:18 Part XI (1981).

Physico-chemical quality analysis

Titratable acidity of *Paneer* was determined by the procedure as described by Boghara and Rajorhia (1982) [2]. The pH of *Paneer* was measured using Systronic digital pH meter, Model 335. The method described by Franklin and Sharpe (1963) [7] for cheese. The water activity of *Paneer* samples, tempered at 25°C temperature, was measured using Rotronic Hygroskop Model: Hygrolab-3 (M/s. Rotronic ag, Switzerland) (Hirpara *et al.*, 2013) [10]. The method prescribed by Deeth *et al*. (1975) [6] was used to estimate the FFA content of *Paneer*.

Texture profile analysis

Four samples of each experimental *Paneer* were tempered to 23±1°C and then subjected to uniaxial compression to 40% of the initial sample height, using a Food Texture Analyzer of Lloyd Instruments LRX Plus material testing machine, England; fitted with 0–5 kN load cell. The force distance curve was obtained for a two-bite deformation cycle employing a Cross Head speed of 50 mm/min, Trigger 10 gf and 40 % compression.

Sensory evaluation

For the organoleptic evaluation of *Paneer*, 8 judges were selected (on the basis of duo-trio test). The *Paneer* samples were evaluated using 100 point scale as described in Indian Standards (IS: 15346, 2003) [12]. The judges were also requested to give criticism for each attribute of the samples.

Statistical analysis

The experiment was designed and responses were analyzed using software Design Expert version 8.0.3. All physicochemical determinations were average of three replicates, whereas sensory data were average of eight replicates. Table 2 shows the treatments to be experimented with reference to the Central Composite Rotatable Design for three independent variables: Coagulation temperature (°C), Rate of addition (%) of $CaCl_2$ and NaCl in actual values.

Table 2: Experimental Design Matrix (CCRD) for levels of factors: coagulation temperature (^{0}C), rates of addition (%) of $CaCl_2$ and NaCl.

Run order	Coagulation temperature (°C) (X_1)	$CaCl_2$ (%) (X_2)	NaCl (%) (X_3)
1	78	0.15	0.50
2	78	0.08	0.50
3	78	0.08	1.00
4	78	0.08	0.50
5	65	0.08	0.50
6	78	0.08	0.50
7	90	0.08	0.50
8	78	0.08	0.50
9	70	0.12	0.80
10	85	0.03	0.80

11	78	0.08	0.50
12	78	0.08	0.00
13	70	0.03	0.20
14	85	0.12	0.80
15	85	0.12	0.20
16	78	0.00	0.50
17	85	0.03	0.20
18	70	0.03	0.80
19	70	0.12	0.20
20	78	0.08	0.50

Results and discussion

Effect on variables on properties of paneer

A second order polynomial was fitted into the data for all responses and the actual values observed are reported in Table 3.

$$Y = \beta_0 + \sum_{i=1}^{3} \beta_i X_i + \sum_{i=1}^{3} \beta_{ii} X_i^2 + \sum_{i,j=1\ i\neq j}^{3} \beta_{ij} X_i X_j$$

Where β_0, β_i, β_{ii}, β_{ij}=Regression coefficients, X_i, X_j=independent variables, Y=dependent variable.

$R^2 > 0.80$ for sensory attributes is statistically adequate for developing a model or equation (Henika 1982) [8]. Presently R^2 was > 0.80 for all the sensory responses. The probability value (p) showed the adequacy of the models so used to describe the effect of variables on different responses. The effect of temperature of coagulation and rates of addition of $Cacl_2$ and NaCl on the responses is shown in equations below. The sign and magnitude of coefficients indicate the effect of the variable on the responses. The models thus developed with actual variables are as follows:

Flavour = $27.45 + 0.41X_1 + 49.65X_2 + 16.36X_3 + 0.041X_{12} + 0.087X_{13} – 55.91X_{23} – 0.0041X_1^2 –277.424X_2^2 – 11.302X_3^2$

Body & Texture = $74.59 – 1.039X_1 – 2.336X_2 + 3.021X_3 + 0.613X_{12} + 0.0224X_{13} – 54.117X_{23} + 0.0053X_1^2 + 4.88X_2^2 + 1.25X_3^2$

Colour and Appearance = $21.48 – 0.32X_1 + 39.32X_2 – 4.10X_3 – 0.388X_{12} + 0.069X_{13} – 2.262X_{23} + 0.0017X_1^2 – 41.26X_2^2 – 0.0084X_3^2$

Total Sensory Score = $200.763 - 2.964X_1 + 221.867X_2 + 35.574X_3 - 1.644X_{12} - 0.107X_{13} -64.111X_{23} + 0.016X_1^2 - 333.365X_2^2 - 10.510X_3^2$

Moisture (%) = $129.095 - 1.906X_1 + 142.668X_2 + 22.859X_3 - 1.057X_{12} - 0.068X_{13} - 41.200X_{23} + 0.0109X_1^2 - 214.316X_2^2 - 6.762X_3^2$

Yield (%) = $54.365-0.933X_1+48.395X_2+9.727X_3-0.109X_{12} - 0.058X_{13} -19.733X_{23} + 0.005X_1^2 - 234.882X_2^2 -1.004X_3^2$.

Table 3: Scores of sensory, compositional, textural properties and yield of *paneer*.

