American Journal of Food Technology

ISSN 1557-4571

Academic Journals Inc.

www.academicjournals.com

American Journal of Food Technology 6 (11): 985-993, 2011
ISSN 1557-4571 / DOI: 10.3923/ajft.2011.985.993

Optimization of Honey Candy Recipe using Response Surface Methodology

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ABSTRACT

Honey, a natural sweet substance produced by honeybees, has a wide range of applications in the food industry. The aim of the study was to optimize the formulation of candy taking honey as one of the ingredients. Optimization of candy ingredients was done using Response Surface Methodology (RSM). The independent variables were honey, butter, starch, Skim Milk Powder (SMP) and pectin. The responses were moisture content, hardness and yellowness index. The proportions of ingredients taken were honey (10-50%), butter (0-30%), starch (10-40%), SMP (0-24%) and pectin (0-6%). The formulated ingredients were blended and heat treated at 85°C for 7 min. The cooked candy was then cooled to 15°C, molded, wrapped with aluminum foil and kept for physico-chemical analysis. It was evident from statistical analysis that moisture content increased with the increase in honey level. Butter had a negative correlation with the moisture content along with pectin. Hardness decreased with the increase in honey level. Butter and pectin followed the negative correlation with hardness. Yellowness index increased with the increase in honey level where as it decreased with the increase in starch as well as skim milk powder level. Contour plots and response surfaces were developed for each response. Optimum values were predicted by superimposition of contours of each response by keeping standard values for each response in view. The optimum combination found were honey 44, butter 15, starch 25, SMP 12% and pectin 5.55%. Honey can be successfully utilized in confectionery with greater functionality.

Key words: Honey candy, hardness, yellowness index, response surface methodology, optimization

INTRODUCTION

Honey industry is an age-old agri-horticultural and forest-based industry in India. Honey is a product of nectar or honeydew produced by honey (Canini *et al*., 2009). Honey contains energy giving carbohydrates, water soluble vitamins like thiamin, riboflavin, ascorbic acid, folic acid etc. The nutritional benefits of honey have been studied by many researchers (Canini *et al*., 2009; McKibben and Engeseth, 2002; Wang and Li, 2011). It is also used for treating ulcers, kidney problems, asthma, wound healing etc. (Aparna and Rajalakshmi, 1999; Fei *et al*., 2003). Antibiotic properties of honey have also been observed by some researchers (Tambekar and Rathod, 2007; Hussein *et al*., 2003; Rozaini *et al*., 2005). Recently it has been recognized that it has the potential to become a major foreign exchange earner by making value added product of honey (Krell, 1996). A lot of research have been carried out in analyzing different varieties of honey as well as value

added product (Khalil *et al.*, 2001; Kamal *et al.*, 2002; Adebiyi *et al.*, 2004; Ahmed *et al.*, 2007). Abano (2010) used honey to make honey dip pine apple slices which was most preferred. An effort had been made to make a value added product taking honey as the main ingredient. The other ingredients taken were starch, butter, Skim Milk Powder (SMP) and pectin. Starch and its derivatives are used as sweeteners, texture stabilizers, gelling agents, crystallization inhibitors, thickening agents, film formers, dusting agents, glazing agents, adhesives, flow agents, molding agents and foam stabilizers in confectioneries (Mason, 2009; Richard, 1991; Sopade *et al.*, 2004). Cocoa butter was replaced with commercial milk butter to cut down the cost of candy. It gives cooked flavor on cooking of confectionery products (Prindiville *et al.*, 2000) and responsible for shinning surface of the confectionery. High concentration of pectin in gelatin/pectin-based gummy confection increases the viscosity of confectionery (DeMars and Ziegler, 2003). SMP has got some hygroscopic properties mainly due to its protein content (Shrestha *et al.*, 2007). So SMP was used to lessen the moisture content of candy to a limited extent (Attaie *et al.*, 2002). Thomas *et al.* (2008) reported the use of SMP as humectants in pork sausages to reduce water activity. The current study was undertaken to optimize the candy ingredients for the formulation of candy to get physico-chemical responses nearer to market samples.

