

# Application of response surface methodology in preparation of low-fat paneer from recombined milk

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**Abstract:** The objective of current study was to optimize the level of milk fat, milk SNF (MSNF) and whey protein concentrate – 80 (WPC) to prepare low-fat paneer from recombined milk using response surface methodology. Milk fat, MSNF and WPC were used as variables while sensory attributes of paneer viz., flavour, body & texture, colour & appearance and overall acceptability, as well as compositional characteristics viz., moisture content and fat on dry matter basis were used as responses. On the basis of the results, RSM suggested the levels of milk fat, MSNF and WPC to be 2.14%, 10.72% and 0.75% respectively with desirability of 0.92. The experimental paneer was prepared as per the suggestions from RSM and compared with control paneer prepared from standardized milk containing 4.5% milk fat and 8.5% MSNF. The chemical composition of experimental paneer was significantly different from control paneer while rheological and sensory characteristics were statistically similar. Hence, RSM can be a useful tool for optimization of low-fat recombined milk paneer.

**Keywords:** Low-fat paneer; Recombined milk; Whey protein concentrate; response surface methodology; sensory parameters

## Introduction

Paneer, a popular heat and acid coagulated traditional Indian dairy product, is an unripened variety of soft cheese. Paneer provides an easy means of conserving and preserving valuable milk solids mostly milk protein and fat. The paneer market in India exhibited strong increase in sales between 2015 and 2020. The average composition of good quality paneer is approximately 53.0-55.0 per cent moisture, 23.0-26.0 per cent fat, 17.0-18.0 per

cent protein, 2.0-2.5 per cent carbohydrate and 1.5-2.0 per cent minerals (Kanawjia and Singh, 2000). The biological value (BV) of protein in paneer is in the range of 80 to 86 (Shrivastava and Goyal, 2007). Ideally, paneer should have a marble white appearance with a firm, cohesive and spongy body and a close-knit texture. It should have a clean, pleasing, boiled milk flavor.

Whey protein concentrate (WPC) is obtained from whey, a by-product obtained during manufacture of paneer and cheese, by using different methods like membrane technology. WPC has been used successfully in several dairy products for years. Whey protein concentrates (34.0-80.0 per cent protein) is the most commonly used ingredients for dairy products. It possesses wide range of functional properties such as foaming, solubility, emulsification ability, gelling and water binding. Whey products such as whey protein concentrates contribute to creaminess, texture, water binding, gelling, emulsification, viscosification, opacity and adhesion in a variety of food systems. Their high nutritional quality and unique range of functional properties make them valuable ingredient in a wide range of low-fat products. Their multifunctional characteristics provide several fat-like attributes (Johnson, 2008). It is widely being used in food sector for enriching various food formulations like frozen desserts, geriatric foods, yoghurt, processed cheese, infant formulae and in traditional dairy products and various bakery applications (Vijaykumar et al. 2020). Utilization of WPC improves viscosity, gelation and water holding capacity and thereby it can be explored in some of the products like soup, yoghurt, Khoa (Shree et al. 2017). The nutritional contribution of whey in this formulation such as whey protein concentrates provides high quality protein, calcium and a variety of health-enhancing components (Bounous,

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2000). Besides the nutritional and functional properties, whey protein also carries a bio-protective agent which enhances anti-inflammatory property, protection of intestinal flora with antibacterial or preservative effects and passive immunity against enteric, respiratory bacteria and viruses (Berber et al. 2015).

Data collection and processing is essential for development of new product and improvement in existing ones. Response surface methodology (RSM) plays a significant role in it. RSM is useful to optimize factors and produce best results. It is a robust and critical tool for data analysis which looks into an adequate approximation relationship between input and output variables and determines the best operating circumstances for a system (Myers et al. 2004).

