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Effect of Mastic Gum and Inulin Incorporation on Physical and Sensory Properties of Low Fat Cream

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Abstract

The aim of this study was to investigate the use of mastic gum and inulin as a fat replacer in the production of low fat cream. Mastic gum (in proportions of 0.2, 0.5, and 0.8 wt./vol.%) in combination with inulin (in proportions of 1.2, 1.6, and 2.0 wt./vol.%) was added to the low fat cream network (in proportions of 18, 19, and 20%) and its effect on rheological and sensory properties was evaluated using response surface method. The results showed that addition of 0.8% mastic gum, 1.6% inulin, at 20% cream concentration significantly improved rigidity and consistency in product and maintained stability during storage. For industrial application, an optimized sample (standardized using Design Expert Software for numerical optimization with concentration of 0.68% mastic gum, 1.88% inulin and 19.8% cream) was compared with the commercial low-fat sample for textural and sensory quality. The results showed that the optimized low fat cream formula was suitable for industrial production with improved textural and organoleptic quality as well as shelf life.

Keywords

Mastic gum, Inulin, Fat replacer, Low fat cream, Textural properties

Introduction

During the last two decades consumption of low fat and fat-free foods has increased manifolds. As the consumption of excessive fat is related to different diseases such as obesity, cardiovascular diseases and cancer, food industry is encountered with ever-increasing demand for reduction of fat in food products. Therefore, food manufacturers are trying to satisfy this demand [1]. As a result, we see an enormous increase in the production of such products. In addition to nutritional aspects, fat affects the rheological and sensory properties like taste, mouth feel and texture. So, omitting fat is not an easy task. Therefore, to formulate low fat products, the use of substitution ingredients which can fully or partially replace the fat by mimicking fat properties are needed. Soluble food fibers and hydrocolloids like inulin act as emulsifier and stabilizer and by creating suitable texture and consistency give the low fat products a state similar to fat and improve mouth feeling [2].

Inulin is a group of natural polysaccharides that are used by some plants as a means for storing energy especially in underground roots and stems. The use of inulin with a polymerization degree above 10 as fat substitute in meat, milk and bread has been reported [3]. Sensory evaluation of many dairy products shows that using this polymer can improve sensory properties and result in general satisfaction of consumer. With regard to increasing the food value and

improving technological properties, it may have an essential role as a raw functional material in formulating food products in future. Inulin can be used to improve the texture of many dairy products. It acts well in these products as a fat substitute because it can properly imitate the fat characteristics for mouth feeling and creamy texture in dairy products [4].

According to literature survey no published report is available on the usage and effect of mastic gum (Iran's local pistachios) as an additive in the formulation of food products, though it has many special properties. It is possible to utilize it in dairy products as an additive to improve their quality. Since this material has a low solubility in water, it has been reported that it needs a stabilizer in the formulation to make a synthetic protein network in the pizza cheese, thus stabilized mastic gum is a filler in the obtained network [5]. In the material engineering science, it is proven that the application of a hard polymeric material as a filler in a scattered phase inside a matrix, may strengthen the mechanical properties of composite materials and this strength depends on the volume and shape of these hard particles [6]. Hence, in the present study, the possibility of using mastic gum and inulin in the production of low-fat cream was explored.

Materials and Methods

Materials

Inulin powder 10 Dp was obtained from Beneo Orafti Company in Tehran, Iran. Mastic gum was obtained from Shiraz, Iran. Milk (2.5% fat) and cream (30% fat) was obtained from Pegah factory, Mashhad, Iran. Sugar and vanilla were procured from the supermarket. A commercial pasteurized low fat cream (from Danone Dairy pars factory, Ghazvin, Iran) was purchased from supermarket to be used as a control sample.

Preparation of low fat cream

For the production of reduced fat cream the proportion of milk (2.5% fat) and cream (30% fat) to be used were derived using Pearson Square. These were mixed with mastic gum-inulin until the cream with 18, 19 and 20% fat could be obtained. The inulin-mastic gum powder used for reduced fat substitute were 1.2, 1.6 and 2.0% of inulin and 0.2, 0.5, and 0.8% of mastic gum respectively. These were mixed thoroughly in 20 random trials.

The process of production of cream was as follows – A known amount of milk was placed in a beaker on a water bath and heated to reach 45 to 50 °C. Then inulin and mastic gum powder were gradually added and stirred well to ensure complete dissolution. The mixture was heated for one minute at 75 °C, removed from the water bath, cooled to room temperature and mixed in a blender with the calculated amount of cream for a minute (twice for 30 seconds) and placed for 24 hours in the refrigerator at a temperature of 6 °C to obtain cream with desired fat [7].

First phase: effect of inulin+mastic gum mixture on properties of formulated cream model for optimum selection

At this stage, the effects of the mastic variables (in proportions of 0.2, 0.5, and 0.8 wt./vol.%) in combination with inulin content (in proportions of 1.2, 1.6, and 2.0 wt./vol.%) and the amount of cream respectively (in proportions of 18, 19, and 20%) on rheological and sensory properties of the formulated model was examined and a sample which, in terms of the characteristics mentioned, had the best properties was selected. A total of 20 different formulas of the cream model were produced according to the type and proportion of variables and the Response Surface Method (RSM) design.

