UDC 664.665.01(083.1):53.093-022.231

OPTIMIZATION OF RECIPE FOR BAKERY PRODUCTS WITH LOW-MOISTURE CONTENT FOR REDUCING THE GLYCEMIC INDEX

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Abstract. The modern concept of recipe development and improvement has to be based on fundamental knowledge about the chemical composition of ingredients as well as mechanisms of their assimilation. Glycemic index of food products, including bakery products, becomes important in the aspect of the spread of a metabolic syndrome that is a complex of various metabolic disorders that lead to the development of atherosclerosis and cardiovascular disease. The article shows the possibility of creating a recipe for sweet baked goods with low moisture content and reduced glycemic index due to using the buckwheat flour, dry wheat gluten, oat bran and aqueous extract of stevia. We have used modern methods of setting up the experiment and processing their results. The influence of these ingredients on the glycemic index has been characterized. The efficiency of using Stevia as natural sweeteners, has shown, for developing approaches to reduce the energy value and the glycemic index of bakery products. The coefficients of the regression model were given as a result; it has helped to find out the patterns of influence of both selected components and their dosage on the glycemic index, energy value and sensory characteristics of the product. The article presents the results of multicriteria optimization, which can be used to create recipe compositions using selected ingredients using of modern software Design-Expert 11. The amount of buckwheat flour was in range 5–20%, dry wheat gluten – 5–15%, oat bran – 2–6% of the total number of dry ingredients in the formulation. A rational ratio of the main ingredients has been found to provide an optimal ratio of the factors "low glycemic index - excellent taste". The glycemic index of developed baked goods with low moisture content was 57–58.This article has shown the possibility of using an integrated approach in forming the recipe of low-moisture bakery products with a reduced glycemic index.

Key words: bakery products, glycemic index, buckwheat flour, rye flour, stevia, sweetener, rusk, wheat dry gluten, oat bran

ОПТИМІЗАЦІЯ РЕЦЕПТУРИ ХЛІБОБУЛОЧНИХ ВИРОБІВ ПОНИЖЕНОЇ ВОЛОГОСТІ ДЛЯ ЗНИЖЕННЯ ГЛІКІМІЧНОГО ІНДЕКСУ

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Анотація. Сучасна концепція створення та удосконалення рецептурних композицій має ґрунтуватись на фундаментальних знаннях не лише про хімічний склад рецептурних інгредієнтів, а й механізмах їхнього засвоєння. Глікемічний індекс продуктів харчування, в тому числі і хлібобулочних виробів, набуває важливого значення в аспекті поширення метаболічного синдрому, що є комплексом різних метаболічних порушень, які призводять до розвитку атеросклерозу та кардіоваскулярних захворювань. У статті показано можливість створення рецептури солодких хлібобулочних виробів пониженої вологості зі зниженим глікемічним індексом за рахунок застосування житнього цільнозернового та гречаного борошна, сухої пшеничної клейковини, вівсяних висівок та водного екстракту стевії з використанням сучасних методів постановки експерименту та обробки їхніх результатів. Охарактеризовано вплив цих інгредієнтів на глікемічний індекс. Показано ефективність застосування натурального підсоложувача, такого як стевія, при розробці підходів до зниження енергетичної цінності та глікемічного індексу хлібобулочних виробів. Отримані в результаті оптимізації коефіцієнти регресійної моделі, допомогли встановити закономірності впливу як обраних рецептурних компонентів, так і їхньої масової частки на глікемічний індекс, енергетичну цінність та сенсорні характеристики готового продукту. У статті наведено результати мультикритеріальної оптимізації, яка може бути застосована для створення рецептурних композицій із обраних інгредієнтів використовуючи сучасне програмне забезпечення Design-Expert 11. Задаючи умови оптимізації, кількість борошна гречаного коливалась в межах 5–20%, сухої пшеничної клейковини – 5–15%, вівсяних висівок – 2–6% від загальної кількості сухих компонентів у рецептурі. Встановлено раціональне дозування основних інгредієнтів для забезпечення оптимального співвідношення факторів «низький глікемічний індекс – відмінний смак». Глікемічний індекс розроблених хлібобулочних виробів пониженої вологості склав 57–58. Результати досліджень показали можливість застосування комплексного підходу у формуванні рецептури хлібобулочних виробів пониженої вологості зі зниженим глікемічним індексом.