Run order	Flavour	B & T	C & A	Total sensory score	Moisture (%)	Yield (%)	Chewiness (Nmm)
1	40.83	30.20	8.15	84.18	54.13	15.46	30.50
2	43.99	29.02	8.44	86.45	55.59	18.40	23.30
3	44.83	29.94	9.20	88.97	57.21	18.94	23.90
4	43.35	28.57	8.26	85.18	54.77	18.13	39.10
5	46.30	31.02	9.55	91.87	62.09	20.55	19.20
6	42.77	29.98	8.38	86.13	55.38	18.33	27.60
7	39.19	29.04	7.78	81.01	52.09	17.24	45.30
8	42.25	29.59	8.26	85.10	54.72	18.11	23.30
9	43.20	33.59	8.92	90.71	61.61	20.39	11.90
10	45.07	29.79	8.66	88.52	56.92	18.84	14.20
11	42.23	29.43	8.24	84.90	54.59	18.07	28.70
12	36.32	29.06	7.57	77.95	50.12	16.59	47.00
13	41.18	30.45	8.24	84.87	54.57	18.06	27.60
14	41.10	30.39	8.22	84.71	54.47	18.03	41.10
15	38.88	30.53	7.94	82.35	52.95	17.53	49.20
16	42.85	28.23	8.16	84.24	54.17	17.93	34.00
17	38.25	26.23	7.44	76.92	49.46	16.37	52.10
18	45.59	32.98	8.02	91.59	58.89	20.13	16.50
19	40.12	33.10	8.44	86.66	55.72	18.44	33.00
20	46.02	33.28	8.12	92.42	59.42	19.67	28.40
R^2	0.875	0.811	0.844	0.855	0.855	0.792	0.817

The manufacture of *Paneer* is dependent on the very important stage of heat coagulation which decides its quality and functionality. The study was undertaken with the main aim of evaluating effect of coagulation temperature, concentration of $CaCl_2$ and NaCl on sensory attributes, moisture content, yield as well as rheological properties (chewiness) of *Paneer*.

In this experiment, different levels of concentration of $CaCl_2$, concentration of NaCl and coagulation temperature during manufacturing of *Paneer* was evaluated. These parameters were decided on the basis of preliminary trials undertaken. The levels for concentration of $CaCl_2$ (@ 0.00 to 0.15 %), concentration of NaCl (@ 0.00 to 1 %) as well as coagulation temperature (65 to 90°C) were selected on the basis of preliminary trials taking into consideration the sensory attributes.

The *Paneer* prepared with varying temperatures of coagulation, concentration of $CaCl_2$ and NaCl which were tried out for coagulation of milk and their responses are shown in design matrix of three factors CCRD deign consisting of 20 experiments. These treatment samples were

evaluated for various sensory, rheological and compositional characteristics.

The most important criteria for evaluating the quality of any traditional Indian dairy products is sensory characteristics which include flavour, body and texture, colour and appearance and total sensory score which in turn determines its acceptability. The sensory score data along with formulations as per their run order is shown in Table 3.

Sensory scores of *Paneer* for Flavour varied from 36.32 to 46.30, Body and Texture 26.23 to 33.59, Colour and Appearance 7.44 to 9.55 and Total sensory score of *Paneer* as depicted in Table 3 ranged from 76.92 to 92.42 (total out of 100). Coagulation temperature has profoundly significant effect on all sensory attributes and they all were affected with change in temperature of coagulation.

Flavour of the *Paneer* was significantly affected and was linearly negatively correlated with coagulation temperature. Addition of sodium chloride at linear level had shown significantly positive correlations for flavour but significantly reverse trend was noted at quadratic level, which might be because of more salty taste prevailed at higher level of addition. Yadav *et al.* (1994) [31] and Kaur *et al*. (2003) [17] also reported addition of NaCl increased flavour score of the experimental *Paneer*.

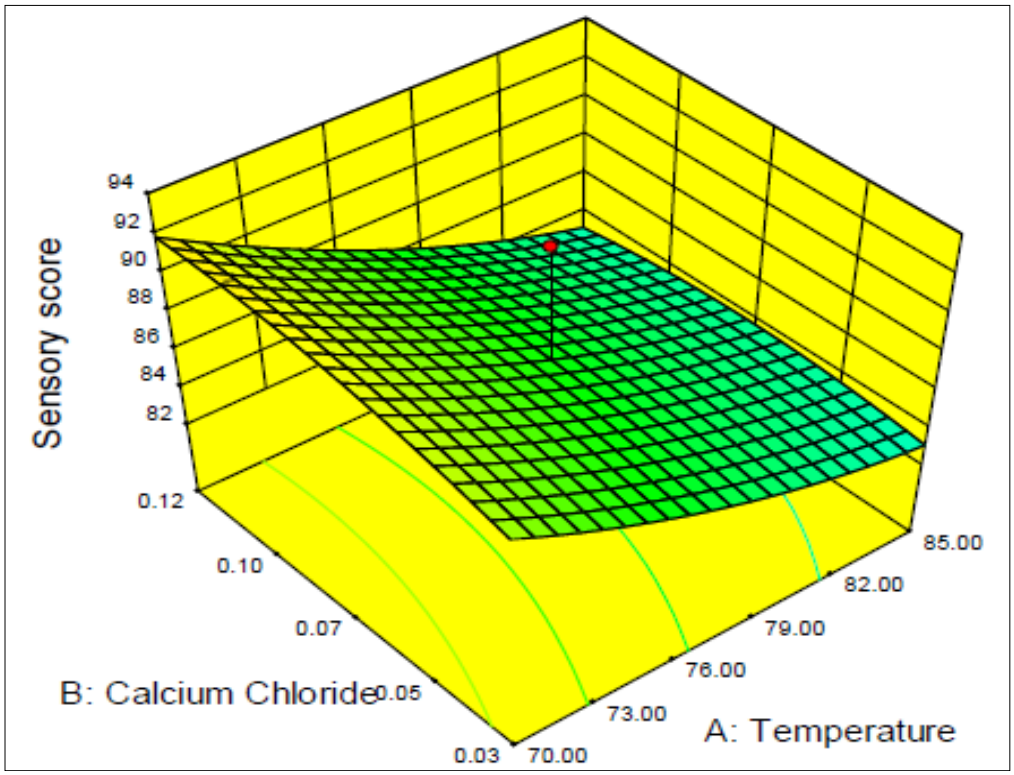
Body and texture score of the *Paneer* was significantly affected with temperature of coagulation. Increase in coagulation temperature resulted in decrease in body and texture score of Paneer. Upon addition of $CaCl_2$, a non-significant increase in body and texture score was observed. Arora *et al*. (1996) [1] when added $CaCl_2$ @ 0.05% in milk, resulted in improvement of Body and Texture score. Similar trend was reported by Singh and Kanawjia (1988) [30] upon addition of $CaCl_2$ @ 0.1% to milk prior to coagulation.

