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Viscosity and Sensory Acceptability of Almond Milkshake as Influenced by Sugar, Almond Paste and Corn Flour-A Response Surface Study

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Abstract: The effect of variables such as sugar, almond paste, and cornflour on viscosity and a sensory score of almond milkshake samples were studied by response surface methodology. The central composite design was used to obtain optimum levels of variables. The values of viscosity and sensory scores obtained from different experiment runs were 170-1085cps and 6.2-7.7. The second-order polynomial model suggested by design expert software for viscosity and a sensory score of almond milkshake showed R^2 (coefficient of determination) of 0.9871 and 0.9590, respectively. Whereas model F-values for viscosity and a sensory score of almond milkshake were 84.9 and 26.02, respectively. Optimum levels of sugar, almond paste, and cornflour suggested by models were 8%, 1% & 2%, respectively. Experimental values of responses obtained from the confirmatory test were almost similar to predicted values of responses suggested by models.

Keywords: milk; viscosity; beverage; sensory; response surface methodology.

1. Introduction

Food is the essential need of all human beings due to daily nutrients requirements. The human body requires specific nutrients or food/chemical components for performing various functions in our body, and some of them exert some health benefits [1-21]. Milk and milk products are very important for us from a nutrition perspective [22-27]. That is why these products are popular among all age groups worldwide and are included in daily diets. The nutritive value of milk and milk products are very high [28-31]. On consumption, these products provide us body-building proteins, minerals for bone formation and strength, lactose, and fat as an energy source. Besides these nutritional benefits, these products also provide some health benefits to the consumers [32]. Recently, dairy and food scientists are working on developing food and dairy-based products with functionality and value addition [33-49].

Milk-based beverages are the new products prepared to get nutritional benefits of milk and other ingredients such as almonds, peanuts, sesame etc., keeping in mind the traditional and local taste or preference of the consumers of a particular geographical area. However, due to globalization and their excellent sensory properties, these beverages have become popular at the global level. Milkshakes are dairy products from Western-countries prepared by freezing the mix just like soft-serve ice-cream mix and vigorous blending/mixing the frozen product in a blender/mixer to get foam formation and pourable consistency. Milkshakes generally contain low levels of fat and sugar as compared to ice-cream, whereas it contains high levels of milk-solids-not-fat (MSNF) as compared to ice-cream. In India, milkshakes are very popular and are generally prepared with milk, flavoring agent, coloring agent, and vigorous shaking but avoid freezing than western milkshakes. A variety of flavors are used in milkshakes leads to several variants in this product. The most popular flavoring agents used in milkshakes are rose, coffee, chocolate, etc. Fruit and nut-based milkshakes include banana, mango, sapota, fig, almond, etc. All these milkshakes attract consumers due to their palatability and nutritive value. But there are regional variations in the preparation methods of these shakes. However, the base material for all milkshakes is milk and sugar. However, variation in flavoring ingredients makes it a product with several variants due to their specific flavor/taste. Almond milkshake is the most popular among other shakes in India and is also known as "Badam Shake". Almond is nutrient-rich dry fruits having potential for inclusion in functional food recipes. Corn flour is also added to the almond milkshake recipe. Corn flour has much application in food products due to its functionality [50]. Response surface methodology is a widely accepted technique for standardization of processes and studying the effect of variables on responses [51]. A little research has been done on the standardization of milkshakes. In a present research study, ingredients such as sugar, almond paste, and cornflour on the viscosity and sensory score of the almond milkshake are studied.

2. Materials and Methods

2.1. Materials.

Locally available raw materials were utilized for this study. Sugar, almond, cornflour was procured from the local market of Mehsana, Gujarat. Standardized milk was procured from Dudhsagar Dairy, Mehsana, India. Chemicals utilized in this project were obtained from Sigma Chemicals (India).

2.2. Formulation and preparation of almond milkshake.

Standardized (4.5% Fat and 8.5% SNF) and pasteurized milk were selected to prepare almond milkshake. Milk was heated, and when the temperature of the milk was reached 70°C then sugar (4.6-11.3%), almond paste (0.31-3.6%), and cornflour (0.65-2.3) was added to milk with agitation as per their levels of selection depicted in Table 1 for different runs. Milk was further heated to 80°C. The heating was stopped when the mix becomes sufficiently viscous similar to the consistency of a milkshake. The mix was then cooled to 10°C. Cardamom and nuts were added to the cooled mix. The mix was thoroughly mixed. After that, an almond milkshake was used for analysis (Figure 1).

