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JUSTIFICATION FOR USE OF TWO-COMPONENT MIXTURES FOR COOKING WHEAT BREAD

Об'єктом дослідження є хліб пшеничний. Одним з найбільш проблемних місць є необхідність корекції харчового раціону населення з метою збагачення традиційних продуктів харчування життєво-необхідними нутрієнтами. Ураховуючи, що хліб належить до продуктів, які є у щоденному раціоні більшості населення, поліпшення його харчової цінності сприятиме покращенню раціону в цілому. Поліпшення харчової цінності хлібу може здійснюватися за рахунок додавання альтернативних видів борошна – кукурудзяного, вівсяного, борошна ярої пшениці.

В ході дослідження використовувалося моделювання рецептур методом дегустаційної оцінки. Розроблено 9 рецептур хліба на основі двокомпонентних борошняних сумішей з додаванням кукурудзяного, вівсяного, гречаного та борошна ярої пшениці (7,5 % та 15 %).

Отримані зразки були досліджені на відповідність органолептичним та фізико-хімічним показникам, а також показникам безпечності. За фізико-хімічними показниками якості (вологість та кислотність) усі зразки відповідали українській нормативній документації, показники безпечності також не перевищували допустимих меж. Найкращими органолептичними властивостями вирізнявся хліб, до складу рецептури якого було додатково введено борошна ярої пшениці у кількості 7,5 % і 15 %. Високу кількість балів одержав хліб із суміші пшеничного і вівсяного борошна (7,5 %). Зразки з додаванням кукурудзяного та гречаного борошна відрізнялися гіршими органолептичними властивостями. Це пов'язано з тим, що різні види борошна по-різному впливають на смакові властивості готового продукту.

Отримані результати досліджень свідчать про доцільність застосування двокомпонентних сумішей борошна. Очікується поліпшення амінокислотного складу продукту, зниження енергетичної цінності за рахунок хімічного складу борошна, застосованого у нових рецептурах.

Завдяки цьому забезпечується можливість отримання хлібу функціонального та дієтичного призначення. У порівнянні з аналогічними відомими рецептурами, розроблені зразки забезпечують такі переваги: поліпшення харчової цінності, покращення органолептичних властивостей продукту.

Ключові слова: *харчова цінність хлібу, показники безпечності, органолептичні показники, двокомпонентна суміш борошна.*

1. Introduction

To meet physiological needs in the diet, traditionally the main place is occupied by bread. The enterprises that produce bread offer a wide range of products that are distinguished by the use of a variety of raw materials to meet the various physiological needs of people, energy and nutritional value, flavor, weight, packaging, etc. [1].

Different needs of consumers (income, preferences, restrictions on the use of various types of bread, availability at points of sale) dictate to producers the direction of forming assortment policy.

According to statistical data, among the most popular types of bread in the first place is wheat bread [1]. The use in the recipe of flour compositions based on the addition of wheat flour with other raw materials solves the problem of providing bread with essentially new consumer properties [2].

Therefore, one of the priority tasks for science and industry is the creation and expansion of an assortment of bakery products with new, for example, health-improving, curative-prophylactic, properties that would meet modern nutritional requirements [3]. That is, the formation and expansion of the assortment of wheat bread is relevant.

2. The object of research and its technological audit

The object of research is wheat bread.

During the audit, 9 recipes of bread were examined, which had such a component composition:

– control, made according to the traditional recipe from wheat flour;

– bread made of wheat flour with the addition of 15 % corn flour;

– bread made of wheat flour with the addition of 7.5 % corn flour;

– bread made of wheat flour with the addition of 15 % buckwheat flour;

– bread made of wheat flour with 7.5 % of buckwheat flour addition;

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– bread made of wheat flour with 15 % of spring wheat flour;
– bread made of wheat flour with 7.5 % of spring wheat flour;
– bread made of wheat flour with the addition of 15 % oatmeal;
– bread made of wheat flour with 7.5 % oat flour addition.

The control sample had high organoleptic properties, but it has disadvantages in terms of nutritional value, as wheat flour differs in chemical composition in comparison with alternative types of flour.

