Представлено результати дослідження впливу шротів зародків пшениці (ШЗП) та вівса (ШЗВ) у кількості 10…20 % і шроту плодів шипшини (ШПШ) у кількості 2…6 % від маси борошна на процеси дозрівання житньо-пшеничного тіста та на якість хліба.

Доведено, що високий вміст у ШЗП, ШЗВ та ШПШ поживних для молочнокислих бактерій речовин сприяє збільшенню титрованої кислотності дослідних зразків тіста на 12,1…25,8 %, 6,1…21,2 % та 9,1…22,9 % відповідно. За рахунок активації дріжджів прискорюється спиртове бродіння. У тісті з додаванням ШЗП, ШЗВ та ШПШ кількість виділеного за період бродіння вуглекислого газу більше, ніж у контрольного зразка на 23,7…49,2, 16,9…33,9 та 20,0…40,0 % відповідно. Проте дослідні добавки по різному впливають на зміну об'єму тіста. За додавання шротів зародків вівса та плодів шипшини об'єм тіста після дозрівання збільшується на 7,3…21,9 % та 7,8…22,3 % порівняно з контрольним зразком, що пов'язане з підвищенням його газоутримуючої здатності. В той же час, за додавання шроту зародків пшениці об'єм тіста, навпаки, знижується на 9,8…31,7 % із-за його високої ферментативної активності.

Відмічається, що вплив дослідних шротів на процеси дозрівання житньо-пшеничного тіста відіграє важливу роль у формуванні якості готових виробів. На підставі результатів дослідження фізико-хімічних показників якості житньо-пшеничного хліба з додаванням ШЗВ та ШПШ встановлено, що його пористість, питомий об'єм,і формостійкість підвищується порівняно із контрольним зразком відповідно на 5,0…11,7, 10,0…25,0, 6,7…15,6 % за додавання ШЗВ, та на 10,0…13,0 %, 10,0…30,0 %, 9,0…33,0 % – у зразках із ШПШ. Тоді як внесення ШЗП веде до зниження зазначених показників якості хліба. Негативний ефект посилюється за мірою збільшення добавки в системі.

Встановлено, що за додавання максимальної кількості шроту зародків вівса (20 %) та шроту плодів шипшини (6 %) у хлібі з'являється надто виражений присмак добавок. Тому для забезпечення високих органолептичних показників якості житньо-пшеничного хліба доцільним є застосування шротів зародків пшениці або вівса у кількості не більше 15 %, а шроту плодів шипшини – не більше 4 % від загальної маси борошна

Ключові слова: житньо-пшеничний хліб, шрот зародків пшениці та вівса, шрот плодів шипшини, мікробіологічні процеси, показники якості

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STUDYING THE INFLUENCE OF MEATS FROM WHEAT AND OAT GERMS, AND ROSE HIPS, ON THE FORMATION OF QUALITY OF RYE-WHEAT DOUGH AND BREAD

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1. Introduction

An important problem of our time is the rapid spread of diseases of an alimentary nature caused by insufficient consumption of nutrients and biologically active substances necessary for the human body. One of the approaches to solving this problem is the enrichment of food with the necessary physiologically functional ingredients [1, 2], an important source of which is plant raw materials, including fruit and berry [3, 4] and grain [5, 6].

Promising objects for enrichment include bakery products that are traditional in the diets of the population of most countries of the world. Widespread in European countries, including Ukraine, has bread made from a mixture of rye and wheat flour. Therefore, there is an acute problem of increasing the content of physiologically functional ingredients in rye-wheat bread.

A source of plant materials for the enrichment of such an important essential product as bread must meet certain requirements: be affordable, relatively cheap, have high nutritional and biological value, and be produced on an industrial scale. From this point of view, the use of secondary resources of plant origin, such as meal and oilcakes of traditional and non-traditional oilseeds, is relevant in the technology of rye-wheat bread. This is reasonably high in them of complete proteins, dietary fiber, minerals, vitamins and other biologically active substances [5, 6].