MATERIALS AND METHODS

The whole study was carried out in the Department of Agricultural and Food Engineering, Indian Institute of Technology Kharagpur, India during the year 2003-05. Honey was collected from Rural Development Centre of the Institute. Other ingredients like butter, starch, skim milk powder and pectin for candy manufacturing were collected from local market of kharagpur.

Statistical analysis: Response surface methodology is a statistical method that uses quantitative data from appropriate experiments to determine and simultaneously solve the multivariate equations. This method is used to determine the optimum combination of factors that yield a desired response and describes the response near the optimum. It also shows how a specific response is affected by changes in the level of factors over the specified levels of interest. Response Surface Methodology (RSM) consists of a group of empirical techniques devoted to the evaluation of relations existing between a cluster of controlled experimental factors and the measured responses, according to one or more selected criteria (Khuri and Cornell, 1987).

Experimental design: A five-level-five-factor Central Composite Rotatable Design (CCRD) with replicate in each point was employed in this study requiring 32 experiments in total (Cochran and Cox, 1957; Montgomery, 2000). The fractional factorial design consisted of 16 factorial points, 10 axial points (two axial points on the axis of each design variable at a distance of two from the design center) and 6 central points. The variables and their levels selected for the formulation of honey candy were: Honey (10-50%), butter (0-30%), starch (10-40%), smp (0-24%) and pectin (0-6%). Table 1 presents the independent factors, levels and experimental design in terms of coded and un-coded values. The ingredients have taken composition as per the CCRD design was mixed, blended thoroughly. Candy was formulated by cooking the blend at 85°C in a hot plate using a saucepan for 7 min. The time and temperature of the process was maintained same for all the formulations. The cooked candy were cooled and shaped. Finally, they were wrapped in aluminum foil for storage. The process flow chart for making honey candy is given in Fig. 1.

Table 1: Central Composite Rotatable Design (CCRD) in terms of coded and experimental data with response variables

Expt. No.	Honey (%w)	Butter (%w)	Starch (%w)	SMP (%w)	Pectin (%w)	Moisture content (%)	Hardness (g)	(YI)
1	-1 (20)[a*]	-1 (7.5)	-1 (17.5)	-1 (6)	-1 (1.5)	6.53*	10263.4	78.08
2	1 (40)	-1 (7.5)	-1 (17.5)	-1 (6)	-1 (1.5)	12.20	500.4	91.99
3	-1 (20)	-1 (7.5)	-1 (17.5)	-1 (6)	1 (4.5)	12.68	1464.5	71.91
4	1 (40)	-1 (7.5)	-1 (17.5)	-1 (6)	1 (4.5)	12.11	7377.6	85.25
5	-1 (20)	-1 (7.5)	-1 (17.5)	1 (18)	1 (4.5)	10.73	4239.8	75.76
6	1 (40)	-1 (7.5)	-1 (17.5)	1 (18)	1 (4.5)	10.83	5200.7	79.75
7	-1 (20)	-1 (7.5)	1 (32.5)	1 (18)	1 (4.5)	11.16	9152.7	42.35
8	1 (40)	-1 (7.5)	1 (32.5)	1 (18)	1 (4.5)	14.68	3600.1	65.37
9	-1 (20)	1 (22.5)	1 (32.5)	1 (18)	1 (4.5)	8.67	1018.5	76.08
10	1 (40)	1 (22.5)	1 (32.5)	1 (18)	1 (4.5)	12.45	5333.3	70.74
11	-1 (20)	1 (22.5)	1 (32.5)	1 (18)	-1 (1.5)	9.73	6797.3	40.17
12	1 (40)	1 (22.5)	1 (32.5)	1 (18)	-1 (1.5)	10.14	2640.6	79.40
13	-1 (20)	1 (22.5)	1 (32.5)	-1 (6)	-1 (1.5)	12.27	2427.6	75.63
14	1 (40)	1 (22.5)	1 (32.5)	-1 (6)	-1 (1.5)	11.72	5638.8	76.01
15	-1 (20)	1 (22.5)	-1 (17.5)	-1 (6)	-1 (1.5)	5.86	2182.7	78.08
16	1 (40)	1 (22.5)	-1 (17.5)	-1 (6)	-1 (1.5)	12.45	5643.9	81.31
17	-2 (10)	0 (15)	0 (25)	0 (12)	0 (3)	8.65	1259.6	74.12
18	2 (50)	0 (15)	0 (25)	0 (12)	0 (3)	15.30	1279.0	72.83
19	0 (30)	-2 (0)	0 (25)	0 (12)	0 (3)	16.19	3361.5	48.46
20	0 (30)	2 (30)	0 (25)	0 (12)	0 (3)	12.50	1575.2	62.85
21	0 (30)	0 (15)	-2 (10)	0 (12)	0 (3)	13.19	1180.4	37.99
22	0 (30)	0 (15)	2 (40)	0 (12)	0 (3)	14.93	1684.0	31.53
23	0 (30)	0 (15)	0 (25)	-2 (0)	0 (3)	17.65	1096.9	78.65
24	0 (30)	0 (15)	0 (25)	2 (24)	0 (3)	17.47	2203.8	69.69
25	0 (30)	0 (15)	0 (25)	0 (12)	-2 (0)	18.40	8607.3	78.16
26	0 (30)	0 (15)	0 (25)	0 (12)	2 (6)	7.26	1528.7	70.33
27	0 (30)	0 (15)	0 (25)	0 (12)	0 (3)	12.14	1630.8	68.60
28	0 (30)	0 (15)	0 (25)	0 (12)	0 (3)	16.43	306.0	72.86
29	0 (30)	0 (15)	0 (25)	0 (12)	0 (3)	14.34	310.2	73.72
30	0 (30)	0 (15)	0 (25)	0 (12)	0 (3)	15.42	306.0	75.57
31	0 (30)	0 (15)	0 (25)	0 (12)	0 (3)	13.17	349.7	78.55
32	0 (30)	0 (15)	0 (25)	0 (12)	0 (3)	16.67	139.4	69.55