Colour and Apperance score of *Paneer* was significantly affected by temperature of coagulation and sodium chloride. Colour and appearance score decreased significantly with linear rise in coagulation temperature; however, it increased with increase in rate of addition of sodium chloride.

Overall acceptability is the indicative parameter of sensory quality of product in totality and consists of appearance, flavour, body and textural characteristics. The increase in coagulation temperature (X_1) decreases the sensory score significantly (<0.01) whereas increasing concentration of $CaCl_2$ (X_2) increased the sensory score at linear level but non-significantly. NaCl concentration (X_3) showed its negative significance in quadratic terms due to unacceptable saltiness in *Paneer* at higher concentrations of NaCl.

A non-significant negative interactive effect on sensory properties was observed with varying coagulation temperature and concentration of $CaCl_2$ and concentration of NaCl. The response surface for total sensory score in relation to coagulation temperature, rate of addition of calcium chloride and sodium chloride are shown in Fig. 1. Sachdeva *et al*. (1991) [23] observed that incorporation of 0.08% $CaCl_2$ in manufacture of Paneer at coagulation pH of 5.20 – 5.25, had maximum sensory score. Singh and Kanawjia (1988) [30] also observed that use of $CaCl_2$ @ 0.1% to milk prior to coagulation increases all the sensory characteristics. When *Paneer* was dipped in 3% brine, Kaur *et al*. (2003) [17] obtained a good sensory score. Similarly, Yadav *et al.* (1994) [31] found that use of common salt @ 0.5% in milk led to an improvement in the total sensory score.

The *Paneer* prepared by using 78°C coagulation temperature, 0.08 % (w/w) $CaCl_2$ and 0.50 % (w/w) NaCl was rated the best for its total sensory score (Table 3).



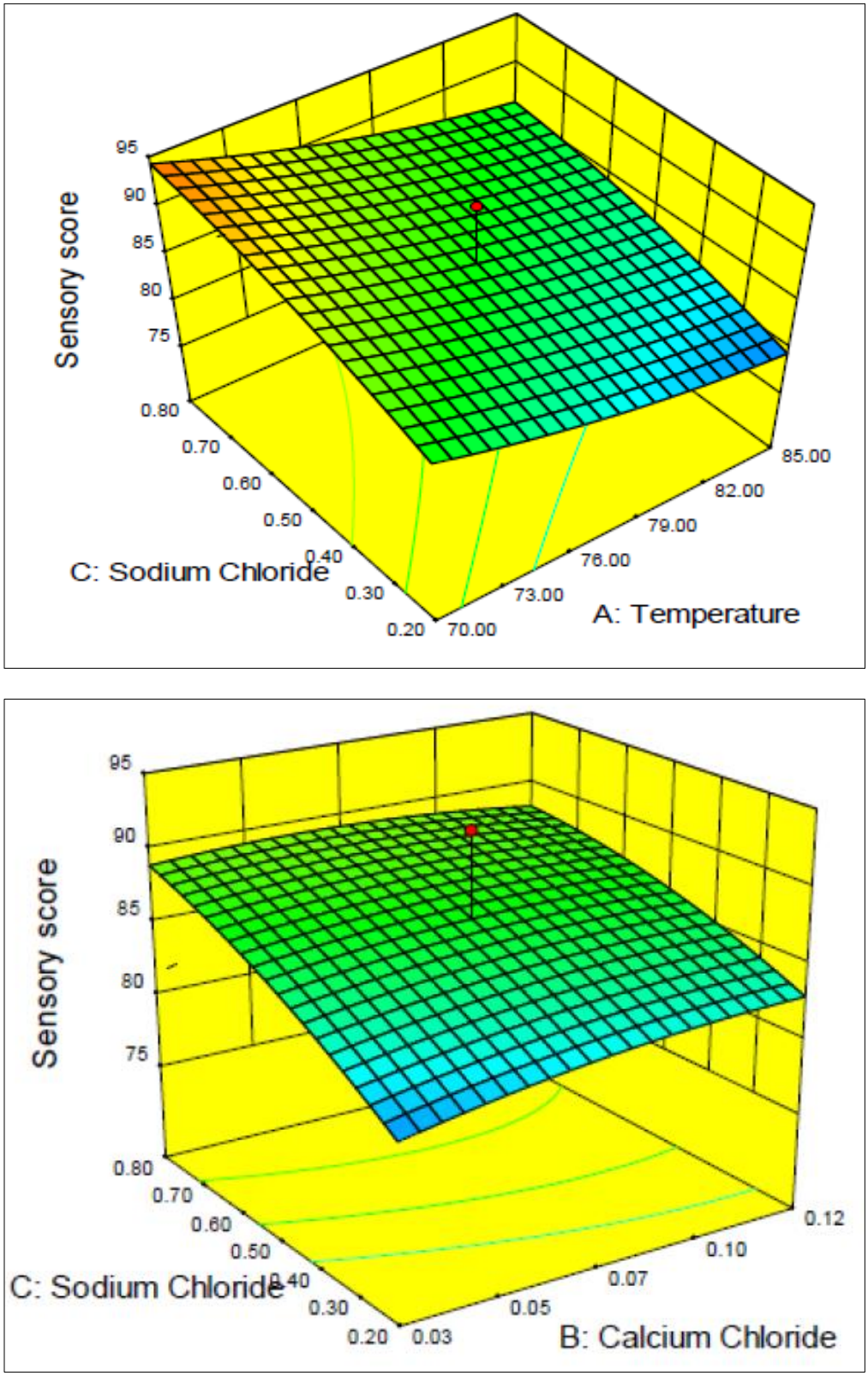


Fig 1: Effect of Coagulation temperature, rate of addition of calcium chloride and sodium chloride on sensory score of *Paneer* (design expert plots).

