RESEARCH ARTICLE

Process optimization for development of low-calorie *milk cake*

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Abstract: Among the indigenous dairy products, *khoa* and *khoa* based milk sweets have served as a good means of conserving and safeguarding surplus milk solids. *Milk cake* is the most popular heat desiccated milk based sweet which is characterized by its well-defined grainy texture and pronounced caramel flavor. In the present study, an attempt was made to develop a low-calorie *milk cake* with the incorporation of artificial sweetener and fat replacer in the milk using Response Surface Methodology and also, to study various physiochemical parameters of the optimized product. An RSM experiment was conducted with three variables viz., Milk Fat (1.0-3.0%), Aspartame (0.3-0.5%) and Gum Acacia (0.3-1.0%). The average value of proximate chemical analysis of fat, protein, added sugar, moisture and ash was 5.30%, 17.31%, 0.00%, 17.23%, and 2.37% respectively. Results showed that the level of fat and carbohydrate was decreased drastically, and helped in reducing the calorific value of *milk cake*. The energy value of low-calorie *milk cake* was reduced about half of the market milk cake as the energy value of low-calorie *milk cake* was 3.782 kcal/gm and market *milk cake* was 6.335 kcal/gm.

Keywords: Fat replacer, Low-calorie, Milk cake, Optimization

Introduction

India ranks first in the world milk production of 165.4 million tons of milk per annum with the per capita availability of 355 gm/day (NDDB, 2017). Use of diverse methods to prepare as well as preserve milk products have been reported in the very early literature. In the present context, *Kalakand*, *Khurchan*, *Rabri*, *Burfi*, *Milk cake*, etc. represents a range of commercially important heat desiccated milk products. Among the indigenous dairy products, *khoa* and *khoa* based milk sweets provide a good means of conserving and preserving surplus milk solids. It is estimated that about 7 percent of total milk in India is converted into heat and acid coagulated indigenous milk products among which *kalakand* and *milk cake* are one of the products (Bhutkar *et al.*, 2015). *Milk cake* is the most popular desiccated milk based sweet characterized by well-defined grains with pronounced caramel flavor than *Kalakand* which is prepared from danedar (granular) variety of *Khoa* (Mathur, 1991). Modification of lifestyle habits may play an important role in changing food trends. The current trend amongst the consumers and in the food industry is towards the food products that contain low-calorie sugar and fat-replacers due to increasing nutritional and health awareness for calorie reduction in the diet (Dilek *et al.*, 2007). Aspartame, an artificial sweetener is used as a sugar substitute which is about 200 times sweeter than sucrose or table sugar. Aspartame is a methyl ester of the aspartic acid/phenylalanine di-peptide due to this property, even though aspartame produce four kilocalorie of energy per gram when metabolized, the quantity of aspartame needed to produce a sweet taste is so small that its calorific contribution is negligible (Magnuson *et al.*, 2007). As a food, acacia gum is used as an emulsifier, fat replacer and a thickening agent in icing, fillings, soft candy, chewing gum, and other confectionery. In the present study, an attempt was made to optimize the process for the manufacture of low-calorie *milk cake* using Response Surface Methodology. And also to study the various physiochemical properties of low-calorie *milk cake*.

Materials and methods

Milk of different fat percentage was collected from Amul outlet from the local market of Varanasi, Uttar Pradesh, Aspartame

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(artificial sweetener) made by NutraSweet Co., USA were procured from Kawar Lal And Company, Chennai, India. Gum Acacia (fat replacer) was procured from Avantor performance India Ltd., Faridabad, Haryana, India and Citric acid from Sisco Research Laboratories Pvt. Ltd. Andheri (E), Mumbai, India.