One of the most problematic places is the creation of a rational bread recipe, which would satisfy the consumer in terms of organoleptic characteristics and nutritional parameters.

3. The aim and objectives of research

The aim of research is substantiation of the use of two-component mixtures for the production of wheat bread.

To achieve the aim, the following objectives were accomplished:

1. To determine the organoleptic properties of wheat bread, made from two-component mixtures according to the developed recipes.

2. To investigate the physicochemical parameters (moisture and acidity of the crumb) of the quality of wheat bread.

3. To set the level of toxic elements of wheat bread, made from two-component mixtures according to the developed recipes.

4. Research of existing solutions of the problem

The world practice has established that the following factors influence the expansion of the bread assortment:
– development of new recipes;
– use of components that improve organoleptic performance (appearance, color, odor, taste);
– use of components, which act as functional ingredients;
– improving the technology of making bread [2, 3].

The analysis of information sources showed that the use of various additives goes in several directions: provide a certain flavor of bread; provide the necessary properties for human health [4]. An insignificant part of the total volume of bread production falls on the production of functional, dietary and special purposes [5]. Alternative types of flour are widely used for dietary products, in particular buckwheat, rice, corn, etc. Effects of combining different types of flour on the consumer properties of bread have been devoted to a lot of work, but still a lot of flour compositions have not yet been studied, which encourages the implementation of research in this direction.

It has been established that grains, grain-legumes and oilseeds, as well as spices, products of fruits, berries, vegetables, nuts and even coffee blends are used as different types of raw materials [6]. However, such ingredients significantly increase the cost of production.

As a source of valuable ingredients, included in the mixtures for the production of bread, products of processing of cereals are used. For example, barley, buckwheat, oats, corn, millet, rice, etc. in the form of whole grains, cereals, flour, flakes, bran, meals, extrusion mixtures, etc. [5]. It should be noted that it is extremely important to study the rational ratio of flour in the mixture.

Based on the conducted studies, it is found that oats, buckwheat, rice and corn flour in different proportions affect the technological and biochemical properties of flour mixtures and can be used as enrichers of micronutrients. And also to stabilize the quality of gluten and the number of drops in flour mixtures [7]. For example, oat flour in an amount of 10 % in the formulation is used to enrich lysine, methionine, tocopherol, biotin, natural antioxidants, silicon and magnesium [8]. The use of oat flour is due to the increased amount of macro- and microelements, tocopherol, contained in its composition [9]. Buckwheat flour is used for enrichment with lysine, albumins and globulins, tocopherol, rice – biotin [7]; barley – fiber, tocopherols, calcium and phosphorus β-glucan [10]; corn – biotin, tocopherol, a large content of minerals, lipids, sugars, hemicellulose [11].

In [12], the authors carry out a study of organoleptic and physico-chemical indicators of the quality of bread made from wheat flour composition with the addition of 10, 20 and 30 % barley flour. It is found that the best option among those studied is bread made from the addition of 10 % barley flour. In addition, the addition of barley flour is a promising direction in the development of bread production with increased nutritional value. However, the study does not optimize the bread recipe for all indicators.

Scientific researches [13] prove that 15 % of barley flour is expediently used as a dresser for high-quality wheat flour. However, studies have not established the effect of this ingredient on the organoleptic parameters.

For the production of protein-wheat bread, compositions containing 20 % dry wheat fiber supplemented with 20, 30 and 40 % buckwheat flour are proposed in [14]. As a result of the analysis, the best samples are chosen with the optimum amount of this component – 20 %. In addition, buckwheat flour is actively used in the production of gluten-free bread [15] and to improve the nutritional value of bread. This makes it possible to expand the assortment of bread products of a functional purpose [16, 17]. However, this amount can significantly affect the price of finished products.

Spring wheat is the best source of vegetable protein, its content in soft varieties reaches 14–16 %, and in solid grades – 15–18 % compared to the grain of winter wheat. At the same time, the total amount of gluten in spring wheat flour ranges from 28 to 40 %. Due to the specified features of the chemical composition, spring wheat flour can improve the baking properties of wheat flour with a reduced content of gluten and promote the production of good quality [18]. Such recipe will affect the content of gluten in finished products and work with its allergen.