Meal and cake are characterized by different chemical composition, enzymatic activity, which mainly depends on the type of feedstock and the characteristics of the technological process of oil production [5]. This leads to a different effect on the processes that occur during the ageing of the dough, and, consequently, on the quality of the finished bread.

In this regard, in studies aimed at creating technologies of bread of high nutritional value using secondary products of oil production, considerable attention is paid to studying its influence on the formation of the quality of products at all stages of the technological process.

2. Literature review and problem statement

It is known to use of flax seed meal in the technology of wheat flour, which is a source of such physiologically functional ingredients as unsaturated fatty acids, lignans and dietary fiber [7]. It has been established that when it is added, the composition of the liquid phase of the dough improves, and it helps to intensify microbiological processes. However, the introduction of flax meal is accompanied by a decrease in the gas-retaining ability of the semi-finished products and, as a result, a decrease in the specific volume, shape stability and porosity of the finished products [8]. This effect limits the amount of flaxseed meal in bread recipes to 5 % by weight of flour.

The possibility of using partially fat-free (FPF) walnut flour, sesame meal and pumpkin meal in the technology of rye custard bread is studied [9]. These types of FPF are natural concentrates of valuable proteins, fats, dietary fiber, a wide range of trace elements. However, it is experimentally established that the recipe amount of BSH from walnut in bread production should be limited to 2 %, and FPF of sesame meal and pumpkin meal to 4 %, since large doses of this enrichment raw material lead to a deterioration in the structure of bread, a decrease in its porosity and specific volume deterioration in taste.

In the literature there is information about the use of pumpkin meal obtained by extrusion processing of pumpkin seeds in the technology of wheat and rye-wheat bread. It is established that this additive has a different effect on the properties of the dough semi-finished products, affects the quality of wheat [10] and rye-wheat [11] products. It is proven that to obtain high-quality wheat bread, it is advisable to use 5 % meal, since its large doses cause a significant increase in the viscosity of wheat dough. And for the production of bread from a mixture of rye and wheat, a higher amount of the additive is recommended – 5–7 %, since an increase in the viscosity of rye-wheat dough has a positive effect on the quality of the bread.

The disadvantage of the above technologies is insignificant doses of secondary oil-seed meal, which fully solves the problem of bread enrichment.

In [12], it is proposed for the production of wheat bread to use powder from cedar oil meal containing biologically valuable polyunsaturated acids, dietary fiber, and other ingredients useful for human health. The authors show that adding cedar meal in the amount of 15 % by weight of flour helps to improve the quality of bread. However, this raw material has a high cost, will affect the cost of products.

Potential raw materials for enriching bread with physiologically functional ingredients are secondary products of wheat germ processing using germ oil technology. Wheat germ is a unique raw material with a high content of biologically valuable protein, B vitamins, vitamin E, antioxidants. However, in their native form, wheat germ is not always used, as it has short shelf life due to the high content of polyunsaturated fatty acids capable of rapid oxidation and can negatively affect the quality of products [13–15]. In [16], it is shown that native wheat germ, even in a small amount (up to 4 %), contribute to the deterioration of the quality of bread.

Seed meal and wheat germ obtained after the removal of germ oil, almost fat-free products, in which the beneficial ingredients laid down by nature are maximally preserved.

In [17, 18], the possibility of using wheat germ meal in wheat grain bread technology is investigated. It is established that its introduction leads to an improvement in the quality and antioxidant activity of products, an increase in the degree of digestibility of bread proteins.