Preparation of low-calorie milk cake

Low-calorie *Milk Cake* was prepared as per the procedure standardized by karwasra *et al.* (2001) with slight modification. For the preparation of low-calorie *milk cake*, toned milk (3 percent fat and 8.5 percent SNF) was taken and strained through a muslin cloth to remove dust and dirt particle. After straining, five liters of milk was taken in a shallow iron *karahi* and boiled till the volume of milk becomes half and then citric acid was added at the rate of 0.02 percent (weight/ volume of milk) and desiccation is continued. When the volume was reduced to one-third of the original volume of the milk, Gum acacia was added at the level of 0.49 percent (w/v). Further, desiccation was continued with fast stirring to obtain dough-like thick consistency followed by addition of aspartame at the rate of 0.23 percent (w/v), the hot dough was then transferred to a greased tray, and was slowly cooled in an insulated box for five to six hours. The bottom of the tray was cooled in ice water while the top of the tray was cooled slowly at room temperature. This result in deferential caramelization of the top and bottom of *milk cake*, the top layer gets a darker color and stronger flavor whereas rapidly cooled bottom layer retains white color. The flow chart of the preparation of low-calorie *milk cake* is shown in Figure 1.

Experimental design and data analysis

RSM was employed to optimize the percentage level of three independent variables such as milk fat, artificial sweetener, and Fat Replacer. The three independent variables used in the experimental design are presented in Table 1. The levels of each variable were established according to preliminary trials. Dependent variables considered were sensory analysis and textural properties such as color & appearance, flavor, body & texture, hardness, gumminess, chewiness. Also, the effect on the color was also considered. Response surface methodology was applied for experimental data using a commercial statistical package, Minitab 18 for the generation of response surface plots. The same software was used for statistical analysis of experimental data. The results were analyzed by a multiple linear regression method which describes the effects of variables in the first order, a three-factor interaction (3FI) and second order polynomial models. Experimental data were fitted to the selected models and regression coefficients were obtained. Statistical significance of the terms in the regression equation was examined by analysis of variance (ANOVA) for each response. A Pearson's correlation matrix on product responses and system parameters was carried out in order to determine correlation coefficients between parameters.

The experiments were done and responses were fitted in the design. After that each individual experiment, responses were analyzed to assess the effect of independent variables on them. Numerical optimization technique of the Design Expert software was used for simultaneous optimization of the multiple responses. The desired goals for each factor and response were chosen. The goals may be applicable to either factors or responses. The possible goals or constraints were: maximize, minimize, target, within range, none (for response only) and set to an exact value (for factors only). In order to search a solution maximizing multiple responses, the goals were combined into an overall composite function, called the desirability function. Desirability is an objective function that ranges from zero outside of the limits to one at the goal. The program of the software (design expert) seeks to maximize the function. The goal seeking begins at a random starting point and proceeds up the steepest slope to a maximum. By starting from several points in the design space, chances improve for finding the "best" local maximum.

The second order polynomial equation of the following form was fitted to the responses:

$$Y = \beta_0 + \sum_{i=1}^4 \beta_i X_i + \sum_{i=1}^4 \beta_{ii} X_i^2 + \sum_{i=1}^3 \sum_{j=i+1}^4 \beta_{ij} X_i X_j$$

Where,

Y = response variable

$\beta_0, \beta_i, \beta_{ii}$ & β_{ij} = regression coefficient

X_i, X_j & X_{ij} = coded independent variables

Responses to optimize the level of fat replacer, artificial sweetener, and milk fat percentage

Sensory evaluation

Low-calorie *Milk Cake* was analyzed for different sensory characteristics like color and appearance, body and texture, flavor and overall acceptance by a panel of 9 semi-trained judges from the Center of Food Science and Technology, Banaras Hindu University, Varanasi and analysis was conducted in triplicate. Sensory evaluation was done at 25°C by using nine-point hedonic rating (9-point scale lies between, 1 = dislike extremely to 9 = like extremely) as described by Amerine *et al.* (1965).