In work [19] the development of dietary bread «Hercules», which contains 20 % of oatmeal flour, is analyzed. The optimal content of oatmeal (30 %) of the total weight of flour and its influence on the baking properties and nutritional value of mixtures with wheat flour have been determined by research. But in this study, the formulation for organoleptic and physicochemical properties is not optimized.

The conducted studies [20, 21] found that the introduction of corn flour in the formula improves the bread

quality indicators and the optimal amount of wheat flour replacement for corn should be 10 %. However, in the same studies it is found that this formulation leads to a reduction in the volume and shape stability of the bread.

Taking into account the theoretical analysis of the conducted studies, it is promising to develop new types of bread based on two-component mixtures, in particular using spring wheat flour.

5. Methods of research

To determine the quality indicators of wheat bread made from binary mixtures, standard methods for standard documentation are used.

For sensor analysis, an improved rating system is applied, developed on the basis of work [22], which used 5 quality indicators. The improved rating system is taken into account the color index of the crumb. According to the developed system, five basic levels of quality are identified for the evaluation of each indicator, it is investigated:

– 5 points – excellent level of quality;
– 4 points – a good level of quality;
– 3 points – satisfactory;
– 2 points – unsatisfactory;
– 1 point – product of poor quality.

This scale has a description of a specific indicator for each quality level (Table 1).

Table 1

Improved 5-point scale of organoleptic quality assessment of bread

Quality indictors	Point	Characteristic
Appearance: form	5	Correct (not crumpled, not blurry, without lateral sagging)
	4	Correct with light clamps
	3	Slightly vague, or somewhat crumpled
	2	Wrong, blurry or wrinkled
	1	Wrong, vague or wrinkled, with lateral follows, does not correspond to this type of product
surface	5	Smooth, slightly roughened, without blasting
	4	Smooth, allowed slightly wrinkled, mealy, without undermining
	3	Small cracks, mealy
	2	Has cracks, mealy, pronounced rough
	1	Decorative and tearing, considerable mealy
colour	5	Even, corresponds to this product
	4	Fairly uniform
	3	Not homogeneous enough
	2	Uniform, pale or dark, dirty
	1	Burnt, too pale with dirt
crumb condition	5	Soft, gentle, very elastic, dry to the touch. Porosity is uniform, well developed, thin-walled
	4	Soft, elastic, dry to the touch. Porosity is fairly uniform, developed
	3	It is soft enough, elastic enough, hardly moisture. Porosity is not uniform enough, time of different sizes
	2	Slightly elastic, moisture to the touch. Time is not homogeneous; very small or too large large, porosity – thick-walled, there are cavities
	1	Not elastic, very wet to the touch. A large number of cavities, non-mixing
crumb color	5	Pleasant, homogeneous, inherent in a certain product
	4	Homogeneous, inherent in a particular product
	3	Insignificant heterogeneity
	2	Heterogeneous
	1	Uneven, unpleasant
smell	5	Very pleasant, harmonious, inherent in this product, well-pronounced, without strange smells
	4	Pleasant, peculiar to the product, expressed, without strange smells
	3	Expressed, empty
	2	Sour yeast, empty
	1	Musty, unpleasant with strange smells
taste	5	Very pleasant, harmonious, inherent in this product, well-pronounced, without strange taste
	4	Pleasant, peculiar to the product, expressed, without strange taste
	3	Expressed, empty
	2	Sour, yeast, empty
	1	Musty, unpleasant with foreign taste

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Determination of the content of zinc, cadmium, lead and copper is carried out by inversion voltammetry. The method is based on the electrochemical concentration of metals at a constant potential. The measurements are carried out on a voltammetric analyzer ABA-2 (Russian Federation).

6. Research results

The influence of components on the quality indicators of the bread samples obtained is studied by indicators – organoleptic, physico-chemical, content of toxic elements.

During the sensory analysis of the obtained samples of wheat bread, such organoleptic parameters were examined: appearance (shape, surface, color), crumb condition, taste and smell.

To establish the differences between the control and prototypes, the organoleptic characteristics of the obtained bread samples are determined.