With increased awareness towards health and nutrition, consumers are now moving to low-fat diet to avoid the risk of obesity, coronary heart disease, atherosclerosis, hypertension and tissue injury (Madadlou et al. 2005). High fat diet is also linked with psychiatric disorders (Jeong et al. 2019). Fat, being a costliest constituent in milk, increases the cost of final product and make the product unaffordable by low income group people. Paneer is a protein rich product and fulfills the protein requirement of most vegetarian people of India. However, reduction in fat content of paneer affects sensory and rheological characteristics of paneer. Therefore, development of a process for preparation of low-fat paneer with desired sensory and rheological characteristics is need of the hour

The market demand for paneer is increasing continuously and paneer is consumed throughout a year. Hence, there is also a need to develop a process to prepare paneer from recombined milk to meet the market demand during lean season. Therefore, in current investigation, reduced-fat paneer has been prepared using recombined milk.

## Materials and Methods

Skimmed milk powder of Sagar brand, containing 1% fat and 95% MSNF, as well as fresh cream, containing 25% fat and 6.8% MSNF was used for recombination. Citric acid (edible grade), supplied by Loba-Chemical Pvt. Ltd., Mumbai was used as a coagulant. Whey protein concentrate-80 (WPC), containing 77.8 per cent protein, supplied by Saisukrithkar supplements Pvt. Ltd., Bengaluru was used as fat replacer. Paneer was packed in 12  $\mu$  polyester + 50  $\mu$  LD/LLDPE laminated pouches.

The fat and total solids content in milk; moisture, fat, protein and ash content in paneer as well as pH and acidity of paneer was estimated by methods described by FSSAI (2015). Lactose content was calculated by difference of all constituents in paneer.

### Preparation of paneer

Low-fat paneer from recombined milk was prepared in the laboratory using method described by Aneja et al. (2002) with minor modifications. A calculated quantity of water, cream, skimmed milk powder and whey protein concentrate-80 were weighed accurately. Skimmed milk powder (SMP) and whey protein concentrate (WPC) were dry blended. Water and cream were mixed at 45°C and the mixture was heated to 55°C followed by addition of SMP and WPC mixture at slow rate. The recombined milk was then heated to 90°C and held for 10 min for the denaturation of whey protein. It was then cooled to 80°C and coagulated with pre-heated (80°C) 1% citric acid solution. The whey was drained with the help of muslin cloth and coagulated mass was pressed for 30 min. The paneer was then dipped in pasteurized chilled water (4°C) for 20 min and packed in laminated pouched followed by refrigerated storage (6 $\pm$ 1°C).

**Texture Profile Analysis:** Compression testing of paneer samples was done with Lloyd Instrument, Hampshire, UK (Model No. 01/2962) using 5.0 KN probe which moved at a speed of 20.0 mm/min. The paneer samples were taken for texture measurement after tempering the same at 23 $\pm$ 1°C for 1 h. All the textural measurements were conducted in a room maintained at 23 $\pm$ 1°C temperature and 65 $\pm$ 1% RH. Cubic samples of the experimental paneer, with edges of 20 mm, were placed in the compression support plate in uniform direction. The cubic samples were compressed up to 70% of their initial size. Five paneer samples were used for each experimental paneer under study and the average value of these readings was reported.

**Sensory evaluation of paneer:** Each block of paneer was cut into approximately 25 g rectangular pieces. The paneer samples were tempered to 15 $\pm$ 2°C before judging. Sensory analysis of paneer samples was performed in isolated booths illuminated with incandescent light maintained at 23 $\pm$ 2°C. The sensory panel (n=9) was composed of staff members and post-graduate students working in the institution. The paneer samples were evaluated using 9-point hedonic scale as described in Indian Standards (IS: 15346, 2003).