2.3. Proximate analysis.

Moisture content, fat content, protein content, and almonds' ash content were determined by standard methods [52]. The proximate composition of milk was analyzed using milkoscan.

2.4. Viscosity.

The viscosity of the almond milkshake samples was determined using a Brookfield viscometer (spindle-type). The viscometer was fixed with UL adaptor and spindle no. 01.

Before viscosity measurement of the samples, the viscometer was subjected for autozeroing in air. After this, the type of spindle and speed of rotation (rpm) were mentioned in the viscometer as per instructions. S01 spindle was selected for viscosity measurement of almond milkshake samples at 30 rpm. Viscosity measurement of almond milkshake samples was carried out at 20°C.

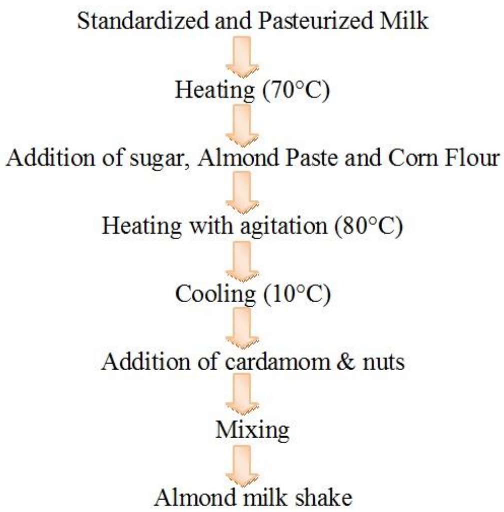

Figure 1. Flow chart for almond milkshake making.

Table 1. Design of experiments (variables) and viscosity and sensory results (responses).

Run	A: Sugar	B: Almond Paste	C: Corn Flour	Viscosity	Sensory Score
	%	%	%	cPs	
1	6	3	2	815	6.5
2	8	2	1.5	214	7.4
3	8	2	2.3409	1085	6.5
4	10	1	1	225	6.3
5	8	2	0.659104	170	6.3
6	4.63641	2	1.5	501	6.2
7	10	3	1	215	6.7
8	6	1	2	789	6.8
9	8	2	1.5	220	7.7
10	10	3	2	817	6.4
11	8	2	1.5	285	7.4
12	10	1	2	791	6.7
13	6	3	1	211	6.6
14	8	0.318207	1.5	505	6.9
15	8	3.68179	1.5	534	6.8
16	6	1	1	195	6.5
17	8	2	1.5	230	7.6
18	8	2	1.5	255	7.3
19	11.3636	2	1.5	520	6.3
20	8	2	1.5	270	7.5

2.5. Sensory evaluation.

In this study, almond milkshake samples prepared using different runs were evaluated for their sensory scores by 30 sensory panelists (between 20 to 54 years of age) and those who had past sensory evaluation experience of similar dairy beverages. Sensory panelists carried out the sensory evaluation study after 24 hours of refrigerated storage (10°C) of almond milkshake samples. Sensory panelists evaluated the samples and gave each almond milk sample a sensory score based on sensory characteristics such as color and appearance, taste, mouthfeel and texture, acceptability on a nine-point hedonic scale, i.e., 1 to 9 (dislike extremely to like extremely).

2.6. Design of experiments.

In this study, the effect of variables on the responses was studied using response surface methodology via a selection of independent variables range for experimental design, model fitting, selecting an optimum value of independent variables w.r.t. dependent response value. The central composite design was chosen to investigate the effect of variables [i.e., sugar(X1), almond paste (X2), and cornflour (X3) levels] at five levels on the responses [i.e., viscosity (Y1) and sensory score (Y2)] for determination of optimum values of independent variables. A set of twenty experimental runs was obtained from design expert software (Table 1). The range selected for sugar, almond paste, and cornflour were 6-10%, 1-3%, and 1-2%, respectively, based on the initial trials. The proposed model for dependent responses was

$$Y = b_0 + \sum_{i=1}^{i=3} b_i X_i + \sum_{i=1}^{i=3} b_{ii} X_{ii}^2 + \sum_{i<j=2}^{i=3} b_{ij} X_i X_j + e$$

b_0= value of fixed response at experimental centre point;
bi = linear coefficient
bii = quadratic coefficient
bij = cross-product coefficient

2.7. Analysis of data.

Design-Expert software was used for the analysis of data for ANOVA and regression model analysis. Regression models/equations were obtained via 2nd order polynomial fitting to data. , The statistical importance of the regression model terms was analyzed. Model adequacy was examined via R^2, F-value (lack-of-fit), and F-value (model). R^2 is also known as the coefficient of determination, which reveals model fitness and is defined as explained variation/total variation ratio [53].