Ключові слова: хлібобулочні вироби, глікемічний індекс, житнє борошно, гречане борошно, стевія, підсолоджувач, сухарні вироби, суха пшенична клейковина, вівсяні висівки

DOI: http://dx.doi.org/ 10.15673/fst.v13i2.1379

Introduction. Formulation of the problem

According to WHO, as of the beginning of 2016, there are more than 1.9 billion overweight adults in the world, of which over 600 million are obese [1]. Nowadays, this number has grown more than double. Nowadays creating the recipe's formula for food is not only about satisfying hunger and nutrient supply for the human body but it is about prevention nutrition-related diseases. We can predict the physical and mental health of consumers by incorporation or excluding one or another ingredient during recipe formation. The revision of the recipe formula and the addition of ingredients, which will have a positive effect on human health and in the same time have a powerful effect on the product properties, such as the alteration of its glycemic index (GI). It is well known that GI associated with chronic diseases such as obesity, metabolic syndrome, insulin resistant etc. [2-4]. Some studies have shown that starchy food products, the product with the high level of simple carbohydrates have a significant effect on the level of glucose in the human blood and the reaction to insulin equally in both healthy and diabetic patients [5-6]. In connection with the above, the food industry faces a rather difficult task– to provide the population with a wide range of products with low GI and high nutritional value. The number of such products on the market is clearly not sufficient, especially for products made from cereals. The biggest part of them it is starchy products, including bakery products.

Rusk and bakery goods with low moisture content occupy a special place among bakery products due to their taste and nutritional properties. However, they are high-caloric, contain a high level of easily digestible carbohydrates, so it is difficult to recommend it as a dietary food. At the same time, their main advantage is a long shelf life, which makes their production highly profitable. Therefore, it is an up-and-coming area.

Analysis of recent research and publications

More and more consumers are striving to a healthy lifestyle and are struggling with being overweight, so the fact of the high popularity of innovative products in the dietary and therapeutic area is natural. Despite the general negative trends in the bakery market, the part of bakery products with low moisture content, such as rusk, breadsticks, grissini, taralli etc., have been increased every year since 2010 [7].

The issue of reducing the glycemic index of food is the most acute as long as a number of studies have shown that high consumption of carbohydrates leads to high glycemic response and has been hypothesized to increase the risk of non-insulin-dependent diabetes, whereas dietary fiber is reduced [8-10]. Some studies have shown possibility of reducing GI by using non-traditional for bakery industry ingredients (Fig. 1).

Fig. 1. Ingredients commonly used in breadmaking for reducing GI

Some of these ingredients were chosen for containing starch granules with different morphology and molecular structure, amylose and amylopectin ratio, nutrient compositions including dietary fibre, protein, lipid and phenolic. These factors can greatly influence the digestibility of starch and thereby resulting in different glycemic index. Using legumes flour, pseudocereal flour is an easy way to low the amount of digestible carbohydrates, include ingredients such as dietary fiber, bioactive compounds that are not available in wheat.

In the works of researchers [11-15], it is noted that buckwheat is highly nutritious, indispensable for diabetes, helps reduce cholesterol levels and is recommended for the prevention of cardiovascular diseases. The biological value of buckwheat protein is significantly higher than that of wheat, oats, barley, rice, and soybean [16]. Studies have shown that buckwheat has a high content of unsaturated fatty acids [17], rutin and vitamin E [18]. It is proved that buckwheat flour has high antioxidant activity [19-21] and contains the most important trace elements [11,22], phytosterols and phytoestrogens [15,23].

Another reason to choose buckwheat flour as an ingredient of bakery products it is proteins, which have recently attracted much interest, due to their well-balanced amino acid composition. One of the great benefits of combining different types of flours it is an opportunity to improve their food imperfection owing to the modern view of Nutrition. Buckwheat prolamins have another characteristic comparison to wheat, barley, and rye prolamins, which widely are used in bread making technology. Buckwheat proteins are rich in arginine and lysine, the primary amino acids limiting the content of proteins in cereals, whereas the contents of methionine and threonine in buckwheat proteins are low [24]. According to studies [25,26], the chemical composition of buckwheat is near 550 mg/g starch, 120 mg/g protein, 70 mg/g total dietary fibre, 40 mg/g lipid, 20 mg/g soluble carbohydrates and 180 mg/g other components such as organic acids, phenolic compounds, tannins, phosphorylated sugars, nucleotides and nucleic acids [27].

