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Optimization of Gluten - Free Bread Formulation from bread improver and fermentation time

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ABSTRACT

The effects of formulation of gluten - free bread based on non - gluten flours (about 100 g) by using the concentrations of hydroxyl propyl methyl cellulose (HPMC), ranging from 1 to 1.5 g, blending with yeast from 2.5 to 3.5 g, water from 95 to 105 g, maltodextrin from 5 to 15 g and fermentation time from 20 to 40 min on specific volume and sensory value were determined. The Box–Behnken factorial design was used in these experiments with response surface methodology (RSM). The final optimum formulation of gluten - free bread contained 1.31 g HPMC, 2.96 g yeast, 100.5 g water, 10.04 g maltodextrin, and 30 min of fermentation. The optimization of formulation of the gluten - free rice bread had maximum specific volume (2.4 cm^3/g) and the highest score of sensory evaluation (7.4).

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1 INTRODUCTION

The demand for gluten - free products has been increasing in recent years due to market trends and increasing number of diagnosed celiac and food hypersensitivities. In spite of large efforts made by researchers and engineers in development and industry, production of high-quality gluten - free products remains a huge technological challenge. Particularly, the problem of the gluten - free bread making is owing to gluten - free flours' inability to form cohesive and elastic doughs. To produce gluten - free bread of acceptable quality, it is necessary to form a matrix with sufficient viscoelastic properties for holding CO_2 released during fermentation and ability to retain the structure during expansion along baking (Marco and Rosell, 2008).

Most of the gluten - free products are starch basis such as rice flour, potato starch, cornstarch, and soy bean flour with the addition of different types of bread improver. Each bread improver type is specifically tailored to enable the desired characteristic of dough or bread type to be achieved. The usage of bread improver can vary widely, often reflecting the level quality or type of the improving ingredients that it contains (Hassan, 2007). Bread improvers provide better gas retention, resulting in higher specific volume (SV) and sensory of bread. Hydrocolloids are one group of additives which fulfil this need. Hydrocolloids are used in gluten - free breads to improve dough handling properties and to enhance the quality and shelf-life of bread. They are capable of controlling the rheology and texture of aqueous systems throughout the stabilization of emulsions, foams and suspensions (Li and Nie, 2015). Among the hydrocolloids, hydroxyl propyl methyl cellulose (HPMC) as a substitute for gluten in a rice bread formula is regarded the best alternative to provide the gas-retaining (Ylimaki *et al.*, 1991). Moreover, HPMC yield is the highest specific loaf volume (Kang *et al.*, 1997) and in baked products, HPMC helps towards moisture retention, improving texture, and extending shelf-life (Whistler and BeMiller, 2008). In the studies presented by McCarthy *et al*. (2005), gluten - free bread prepared with different water additions was supplemented with HPMC to improve the quality of gluten - free bread. Water in batter of gluten - free bread is higher dough of bread (Royalo *et al.*, 2015).

Besides HPMC and water, maltodextrin was used to the development of good-quality gluten -free bread. The application of maltodextrin as antistaling agents for wheat bread was already studied by several authors. Miyazaki *et al.* (2004) concluded that the retrogradation of starch in crumb during storage was significantly retarded if lower molecular weight dextrins were used as compared with high molecular weight dextrins.

Baker's yeast is a commercial preparation consisting of dried cells of one or more strains of the fungus *Saccharomyces cerevisiae*. Bakers use yeast as a leavening agent in the rising of dough for baking. A secondary contribution of yeast to bread is flavoring and aroma. As soon as the yeast has been added to the dough or batter, yeast begins to feed on sugars, forming alcohol and carbon dioxide. The bubbles of CO_2 cause the dough to expand. If the mixture is left too long, acid will be produced by the oxidation of the alcohol results in taste sour of the product (Ali *et al.*, 2012).