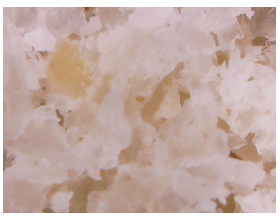
According to the research results, it has been established that the experimental bread samples have an oval and semi-oval shape, light brown color, the surface state – from smooth to rough, wrinkled, bumpy (samples 5 and 8 show cracks). The state of the crumb is characterized as a moderately thin-walled uniform (samples 7–9), moderately coarse, uniform (samples 5, 6), moderately thick-walled (samples 3, 4), moderately coarse, uneven (sample 1). The color of the crumb of the prototypes varies from white with a yellowish tint (samples 1, 3, 7) to light yellow, yellow and golden (samples 2 and 9 and 6) and even gray (samples 4, 5, 8). So, various additives had the greatest influence on the surface, the state of the crumb of the experimental bread samples and its color.

The state of the bread crumb depends on how complete and fast the bread that gets into the stomach and intestines of a person will be absorbed by its body. Well developed, uniform, thin-walled porosity of bread promotes maximum penetration of digestive juices and improves digestibility and digestibility of food.

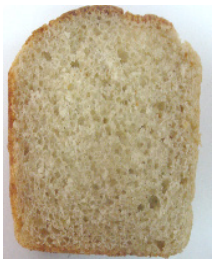
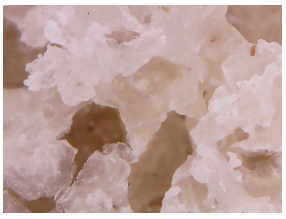
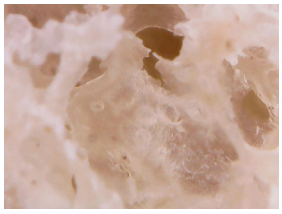
For visualization and a more complete picture of the state of the crumb, a macro- and microscopic study was made of the structure of wheat bread samples obtained by new recipes (Table 2).

Table 2

Macro- and microstructure of crumb of samples of wheat bread made from two-component mixtures

No. of variant	macrostructure	microstructure up to ×500
1	2	3
1	 Porosity is moderately large, uniform	 Mass of coagulated protein in the form of spatial elongated films
2	 Porosity is moderately large, uneven, thick-walled	 The solid mass of the coagulated protein in the form of spatial elongated films
3	 Porosity is moderately large, uniform, thin-walled	 Coagulated protein in the form of three-dimensional branched thin-walled films

Continuation of Table 2

1	2	3
4	 The porosity is large, uniform, moderately thick-walled	 The solid mass of the coagulated protein in the form of spatial elongated films
5	 Porosity is large, uniform, moderately thin-walled	 The solid mass of the coagulated protein in the form of spatial elongated branched thin-walled films
6	 Porosity is moderately large, uniform, moderately thick-walled	 The solid mass of the coagulated protein in the form of spatial elongated films
7	 Porosity is moderately large, uniform, thin-walled	 The solid mass of the coagulated protein in the form of spatial elongated branched thin-walled films
8	 Porosity is moderately large, uniform, thin-walled	 The solid mass of the coagulated protein in the form of spatial elongated films
9	 Porosity is moderately large, uniform, thin-walled	 The solid mass of the coagulated protein in the form of spatial elongated branched thin-walled films

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Microphotographs of crumb samples of wheat bread made it possible to conclude that interporous walls consist of a continuous mass curdled during the baking of the protein in the form of spatial elongated films, with no noticeable individual granules of starch.

It is established that the spatial structure of experimental samples of wheat bread made from two-component mixtures 3, 5, 7, 9 is more branched, thin-walled.

The total score of organoleptic quality indices of samples of wheat bread enriched with various types of flour is shown in Fig. 1.