Table 4: P values and partial coefficient of regression equations of suggested model for Sensory properties of *Paneer*

Factors		Flavour		Body & Texture		Colour & Appearance		Total Sensory Score	
		P Value	Partial Coefficient	P Value	Partial Coefficient	P Value	Partial Coefficient	P Value	Partial Coefficient
Model			125.170		40.049		3.552		421.536
Linear Level	X_1	0.0035*	-1.373	0.019*	-1.209	0.007*	-0.317	0.0003*	-3.850
	X_2	0.066	-0.746	0.086	0.840	0.397	0.084	0.4622	0.551
	X_3	0.0001*	2.258	0.209	0.580	0.006*	0.330	0.0006*	3.542
Interactive Effect	$X_1x\ X_2$	0.977	0.014	0.724	0.205	0.317	-0.13	0.5724	-0.55
	$X_1x\ X_3$	0.690	0.194	0.931	0.050	0.238	0.155	0.8041	-0.24
	$X_2x\ X_3$	0.148	-0.741	0.232	-0.718	0.813	-0.03	0.3883	-0.85

Quadratic Level	X_1^2	0.525	-0.231	0.495	0.297	0.311	0.098	0.2042	0.953
	X_2^2	0.148	-0.551	0.982	0.009	0.394	-0.082	0.3673	-0.662
	X_3^2	0.018*	-0.999	0.798	0.110	0.994	-0.001	0.2152	-0.929

Table 5: P values and partial coefficient of regression equations of suggested model for composition and rheological properties of *Paneer*

Factors		Moisture (%)		Yield (%)		Chewiness (Nmm)	
		P Value	Partial Coefficient	P Value	Partial Coefficient	P Value	Partial Coefficient
Model			174.288		25.501		2138.888
Linear Level	X_1	0.0003*	-2.475	0.002*	-0.865	0.001*	8.164
	X_2	0.462	0.354	0.319	-0.231	0.476	1.384
	X_3	0.0006*	2.278	0.004*	0.801	0.001*	-8.570
Interactive Effect	X_1x X_2	0.572	-0.353	0.901	-0.036	0.263	2.900
	X_1x X_3	0.804	-0.153	0.660	-0.130	0.496	-1.725
	X_2x X_3	0.388	-0.546	0.386	-0.261	0.335	2.475
Quadratic Level	X_1^2	0.204	0.613	0.179	0.310	0.690	0.746
	X_2^2	0.367	-0.426	0.055	-0.467	0.690	0.746
	X_3^2	0.215	-0.597	0.688	-0.088	0.327	1.877

Effect of variables on compositional and textural responses Moisture (%)

The values of moisture of *Paneer* shown in Table 3 ranged from 49.46 to 62.09 %. The *Paneer* prepared by using coagulation temperature 65°C, 0.08% of $CaCl_2$ and 0.50% of NaCl had the highest value of moisture in *paneer*. The *paneer* prepared by using coagulation temperature 85°C, 0.03% of $CaCl_2$ and 0.2 % of NaCl had lowest value of moisture. The P value for coagulation temperature showed its significance in quadratic terms (Table 5). This indicates that the increase in coagulation temperature (X_1) decreases the moisture significantly (P<0.01) while increasing concentration of $CaCl_2$ (X_2) increases the moisture at linear level non-significantly. While at linear level concentration of NaCl (X_3) showed a significant positive effect stating that upon increasing concentration of NaCl, the moisture content of resultant *paneer* increases significantly. The P value for all the three parameters showed that they have non-significant effect at quadratic terms (Table 5). The negative sign indicates the negative effect of concentration of $CaCl_2$ and NaCl on moisture content of *paneer*. In quadratic term a non-significant positive effect on moisture was found with the varying coagulation temperature (X_1^2). Use of coagulation temperature greater than 70 °C resulted in hard and dry *paneer* while free surface moisture was evident when coagulated at lower (<70°C) temperatures (Sachdeva and Singh 1988a) [21]. Masud (2002) [19] recommended use of higher (85°C) coagulation temperature for buffalo milk *paneer*.

Yield (%)