RSM represents a collection of statistical and mathematical techniques, and it is often used for development, improvement and optimization of various processes (Bas and Boyac, 2007). The relative contribution of predictor variables to product characteristics is evaluated and allows optimum ingredient levels to be determined (Crowley *et al.*, 2001). In this study, optimal levels of five variables, namely, the amounts of HPMC, maltodextrin, water, yeast and the fermentation time were determined by using Box-Behnken experimental design in order to improve the special volume and sensory of gluten - free bread.

2 MATERIALS AND METHODS

2.1 Materials

"Cẩm" rice, the purple rice, was grown at Cai Lay district, Tien Giang province. Rice was milled and sifted with screens of 0.25 mm to obtain fine fractions. The rice flour composition was protein 9.8%, moisture 12.8% and anthocyanin 66.4 mg per 100 g. Cornstarch (Roquette, France), potato starch (Thailan), soybean (Huong Que, Vietnam), sugar (sucrose), salt, dried instant yeast (*Saccharomyces cerevisiae*-Mauri), fresh milk (no sugar – Vinamilk, Vietnam), whole chicken egg and soybean oil were purchased from local markets of Tien Giang.

Gluten - free batter included 64.9 g rice, 20.3 g cornstarch, 10.2 g potatostarch and 4.9 g soybean power, sugar 10 g, salt 1.25g, oil 6 g, whole chicken egg mixture 12 g, fresh milk 25 g. The amount of HPMC, maltodextrin, water, yeast and the fermentation time were in the range of 1 to 1.5 g; 5g to 15 g; 95 to 105 g; 2.5 to 3.5 g and 20 to 40 min, respectively.

2.2 Methods

RSM was applied to evaluate the effects of HPMC, yeast, water, maltodextrin and fermentation time on sensory characteristics and SV. Box– Behnken experimental design with five numeric factors on three levels was used. Fourty-six experimental runs with three replicates. Experiment design of bread formulations was shown in Table 1. The selected design has 138 runs. The default model is quadratic with 21 coefficients, 6 center points per block.

Table 1: Experimental domain with coded values of independent variables used in Box–Behnken design

Variable	Coded levels		
	-1	0	1
HPMC (g) (X_1)	1	1.25	1.5
Yeast (g) (X_2)	2.5	3	3.5
Water (g) (X_3)	95	100	105
Maltodextrin (g) (X_4)	5	10	15
Fermentation time (min) (X_5)	20	30	40

2.3 Laboratory bread baking

For laboratory bread making, half of the total rice flour and boiling water (half of the total water) were mixed until the flour is converted into a stiff paste or batter (about five min). The resultant batter was left to rest until the temperature decreased to 30ºC. The yeast previously soluted in warm water (35ºC) about 15 min, then it was added to the mixture of remaining flour, the other ingredients and water. The batter was blended for 10 min in Bear mixer. One hundred g of the resulting batter was placed in a greased bread pan (height 5 cm, top and bottom length and breadth 15 cm x 9.5 cm and 12.5 cm x 6.5 cm, respectively) and fermented at ambient temperature (28±2ºC). Finally, the fermented batter was baked at 175ºC for 30 min. The capacity 80 L oven with dimension of width, length and height (41.5 x 62 x 45 cm, respectively) was used. There were three pans in an oven. After baking, bread loaves were removed from the pans and cooled at ambient temperature (28±2°C). After 1hrs of cooling, sensory evaluation and determination of SV of bread samples were performed. TPA-test was carried out after 2 hrs standing at room temperature (25°C) by CT3 Brookfield. For shelf-life analysis, the bread loaves were packed in *low-density* polyethylene (LDPE) bags and stored at 4°C for 5 days. The batches were prepared in three replicates.