Of particular interest for bread enrichment is the use of wheat germ meal obtained in the process of obtaining oil by low-temperature extraction, which is the key to the maximum preservation in it of the natural content of biologically active and nutrients. The work [19] proves the feasibility of its use in the technology of wheat bread in an amount of 10–20 % by weight of flour. It is established that a significant content of high hydrophilic substances ensures its great water-clay ability. The high activity of amylases and meal proteinases leads to a decrease in the viscosity of the dough, which limits its use in unprotected bread technology to 15 % by weight of flour. The presence of amino acids, vitamins, and minerals in the composition leads to the activation of fermentation microflora and, as a result, to a more intensive course of microbiological processes in the dough, which reduces the duration of the dough fermentation [5, 20].

A promising raw material for increasing the nutritional and biological value of bread is oat germ meal. According to the chemical composition, meal contains a significant amount of protein (23.0 %), dietary fiber (23.3 %) of minerals and vitamin [21]. An important component of non-starch polysaccharides of oat germ meal is physiologically valuable β-glucans, which exhibit a potent immunostimulating effect [22], help to prevent the development of cancer, reduce the glycemic index of starch-resistant products, and the like.

The authors of [21] found that the addition of 15 % of the meal of oat germ by the unpaired production method allows to obtain wheat bread with the necessary physicochemical quality indicators and enrich the finished product with protein, dietary fiber, antioxidants, vitamins and the like.

No data are found in the literature on the effect of the aforementioned wheat and oat germ meal on the processes that occur during the ageing of rye-wheat dough and the quality of the finished bread. Given the differences in the ageing processes of wheat and rye-wheat dough [23], it is possible to assume an excellent influence of meal on the formation of the quality of finished rye-wheat products, therefore, studies in this direction are advisable.

In order to improve the technology of bread of high nutritional value, it is a search for new natural enrichment additives, which simultaneously acted as both an enrichment agent and a quality improver.

In this regard, of interest is the rosehip meal – a secondary product in the technology of rosehip oil. It is known that in the wild rose, which has long been a symbol of health, a significant amount of mineral substances, antioxidants, primarily ascorbic acid, is concentrated [23].

No information was found in the literature on the use of rosehip meal in bakery production. However, there are some data on the use of other products of rosehip processing for this purpose.

So, in [24], the possibility of using the dried aqueous extract of rosehip meal in the amount of 3 % by weight of flour in the production of grain bread was investigated. It has been established that its addition contributes to some improvement in porosity and specific volume of bread, however, the chemical composition of the products does not change significantly.

The authors of [25] considered the possibility of using aqueous or whey extracts of rosehips to a mass of wheat flour. This helps to reduce the duration of the dough ageing due to the activation of fermentation microflora in the presence of additional nutrients, as well as the production of wheat bread with high physico-chemical quality indicators.

It has been proven to improve the dough spreadability, porosity and specific volume of wheat bread for the use of 5 % rosehip powder [26] or in combination with mountain ash powder in an amount of 1–3 % [27]. According to researchers, this is due to the strengthening of gluten under the action of ascorbic acid contained in the studied powders. These data indicate the feasibility of attracting new products from rosehips, namely, rosehip meal to increase nutritional value and improve the quality of bread, in particular rye-wheat.

Thus, an analysis of literary sources on the use of wheat and oat germ meal in bread technology [13–22] and rosehip meal [24–27] indicates the feasibility of studying their effect on the ageing of rye-wheat dough and the quality of finished products.

3. The aim and objectives of research

The aim of research is determination of the influence of meal of wheat, oats and rosehips on the formation of the quality of rye-wheat dough and bread.

To achieve this aim, the following objectives are formulated:

– to study the course of ageing processes in rye-wheat dough for the addition of research meal;

– to determine the influence wheat germ (WGM), oats (OM) and rosehips (RHM) meals on the physical and organoleptic quality indicators of rye-wheat bread.

4. Materials and methods for studying the properties of rye-wheat dough and bread

4. 1. Characteristics of raw materials used in research

The studies used peeled rye flour (GOST 7045-90), first grade wheat flour (GOST 46.004-99), wheat germ meal (TU U 20608169.002-99), oats (TU 15.8-32062796-003: 2008) and rosehips, what are the secondary products in the production of the corresponding oils at the enterprise NPP LLC Zhytomyrbioproduct (Ukraine). Data on physico-chemical and organoleptic quality indicators of research meal are given in Table 1.

