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Textural properties of functional *Rabri* enriched with sapota pulp by response surface methodology

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The study was conducted to evaluate textural properties of functional *Rabri* enriched with sapota pulp by response surface methodology. Twenty different runs according to the CCRD were used to study the textural parameters of sapota pulp enriched functional *Rabri,* to study textual parameters for the sapota pulp enriched functional *Rabri* comprising of sapota pulp (3.5 - 8.5%), sugar (3 -5%) and milk fat (4 – 6%). There were four textural parameters (Firmness, Textural consistency, Cohesiveness and Index of viscosity) of *Rabri* positively enhanced by incorporation of sapota pulp .The optimum processing conditions were experimentally verified and proven to be adequately reproducible with gross efficiency of 68.3 %.

Key Words : Central composite rotatable design, *Rabri,* Response surface methodology, Sapota pulp

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INTRODUCTION

The flaky texture, which is a fundamental and desirable attribute of *Rabri* and produced by adding malai, can be feign by incorporating similar fibrous and flaky material in from of shredded *Chhana*/*Paneer* to this concentrated milk. The incorporation of sapota pulp in *Rabri* in which flaky textural properties was positively enhanced by dietary fibre of sapota pulp. The present experiment was undertaken to optimize production of sapota pulp-based Indian dairy dessert (*Rabri*) using a statistical software tool namely response surface methodology (RSM). Validation of predicted and actual value was done in order to get the best quality of sapota pulp enriched *Rabri* in terms of sensory perceptions. RSM was used earlier to optimize the various parameters in the production of food products with desired quality (Castro *et al*., 2000 and Kurien and Mishra, 2008). Sapota fruit is a great source of dietary fibre, which is a good laxative and protects the outer membrane of our colon from carcinogenic toxins. Sapota fruit is a good source of sugar, which ranges between 12 and 14 per cent. A 100 g of edible portion of fruit contains moisture (73.7 g), carbohydrates (21.49 g), protein (0.7 g), fat (1.1 g), calcium (28 mg), phosphorus (27 mg), Iron (2 mg) and ascorbic acid (6 mg) as reported by Bose and Mitra (1990). Sapota fruits are used for making jams, jellies, osmodehydrated slices and squash (Reddy, 1959).

Rabri is one of the most common desserts in India; it is very popular in northern and eastern part of India. *Rabri* is a concentrated whole milk delicacy, containing several layers of clotted cream and skimmed off from slowly evaporating milk.

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The numerical process optimization was carried out by Design Expert 9.0.5 by applying response surface methodology, many solution were obtained for the optimum covering criteria with a highest desirability of 1.0 under these circumstances, the solution contained the maximum sapota pulp, sugar and milk fat were in the normal range. The solution was obtained for optimized sapota pulp enriched *Rabri* condition by incorporation of 10.5% sapota pulp, 5% sugar and 6% milk fat.

METHODOLOGY

Experimental design :

A laboratory experiment conducted for manufacturing of *Rabri* blended with sapota pulp, sugar and milk as main ingredients was optimized. Sapota var. Baramasi and sugar were procured from local market. Milk was procured from dairy farm of Banaras Hindu University. Various levels of sapota pulp (3.5–10.5%) sugar (2.5-5%) and milk fat (3.5-6.5%) and three different temperatures (85°C, 87°C and 90°C) were used in the investigation. 20 trials generated by the Central Composite Rotatable Design (CCRD) of Design expert, which were conducted to obtain a combination of selected parameters for production of the best quality sapota pupl enriched *Rabri*. The relationship between levels of different actual form of independent variables is given in Table A. As per response colour and appearance, flavour, body and texture, sweetness, consistency and overall acceptability were selected on which the effect of the three individual ingredients has to be evaluated. A combination of 20 number of experiment were generated (Table B) in Design Expert 9.0.5 using CCRD during investigation.

