International Journal of Engineering and Advanced Technology (IJEAT)
ISSN: 2249-8958 (Online), Volume-8 Issue-5, June 2019

Optimizing the Making Conditions of Gluten Free Bread Based On Xanthan Gum, Potato Starch and Sorbitol

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***Abstract:** This work aims on the production conditions of gluten free bread (GFB)by adding potato starch, xanthan gum and sorbitol. Response surface methodology was performed to optimise the making conditions using independent variables (Xanthan gum, potato starch and Sorbitol) and responses (moisture content, firmness, loaf volume and baking time). The optimum formulation, determined from the study, contained20.6 g/100g of potato starch, 0.59 g/100g xanthan gum, 5.57 g/100g sorbitol.From this study, we can confirm that the production of gluten free bread is an innovative food source for gluten insensitive or tolerant consumers in India.*

***Key Words:** Response surface methodology, optimization, xanthan gum, potato starch, sorbitol, firmness, loaf volume, gluten free bread and coeliac disease.*

I. INTRODUCTION

Bread is the oldest staple and artificial food westerncountries. It is usually prepared from wheat flour dough cultured with yeast which gives rise to bread and baked in oven. It is one of nutrition enrich product available to customer these days. In India, chapaties and millet cakes are popular.

In most countries, the main ingredient used in bread making is wheat which comprises of glutenin and gliadin protein that makes its structure elastic-plastic foam in nature.Coeliac disease (CD) is an autoimmune disorder that interferes with the nutrients adsorption into the small intestine, occurring from childhood to adulthood (Fasano and Catassi 2001; Fasano et al. 2003). When a person with gluten intolerance eats food containing gluten, the immune system of that person causes a reaction in the small intestinewhich damages villi (finger-like projection) as a result the person suffer from malnutrition, osteoporosis, anaemia, etc. The only effective treatment for this disease is strict gluten-free (GF) diet throughout the lifetime.

Response surface methodology (RSM) is the most popular and statistical technique that explores the relation between independent and one or more responses (Malcolmson et al. 1993; Bas and Boyaci2007). Recently, RSM was proficientlyused to map the making of gluten free bread by incorporating soya proteins, gums, egg whites.Several researches aremade on formulation and process condition of GFB using sorghum, hydrocolloids, modified starch and rice flour, maize and tapioca flour using seaweed agar, methylcellulose, gum Arabic, etc.

This work primarily focus to optimize the development and characterization of gluten-free bread by incorporating potato starch, xanthan gum and sorbitol as thickener and sweetener to improvise the quality of bread as well as to provide an innovative product for gluten- intolerant people.

Manuscript published on 30 June 2019.
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II. MATERIALS AND METHOD

RAW MATERIALS AND BREAD MAKING

The gluten free bread formulation comprises of rice flour, potato starch, xanthan gum and sorbitol of food grade, soybean oil, salt and sugar were bought from local market. The dry raw materials were put in a mixer and kneaded for 2-3 mins at 100 rpm after which yeast dissolved in lukewarm water was added to the mixture. To the same mixture, oil is added and mixed at 90 rpm for 4 mins and again at 180 rpm for 8 mins. The resultant dough weighing 240 g was placed in baking pan and baked at210°C for 45 mins. The bread were removed and kept at room temperature for cooling (Baik and Marcotte, 2001).

III. EVALUATION OF BREAD MAKING

BREAD VOLUME

The bread volume was calculated by using the modified standard rapeseed or sesame seed displacement method (AACC, 2000) and specific volume was determined after an hour of baking by using formula

Specific volume (cm3/g) = Volume of bread (cm3) /Dough weight (g) (Azwin et al.2016)

CRUMB FIRMNESS

To evaluate the crumb firmness, Texture analyser (TA-XTi2 Stable Microsystems, Surrey, UK) was used. The samples are sliced in the middle of about 1cm thickness to performa two cycle of crumb compression test using P/75 aluminium platen probe and the peak force of compression was recorded as firmness (AACC,2000).