It is known some attempts to incorporate the buckwheat flour in the recipe of wheat bread. It is proved that bread recipe can be enriched by the buckwheat flour up to 30%. It leads to increasing of antioxidant activity [28]. It was shown the possibility of using 15% of buckwheat flour in bread formula in order to investigate its antioxidant activity [29]. Nutrition value of buckwheat starch and loaves of bread with addition from 30 up to 70% of buckwheat flour were studied by Skrabanja V. et al. [30,31], who comes to the conclusion, that buckwheat reduces the post-meal metabolic responses. Suitable nutritional trends for dietary starch fractions were considered by C. Collar et al. [32], who successful investigated and proved the impact of the special blend made from 7.5% teff, 15% green pea and 15 % buckwheat flours on starch hydrolysis and antiradical activity of wheat bread.

Over the past decade, most research in food technologies has emphasized the use of dietary fiber as the main factor of reducing glycemic response. It is important to note that recently, special attention has paid to the use of "inaccessible" carbohydrates, which by definition includes all vegetable polysaccharides that are not digested, such as hemicellulose and dietary fiber [33]. Reynolds A. et al. [34] have shown that the dietary fibers have greater advantages when it consumed up to 29g per day. This amount of dietary fiber has decreased the risk of cardiovascular diseases, type 2 diabetes and colorectal cancer and breast cancer.

Much work on the potential of bran in bread making has been carried out [35-37], however, there are still some critical issues about the quantity and particle size of bran. Some studies were connected with applying different types of bran in range of 3–20%.Campbell has studied the effect of it on rheological properties of dough and quality of wheat bread [37]. Dhinda F. et al. to improve dough quality and to achieve the high content of protein, fibre and low carbohydrate content have applied the blend that includes soy protein isolate, oat bran and chickpea flour (SPOBCP) at the levels of 20%, 40% and 60% [38]. There is evidence that oats bran has low baking properties, which can be compensated by adding dry gluten to the dough [39].

One of the great advantages of combining different types of flour is the ability to improve their nutritional imperfections thanks to modern knowledge of nutrition and nutrients. The use of wheat-rye mixture at different ratios can have a positive effect on the nutritional value and help to reduce the glycemic index of bread products. Rye flour contains amino acids that are more valuable than in wheat flour, B vitamins and minerals are present too. It contains cellulose and hemicelluloses, which are very valuable for the normal functioning of the intestine and contribute to the functioning of its microflora, in addition it has a low calorie content. The starchy rye grains are much larger than those of wheat, and are more easily acted upon by amylolytic enzymes. [40]. It has been established that rye products cause a relatively low level of insulin response after a meal, due to the endosperm and the chemical composition [41,42].There is no information about application this type of flour in recipe formula of sweet bakery goods. In the same time, preparation of dough from whole rye flour is a complex process, since rye protein substances differ significantly from wheat proteins in their properties. Adding to the recipe of dry wheat gluten on the one hand helped to reduce the glycemic index and on the other hand can help to solve a problem with the structure of dough.

Sucrose is one of the main ingredients in sweet bakery products and contributes significantly to their energy content. Low-calorie sweeteners (LCS) are commonly-used substitutes for caloric sugars, however the biggest part of them have not studied their role on human health. In addition, some of them may even have a negative impact. For example, information about the health effects of high-fructose corn syrup is rather contradictory, the same with sorbitol and xylitol. LCS are also referred to as artificial sweeteners, nonnutritive sweeteners, high intensity sweeteners, and non-caloric sweeteners [43]. Despite their excellent technological properties, first of all they must be safe.

Stevia is natural sweeteners that are up to 300 times sweeter than sucrose and show a great technological property (Fig. 2) [44,45].