### Statistical Analysis

The minimum and maximum levels of milk fat, milk SNF and WPC-80 were selected as 1 and 3%, 9 and 11% as well as 0.5 and 1.0% respectively, on the basis of preliminary trials. A central composite rotatable design (CCRD) of the response surface methodology (RSM) technique was adopted for the optimization of milk fat, milk SNF and WPC-80. The CCRD of three factors contained 20 combinations, including lower and upper limits, along with their responses for sensory parameters as well as moisture and FDM are displayed in Table 1. The data generated for different responses were analyzed using Design Expert® software (13.0.2 version) (Stat-Ease, Inc., 2021 E. Hennepin Avenue, Minneapolis, USA). A general polynomial equation given below was fitted for each response.

$$Y = a_0 + a_1x_1 + a_2x_2 + a_3x_3 + a_{11}x_1^2 + a_{22}x_2^2 + a_{33}x_3^2 + a_{12}x_1x_2 + a_{23}x_2x_3 + a_{13}x_1x_3 + \text{Error term}$$

where Y represents the predicted response;  $a_0$  the constant coefficient;  $a_{11}$ ,  $a_{22}$  and  $a_{33}$  denote quadratic coefficients;  $a_{12}$ ,  $a_{23}$  and  $a_{13}$  denote interaction coefficients;  $x_1$ ,  $x_2$  and  $x_3$  denote milk fat, milk SNF and WPC content in milk.

Adequacy of the model was evaluated using coefficient of determination ( $R^2$ ) and statistical significance was examined by F value. The effect of independent variables and individual responses was described at  $P < 0.01$  and  $P < 0.05$ . t-test for two samples assuming equal variance was applied using Microsoft Excel for comparison of predicted values with the actual values of the responses. The variation between control and low-fat recombined milk paneer samples was analyzed using independent t-test.

### Results and Discussion

The optimization of the level of milk fat, milk SNf and rate of addition of WPC was carried out on the basis of sensory characteristics of low-fat recombined milk paneer viz. flavour,

**Table 1:** Design matrix showing factors and their responses for the

Run	A: Milk fat content (%)	B: MSNF content (%)	C: Rate of addition of WPC (%)	Response 1: Flavour	Response 2: Body & Texture	Response 3: Colour & Appearance	Response 4: Overall Acceptability	Response 5: Moisture	Response 6: Fat on Dry Matter basis
1	2	10	0.75	7.69	7.81	8.15	7.93	58.61	19.51
2	0.32	10	0.75	6.12	6.55	7.51	6.71	63.15	4.15
3	1	11	1	6.56	6.98	7.73	7.16	62.59	10.11
4	3.68	10	0.75	7.98	8.05	8.15	8.03	58.75	27.07
5	3	9	0.5	7.85	7.94	8.1	7.96	54.87	27.57
6	2	10	0.75	7.72	7.84	8.12	7.95	58.39	19.62
7	2	10	0.75	7.7	7.85	8.11	7.94	58.66	19.35
8	2	10	0.75	7.66	7.86	8.16	7.95	58.31	19.47
9	2	11.68	0.75	7.56	7.61	8.03	7.76	62.11	16.49
10	2	8.32	0.75	7.26	7.38	7.91	7.56	66.42	23.78
11	3	11	0.5	7.91	7.58	7.95	7.81	56.42	23.05
12	2	10	0.75	7.73	7.84	8.11	7.91	59.02	19.16
13	3	11	1	7.41	7.12	7.82	7.51	65.12	22.07
14	2	10	0.33	7.62	7.05	7.89	7.43	53.26	20.43
15	1	9	1	6.91	6.84	7.84	7.08	64.95	13.29
16	2	10	0.75	7.71	7.8	8.12	7.95	58.14	19.72
17	1	9	0.5	6.61	6.52	7.82	6.99	55.21	14.39
18	2	10	1.17	7.11	7.29	7.89	7.42	67.06	18.67
19	3	9	1	7.16	7.25	7.96	7.46	64.78	26.27
20	1	11	0.5	7.21	7.51	7.88	7.49	56.24	10.79

body & texture, colour & appearance and overall acceptability as well as its moisture content and fat content on dry matter basis. The successive regression analysis of the responses produced the quadratic models for each response. The variation in the experimental data of fitted quadratic model was given by coefficient of determination ( $R^2$ ) which ranged between 86 per cent and 96 per cent (Table 2). The model F-value of the fitted quadratic model for all responses was found to be significant. The sufficient accuracy for predicting all response variables of lo-fat recombined milk paneer prepared from any combinations of variables within the range was evaluated by non-significant lack of fit. These indicate that the obtained quadratic model fitted the data strongly. The signal to noise ration called *Adequate precision value (APV)* for a well fitted model should be more than four. This measure also fulfilled for the obtained mode with APVs ranging between 6.023 and 11.025. All these results firmly recommended that the model could be used to develop low fat recombined milk paneer.