2.8. Optimization.

A numerical optimization approach was used for the optimization of responses using a design expert.

Required goals for all the independent variables and responses were selected. Independent variables such as sugar, almond paste, and cornflour levels were kept within range. Dependent responses such as viscosity and sensory score were selected as maximize. Different variables on the responses were obtained in response surface graphs obtained from design expert software.

3. Results and Discussion

3.1. Proximate analysis.

Proximate analysis data of ingredients, i.e., almond, cornflour, and standardized milk used in this study, are shown in Table 2. Fat, protein, carbohydrate, ash, and moisture content of the almonds were 49.8, 22.1, 21.4, 4.3, and 5.0 %. These results are in agreement with the published literature [54]. Fat, protein, carbohydrate, ash, and moisture content of the cornflour were 2.5, 9.8, 75.6, 0.6, and 10.2 %, respectively. These results are in agreement with the published literature [55]. Fat, protein, carbohydrate, ash, and moisture content of the cornflour were 4.6, 3.41, 4.52, 87.03, and 0.7 %, respectively. SNF and total solids content of the standardized milk were 8.59 and 12.97 %, respectively.

Table 2. Proximate analysis data of almond, cornflour, and standardized milk.

	Almond	Corn Flour	Standardized Milk
Fat	49.8±0.15	2.5±0.10	4.60±0.07
Protein	22.1±0.10	9.8±0.24	3.41±0.04
Carbohydrate	21.4±0.09	75.6±0.49	4.52±0.12
Moisture	5.0±0.20	10.2±0.21	87.03±0.10
Ash	4.3±0.08	0.6±0.11	0.70±0.10
TS	-	-	12.97±0.30
SNF	-	-	8.59±0.08

3.2. Model diagnosis.

Model terms obtained from the design expert software were analyzed for their statistical importance using ANOVA (analysis of variance). The coefficient of determination value (R^2) should be close to 1 for a good model. R^2 values for viscosity and sensory score models were 0.98 & 0.95, respectively, which were high enough to validate the competence of the models obtained [56]. Adequacy of models may also be validated via analyzing F-values of the model and lack of fit [57]. Adequacy of models also validated by high model's F-value and less lack-of-fit F-value. Model's F-value for viscosity and sensory score were 84.9 and 26.02, respectively. Lack-of-fit F-value for viscosity and sensory score were 3.62 and 0.70, respectively. Table 3 represents regression analysis data of models obtained for viscosity and sensory score. Table 3 shows that viscosity was positively affected by all the variables. However, the effect of cornflour level on the viscosity of almond milkshake was more prominent than sugar and almond paste. The sensory score was the least affected by all variables. It was negatively affected by sugar and almond paste and positively affected by corn flour.

3.3. Effect of variables on viscosity.

Figure 2 (a) shows almond paste and sugar's effect on the almond milkshake's viscosity. It is revealed that both almond paste and sugar showed little effect on the almond milkshake's viscosity.

Table 3. Regression analysis of the second-order polynomial models for the various responses.

Predictor	β (Coded Factors)	
	Viscosity	Sensory Score
Intercept	247.73	7.48
A-Sugar	5.12	-0.0097
B-Almond Paste	7.82	-0.0196
C-Corn Flour	285.93	0.0466
AB	-3.25	0.0375
AC	-3.75	-0.0125
BC	5.75	-0.1375
A^2	80.16	-0.4103
B^2	83.34	-0.1981
C^2	121.52	-0.3572
ANOVA		
R^2	0.9871	0.9590
Adusted R^2	0.9755	0.9222
Predicted R^2	0.9194	0.8333
Model F-value	84.90	26.02
Lack of fit F-value	3.62	0.7058

