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RESEARCH PAPER

Optimization of ingredient levels of jaggery chocolate by using response surface methodology

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SUMMARY : Jaggery, despite of a low cost, eco-friendly and a viable alternative to sucrose. jaggery chocolate prepared by using skim milk powder, cocoa powder, cocoa butter, emulsifier and flavoring agent per 100g of powder jaggery. Response surface methodology (RSM) was used to prepare and investigate the overall acceptability and textural characteristic *i.e.* hardness of Jaggery chocolate using sensory and penetration test as part of instrumental texture profile analysis. Cocoa, skim milk powder and cocoa butter in per cent were taken as independent variables influencing the product. Colour, texture and overall acceptability taken as responses. Experiments were designed using response surface methodology. The Box-benken 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. It is concluded from the present study that the chocolate prepared in this study had the sensory rating ranging from 6.00-7.85 for colour, 6.23-7.55 for texture and 6.35-7.5 for overall acceptability. The sensory characteristics were statistically significant at 1 per cent probability level for evaluating the quality. The optimum process conditions for making chocolate using jaggery as sweetener were SMP 20.30 per cent; cocoa powder 10.04 per cent; cocoa butter 25.15 per cent, 30 minute mixing time and 4 hours of conching process. Corresponding sensory attributes were colour 7.2, texture 7.1 and overall acceptability 7.23.

Key Words : Jaggery, Chocolate, RSM, Texture, Sensory, Hardness

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Chocolate confectionary has been a novelty food item over the years. Consumers of all ages and social classes have been enjoying it in various forms. Commercial chocolate manufacture in present sense started in the 18th century. It has been reported that in India per capita chocolate consumption is around 160 g and is extremely low as compared to developed countries (Anonymous, 2003). Annual per capita chocolate consumption in Briton was about 11.2 kg per year. Belgium, the second highest consumer was 8.4 kg per capita, while France and Germany's average consumption was 6.7 kg and 4.9kg per year, respectively (Anonymous, 2003).

Pure chocolate bars contain more than 65 per cent cocoa and remaining (35%) consists of necessary and optional ingredients. The necessary ingredients are cocoa paste, cocoa butter and sugar while the optional ingredients are flavorings, emulsifiers, fruits and nuts. The macronutrients content of chocolate depends on manufacturer's recipe but consists mainly of carbohydrate and fat with a small proportion of protein. Riesen (1977) has given the composition of a typical dietetic milk chocolate, which contains approximately 9 per cent cocoa beans, 15 per cent dried whole milk, 7 per cent dried skim-milk, 31 per cent sorbitol, 38 per cent cocoa butter, 0.12 per cent cyclamate, 0.6 per cent lecithin, and 0.01 per cent vanilla.

The composition of chocolate in the U. S. is specified by FDA (1988C). According to these specifications, chocolate

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liquor should be 15 per cent for sweet chocolate, 35 per cent for the bitter chocolate and 10 per cent for plain milk chocolates. Soy lecithin is the main and the least expensive emulsifier used to improve the fluidity of chocolate mix. The term 'lecithin' refers to the material obtained by degumming of crude vegetable oil and then drying of the hydrated gums, mainly from soybean oil. The specific phospholipid called lecithin is referred to as phosphatidylcholine. Lecithin is the commercial name given to a mixture of phospholipids, neutral lipids and free fatty acids, glycolipids, carbohydrates and water (Bonekamp, 1992).

General concept is that consumption of chocolate leads to the various health hazards like dental caries, constipation, diabetes, obesity and an increase in cholesterol level leading to heart attacks. Besides, chocolates in general are found to be low in mineral content and having high fat value. Therefore, supplementation of minerals and low fat chocolate with equal textural and organoleptic qualities is desirable. 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. Jaggery is a natural sweetener made from sugarcane juice simply by evaporation. It contains an enormous wealth of minerals, protein, vitamins and useful sugar (Makde, 2006).

In Ayurveda, jaggery is considered to be best of all sugarcane preparations and as 'medicinal sugar'. It promotes digestion and has on overall nourishing effects on health. If we study the modern confectionary products available in the market, for the inclusion of jaggery as sweetener, chocolate emerges as a prospective preference. The nature of jaggery in terms of its colour, texture and sweetness, would make it very suitable for a chocolate like product. Therefore, jaggery would be a healthier alternative due to its low fat and higher mineral content. The low cost of jaggery will make it popular among the middle and poor classes which presently cannot afford the luxury of milk chocolate. Also, the jaggery chocolate is healthier alternative due to its low fat and higher mineral content. Therefore, research will be taken to standardize the chocolate based on jaggery so it will compete with the commercial chocolate.