Second phase: comparative evaluation of selected optimal model with the control sample

In the second step, the optimized cream model from the previous stage was compared and evaluated with low-fat commercial control samples in terms of rheological and sensory properties. This evaluation was based on the shelf-life of the cream in the intervals of 1, 3, 6 and 10 days (D).

Optimization of formula

For optimization of formula, Design Expert software was used for numerical optimization. The aim of optimizing the production process of the creamy model was to obtain the ideal proportion of ingredients for best quality product with respect to the rheological parameters measured. In this context, as suggested by numerous literature reports on cream, the viscosity traits, texture profile analysis (TPA), consistency, and minimum freeze thaw stability values were considered.

Viscosity measurement using a rheometer (Pa.s)

In this test, a rheometer (Model: KNX2110, Malvern Instruments Ltd., Worcestershire, UK) with the ability to control the shear stress was used. The rheometer consisted of a parallel plate geometry model and the gap geometry between the plate and the base was of 2 mm. The test was conducted on shear mode for all formulations with 18, 19 and 20% fat; 0.2, 0.5 and 0.8% mastic gum and 1.2, 1.6 and 2.0% of inulin with three replications for each formulation at 15 °C. The viscosity was obtained from the following formula as per the method of Gholamhossein pour and Tehrani [8].

$$\tau = \mathrm{k}.\eta.\omega$$

Texture analysis (TPA, Dyne/cm)

Texture Analyzer (model RS232- Amtech, USA) was used for texture analysis. Diameter of probe used was 2.5 cm with 5.0 cm. Speed of probe was 2 mm per second and distance traveled was set at 5 mm. In this test, the maximum strength denotes stiffness index of cream. This experiment was carried out with three replications at a temperature of 6 °C [9].

Measurement of consistency by Bostwick method (cm/30 sec)

Bostwick consistometer (model RV Brookfield, USA) is a device consisting of a container, a plate located on the front of container with graduations. A known amount of sample is poured into container, the front plate is taken off and the distance traveled by the sample in a specified time (usually 30 seconds) is measured. In this experiment, the distance traveled by 75 ml of cream in 30 seconds was measured. The distance traveled by liquid denotes the index of consistency.

This experiment was repeated three times at a temperature of 6 °C [10].

Freeze–thaw stability

The cream samples were placed at room temperature of 25 °C in order to reach uniform temperature in the sample, and then they were centrifuged at 100 rpm for 30 min. The supernatant (free water) was decanted. The remainder was frozen at -15 °C for 10 h and then thawed in a 30 °C water bath for 1 h. Finally, the sample was centrifuged at 100 rpm for 30 min, and the mass of the supernatant (separated water) was determined. The percentage of separated water was the ratio of the mass of the separated water to the mass of the paste as given below. In the current study, 20 freeze–thaw cycles were conducted for every product in order to measure the freeze-thaw stability of the cream [11].

Percent phase-separated = (weight isolated phase/weight of fat) × 100.

Sensory evaluation

The characteristics of a standardized good quality cream as suggested under Iran National Standard No. 191 [12] include color of the cream as white or creamy white; the texture as rigid and homogeneous; natural smell and taste without any unpleasant and unnatural flavor and desirable parameters from all angles. The sensory analysis was conducted using descriptive quality profile method of Zook and Weissermann [13]. The sensory panel consisted of 20 trained members selected from Department of Food Science and Technology, University of Ferdosi, Iran on the basis of their willingness to participate. In the first stage, 20 formulated samples with three digit random codes were subjected to sensory evaluation on the 10th day after production to determine the acceptability. The cream samples were evaluated for all quality attributes of color, body and texture, flavor and aroma and overall acceptability. In the second stage, the optimized sample was compared with a commercial low fat pasteurized cream (control sample).

Statistical analysis

For the first phase, the treatment and determination of the proportions based on the central composite design and Response Surface Method (RSM) were determined using the Design Expert software version 7.0. In the second phase, for optimization of formula, Design Expert software was used for numerical optimization. The data is presented are expressed as mean ± SD. Data was subjected to two way ANOVA by SPSS 11th version and Microsoft Excel, 2010.

Results and Discussion

The results of the study are compiled in tables 1-4 and figures 1-9. As can be seen in tables 1-3, the quadratic model to test viscosity, TPA and consistency on 0 and 10th day, freeze-thaw stability on 0, 3rd, 6th, and 10th day and sensory evaluation results for the formulated cream sample was statistically significant at a confidence level of 99% ($P<0.01$) and lack of fit value is not significant ($P>0.05$).

Table 1: Analysis of variance (ANOVA) of quadratic polynomial models for characteristics of viscosity, texture profile analysis and consistency.