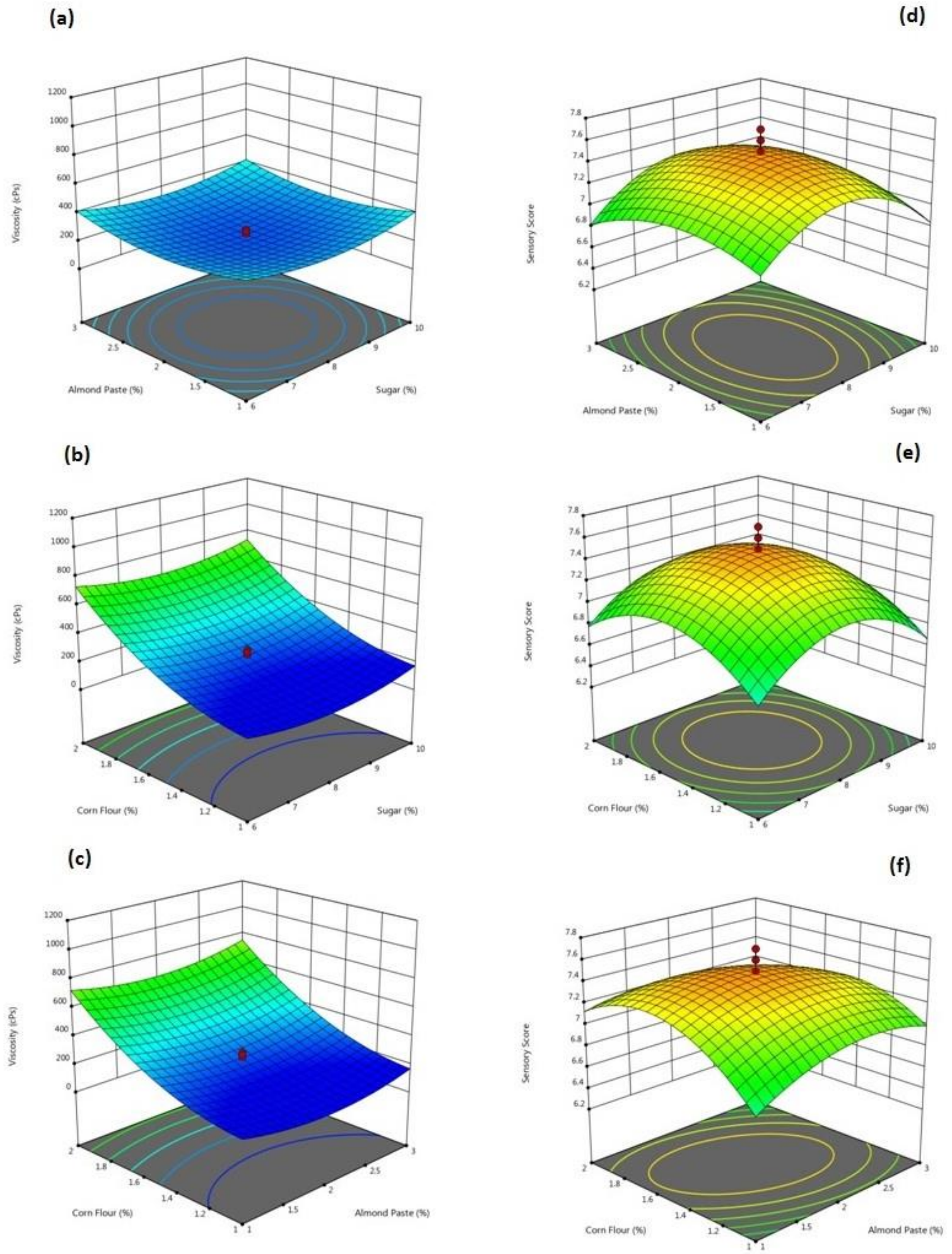

Figure 2 (a-f). Effect of sugar, almond paste, and cornflour on viscosity and a sensory score of an almond milkshake.