### Effect of different variables on flavour

Flavour is a combination of taste, smell and mouthfeel. It is a major factor in sensory analysis and consumer acceptance of development of low-fat recombined milk paneer

any food product. The flavour score of experimental paneer samples ranged between 6.12 and 7.98. The minimum flavour score was obtained by paneer sample when fat content, milk SNF content and rate of addition of WPC in milk were 0.32%, 10% and 0.75% respectively while maximum flavour score was obtained when fat content, milk SNF content and rate of addition of WPC in milk were 3.68%, 10% and 0.75% respectively (Table 1). The paneer sample containing minimum fat content in milk displayed minimum flavour score and vice-versa which could be attributed to the rich flavour imparted by milk fat. The RSM estimated equation in terms of actual factors for predicting the effect of different variables on flavour is presented in table 3. The partial coefficients of flavour in terms of linear order, second order and interaction of two independent parameters are presented in the regression analysis data (Table 2). Milk fat had significant ( $P<0.05$ ) positive impact while WPC had significant ( $P<0.05$ ) negative impact on flavour score of paneer while MSNF failed to influence it. Addition of WPC led to increase in moisture content of paneer which resulted in flat flavour. At quadratic level, all the three parameters had significant ( $P<0.05$ ) negative impact on flavour score while the interaction of the parameters had no significant impact on it. Higher milk fat content led to slight lipolytic flavour while higher milk SNF and WPC resulted in flat flavour. Khan et al. (2012) and Vashishta et al. (2019) also reported similar findings. Increasing fat from 3% to 6% increased flavour score of paneer

samples (Sivakumar et al. 2011). The flavour scores of soft cheese (Soryal et al. 2005) as well as Kefalograviera-type cheese (Katsiari et al. 2002) were directly proportional to fat content of milk. Addition of WPC increased flavour score up to certain level followed by reduction in it (Mishra et al. 2022).

**Effect of different variables on body and texture**

Body and texture is also an important sensory parameter for paneer. The body and texture score for the experimental paneer samples ranged between 6.52 and 8.05. The paneer sample displayed minimum body and texture score was prepared from milk containing 1% milk fat, 9% MSNF and 0.5% WPC and the paneer sample contained 4.15% FDM while the paneer sample having maximum body and texture score was prepared from milk containing 3.68% milk fat, 10% MSNF and 0.75% WPC and the paneer sample contained 27.07% FDM (Table 1). The paneer sample with lower fat content was criticized for chewy body while the paneer sample with higher fat content was appreciated for good cohesive and firm body. The RSM estimated equation in terms of actual factors for predicting the effect of different variables on body and texture is presented in table 3. The partial coefficients of body and texture in terms of linear order, second order and interaction of two independent parameters are presented in the regression analysis data (Table 2). Milk fat and

**Table 2:** Regression coefficients and ANOVA fitted quadratic model for the responses of low-fat recombined milk paneer