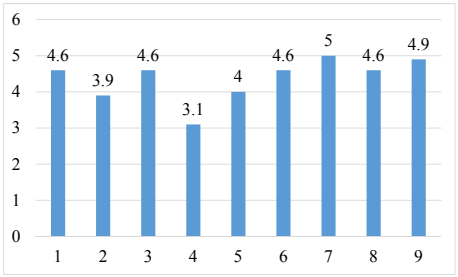

Fig. 1. The total score of organoleptic quality parameters of samples of wheat bread made from two-component mixtures, points

The maximum number of points (5.0), based on the research results, was sample 7. This sample was distinguished by a smooth surface, light brown color, elastic crumb, the porosity of which was moderately thin-walled and uniform. The tasters noted the attractive color of the crumb – white with a yellowish tinge. High scores (4.9) received sample 9 and samples 3, 6 and 8, in which the tasters noted their fineness, uniform porosity and very pleasant crumb color (golden for sample 6 and light yellow for sample 9).

Additions of buckwheat flour degrade the organoleptic properties of the experimental bread samples. The most negative changes were the color, which in the samples was characterized as gray. Tasters also noted the presence of a wrinkled surface and thick-walled porosity, which affected the average score, which for sample 4 was 3.1 points, and for sample 5, 4.0 points.

In 3.9 points, sample 2 was evaluated, which should slightly wrinkled, hilly surface, the crumb porosity was moderately large, uneven. Tasters liked less and expressed yellow crumb color.

The final stage of the organoleptic evaluation of samples of wheat bread made from two-component mixtures was the construction of petal diagrams depending on the content of the components (Fig. 2).

The moisture content and acidity of the crumb of the obtained bread samples were determined according to the standard methods stipulated in GOST 7517:2014. These indicators have a significant effect on the quality of bread. With increased humidity, the nutritional value of bread decreases, it is absorbed by the body worse, it is easily deformed, it becomes more moldy and sick; at low humidity, the crumb becomes too dry, slightly elastic, brittle, and the taste of the products deteriorates. Increased and reduced acidity affects the taste of bread that becomes too acidic or fresh.

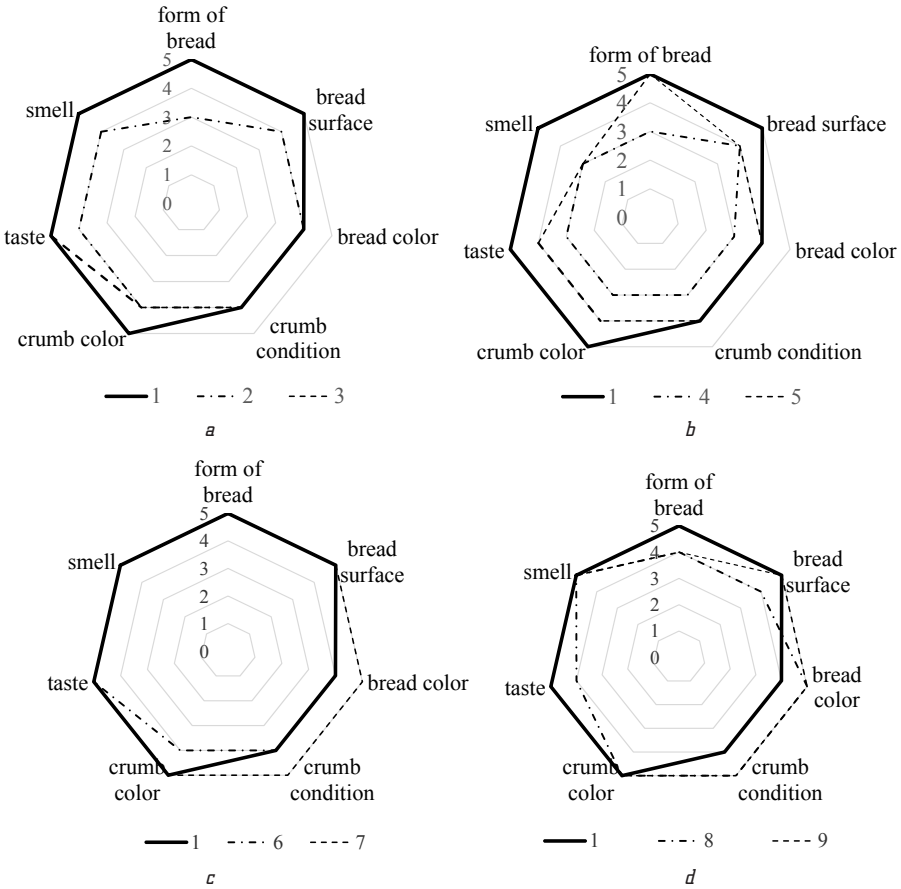

Fig. 2. The petal diagram of samples of wheat bread made from two-component mixtures: *a* – with corn flour; *b* – with buckwheat flour; *c* – with flour of spring wheat; *d* – with oat flour

