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Quality assurance in the gluen-free bread technology, using responce surfaces method

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Abstract

Using RSM(response surfaces method) has proven to be a method that highlights the synergy components manufacturing recipe gluten free bread. The purpose of this research was to study the influence of the independent variables: the ratio starch/xanthan, starch/yeast *Saccharomyces cerevisiae*, starch/salt at obtaing the gluten-free loaf volume, porosity and note sensory as good as possible. We used the 2^3 factorial design. As a result of the creation of the mathematical model equation are obtained by regression polynomial. These models have helped to optimize the formulation and the best values of the dependent variables were obtained for the addition of 4% yeast, 1% of xanthan gum, 1.5% salt, and a constant addition of water. Reporting is made towards the main raw material starch.

Keywords: celiac disease, gluten free bread, response surface, xantan

1. Introduction

Celiac disease or gluten enteropathy is an inflammatory disease, chronic the intestinal [1]. As a therapeutic principles recommended imposition gluten-free diet food excluding gluten from wheat, rye, barley, oats. There are international research relating to the development of gluten-free products. The replacement of gluten presents a major technological challenge, as it is an essential structure-building protein, which is necessary for formulating high quality cereal-based goods [2].

The bread is a food that is consumed at any age. It is part of the eating habits of many people. Gluten-free diet is not a diet non nutrient [3]. There are papers on the study of factors influencing the quality of gluten-free bread [4]. The raw materials which form the basic structure of the grain that is free of component "toxic"(prolamines), water, yeast and salt. For fill the three-dimensional matrix grid network viscoelastic gluten-free flour products using a range of hydrocolloids [5-6]. Xanthan is from the point of view of food industry a thickening agent, an additive E415. It is a substance that promotes digestion ballast. Interfere with the absorption of lipids and mineral salts. It is recommended to consume in moderation [7].

Xanthan gum is a branched, anionic polysaccharide produced by aerobic fermentation of the bacterium *Xanthomonas campestris*. The primary structure consists of a cellulosic backbone having a charged trisaccharide side chain attached to alternate glucose residues [8]. The molecular weight of xanthan is usually in the range 2-5.5. Aqueous xanthan dispersions are thixotropic. The weak gel structure formed results in an unusually high “low shear-rate” viscosity at low polymer concentrations, which can be used to thicken aqueous samples and permits stabilization of emulsions, foams and particulate suspensions [9]. This behaviour results from the ability of xanthan molecules, in solution, to form

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aggregates through hydrogen bonding and polymer entanglement. This highly ordered network of entangled, stiff molecules results in high viscosity at low shear rates, and in practical terms, accounts for the outstanding suspending properties of xanthan solutions [10]. This interaction results in enhanced viscosity or gelation [10]. This polymer has many advantages such as high solubility in cold or hot water, high solution viscosity at low concentrations, no discernable change in viscosity over a wide temperature range, excellent stability in acid conditions, and thermal or freeze-thaw stability [11]. A synergistic interaction occurs between xanthan and galactomannans such as guar gum, locust bean gum and cassia gum and glucomannans such as konjac mannan. Xanthan gum was used as a gluten replacement in the development of gluten free bread improving dough elasticity [12-13].

The increasing demand for high-quality gluten-free bread represents a challenging task for the cereal technologist due to the low baking quality of GF flours as a consequence of the absent gluten network [14].

For improving sensory characteristics, texture and increasing the duration of retention of freshness is used factor analysis and RSM to establish the proportions of the components of the formulation. For this study RSM was used to create a minimalist recipe using xanthan as feedstock can substitute gluten network specific wheat flours. The independent variables was to be permuted amount of xanthan, yeast species *Scacharomyces cerevisiae*, salt a constant amount of water will be 1:15. It emphasizes also the synergism of the two hydrocolloids used. The dependent variables calculated and analyzed, basically are the specific volume of gluten free bread, crumb porosity and bread score (sensory note).

2. Material and methods

2.1.Materials. Was used in this study cornstarch commercial product type dr. Oetker, yeast supplied by Pakmaya, Romania, xanthan gum company offered Brentang SRL. Xanthan according to the microbiological point of view, the important chemical and physical characteristics are as follows: color creamy white, pH = 6-8, viscosity (1% KCL eps.) 1.400 to 1.700 added to a suspension of 1% moisture (u =13%).

2.2. Methods

2.2.1.Recipe manufacturing, operational parameters and analysis methods bread. To prepare the bread using corn starch 100%, 4% yeast, 1,5% salt, 2% xanthan gum and water in a ratio of 1:15 to% dry matter (dry matter). of the starch. Mixing was done with the mixer type SADKIEWICZ. Add all ingredients together. Xanthan are hydrated by mixing for 20 minutes before by 50% of the total amount of water in the recipe. The kneading temperature is 28 °C, during 10 minutes. The fermentation is performed at 30 °C for 50 minutes and baking for 30 minutes at 240 °C. Shall be used for baking trays with size (17 x 9.5 x 7.5) cm.