Table A : Independent variables used for optimization

Independent variables	Symbol code	Unit	Actual levels	
			Low	High
Sapota pulp	A	%	3.5	8.5
Sugar	B	%	3	5
Fat	C	%	4.5	6

Statistical analysis :

The statistical analysis was done by central composite rotatable design method by Madamba *et al*. (2001).

Estimation of yield of sapota pulp enriched *Rabri* :

The yield of sapota pulp enriched *Rabri* was calculated using following formula

$$\text{Yield per cent} = \frac{\text{Weight of sapota pulp enriched } Rabri}{\text{Weight of (Milk + sapota pulp + sugar)}} \times 100$$

Table B : Experimental design for analysis and optimization of functional *Rabri*

Run	A: Sapota pulp	B: Sugar	C: Fat
1	6	4	5
2	3.5	3	6
3	6	4	5
4	3.5	3	4
5	1.5	4	5
6	6	4	3.5
7	3.5	5	6
8	10.5	4	5
9	6	5	5
10	8.5	3	4
11	6	4	5
12	6	4	5
13	3.5	5	4
14	8.5	5	4
15	8.5	3	6
16	6	4	6.5
17	6	4	5
18	8.5	5	6
19	6	2.5	5
20	6	4	5

Receiving of milk (cow milk)
↓
Preheated (35-40°C)
↓
Standardization (As per treatment)
↓
Adding of sapota pulp (As per treatment)
↓
Heated at simmering temperature (85-90°C)
↓
Fanned the surface to facilitate skin formation
↓
Broken skin (3-4 cm pieces) with a wooden stick and remove to cooler parts of vessel
↓
Adding sugar (As per treatment) 1/2 Reduced volume of milk
↓
Reduced volume to $1/5^{th}$
↓
Immersed the layers of skin in the sweetened condensed milk
↓
Cool the sample at 37 ± 5°C temp.
↓
Storage at 10 and 25°C temp.

Fig. A : Flow chart for preparation of functional *Rabri*

Estimation of moisture, fat, protein and ash content:

All chemical analyses were carried out in triplicate. Moisture, total solids, fat, sugar, lactose and ash contents of the product were analysed by the method given in AOAC (1995). Protein content of the sample was determined by Kjeldahl method (IDF, 2001). Moisture content was calculated as per the method of AOAC 1995. The fat content of sapota pup enriched *Rabri* was estimated by using Soxhlet apparatus (Socs-plus). The method is recognized by the AOAC (1995). The sample was kept for ashing in a muffle furnace at 550 ± 2°C for 4 hrs. as per the protocol of AOAC (1995).

OBSERVATIONS AND ASSESSMENT

In present study, CCRD was used to design experiment with three variables at two actual levels with six center point. The product variables for presented research work are concentration of sapota pulp, sugar and milk fat. The attempt was made to understand effect of various concentration of sapota pulp, sugar and milk fat on textural characteristics of process optimized product. Response surface methodology (RSM) which involves design of experiments, selection of variables in experimental runs, shown in Table 1 fitting mathematical models and finally selecting variables levels by optimizing the response was employed in the study (Khuri and Cornell, 1987). A second-order polynomial model was fitted to study the textural responses such as firmness, textural consistency, cohesiveness and index of viscosity.

Textural properties for sapota pulp enriched *Rabri*:

Effect on firmness :

The average Firmness of sapota pulp enriched *Rabri* varied from 344.76 to 485.89 g (Table 1). Fig. 1 shows that the response surface plot for firmness as influenced by level of sugar and sapota pulp, by keeping constant milk fat. It can be observed from figure that with the increase in the level of sapota pulp there was steep increase in the firmness of the optimized product but there was little effect on firmness due to sugar.

