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Nitesh Kumar
Banaras Hindu University, Varanasi, Uttar Pradesh, India

DC Rai
Banaras Hindu University, Varanasi, Uttar Pradesh, India

BC Andhare
College of Agriculture, Badnapur, Maharashtra, India

Uday Pratap Singh
Banaras Hindu University, Varanasi, Uttar Pradesh, India

Correspondence
BC Andhare
College of Agriculture, Badnapur, Maharashtra, India

Optimization of technical process for manufacture of sapota pulp enriched *rabri*

Nitesh Kumar, DC Rai, BC Andhare and Uday Pratap Singh

Abstract
A laboratory experiment conducted to process for manufacturing of *rabri* blended with sapota pulp, sugar and milk as main ingredients were optimized. During the experiment, the effect of different levels of sapota pulp, sugar and milk fat, was studied by employing a 3 factor central composite rotatable design version 9.0.5. The best formulation with 8.5 % sapota pulp, 3 % sugar and 4 % milk fat at process temperature of 89.5 °C yielded 27.52% of the product on the basis of the weight of mix used. This formulation was found to be most appropriate for manufacture of sapota pulp enriched *rabri* with predicted scores of 8.79, 8.87, 8.11, 8.67, 8.21 and 8.44 for get maximum possible quality, color and appearance, flavour, body and texture, sweetness, consistency and overall acceptability respectively.

Keywords: Central Composite Rotatable Design, *Rabri*, Response surface methodology, Sapota pulp

1. Introduction
Rabri is a heat-desiccated milk-based sweetened, condensed and nutritious Indian dairy dessert which is very popular in northern and eastern parts of the country, in recent times increased attention has been focused on utilization of sapota pulp enriched foods. India is one of the leading producer of sapota in the world with an annual production of 1.42 million metric tons 1 and accounts to about 10 % of world production 2. Sapota (*Achras zapota*), a delicious tropical fruit is rich in vitamins, dietary fibre, B_5, B_1, B_2, B_6 & B_9, A and C, minerals (minerals like calcium, phosphorous and iron) & health benefiting anti-oxidant tannin. In a study by 3 4-O-galloylchlorogenate and 4-O-galloylchlorogenic acid were reported to be found in *chiku* extracts. 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) to optimize the various parameters in the production of food products with desired quality 4 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. Due to huge production of sapota in some states of India where farmer can't store or handle over produce sapota for long duration, because the nature of sapota is highly perishable. If value added products are made by using sapota that will lead to the benefit of both consumer and producer. This will result higher utility creation for the consumer and more return for the producer which ultimately helps in the betterment of processing sector and as a result growth of secondary sector of Indian economy. Main objective of this experiment is to find out the optimum level of different ingredient which is being used in the manufacturing of sapota pulp enriched *rabri*.

2. Materials and methods
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%) & 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 1. As per response color and appearance, flavor, body & 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 2) in Design Expert 9.0.5 using CCRD during investigation.

Preparation of sapota pulp enriched rabri

For the preparation of sapota pulp enriched *rabri*, buffalo milk was taken and strained to remove visible dust and dirt particles through muslin cloth. After straining one liter of milk was taken in shallow iron *karahi* then fully ripe healthy and fresh sapota was washed thoroughly with potable water and the skin was removed by a knife. The seeds were removed and then sapota pulp was sieved (for removing of hard cells). Sapota pulp was weighed using an electronic scale. Addition of sapota pulp in milk before preheating stage, precooked slurry heated at simmering temperature (85-90°C) over an open fire and held undisturbed at this temperature by controlled heating for 120±10 min. The milk was neither stirred nor allowed to boil; surface of the milk was fanned to help the process of skin formation. A piece of skin was broken required with a bamboo splint and moved to the sides of the cooler part of *karahi*. As soon as the volume of milk reduced to 1/5th of its original volume, the layer of skin collected on the sides of *karahi* were immersed in the condensed milk, and allowed to cool at room temperature.

De (1989), Gayen *et al*. (1999) and Aneja *et al*. (2002) had reported that preparation *rabri* with slight modification of *rabri* like texture, color appearance.

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 1/5th
↓
Immersed the layers of skin in the sweetened condensed milk
↓
Cool the sample at 37 ± 5°C Temp.
↓
Storage at 10 & 25°C Temp

Flow chart for preparation of Functional *rabri*

Estimation of yield of sapota pulp enriched rabri

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

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

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 (1990) [1]. 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.