[a]Numbers in parentheses represent actual values. *The values represent means of three replicates

Analysis of response variables: The prepared samples were analyzed for colour, moisture content and texture using standard analytical procedures. Moisture content of the product is one of the most important criteria for determination of the stickiness of the product and thus the acceptance of the product. Moisture content of the candy samples was found out by oven drying method (AOAC, 1997). Color is an important criterion for deciding the acceptability of any product. Colour was determined using Hunter Lab Colour meter. International Commission on Illumination (CIE) Tristimulus values (X, Y, Z) were calculated from L, a, b values using following formula:

$$X = 0.98041\ (Y+0.1\ aL/17.5),$$
$$Y = 0.01\ L^2$$
$$Z = 1.18103\ (Y-0.1\ bL/7.0)$$

Yellowness index was measured using the following formula:

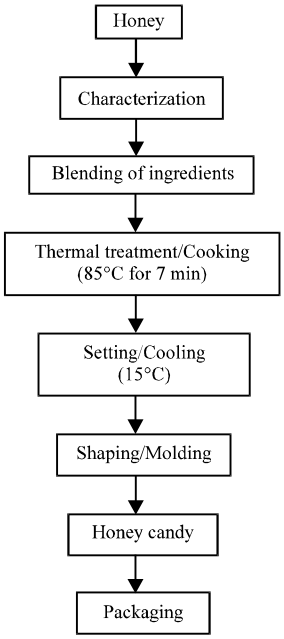

Fig. 1: Process flow chart for honey candy formulation

$$YI = 100\,(1.28\,X - 1.06\,Z)/Y$$

The hardness of the samples was determined using TA-XT2-i Texture Analyzer. For measurement of these properties, rectangular samples having 1.5 cm width and 1 cm height were placed beneath the probe. The samples were compressed to 20% of its height. The force applied for compression of the candy samples was 25 kg.