In the present study effect of sapota pulp ,sugar and milk fat on consistency of sapota pulp enriched *Rabri* could be described by the following equation:

$$\text{Firmness} = +379.08+36.77*A-0.34*B+7.23*C+0.63*AB+8.10*AC-8.34*BC+14.10*A^2+0.033*B^2-1.42*C^2 \quad \ldots\ldots\ldots\ (1)$$

Here A, B and C are coded terms for the three variables, *i.e.* sapota pulp, sugar and milk fat, respectively. The co-efficient estimates of consistency showed that

Table 1 : Experimental runs and actual values of factors used in central composite rotatable design

Trial No.	Sapota pulp (%)	Sugar (%)	Fat (%)	Firmness (g)	Texture consistency (g sec)	Cohesiveness (g)	Index of viscosity (g sec)
1	6	4	5	378.76	6740.75	-325.98	-515.86
2	3.5	3	6	362.78	6430.65	-293.67	-488.69
3	6	4	5	377.98	6706.76	-326.76	-513.76
4	3.5	3	4	351.87	6208.98	-290.67	-485.76
5	1.5	4	5	365.87	6470.87	-285.78	-458.97
6	6	4	3.5	375.43	6570.89	-307.87	-513.87
7	3.5	5	6	344.76	6450.67	295.12	-486.93
8	10.5	4	5	485.89	7270.97	-358.09	-528.76
9	6	5	5	405.74	6876.95	-330.84	-514.76
10	8.5	3	4	402.87	6965.67	-345.76	-520.94
11	6	4	5	378.67	6730.75	-325.98	-512.76
12	6	4	5	372.87	6730.9	-325.96	-514.87
13	3.5	5	4	345.96	6324.8	-293.1	-480.56
14	8.5	5	4	420.75	7032.87	-347.87	-522.87
15	8.5	3	6	467.43	7010.65	-348.87	-522.98
16	6	4	6.5	379.56	6890.97	-333.87	-516.89
17	6	4	5	373.98	6743.65	-324.98	-514.98
18	8.5	5	6	430.67	7176.73	-350.78	-518.97
19	6	2.5	5	370.89	6587.98	-320.97	-510.73
20	6	4	5	375.78	6747.79	-325.57	-515.56

the linear model terms milk fat (C)and the linear interactive term had +388.4255+36.766* A significant effect (p<0.0001) on textural consistency of the product.

Effect on textural consistency :

The average textural consistency of sapota pulp enriched *Rabri* varied from 6208.98 to 7270.97 g sec. (Table 1). Fig. 2 shows that the response surface plot for textural consistency as influenced by the level of sapota pulp and sugar, by keeping milk fat constant. From figure it can observed that with the increase in the level of sapota pulp there was steep increase in the textural consistency of product. In case of sugar there was comparatively less increase in textural consistency.

In the present study effect on consistency of sapota pulp enriched rabri could be described by the following equation:

Texture consistency = 6748.34290.81 * A57.29 * B81.40* C12.20* AB-19.83 * AC0.38 * BC31.00* A^2-39.50* B^2-21.90 * C^2… (2)

Here A, B and C are coded terms for the three variables, *i.e.* sapota pulp, sugar and milk fat, respectively. The co-efficient estimates of consistency showed that the linear model terms milk fat (C) and the quadratic interactive term had +6735.13+290.8 *A+65.04* B+81.32* C significant effect (p<0.0001) on textural consistency of the product.

Effect on cohesiveness :

The average cohesiveness of sapota pulp enriched *Rabri* varied from -285.78 to -358.090 g. Table 2. It can be observed from Fig. 3 that there was steep increase in cohesiveness with the increase in the level of milk fat. While there was not much effect on cohesiveness of product due to sapota pulp. In the present study effect of

Table 2 : Predicted score of the suggested formulation of sapota pulp enriched *Rabri* by design Expert 9.0.5