Keeping in view and highlighting the importance of above points research objectives have been decided as to formulate chocolate using jaggery powder, skim milk powder, cocoa powder, cocoa butter, emulsifier and flavouring agent and optimize the level of ingredients based on sensory characteristics.

EXPERIMENTAL METHODS

Powder jaggery, cocoa powder, skim milk powder, cocoa butter were the main ingredients for jaggery chocolate. 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 treading company, Lucknow.

A number of experimental setup was required in the study. The apparatus was modified fluid mixing apparatus supplied by M/S Arm field Technical Education Co. Ltd. U. K. Wet grinder of Maharaja Company work on shear force principle was used as 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. Billion (1984) described a special design of cooker-extruder (Clextral SA) which can be used for conching of chocolate. The machine contains two co-rotating and interpenetrated screws, and is equipped to allow addition of ingredients to the product stream during operation and removal of volatiles. It is having the advantages of lower investment, energy savings and continuous processing. Conching is the kneading and mixing of the chocolate mass during manufacture, the finer the chocolate mass the better will be the gloss and greater the adhesion and retention of fat. Conching of milk chocolate is done at lower temperature than that required for plain chocolate. Time requirement is generally 72-96 hours, which is sufficient to produce a satisfactory fineness of sugar and cocoa particles. The conching process can be of two types. The cold conching process, which is done at temperature 45-55 ^{0}C and the 'hot conching process'

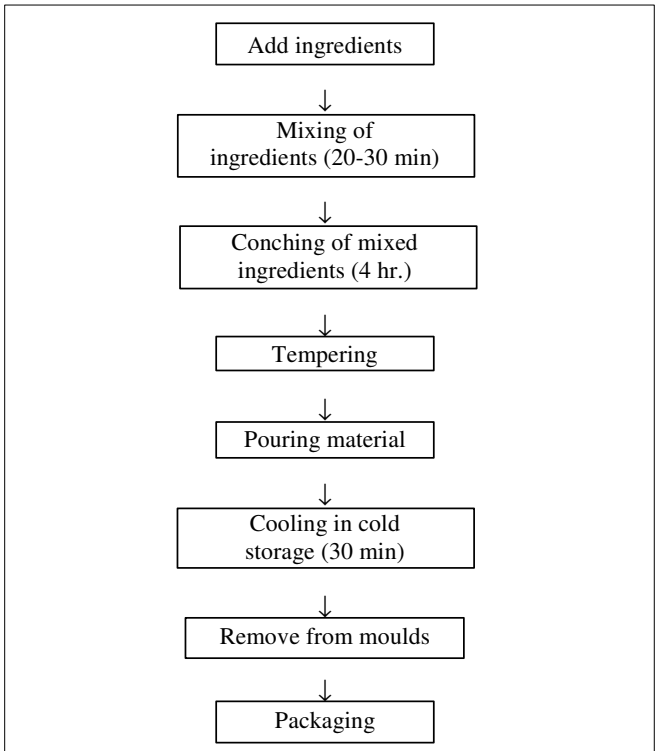

Fig. A : Flow chart for chocolate making process

carried out at 70-80^0 C temperature (Anonymous, 1987). Process of conching is carried out in special equipment called 'conchae' or kneading machine. It is a mixing tank provided with pressure rollers to grind and aerate the mass (Joshi and Sharma, 1992).

Hot air blower was used to maintain the temperature process for making chocolate is given in flow chart (Fig. A).

Experiments are executed as per Box-Benken Design, with three variables as cocoa powder, cocoa butter and skim milk powder (SMP) and sweetener powder jaggery, emulsifier and flavouring agent was kept constant at 40 per cent , 0.3 per cent and 0.05 per cent, respectively. Level of ingredients on 100 g jaggery basis given in Table A.