The baking test were carried aut in an electric oven with an incorporated proofing chamber(type ESM3710 SADKIEWICZ). Bread was analyzed after 2 hours from the removal from the oven. Determination of specific volume in cm^3/g was made by displaced volume method of rape seed [15], the porosity is in principle to determine the total volume of voids in a given volume of the crumb, knowing the volume of oil displaced crumb scoreless) and its weight [16].

The exam organoleptic is to evaluate the organoleptic characteristics of bakery products, with sense organs. The exam organoleptic was performed by a group of panelists made up ofstudents from the Faculty of Food Industry at the University "Lucian Blaga" of Sibiu, girls and boys aged 20 to 22 years, healthy. This examination consisted in characterizing the volume (15 points maximum), shell color (10 points maximum), bark (15p max.), Texture (15 points maximum), taste (20 points maximum), flavor (15 points maximum) firmness (10p)[16].

2.2.2.Experimental design. We studied the response surface three dependent variables Y_1; Y'_1 - specific volume cm^3/g, Y_2 ,Y'_2–bread porosity %, Y_3, Y'_3-note sensory,points(bread score)(Y- experimental; Y'- calculated). The three independent variables are: x_1=% dw. starch/xanthan, x_2=% dw starch/yeast; x_3=% dw.starch/salt; x_4 = amount of water is constant. Each independent variable is coded and has three levels -1, 0, +1. We used a model of factorial order 2^3. There have been experiments point 0 and 8

variants work as experimental model [17-20]. For model numerically and graphically using Excel computer program.

3. Results and Discussion

This virtual simulation combined with practical tests will ultimately lead to establishing proportions of the constituent materials making up recipes and underlying biotechnology for obtaining gluten-free products.

The process is influenced by important parameters such as: the amount of hydrocolloid used yeast bread and salt which plays an important technological and sensory. The report used has a maximum and minimum, and is formed on the basis of independent variables.

Using the RSM to highlight the relationship between the independent variables to obtain the best values of the dependent variables Y: Y_1 specific volume, porosity crumb –Y_2, Y_3- bread score.

Table 1. Variables and level for central design

Independent variabiles	Symbol	Codes variable level		
		-1	0	+1
% dw. starch/% xanthan	x_1	45	50	55
% dw. starch/% yeast	x_2	20	25	30
% dw.starch/% salt	x_3	50	55	60
water(mL)	x_4		1:15	

Maximum and minimum values around the points of coordinates (0,0,0) are shown in Table 1 were considered for optimizing the recipe quantities commodity to be concluded to be calculated according to the amount of starch with u=12% with dw = 88%. The amount of water added is the same for all experiments.

Table 2. Central composite design and response

Exp.	Coded			Responses					
	x_1	x_2	x_3	Y_1	Y'_1	Y_2	Y'_2	Y_3	Y'_3
1	-1	-1	-1	2,01	2	63,00	61,69	60,1	79,97
2	1	-1	-1	2,38	2,4	68,00	61,69	73,4	73,23
3	-1	1	-1	2,45	2,4	68,00	61,69	60,19	60,05
4	1	1	-1	2.25	2,24	69,00	70,93	68,1	67,25
5	-1	-1	1	2,89	2,87	77	70,93	73,4	73,43
6	1	-1	1	2,45	2,47	76	70,93	60,00	59,27
7	-1	1	1	2,52	2,48	74	70,93	44,2	45,05
8	1	1	1	2,64	2,63	78	70,93	52,2	51,47
9	0	0	0	2,42	-	78	-	68,4	-
9'	0	0	0	2,64	-	82	-	66,00	-
9''	0	0	0	2,8	-	76	-	65,3	-

Y'_1;Y_1- specific volum(calculated, experimental),Y'_2;Y_2-crumb porosity (calculated, experimental), Y'_3;Y_3- bread score(calculated, experimental).

Table 3. Regression polynomial coefficients

Coefficients	Y'_1	Y'_2	Y'_3
b_0	+2,44	+61,45	+71,63
b_1	-1,0188	+1,98	+1,125
b_2	+0,0163	-5,2	+0,625
b_3	+0,1763	-4	+4,6251
b_{12}	-0,0013	2	+0,125
b_{13}	-0,0613	-3,33	-0,375
b_{23}	-0,0613	-3,97	-0,87
b_{123}	-0,1413	+3,35	+1,125

The significance level is 0.95
Y'_1;Y_1- specific volum, Y'_2;Y_2- crumb porosity,
Y'_3;Y_3- bread score.