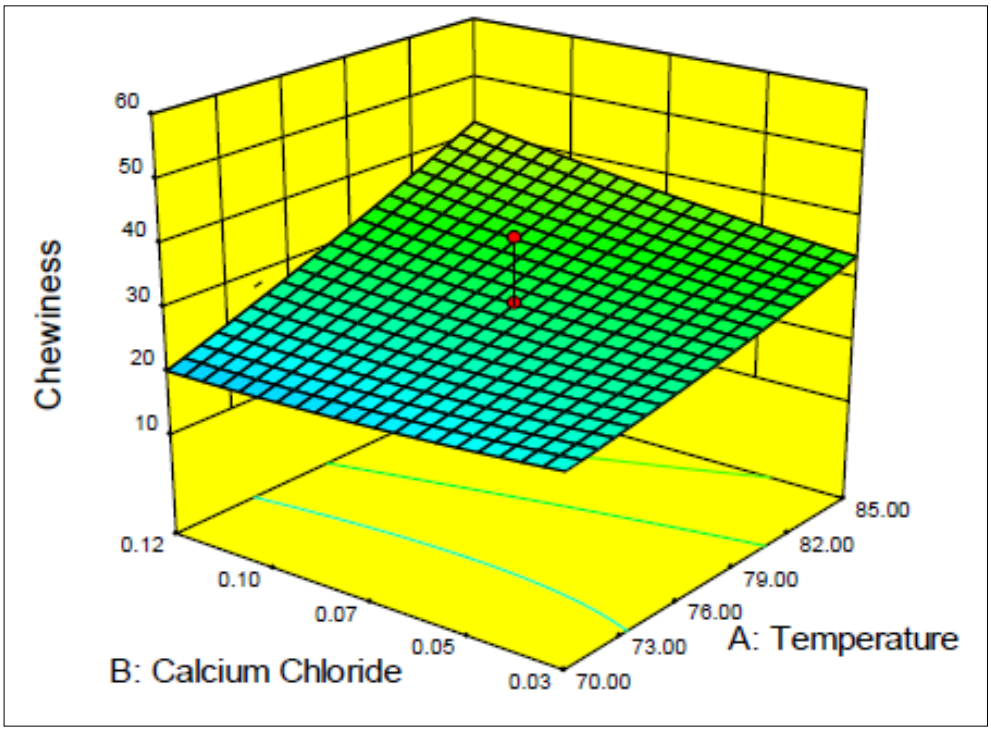
The yield of the product aims at quantifying objectively the solids recovered during product manufacture to the maximum extent possible into the finished product. The values of yield of *Paneer* shown in Table 3 ranged from 15.46 to 20.55 %. The *Paneer* prepared by using coagulation temperature 65°C, 0.08% of $CaCl_2$ and 0.50% of NaCl had the highest value of yield in *Paneer*. The *Paneer* prepared by using coagulation temperature 78°C, 0.15% of $CaCl_2$ and 0.50% of NaCl had lowest value of yield. The tabulated values in Table 5 indicates that the increase in coagulation temperature (X_1) decreases the yield significantly (P<0.01) while increasing concentration of $CaCl_2$ (X_2) decreased the yield at linear level but non-significantly. For different concentration of NaCl (X_3) indicates the significant positive effect on yield of *Paneer*. A non-significant negative interactive effect on yield was observed with varying coagulation temperature and concentration of $CaCl_2$, varying coagulation temperature and concentration of NaCl and varying concentration of $CaCl_2$ and NaCl. A non-significant positive effect on yield was found with the varying coagulation temperature (X_1^2). A non-significant negative effect on yield was found with concentration of $CaCl_2$ (X_2^2) and concentration of NaCl (X_3^2). Hill *et al*. (1982) [9] recommended use of high temperature and $CaCl_2$ for getting better yield through co-precipitation of casein and whey proteins. Singh and Kanawjia (1988) [30] when added $CaCl_2$ @ 0.1% to milk prior to coagulation observed increased total solids recovery and yield of *Paneer*. Arora *et al*. (1996) [1] observed that addition of $CaCl_2$ increased fat, protein, TS, pH and TS recovery and thus yield of *Paneer* made from diluted milk. Makhal and Kanawjia (2005) [18] obtained enhanced yield of *Paneer* during co-precipitation of casein and whey protein through acidification in presence of calcium chloride added @ 0.15%. The yield of *Paneer* from buffalo milk was found to decrease with an increase in coagulation temperature as observed by Sachdeva and Singh (1988b) [22], while for cow milk it increased as reported by Singh and Kanawjia (1988) [30]. Chawla *et al*. (1987) [5] observed that the incorporation of sodium chloride @ 0.5% and NFDM dramatically helped in increasing the moisture content of low fat *Paneer* and thereby improved the yield of *Paneer*. Sanyal and Yadav (2000) [25] found that addition of common salt @ 0.25% along with 2.5% cultured skim milk increased the yield of reduced-fat *Paneer*. Sanyal *et al*. (2004) [27] observed that the addition of common salt @ 0.75% to milk increased the yield of reduced-fat *Paneer* by 19.59% above that of control.

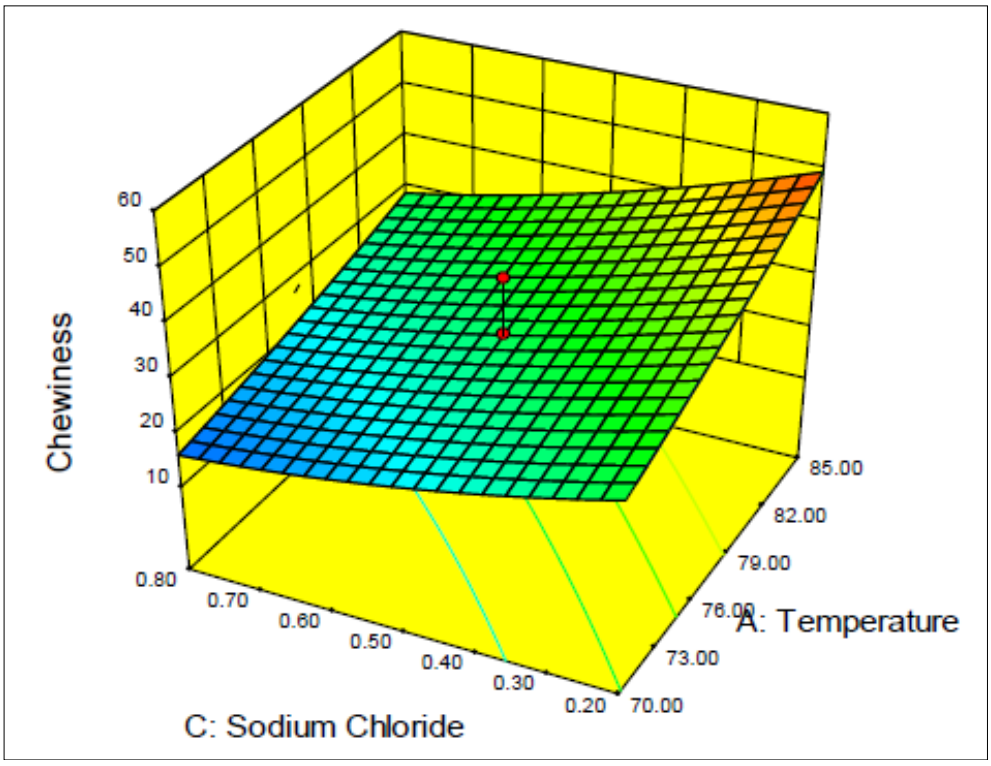
Chewiness (Nmm)