Texture profile analysis

Low-calorie *Milk Cake* was analyzed for different textural parameters like hardness, gumminess, and chewiness using a texture profile analyzer (Model TA-XT Plus, UK). In this experiment cylindrical probe (p/75) was used, the size of the sample

was 20mm in height and 20 mm width. The product was subjected to compressive force by probe up to a distance of 20 mm twice. The conditions of texture analyzer set for measuring textural properties are as follows: pre-test speed 2mm/sec and test and post-test speed was 0.5 mm/ sec, trigger force 5.0 g and time 5.0 sec for each evaluation, about 25 g was used during texture analysis.

Color analysis

The color of Low-calorie *Milk Cake* was measured with a hunter color lab equipped with a measuring head (diameter 127 mm). Low-calorie *milk cake* was crushed, filled three fourth into the measuring head and color was evaluated. The Hunter L, a, b color scale indicates color as L, a, b where L* scale indicates Light Vs dark where a low number (0-50) indicates dark and a high number (51-100) indicates light, a* scale indicates red Vs green where a positive number indicates red and negative number indicates green and b* scale depicts yellow Vs blue where a positive number indicates yellow and negative number indicates blue. The L* value for each scale, therefore, indicates the level of light or dark, the a* value redness or greenness, and b* value yellowness or blueness. All three values are required to completely describe an object's color.

Physicochemical analysis of low-calorie milk cake

Physicochemical parameters such as % protein, fat, Moisture, and ash content were determined as per the method described by AOAC (1995). Reducing sugar content in Low-Calorie *Milk Cake* was determined as per the method recommended by Miller *et al.* (1959).

Energy value

Energy value was measured using bomb calorimeter. About 1g of the sample was weighed in a crucible and placed inside a stainless-steel container (the "decomposition vessel") filled with 30 bar (435psi) of oxygen. Next, the sample was ignited through a cotton thread connected to an ignition wire inside the decomposition vessel and burned (combusted). During combustion, the core temperature in the crucible can rise up to 1000°C (1800°F), and the pressure rises for a short period of time to approximately 200 bar (2900psi), or sometimes even higher. All organic matter is burned under these conditions and oxidized. Inorganic matter (minerals) will be oxidized; often, even

vitrification takes place. The heat created during the burning process can be determined in different ways. After the combustion process was completed the energy value was displayed on the screen in terms of cal/g.

Statistical analysis

The data obtained during the present investigation were suitably analyzed by employing statistical designs. Response surface methodology (RSM) was used to optimize the various parameters such as milk fat, artificial sweetener and gum acacia level for optimization of Low-calorie milk cake. The results of preliminary studies are expressed as a mean $\pm$ standard error. Statistical significance was tested by employing one-way & two-way analysis of variance (ANOVA) and comparison between means was made by least significant difference pairwise comparison. For computation of data, software application programmes like Minitab 18 were used.

Results and discussion

Response surface methodology (RSM) was used to optimize the various independent parameters such as milk fat, artificial sweetener and gum acacia level for optimization of Low-calorie *milk cake* based on various sensorial and textural attributes. Color analysis mainly a* (Redness) was also considered for optimization of product for the various independent parameters Table 2. The quadratic models for various sensorial and textural parameters were obtained through successive regression analysis. The partial regression coefficients for % yield in terms of linear order, second order, and interaction of all three ingredients were included in Table 3.

Optimization of milk cake on the basis of Sensory Evaluation

Effect on Color and Appearance

The average color and appearance score varied from 7.5 to 8.0. Figure 2 (a) clearly depicts that with an increase in gum acacia level there was an increase in the color and appearance and with an increase in the level of milk fat the color and appearance decreases. Once the gum acacia was incorporated in the sample, it became slight brown in color. In the present study effect of gum acacia and level of milk fat on color and appearance could be described by the quadratic equation:

Table 1 Three independent process variables used in response surface methodology

Factor	Name	Units	Type	Subtype	Minimum	Maximum
A	Milk fat	%	Numeric	Continuous	1.0	3.0
B	Artificial sweetener	%	Numeric	Continuous	0.3	0.5
C	Gum acacia	%	Numeric	Continuous	0.3	1.0