Sensory characteristics of sapota pulp enriched rabri

Sensory quality of sapota pulp enriched *rabri* samples was judged by a panel of 15 judges. The sapota pulp enriched *rabri* samples of each trial were evaluated for sensory attributes viz characteristics like colour and appearance, body and texture, sweetness, flavor, consistency and overall acceptability based on 9-point hedonic scale with slight modifications.

Statistical analysis

The statistical analysis was done by central composite rotatable design method by Madamba *et al*., 2001 [10].

Results and discussion

Optimization of parameters

In the 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. All major impacts, linear, quadratic and interaction effects were calculated for each model. Fig. a-g shows the response surface plot for various sensory parameters. The sensory scores were influenced by different levels of sapota pulp, sugar, and milk fat (Table 2). With increasing level of sapota pulp, the score tended to decline due to the presence of excess sapota pulp (Fig. c). From the response surface plot (Fig. a) for sweetness, it was observed that sweetness score is influenced by sapota pulp levels. It can also be seen that with increasing levels of sugar, the sensory score of sweetness is also increased in the consistency.

Proximate composition of sapota pulp enriched rabri

The chemical composition of sapota pulp enriched *rabri* prepared by using incorporation of 10.5% sapota pulp, 5% sugar and 6% milk fat was determined and the results are presented in Table 3. The total solids content of sapota pulp enriched *rabri* was 38.75±0.87%, higher then total solids contents (32.26±0.23%) were earlier reported for Indigenous Milk Based Product 'Rabri' (Khaskheli *et al*., 2008) [8]. The moisture, sucrose, fat, protein, and ash contents of the product were 30.08±0.52, 11.03±0.76, 19.80±0.98, 10.09±0.57 and 3.05±0.27%, respectively. The moisture content (31.76±0.96%) slightly lower was earlier reported for Indigenous Milk Based Product 'Rabri' (Khaskheli *et al*., 2008) [8]. Total sugar content increased with increase in the content of SP, which contains sugar in significant amount.

Effect on color and appearance

The average colour and appearance score varied from 7.33 to 8.93 (Table 4). Fig. (B) Shows that response surface plot for colour and appearance as influenced by the level of sugar and sapota pulp, by keeping milk fat constant. From the figure it can observed that with the increase in the level of sugar the colour and appearance little increase but there was comparatively increase in colour and appearance due to sapota pulp.

Effect on flavour

The average flavour scores for sapota pulp enriched *rabri* varied from 6.87 to 8.89 (Table 4). Fig. (C) Shows that the response surface plot for flavor as influenced by the level of milk fat and sapota pulp, by keeping sugar constant. From the figure brings out the fact that there was steep increase in flavor with the increase in the level of sapota pulp but no effect was found on flavor due to milk fat.

Effect on body and texture

The average body and texture score for sapota pulp enriched *rabri* varied from7.11 to 8.76 (Table 4). It can be observed from figure C that there was more increasing effect on body and texture with increase in sapota pulp but little increasing effect in case of sugar.

Effect on sweetness

The average sweetness score varied from 7.04 to 8.76 (Table 4). Fig. (d) Shows that the response surface plot for sweetness as influenced by the level of milk fat and sapota pulp, by keeping sugar constant. From the figure it can be observed that with the increase in the level of fat and sapota pulp body and texture increase gradually approximately same.

The F-value for quadratic model of texture was significant ($p < 0.013$).

Effect on consistency

The average consistency sapota pulp enriched *rabri* varied from7.21 to 8.60 (Table 4). Fig. (F) Shows that the response surface plot for consistency as influenced by the level of sapota pulp and sugar, by keeping milk fat constant. It can be observed from figure that there was more increasing effect on consistency with increase in sapota pulp than sugar.

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

Here A, B and C are coded terms for the three variables, i.e. sapota pulp, sugar and milk fat respectively. The F-value for quadratic model of consistency was significant ($p<0.0001$). R^2 was found to be, 0.85 indicating that Std. Dev. (0.29) of the variability in the response could be explained by the model.

Effect on overall acceptability

The average overall acceptability score of sapota pulp enriched *rabri* varied from 7.34 to 8.65 (Table 4). Fig. (G) shows that the response surface plot for overall acceptability as influenced by the level of milk fat and sapota pulp, by keeping sugar constant. It can be observed from figure that there was steep increase in overall acceptability with the increase in the level of sapota pulp but there was comparatively little increase in case milk fat.