Variables	df	Viscosity		Texture profile analysis				Consistency			
			0 (D)		10 (D)			0 (D)		10 (D)	
		Coefficient Estimate	Sum of Squares	Coefficient Estimate	Sum of Squares	Coefficient Estimate	Sum of Squares	Coefficient Estimate	Sum of Squares	Coefficient Estimate	Sum of Squares
Model	9	18985.11**	1.831	69.63**	1417.13	70.06**	1458.56	0.11**	0.15	0.087**	0.16
A-mastic	1	505.70**	2.557	3.65**	133.22	3.81**	145.16	-0.049**	0.024	-0.040**	0.016
B-inulin	1	920.00**	8.464	5.02**	252.00	4.93**	243.05	-0.078**	0.061	-0.095**	0.090
C-cream	1	524.10**	2.747	10.02**	1004.00	10.20**	1040.40	-0.056**	0.031	-0.048**	0.023
AB	1	-227.25*	4.131	-0.82**	5.44	-0.96**	7.41	0.031*	7.813	0.025*	5.000
AC	1	211.25*	3.570	0.85**	5.78	1..11**	9.90	-8.750ns	6.125	-5.000ns	2.000
BC	1	-253.50*	5.141	0.65*	3.38	0.46*	1.71	0.026ns	5.513	0.025ns	5.000
A^2	1	-432.77**	5.151	-0.98ns	2.63	-0.90ns	2.25	0.051ns	7.127	0.022ns	1.309
B^2	1	-708.27**	1.380	-1.43ns	5.60	-1.30ns	4.68	-0.024ns	1.596	0.047ns	6.028
C^2	1	431.23**	5.114	1.17ns	3.78	1.25ns	4.27	0.036ns	3.546	1.818ns	9.091
Residual	10	---------	2.987	-------	10.86	--------	12.07	--------	0.015	---------	1.851
Lack of Fit	5	ns	91915.41	ns	10.75	ns	11.91	ns	0.012	ns	1.451
Pure Error	5	---------	2.068	--------	0.11	--------	0.16	---------	2.550	---------	4.000
Cor Total	19	---------	1.861	--------	1427.99	--------	1470.63	---------	0.17	---------	0.16
C.V. %	--	0.93	--------	1.51	--------	1.58	--------	27.32	--------	11.11	--------
R^2	--	0.9840	--------	0.9924	--------	0.9918	--------	0.9093	--------	0.9885	--------
R^2_{adj}	--	0.9695	--------	0.9855	--------	0.9844	--------	0.8277	--------	0.9782	--------

($P\leq0.05$)*, ($P\leq0.01$)**, ns: not significant at 95% level. (D) – days.

Physical properties of product

Viscosity

The data regarding quadratic model of viscosity and the RSM graphs are presented in table 1 and figure 1. All linear and quadratic expressions of independent variables, i.e., cream, gum and inulin were significant at level of 99% (P<0.01) and accordingly a curve in three-dimensional chart was observed. Associations related to interaction of gum-inulin and inulin-cream were significant at level of 95% (P<0.05). Based on the sum of squares, the importance of the variables was as follows: all interaction expression < all quadratic expression < all linear expression. The viscosity was influenced individually by each one of the variable. Cream, gum and inulin independently increased the viscosity with increasing concentration, the difference being significant. The interaction between two variables either cream and gum or gum and inulin, were also significant, although at a lower level (P<0.05). It is also evident from the figure 1 which shows clearly that viscosity increased with increasing concentration of all variables. Hence, it can be said that viscosity was influenced all three variables independently. The use of inulin and gum in low-fat cream enhances water holding capacity, and the increase can be seen as a decrease in free water and increase in viscosity. At lower concentrations of inulin and gum, the viscosity decreased, which reduced the water holding capacity. The results of the comparison of treatments containing different stabilizers indicate the direct relationship between cream stability and the amount of gum and inulin. In fact, on account of enhanced fragmentation of fat globule in the pasteurized cream and resultant increase in the total surface area of fat, higher stabilization is needed to reduce the surface tension between fat and water phase. A similar trend was reported by El-Nagar et al. and Soukoulis et al., when using inulin (dietary fiber) as a fat replacer in low fat ice cream [14, 15]. The results showed that the increased proportion of inulin inclusion increased the viscosity significantly due to the ability of inulin to retain water.

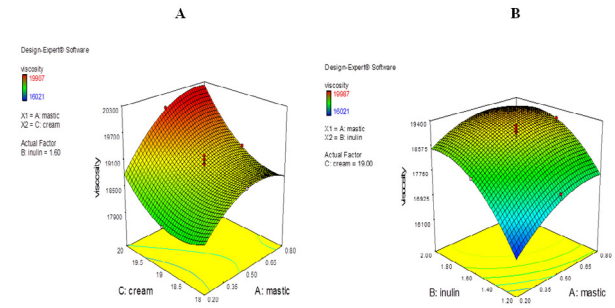

Figure 1: Change in viscosity as a function of interaction between A: Gum - cream and B: Gum – inulin.