Partial Coefficients	Flavour	Body & texture	Colour & appearance	Overall acceptability	Moisture	FDM
Intercept	7.70	7.84	8.13	7.94	58.59	19.47
A-Milk fat	0.45*	0.33*	0.12*	0.31*	-0.38	6.51*
B-MSNF	0.08	0.08	-0.01	0.06	-0.49	-2.03*
C-WPC	-0.18*	0.17*	-0.03	0.18*	4.24*	-0.51*
AB	0.01	-0.20*	-0.03	-0.09	0.40	-0.24
AC	-0.11	-0.12	-0.02	-0.07	0.32	-0.06
BC	-0.10	-0.08	-0.02	-0.03	-0.58	0.09
A <sup>2</sup>	-0.24*	-0.20*	-0.10*	-0.21*	0.44	1.35*
B <sup>2</sup>	-0.11*	-0.14*	-0.05*	-0.10*	1.62*	-0.25*
C <sup>2</sup>	-0.13*	-0.25*	-0.08*	-0.19*	0.16	0.04
Model fit statistics						
Lack of fit	0.0641	0.0612	0.0582	0.0551	0.0632	0.0651
Model F value	18.21	15.66	12.11	16.43	18.75	16.23
R <sup>2</sup>	0.91	0.86	0.96	0.94	0.89	0.94
APV	11.025	6.147	6.023	7.236	9.12	7.26

**Table 3:** Regression equations for predicting sensory score, moisture and FDM of low-fat paneer recombined milk paneer

Property	Equation	R <sup>2</sup>
Flavour	$7.70+0.45A+0.08B-0.18C+0.01AB-0.11AC-0.10BC-0.24A^2-0.11B^2-0.13C^2$	0.91
Body & texture	$7.84+0.33A+0.08B+0.17C-0.20AB-0.12AC-0.02BC-0.10A^2-0.05B^2-0.08C^2$	0.86
Colour & appearance	$8.13+0.12A-0.01B-0.03C-0.03AB-0.02AC-0.02BC-0.10A^2-0.05B^2-0.08C^2$	0.96
Overall acceptability	$7.94+0.31A+0.06B+0.18C+0.09AB-0.07AC-0.03BC-0.21A^2-0.10B^2-0.19C^2$	0.94
Moisture	$58.59-0.38A-0.49B+4.24C+0.40AB+0.32AC-0.58BC+0.44A^2+1.62B^2+0.16C^2$	0.86
FDM	$19.47+6.51A-2.03B-0.51C-0.24AB-0.06AC+0.09BC-1.35A^2+0.25B^2+0.04C^2$	0.94

WPC had significantly ( $P<0.05$ ) increased body and texture score of paneer samples while MSNF had no significant impact. Looking to the interaction effect, the interaction of milk fat and MSNF showed significant ( $P<0.05$ ) decrease in body and texture while the interaction of milk fat and WPC as well as of MSNF and WPC had no significant impact on it. At quadratic level, all the three factors had significant ( $P<0.05$ ) negative impact on body and texture score of paneer samples. Soryal et al. (2005) and Katsiary et al. (2002) reported improvement in body and texture of soft cheese and Kefalograviera-type cheese respectively with increase in fat and SNF content of milk. Dwivedi et al. (2010), Khan and Pal (2011) and Chauhan et al. (2017) also observed similar results in paneer. Mishra et al (2022) reported similar results for goat-milk chhana.

**Effect of different variables on colour and appearance**

Colour and appearance is the first sensory parameter to be observed by the judges. The colour and appearance score for paneer samples ranged between 7.51 and 8.16. The paneer samples with minimum score for colour and appearance was prepared from milk containing 0.32% milk fat, 10% MSNF and 0.75% WPC while that with maximum score was prepared from milk containing 2% milk fat, 10% MSNF and 0.75% WPC (Table 1). The paneer sample with minimum colour and appearance score was criticized for dull appearance while the one with maximum score had comparatively bright white colour. Looking into the impact of different variables on colour and appearance, only milk fat had significant ( $P<0.05$ ) influence while MSNF and WPC had no influence on the same at linear level. Interaction of different variables also failed to influence colour and appearance. Higher level of milk fat resulted in a typical objectionable glossiness

while that of milk SNF and WPC led to dullness in the appearance (Table 2). Dwivedi et al. (2010), Khan et al. (2012) and Chauhan et al. (2017) also found similar results in paneer.

