

Development of Jaggery based Energy Bar and its Sensory Evaluation

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Abstract—Jaggery is a traditional non-centrifugal cane sugar consumed in Asia and Africa. It is a concentrated product of date, cane juice, or palm sap without separation of the molasses and crystals, and can vary from golden brown to dark brown in colour. As per examination of the modern confectionary products available in the market, for incorporation of jaggery as sweetener, chocolate emerges as a potential choice. Caffeine is a bitter, white crystalline powder. In humans, caffeine acts as a central nervous system stimulant, temporarily warding off drowsiness and restoring alertness. This paper contributes to the formation of jaggery based energy bar using Caffeine as the source of energy. The experiments were planned using Response Surface Methodology. The skim milk powder, cocoa powder and caffeine were used in different proportions. Total numbers of experiments conducted using RSM were 17. The responses studied were appearance, colour, taste, texture, flavour and overall acceptability. Sensory evaluation of the final product was done using 9-point hedonic scale method.

Keywords: Jaggery, Caffeine, RSM, Sensory.

1. INTRODUCTION

Jaggery is a coarse brown sugar made in the East Indies from the sap of the date palm. The quality of the jaggery is judged by its colour; brown means it is higher in impurities and golden-yellow implies it is relatively pure. Due to this grading scale there are malpractices of adding colour or harmful chemicals to simulate the golden colour.

Chocolate confectionary has been novelty food item over the years. Consumers of all ages and social classes have been enjoying it in various forms. Once seem as an item for children only, adults now savour chocolates as well. Chocolate bars" containing other ingredients feature a wide variety of layerings or mixtures that include nuts, fruit, caramel, nougat, and fondant. A popular example is a Snickers bar, which consists of nougat mixed with caramel and peanuts. A wide selection of similar chocolate treats are produced with added sources of protein and vitamins. These include forms of energy bar and granola bar and are sold as snacks and nutritional supplements. Energy bars are supplemental bars containing cereals and other high energy foods targeted at people that require quick energy but do not have time for a

meal. The first energy bar in the American marketplace was Space Food Sticks which Pillsbury Company created in the late 1960s to capitalize on the popularity of the space program. Space Food Sticks were developed by Robert Muller, the inventor of the HACCP standards used by the food industry to ensure food safety. Energy in food comes from all three main sources: fat, protein, and carbohydrates, but mostly from carbohydrates. In order to provide energy quickly, most of the carbohydrates are various types of sugars like fructose, glucose, maltodextrin, dextrose and others in various ratios. Use of complex carbohydrate sources like oats and barley is limited and such carbohydrate sources are mostly used in protein bars. To remain competitive in the growing industry, confectioners are faced with of creating innovating products with unique shapes, textures and flavours. The technological advancements have expanded the variety of ingredients available. Careful choice of their functionality, ingredients provide just one aspect of complete task developing new products. Ingredient selection is critical, as it can prevent or invite potential problem in the finished condition.

2. MATERIALS AND METHODS

The preliminary experiments were conducted to identify ingredients and process variables and their range for producing an acceptable jaggery based energy bar. The details of the preliminary trials and their results are summarized. Sensory evaluation regarding jaggery was done by making samples of jaggery energy bar using cocoa powder 30, 35, 40, skim milk powder 100, 120, 140 g. The caffeine content of energy bar can vary greatly. To put this into perspective, moderate caffeine consumption for most individual is about 500mg per day. So we kept 150,250 and 350 g.

Based on the preliminary experiments, the ingredients and process for making jaggery energy bar was finalized:

1. Weighing of ingredients.
2. Jaggery powder, Skim Milk Powder, and 20% of total quantity of butter is added in mixer and mix them all up to 3 min.

3. The process will take total time about 10 min. for hot mixing process.
4. Weighed caffeine powder is added and blend with jaggery.
5. The molten chocolate mass is heating at temperature 80-110°C.
6. After the above step, the adequate quantity of cocoa powder is added and then final mixing was completed.
7. The mixture was then moulded in the form of bar.
8. The bars were then allowed to cool and dry for a period of about 6-12 hours from the time of moulding.
9. After 12 hours of natural drying, the bars were wrapped in Aluminium foil.

3. RESPONSE SURFACE METHODOLOGY

RSM is a statistical technique which consists of a group of mathematical and statistical procedures that uses quantitative sensory data to determine and simultaneously solve multivariate equations which specify the optimum product for a specified set of factors. This considers interaction among the test factors and can be used determine how the product changes with changes in the factor level (Thompson, 1982).