Texture profile analysis

The quadratic model for texture profile analysis on 0 day and 10th day is presented in table 1. All linear expressions of independent variables, i.e., cream, gum and inulin were significant (P<0.01), but none of their quadratic expression were significant. In 3-D charts, the extensive linear state could be seen (Figure 2). Associations related to interaction of gum-inulin and gum-cream were significant at level of 99% (P<0.01) and that of inulin-cream was significant at level of 95% (P<0.05) on first and tenth day. Based on the sum of squares, the importance of the variables in first and tenth day followed the order as interaction between inulin-cream < interaction between gum-inulin and gum-cream < all linear interactions.

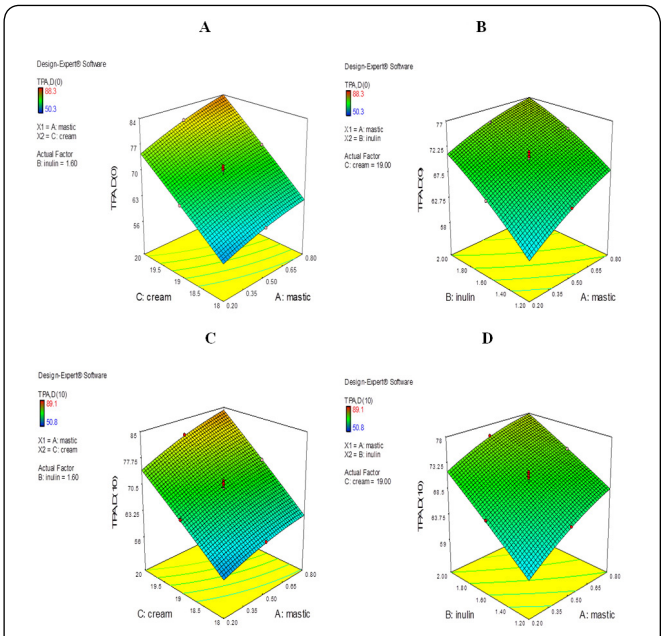

Figure 2: Change in texture as a function of interaction between gum – cream and gum –inulin on 0(D): A and B, and 10(D): C and D.

As shown in figure 2A-D, the interactions between mastic gum (as a filler), inulin (dietary fiber) and lipid globule in cream samples with each other and also with liquid components of the cream created a network which increased the stiffness of product. By increasing the amount of gum and inulin in low fat matrix, the stiffness of the matrix could be increased significantly, which was good for low-fat cream. During the storage period, the firmness of the tissue increased and attained the highest rigidity on the tenth day, as the links between gum, inulin, and lipid globule were further strengthened during the shelf life making the network firmer. With lower proportion of additives, the texture of product was less favorable. Cheng et al. [16] optimized fish gelatin and pectin for the production of low-fat spread and observed that a decrease in the ratio of gelatin to pectin increased hardness of product.

Consistency

Data regarding consistency of product given in table 1 shows that all linear expressions of independent variables, i.e., cream, gum and inulin were significant (P<0.01) on first and tenth day, whereas all quadratic expression were non-significant. In 3-D charts, linear state could be observed (Figure 3). Interactive association for gum-inulin was significant at level of 95% (P<0.05) on first and tenth day. Based on the sum of squares, the important variables were found to be all linear associations followed by interaction between gum-inulin on first and 10th day. In the Bostwick consistency meter, if the distance traveled by the sample over the given time is less, it indicates higher consistency. By increasing the gum and inulin,

the consistency of low-fat samples could be increased and it was highest on the tenth day. This was obviously due to better bonding of cream with inulin and gum during the storage period as can be seen in figure 3. These results are in agreement with previous studies of Farhnaky et al. [10] on using gelatin as fat replacer for low fat cream production. As the amount of gelatin increased, the consistency of low-fat cream sample also increased, so that the difference between experimental samples with 0.75 and 1% gelatin and control sample was not significant (P<0.05). The study indicated that addition of about 0.75% gelatin to low fat cream product provided a similar consistency of full fat cream.

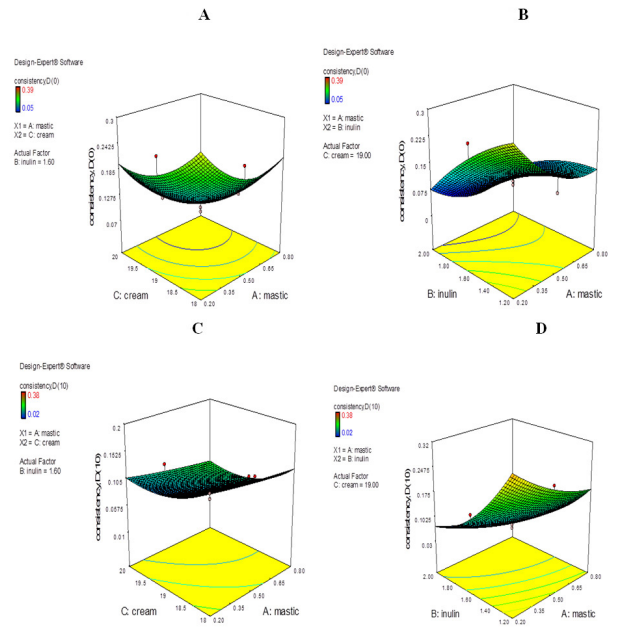

Figure 3: Change in consistency as a function of interaction between gum – cream and gum –inulin on 0(D): A and B, and 10(D): C and D.