Chewiness (Nmm) is the amount of effort that goes into preparing a solid product ready for swallowing. *Paneer* ideally requires some chewiness to exhibit its functionality for frying and cooking purposes. The values of chewiness (Nmm) of *Paneer* shown in Table 3 ranged from 11.90 to 52.10 Nmm. Increase in coagulation temperature (X_1) increased the chewiness significantly (P<0.01) while increasing concentration of $CaCl_2$ (X_2) increased the chewiness at linear level but non-significantly. The P value for concentration of NaCl (X_3) (Table 5) showed its significance in linear terms and indicates the negative effect of concentration of NaCl (X_3) on chewiness of *Paneer*. A non-significant positive interactive effect on chewiness was observed with varying coagulation temperature and concentration of $CaCl_2$ and varying concentration of $CaCl_2$ and NaCl (Fig. 2). A non-

significant negative interactive effect on chewiness was observed with varying Coagulation temperature and concentration of NaCl. The square of factor indicates the effect of factor at highest level used in the product standardization. A non-significant positive effect on chewiness was found with the varying Coagulation temperature (X_1^2), varying level of concentration of $CaCl_2$ (X_2^2) and concentration of NaCl (X_3^2).

Sindhu (1996) attributed higher hardness and chewiness in buffalo milk *Paneer* to the higher concentration of casein in the micellar state and higher content of total and colloidal calcium. In the present study *Paneer* prepared by employing 85ºC coagulation temperature, addition of $CaCl_2$ @ 0.03% (w/w) and NaCl @ 0.20% (w/w) resulted in to the highest value of chewiness (Nmm) in *Paneer* which is desirable for its better functionality for the culinary purposes. Both the coagulation temperature as well as addition of $CaCl_2$ has positive effect on chewiness (Nmm) property of *Paneer*, the former being statistically significant ($P<0.01$). The response surface plots as shown in Fig. 2 are based on the above model.





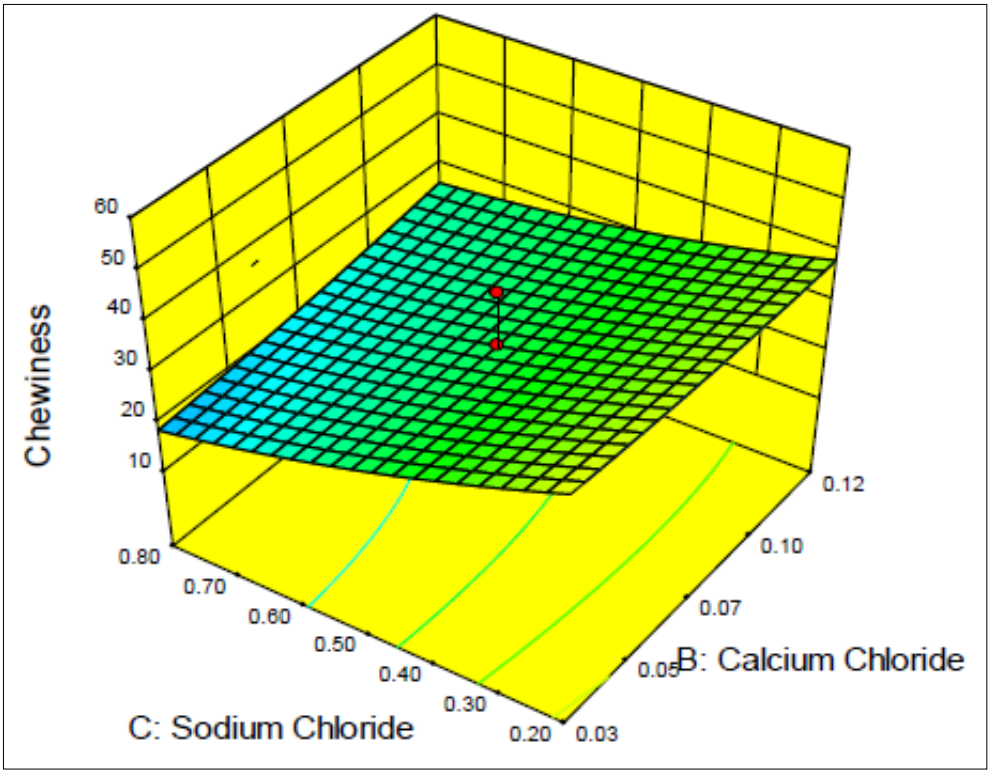


Fig 2: Effect of Coagulation temperature, rate of addition of calcium chloride and sodium chloride on chewiness of *Paneer* (design expert plots).

Optimization of independent variables

Process optimization for the manufacture of *Paneer* was carried out with the objective of determining the best possible combination(s) of different levels of factors viz. coagulation temperature (^{0}C) (X_1), addition of $CaCl_2$ % (w/w) (X_2) and NaCl % (w/w) (X_3) that would lead to the most acceptable product in terms of sensory scores, composition attributes and rheological characteristics.

The optimum levels suggested by the software Design expert 8.0.3 for Coagulation temperature, rate of calcium chloride and sodium chloride addition were 77°C, 0.05 % and 0.5 % with the desirability of 0.781. The predicted and actual response values (obtained after making the product using the optimum level of ingredients) have been presented in Table 6 from which it can be observed that both the values were statistically at par, hence, the above levels of ingredients were recommended. The Schematic Flow Diagram Standardized for the manufacture of *Paneer* is shown in Fig. 3. This standardized process yielded standardized *Paneer* having the proximate composition as depicted in Table 7. The detailed analysis of the compositional, physico- chemical, textural, sensory as well microbial attributes obtained from the three replications employing the optimized processing factors was performed and their average values are tabulated here under in Table 7.