Optimization of candy ingredients: The objective of the optimization was to obtain level optimum hardness, minimum water content and optimum colour. Optimization of ingredient combination was carried out using response surface methodology (Fannin *et al*., 1981; Mishra *et al*., 2011; Mullen and Ennis, 1979). The statistical model for five independent variables (Y) is given as follows:

$$Y = B_0 + \sum_{i=1}^{4} B_i X_i + \sum_{i=1}^{4} B_{ii} X_{ii}^2 + \sum_{i=1}^{4} \sum_{j=1}^{4} B_{ij} X_i X_j$$

where, B_0, B_i and B_{ii} are regression coefficients and X_i and X_j are coded values of independent variables i and j.

Statistical analysis: The software package called SURFER was used to optimize the independent variables. The effects of responses were analyzed taking two independent variables at a time keeping others at their central point. From the software package both surface as well as the contour plots were taken for analysis. The contours were superimposed for different ingredients for a particular response to find out the optimum values.

RESULTS AND DISCUSSION

Data analysis for different percent composition of recipe: Data obtained were fit in SYSTAT to develop regression equations between dependent and independent variables. The equations obtained are given in the following equations:

$$\text{Moisture content} = 13.236 + 1.344X_1 - 1.175X_2 + 0.846X_3 - 0.803X_5 + 0.915X_4^2 - 3.982X_3*X_4 + 3.538X_3*X_5 - 3.871X_4*X_5 \quad (R^2 = 0.80)$$

$$\text{Hardness} = 33477.793 - 631.706X_1 - 1412.060X_2 - 9639.404X_5 + 5.175X_3^2 + 497.909X_5^2 + 37.529X_1*X_2 - 7.874X_1*X_3 - 30.574X_1*X_4 + 208.652X_1*X_5 + 31.918X_2*X_4 + 174.311X_4*X_5 \quad (R^2 = 0.94)$$

$$\text{Yellowness index (YI)} = 77.241 + 3.716X_1 + 2.306X_2 - 4.949X_3 - 3.623X_4 - 4.474X_2^2 - 9.698X_3^2 - 3.870X_1*X_2 + 4.699X_1*X_4 - 5.642X_1*X_5 + 6.222X_2*X_3 + 8.600X_4*X_5 \quad (R^2 = 0.93)$$

where, X_1, X_2, X_3, X_4, X_5 represent coded values of honey, butter, starch, SMP and pectin, respectively.

Moisture regression showed that moisture content increases linearly with the increase in honey level. This may be due to increased crystallization of sugar components in honey which retains more moisture (Doner, 1977). The hygroscopic nature of sugar increases the uptake of moisture from the atmosphere (Jeffery, 1993; Yao *et al*., 2003). Butter had a negative correlation with the moisture content along with pectin. Hardness decreased with the increase in honey level. There is no effect of SMP in linear and quadratic terms, though a negative effect was observed in interaction term which is in support of earlier findings (Attaie *et al*., 2002). Butter and pectin followed the negative correlation with hardness. DeMars and Ziegler (2003) also interpreted the same relationship between butter and hardness of chocolate. YI increased with the increase in honey level where as it decreased with the increase in starch as well as skim milk powder level.

Effect of independent variables on moisture content of candy: Contour and surface plots were traced taking two independent variables at a time keeping other variables at central points against moisture content of candy. SURFER was used for contour and surface making. Figure 2