Trial No.	Sapota pulp (%)	Sugar (%)	Fat (%)	Firmness (g)	Textural consistency (g sec)	Cohesiveness (g)	Index of viscosity (g sec)	Desirability
1	8.500	5.000	6.000	478.76	6770.75	-325.98	-515.86	1.000
2	6.000	4.000	5.000	372.78	6450.65	-293.67	-488.69	1.000
3	6.000	5.000	5.000	377.98	6766.76	-326.76	-513.76	1.000
4	3.500	5.000	4.000	351.87	6108.98	-290.67	-485.76	1.000
5	8.500	3.000	4.000	365.87	6470.87	-285.78	-448.97	1.000
6	3.500	5.000	6.000	375.43	6570.89	-307.87	-503.87	1.000
7	8.500	5.000	4.000	344.76	6450.67	-295.12	-486.93	1.000
8	3.500	3.000	4.000	485.89	7270.97	-358.09	-528.76	1.000
9	3.500	3.000	6.000	405.74	6876.95	-330.84	-514.76	1.000
10	8.500	3.000	6.000	402.87	6965.67	-345.76	-520.94	1.000

Table 3 : ANOVA for different predicted models for responses

Source	Degree of freedom	F-Value			
		Firmness (g)	Textural consistency (g sec)	Cohesiveness (g)	Index of viscosity (g sec)
Model	9	16.36	18.08	25.98	115.69
A-Sapota Pulp	1	115.06	142.63	224.48	868.30
B-Sugar	1	7.083E-003	4.06	0.71	1.63
C-Fat	1	3.84	9.63	5.28	1.99
AB	1	0.019	0.14	6.46	0.52
AC	1	3.08	0.37	0.003	2.70
BC	1	3.27	1.381E-004	0.004	0.14
A^2	1	21.49	2.06	1.07	153.03
B^2	1	4.771E-005	1.32	0.22	13.59
C^2	1	0.12	0.56	1.940	0.71
Residual	10	-	-	-	-
Lack of Fit	5	52.33	77.83	220.94	7.48
Pure Error	5	-	-	-	-

sapota pulp, sugar and milk fat on consistency of sapota pulp enriched *Rabri* could be described by the following equation:

Cohesiveness = -338.86-64.99*A+60.53*B+43.22*C-73.80*AB 3.91*AC +73.93* BC+10.36* A^2+49.45* B^2+18.64* C^2 …………………… (3)

Here A, B and C are coded terms,for the three variables, *i.e.* sapota pulp, sugar and milk fat, respectively.

The co-efficient estimates of consistency showed that the linear model terms Values of ‘Prob. > F’ less than 0.0500 indicate model terms are significant.

Effect on index of viscosity :

The average index of viscosity of sapota pulp enriched *Rabri* varied from -528.76 to -458.97 g sec.