Table 6: Comparison of predicted v/s actual values of responses used for process optimization for *Paneer* manufacture

Response	P Value	Predicted Value *	Actual Value @	Cal. t-Value #	Level of Significance
Flavour (out of 50)	0.852	43.60	43.61	0.199	NS
Body and Texture (out of 35)	0.276	29.56	29.63	1.263	NS
Colour and appearance (out of 10)	0.421	8.23	8.21	0.895	NS
Total Sensory Score (out of 100)	0.906	86.38	86.40	0.127	NS
Moisture (%)	0.454	55.54	55.09	0.857	NS
Yield (%)	0.471	18.46	18.37	0.821	NS
Chewiness (Nmm)	0.354	27.51	28.10	1.092	NS

* Predicted values of Design Expert 9.0.3.1 package
@ Actual values are average of five trials for optimised product
# t-values found non-significant at 5 % level of significance
NS = Non Significant
Tabulated t-value = 2.776 (cal. t-value less than tabulated value)

Conclusion

The sensory scores of *Paneer* manufactured employing various coagulation temperature, concentration of $CaCl_2$ and concentration of NaCl were influenced markedly. The *Paneer* prepared by using 77°C coagulation temperature, 0.08%, w/w $CaCl_2$ and 0.50 %, w/w NaCl addition was rated the best. Thus, good quality *Paneer* can be prepared with improved Yield and rheological properties by employing coagulation temperature at 77°C along with 0.05%, w/w $CaCl_2$ and 0.50 %, w/w NaCl addition.

Table 7: Average proximate chemical composition, physicochemical properties, rheological properties, sensory attributes and microbiological quality of *Paneer* manufactured by standardized process

Attributes	Value	Attributes	Value
Composition Attributes		**Rheological Properties**	
Moisture (%)	55.16±0.57	Hardness (N)	15.36±0.02
Fat (%)	23.75±0.65	Cohesiveness	0.38±0.01
Total Protein (%)	17.84±0.15	Springiness (mm)	4.81±0.06
Lactose (%)	2.57±0.17	Gumminess (N)	5.84±0.22
Ash (%)	1.33±0.02	Chewiness (Nmm)	28.10±1.14
Salt (%)	0.29±0.02	Adhesiveness (Nmm)	1.33±0.01
Physico-Chemical Properties		**Sensory Attributes**	
Acidity (% L.A.)	0.473±0.02	Flavour (out of 50)	43.61±0.56
pH	6.133±0.01	Body and Texture (out of 35)	29.63±0.58
Water Activity (a_w)	0.99±0.00	Colour and Appearance (out of 10)	8.21±0.50
Free Fatty Acid (µ eq/g)	0.365±0.01	Total score (out of 100)*	86.40±0.16
Microbial Count			
Standard Plate count (log_{10} cfu/g)	3.22±0.02	*Salmonella* count	Absent in 25 g
Yeast and Mold Count	Absent in 1 g	*Staphylococcus aureus* count	Absent in 1 g
Coliform Count	Absent in 1 g	*Listeria monocytogenes* count	Absent in 1 g

*Total score include 5 score (out of 5) given to package.