Table A : Levels of variables on 100g jaggery powder basis

Independent variables per 100 g of jaggery powder		Coded variables		
		-1	0	1
Skim milk powder, g	X_1	42.5	50	57.5
Cocoa powder, g	X_2	20	25	30
Cocoa butter, g	X_3	55	62.5	70

EXPERIMENTAL FINDINGS AND ANALYSIS

The experiments were conducted to develop chocolate using jaggery as sweetener. The experiments were planned using Box-Benken Design in 3 variables and Response Surface Methodology was used for data analysis

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

where, β_0, β_i, β_{ij}, β_{ii} are coefficient.

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

The concentration of skim milk powder, cocoa powder and cocoa butter were taken as independent variables. The responses studied were the sensory characteristics *viz*., colour, texture and overall acceptability. 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. A second order response surface model in 3 variables has the following general form, Statistical package Design Expert 8.0.1 (Stat-Ease, Inc.) used for statistical analysis. The chocolate samples evaluated for its acceptability. For sensory evaluation chocolate samples were served to a panel of ten trained panelists. The panelists were asked to evaluate the sensory quality of chocolate sample as per sensory score card. Panel members were directed to judge each samples on the basis of colour, texture and overall acceptability and to indicate their degree of liking on a 9-point Hedonic scale (Lawless and Haymann, 1998). The analysis of variance (ANOVA) for each response was calculated and second order response surface model was developed for each response. The developed model is analyzed for adequacy to explain variability in responses on the basis of F_{cal}, coefficient of determination (R^2), lack of fit and adequate precision ratio.

Colour:

The lack of fit for the response surface model developed for colour score was not significant at 1 per cent level of significance and the calculated adequate precision model was acceptable. The ANOVA for the response indicated that the model was adequate and explained more variability. The model

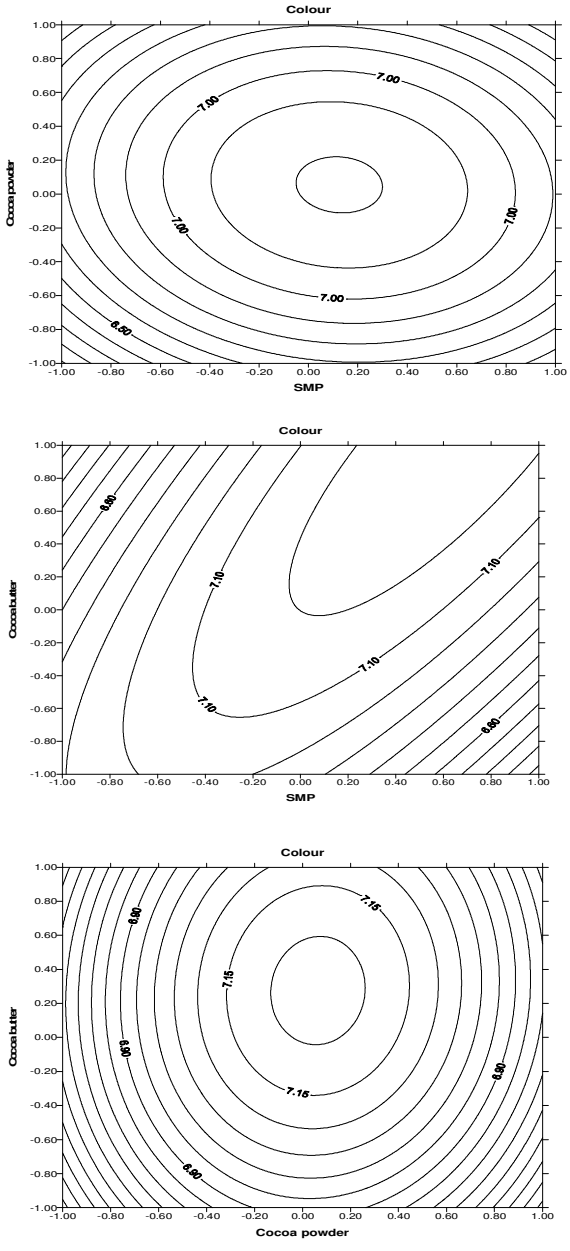

Fig. 1 : Effect of independent varibles on colour score of chocolate

was significant on the basis of model 'F_{cal}' value .

The effect of SMP and cocoa powder was significant at quadratic level ($P<0.05$). The quadratic effect was negative indicating colour score was maximum at centre point and it decreased with increase or decrease of the levels SMP and cocoa powder from centre point. The interaction between cocoa powder and cocoa butter was significant at $P<0.05$. The effect of independent variables on colour score is shown in Fig. 1. Contours shown in Fig. 1 indicated that the maximum colour score was obtained at level center point of cocoa powder with SMP, cocoa powder and cocoa butter also at center point. The shaded portion shown in Fig. 1 indicated maximum score range for colour.