Pressed yeast (DSTU 4812-2007), table salt (DSTU 3583-2015), dry rye sourdough TM "Puratos Othello Norma" (Belgium) are also used in the work.

Table 1

Physicochemical and organoleptic quality indicators of meal of wheat germ, oats and rosehips

Indicator	Indicator value		
	WGM	OM	RHM
Acidity, degrees	6.0	5.9	53.0
Moisture content, %	12.4	11.4	7.1
appearance	Dry powder product		
color	Light cream	White gray	Brown red
taste	Sweet wheat	oat	Sour, characteristic of rosehips
smell	Wheat	oat	Inherent in rosehips

4. 2. Methods for preparing dough and bread samples

Let's study samples of rye-wheat dough and bread without additives (control sample) and with the addition of wheat germ and oat seed meal in an amount of 10...20 %, as well as with the addition of a rosehip meal in an amount of 2...6 % of the total weight of rye and wheat flour. The experimental dosage ranges of WGM and OM are determined by the analysis of literature on their use in wheat bread technology [25, 30], and the research amount of rosehip meal, is selected on the basis of data on the use of rosehip powder given in [37, 38].

A control sample of dough and bread is made from a mixture of first-grade rye peeled and wheat flour in a 1:1 ratio with the addition of 2.5 % dry rye yeast, 2 % baked pressed yeast, and 1.5 % table salt. The moisture content of the dough is 47 %. During the preparation of test prototypes, wheat germ, oat seed meal, or rosehip meal were added. Considering that research additives have a higher water-clay ability than rye and wheat flour, the moisture content of the dough by adding them is increased by 0.5...1.0 % compared to the control.

Ageing of all dough samples is carried out for 90 min at a temperature of 30±2 °C, after which dough blanks are formed, subjected to aging at a temperature of 32±2 °C and a relative humidity of 80±5 %, and baked at a temperature of 210±10 °C within 25±2 minutes

4. 3. Research methods for the properties of rye-wheat dough and bread

The titratable acidity of the rye-wheat dough is determined by titration with 0.1 n sodium hydroxide according to the procedure described in [23].

The gas-releasing ability of the dough is determined on a Yago-Ostrovsky device by the total amount of CO_2 emitted during fermentation [23]. For this, a test sample made from 100 g of flour is placed in a 5 dm^3 flask. The flask with the dough is closed with a rubber stopper with a tube connecting it to a flask filled with a saturated solution of sodium chloride. The device is placed in a thermostat with a temperature of 30 °C. The carbon dioxide emitted during the fermentation of the dough entered the flask with sodium chloride and forced it into the measuring cylinder The gas-releasing ability of the dough is determined by the amount of carbon dioxide displaced, which is measured every 30 minutes for 90 minutes of dough fermentation.

The change in the volume of dough during its ageing is determined as follows: 50 g of dough is placed in a graduated cylinder with a volume of 250 cm^3, which is covered with plastic wrap and placed in a thermostat with a temperature of 30±2 °C for 90 min for fermentation. Measurements of changes in the volume of dough in the cylinder are carried out every 30 min.

After complete cooling, baked bread is determined physic-chemical and organoleptic quality indicators.

Physico-chemical indicators of product quality, such as humidity, titratable acidity, porosity, specific volume are determined by standard methods given in [29]. The shape stability of the products was determined by calculating the ratio of height to the diameter of the hearth bread (H/D) [23].

Organoleptic indicators of bread quality (appearance, color and condition of the crust, crumb condition, taste, smell) are determined according to generally accepted methods by evaluating the shape and surface of the products, the color of their crust and crumb, the state of porosity and elasticity of the products, and also assessed the taste and smell bread [29].