2.4 Specific volume

Bread loaf volume (cm^3) and weight (g) were determined after 60 min of cooling. Loaf volume was measured by small seeds displacement method (Greene and Bovell-Benjamin, 2004). Sesame seeds were poured into *container* whose *volume* is *known* until the bottom was covered. The loaf was placed inside the container which was then filled to the top with more seeds. The extra sesame seeds, which equal the loaf volume, were measured in a graduated cylinder. The SV of the loaf was calculated using the following equation (Eq. 1):

Specific volume (cm^3/g) = loaf volume (cm^3)/loaf weight (g) (1)

2.5 Texture profile analysis

Texture Profile Analysis (TPA) was performed with a CT3 Texture Analyzer (Brookfield, USA). Single slice of 25 mm or two slices of 12.5 mm in thickness of bread are placed under a 38.1 mm diameter cylindrical probe (TA4). With the latter, TPA of the crumb was conducted with a constant speed of 2.0 mm/s (pretest speed, test speed, and post-test speed) over a distance of 10.0 mm. The wait time between the first and the second compression cycle was 5 seconds, and the trigger force was 10 g. Triplicate measurements for each sample were made (Moore *et al.*, 2004). Three of twelve loaves were used for performing the texture and structural analyses on day 0, the remaining four loaves were used for the texture analysis on storage after the first day (26 hrs after baking), the third day (74 hrs after baking) and the fifth day of storage (122 hrs after baking), respectively.

2.6 Sensory analysis

Breads were sensory evaluated by panel of 30 individuals (aged 18–40) both male and female were recruited from the students and lecturers of Tien Giang University. The bread crust was removed, and the crumb was cut into cubes (width, length and height: 6.5x15x1.5 cm) before serving to the panelists on coded plates. The panelists who were habitual consumers of bread were instructed to visually evaluate for the nine-point hedonic scale with appearance and odor, then take at least three-fourths of bread, and slowly masticate the product before providing overall acceptability of bread, all on a 9-points hedonic scale consist of like extremely, like very much, like moderately, like slightly, neither like nor dislike, dislike slightly, dislike moderately, dislike very much, dislike extremely (Wongklom *et al.,* 2016).

2.7 Chemical analyses

The water content of the rice flour was determined by the approved AACC method 44-15.02. Protein content of the rice flour was analyzed using the classical Kjeldahl method. Anthocyanin content of the rice flour was measured using a spectrophotometric pH-differential method according to the previous method (Lee *et al.*, 2005).

2.8 Statistical analysis

The optimum levels of the components in the formulation for gluten - free bread were determined with RSM. The breads were prepared according to the experimental design (Table 1) in order to develop gluten - free bread formulation by using Statgraphics Centurion 16. The data obtained were statistically treated by analysis of variance (ANOVA), and the means were compared by the Fisher LSD test at a significance level of 0.05. Data were presented as mean of sample sets. Statistical analysis of the results to assess significant differences among samples was performed.

3 RESULTS AND DISCUSSION

Making high-quality bread requires the presence of gluten, a protein which is responsible for the final structure of bread and also helps to retain gas bubbles, imparts a pleasing volume and texture to the bread batter system. Therefore, elimination of gluten from the diet of patients with celiac disease implies greater difficulties in the bread making process such as lack of cohesion, elasticity and low gas retention capacity of the gluten - free batter. Thus, bread without gluten displays properties such as low volume, friable texture, and rapid firming compared to popular wheat breads. Using of bread quality improvers such as HPMC, maltodextrin combined with yeast, water content and fermentation time improves the quality of bread products. The optimized recipes for gluten - free bread with different ingredients were developed in order to maximize SV and the highest sensory scores.

3.1 Effects HPMC, yeast, water, maltodextrin and fermentation time on specific - free of gluten - free bread

Bread loaf volume is an important parameter used in the determination and assessment of quality of bread

(Matos *et al*., 2014). The SV of the breads produced with various level of HPMC, yeast, water, maltodextrin and fermentation time were shown in Fig. 1 and Fig. 2. The results showed that all of factors effect on specific volume. As can be seen in Fig. 1, the effect of factors indicated that a medium concentration of this factor was nearly optimum levels. A negative sign for a factor indicated that very low or high concentration of this variable made slow SV. The main effect plot for SV of gluten – free bread was HPMC. So two-factor analysis of variance proved that three the level of five factors and their interactions had significant impact on bread SV. In this case, two-way interaction of HPMC with the presence of fermentation, yeast, water, and maltodextrin showed more effect than two-way interaction of another factors in Fig. 2.