Freeze thaw stability

The freeze-thaw stability of cream is very important as it is stored at low temperature and its repeated use can entail temperature variations over the storage period. Hence the freeze-thaw stability of sample was measured over 0, 3, 6, and 10th day and the results are compiled in table 2 and figure 4. All linear expressions of independent variables were significant (P<0.01) on first, third, sixth and tenth day. Among dependent variables on first day interaction between gum-inulin was found to be significant (P<0.01), however, none of interactive variables were significant on first day or during storage. Quadratic interactions were found to be significant for all variables on first day, (P<0.01), for gum and inulin on first and third day, (P<0.05) and for gum on sixth and third day (P<0.01).

Mastic gum is known to decrease the surface tension in the membranes of fat globules. It prevents the clustering and separation of fat from the emulsion matrix, reduces the amount of free water and increases the stability of the emulsion. As shown in figure 4 A-H, the role of increasing proportion of mastic gum in deceasing separation of the phases through linear and quadratic interactions was evident. It also indicates the function of mastic gum resin as an active agent in the stabilizing the network by preventing rearrangement of fat cells and functioning as fat mimic in the development of the network [17]. It helps to maintain the fatty phase inside the net giving the feeling of creamy texture. The texture of product was stable throughout storage duration showing the significant influence of mastic gum alone as an important variable.

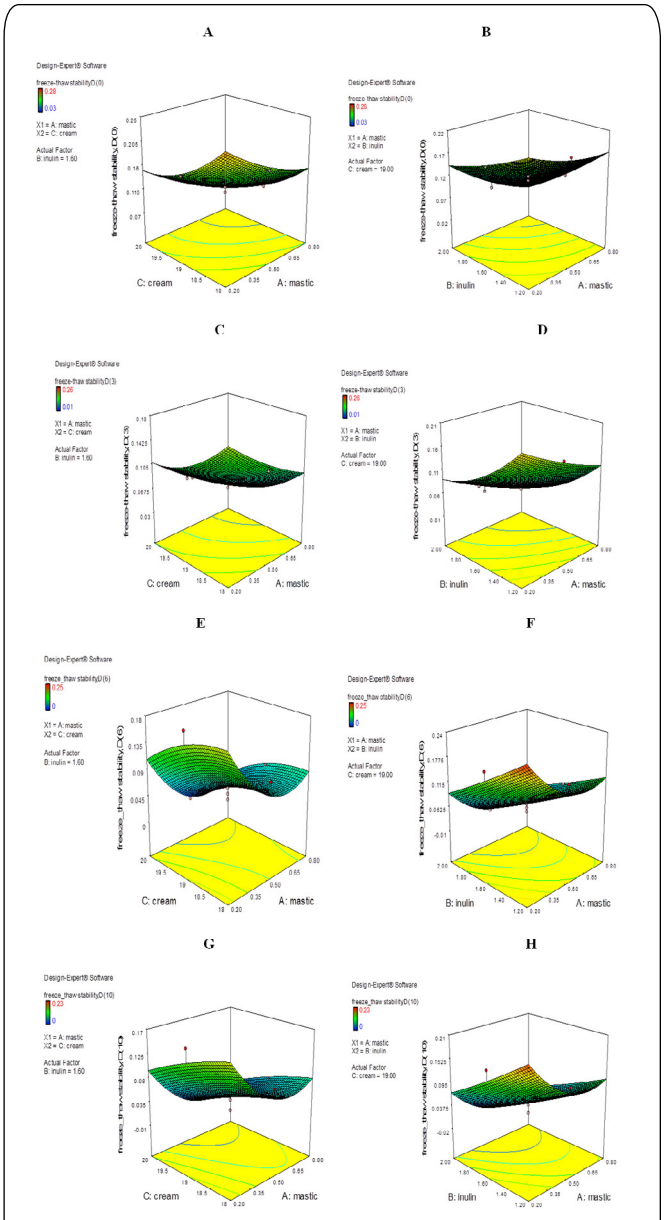

Figure 4: Change in freeze thaw stability as a function of interaction between gum – cream and gum –inulin on 0(D): A and B, 3(D) C and D, 6(D) E and F, 10(D): G and H.

Sensory quality

The sensory quality of all products was evaluated by a panel of trained judges and the results are compiled in table 3 and figure 5-8 for different sensory attributes. All linear associations of independent variables, i.e., cream, gum and inulin were significant (P<0.01) for color, body and texture, flavor and aroma and overall acceptability. The interaction

Table 2: Analysis of variance (ANOVA) of quadratic polynomial models for characteristics of freeze-thaw stability during storage.