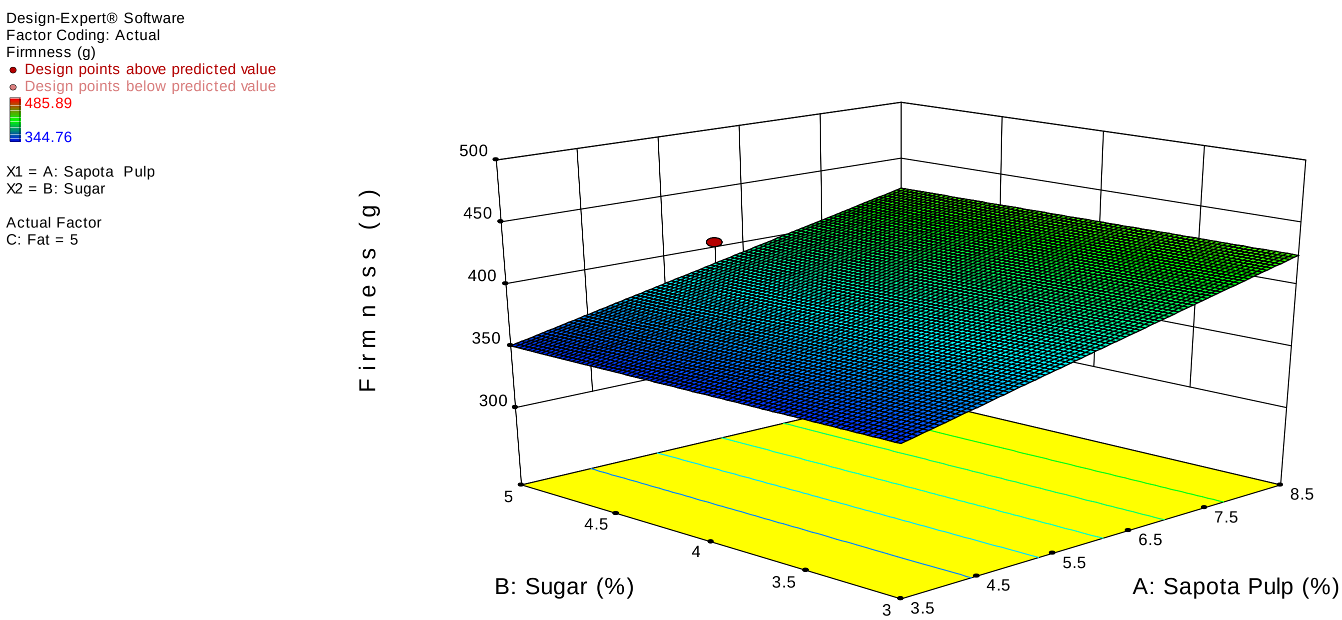

Fig. 1 : Effect of sapota pulp, sugar and milk fat on firmness

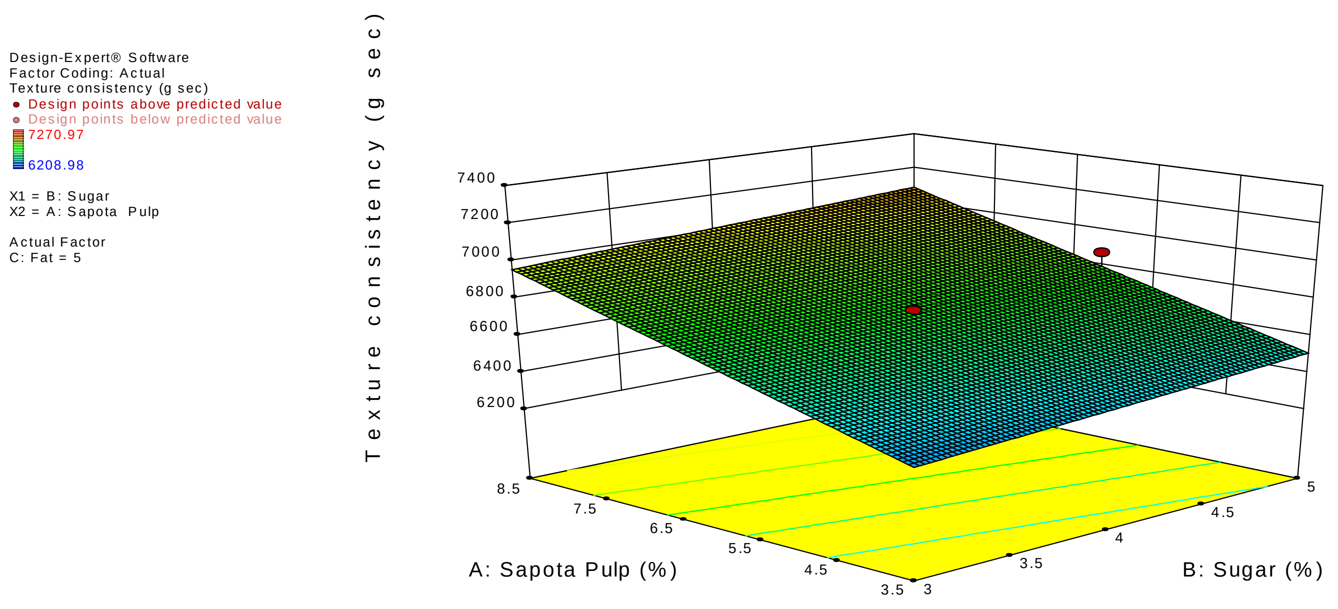

Fig. 2 : Effect of sapota pulp, sugar and milk fat on textural consistency

(Table 3). Fig. 4 shows that the response surface plot for index of viscosity as influenced by the level of sugar and sapota pulp, by keeping milk fat constant. It can be observed from figure that with increase in the level of sugar and sapota pulp, index of viscosity increase gradually but it was comparatively more than due to sapota pulp.

In the present study effect on index of viscosity of sapota pulp enriched *Rabri* could be described by the following equation:

Index of viscosity = -515.22-18.61* A+0.94* B-0.96* C-0.61*AB+1.39* AC+0.31* BC+6.93* A^2+3.29* B^2+0.64* C^2.........................(4)

Here A, B and C are coded terms for the three variables, *i.e.* sapota pulp, sugar and milk fat, respectively. The Model F-value of 115.69 implies the model is