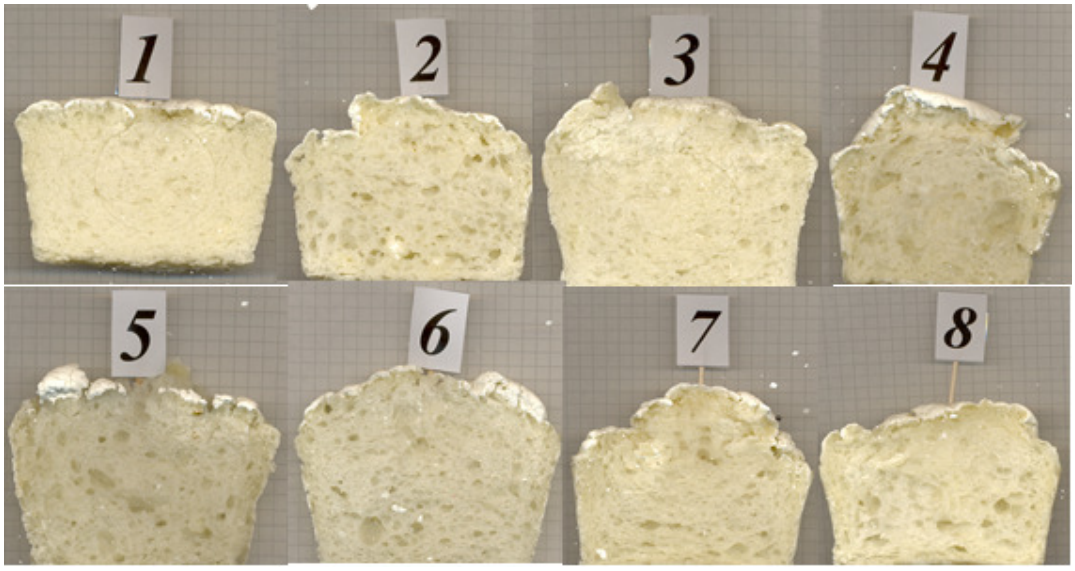

Figure 2. Gluten- free breads experiments with xanthan, starch, salts and yeast: exp.1(1% xanthan), exp.2(2% xanthan), exp.3(1% xanthan), exp.4(2% xanthan), exp.5(1% xanthan), exp.6(1% xanthan), exp.7(1% xanthan), exp. 8(1% xanthan).

The matrix with which the sign of the coefficients is calculated and the calculated values of the dependent variable Y' and Y measured from 11 experiments are shown in Table 2. Polynomial regression equations obtained are of the type:

$$Y = b_o \pm b_1 x_1 \pm b_2 x_2 \pm b_3 x_3 \pm b_{12} x_1 x_2 \pm b_{13} x_1 x_3 \pm b_{23} x_2 x_3 \pm b_{123} x_1 x_2 x_3 \quad (1)$$

The coefficients and their sign are shown in Table 3. These values are demonstrates that there are other factors that influence the dependent variables. Volume, porosity and grade sensors are quality indicators that change with the changing composition of the formulation of gluten-free bread.

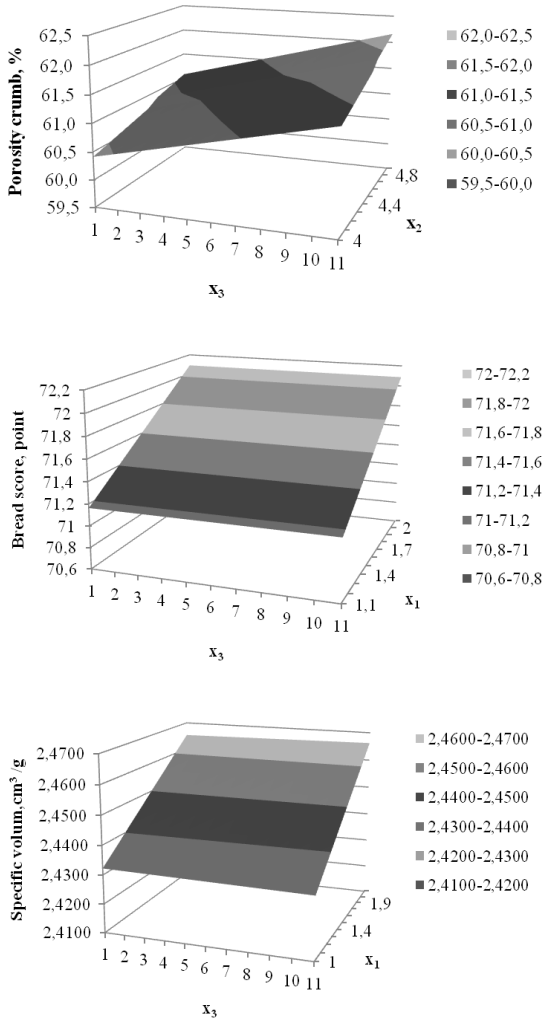

Figure 1. Response surface for Y'_1(calculated)- specific volum, as a function x_3 and x_1 at x_2–constant, Y'_2(calculated)–crumb porosity as a function x_3 and x_2 at x_1–constant and Y'_3(calculated)- bread score as a function x_3 and x_1 at x_2 – constant.