Variables	df	Freeze-thaw stability							
		0 (D)		3(D)		6 (D)		10 (D)	
		Coefficient Estimate	Sum of Squares	Coefficient Estimate	Sum of Squares	Coefficient Estimate	Sum of Squares	Coefficient Estimate	Sum of Squares
Model	9	0.12**	0.073	0.079**	0.067	0.063**	0.080	0.046**	0.073
A-mastic	1	-0.040**	0.016	-0.041**	0.017	-0.042**	0.018	-0.040**	0.016
B-inulin	1	-0.055**	0.030	-0.056**	0.031	-0.062**	0.038	-0.057**	0.032
C-cream	1	-0.042**	0.018	-0.033**	0.011	-0.032**	0.010	-0.033**	0.011
AB	1	-0.017**	2.450	1.250^{ns}	1.250	0.011^{ns}	1.013	0.011^{ns}	1.012
AC	1	2.500^{ns}	5.000	1.250^{ns}	1.250	1.250^{ns}	1.250	1.250^{ns}	1.250
BC	1	5.000^{ns}	2.000	6.250^{ns}	3.125	0.011^{ns}	1.013	0.011^{ns}	1.012
A^2	1	0.012**	4.142	6.818*	1.278	0.054**	7.911	0.049**	6.627
B^2	1	7.273**	1.455	0.022*	1.309	3.636^{ns}	3.636	4.091^{ns}	4.602
C^2	1	0.022**	1.364	0.017^{ns}	7.778	-0.016^{ns}	7.364	-5.909^{ns}	9.602
Residual	10	--------	1.785	-------	1.513	--------	2.526	--------	2.755
Lack of Fit	5	ns	1.235	ns	1.180	ns	1.993	ns	2.155
Pure Error	5	--------	5.500	-------	3.333	--------	5.333	--------	6.000
Cor Total	19	--------	0.075	-------	0.069	--------	0.082	--------	0.076
C.V. %	--	9.34	-------	12.06	--------	19.15	--------	23.71	--------
R^2	--	0.9762	-------	0.9780	--------	0.9693	--------	0.9637	--------
R^2_{adj}	--	0.9548	-------	0.9582	--------	0.9416	--------	0.9309	--------

(P≤0.05)*, (P≤0.01)**, ns: not significant at 95% level. (D) – days.

Table 3: Analysis of variance (ANOVA) of quadratic polynomial models for sensory attributes.

Variables	df	color		Body and Texture		Flavor and Taste		Total acceptability	
		Coefficient Estimate	Sum of Squares	Coefficient Estimate	Sum of Squares	Coefficient Estimate	Sum of Squares	Coefficient Estimate	Sum of Squares
Model	9	3.44**	1.58	3.94**	3.37	3.89**	3.67	3.67**	7.51
A-mastic	1	0.17**	0.29	0.17**	0.29	0.16**	0.26	0.40**	1.60
B-inulin	1	0.24**	0.58	0.32**	1.02	0.29**	0.84	0.43**	1.85
C-cream	1	0.24**	0.58	0.44**	1.94	0.48**	2.30	0.52**	2.70
AB	1	-0.075^{ns}	0.045	-0.075^{ns}	0.045	-0.025^{ns}	5.000	-0.087^{ns}	0.061
AC	1	-0.025^{ns}	5.000	-0.025^{ns}	5.000	-0.050^{ns}	0.020	0.013^{ns}	1.250
BC	1	0.050^{ns}	0.020	-0.050^{ns}	0.020	-0.100^{ns}	0.080	-0.087^{ns}	0.061
A^2	1	-0.15^{ns}	0.062	-4.545^{ns}	5.682	0.018^{ns}	9.091	0.40**	0.45
B^2	1	0.000^{ns}	0.000	-0.055^{ns}	8.182	-0.13^{ns}	0.048	-0.45**	0.55
C^2	1	0.10^{ns}	0.028	-0.055^{ns}	8.182	-0.082^{ns}	0.018	-0.30**	0.24
Residual	10	--------	0.16	--------	0.12	--------	0.30	--------	0.17
Lack of Fit	5	ns	0.069	ns	0.096	ns	0.21	ns	0.14
Pure Error	5	--------	0.093	--------	0.020	--------	0.093	--------	0.028
Cor Total	19	--------	1.75	--------	3.49	--------	3.97	--------	7.68
C.V. %	--	3.73	--------	2.77	--------	4.56	--------	3.67	--------
R^2	--	0.9072	--------	0.9668	--------	0.9244	--------	0.9785	--------
R^2_{adj}	--	0.8237	--------	0.9369	--------	0.8564	--------	0.9592	--------

(P≤0.05)*, (P≤0.01)**, ns: not significant at 95% level.

between different variables of gum, inulin and cream did not influence the sensory attributes adversely indicating no significant differences. None of the associations related to quadratic interactions were significant except for the attribute

of overall acceptability indicating that additives did not affect the organoleptic quality of products. This was also evident by the linear response surface charts showing minimum curvilinear deviations.

