

Ingredients optimization in jaggery based nuggets with spices using RSM

■ NEHA KULKARNI, ASHOK KUMAR, P.K.OMRE AND B.K. KUMBHAR

SUMMARY : Optimization of jaggery based chocolate nugget was done using response surface methodology (RSM). Thirty chocolate nugget formulations were processed by mixing basic ingredients: cocoa powder (15, 20, 25, 30 and 35g), cocoa butter (50, 55, 60, 65 and 70g) and black pepper powder (1, 1.5, 2, 2.5 and 3g) in per 100 g jaggery powder. The experimental design was based on Response Surface Methodology using Center Composite Rotatable Design in 4 variables. Sensory evaluation score were taken as dependent variables representing the product quality. Optimum formulations were all the combinations of cocoa powder 8.59 per cent, cocoa butter 26.98 per cent, SMP 22.57 per cent and black pepper powder 0.86 per cent at 4 h. of conching at 55-60°C.

KEY WORDS : Jaggery, Nugget, Cocoa butter, Conching, SMP, RSM

How to cite this paper : Kulkarni, Neha, Kumar, Ashok, Omre, P.K. and Kumbhar, B.K. (2012).Ingredients optimization in jaggery based nuggets with spices using RSM. *Internat. J. Proc. & Post Harvest Technol.*, **3** (2) : 237-242.

Research chronicle : Received : 13.06.2012; **Revised :** 19.08.2012; **Accepted :** 06.10.2012

Chocolate conching is known to be one of the key quality driving steps in chocolate manufacturing. The initial dry conching phase is very important to decrease moisture and to improve rheology. The final liquid conching phase, initiated by lecithin and cocoa butter addition (Fischer *et al.*, 2005). The conching stages are filling, low-fat conching (dry conching, plasticising), addition of remaining fat and emulsifier, liquid conching.

Jaggery, commonly known as *gur* is one of the products of sugarcane. During processing the white crystal sugar loses natural minerals and vitamins and requires extra energy for its

digestion which is taken from body. On the other hand, jaggery being a low cost traditional, eco-friendly and nutritive sweetener offers a viable alternative. It may look less attractive than crystal sugar but it is a healthier food.

The main objective of work was to develop jaggery based chocolate nuggets with spices and nuts by applying conching process and to optimize the chocolate nuggets using Response Surface Methodology.

EXPERIMENTAL METHODS

Powder jaggery, cocoa powder, skim milk powder, cocoa butter, nuts (almond) and spices black pepper powder were the main ingredients for jaggery chocolate nugget.

The powder jaggery was purchased from the local market of Rudrapur, dist. U.S. Nagar, Uttarakhand. Cocoa butter and cocoa powder was procured from Laxmi trading company, Lucknow.

Experimental set up :

Wet grinder of Maharaja company working on shear force principle was used as concher. Concher is provided with steel pot having stone base and two stone rollers. Rollers are placed inside the pot move in opposite direction of pot movement.

Hot air blower was used to maintain the temperature

MEMBERS OF THE RESEARCH FORUM

Author for Correspondence :

NEHA KULKARNI, Department of Post-Harvest Process and Food Engineering, G.B. Pant University of Agriculture and Technology, Pantnagar, U.S.NAGAR (UTTARAKHAND) INDIA
Email : nehecae@gmail.com

Coopted Authors:

ASHOK KUMAR, Department of Processing and Food Engineering, College of Technology and Agricultural Engineering, Maharana Pratap University of Agriculture and Technology, UDAIPUR (RAJASTHAN) INDIA
Email : ashokcae@gmail.com

P.K.OMRE AND B.K. KUMBHAR, Department of Post-Harvest Process and Food Engineering, G.B. Pant University of Agriculture and Technology, Pantnagar, U.S.NAGAR (UTTARAKHAND) INDIA
Email : pkomre@rediffmail.com, bkkumbhar@rediffmail.com

during conching was used to maintain temperature in range 50-60°C.