4. 4. Statistical processing of research results

The error for all studies is σ=3...5 %, the number of repetitions of the experiments is n=5, and the probability is $p\geq 0.05$. The experimental data are processed statistically by the Fischer-Student method at a reliability level of 0.95. Research results are calculated as an average of at least five replicates. To process the experimental data, let's use the MS Office 2016 application package version, including MS Excel 2016.

5. Research results of the influence of research meal on the ageing processes of rye-wheat dough and bread quality

5. 1. Research on the course of ageing processes in rye-wheat dough for the addition of research meal

A key role in shaping the quality of bread is played by the processes that occur during the ageing of the dough. So, lactic acid fermentation products – lactic and other acids – are involved in providing the organoleptic, physico-chemical and structural-mechanical properties of the dough and finished products. The main indicator of the readiness of the dough for cutting is titratable acidity, reflecting the total acidity due to all acids and acidic compounds that are contained in the dough. On the intensity of alcoholic fermentation, the gas-retaining ability of the dough, the looseness and volume of the dough pieces, and therefore the volume of bread, the nature of its porosity, largely depends.

In this regard, the effect of WGM, OM, RHM on the change in titratable acidity, the amount of carbon dioxide and volume released during the fermentation of the dough was studied.

The results of a set of studies are presented in Table 2 and in Fig. 1–3.

The analysis given in Table 2 data indicates that the addition of research meal leads to both an increase in the initial titratable acidity of rye-wheat dough and to a more intense change during ageing. So, at the end of the experiment, the value of this dough indicator with the addition of WGM, OM and RHM is higher than that of the control sample by 12.1...25.8 %, 6.1...21.2 % and 9.1...22.9 % respectively.

Alcohol fermentation is also accelerated during the dough ageing with the addition of research meal, as evidenced by the results of determining gas formation. According to the data obtained, the greatest influence on the value of this indicator is observed from the pressure of 10...20 % of the meal of wheat germ – the amount of CO_2 released in these dough samples is higher than that of the control by 23.7...49.2 % of oats and rosehips leads to an increase in the amount of carbon dioxide released by 16.9...33.9 and 20.0...40.0 %, respectively.

Along with the intensity of gas generation, the looseness of the dough, porosity and volume of finished products are significantly affected by the dough ability to retain the released CO_2. One of the characteristics of this process is the change in the volume of dough during ageing.

Table 2

The influence of meal of wheat germ, oats and rosehips on the change in titratable acidity and the amount of CO_2 emitted in rye-wheat dough (n=5, $P\geq$0,95, σ=3...5 %)

Indicator	Characteristic of the indicator in rye-wheat dough									
	no additives (control)	with the addition of research additives, % of the total mass of flour								
		WGM			OM			RHM		
		10	15	20	10	15	20	2	4	6
Titratable acidity, degrees										
initial	4.5	4.6	4.7	4.8	4.6	4.7	4.8	4.8	5.0	5.2
ultimate	6.6	7.4	7.8	8.3	7.0	7.5	8.0	7.2	7.7	8.1
Amount of CO_2 emitted in 90 min, cm^3/g	590	730	820	880	690	754	790	710	790	830

It is established that experimental meal has a different effect on this indicator (Fig. 1–3). Thus, the addition of meal of oat embryos and rosehips contributes to an intensive change in the volume of dough during the experiment (Fig. 1, 2), and this effect increases with increasing dosage. 90 min of fermentation, the dough volume of prototypes with WGM and RHM increases by 7.3...21.9 and 7.8...22.3 % compared with this indicator in the control sample, respectively.