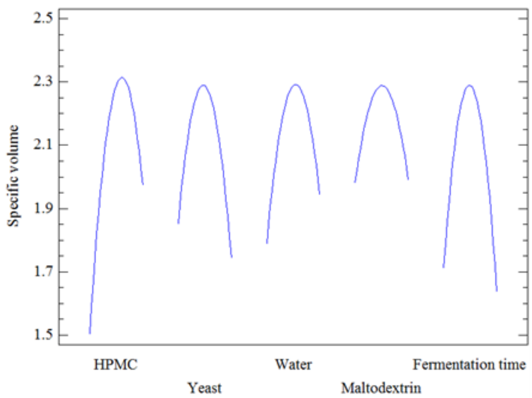

Fig. 1: Main effect plot of five factors on SV

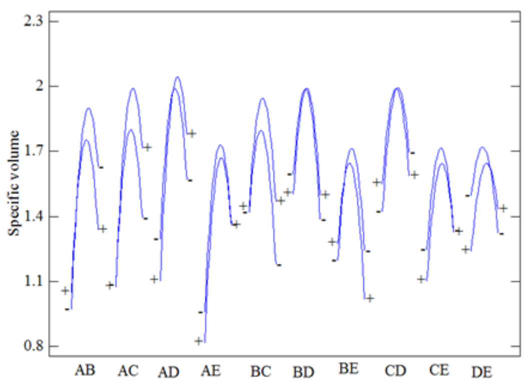

Fig. 2: Interaction plot of five factors on SV

A: HPMC; B: Yeast; C: Water; D: Maltodextrin; E: Fermentation time

HPMC which forms thermoreversible gel networks on heating had been proved the most effective in structuring baked products (Sabanis and Constantina, 2011). Addition of HPMC in gluten - free bread formulation is necessary in order to act as polymeric substances that should mimic the viscoelastic properties of gluten and increase gas retaining ability of batter. In bread batter blended with non - gluten starches with HPMC to mimic gluten network to made high SV of bread. In the result parameters, addition of extreme levels of HPMC (over 1.25 g) decreased SV. This reduction may be due to the interaction of HPMC with starch and water, thus to a decrease of gas retention capacity. Results were the lower consistency of the batter and high plasticity of the structure. The lower consistency causes the bubbles to become unstable in collapse of structure.

The concluding bread structure depends on batter ingredients, yeast activity, fermentation time and gas bubble formation. During leavening, the metabolism of yeasts chemically transforms assimilable carbohydrates into carbon dioxide and ethyl alcohol as the principal finished products (Ali *et al.*, 2012). The bubbles of CO_2 cause the batter to expand. The amount of yeast in the bread and SV share a positive relationship. Increase in SV reflected enhanced inculcation of air spaces in the bread structure, more the yeast in the batter more shall be such air pockets (Chakraborty *et al.*, 2016). However, using high yeast content (over 3 g), bread collapsed due to a decrease of gas retention capacity and also to the lower consistency of the batter and high plasticity of the structure. If the fermentation time of batters was too long (over 30 min), acid was produced by the oxidation of the alcohol to make the product have sour taste (Alba-Lois and Segal-Kischinevzky, 2010). Addition of proper yeast contents with fermentation suitable time for batter could be essential for gas retention as well as the expansion of gas bubbles during proofing and baking, and contribution to the structural architecture and mechanical strength of gluten - free bread.