Process for making jaggery chocolate nugget :

All ingredients such as jaggery powder, skim milk powder, cocoa powder and cocoa butter are mixed in concher.

Conching :

Conching involves two stages, firstly conched in dry state called dry conching process for 150min. Then cocoa butter was added and further conched for 30min, there after emulsion was added. After that it was conched for 60 min. During this process the temp of the material in the concher was kept at 40-50°C by mean of hot air blower. The total time of conching process was about 4h (Ziegleder, 2004).

Tempering :

The molten chocolate mass at temp 40-45°C was lower down to 28°C and increased to temp of 32°C (Baichoo, 2007). After the above steps, the adequate quantity of almond and black pepper powder was added and final mixing was completed.

Moulding :

The molten mass was then poured in plastic moulds and allowed to cool for 30min (Baichoo, 2007). For the physical characters study hardness by using texture analyzer was determined.

Design of experiments :

Independent variables were defined as cocoa powder, cocoa butter, skim milk powder, black pepper powder. Experiments were designed using Response Surface Methodology. The RSM design was chosen as it allows reduction in number of experiments without affecting the accuracy of results and to decide interactive effects of variables on the responses (Myers, 1987). A Central Composite Rotatable Design based on 5 levels for 4 factors (Table A).

Independent variables per 100g of jaggery powder	Coded variables					
	-2	-1	0	1	2	
Cocoa powder, g	X ₁	15	20	25	30	35
Cocoa butter, g	X ₂	50	55	60	65	70
SMP, g	X ₃	40	45	50	55	60
Black pepper powder, g	X ₄	1	1.5	2	2.5	3

Sensory evaluation :

Sensory quality is important to both producer as well as consumer. It is the combination of different senses of perception coming into play in choosing a food. The sensory evaluation was done for liking on the basis of taste, flavour and texture using 9 point hedonic scale with the help of a 10 member panel.

EXPERIMENTAL FINDINGS AND ANALYSIS

The experiments were conducted to develop chocolate nuggets using jaggery as sweetener. The experiments were planned using center composite rotatable design in 4 variables and Response Surface Methodology was used for data analysis.

The concentration of cocoa powder, cocoa butter, skim milk powder and black pepper powder were taken as independent variables. The responses studied were the sensory characteristics viz, taste, texture and flavour. The second order response surface model was fitted to these response variables using multiple regression analysis. The process was optimized on the basis of sensory rating.

Development of second order model :

A second order response surface model in 4 variables has the following general form :

$$Y = \beta_0 + \sum_{i=1}^4 \beta_i x_i + \sum_{i=1}^3 \sum_{j=i+1}^4 \beta_{ij} x_i x_j + \sum_{i=1}^4 \beta_{ii} x_i^2 \dots\dots\dots(1)$$

where,

$\beta_0, \beta_i, \beta_{ij}, \beta_{ii}$ are coefficient.

x_i, x_j are independent variables and Y is dependant variable.

Equation (1) can be fitted to the experimental data using statistical package Design Expert 8.0.1 (Stat-Ease, Inc.). The programme provided the values of coefficients of the model and related statistics.

Taste :

The taste score of the freshly prepared chocolate nugget was found to be in the range of 6.32-8.38. A minimum taste score was found in nuggets containing 8.23 per cent cocoa powder, 21.99 per cent cocoa butter, 21.99 per cent SMP and 0.87 per cent black pepper powder where as in maximum composition of 8.23 per cent cocoa powder, 26.77 per cent cocoa butter, 22.65 per cent SMP and 1.02 per cent black pepper powder (Table 1).

$$Y = 7.80000 - 0.017917x_1 + 0.37542x_2 - 0.18208x_3 - 0.024583x_4 - 0.13937x_1x_2 + 0.15187x_1x_3 - 0.051875x_1x_4 + 0.098125x_2x_3 + 0.098125x_2x_4 - 1.875x_3x_4 - 0.15948x_1^2 - 0.15448x_2^2 - 0.22448x_3^2 - 0.19198x_4^2 \dots\dots\dots(2)$$

The co-efficient estimates (Table 2) of taste score showed cocoa powder, cocoa butter, SMP and black pepper powder in quadratic terms. Negative coefficient of cocoa powder at linear level showed increase or decrease in these ingredients and showed negative effect on taste score. Cocoa powder, cocoa butter, SMP and black pepper powder in quadratic level having negative coefficients of estimates. Fig. 1 shows the effect of independent variables on taste score. Contours shown in Fig.