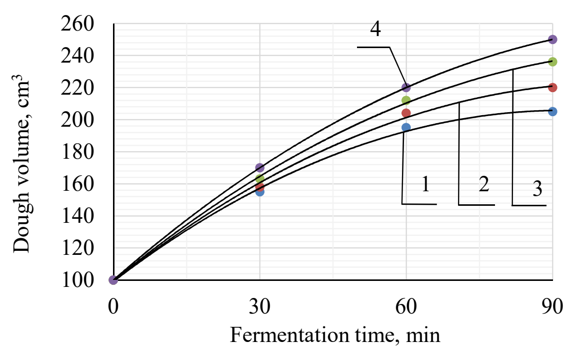

Fig. 1. Change in volume during the ageing of rye-wheat dough: 1 – no additives (control); with the addition of oat germ meal in the amount of 2, 3, 4 – 10, 15, 20 % by flour weight

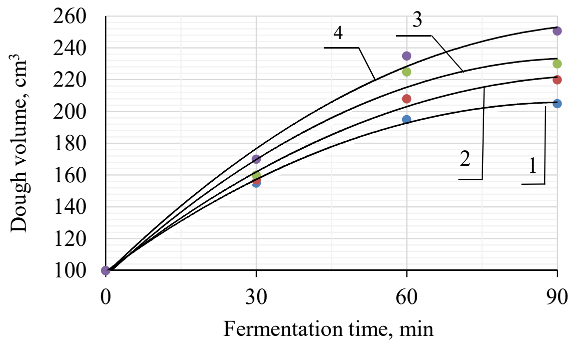

Fig. 2. Change in volume during the ageing of rye-wheat dough: 1 – no additives (control); with the addition of meal of rosehips in the amount of 2, 3, 4 – 2, 4, 6 % by flour weight

At the same time, for the addition of 10...20 % of WGM, the dough volume, on the contrary, decreases by 9.8...31.7 % as its dose increases.

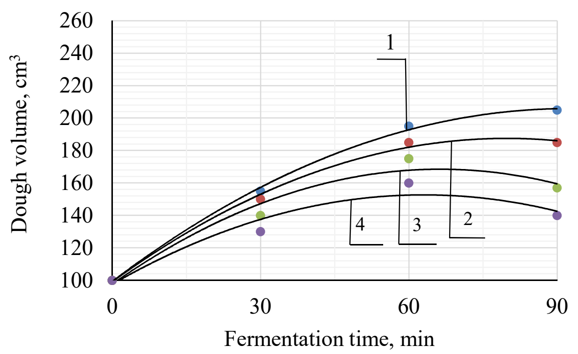

Fig. 3. Change in volume during the ageing of rye-wheat dough: 1 – no additives (control); with the addition of meal of wheat germ in an amount of 2, 3, 4 – 10, 15, 20 % by flour weight

5. 2. Determination of the influence of meal of wheat germ, oats and rosehips on the physico-chemical and organoleptic quality indicators of rye-wheat bread

To determine the effect of meal of wheat germ, oats and rosehips on the physicochemical and organoleptic quality indicators of rye-wheat bread, laboratory baking of products is carried out with the addition of additives in the study dosage range.

The results of studies of physical and chemical indicators of bread quality are presented in Table 3.

Data in Table 3 indicate that the addition of 10...20 % of the meal of the germ of wheat, oats and 2...6 % of the meal of the rosehips increases the humidity of the finished products. Their acidity also grows by 8.3...21.7, 6.7...16.7 % and 5.0...20.0 %, respectively.

At the same time, additives affect porosity, specific volume and shape stability of bread in different ways. For the addition of meal of oat embryos in the research dosage range, their value increases by 5.0...11.7, 10.0...25.0 and 6.7...15.6 % relative to the control. A similar trend is observed for the introduction of rosehip meal into the rye-wheat dough. As its dose increases, the porosity, specific volume and shape stability of bread increases by 10.0...13.0 %, 10.0...30.0 % and 9.0...33.0 %, respectively.