**Effect of different variables on overall acceptability**

Overall acceptability is the sum of all the sensory parameters. Overall acceptability score for paneer samples ranged between 6.71 and 8.03. The paneer samples with minimum score for overall acceptability was prepared from milk containing 0.32% milk fat, 10% MSNF and 0.75% WPC while that with maximum score was prepared from milk containing 3.68% milk fat, 10% MSNF and 0.75% WPC (Table 1). Milk fat and WPC had significant ( $P<0.05$ ) effect on overall acceptability while MSNF had no impact on it at linear level. Interaction of different variables also had no significant impact while all factors had significant ( $P<0.05$ ) negative effect on overall acceptability of paneer (Table 2). Dwivedi et al. (2010), Khan et al. (2012) and Chauhan et al. (2017) also found similar results in paneer. Mishra et al. (2022) also observed rise in overall acceptability of goat-milk chhana upto certain level of WPC followed by reduction in it.

**Effect of different variables on moisture content of paneer**

Moisture content of low-fat paneer should not be more than 60% (w/w) (FSSAI, 2006). Good quality paneer contains around 56-58% moisture, when WPC is incorporated. Moisture content of paneer samples ranged from 53.26% to 67.06%. The paneer sample containing minimum moisture was prepared from milk containing 2.0% milk fat, 10.0% MSNF and 0.33% WPC while the one containing maximum moisture was prepared from milk containing 2% milk fat, 10% MSNF and 1.17% WPC (Table 1). The hydrophilic

**Table 4:** Goals set for constraints to optimize the low-fat paneer prepared from recombined milk paneer

Constraint	Goal	Lower limit	Upper limit
Milk fat, %	In range	1	3
Milk SNF, %	In range	9	11
WPC, %	In range	0.5	1.0
Flavour	Maximize	6.12	7.98
Body & texture	Maximize	6.52	8.05
Colour & appearance	Maximize	7.51	8.16
Overall acceptability	Maximize	6.71	8.03
Moisture	Range – 55 to 59	53.26	67.06
FDM	Range – 16 to 19	4.15	27.57

**Table 5:** Comparison of predicted values and observed values for low-fat recombined milk paneer

Attributes	Predicted value	Observed value	p-value
Flavour	7.76	7.74	NS
Body & texture	7.85	7.88	NS
Colour & appearance	8.11	8.09	NS
Overall acceptability	7.91	7.95	NS
Moisture	58.54	58.89	NS
FDM	18.92	18.98	NS

nature of added WPC as well as native milk protein could be attributed for the variation in moisture content. Milk fat and milk SNF had no significant effect on moisture content of paneer while WPC had significant ( $P<0.05$ ) positive impact on it. At quadratic level, only milk SNF had significant ( $P<0.05$ ) positive impact on moisture content of paneer (Table 2). Moisture content of Grana Padano cheese reduced with increase in fat content in milk (Pretto et al. 2013). Pazzola et al. (2019) reported increase in moisture content of cheese with increase in protein content of milk while Soryal et al. (2004) observed increase in moisture content of Domiati cheese with increase in SNF content of milk. Moisture content of soft cheese was directly proportional to protein content of milk (Soryal et al. 2005). Several other researchers observed similar results in paneer (Dwivedi et al. 2010; Khan et al. 2012) respectively. Increase in the level of WPC from 0.25% to 0.75% also increased moisture content of chhana from 62.05% to 69.72% (Mishra et al. 2022).

#### Effect of different variables on FDM content of paneer

Fat content on dry matter basis should not be more than 20% (w/w) for low-fat paneer (FSSAI, 2006). The FDM content of paneer samples ranged from 4.15% to 27.57%. The paneer samples containing minimum FDM was prepared from milk containing 0.32% milk fat, 10% MSNF and 0.75% WPC while that with maximum FDM was prepared from milk containing 3.0% milk fat, 9.0% MSNF and 0.5% WPC (Table 1). Milk fat significantly ( $P<0.05$ ) increased FDM content of paneer while milk SNF and WPC significantly ( $P<0.05$ ) decreased FDM content of paneer at linear level. At quadratic level, Milk fat had significantly ( $P<0.05$ ) impact while milk SNF had significantly ( $P<0.05$ ) positive impact

on FDM content of paneer. Fat content of paneer is directly proportional to fat content of milk upto certain level, beyond that there is tendency to increase fat loss in whey. An increase in fat content of milk increased FDM content of cheddar cheese (Lucas et al. 2006) and soft cheese (Soryal et al. 2005). Gareem et al. (2000), Dwivedi et al. (2010) and Dikshit et al. (2015) observed similar results in low-fat paneer and recombined milk paneer respectively. Mishra et al. (2022) also observed reduction in FDM content with increase in the level of WPC.