Water also showed a positive effect on SV of gluten - free bread. Thus, increase of the proper water content would be expected to enhance starch gelatinization and hydration of the protein, resulting in softer and less gummy bread with improved bread loaf volume. The amount of water was not enough to use in the gluten –free bread formation which did not increase the bread volume well, so the crumb was dense and brittle. In contrast, addition of excess amounts of water led to irregularly shaped bread with collapsed surfaces. Water positively affects the volume of gluten - free bread if using suitable content (Bourekoua *et al.*, 2016).

Maltodextrin was a factor to effect on SV. The results revealed that larger volume of loaves prepared with the addition of maltodextrins was probably due to the increasing number of low-molecular weight carbohydrates, which could be used by yeast for fermentation (Witczak *et al.*, 2010). However, the formulations with high maltodextrins content reduced amounts of water that would reduce SV. This reason would be explained by limited availability of water for starch swelling, caused by the addition of highly hydrophilic maltodextrins. Less swollen starch granules occupy less volume and have lower impact on structure formation of the batter. This result was already proved by Witczak *et al.* (2010).

To build up the structure, the ingredients are mixed and kneaded, the batter leavened and baked. Enormous structural changes take place during the bread making (Autio and Laurikainen, 1997). During mixing, the ingredients are transformed into a viscoelastic material as a result of the formation of a three - dimensional protein network, in which starch granules are consistently detached to make SV. The combination of medium levels of five factors resulted in the highest SV was illustrated in Fig. 2. The obtained results showed that the bread volume was significantly dependent on both the fermentation time and the amount of bread improvers used in the recipe. The source and addition levels of bread improvers influenced the power and stability of SV. This result is dependent on the interaction with other ingredients in the formulation (Miyazaki *et al.*, 2004).

3.2 Effects of HPMC, yeast, water, maltodextrin and fermentation time on sensory value of gluten - free bread

Sensory analysis with habitual consumers of bread was performed with a one selected bread formulation. Sensory analysis revealed great divergences in crumb firmness, appearance, odor, taste, and color of samples. In this case, crumb firmness was the most effect to the sensory value. Main effect plot and interaction plot for sensory was the same main effect plot and interaction plot for SV. However, maltodextrin was more effect plot for sensory than SV. Maltodextrin consists of D-glucose units connected in chains of various lengths. So, the presence of maltodextrin helps Maillard reaction, and hence the formation of golden - brown pigment (Chuaychan and Benjakul, 2016). The crust in bread was darker when using more maltodextrin content because it is a very easily digestible sugar. The color of the crumb is also an important parameter for sensory value of gluten - free bread because it contributes to consumer preference. It depends on physicochemical characteristic of the batter and on the operating conditions applied during baking (Esteller and Lannes, 2008).

The sensory evaluation of the fresh bread was performed from matrix plot of data variables of Fig. 3. With respect to the sensory evaluation of each product, quantitative scores information was analyzed by frequencies. The results revealed that all gluten - free formulations were acceptable, since they received scores much higher than 5, ranging from 5.6 to 7.4 (like moderately to like slightly). Breads containing middle levels of the independent variables were rated high due to their good appearance and high SV.