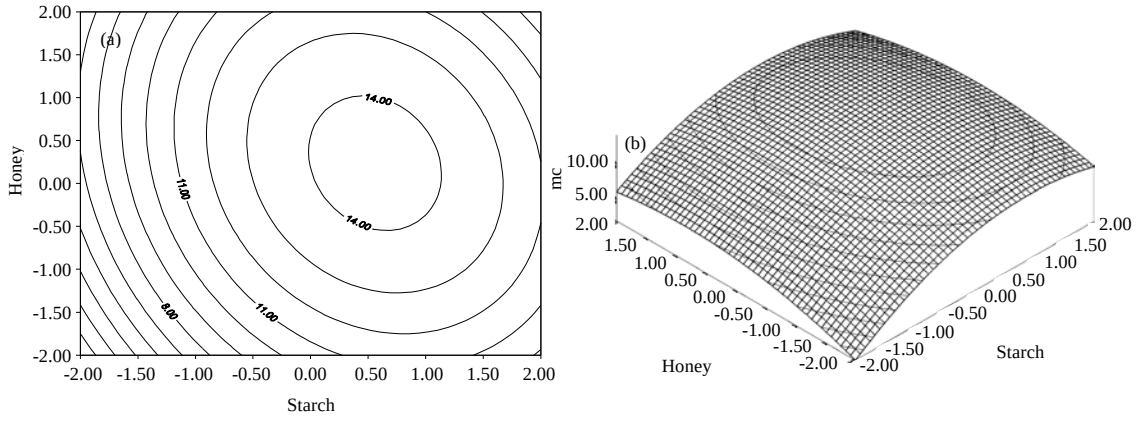

Fig. 2(a-b): Effect of honey and starch on moisture content of honey candy

shows the effect of independent variables on moisture content. It was interpreted and concluded that increased honey level has a positive response to moisture content (Yao *et al*., 2003).

Effect of independent variables on hardness of candy: It can be interpreted from Fig. 3 that hardness decreased with the increase in honey content. This may be due to increased moisture content of candy. Butter reduced the hardness of candy. Starch showed little impact on hardness. SMP has no influence on hardness.

Effect of independent variables on yellowness index of candy: It is shown from the Fig. 4 that Yellowness index of candy increases with increase in honey level. This may be contributed by the colour of honey i.e., yellow. Since starch and skim milk powder are white in colour, they have a negative correlation with the yellowness index. Pectin contributes very little to the colour of the candy.

Optimization of candy ingredients: Optimization was carried out by superimposing the contours taking two independent variables at a time. Since there were five independent variables, total of 10 superimposition graphs were plotted. Commercial candy's moisture content, color and