Table 1: Response characteristics of fresh chocolate nugget

Experiment No.	Sensory score		
	Taste	Texture	Flavor
1.	6.57	6.67	6.73
2.	6.54	6.78	7.04
3.	7.12	7.08	6.68
4.	7.54	7.52	6.74
5.	6.56	6.35	6.21
6.	7.59	7.02	7.24
7.	8.37	8.3	8.4
8.	7.19	7.44	6.56
9.	6.54	6.89	6.97
10.	6.79	6.71	7.09
11.	6.81	7.06	7.42
12.	7.21	7.45	7.16
13.	6.87	6.78	7.29
14.	6.56	6.87	7.14
15.	8.38	8.3	8.46
16.	7.45	7.41	7.65
17.	7.06	7.31	7.71
18.	7.02	6.94	6.97
19.	6.32	6.42	7.24
20.	7.8	7.32	7.14
21.	6.65	6.87	6.94
22.	6.91	6.87	7.06
23.	6.84	7.04	6.54
24.	6.98	7.21	7.43
25.	7.8	7.7	7.89
26.	7.8	7.7	7.89
27.	7.8	7.7	7.89
28.	7.8	7.7	7.89
29.	7.8	7.7	7.89
30.	7.8	7.7	7.89

1 indicated that the taste score was maximum at lower level of cocoa powder with cocoa butter and SMP. The shaded portion shown in Fig. 1 indicated maximum score range for taste. Equation 2 gives the multiple regression equation.

Texture :

The texture score of the freshly prepared chocolate nugget was found to be in the range of 6.35-8.30. A minimum texture

Table2: Regression model results for taste score of chocolate nugget

Source		Taste		Regression co-efficient
		F-value	P-value	
Model		4.67**	0.0027	7.88**
Linear	X ₁	0.065	0.8022	-0.018
	X ₂	28.55	<0.0001	0.38
	X ₃	6.72	0.0204	0.18
	X ₄	0.12	0.7313	-0.025
Quadratic	X ₁₂	5.89*	0.0283	-0.16*
	X ₂₂	5.52*	0.0329	-0.15*
	X ₃₂	11.66**	0.0038	-0.22**
	X ₄₂	8.53*	0.0105	-0.19*
Interaction	X ₁ X ₂	2.62	0.1262	-0.14
	X ₁ X ₃	3.11	0.0979	-0.15
	X ₁ X ₄	0.36	0.5557	-0.052
	X ₂ X ₃	1.30	0.2721	0.098
	X ₂ X ₄	8.914E-	0.9260	8.125E-003
	X ₃ X ₄	003	0.9829	-1.875E-003
Lock of fit		0.20		0.8803
R ²				81.33%
Adeq precision				7.198

* and ** Indicates significance of values at P=0.05 and 0.01, respectively

score was found in nuggets containing 8.62 per cent cocoa powder, 23.72 per cent cocoa butter, 23.72 per cent SMP and 1.07 per cent black pepper powder and in maximum composition of 8.23 per cent cocoa powder, 26.77 per cent cocoa butter, 22.65 per cent SMP, 1.02 per cent black pepper powder.