The significance of each coefficient was tested with "t" students. The insignificant were eliminated, those who are less than t table 2.5.

Thus the equations for Y calculated as:

***Specific Volume**:*

$$Y'_1 = 2,44 + 0,1763x_3 - 0,0613\ x_1\ x_3 - 3,46\ x_2\ x_3 + 0,1413\ x_1\ x_2\ x_3 \quad (2)$$

Crumb porosity:

$$Y'_2 = 61,45 + 1,98x_1 - 5,28x_2 - 4x_3 + 2x_1\ x_2 - 3,33x_1\ x_3 - 3,97x_2\ x_3 + 3,35x_1\ x_2\ x_3 \quad (3)$$

Bread score:

$$Y'_3 = 71,62 + 4,62x_3 \quad (4)$$

The significance of each coefficient was tested with "t" students. The insignificant were eliminated, those who are less than t table 2.5. Thus the equations for Y calculated as: Based on the data obtained so far, for all experiments mapped 3D graphics under:

$Y_{ij} = f(x_{ij})$ when x_i or x_j constant

With these graphics are better put in evidence the influence of independent variables which act synergistically on the quality of gluten-free bread. At small values of the variables x_i, x_j, the values of the dependent variables, specific volume, porosity and grade sensors are minimum values. Each of these values generates values of Y.

The gluten-free bread specific volume, in cm^3/g is an important quality index influenced the capacity mix "forming gas" growing power of the yeast(*Saccharomyces cerevisiae*) its ability to retain gas mixture fermentation [21]. Of the nine screenng considered the most representative one in figure 1. In terms of representation **specific volum**, $Y_1 = f(x_1$ and $x_3)$ at x_2 = constant, the maximum volume was $2,87^{calc.}$ cm^3/g and $2,89^{exp.}$ cm^3/g. Ingredients were used in the amounts 1% xanthan gum, 1.5% salt, 4% yeast. The amount of salt can support well the need for nutrient yeast bread that biochemical soil mellowing along trace.

The gluten-free bread porosity, in %, obtained by prescription studied is not uniform and small pores (Fig. 2). Studies have shown that coarser porosity even in the core the holes can be eliminated by the addition of soybean meal [22]. It is an important quality indicator that has the highest value of $73,4^{exp.}$%, $73,23^{calc.}$%. From the graphical representation $Y_2=f(x_3$ and $x_2)$ to x_1 constant at the maximum value of the porosity is obtained for the addition of 2% gum, 4% yeast, and 0.5% salt water at a constant addition of starch to 88% dw. corn starch (Fig. 1).

We know that gluten free bread is not a **sensory** as the bread of wheat flour, which is much lower[23].

From the graph in figure 1 obtained by representing the function, crumb porosity, Y_2 = f(x_3 şi x_1) la x_2 = constant. Maximum sensory assessment was 77 points. All experiments 5 working as in the case of the volume afforded the maximum value. This is xanthan 1%, 4% yeast and 1.5% salt. Maximum score according to the method used is 100 points. Gluten-free bread obtained in this study achieved much lower.

4.Conclusions

From the synergism effect of each component of the recipe and using permutation independent variables to obtain the dependent variables showed that:

- RSM -use help determine which types of work a greater combination of the variants compared to other methods,
- to obtain a specific volume of the bread without gluten maximum value when bread is made only from corn starch is preferable to use 4% yeast, 1% xanthan gum and 1.5% salt. How bread volume greatly influences sensory note is recommends reporting the same ingredients in the recipe. Was demonstrated this occasion that the porosity of bread without gluten is a problem. Xanthan tried to solve it, though not the version that gives the maximum value of porosity can be considered a good choice. Thus the combination of the experiment 5 (4% yeast, 1% of xanthan gum, 1.5% salt) will be selected. For the value 73.4% was obtained as in embodiment 3 of xanthan 1%, 5% yeast and 0.5% salt. In this variant with 5% yeast yeast was transmitted taste the finished product. It was sanctioned this team tasters and recommends finding solutions for remediation. maximum the score the method used is 100 points. Gluten-free bread obtained in this study did not obtain a score greater than 73 points. To improve the quality of bread is recommended researching new natural ways sanogen.

Compliance with Ethics Requirements. Authors declare that they respect the journal's ethics requirements. Authors declare that they have no conflict of interest and all procedures involving human / or animal subjects (if exist) respect the specific regulation and standards.

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