During the moisture determination (Fig. 3), it is found that for all the obtained samples of wheat bread this indicator was within the permissible limits according to the normative documentation (35.7–45.8 %).

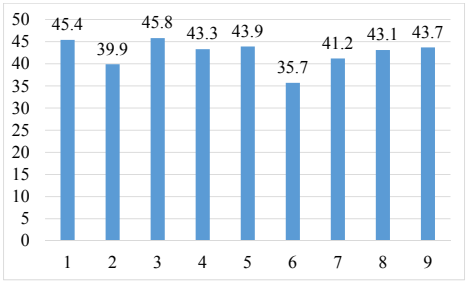

Fig. 3. Moisture of the crumb of the obtained samples of wheat bread made from two-component mixtures, %

In addition, it is found that with increasing the proportion of other flour, the moisture of the crumb decreases (Fig. 4). So for corn flour the decrease is 14.8 %, and for the wheat flour – 15.4 %.

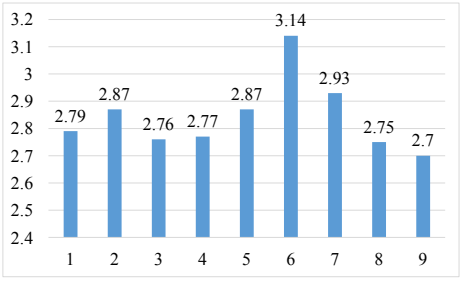

Fig. 4. Acidity of the crumb of experimental samples of wheat bread made from bicomponent mixtures, deg

As can be seen from Fig. 4, the acidity of the crumb of the experimental samples of wheat bread made from two-component mixtures varies from 2.7° (sample 9) to 3.14° (sample 6), which corresponds to the quality indicators according to the normative documentation.

The definition of toxic elements is important when it comes to food safety. The content of these compounds is of particular importance in products of daily use, including in bakery products. Lead and cadmium are among the most dangerous toxic metals, zinc and copper become dangerous when the intake exceeds the permissible daily dose. Lead and cadmium are among the most dangerous toxic metals, zinc and copper are becoming dangerous when the amount in the food ration exceeds the permissible daily dose. The danger of lead lies in the negative effect on the activity of the nervous system of man as a whole. At present, the main sources of this trace element include hazardous wastes from many industrial enterprises, blowing out gasoline, some pesticides. The toxicity of cadmium exceeds the harmful effect of lead, due to its ability to gradually accumulate in various tissues of the body. The excessive amount of cadmium negatively affects the metabolism of iron and calcium, and is also a cause of complex poisoning and dangerous diseases.

Conducting voltammetric analysis allowed to determine the levels of toxic elements in wheat bread samples, made from two-component mixtures (Table 3). The content of zinc, copper, lead, cadmium is determined.

Table 3

The results of the analysis of the level of toxic elements in wheat bread samples made from two-component composite mixtures

No. of variant	Zn content. mg/kg		Cd content. mg/kg		Cu content. mg/kg		Pb content. mg/kg	
	MPL	measured	MPL	measured	MPL	measured	MPL	measured
1	25.0	4.49	0.05	0.01	5.0	2.83	0.3	0.04
2		3.87		0.01		3.36		0.04
3		2.91		0.02		4.21		0.02
4		4.38		0.02		4.78		0.05
5		2.81		0.01		4.85		0.01
6		2.71		0.01		3.34		0.02
7		5.39		0.01		2.83		0.02
8		5.21		0.02		3.93		0.02
9		5.17		0.02		3.97		0.05

Note: MPL – maximum permissible level.