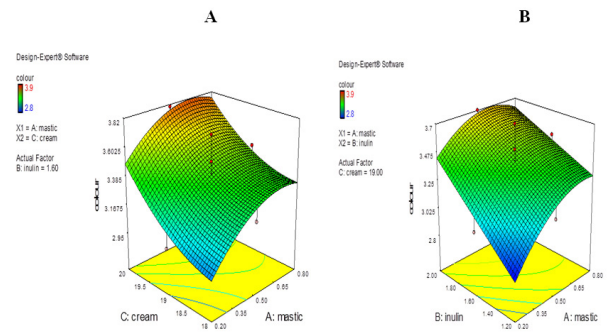

Figure 5: Change in color as a function of interaction between A: gum – cream and B: gum –inulin

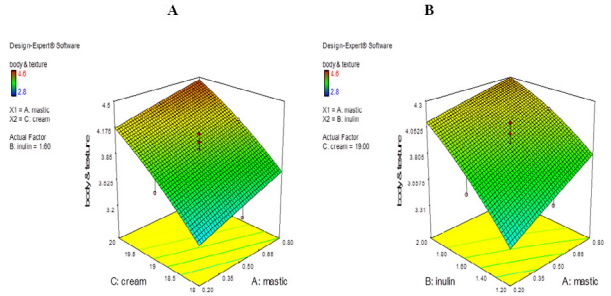

Figure 6: Change in body and texture content as a function of interaction between A: Gum – cream and B: Gum –inulin.

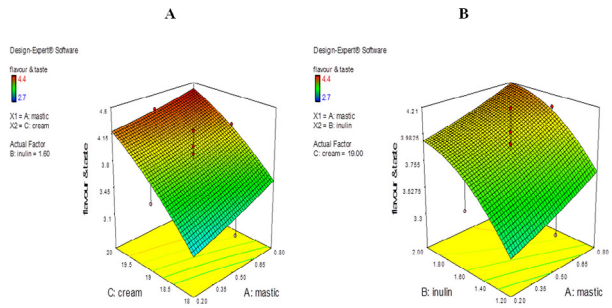

Figure 7: Change in flavor and taste content as a function of interaction between A: gum – cream and B: gum – inulin.

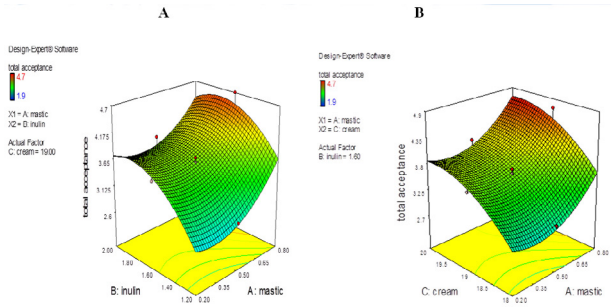

Figure 8: Change in overall acceptance content as a function of interaction between A: gum – cream and B: gum –inulin

The evaluator group did not detect significant differences in color between the low fat cream samples. However, samples containing more of mastic gum, inulin and cream were found to have slightly better color. This shows that the addition of mastic gum and inulin to low-fat cream did not affect the quality of color adversely. The findings are in agreement with the reported addition of gelatin as a fat replacer and the resultant color in cream samples [10]. The best scores for the attribute of body and texture in cream was given to product with 0.8 gum, 1.6 inulin and 19% cream. Samples having lesser proportion of these ingredients were given lesser scores as the texture was adversely affected. All samples had pleasant and natural flavor and taste. Only in the samples containing the lowest percentage of fat the flavor and aroma were given lesser scores. The overall acceptance of low-fat cream samples showed that the samples had proper color, body & texture and flavor & taste. Low-fat cream with 0.8 gum, 1.6 inulin and 19% cream was found to have the best quality characteristics.

For all variables in first stage, at fixed concentration of 19% of cream, with increase in gum and inulin concentration to a medium level, there were large variations observed in quality parameters. The quality parameters also varied considerably at fixed inulin concentration (1.6%), with increase in gum and cream concentration. Maximum variables in samples was produced at 0.8% and 20% concentration of gum and cream, and the minimum variables in cream samples was produced at 0.2% and 20% concentrations of gum and cream, respectively.

Optimization of product formula

After analyzing the variance of the data by selecting the variables and the desired response to maximize or minimize in the obtained domain, the target range is selected. In this study inulin, viscosity, texture profile analysis, consistency in the maximum range, mastic gum, cream in the range and minimum freeze thaw stability values were considered. The upper, lower, and the range of each of these variables were determined. Finally, an optimized model for the production of cream using the combination of variables was obtained and the data is presented as a desirable formula software prediction in table 4.