3.1 Steps in RSM

RSM is a four step process:

1. **Identify factors:** The first is to identify the factors which are critical and account for most of variation in the quality of the product under study.
2. **Define factor levels:** the second step is to define a range of factor levels which encircle the product quality. These factor levels have to be carefully selected keeping in view the feasibility, cost and government regulation if any.
3. **Select test samples:** the third step is to select pertinent samples, from among all the possible combinations to be tested using proper statistical design. The experimental design specifies only those samples which are close to the midpoints of these ranges, thereby decreasing the total number of the samples, experiments are conducted and related data for example quantitative sensory data on the product quality are obtained and subjected to appropriate statistical analysis.
4. **Data analysis:** The data so obtained are analysed by an appropriate computer program, which are further interpreted collectively by a statistician, experimenter sensory scientist and others, who have participated in data collection.

3.2 Design of experiments

According to the process the independent variables were defined as milk powder, Cocoa powder and caffeine. 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.

Table 1: Coding of variables for experimental design using RSM

Independent variable	Coded levels		
	-1	0	1
A.Milk powder (g)	100	120	140
B.Cocoa powder (g)	30	35	40
C.Caffeine (mg)	150	250	350

4. SENSORY EVALUATION

Sensory quality is important to both the processor as well as the consumer. It is the combination of different senses of perception coming into play into choosing and eating food. The sensory evaluation was done on 9 point Hedonic scale as per IS standard (IS: 6271, 1971) with the help of 10 member panel. The sensory valuation was done for liking on the basis of visual characteristics (colour and surface appearance), texture (mouth feel and hardness) and taste.

To analyse the result the numerical value are assigned to each point on the scale.

Liked extremely	9
Liked very much	8
Liked moderately	7
Liked slightly	6

5. RESULTS AND DISCUSSION

Table2. Response surface design of experiments

Expt. No.	Ski m milk powder	Coc oa powder	Caff eine	Sensory Responses					Over all acceptability
				Col our	Appear ance	Ta ste	Text ure	Flav our	
1.	0	0	0	8	8	7	8	7	8
2.	0	1	-1	7	7	8	8	7	8
3.	-1	1	0	8	8	7	7	8	7
4.	-1	0	1	8	8	8	9	9	9
5.	0	0	0	7	7	8	7	8	8
6.	0	0	0	8	8	8	7	7	8
7.	1	-1	0	7	7	6	7	7	7
8.	0	0	0	8	8	6	7	8	7
9.	0	-1	1	8	7	7	7	8	8
10.	1	1	0	7	7	7	6	7	7
11.	0	0	0	8	8	7	7	7	8
12.	1	0	-1	7	7	6	7	8	7
13.	-1	-1	0	8	8	7	7	7	7
14.	0	-1	-1	8	8	8	9	8	9
15.	-1	0	-1	7	7	7	6	7	7
16.	0	1	1	8	8	7	7	7	7
17.	1	0	1	8	7	8	8	7	8

Neither liked nor disliked	5
Disliked slightly	4
Disliked moderately	3
Disliked very much	2
Disliked extremely	1

The experiments to develop jaggery based energy bar were planned using Response surface methodology. The skim milk powder, cocoa powder and caffeine were taken as the independent variables. Total numbers of experiments conducted using RSM were 17. The responses studied were appearance, colour, taste, texture, flavour and overall acceptability. The response surface model was fitted to these response variables using multiple regressions.

5.1 Sensory Characteristics of Jaggery Energy Bar Samples

Sensory attributes viz. appearance, colour, taste, texture, flavor and overall acceptability of chocolate samples were reported. The analysis of the variance (ANOVA) for each response was calculated and response surface method was developed for each response. The developed product is analyzed for adequacy to explain variability in responses on the basis of Fcal, coefficient of determination (R^2), standard error and lack of fit and adequate precision ratio.

5.1.1 Colour

The colour score of the jaggery energy bar was found in the range of 7-8. A maximum and minimum colour was found in chocolates having 100g skim milk powder, 35g cocoa powder, 350mg caffeine and 140g skim milk powder, 35g cocoa powder, 150mg caffeine. The lack of fit for the response surface method developed for colour score was not significant and the calculated adequate precision was greater than 6 and is desirable. R^2 was found to be 82.35%. Therefore the product was acceptable. The product was significant ($p < 0.05$) on the basis of method "Fcal" value.

The coefficient estimates of appearance shows that the caffeine, composition of cocoa powder and skim milk powder in quadratic terms significantly affected the colour score of the jaggery energy bar.

5.1.2 Appearance

The appearance score of jaggery energy bar ranged from 7-8. The lack of fit for the response surface method developed for appearance was not significant and the calculated adequate precision was greater than 4 and is desirable. R^2 was found to be 83.56%. Therefore the model was acceptable. The product was significant on the basis of method "Fcal" value.