$$Y = 7.70000 - 0.040417x_1 + 0.3454283x_2 + 0.096250x_3 + 0.027083x_4 - 0.10062x_1x_2 - 0.10937x_1x_3 - 0.059375x_1x_4 + 0.14813x_2x_3 - 0.034375x_2x_4 + 0.011875x_3x_4 - 0.115948x_1^2 - 0.17969x_2^2 - 0.17969x_3^2 - 0.11594x_4^2 \dots\dots\dots(3)$$

The effect of cocoa butter was significant at linear at 1 per cent while the effect of cocoa powder and SMP was significant at quadratic level at 10 per cent and 1 per cent, respectively. The quadratic effect was negative for cocoa powder, cocoa butter and SMP indicating texture score was decreased with increase of the levels of cocoa powder, cocoa butter and SMP. SMP in interaction with cocoa butter (P<0.1) significantly affected the texture score of the fresh chocolate (Table 3). The effect of independent variables on texture score is shown in Fig 2.

Flavour :

The flavour score of the freshly prepared chocolate nugget was found to be in the range of 6.21-8.46. A minimum flavour

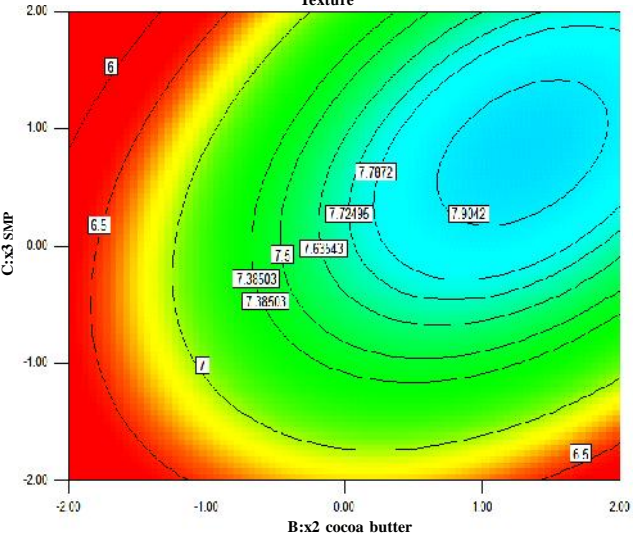
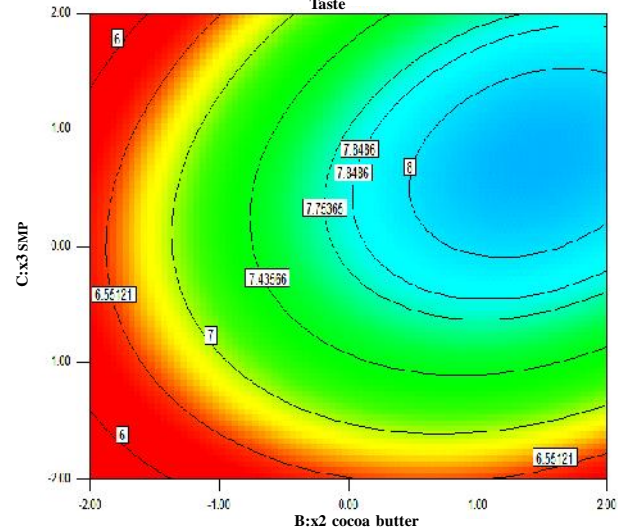
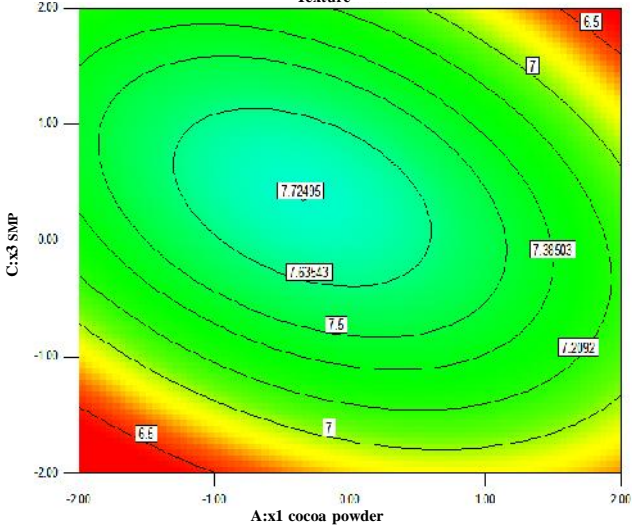
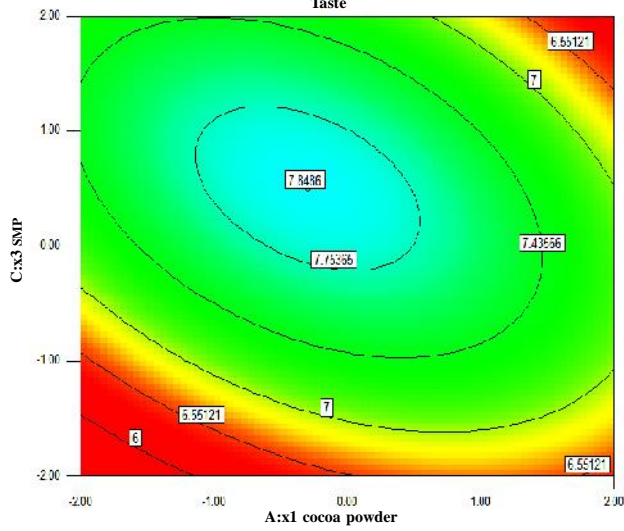
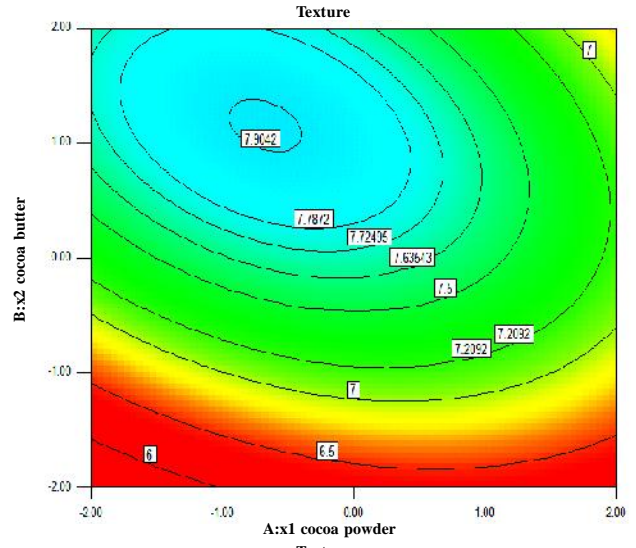
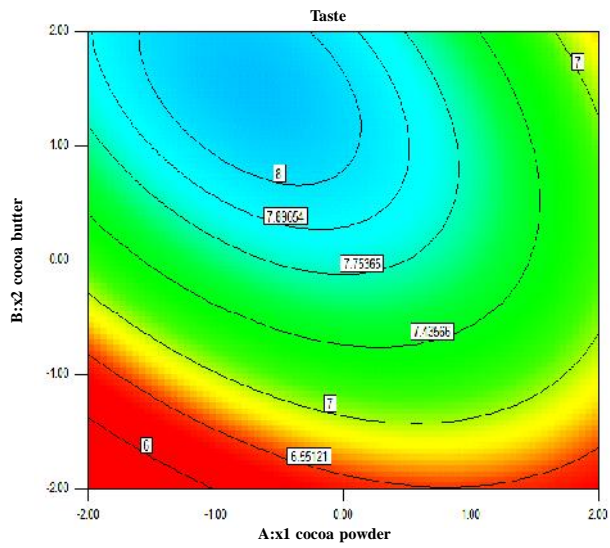