Here A, B and C are coded terms for the three variables, i.e. sapota pulp, sugar and milk fat respectively. The F-value for quadratic model of overall acceptability was Significant ($p<0.00019$).

Table 1: 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

Table 2: 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

Table 3: Composition of sapota pulp enriched *rabri*.

Constituents	Amount (g/100 g. of the sample)
Total solid	38.75±0.42
Moisture	30.08±0.52
Fat	19.80±0.98
Sucrose	11.03±0.76
Protein	10.09±0.57
Ash	3.05±0.2
Data is represented as Mean, ± Standard Deviation (n=3)	

Table 4: Experimental runs and actual values of factors used in central composite rotatable design.

Trial No.	Sapota Pulp (%)	Sugar (%)	Fat (%)	Color and appearance	Flavour	Body and texture	Sweetness	Consistency	OAA score
1	6	4	5	8.27	8.22	8.54	7.54	8.51	8.43
2	3.5	3	6	7.82	7.11	7.45	8.53	7.32	7.87
3	6	4	5	8.25	8.23	8.76	7.65	8.54	8.41
4	3.5	3	4	8.55	7.56	7.54	8.54	7.39	8.25
5	1.5	4	5	7.79	6.87	7.11	7.67	7.21	7.34
6	6	4	3.5	8.21	7.88	8.54	7.45	8.47	7.98
7	3.5	5	6	8.22	7.64	7.54	7.11	7.46	8.21
8	10.5	4	5	7.92	8.89	7.65	7.3	7.3	7.85
9	6	5	5	8.15	8.54	8.34	7.09	8.38	8.31
10	8.5	3	4	8.93	8.56	8.11	8.67	8.6	8.55
11	6	4	5	8.26	8.22	8.53	7.66	8.54	8.45
12	6	4	5	8.26	8.31	8.52	7.75	8.53	8.65
13	3.5	5	4	7.33	7.78	7.43	7.21	7.35	7.51
14	8.5	5	4	8.37	8.67	8.21	7.08	7.87	8.34
15	8.5	3	6	7.78	8.55	8.33	8.76	7.89	8.32
16	6	4	6.5	8.24	8.68	8.56	7.54	8.57	8.46
17	6	4	5	7.98	8.25	8.65	7.65	8.51	8.44
18	8.5	5	6	7.79	8.79	8.1	7.12	8.57	8.13
19	6	2.5	5	8.11	8.56	8.57	7.04	7.53	8.39
20	6	4	5	8.24	8.24	8.58	7.32	8.53	8.45

Table 5: Predicted score of the suggested formulation of sapota pulp enriched rabri by design Expert 9.0.5

Trial No.	Sapota Pulp (%)	Sugar (%)	Fat (%)	Color and appearance	Flavour	Body and texture	Sweetness	Consistency	OAA Score
1	8.500	5.000	6.000	8.27	7.82	8.54	7.54	8.51	8.43
2	6.000	4.000	5.000	8.82	7.81	8.45	8.53	8.32	8.27
3	6.000	5.000	5.000	8.25	7.93	8.76	7.65	8.34	8.41
4	3.500	5.000	4.000	8.55	7.56	7.54	8.54	7.39	8.25
5	8.500	3.000	4.000	8.79	8.87	8.11	8.67	8.21	8.44
6	3.500	5.000	6.000	8.21	7.88	8.54	8.45	7.47	8.18
7	8.500	5.000	4.000	8.22	8.64	8.54	7.11	8.46	8.21
8	3.500	3.000	4.000	8.92	8.89	7.65	7.95	7.39	8.05
9	3.500	3.000	6.000	8.15	8.54	8.34	7.09	7.38	8.21
10	8.500	3.000	6.000	8.93	8.56	8.11	8.67	8.61	8.55

Table 6: ANOVA for different predicted models for responses.