Physical properties

The physical properties of formulated product were compared with predicted optimized formula and a commercial product and results are presented in figure 9. The viscosity of the produced cream was not significantly different from the predicted model. The viscosity of cream produced in comparison with commercially available low-fat cream was evaluated as optimal. The combination of gum and inulin in the formulated product increased the water holding capacity and as a result reduced water loss and increased the viscosity. In commercial creams, materials such as gelatin, milk, carboxymethyl cellulose, etc. are used to increase viscosity. There was no significant difference in the texture of formulated and the commercial cream. Scores for texture for experimental and commercial creams were slightly higher on the 10th day than the first day. For consistency, there was no significant difference between

Table 4: Optimization of product formula for desirable quality.

Variable		Desirable formula software prediction	Desirable formula production	Control sample
Mastic gum		0.68[a]	0.680 [a]	---------
Inulin		1.88[a]	1.88 [a]	---------
Cream		19.8 [a]	19.802 [a]	---------
Viscosity		19987[a]	20112 ±1.521[a]	19656 ± 2.000 [a]
Texture profile analysis	D(0)	83.9433 [a]	84.1361 ± 0.0004[a]	84.1247 ± 0.003[a]
	D(10)	84.5793 [a]	84.8433 ± 0.0003[a]	84.2358 ± 0.001[a]
Consistency	D(0)	0.0342484[a]	0.03384 ± 0.00002[a]	0.07354 ± 0.00003[b]
	D(10)	0.0124278 [a]	0.01651± 0.00004[a]	0.06896 ± 0.00001[b]
Freeze-Thaw Stability	D(0)	0.0441976 [a]	0.03125 ± 0.00004[a]	0.09439 ± 0.00003[b]
	D(3)	0.0173031 [a]	0.00120 ± 0.00003[a]	0.08495 ± 0.00001[b]
	D(6)	-0.0091924 [a]	0.00119 ± 0.00002[a]	0.08336 ± 0.00001[b]
	D(10)	-0.0168302 [a]	0.00052 ± 0.00003[a]	0.08023 ± 0.00002[b]
Color		3.89999 [a]	3.9 ± 0.01[a]	4.5 ± 0.03[b]
Body & Texture		4.48782 [a]	4.5 ± 0.05[a]	4.4 ± 0.02[a]
Flavor and taste		4.37584[a]	4.4 ± 0.03[a]	4.5 ± 0.06[a]
Total acceptance		4.28217 [a]	4.3 ± 0.02[a]	4.2 ± 0.04[a]
Desirability		0.829	----------	----------

The mean value with different letters has a significant difference (P≤0.05).

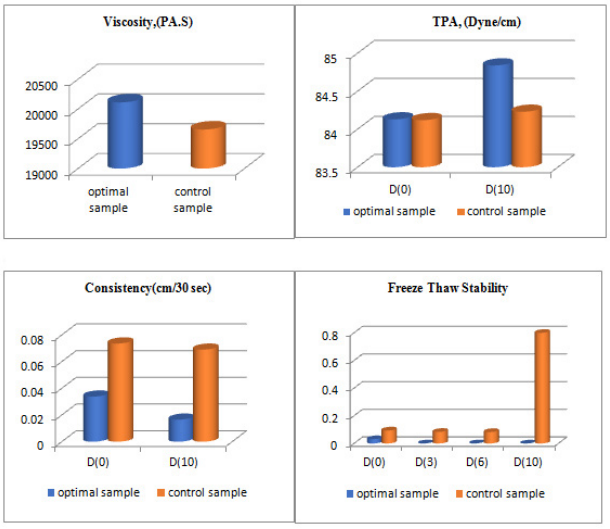

Figure 9: Comparison of physical properties between optimized experimental product and commercial control product.

the formulated cream and the predictive model. The highest consistency of 0.01651 was obtained on the 10th day. There was a significant difference between the consistency of formulated and commercial cream. The formulated cream had a greater consistency than the commercial one which indicated the effectiveness of inulin-gum in the former. For freeze-thaw stability the highest amount of oily phase separation in the commercial and experimental samples occurred on the first day and during storage, integrity of the samples increased and the amount of oily phase separation decreased. The phase separation of the commercial cream was higher than the formulated cream and the difference was significant but there was no significant difference between the formulated product and the predictive model.

Sensory quality

Commercial cream got a higher rating than the produced cream in terms of color quality. This could be due to the fact that in the commercial cream an additive, titanium dioxide is used to improve the color. For texture & body, no significant differences were observed between experimental and commercial product. Similarly, no differences were seen for flavor and taste. Mastic gum undergoes a process of decolorization and it is a white powder that does not have any specific smell and color. The taste quality of formulated product was good. The overall acceptability of product was also comparable to commercial product.

Conclusion

In conclusion, it can be said that mastic gum and inulin can be successfully incorporated into cream at the levels of the 0.68% (volumetric weight) mastic gum, 1.88% inulin and 19.8% cream. At this level the textural, sensory, rheological properties were compared with control sample. Mastic gum, especially in the 0.6 range, can compensate for the unpleasantness of fat reduction in the creamy texture without affecting other properties of the cream. In other words, when mastic gum is added to low-fat cream, a product can be accepted from a consumer's point of view in terms of texture, color, flavor, and overall properties, similar to commercial low-fat cream.

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