Fig.1: Effect of independent variable on taste score of nugget

Fig.2: Effect of independent variable on texture score of nugget

Table 3 : Regression model results for texture scores of chocolate nuggets

Source	Texture		Regression co-efficient
	F-value	P-value	
Model	4.93***	0.0020	7.70***
Linear	X ₁	0.47	-0.040
	X ₂	34.48***	<0.0001
	X ₃	2.68	0.1226
	X ₄	0.21	0.6518
Quadratic	X ₁ ²	4.44*	-0.12*
	X ₂ ²	10.66**	-0.18***
	X ₃ ²	10.66***	-0.18***
	X ₄ ²	4.44	-0.12
	X ₁ X ₂	1.95	0.1828
Interaction	X ₁ X ₃	2.30	-0.11
	X ₁ X ₄	0.68	0.4228
	X ₂ X ₃	4.23*	0.0576*
	X ₂ X ₄	0.23	0.6401
X ₃ X ₄	0.027	0.8713	
Lock of fit	0.54	0.6847	
R ²	82.15%		
Adeq precision	8.453		

* and ** indicates significance of values at P=0.05, respectively

Table 4 : Regression model results for flavour scores of chocolate nuggets sample

Source	Flavour		Regression co-efficient
	F-value	P-value	
Model	4.64**	0.0028	7.89**
Linear	X ₁	3.41**	-0.13**
	X ₂	3.74	0.0723
	X ₃	4.23	0.0576
	X ₄	10.76**	0.0051
Quadratic	X ₁ ²	4.16	0.0593
	X ₂ ²	6.91*	-0.17*
	X ₃ ²	11.39**	-0.21**
	X ₄ ²	11.79	0.0037
	X ₁ X ₂	9.72**	-0.26**
Interaction	X ₁ X ₃	2.25	0.1547
	X ₁ X ₄	0.24	0.6281
	X ₂ X ₃	5.12	0.0389
	X ₂ X ₄	0.61	0.4479
X ₃ X ₄	0.26	0.6178	
Lock of fit	1.07	0.4596	
R ²	81.23%		
Adeq precision	8.503		