The coefficient estimates of appearance shows the skim milk powder, cocoa powder and caffeine in quadratic terms significantly affected the appearance score of the jaggery energy bar.

5.1.3 Taste

The taste score of the jaggery energy bar was found in the range of 6-8. A maximum taste was found in chocolates having 100 g skim milk powder, 35g cocoa powder and 350mg caffeine respectively. The lack of fit for the response surface method developed for taste score was not significant and the calculated adequate precision was greater than 2 and is desirable. R^2 was found to be 81.24%. Therefore the product was acceptable. The product was significant ($p < 0.05$) on the basis of method "Fcal" value.

The coefficient estimates of appearance shows that the amount of skim milk powder, cocoa powder and caffeine in quadratic terms significantly affected the taste score of the jaggery energy bar.

5.1.4 Texture

The texture score of the jaggery energy bar was found in the range of 7-9. A maximum and minimum taste was found in chocolates having 100g skim milk powder, 35g cocoa powder, 350mg caffeine and 140g skim milk powder, 35g cocoa powder, 150mg caffeine. The lack of fit for the response surface method developed for texture score was not significant and the calculated adequate precision was greater than 5 and is desirable. R^2 was found to be 84.39%. Therefore the product was acceptable. The product was significant on the basis of method "Fcal" value.

The coefficient estimates of appearance shows that the skim milk powder, cocoa powder and caffeine in quadratic terms significantly affected the texture score of the chocolate jaggery energy bar.

5.1.5 Flavour

The flavor score of the jaggery energy bar was found in the range of 7-8. A maximum and minimum taste was found in chocolates having 100g skim milk powder, 35g cocoa powder, 350mg caffeine and 140g skim milk powder, 35g cocoa powder, 150mg caffeine. The lack of fit for the response surface method developed for flavour score was not significant and the calculated adequate precision was greater than 3 and is desirable. R^2 was found to be 83.65%. Therefore the product was acceptable. The product was significant ($p < 0.05$) on the basis of method "Fcal" value.

The coefficient estimates of appearance shows that the parameters significantly affected the flavour score of the jaggery energy bar.

5.1.6 Overall acceptability

The overall acceptability score of the jaggery energy bar was found in the range of 7-9. A maximum and minimum overall acceptability was found in chocolates having energy bar having 100 g skim milk powder, 35g cocoa powder, 350mg caffeine and 140g skim milk powder, 35g cocoa powder, 150 mg caffeine. The lack of fit for the response surface method developed for overall acceptability score was not significant and the calculated adequate precision was greater than 3 and is desirable. R^2 was found to be 82.74%. Therefore the product

was acceptable. The product was significant on the basis of method 'F_{cal}' value.

The coefficient estimates of overall acceptability shows that skim milk powder, cocoa powder, caffeine in quadratic terms significantly affected the overall acceptability score of the chocolate.

5.1.7 Optimization of Jaggery based Energy Bar Ingredients with Caffeine

Numerical optimization was carried out using design expert 9.0 statistical software. The goal was fixed in range for skim milk powder, cocoa powder, caffeine, colour, taste, texture, appearance, flavour and overall acceptability. The range for independent variables was 100 to 140g for skim milk powder, 30 to 40g cocoa powder and 150 to 350mg caffeine for colour, taste, appearance, flavour, texture and overall acceptability it was fixed to be 7-9. All the responses and independent variables were given similar (+++) importance.

The optimized levels of skim milk powder, cocoa powder and caffeine were found to be 0, 0 and 0 respectively. And for sensory characteristics it was found to be:

Appearance = 7.4

Taste = 7.3

Colour = 7.2

Texture = 7.1

Flavour = 7.4

Overall acceptability = 7.5

6. SUMMARY AND CONCLUSION

Planned experiments were conducted on preparation of jaggery energy bar. The experimental design was based on response surface methodology. Sensory evaluation of the product was conducted using 10 member panels. The sensory panel rated their liking or disliking of product on 9 point hedonic scale based on appearance, colour, flavour, taste, texture and overall acceptability. Adequacy of the models obtained for sensory attributes of energy bar was determined using R², F_{cal}, and lack of fit and adequate precision.

Based on characteristic and quality evaluation results of energy bar, the following conclusions could be drawn:

1. The chocolate prepared in this study had the overall sensory rating of 8.
2. The optimum ingredients level indicating that it was 'liked moderately'.
3. The optimum ingredients level for making jaggery energy bar with skim milk powder 120gm, cocoa powder 35gm and caffeine 250mg.

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