Source	F-Value						
	Degree of Freedom	Color and appearance	Flavor	Body and texture	sweetness	Consistency	OAA score
Model	9	4.62	11.88	11.41	1.46	6.81	6.55
A-Sapota Pulp	1	2.34	92.65	22.49	0.049	10.65	12.36
B-Sugar	1	4.16	2.28	1.30	12.00	0.30	2.13
C-Fat	1	4.49	0.84	0.047	7.517E-003	0.031	0.88
AB	1	0.22	0.41	0.035	0.11	0.034	6.799E-015
AC	1	10.78	1.25	0.023	0.028	3.778E-003	2.21
BC	1	14.47	0.49	0.049	9.582E-003	3.82	4.63
A^2	1	4.56	8.39	71.75	0.37	33.80	35.35
B^2	1	0.75	1.24	6.37	0.69	11.38	0.16
C^2	1	0.15	0.64	1.96	1.10	2.421E-003	1.65
Residual	10	-	-	-	-	-	-
Lack of Fit	5	5.47	84.3	9.03	21.64	885.16	7.31
Pure Error	5	-	-	-	-	-	-

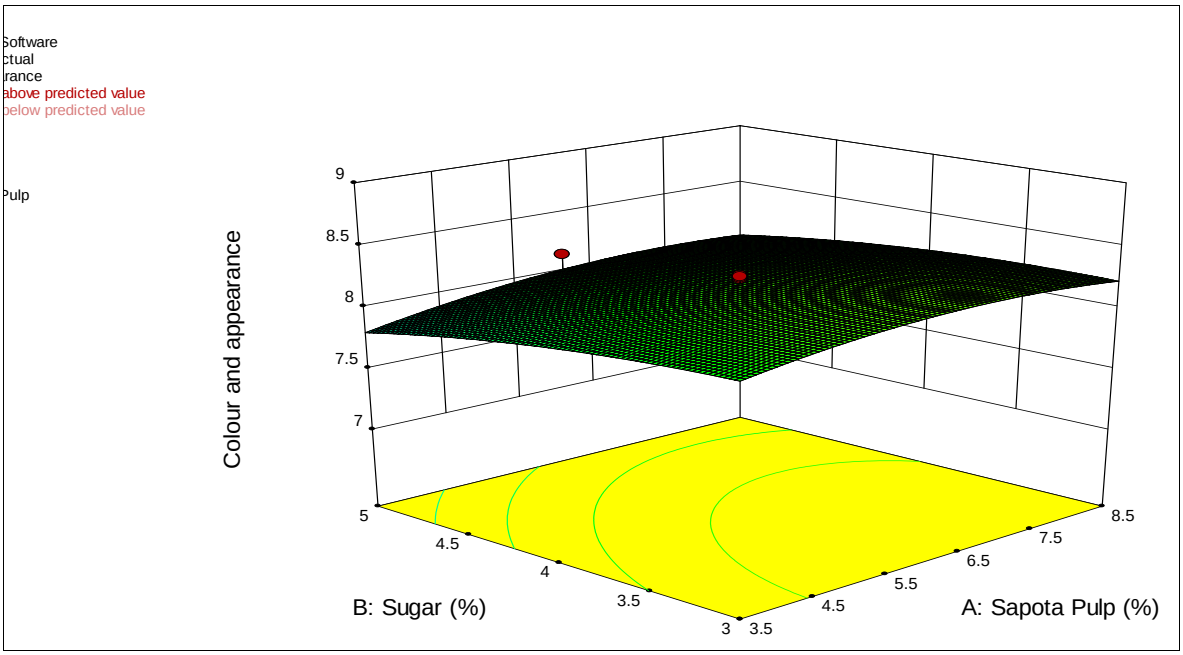

Fig a: Effect of sapota pulp, sugar and milk fat on colour and appearance.