Fig. 1 Flow chart for the manufacturing of low-calorie *milk cake*

Color & Appearance = $8.18 - 0.442 A - 2.5 B + 1.59 C + 0.102 A^*A + 1.3 B^*B - 0.614 C^*C + 0.62 A^*B$

Here A, B, and C are coded term for the variables milk fat, aspartame and gum acacia respectively. The coefficient of the estimate of color and appearance showed that the model was linear. The quadratic model for color and appearance was found to be significant ($p < 0.0001$). The coefficient of determination (R^2)

was 0.9362. The “Pred R-Squared” of 0.8233 is in reasonable agreement with the “Adj R-Squared” of 0.9467. “Adeq Precision” was 21.435 and signal that ratio was greater than 4 was the desired value which indicates an adequate signal. Hence, the model could navigate the design space.

Effect on flavor

Table 2 Response Surface Methods for optimization of Sensory Evaluation, Texture Response and Color Analysis obtain in different trials performed by RSM

Trial	Milk Fat	Sweetener	Gum Acacia	Color & Appearance	Body & Texture	Flavor	Overall Acceptance	Hardness	Chewiness	Gumminess	a *
1	2	0.4	0.65	7.5	7.5	8	7.5	9.0734	0.169	0.5432	7.59
2	0.318207	0.4	0.65	7.5	7	7.5	7	10.4066	2.295	1.0205	8.2
3	2	0.4	0.65	7.5	7.5	8	7.5	9.0734	0.169	0.5432	7.59
4	3	0.3	1	8	8	7.5	8	1.901	0.388	0.207	9.71
5	3	0.5	1	7	8	8	8	1.6204	0.2837	0.195	6.92
6	2	0.4	0.65	7.5	7.5	8	7.5	9.0734	0.169	0.5432	7.59
7	1	0.5	1	7	7	7.5	7	7.5364	1.7544	1.0468	7.06
8	1	0.3	1	8	7	7	7	5.0783	1.2954	1.2354	7.32
9	2	0.4	0.061373	7.5	7	7.5	7	21.508	6.653	3.2131	6.09
10	2	0.4	0.65	7.5	7.5	8	7.5	9.0734	0.169	0.5432	7.59
11	2	0.4	0.65	7.5	7.5	8	7.5	9.0734	0.169	0.5432	7.59
12	1	0.3	0.3	8	8	8.5	8.2	2.529	0.491	0.2215	9.61
13	2	0.568179	0.65	8	7	6	7	6.0782	1.2556	0.7377	8.09
14	2	0.4	0.65	7.5	7.5	8	7.5	9.0734	0.169	0.5432	7.59
15	2	0.231821	0.65	7	7.5	8	7.5	15.1898	4.4769	2.355	8.3
16	3	0.3	0.3	8	8	7.5	8	6.0732	1.1736	0.5928	5.04
17	3.681793	0.4	0.65	8	7.3	7.5	7.5	6.034	0.9543	0.3424	7.79
18	3	0.5	0.3	7.5	7	8	7.5	5.4321	1.3202	1.0432	6.45
19	2	0.4	1.238627	7	7	7.5	7	1.9043	0.5432	0.169	8.16
20	1	0.5	0.3	7	8	8	7.5	9.0544	0.9322	0.3445	7.34

Figure 2 Response surface plot for Sensory parameters (a) Effect on Color and Appearance (b) Effect on Flavor (c) Effect on Body and Texture (d) Effect on Overall acceptability

The average flavor score for low-calorie *milk cake* varied from 7.5 to 8.0. Figure 2 (b) gives out the fact that with an increased level of milk fat and aspartame, the flavor score was initially increased and then decreased gradually. Baldwin and Korschgen (1997) reported that the various food and beverage flavor was enhanced or extended by incorporation of aspartame especially in the case of acidic fruit flavors. Such flavor extension is particularly evident with naturally dried flavors. Bahoshy *et al.* (1997) reported that the flavor enhancing property of aspartame was evident in chewing gum with increased flavor up to four times longer and such characteristics are promising for many food applications.