* and ** indicates significance of values at p=0.05 and 0.01, respectively

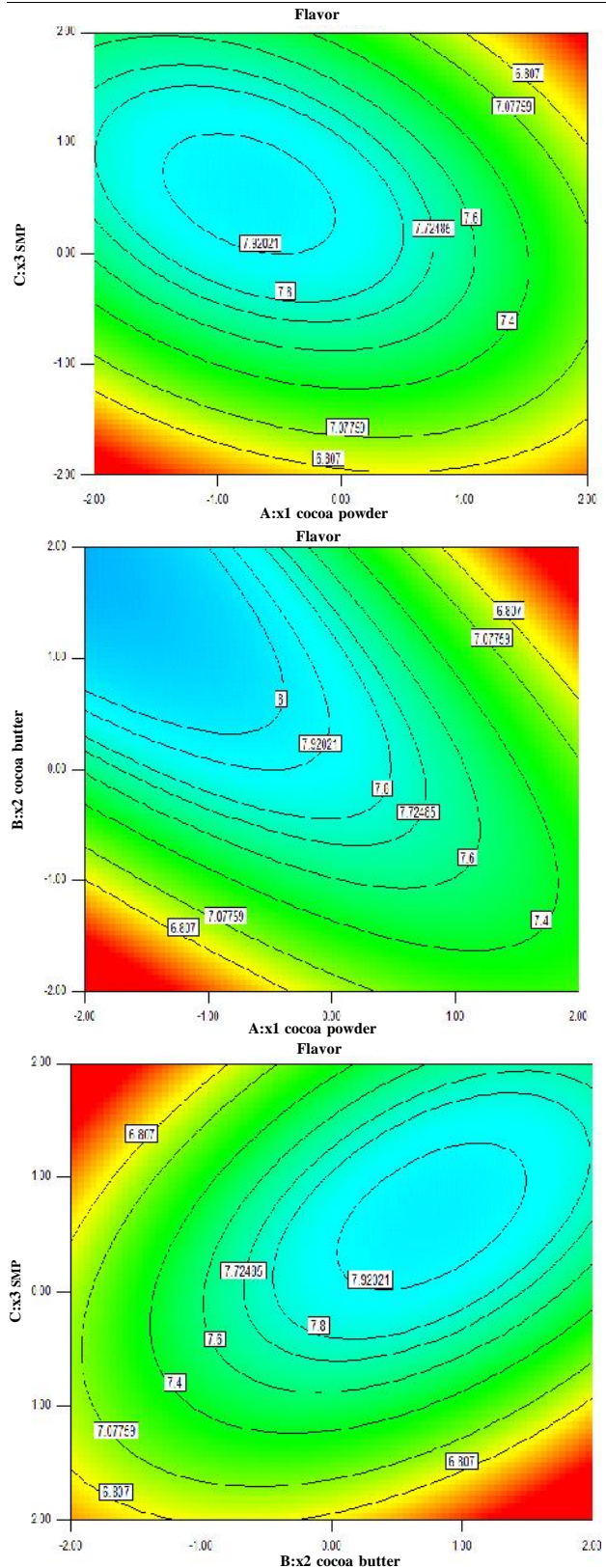


Fig.3: Effect of independent variable on flavour score of nugget

score was found in fresh chocolate nuggets containing 8.62 per cent cocoa powder, 23.72 per cent cocoa butter, 23.72 per cent SMP, 0.64 per cent black pepper powder and maximum in composition of 8.23 per cent cocoa powder, 26.77 per cent cocoa butter, 23.65 per cent SMP, 1.02 per cent black pepper powder.

$$Y = 7.89000 - 0.12583x_1 + 0.13167x_2 + 0.14000x_3 + 0.22333x_4 - 0.26000x_1x_2 - 0.12500x_1x_3 - 0.041250x_1x_4 + 0.18875x_2x_3 + 0.065000x_2x_4 + 0.042500x_3x_4 - 0.13000x_1^2 - 0.16750x_2^2 - 0.21500x_3^2 - 0.21875x_4^2 \quad \dots(4)$$

The co-efficient estimates of flavour score shows that cocoa powder and black pepper powder in linear term while SMP and cocoa butter in quadratic term significantly affected the flavour score of the fresh chocolate (Table 4). The effect of independent variables on appearance score is shown in Fig. 3. Contours shown in Fig. 3 indicated that the higher flavour score was at lower level of cocoa powder in combination with cocoa butter and at medium level of cocoa butter with

SMP. Shaded region in Fig 3 showed maximum score range for flavour.

Conclusion :

The sensory panel rated their liking or disliking of product on 9 point hedonic scale based on colour, appearance, taste, texture, flavour and overall acceptability. Chocolate nugget prepared in this study had the sensory rating ranging from 6.32-8.38 for taste, 6.35-8.3 for texture and 6.21-8.46 for flavour indicating that it lies from 'like slightly to like very much'. Models obtained for all responses.

- The optimum ingredient levels for making chocolate nugget are cocoa powder 8.59 per cent, cocoa butter 26.98 per cent, SMP 22.57 per cent and black pepper powder 0.86 per cent at 30 min. of mixing and 4 h. of conching at 55-60°C.
- The effect of cocoa powder was more on all responses followed by cocoa butter, skim milk powder and black pepper powder in that order.

LITERATURE CITED

- Baichoo, N. (2007).** The effect of rapid cooling on the fat phase of chocolate. University of Nottingham, NOTTINGHAM.
- Fischer, A., Abubaker, T. and Ullrich, F. (2005).** Understanding the impact of conching on chocolate flavour using a combination of instrumental flavour analysis and tasting techniques, University of Germany, GERMANY.
- Myers, R.H. (1987).** Response Surface Methodology. Allyn and Bacon, BOSTON.
- Ziegleder, G. (2004).** Conching. Advanced chocolate technology. Bühler Seminar, UZWIL.