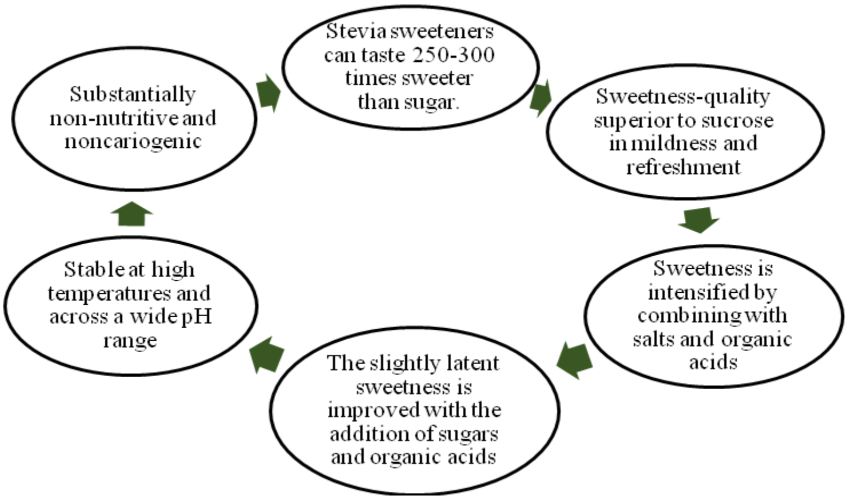

Fig. 2. Technological properties of Stevia rebaudiana

Leaves of S. rebaudiana contain 0.46% fructooligosaccharides, such as inulin – a natural polysaccharide with important functional properties, which refers to prebiotics and food fibers. They play an important role in the metabolism of lipids and the control of diabetes. In 2011, steviol glycosides were approved by the European Union as additive for specified foods; the acceptable daily intake is 4 mg for 1 kg of body weight, and the assigned E-number isE960 [46].

The purpose of the study is to optimize recipe of bakery products with low moisture content to reduce the glycemic index.

Research tasks:

1. Select the factors that will be the subject of optimization.
2. To evaluate the influence of the choice of ingredients on the glycemic index, energy value and sensory characteristics of crackers
3. Create a mathematical model of the interaction between various factors.
4. Assess the adequacy of the experimental conditions of the resulting model.
5. Determine the physical and chemical characteristics of the product, which was made according to the new optimization recipe.

Research materials and methods

In order to develop the recipe formula for bakery goods low-moisture content with the reduced level of GI, high level of protein and dietary fiber, blends were prepared using rye wholemeal flour, buckwheat flour, dry gluten, oat bran to substitute wheat flour as much as possible. As sweetener was used water extract of Stevia, parameters of Stevia water extraction were used due to the study of D.B. Kovačević [47]. Water was replaced with Stevia extract. The quantity of rye wholemeal flour varied within 15–60%, dry wheat gluten – 5–15%, bran – 2–6% of the total amount of flour component. Leaves S. rebaudiana contain 0.46% of fructooligosaccharides. These are natural polysaccharides with important functional properties that relate to prebiotics, so the dry matter after extraction was used in the recipe too.

Duration of dough mixing was 5 min, the dough temperature after the kneading was 26–28°C, moisture content – 45±1%, dough fermentation – 60 min at 32±1ºC. After fermentation, the dough was formed into a long and thin cylinder (weigh 0.5±0.05 kg) and was proofed at 35±1°C with humidity – 45% during 40 min.

Semi-finished product for rusks was baked at 220°C during 30 min, it was left for 24 hours and was cut into paces (weight 10±1 g). It was dried at 120°C during 20–30 min till moisture content of the rusk was on the level 18–19%. The control sample was prepared according to the recipe, which contained a wheat-rye mixture – 41% wheat flour, 59% rye flour, in addition, the recipe contained 10% sugar, 9% margarine, 4% yeast by weight of dry ingredients. The conditions of kneading, proofing and baking were the same as described below.

Sensory characteristics were evaluated by 20 persons (both males and females), who had experience in sensory evaluation. For sensory evaluation used the method of preferential scale. This method of quality evaluation based on a 10-point scale. The evaluator determines the degree of desirability of the product on a 10-point scale of advantage. This method evaluates exclusively the consumer desirability of the product. The evaluation method was as follows: it is necessary to evaluate 3 samples and answer which one corresponds to the habit and taste of the appraiser on a scale of 10–9 – highly desirable; 8 – very desirable; 7 – medium desirable; 6 – few desired; 5 – neutral; 4 –slightly neutral; 3 – medium neutral; 2 – neutral; 1 – highly neutral.

To determine the physical and chemical characteristics of semi-finished product for rusks and rusks, was used DSTU 7045: 2009. Bakery products. Methods of determination of physical and chemical characteristics

Statistical methods for planning an active experiment are one of the empirical methods for obtaining a mathematical description of the relation equation of an object and input variables (factors). At the same time, the mathematical description is represented in the form of a certain polynomial - a segment of the Taylor series, into which an unknown relation expands in a neighborhood of the main point.