In the present study effect of Milk Fat and Aspartame on Flavor score could be described by the following equation:

$$\text{Flavor} = 7.09 - 0.643A + 14.0B - 2.42C - 0.080A^2 - 25.7B^2 - 0.66C^2 + 1.25AB + 0.714AC + 3.57BC$$

Here A, B, and C are encoded for the three variables milk fat, aspartame (artificial sweetener) and gum acacia. The quadratic model for flavor was significant at ($p < 0.0001$). The coefficient of determination (R^2) was 0.8865. The "Pred R-Squared" of 0.8233 is in reasonable agreement with the "Adj R-Squared" of 0.8267. "Adeq Precision" was 21.435 and signal that ratio was greater

Figure 3 Response Surface plot for Textural parameters (a) Effect on Hardness (b) Effect on Gumminess (c) Effect on Chewiness

than 4 was the desired value which indicates an adequate signal. Hence, the model could navigate the design space.

Effect on body and texture

The average body and texture score for low-calorie *milk cake* was 7.3 to 8.0 (Table 2). Figure 2 (c) brings out the fact that with increase in level of gum acacia the body and texture score was also increased and increased in the level of aspartame had very slight effect on the body and texture and also the level of milk fat had some effect on body and texture, milk fat level increased they soften the body and texture. Tarrega and Costell (2006) studied that the observed change in the rheological behavior, induced by the inulin and gum acacia addition, may modify the sample texture perceived. The texture similar to fat can be obtained by increased in concentration. In the present study of gum acacia and sweetener to the body and texture could be described by the following equation:

$$\text{Body and Texture} = 9.28 - 0.025 A - 2.77 B - 3.06 C - 0.0153 A^2 A + 2.01 B^2 B - 0.558 C^2 C - 1.25 A^2 B + 1.071 A^2 C + 3.57 B^2 C$$

Here A, B, and C are encoded for the three variables milk fat, aspartame (artificial sweetener) and gum acacia. The quadratic model for body and texture was found to be significant at ($p < 0.0001$). The coefficient of determination (R^2) was 0.9065. The “Pred R-Squared” of 0.8423 is in reasonable agreement with the “Adj R-Squared” of 0.8047. “Adeq Precision” was 20.012 and signal that ratio was greater than 4 was the desired value which indicates an adequate signal. Hence the model could navigate the design space.

Effect on overall acceptance

Fig. 4 Response Surface Plot shows the interaction between Gum Acacia, Artificial Sweetener and a^* (Redness)

The maximum and minimum values obtained of overall acceptability were 8.2 and 7.5, respectively. The coefficient of determination (R^2) was 0.9645. The “Pred R-Squared” of 0.9876 is in reasonable agreement with the “Adj R-Squared” of 0.9927. “Adeq Precision” was 21.435 and signal that ratio was greater than 4 was the desired value which indicates an adequate signal. Hence, the model could navigate the design space. Figure 2 (d) shows the effect of gum acacia, sweetener on overall acceptance of Low-Calorie *Milk Cake*. As the level of gum acacia increased

Table 3 Coefficient of estimation of coded factors for low-calorie *milk cake*

Factor	Coefficient of estimation Yield (%)
A	-0.095
B	0.023
C	0.248
A ²	-0.313
B ²	-0.423
C ²	-0.693
AB	0.124
AC	-0.151
BC	0.041

Table 4 p and R^2 value of regression equation of suggested model for sensory, textural and Colour Characteristics

	C&A	B&T	Flavour	OAA	Hardness	Chewiness	Gumminess	a^*
p value	p<0.0001	p<0.0001	p<0.0001	p<0.0001	p<0.0001	p<0.0001	p<0.0001	p<0.0001
R^2	0.9362	0.9065	0.8865	0.9645	0.8762	0.8683	0.7983	0.7643
Pred R-Squared	0.8233	0.8423	0.8233	0.9876	0.8039	0.7925	0.8033	0.7925
Adj R-Squared	0.9467	0.8047	0.8267	0.9927	0.8342	0.7835	0.6685	0.8423
Adeq Precision	21.435	20.012	21.43	21.435		19.231	17.23	18.20
Model	Linear	Linear	Linear	Linear	Linear	Linear	Linear	Linear

the overall acceptability was decreased whereas, it increases with increase in the level of aspartame (sweetener).