The viscosity of almond milkshake first decreased and then increased with an increase in almond paste and sugar levels. Minimum viscosity of the shake was observed in the middle of the selected range of almond paste and sugar levels. Figure 2 (b) shows the effect of cornflour and sugar on the almond milkshake's viscosity. It was observed that sugar showed a similar effect on the viscosity of almond milkshake, as shown in figure 2(a), at low as well as high levels of the cornflour. Figure 2(b) revealed that the almond milkshake samples' viscosity tremendously increased with the increase in cornflour levels in the selected range at low and high levels of sugar. Figure 2(c) shows the effect of cornflour and almond paste on the almond milkshake's viscosity. Effect of almond paste levels on the viscosity of almond milkshake showed a similar effect, as shown in figure 2(a) at low as well as high levels of the cornflour.

However, the almond milkshake samples' viscosity tremendously increased with the increase in cornflour levels in the selected range at low and high levels of almond paste.

3.4. Effect of variables on the sensory score.

Figure 2 (d) shows almond paste and sugar's effect on the sensory score of almond milkshake samples. It is revealed that the effect of sugar on the sensory score of almond milkshake is more pronounced as compared to the almond paste. , The sensory score of almond milkshake first increased and then decreased with increasing almond paste and sugar levels. A maximum sensory score was observed in the middle of the selected range of almond paste and sugar level (around 8%). Figure 2 (e) shows the effect of cornflour and sugar on an almond milkshake's sensory score. It was observed that sugar showed a similar effect on the sensory score of almond milkshake, as shown in figure 2(d), at low as well as high levels of the cornflour. Figure 2 (e) revealed that the almond milkshake samples' viscosity first increased and then decreased with the increase in cornflour levels in the selected range at low and high levels of sugar. A maximum sensory score was observed around 2% level of cornflour and around 8% sugar level.

Figure 2 (f) shows the effect of cornflour and almond paste on an almond milkshake's sensory score. Effect of almond paste levels on almond milkshake's viscosity showed a similar effect, as shown in figure 2(a) at low and high levels of the cornflour. However, the almond milkshake samples' sensory score first increased and then decreased with the increase in cornflour levels in the selected range at low and high levels of almond paste. A maximum sensory score was observed around 2% level of cornflour and around 8% sugar level.

3.5. Model verification.

The numerical optimization technique of Design-Expert software was chosen for the optimization of variables. Optimization was carried out after designating certain conditions to variables and responses. Goals for variables, i.e., sugar, almond paste, and cornflour, were selected ‘in-range. Whereas goals for sensory score and viscosity were designated as ‘maximum’ for almond milkshake samples. Table 4 represents the optimum value of variables (i.e., sugar, almond paste, and cornflour) and responses (viscosity and sensory score). These optimum sugar, almond paste, and cornflour values were used for model-verification by a confirmation test. The experimental values observed for viscosity were 730 cps, which is slightly higher than the optimum value (i.e., 725) predicted by the model. In contrast, the confirmative test's sensory score was 7.0, which is slightly lower than the optimum value of the sensory score (i.e., 7.12) predicted by the model. Hence, the confirmation test validated the adequacy of the regression model obtained from experimental data.

Table 4. Numerical optimization of independent variables.

Parameters	**Goal**	**Low level**	**High level**	**Optimum level**
Sugar	In range	6.0	10.0	7.81
Almond paste	In range	1.0	3.0	1.0
Corn Flour	In range	1.0	2.0	2.0
Responses				
Viscosity	Maximize	170	1085	725.21
Sensory Score	Maximize	6.2	7.7	7.12

4. Conclusions

Response surface methodology was successfully used to study the effect of sugar, almond paste, and cornflour on viscosity and a sensory score of the almond milkshake. The optimum levels of sugar, almond paste, and cornflour for desirable responses levels were determined using regression analysis of models obtained from design expert software. The obtained models were validated using statistical terms like R^2, model F-value and lack of fit F-value. The values of R^2, model F-value and lack of fit F-value revealed that obtained models were statistically adequate. It can be concluded that cornflour levels showed a significantly more significant effect on viscosity and a sensory score of the almond milkshake samples than sugar and almond paste. Numerical optimization provided optimum levels of variables concerning selected constraints for viscosity and sensory score. Experimental values of responses obtained from the confirmatory test were almost similar to predicted values of responses suggested by models. It can be concluded that good quality almond milkshake w.r.t. viscosity and sensory scores can be prepared using optimum levels of sugar (7.81%), almond paste (1%), and cornflour (2%).

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Conflicts of Interest

The authors declare no conflict of interest.

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