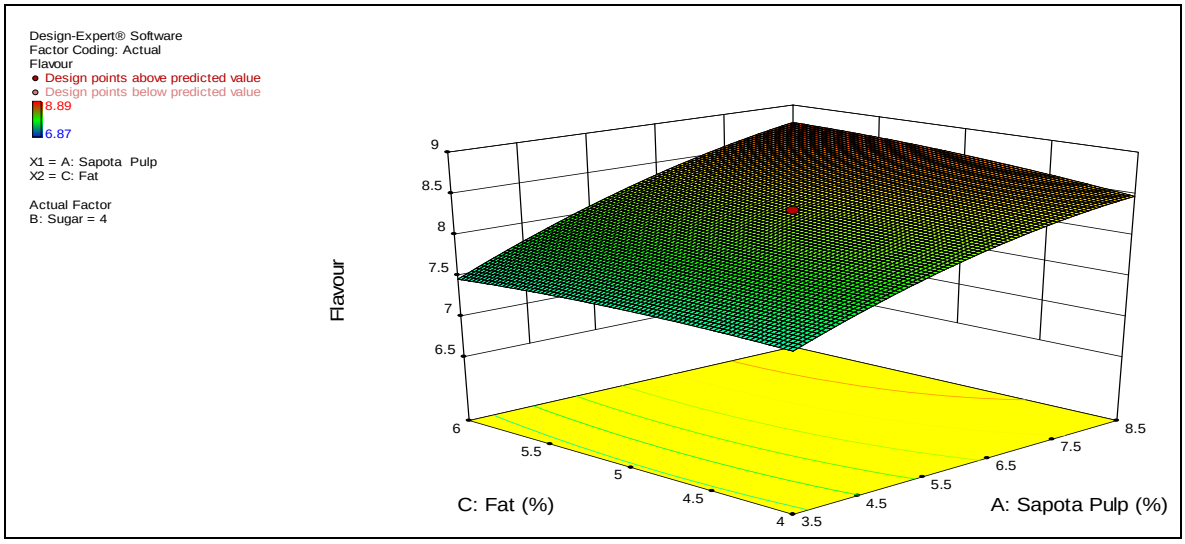

Fig b: Effect of sapota pulp, sugar and milk fat on flavor.