MOISTURE CONTENT

By measuring the difference in weight before and after drying in a hot air oven at 105 ± 2°C, the moisture content of bread crumb was determined (AACC,2000).

COLOUR MEASUREMENT

Bread crust were measured for colour by using a Minolta colorimeter CR-400 in the L*, a*,b* system (where L* is lightness, a* and b* are colour coordinates) and the images were captured using flatbed scanner (Hutchings 1994).

SENSORY EVALUATION

The evaluation was conducted using panel of 20 members with 5 point hedonic scales (1(dislike extremely) to 5 (like extremely)) to predict sample individually for customer acceptance and preference. Each participantreviewed the bread based on its texture, fluffiness, bread crumb and crust colour, taste and aroma.

EXPERIMENTAL DESIGN

RSM was used to optimise the making and baking condition of gluten-free bread. A Box-Behnken design was employed using three independent factors (Xanthan gum (X_1), potato starch (X_2) and sorbitol (X_3)) and four responses (moisture content (Y_1), firmness (Y_2,) loaf volume (Y_3), baking time (Y_4)). For the preliminary experiment the ranges was setup for xanthan gum from 0.5-1.5 g/100g, potato starch from 20-40 g/100g and sorbitol from 3-7 g/100g. The 17 baking trails were performed to evaluate the optimized formulation. Using the ANOVA, the physical properties of bread were analysed. Each response variable from experimental data was fitted into the linear and mean model and the regression parameters (R^2) are also calculated for the equation.

Std	Run	Factor 1 A:xanthan gum g/100g	Factor 2 B:potato starch g/100g	Factor 3 C:sorbitol g/100g	Response 1 moisture content %	Response 2 firmness g	Response 3 loaf volume cubic centimetre	Response 4 baking time minutes
5	1	0.5	30	3	47.28	329.69	655	25
2	2	1.5	20	5	45.27	962.085	1350	40
17	3	1	30	5	49.98	1431.37	1275	40
16	4	1	30	5	46.12	409.47	746	35
14	5	1	30	5	45.32	513.27	748	60
3	6	0.5	40	5	45.29	2590	884	50
9	7	1	20	3	47.68	1405.96	750	35
7	8	0.5	30	7	48.23	1115.09	561	35
10	9	1	40	3	49.91	1412.13	1156	60
11	10	1	20	7	45.27	1422.3	798	45
6	11	1.5	30	3	46.01	111.05	750	50
8	12	1.5	30	7	45.34	1421.26	796	25
15	13	1	30	5	45.29	1398.89	531	35
12	14	1	40	7	47.28	467.46	497	25
1	15	0.5	20	5	48.13	513.27	1207	60
4	16	1.5	40	5	49.12	997.14	629	40
13	17	1	30	5	48.67	649.58	692	40

Table1. The Box-Behnken experimental design and responses

IV. RESULTS AND DISCUSSION

STATISTICAL ANALYSIS

The lack of fit for different models and interaction effect between the factors (independent variables) and responses (dependent variables) were determined. The estimated regression coefficients (R^2) for responses were calculated from responses are shown below:

Moisture content

(Y_1)=

$54.98375-8.80X_1+2.25000X_2+23.12500X_3+0.500000$ (1)

$X_1.X_2-8.75000-X_1.X_3-0.562500\ X_2.X_3$

Firmness (Y_2) = $-982.59409+2332.70025\ X_1-68.65351\ X_2+583.26219$ (2)

$X_3-102.08375\ X_1.X_2+131.20250\ X_1.X_3-12.01262\ X_2.X_3-95.16450X_1^2+4.08899\ X_2^2$

$-28.11309X_3^2$

Loaf volume (y_3) = $236.76875+39.10000\ x_1-46.30500\ x_2+595.37500\ x_3-$ (3)

$19.90000\ x_1.x_2+35\ x1.x3-8.86750\ x_2.x_3+218.70000\ x_1^2+1.6442x_2^2-40.64375\ x_3^2$