The object of study was made in the form of a “black box”, whose input is affected by the factors x_i, I = 1, 2, 3. And the object’s response to input influences is denoted by Y (our object has 3 responses that we will consider for building models independently of friend). As the mathematical model we will understand the equation linking the response and factors (regression equation):

$$Y=f(x_1, x_2, x_3) \quad (1)$$

Optimization was made using the Design expert pro 11. To develop a new recipe, it was necessary to apply a modern mathematical tool, build a mathematical model of the process, optimize it and get the best parameters. Design-Expert Software Version 11 was used for data processing, it allows you to correctly construct an experiment, analyze the interaction between factors, apply optimization methods and find the optimal composition of products.

The calculation of the chemical composition and energy value of the products was carried out basing on the determined chemical composition of flour materials and on reference tables of the chemical composition of food products [48].

The glycemic index was calculated according to [49] and using International table of glycemic index [50].

Results of the research and their discussion

The incorporating appropriate ingredient into the recipe is not the main point of succeeding but the processing of food important too. Using the priori ranking method was found that to achieve the goal of evaluating bakery products is important to taste, glycemic index and energy value. The purpose of optimization was to reduce the glycemic index and determine the influence of selected recipe ingredients on the energy value of the products. Taste was chosen as one of the most significant factors in evaluating the effectiveness of creating a new recipe. Non-bakery flour (buckwheat flour), Dry gluten and Bran were the most influential ingredients on the optimized parameters. Due to the task, firstly it was necessary to find the mathematical dependencies of the responses on input factors, secondly, on the basis of the models obtained, to determine the best proportions of ingredients in the composition of recipes for sweet bakery products.

A model of the form (1) may be different, but we will consider polynomial models as the most common (for acceptable accuracy, we restrict ourselves to the second degree). In this case, the regression quadratic formula for the formulated problem will be:

$$Y=b_0+b_1x_1+b_2x_2+ b_3x_3+b_4x_1x_2+ b_5x_1x_3+ b_6x_2x_3+b_7x_1^2+b_8x_2^2+ b_9x_3^2 \quad (2)$$

The polynomial models were used to predict and evaluate the response due to input parameters. Polynomial models suit for determination input factors drive responses and their direction. It is the most popular model for analysis and description of experimental data. To obtain the design of the experiment in the Design-Expert 11, the levels of the Non-bakery flour, Dry gluten and Bran factors were set in table 1.To choose a range of doses of ingredients its technological properties such as humidity, dispersion, moisture content, nutrition value and water absorption capacity were taken into account.

Table 1 – Limit levels of factors

Name	Units	Min	Max	Coded low	Coded High	Mean	St. Dev
Non-bakery flour (Buckwheat flour)	%	0.1134	25.11	-1 ↔ 5.00	+1 ↔ 20.00	12.50	6.93
Dry gluten	%	1.59	18.41	-1 ↔ 5.00	+1 ↔ 15.00	10.00	4.62
Bran	%	0.9773	6.02	-1 ↔ 2.00	+1 ↔ 5.00	3.50	1.39

The program has formed an experimental plan, taking into account the significant factors and their relative values (Table 2). According to this plan, experiments were carried out, the results of which were entered in the table in the form of numerical values of GI, sensor evaluation, energy. Search for unknown coefficients of the regression model will be searched for in terms of A, B, C , AB, AC, BC, A^2, B^2, C^2 (which are analogues of the variables x_1,x_2, x_3, x_1x_2, x_1x_3, x_2x_3, x_1^2, x_2^2,x_3^2 in model (1)).

A preliminary analysis of the effects in the program shows the effect of individual factors on the response – GI (Fig. 3). The analysis showed that the «Non-bakery flour» factor has the greatest impact on the Glycemic index response, the indicator of which is the strong link is the red color in the correlation matrix at the intersection of these two variables (the correlation is high at 0.522).