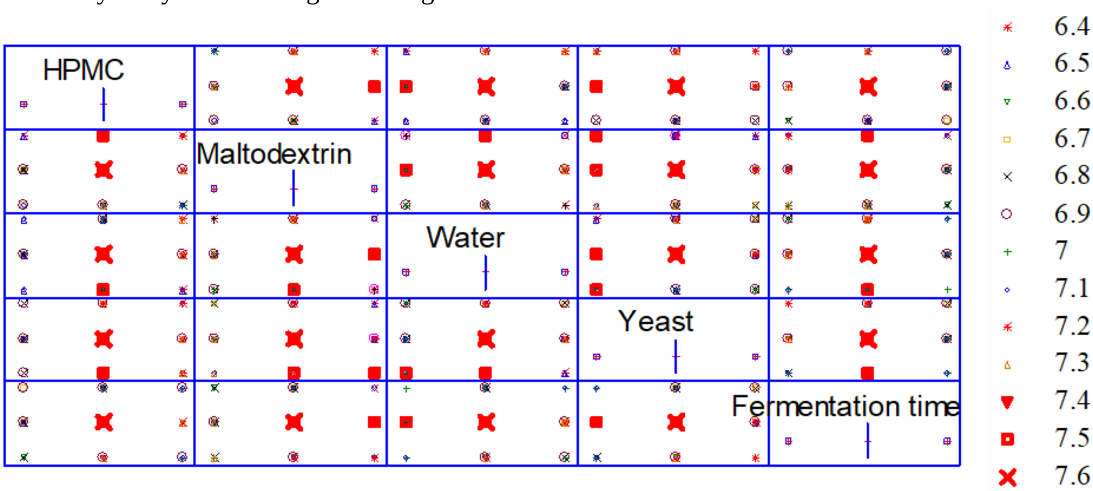

Fig. 3: Matrix plot of data variables for effect of HPMC, yeast, water, maltodextrin and fermentation time on sensory characteristics of bread

Matrix plot of data variables of bread improvers showed that up to a certain limit acceptability increased as the independent variable interacted among each other. The combination of medium levels of five factors (HPMC, yeast, water, maltodextrin and fermentation time) resulted in the highest scores from 7.2 to 7.4 in terms of overall acceptability.

3.3 Effects of hydroxyl propyl methyl cellulose, yeast, water, maltodextrin and fermentation time on hardness of gluten - free bread

Hardness is the most important parameter to measure the staling rate of bread and to determine various food product qualities. From a consumer's standpoint, softer and more cohesive and elastic crumbs are preferred than harder and stiffer crumbs (Christian *et al.*, 2019). Analysis of the results showed that five-factor interaction: HPMC, yeast, water, maltodextrin, and fermentation time were the effects on hardness of gluten free bread (Fig 4). In this case, HPMC is one of the most important hydrocolloids used in the elaboration of gluten free breads due to its capacity to decrease crumb hardness. Gluten free breads of greater and lower hardness were obtained with low or high content of HPMC (1 g or 1.5 g). Gluten - free breads had softy but not sticky when were from intermediate content of HPMC (1.25 g). HPMC has viscous and water-holding capacity, not only can bond starch granules together and then decrease the fluidity of the starch granules, but also can bond bread crumbs and improve the bonding force, thereby retaining moisture of bread (Rosell and Foegeding, 2007). In addition, the changes in hardness of gluten free bread were caused by a wide range of added water, yeast, maltodextrin and fermentation time. In general, addition of lower amounts of water (95 g), yeast (2.5 g), maltodextrin (5 g), and fermentation time (20 min), the gluten - free bread was not well-risen and the crumb was dense and brittle. gluten - free breads had smaller volume and harder crumb when adding higher amounts of yeast (3.5 g) and maltodextrin (15 g) with longer fermentation time (40 min). Moreover, adding with a higher amount of water (110%), the bread crumb had lowest hardness but more stickiness. With addition of 100 g of water and 3 g of yeast, 10 g of maltodextrin and 1.25 g HPMC, for 30 min of fermentation time, the gluten - free bread had the lowest hardness (1123-1201 g/mm^2) but was not sticky. It can be concluded that the hardness of the final gluten - free bread is affected by the interactions that take place between the five factors.