Texture:

The lack of fit for the response surface model developed for texture score was significant at 5 per cent level of significance and the calculated adequate precision was greater

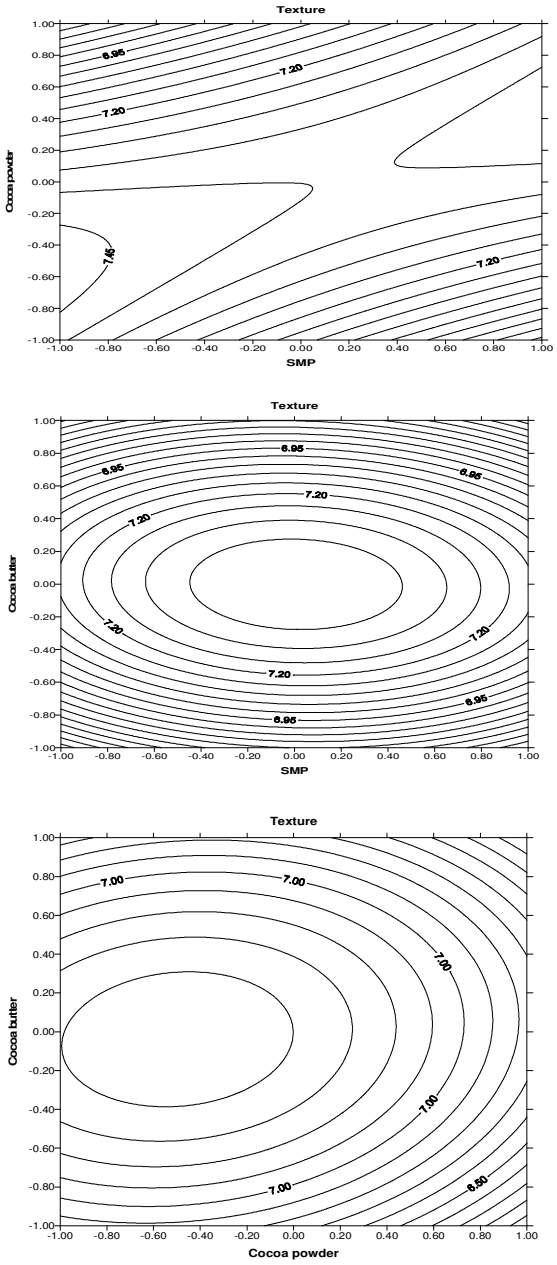

Fig. 2 : Effect of independent variable on texture score of chocolate

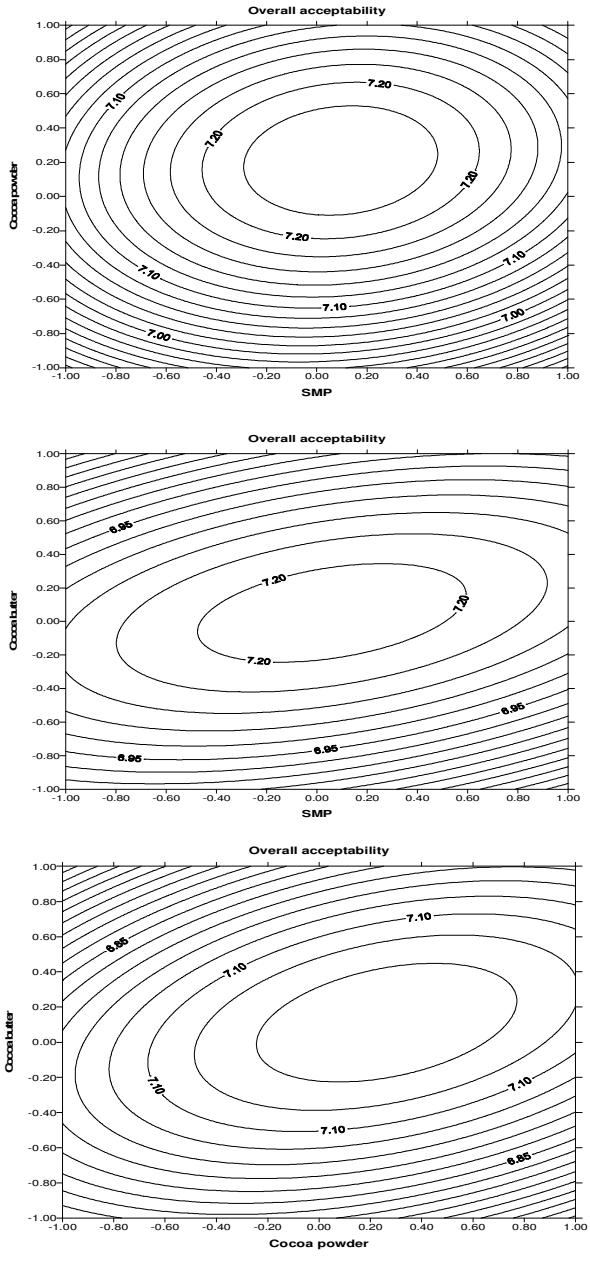

Fig. 3 : Effect of independent variables on overall acceptablity score of chocolate

than 4 and is desirable. Coefficient of determination was found to be 89.50 per cent . Therefore, the model was acceptable. The ANOVA for the response indicated that the model was adequate and explained more variability. The model was significant on the basis of model 'F_{cal}' value.

The effect of cocoa powder and cocoa butter was significant at quadratic level at 5 per cent and 1 per cent, respectively. The linear effect was negative for SMP, cocoa powder and cocoa butter indicating texture score was decreased with increase of the levels of cocoa powder. SMP in intraction with cocoa powder ($P<0.05$) significantly affected the texture score of the fresh chocolate. The effect of independent variables on texture score is shown in Fig. 2. Contours shown in Fig. 2 indicated that maximum texture score was observed at minimum level of cocoa powder with SMP and at higher level of cocoa butter with cocoa power. The saddle points were observed for the combination of SMP with cocoa powder. The shaded portion shown in Fig. 3 indicated maximum score range for texture.

Overall acceptability:

The lack of fit for the response surface model developed for overall acceptability score was significant at 5 per cent level of significance and the calculated adequate precision was greater than 4 and is desirable. R^2 was found to be 83.53 per cent. Therefore, the model was acceptable. The ANOVA for the response indicated that the model was adequate and explained more variability. The model was significant on the basis of model 'F_{cal}' value .