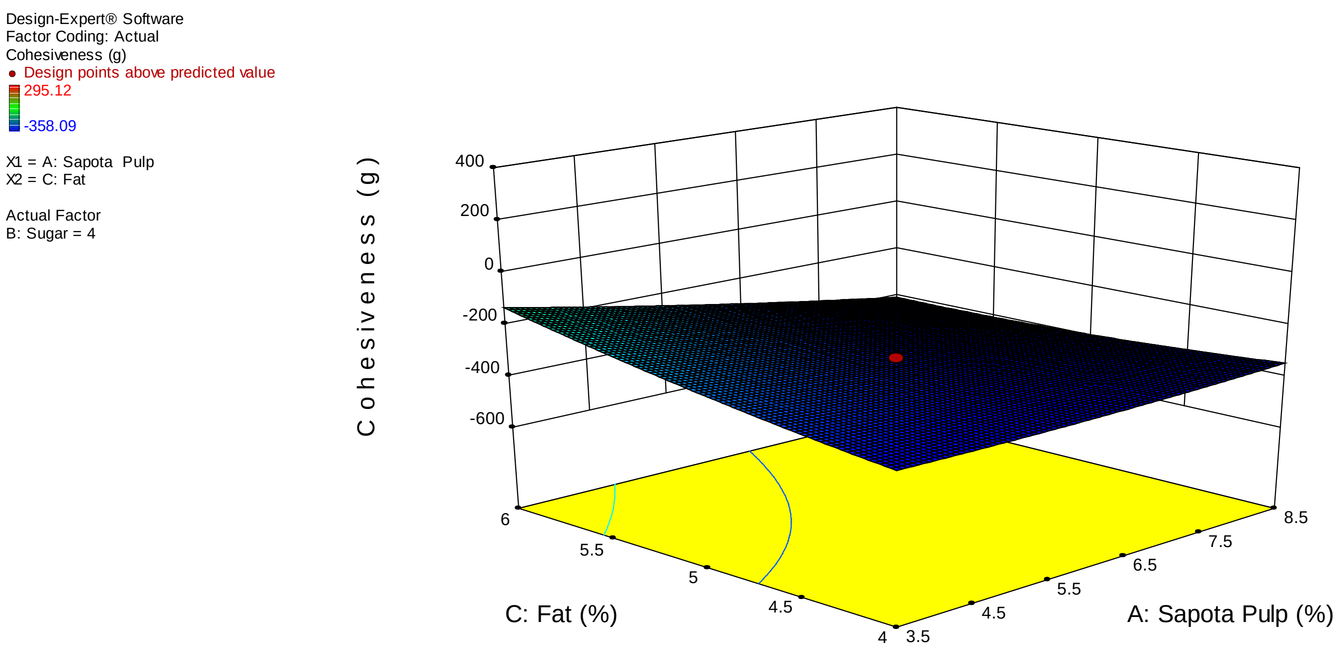

Fig. 3 : Effect of sapota pulp, sugar and milk fat on cohesiveness

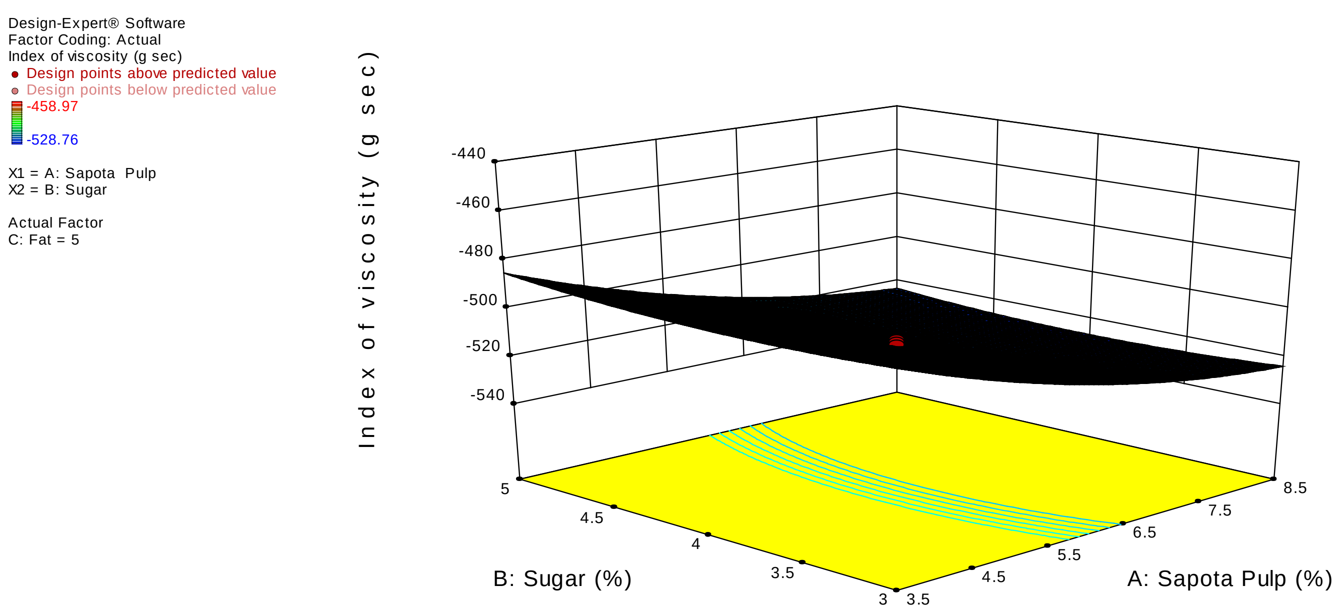

Fig. 4 : Effect of sapota pulp, sugar and milk fat on index of viscosity

significant. There is only a 0.01% chance that an F-value this large could occur due to noise.

Conclusion :

Twenty different runs according to the CCRD were used to study the textural parameters of sapota pulp enriched *Rabri*. Response surface methodology was effective in optimizing process and textural parameters of functional *Rabri*. The regression equations obtained in this study can be used for optimum conditions for desired responses within the range of conditions applied in this study. Graphical techniques, in connection with response surface methodology (RSM), Aided in locating optimum operating conditions, which experimentally verified and proven to be adequately reproducible. Optimum solution by numerical optimization obtained was 8.5 % sapota pulp, 3 % sugar and 4 % to get maximum possible quality, solute gain and textural parameters. The optimum processing conditions were experimentally verified and proven to be adequately reproducible with G Efficiency of 68.3 %.

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