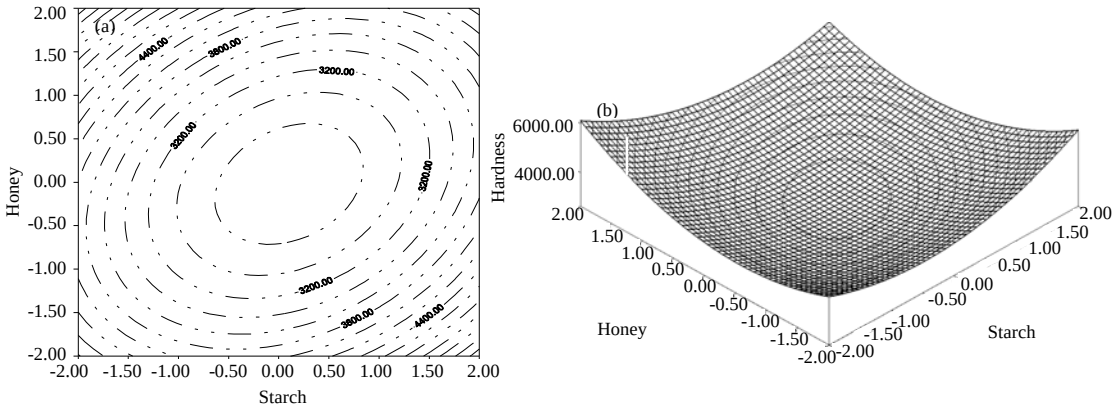

Fig. 3(a-b): Effect of honey and starch on hardness of candy

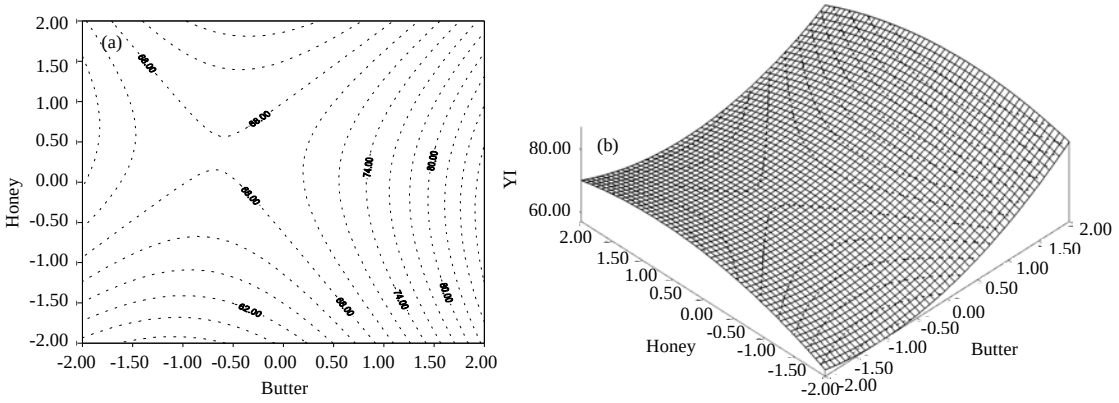

Fig. 4(a-b): Effect of honey and butter on yellowness index of candy

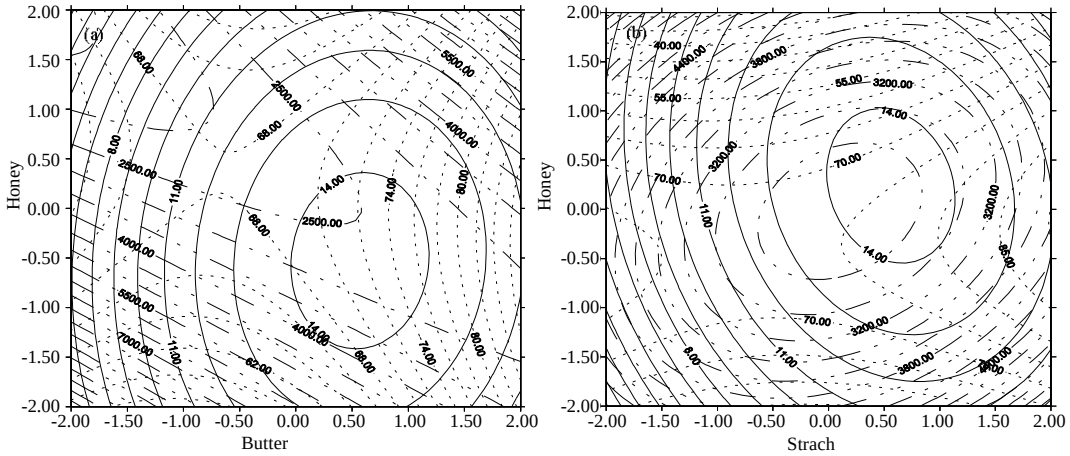

Fig. 5(a-b): Superimposed response contour for moisture content, hardness and YI

hardness were considered as standard response for the design. Taking into consideration the standard response, optimum ranges of the independent variables were selected. Two of the superimposed graphs of moisture content, hardness and yellowness index taking two independent variables and keeping others at their central points is given in Fig. 5. Certain combinations of optimum values were not accepted due to some valid reasons. Butter level of 7.5 and 6.0 were eliminated because it causes stickiness of the product attributed by relatively higher proportion of starch (DeMars and Ziegler, 2003). Higher level like 28.5 can't be used since it prevents product from moulding. Starch level of 39.25 cause product powdery instead of gelling, even lower level like 13.75 and 15.0 reduces bulkiness of the product. So they can be eliminated from the economy point of view. Skim milk powder of level 24 is rejected from colour acceptance point of view. Considering above findings optimum combination of recipe found were honey 44, butter 15, starch 25, SMP 12 and pectin 5.55%.

CONCLUSION

During preparation of honey candy it was shown that moisture content increased with the increase in honey level whereas it decreased with butter and pectin levels. Hardness decreased with the increase in honey, butter and pectin levels. Yellowness index increased with the increase in honey level where as it decreased with the increase in starch as well as skim milk powder level. The study showed that incorporation of honey 44, butter 15, starch 25, SMP 12 and pectin 5.55% gives a better product with acceptable hardness, colour and moisture content.

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