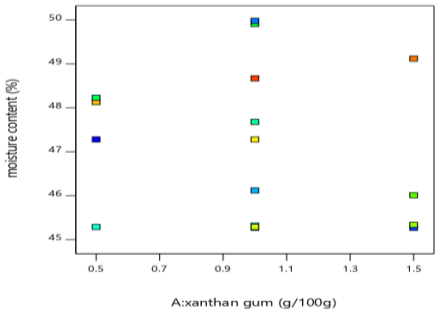
Baking time (Y_4) = $-53.82353+25.00000X_1+2.25000X_2+23.12500X_3+0.500000$ (4)

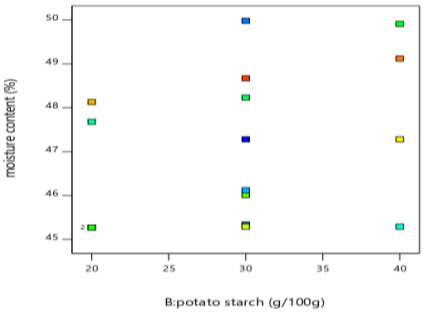
$X_1.X_2-8.75000\ X_1.X_3-0.562500\ X_2.X_3$

Where X_1 ,X_2 and X_3 are the xanthan gum, potato starch and sorbitol.

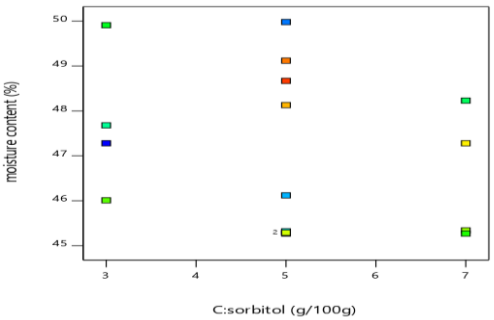
V. EFFECT OF FACTORS (INDEPENDENT VARIABLES) ON MOISTURE CONTENT

Moisture content is the amount of water present in the substance. The amount of water present in the gluten free bread is much higher than the non-gluten free bread due to the xanthan gum, potato starch and sorbitol present in bread which makes the bread less firmness. It is also found that the hydrocolloid (such as xanthan gum) impact is much more than other two independent variables (potato starch and sorbitol) (Mohammadi and Azizi, 2014).





(A) (B)



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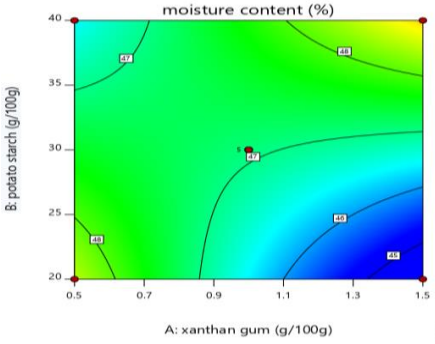
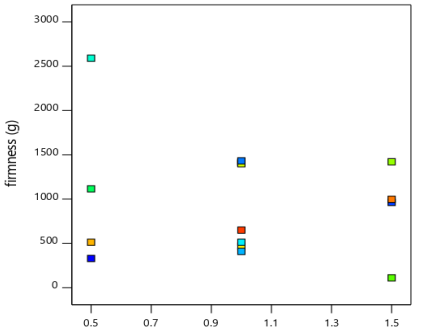


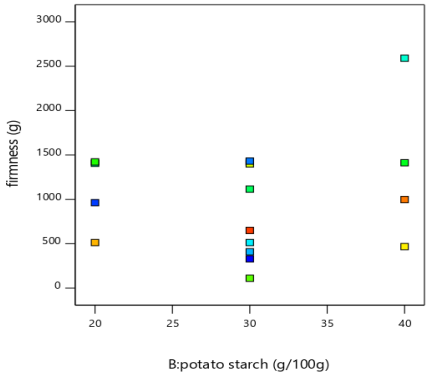
(C) (D)

Fig.1. (A), (B) & (C) depicts the relationship between independent variables (xanthan gum, potato starch and sorbitol) versus moisture content and (D) depicts the relationship of moisture content with xanthan gum and potato starch

VI. EFFECT OF FACTORS (INDEPENDENT VARIABLES) ON FIRMNESS

Firmness is the compressibility (maximum force) of bread between teeth and it is very important factor for bread freshness. From the regression coefficient, it was found fitted to both 2FI and linear models. The crumb hardness decreases leading better water distribution in the bread crumb due to presence of xanthan gum, potato starch and sorbitol. From this, it is concluded that xanthan gum have influence on the softening of gluten free bread.