The effects of cocoa powder ($P <0.05$) and cocoa butter ($P <0.05$) were significant at quadratic level. The quadratic effect was negative for SMP, cocoa powder and cocoa butter indicating overall acceptability score was decreased with increase of levels of SMP, cocoa powder and cocoa butter from centre point. Fig. 3 shows the effect of independent variables on overall acceptability score. The shaded region shown in Fig. 4 indicated optimum overall acceptability score range.

The optimized levels of SMP, cocoa powder and butter were 20.36 per cent, 10.04 per cent and 25.15 per cent, respectively.

LITERATURE CITED

Anonymous (1987). Pumping chocolate and cocoa products with Rand M. *Confec. Prod.,* **53**(9): 675-678.

Anonymous (2003). Brits top chocolate consumer's league. *Ind. Sugar.* pp. 203.

Anonymous (2003a). Executive summary: Cadbury India Ltd.

Billon, M. (1984). Conching chocolate in a cooker extruder, *Rev. Indus. Biscot. Boul. Choc. Confic.,* **79**: 12-14.

Bonekamp, N. A. (1992). Emulsifier- Lecithin and Lecithin derivatives in chocolate. *Confect. Product,* **58**: 66-68.

FDA (1988c). Milk products: Dry milk and nonfat milk. Code of Federal Regulations, Title 21, Sec. 131, 147-148. U.S. Food and Drug Administration, Washington, D.C. April.

Joshi, N.S. and Sharma, R.S. (1992). Milk chocolate. *Ind. Dairy,* **44**: 225-230.

Lawless, H.T. and Haymann, H. (1998). *Consumer field tests and questionnaire design*. Sensory evaluation of food (Lawless, H.T. and Haymann, fields. Chapmann and Hall New York, pp. 480-518.

Makede, O. (2006). The times of India. Open Space. Article.

Riesen, A. (1977). Dietetic chocolate composition. United States Patent 4 011 349.

WEBLIOGRAPHY

www.indiainfoline.com