Table 3

The influence of meal of wheat germ, oats and rosehips on the physic-chemical parameters of rye-wheat bread (n=5, p≥0.95, σ=3...5 %)

Enrichment dosage, %	Quality indicators and their values				
	Humidity, %	Acidity, degree	Porosity, %	Specific volume, cm/100 g	Form resistance (H/D)
No additives (control)	46.2	6.0	60.0	2.0	0.45
Bread with WGM, % by weight of flour					
10	46.7	6.5	59.0	1.9	0.42
15	47.1	6.9	58.0	1.7	0.39
20	47.6	7.3	55.0	1.5	0.34
Bread with OM, % by weight of flour					
10	47.0	6.3	63.0	2.2	0.48
15	47.5	6.8	65.0	2.4	0.50
20	47.8	7.0	66.0	2.4	0.51
Bread with RHM, % by weight of flour					
2	46.6	6.4	62.0	2.2	0.49
4	46.9	7.0	66.0	2.5	0.53
6	47.2	7.4	68.0	2.6	0.60

However, the introduction of wheat germ meal negatively affects the listed quality indicators of rye-wheat bread. When it is added in the amount of 10 and 15 %, the listed indicators are reduced by 3.0 and 5.0, 5.0 and 10.0 and 10.0 and 13.3 %, respectively. The presence in the dough of the maximum number of WGM (20 %) contributes to a significant deterioration in the quality of bread. In this sample, the porosity, specific volume and dimensional stability of the products are 8.3; 25.0 and 24.4 % lower than that of the control sample.

One of the key characteristics of the quality of bread is its organoleptic characteristics. It is established that experienced meal affects such indicators as the state of the crumb, color, taste and aroma of the products. So, as the dosage of meal of oat embryos and rosehips increases, the elasticity of the bread crumb increases, its porosity becomes more developed. At the same time, the bread crumb becomes less elastic, and the porosity becomes more coarse and thick-walled due to the introduction of the meal of wheat germ. It should be noted that for the addition of this additive in an amount of 20 %, the most pronounced negative effect on the state of the bread crumb is observed, which becomes weakly elastic with poorly developed porosity, which does not allow the use of dosing additives in further studies.

It is determined that for making all the research meal, the crust and crumb of the bread acquire a darker color. The addition of meal has a significant effect on the taste and aroma of bread. For introducing the meal of wheat germ seeds throughout the study dosage range, and the meal of oat germ and rosehips in the amount of 10 and 15 and 2 and 4 %, respectively, a pleasant aroma and taste characteristic of additives appears in the products, and the taste is more acidic compared to the control sample. Bread with a maximum amount of oat germ meal (20 %) has a pronounced oatmeal aroma and an unpleasant bitter taste, which does not allow to recommend this dosage for further research. Also impractical is the use of 6 % meal of rosehips in the technology of rye-wheat bread, as this leads to the appearance of too sour taste.

6. Discussion of the research results of the influence of investigated meal on the quality of rye-wheat dough and bread

As a result of the determination of the influence of meal of wheat, oat and rosehip seeds on the ageing of rye-wheat dough, it is found that their addition over the entire dosage range contributes to the intensification of lactic acid and alcoholic fermentation (Table 2). This is probably due to the activation of lactic acid bacteria and baker's yeast due to the introduction, together with the meal, of an additional nutrient-rich medium for fermentation microflora, namely proteins, vitamins, and minerals.

According to the data obtained, the initial titratable acidity of rye-wheat dough with meal is higher compared to the same control indicator, due to the higher acidity of the research meal compared to rye and wheat flour (Table 1). At the same time, in the test dough samples, as compared with the control one, a more intense acid accumulation during ageing is observed (Table 2), which confirms the activation of fermentation microflora.