Optimization of *milk cake* on the basis of texture profile analysis

Effect on hardness

Figures 3 (a) shows that the hardness of product during texture profile analysis was significantly affected by gum acacia and milk fat. As the level of gum acacia increased the hardness of the product is also increased whereas, increased level of milk fat decreases the hardness of the product gradually. The average value for hardness was indicated in Table 2. The effect of aspartame was negligible on the hardness of the product. The effect of gum acacia and milk fat on the hardness of the product described by the following equation:

$$\text{Hardness} = -14.0 + 11.56 A + 74 B + 5.5 C - 1.43 A^2 A - 58 B^2 B - 1.6 C^2 C - 12.4 A^2 B - 3.22 A^2 C - 13.2 B^2 C$$

Here A, B, and C are encoded by the three independent variables milk fat, aspartame and gum acacia. The quadratic model for Hardness was significant at ($p < 0.0001$). The coefficient of determination (R^2) was 0.8762. The “Pred R-Squared” of 0.8039 is in reasonable agreement with the “Adj R-Squared” of 0.8342. Hence the model could navigate the design space.

Effect on gumminess

The gumminess of the Low-Calorie *Milk Cake* was significantly affected by gum acacia, milk fat and slightly affected by

aspartame. Gum acacia had shown the highest ability to give gummy texture and also provide the binding properties so they help to bind the product. Figure 3(b) shows the interaction between the gumminess and the independent variable. The average value of gumminess was 0.169 to 3.25 g. The level of milk fat increased the gumminess of the product is decreased gradually. There was no very slight effect of sweetener on the gumminess of the product. The present study of the effect of milk fat, aspartame, and gum acacia are described by the following equation:

$$\text{Gumminess} = 4.19 + 0.72 A - 17.0 B - 0.40 C - 0.108 A^2 + 19.8 B^2 + 2.04 C^2 + 0.63 A*B - 1.054 A*C - 2.76 B*B$$

Here A, B, and C are encoded for the three variables milk fat, aspartame, and gum acacia. The quadratic model for Gumminess was significant at ($p < 0.0001$). The coefficient of determination (R^2) was 0.7983. The “Pred R-Squared” of 0.8033 is in reasonable agreement with the “Adj R-Squared” of 0.6685. “Adeq Precision” was 17.23 and signal that ratio was greater than 3 was the desired value which indicates an adequate signal. Hence, the model could navigate the design space.

Effect on chewiness

The Figure 3(c) shows chewiness of the low-calorie *milk cake* was significantly affected by gum acacia the concentration of gum acacia increased the chewiness was decreased and the level

of milk fat increased the chewiness was high at the low and high level of milk fat and low at the mid value. The minimum and maximum values for Chewiness were 0.169 to 3.23. The present effect of gum acacia and milk fat was described by the following equation:

$$\text{Chewiness} = 12.93 + 0.51 A - 44.9 B - 8.02 C + 0.115 A^2 + 55.4 B^2 + 6.63 C^2 - 1.07 A*B - 1.23 A*C - 0.8 B*B$$

Here A, B, and C are encoded for the three variables milk fat, aspartame, and gum acacia. The quadratic model for Chewiness was significant at ($p < 0.0001$). The coefficient of determination (R^2) was 0.8683. The “Pred R-Squared” of 0.7925 is in reasonable agreement with the “Adj R-Squared” of 0.7835. “Adeq Precision” was 19.231 and signal that ratio was greater than 4 was the desired value which indicates an adequate signal. Hence the model could navigate the design space.