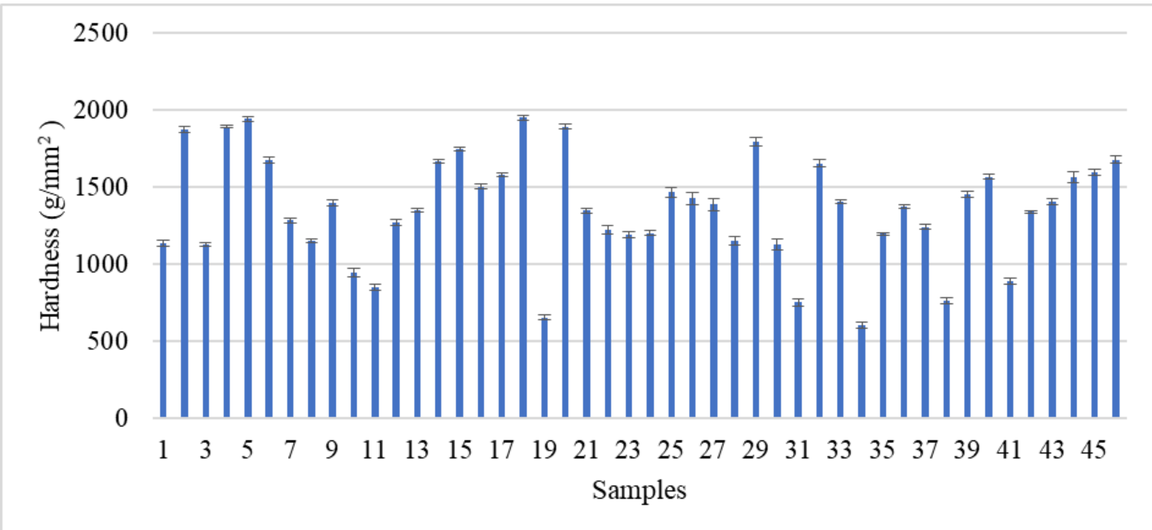

Fig. 3: Hardness of samples with different HPMC, yeast, water, maltodextrin content and fermentation time

Samples from 1 to 46 with different HPMC, yeast, water, maltodextrin content and fermentation time: 1.25:3:100:10:30; 1.5:3:100:15:30; 1.25:3:100:10:30; 1.25:3:100:5:20; 1.25:3:95:10:40; 1:3:100:15:30; 1.5:3:95:10:30; 1:3:100:5:30; 1:3:100:10:20; 1.25:3.5:105:10:10; 1.25:3:105:10:40; 1.25:3.5:100:10:40; 1:2.5:100:10:30; 1:3:100:10:40; 1.25:2.5:100:10:40; 1:3.5:100:10:30; 1.25:3:95:15:30; 1.25:2.5:105:10:30; 1.5:3.5:100:10:30; 1.25:3.5:100:15:30; 1.5:3:100: 10:40; 1.25:3:100:10:30; 1.25:3:100:10:30; 1.25:3.5:100:10:20; 1.25:3:100:15:40; 1.5:3:100:10:20; 1.25:3:100:10:30; 1.25:3.5:95:10:30; 1.25:3:100:10:30; 1.5:3:105:10:30; 1.25:3:95:5:30; 1.25:2.5:100:15:30; 1.25:3:105:10:20; 1.5:3:100:5:30; 1.25:3:105:15:30; 1.25:3.5:100:5:30; 1.25:3:105:5:30; 1.25:2.5:100:10:20; 1.25:3:95:100:20; 1:3:105:10:30; 1.25:3:100:15:20; 1.25:2.5:100:5:30; 1:3:95:10:30; 1.25:3: 90: 10: 35; 1.5:2.5:100:10:30; 1.25:2.5:95:10:30, respectively.

3.4 Optimization of gluten - free bread formulation

The ANOVA table partitions the variability in sensory into separate pieces for each of the effects. It then tests the statistical significance of each effect by comparing the mean square against an estimate of the experimental error. In this case, 10 effects had P-values less than 0.05, indicating that they were significantly different from zero at the 95.0% confidence level. This pane displays the regression equation which have been fitted to the data. The equation of sensory about overall acceptability of bread the fitted model was Y_1 (Eq. 2)

$$Y_1 = -204.32 + 23.97X_1 + 12.19X_2 + 3.42X_3 + 0.36X_4 + 0.29X_5 - 9.47X_1^2 + 0.05\,X_1X_5 - 2.06X_2^2 - 0.02X_3^2 - 0.018X_4^2 - 0.006X_5^2 \qquad (2)$$

The R-squared statistic indicated that the model as fitted explains 82.7% of the variability in sensory. The adjusted R-squared statistic, which was more suitable for comparing models with different numbers of independent variables, was 81.3%. The standard error of the estimate showed the standard deviation of the residuals to be 0.19. The mean absolute error (MAE) of 0.15 was the average value of the residuals.