The level of optimized contents of milk fat, MSNF and WPC to be used in low-fat recombined milk paneer was carried out using numerical optimization technique. The criteria used for optimization are summarized in Table 4. All factors as well as moisture and FDM content were kept in range while sensory parameters were kept at maximum during the optimization process. RSM suggested levels of milk fat, MSNF and WPC to be 2.14%, 10.72% and 0.75% respectively with desirability of 0.92. Low-fat recombined milk paneer was prepared at desired optimum level of milk fat, MSNF and WPC as suggested by RSM. The predicted values for flavour, body & texture, colour & appearance, overall acceptability, moisture and FDM content for the experimental paneer were 7.76, 7.85, 8.11, 7.91, 58.54% and 18.92% respectively (Table 5). It is evident from the table that the observed values were not significantly ( $P>0.05$ ) different from predicted values with respect to all attributes. Therefore, it was confirmed that the selected level of combination of milk fat, MSNF and WPC is best for preparation of low-fat recombined milk paneer with optimum sensory as well as compositional attributes.

#### Analysis of low-fat recombined milk paneer

**Table 6:** Comparison of low-fat recombined milk paneer with control paneer

Parameter	Control paneer	Reduced-fat paneer	t-value
Chemical composition			
Moisture, %	55.18	58.89	31.632**
Fat, %	25.30	11.17	30.341**
FDM, % on DMB	52.92	18.98	24.491**
Protein, %	18.11	23.99	7.307*
Lactose, %	2.52	2.69	NS
Ash, %	1.89	2.29	9.115**
Rheological characteristics			
Hardness, N	18.952	17.407	NS
Cohesiveness	0.438	0.426	NS
Springiness, mm	6.978	7.279	NS
Gumminess, N	6.986	7.841	NS
Chewiness, N.mm	48.748	57.074	NS
Adhesiveness, N	0.355	0.422	NS
Sensory characteristics			
Flavour	8.51	8.39	NS
Body & texture	8.32	8.16	NS
Colour & appearance	8.42	8.39	NS
Overall acceptability	8.43	8.29	NS

Low-fat recombined milk paneer was analyzed along with traditional paneer for its compositional parameters as well as rheological and sensory characteristics and analyzed statistically using t-test (Table 6). Fat and FDM content of low-fat recombined milk paneer were significantly ( $P<0.01$ ) lower than that of control paneer while moisture ( $P<0.01$ ), protein ( $P<0.05$ ) and ash ( $P<0.05$ ) content of experimental paneer were significantly higher than those of control paneer. Protein content of paneer increased with reduction in fat content. Fat and protein are two major constituents in paneer and their content is inversely proportional to each other (Lobato-calleros et al. 2001). The experimental as well as control paneer samples were also analyzed for rheological and sensory characteristics and found no significant difference.

## Conclusion

Low-fat recombined milk paneer was prepared using response surface methodology and the levels of milk fat, MSNF and WPC were optimized in order to obtain sensorially acceptable product with similar rheological characteristics. The final product also met the legal requirement for chemical composition. At linear level, milk fat improved sensory profile and increased FDM content while milk SNF showed reduction in FDM content while WPC had negative influence on flavour but positive influence on body and texture as well as overall acceptability. It also showed increase in moisture content and reduction in FDM content. At quadratic level, all the three parameters had negative impact on sensory profile while milk fat increased FDM content and milk SNF increased moisture content but reduced FDM content. Hence, response surface methodology can be used as an important application for development of low-fat recombined milk paneer or any other similar product.

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