All the samples of wheat bread, made of two-component composite mixtures, tested had a level of toxic elements (Zn, Cd, Cu, Pb) within the limits of normative values. Separately, it should be noted samples in which to use buckwheat flour. In these samples an increased level of Zn, Cu and Pb – sample 4 and Cu in sample 5 was noted. This may be due to the agrotechnics of buckwheat cultivation.

7. SWOT analysis of research results

Strengths. The developed bread recipes have advantages over traditional ones, since alternative types of flour offered in new formulations differ in their better amino acid composition compared to wheat flour. It is established that additives are used to influence the formation of the state of crumb of bread. In particular, the porosity of the bread crumb, as well as the color and surface of the products.

The inclusion of two-component flour mixtures from spring wheat grain promoted the formation of an elastic crumb, characterized by a moderately thin-walled and uniform porosity and a pleasant light yellow color. The obtained products were characterized by a smooth surface. Bread of a mixture of wheat and oat flour was light-yellow color, the crumb had a homogeneous, thin-walled porosity. Corn flour, the amount of which in the mixture was 7.5 %, provided the products with an attractive golden color, promoted the formation of an elastic crumb with a thin-walled, uniform porosity.

The content of toxic elements – lead, copper, zinc, cadmium did not exceed the permissible limits in the samples, where one of the components was selected for the flour of spring wheat, corn and oatmeal. The use of buckwheat flour resulted in an increase in the content of these metals in the finished product.

Weaknesses. Additions of buckwheat flour in the amount of 7.5 and 15 % deteriorated the organoleptic properties of the experimental bread samples, had a wrinkled surface, thick-walled porosity and an insufficiently attractive gray color.

In the case where the content of corn flour was increased to 15 %, a slightly wrinkled, hilly surface of the bread was found, the crumb porosity was moderately

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large, not uniform. Tasters liked less and expressed yellow crumb color.

A significant disadvantage of this study is that the cost of the developed samples has increased in comparison with the control sample, since the cost of the proposed types of flour is higher.

Opportunities. Opportunities for further research are a detailed study of the nutritional value of the products obtained (fatty acid, amino acid, vitamin and mineral composition). The developed samples can be used by the enterprises of the bakery industry in order to expand the assortment of products for functional purposes. The proposed recipes can be introduced into production not only in Ukraine, but also abroad.

Threats. The main threats are the cost price of the proposed samples in comparison with traditional bread. Eliminate this risk by reducing energy costs for production. Another threat is that consumers are accustomed to bread from wheat flour, but to establish the demand for developed samples, it is necessary to conduct marketing research.

8. Conclusions

1. The use of other types of flour in the recipe (together with the main raw material – wheat flour) affects the organoleptic properties of the finished bread. The additives used most influence the surface, the state of the crumb of the experimental bread samples and its color. The best organoleptic properties were bread, the composition of the recipes was added wheat flour in the amount of 7.5 % (5.0 points) and 15 % (4.8 points). A high score was given to bread from a mixture of wheat and oat flour (7.5 %), which according to the results is taken into account in rating received 4.8 points. The negative influence on the quality of bread is a supplement to wheat flour 15 % corn (average grade is 3.4), the prototype had a moderately large, uneven porosity, hilly surface, yellow crumb color. Additions of buckwheat flour in the amount of 7.5 and 15 % also worsened the organoleptic properties of the experimental bread samples. The most negative changes were the color, which in the samples was characterized as gray.

2. Humidity of the crumb of bread samples is in the range from 35.7 to 45.8 %, which corresponds to the requirements of the current regulatory documentation. The maximum moisture should be bread with additives of corn flour and spring wheat flour. The acidity of the crumb of the prototypes corresponds to the standard and varies depending on the type of bread from 2.7 to 3.14°.

3. Samples of wheat bread made from two-component composite mixtures, in which corn, oatmeal and spring wheat flour were used as additional raw materials, had a level of toxic elements (Zn, Cd, Cu, Pb) within the limits of normative values. Experimental samples of bread, the composition of which consisted of buckwheat flour, differed in elevated levels of Zn, Cu and Pb (sample 4) and Cu (sample 5). This may be due to the cultivation of buckwheat.

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