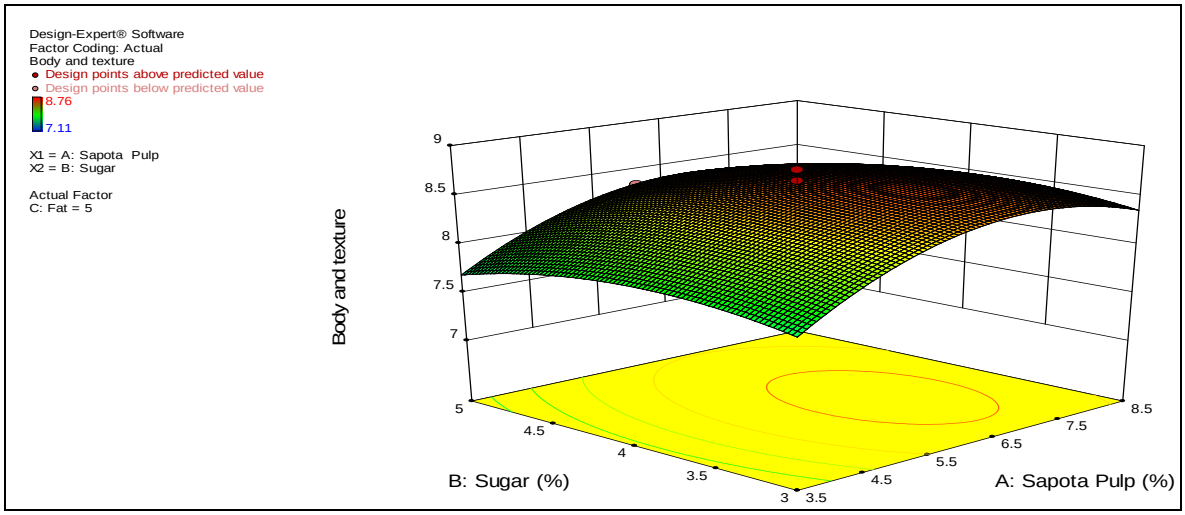

Fig c: Effect of Sapota pulp, sugar and milk fat on body and texture

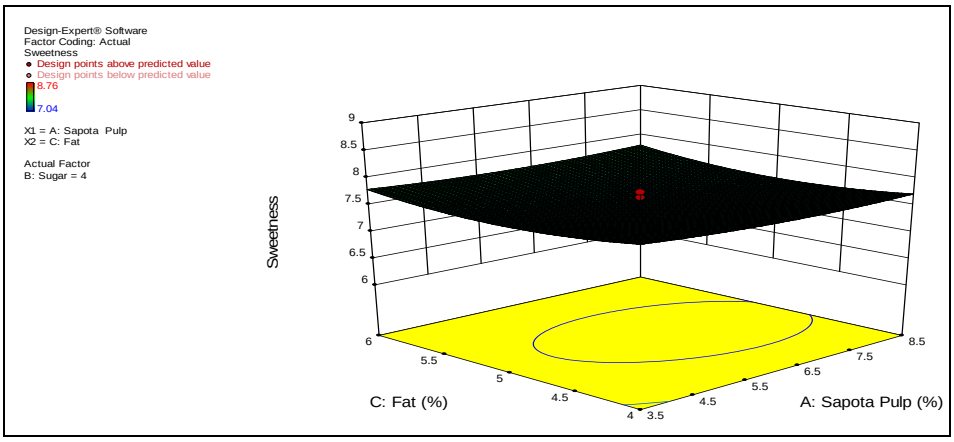

Fig. d: Effect of sapota pulp, sugar and milk fat on sweetness

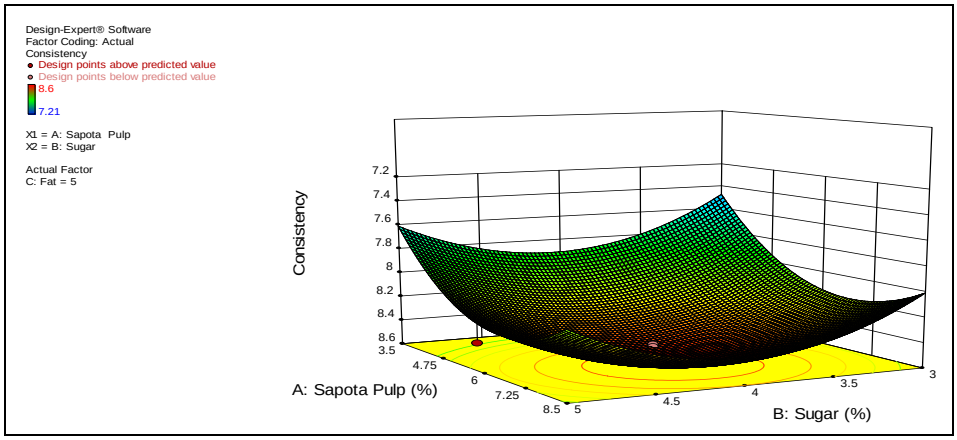

Fig e: Effect of saota pulp, sugar and milk fat on consistency.

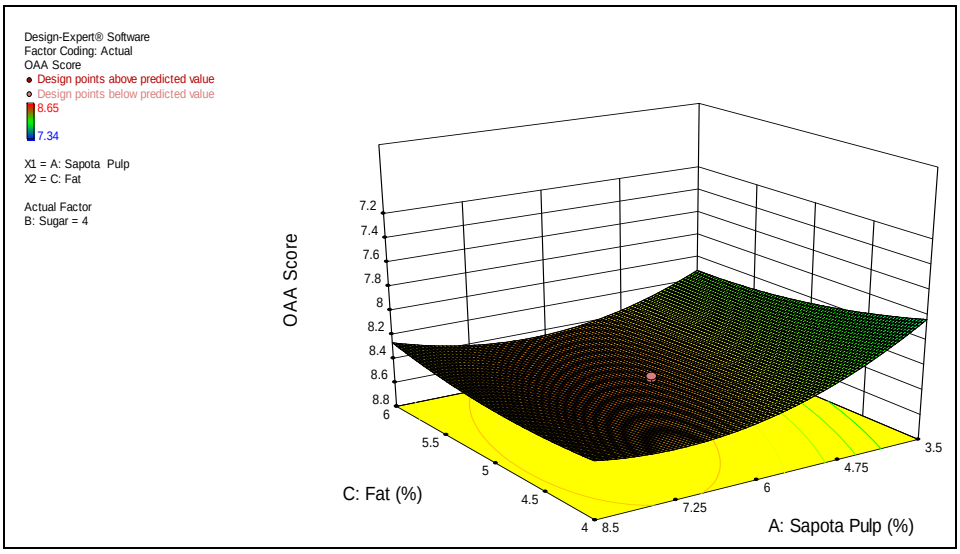

Fig f: Effect of sapota pulp, milk fat and sugar on overall acceptability.

Conclusion

Response surface methodology was effective in optimizing process and physical parameters of sapota pulp enriched *rabri*, optimization of sapota pulp, sugar and milk fat for manufacture of sapota pulp enriched *rabri* is predicted based on score of sensory quality using RSM package. Out of 10 suggested formulations, the formulation No. 5 had better overall rating of 8.55 than all other formulations and also the desirability was 1, highest amongst all other formulations (Table 5). Hence, the formulation with 8.5% sapota pulp, 3% sugar and 4% milk fat was considered to be the most appropriate for manufacturing sapota pulp enriched *rabri* with the predicted scores of 8.79 for colour and appearance, 8.87for flavour, 8.11for body and texture, 8.67for sweetness, 8.21 for consistency, 8.55 for overall. From these results, it could be concluded that sapota pulp enriched *rabri* can be manufactured by the dairy industry to promote value addition, export promotion and product diversification.

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