Table 2 – Design of experiment

Run	№	Buckwheat flour,% (A)	Dry gluten,% (B)	Bran,% (C)	GI	Sensor evaluation, Mark	Energy, kcal
7	1	5	15	5	60.8	7	242.4
8	2	20	15	5	57.0	9	247.0
16	3	12.5	10	3	63.1	7.4	240.8
6	4	20	5	5	57.7	10	240.0
1	5	5	5	1	71.1	6.6	237.1
12	6	12.5	18.4	3	56.9	7.4	246.7
2	7	20	5	1	65.3	7.3	238.9
5	8	5	5	5	68.3	6	236.0
14	9	12.5	10	6.3	60.7	7	240.3
10	10	25.1	10	3	59.4	4	244.4
9	11	0	10	3	67.7	7.1	239.0
13	12	12.5	10	0	64.2	7	239.3
17	13	12.5	10	3	62.1	6.3	238.9
11	14	12.5	1.5	3	71.2	6.2	238.6
15	15	12.5	10	3	62.5	6.6	239.7
3	16	5	15	1	62.6	8	241.9
4	17	20	15	1	57.8	8	243.2

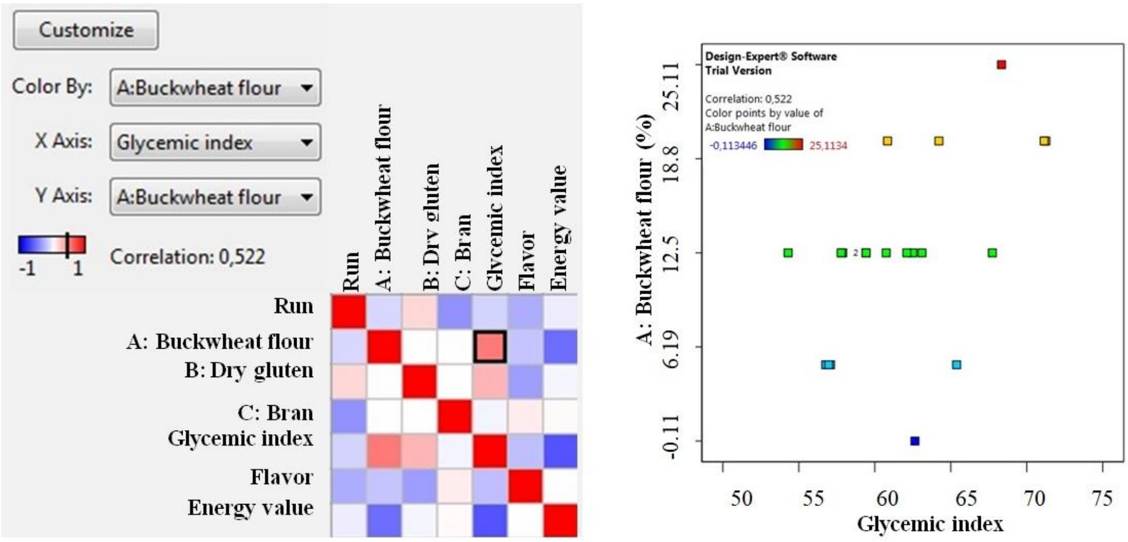

Fig. 3. Correlation matrix «Non-bakery flour-Glycemic index»

The interaction is a second-order nonlinear response. It is very useful to look at the contour and three-dimensional images of the interaction to see the nonlinearity (Fig. 4). From three-dimensional images in the form of dependencies of all responses on factors «Non-bakery flour», «Dry gluten» (Bran factor is a constant here).

The images make it possible to evaluate the nonlinearity of a particular model (for example, the dependence of the «Glycemic index» on «Dry gluten» is almost proportional).The analyses of the data haveshowed a strong influence of the amount of bran on the energy value. Oat bran has a carbohydrate nature [35] so they largely increase the calculated energy value while capable of significantly reducing the glycemic index. Increasing the amount of wheat gluten in the recipe had a significant effect on the negative sensory evaluation, more than the amount of buckwheat flour.

The data in fig. 5 helps not only to interpret the data, but also to predict the conduct of the model when the input parameters will be changed. The results, which present in the form of model coefficients for all three types of response, are shown in Table 3.