With SV, the ANOVA table partitions the variability in into separate pieces for each of the effects. In this case, 9 effects had P-values less than 0.05, indicating that they are significantly different from zero at the 95.0% confidence level. The equation of SV the fitted model was Y_2 (Eq. 3)

$$Y_2 = -215.58 + 22.83X_1 + 12.18X_2 + 3.55X_3 + 0.16X_4 + 0.38X_5 - 9.1X_1^2 + 0.08\,X_1X_4 - 2.05X_2^2 - 0.02X_3^2 - 0.013X_4^2 - 0.006X_5^2 \qquad (3)$$

The model for SV showed high R^2 (84.9%), adjusted R^2 (83.9%). They indicated that the model was fitted regression line. The standard error of the estimate showed the standard deviation of the residuals to be 0.17. The mean absolute error (MAE-the average of all absolute errors) was 0.13.

Based on the above-described results, it can be asserted that the quality of the gluten - free bread depended on all five factors, but not any single factors. Therefore, the next step involved the detection of the best combination of factors that are able to produce the expected characteristics of the final product (Table 2). All comments arising from the response surface plots were taken into account in the optimization, considering that the optimal solution arises from a compromise among the different responses (Sabanis and Constantina, 2011).

Table 2: Factor settings at optimum

Factor	Setting	Optimal response SV (cm^3/g)	Optimal response of sensory
HPMC	1.31	1.30	1.30
Yeast	2.96	2.97	2.95
Water	100.5	100.4	100.5
Maltodextrin	10.04	10.16	10.00
Fermentation time	29.8	30.00	29.6
Optimum value		2.36	7.43
Optimum desirability	0.98	0.99	0.98

In Table 2, the mixture of HPMC, yeast, water, maltodextrin and fermentation time gave good results at intermediate level. The HPMC as major component had in the mixture due to the favorable characteristics in the SV and sensory value about overall acceptability of bread.

As a result of the optimization step, the best condition, which was attained for the expected response values, was 1.31 g HPMC, 2.96 g yeast, 100.5 g water, 10.04 g maltodextrin, and 29.76~30 min of fermentation. At the optimal conditions (improver and yeast contents, and fermentation time), the bread obtained the maximum SV (2.4 cm^3/g) and the highest sensory values (7.4 - like) The calculated desirability for this formulation was 98,7% for SV, 97.8% for sensory value and 98.3% for the overall optimized desirability. This SV was higher than that of the gluten - free bread described by Kim *et al.* (2015), which yielded 1.86 cm^3/g. Overall acceptability evaluation depicted that the optimized bread exhibited fine taste, more uniform crumb texture, flavor, color and appearance being rated with seven scores on a nine-point scale. It was also observed that the crumb of the optimized bread had medium size air pores and good uniformity. Panelists commented that this bread "*looked more like wheat bread*" and that the loaves had "*loaf volume and sensory value similar to wheat bread*". The similar results of sensory characteristics of bread were found as reported by Breshears and Crowe (2013).

4 CONCLUSION

The best quality of gluten - free rice bread (high overall acceptability scores, high SV and low hardness) was successfully achieved with 1.31 g HPMC, 2.96 g yeast, 100.5 g water, 10.04 g maltodextrin, and 30 min of fermentation. The combination of four ingredients and fermentation time applied in this study influenced much on the quality of gluten - free rice bread. HPMC was the most effective factor reducing hardness of the crumb and increasing SV and sensory value of gluten - free bread. Maltodextrin showed good interactions in their effect on sensory value more than SV in rice bread. The RSM with different parameters could be applied for optimization of gluten-free breads processing in future.

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