(A)

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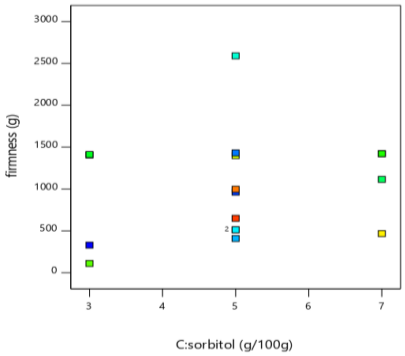
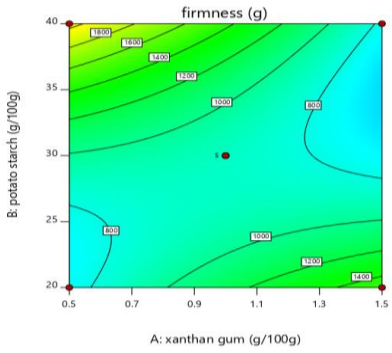




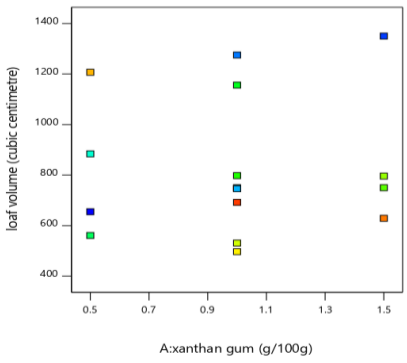
(C) (D)

Fig.2. (A), (B) & (C) depicts the relationship between independent variables (xanthan gum, potato starch and sorbitol) versus firmness and (D) depicts the relationship of firmness with xanthan gum and potato starch

VII. EFFECT OF FACTORS (INDEPENDENT VARIABLES) ON LOAF VOLUME

The specific volume has a significant effect ($P < 0.05$) against the independent variables (xanthan gum, potato starch and sorbitol) from the analysis of variance of responses.

All the four variables show positive for mean and linear model as seen from the equation. By the addition of xanthan gum, potato starch and sorbitol, loaf volume of the gluten free bread was observed to be increased. Therefore, it can be said that by incorporating xanthan gum may increase the plasticity of the overall structure.



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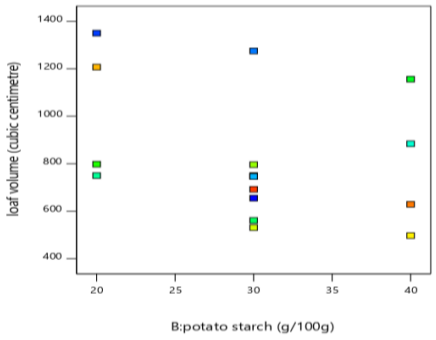
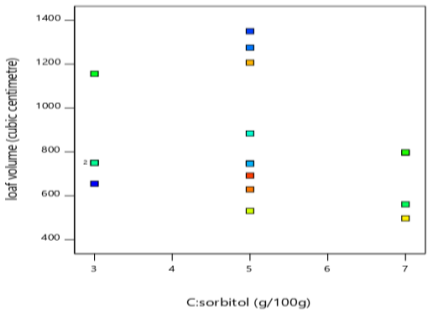
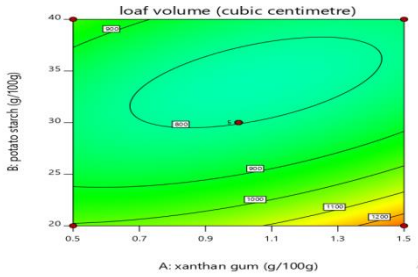