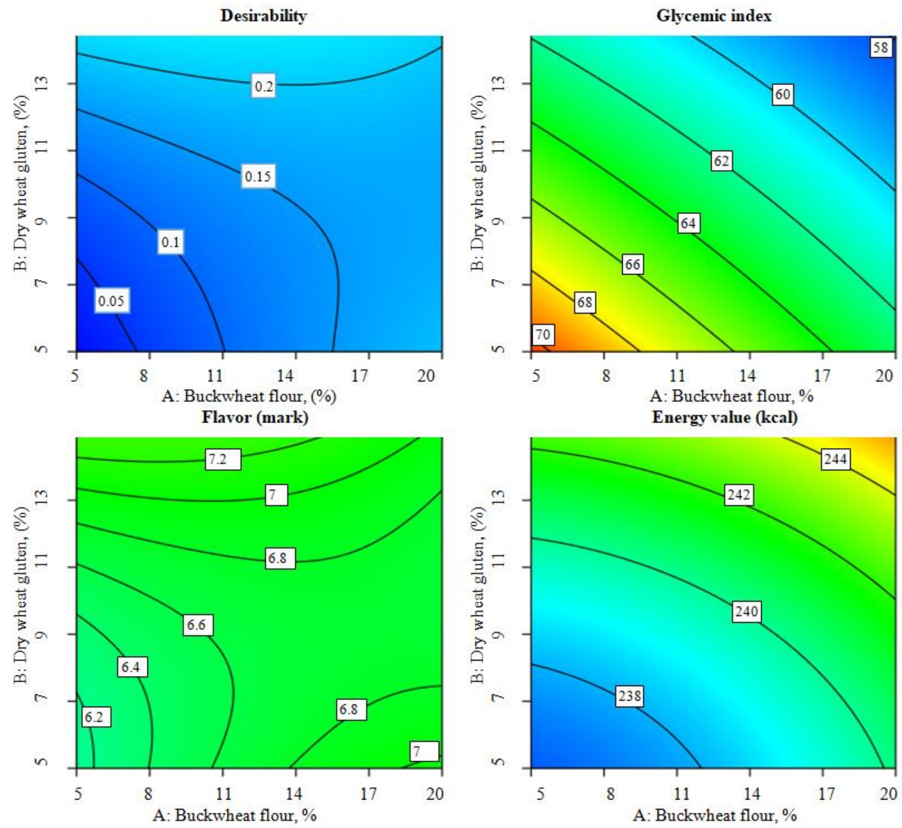

Fig. 4. Contour graphs of the factors interaction A and B

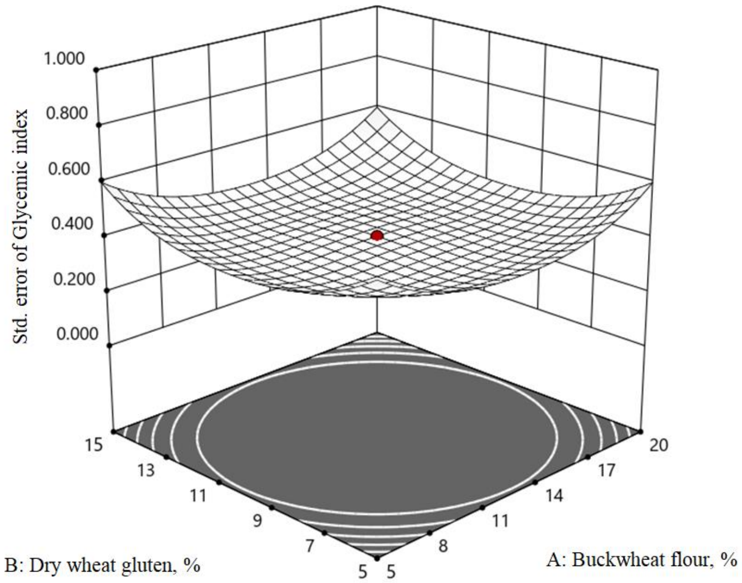

Fig. 5. Three-dimensional type of interaction and the influence of factors A and B

Table 3 – Regression coefficients of the model

Indicator	Intercept	A	B	C	AB	AC	BC	A²	B²	C²
Glycemic index	62.6284	3.6450	5.9649	14.4342	-0.1217	-0.3087	-0.4011	-0.0665	-0.1783	-1.0634
Flavor	6.70625	0.4939	0.7484	0.2735	-0.0328	0.0468	-0.0300	-0.0123	-0.0109	-0.0454
Energy	239.892	11.9303	20.9621	46.3789	-0.3573	-0.8917	-1.5900	-0.1879	-0.4969	-2.8747

These mathematical models of dependencies can be further used to optimize the best values of the composition for different tasks. Therefore, we set the minimization for the Glycemic index response, and for the Flavor response – maximization, there is a multi-criteria optimization problem in which you need to find the best point in the Pareto area. The numerical values can already be used to recommend the optimal composition of ingredient (Table 4).