The activation of fermentation microflora in the dough is also evidenced by the amount of carbon dioxide released during the ageing of test dough samples (Table 2). However, to obtain high-quality products, it is also important how much the released gas is able to be held in the dough (Fig. 1–3). It should be noted that the proposed additives have a different effect on the change in the volume of rye-wheat bread, which is associated with their chemical composition, the activity of enzymes in them and other functional and technological characteristics [19, 25, 30]. It has been established that the addition of oat germ meal and rosehip flakes contributes to a more intensive change in the volume of dough. Such action of these additives on this indicator can be caused by a number of factors. Both meals contain a significant amount of non-starch polysaccharides, contributes to an increase in bound moisture in the dough and positively affects its structure. In samples with a fraction of rosehips, the improvement in the volume of rye-wheat dough is largely associated with the strengthening of gluten of wheat flour under the action of ascorbic acid. It is known that ascorbic acid, turning into dehydroascorbic acid in the dough, oxidizes the SH groups of gluten proteins, proteolytic enzymes and proteolysis activators, thereby reducing the proteolysis intensity in the dough [40].

At the same time, a negative effect of wheat germ meal on the change in the volume of dough is noted, caused by enzymatic hydrolysis of starch of rye and wheat flour due to the significant activity of α-amylase in this additive [25]. This negatively affects the technological parameters of flour.

The influence of meal on the ageing processes of rye-wheat dough is determined in the paper affects the quality of bread. According to the above data (Table 3), the introduction of all the proposed meal makes the products moister due to the high water-clay ability of the additives due to the significant content of non-starch polysaccharides in them. An increase in the acidity of bread with additives is also noted. This is especially noticeable in samples with a fraction of wheat germ and rosehips, which is associated with the intensification of acid accumulation in the dough with these additives (Table 2).

The addition of oat seed meal and rosehip meal to the dough in the entire proposed dosage range improves the quality indicators of finished products, such as porosity, specific volume, shape stability (Table 3), which can be explained by the large amount of CO_2 emitted in the test dough samples (Table 2) and the best ability to hold it (Fig. 1, 2).

For the addition of meal of wheat germ, a different trend is observed, namely, there is a deterioration of these indicators. The effect is enhanced with an increase in the amount of meal in the dough. This is probably caused by a decrease in the gas-retaining ability of the dough with its addition, especially in an amount of more than 15 % (Fig. 3).

The introduction of all the proposed meal has a significant impact on the organoleptic characteristics of the products: their crust and crumb acquire a darker color, the crumb state, the taste and aroma of bread change. Organoleptic analysis showed that bread with the maximum amount of oat germ meal (20 %) has too pronounced oatmeal aroma and an unpleasant bitter taste, and the use of 6 % of rosehip meal in the technology leads to a too sour taste. All these characteristics make further research with the proposed meal in the above doses not appropriate. Therefore, it is proposed in further studies to use the meal of wheat and oat embryos in the amount of 15 %, and the meal of rosehips – 4 % of the total mass of flour.

In the future, the feasibility of sharing WGM mixed with RHM will be considered. Such a technological solution can have a positive effect due to the high content of ascorbic acid and other organic acids in the RHM, which is likely to reduce the activity of amylolytic and proteolytic enzymes of WGM.

7. Conclusions

1. It is found that the introduction of wheat and oat germ meal, in a quantity of 2–6 % of the total weight of flour, of rosehip, helps to intensify the ageing of rye-wheat dough This is indicated by higher indicators than in the control samples its titratable acidity by 12.1...25.8 %, 6.1...21.2 % and 9.1...22.9 %, and the amount of carbon dioxide released by 23.7...49.2 %, 16.9...33.9 and 20.0...40.0 %, respectively. The volume of fermenting dough for adding the meal of oat embryos and rosehips is higher than that of the control sample by 7.3...21.9 % and 7.3...22.3 %, which is associated with both intense gas formation and increasing its gas retention capacity. At the same time, for the addition of wheat germ meal, the dough volume, on the contrary, is lower than in the control sample by 9.8...31.7 %, which is caused by the deterioration of the dough structure due to the high enzymatic activity of this meal.

2. As a result of determining the physicochemical and organoleptic quality indicators of rye-wheat bread with the addition of research additives, it is found that, to ensure its high quality, it is advisable to use wheat germ or oat meal in an amount of not more than 15 %, and meal of rosehips – not more than 4 % of the total mass of flour.

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