Optimization of *milk cake* on the basis of color evaluation

Effect on a^* (Redness)

The effect of ingredients on the color of low-calorie *milk cake* is shown in figure 4. a^* is the scale of color analysis that lies between -120 to 120 (green and red) where a positive number

indicates red and negative number indicates green. The maximum and minimum value of a^* was ranged between 9.61 and 5.04. The value was fitted into the following quadratic equation:

Table 5 Analysis of optimized low-calorie *milk cake*

Attributes		Value
Physico-chemical	% Protein	17.31
	% Fat	5.30
	% Carbohydrate	57.79
	% Added sugar	0.0
	% Moisture	17.23
	% Ash	2.37
Textural	Hardness	9.032±0.023
	Gumminess	0.890±0.05
	Chewiness	1.210±0.03
Sensorial	Color and appearance	8.32±0.003
	Body and texture	8.23±0.015
	Flavor	7.32±0.005
	Over all acceptability	8.62±0.004

Table 6 ANOVA on the predicted value of for the different sensory attributes of low calorie *milk cake*

Attributes	Expected optimized attributes	Observed optimized attributes	<i>p</i> -Value
Color and appearance	8.20	8.32±0.003	0.931
Body and texture	7.55	8.23±0.015	0.767
Flavor	7.94	7.32±0.005	0.598
Overall acceptability	8.40	8.62±0.004	0.890

$$a^*(\text{Redness}) = 12.98 - 2.93 A - 12.1 B + 1.42 C + 0.069 A^2 + 14.0 B^2 - 1.95 C^2 + 1.44 A^2B + 2.754 A^2C - 7.82 B^2C$$

Here A, B, and C are encoded for the three variables milk fat, aspartame, and gum acacia. The quadratic model for $a^*(\text{Redness})$ was found to be significant at ($p < 0.0001$). The coefficient of determination (R^2) was 0.7643. The “Pred R-Squared” of 0.7925 is in reasonable agreement with the “Adj R-Squared” of 0.8423. “Adeq Precision” -was 18.20 and signal that ratio was greater than 4 was the desired value which indicates an adequate signal. Hence, the model could navigate the design space (Table 2).

Analysis of the optimized low-calorie milk cake

Low-calorie *milk cake* was prepared as per the optimized formulation suggested by RSM software and was analyzed for various physicochemical, sensory and textural attributes as given in Table 5 and the predicted and observed value for different sensorial parameters are given in Table 6. Table 4 shows the p -value and other constraints of the applied model. The three independent variables were optimized at 2.61%, 0.23% and 0.49% level for Milk fat, artificial sweeteners, and acacia gum, respectively and exhibit 0.86 desirabilities. Proximate composition of optimized low-calorie milk cake was found to be 17.31% protein, 5.30% fat, 17.23% moisture, 2.37% ash content and 0.0% added sugar. According to a market survey, the market sample of *milk cake* contained about 16.23% fat, 30.13% reducing sugar, 52-55% total carbohydrate 11.08% protein, 16.03% moisture and 2.67% ash content. So, in this study, the fat and sugar content was reduced about one-third of the amount present into the market *milk cake*.

Energy value of low-calorie milk cake

The energy value of Low-calorie *milk cake* was measured using bomb calorimeter as calorie per gram. The energy value of the control sample (market sample) was 6334.5 cal/g and the energy value of Low-calorie *milk cake* was 3782 cal/g. So, the energy value of Low-calorie *milk cake* was nearly half of the control sample.

Conclusions

The optimization process for the development of low-calorie *milk cake* was found to be successful in reducing the calorific value of the *milk cake* using Responses Surface Methodology (RSM). The developed low-calorie *milk cake* is preferably formulated keeping in mind the low-calorie requirement of people with different dietary requirements as in this case it could be for suitable for consumption by diabetic people. Apart from sweetness provided by aspartame, the acacia gum provides excellent texture even at a low-fat percentage.

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