Structural and mechanical propertiesdepend on the quality of the product. These characteristics are extremely important as well as sensor evaluation. The quality of bakery products is regulated by the National standards and technical documentation, which sets certain requirements for the appearance and properties of products. Therefore, it was important made the determination of main parameters that will describe the quality of semi-finished product for rusk and rusk. According to the results(Table 5), it was found that the samples obtained using the new recipes had characteristics that were not as low as those of the control sample were. At the same time, the energy value and glycemic index were reduced by 39% and 45% for both samples.

Table 4 – New recipe of sweet bakery products (rusk) after optimization

Ingredient, %	Quantity
Wheat flour	7.72
Rye whole meal flour	49
Non-bakery flour	10.11
Bran	3.32
Dry gluten	5
Dry matter after extraction	1
Salt	0.3
Bakery yeasts	4
Margarine	9
Water extract of Stevia	28.3
Water	calculate

Table 5 – The chemical and physical properties of Semi-finished product for rusks

Index	Control sample	Sample 1 (High sensory evaluated)	Sample 2 (After optimization)
Semi-finished product for rusks			
Porosity, %	65.00	65.00	63.00
Ability to hold shape, H/D	3.25	2.95	2.57
Moisture content, %	44.00	44.00	44.50
Titratable acidity, °H	4.50	5.50	6.40
Quantity of crumbs, %	9.80	9.20	8.50
Rusks			
Moisture content, %	19.10	18.60	18.40
Titratable acidity, °H	4.20	5.30	6.20
Ability to water absorbtion, min	2.00	2.50	3.50
Hardness, units	9.00	9.00	9.00
GI	83.00	57.70	57.66
Energy values, kcal	382.00	240.00	239.00

On the other hand, it was found that the ability to hold shape in sample 2 was lower by 27% compared with the control. The sample, which was highly scored (sample 1), had a better form-stability of the semi-finished product for rusk by 13%, compared with sample 2. It was also noted that sample 1 had a lower titrated acidity value compared to sample 2 by 0.9 degrees, which can be explained by the lower content of wholegrain rye flour in its recipe, which significantly increases the titratable acidity. Smaller quantity of crumbs was noted both in sample 1 and 2, which is most likely due to the large amount of gluten in this recipe, which significantly affected the structural and rheological properties. The hardness of the rusks was the same for all samples.

Conclusion

The optimized model made it possible to evaluate the effect of buckwheat flour, oat bran and dry wheat gluten on the glycemic index, energy value and sensory characteristics of rusks. Due to the analysis of the optimization data, it was found that the decrease in the calculated glycemic index is more influenced by the amount of bran in the mixture than buckwheat flour or dry wheat gluten, which in turn has a significant effect on the sensory evaluation of the products. The resulting models and coefficients in the future will help to more effectively approach the issue of optimizing the formulation of bakery products with a reduced glycemic index.

The characteristics of rusks, made according to the optimized recipe, are differed in their satisfactory characteristics and at the same time, they had reduced calculated glycemic index and energy value. It makes possible to consider such products as a potential product in range category “without sugar” and labeled “low glycemic index”. Furthermore, it leads to partially fitting for the basic requirements for food that can be used in the daily diet of people with metabolic syndrome.

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Отримано в редакцію 12.03.2019 Received 12.03.2019
Прийнято до друку 07.06.2019 Approved 07.06.2019

Цитування згідно ДСТУ 8302:2015

Iorgachova K., Sokolova N., Kotlik S. Optimization of recipe for bakery productswith low-moisture contentfor reducing the glycemic index // Food science and technology. 2019. Vol. 13, Issue 2. P. 4-14. DOI: http://dx.doi.org/ 10.15673/fst.v13i2.1379

Cite as Vancuver style citation

Iorgachova K, Sokolova N, Kotlik S. Optimization of recipe for bakery productswith low-moisture contentfor reducing the glycemic index. Food science and technology. 2019;13(2):4-14. DOI: http://dx.doi.org/ 10.15673/fst.v13i2.1379