(A)

(B)



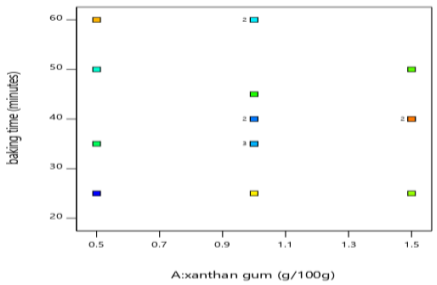


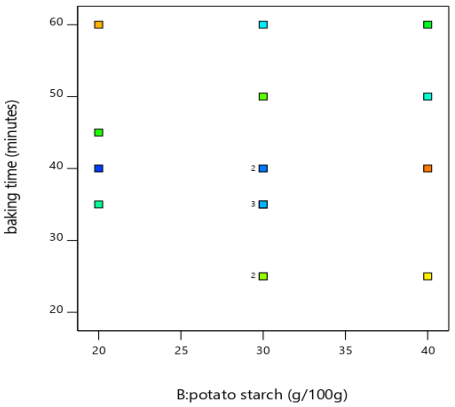
(C) (D)

Fig.3. (A), (B) & (C) depicts the relationship between independent variables (xanthan gum, potato starch and sorbitol) versus loaf volume and (D) depicts the relationship of loaf volume with xanthan gum and potato starch

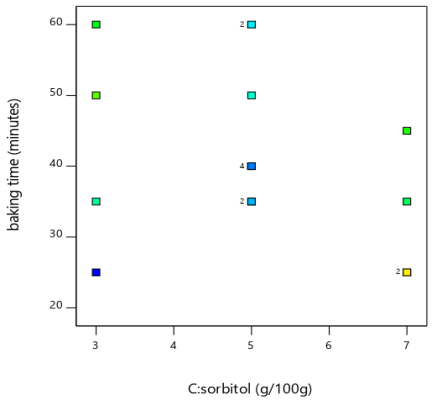
VIII. EFFECT OF FACTORS (INDEPENDENT VARIABLES) ON BAKING TIME

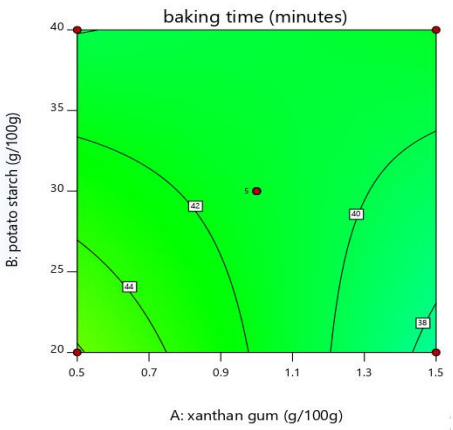
Baking is an important feature essential for the influencing theproduction volume due to the bulk density increment of the substance. It was observed that high temperature, long baking time and slightly thick dough result in the lesser expansion of bread dough during baking. The optimal baking time was estimated for gluten free bread ranges from 48.98 to 76.92 minutes.





(A) (B)





(C) (D)

Fig.4. (A), (B) & (C) depicts the relationship between independent variables (xanthan gum, potato starch and sorbitol) versus baking time and (D) depicts the relationship of baking time with xanthan gum and potato starch

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IX. CONCLUSION

This research aims on the production of gluten-free bread by adding xanthan gum, potato starch and sorbitol with high nutritional value and a substituted product for gluten intolerant people.

The response surface methodology was used successfully for optimizing the making condition of gluten-free bread using independent variables (xanthan gum, potato starch and sorbitol) and responses (moisture content, firmness, loaf volume and baking time). It presented a simple and straight analysis and the optimized bread contained moisture content (47.98-52.43%), firmness (873.815-2934.84g), loaf volume (993.88-1808.34 cm^3) and baking time (47.98-76.92 minutes). The model from the experimental data allowed for the prediction of system behaviour under different factor combinations.

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