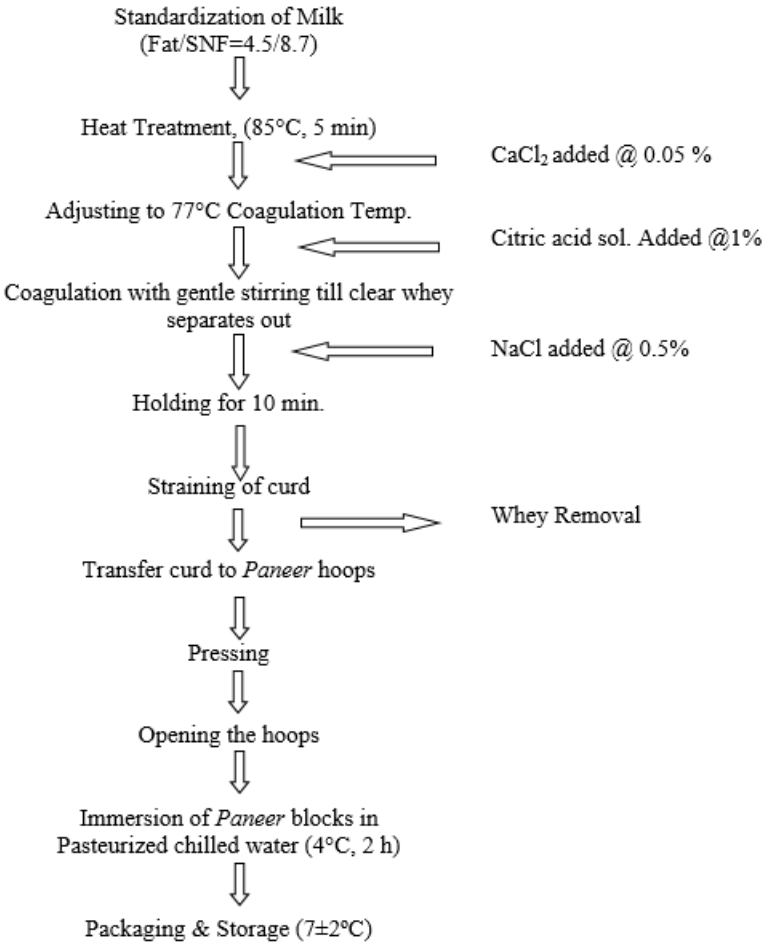


Fig 3: Standardized process for the manufacture of *Paneer*

References

1. Arora KL, Sabikhi L, Kanawjia SK. Manufacture of paneer from substandard buffalo milk. Indian J Dairy Biosci. 1996; 7(1):71-75.
2. Boghara VR, Rajorhia GS. Chemical quality of some marketed indigenous milk products – I. Major constituents and mineral composition of *Paneer*. J Fd. Sci. Technol. 1982; 28(1):57-68.
3. Chandan RC. Manufacture of Paneer. In: Gupta S, Gupta S (Eds.) Dairy India 2007, 6th Edn. Dairy India Yearbook, A Dairy India Publication, New Dehli, 2007, 411-412.
4. Chawla AK, Singh S, Kanawjia SK. Effect of fat levels, additives and process modifications on composition and quality of paneer and whey. Asian J Dairy Res. 1987; 6(2):87-92.
5. Chawla AK, Singh S, Kanawjia SK. Effect of fat levels, additives and process modifications on composition and quality of paneer and whey. Asian J Dairy Res. 1987; 6(2):87-92.
6. Deeth HC, Fitz-Gerald CH, Wood AF. A convenient method for determining the extent of lipolysis in milk. Aust. J Dairy Technol. 1975; 30(3):109-111.

7. Franklin JG, Harpe ME. The incidence of bacteria in cheese milk and Cheddar cheese and their association with flavour. J Dairy Res. 1963; 30(1):87-99.
8. Henika RG. Use of response surface methodology in sensory evaluation. Food Technol. 1982; 36(1):96-101.
9. Hill AR, Irvine DM, Bullock DH. Precipitation and recovery of whey proteins: A review. Can Inst Food Sci. Technol. J. 1982; 15(3):155-160.
10. Hirpara KB, Patel HG, Prajapati JP. Standardization of rate of sugar addition for the manufacture of Thabdi. J Food Sci Technol. 2013. doi:10.1007/s13197-013-1048-1
11. Indian Standard: 1479 (Part II). Methods of test for dairy industry, (Part II). Chemical analysis of milk. Bureau of Indian Standards, Manak Bhavan, New Delhi, 1961.
12. Indian Standard: 15346. Method for Sensory Evaluation of *Paneer*/Chhana. Bureau of Indian Standards, Manak Bhavan, New Delhi, 2003.
13. Indian Standard: 1547. Specifications for infant milk foods. Bureau of Indian Standards, Manak Bhavan, New Delhi, 1985.
14. Indian Standard: 2311. Fat extraction apparatus for milk and milk products (first revision). Bureau of Indian Standards, Manak Bhavan, New Delhi, 1963.
15. Indian Standard: 2785. Specifications for natural cheese (hard variety), processed cheese, processed cheese spread and soft cheese. Bureau of Indian Standards, Manak Bhavan, New Delhi, 1979.
16. Kanawjia SK, Singh S. Sensory and textural changes in paneer during storage. Buffalo J. 1996; 12:329-334.
17. Kaur J, Bajwa U. Effect of pretreatments of green leafy vegetables on the quality attributes of vegetable impregnated paneer. J Fd. Sci. Technol. 2003; 40(6):632-637.
18. Makhal S, Kanawjia SK. Effect of calcium chloride and high heat treatment on the yield of direct acidified cottage cheese. In: Proceedings of National Seminar on Value Added Dairy Products, National Dairy Research Institute, Karnal. 2005; 21-22:157.
19. Masud T. Effect of coagulation temperatures and strength of coagulant used on the composition of *Paneer*. Indian J Nutr Diet. 2002; 39(12):548-550.
20. Modha H, Pal D. Optimization of Rabadi-like fermented milk beverage using pearl millet. J Food Sci Technol. 2011; 48(2):190-196.
21. Sachdeva S, Singh S. Optimisation of processing parameters in the manufacture of *Paneer*. J Fd. Sci. Technol. 1988a; 25(3):142-145.
22. Sachdeva S, Singh S. Incorporation of hydrocolloids to improve the yield, solids recovery and quality of paneer. Indian J Dairy Sci. 1988b; 41(2):189-193.
23. Sachdeva S, Prokopek D, Reuter H. Technology of paneer from cow milk. Jpn J Dairy Food Sci. 1991; 40(2):A85-A90.
24. Sanyal MK, Yadav PL. Improvement in the quality of reduced-fat paneer from buffalo milk through sodium chloride incorporation. Buffalo J. 2000; 16(2):153-162.
25. Sanyal MK, Yadav PL. Effect of fermented skimmed milk incorporation into buffalo milk on quality of reduced-fat paneer. Indian J Anim Sci. 2000; 70(6):628-631.
26. Sanyal MK, Yadav PL, Gangopadhyay SK, Paul SC. Influence of sodium chloride incorporation into buffalo milk on the quality of reduced-fat paneer. Indian J Dairy Biosci. 2004; 15(1-2):28-31.
27. Sanyal MK, Yadav PL, Gangopadhyay SK, Paul SC. Influence of sodium chloride incorporation into buffalo milk on the quality of reduced-fat paneer. Indian J Dairy Biosci. 2004; 15(1-2):28-31.
28. Sharma RB, Kumar M, Pathak V, Kumar M. Effect of different seasons on crossbred cow milk composition and paneer yield in sub- himalayan region. Asian Australas J Anim. Sci. 2002; 15(4):528-530.
29. Sindhu JS. Suitability of buffalo milk for products manufacturing technique for paneer from cow milk. Indian J Dairy Sci. 1996; 41:322-325.
30. Singh S, Kanawjia SK. Development of manufacturing technique for *Paneer* from cow milk. Indian J Dairy Sci. 1988; 41(3):322-325.
31. Yadav PL, Rao KH, Rao KVSS, Sanyal MK, Singh RRB. Manufacture of low-fat paneer with enhanced shelf-life at ambient temperature. In: Proceeding of National Symposium on Meat and Milk Industry: Trends and Developmental Strategies. CCS Haryana Agricultural University, Hissar. 1994; 25-27:121.