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STUDYING THE EFFECT OF THE INTEGRATED BREAD BAKING IMPROVER "MINERAL FRESHNESS SUPER" ON CONSUMER PROPERTIES OF WHEAT BREAD

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Одним із основних показників споживних характеристик хлібобулочних виробів є тривалість зберігання свіжості, особливо не упакованих. В Національному університеті харчових технологій (Україна) розроблено комплексний хлібопекарський поліпшувач «Мінеральна Свіжість Супер» до складу якого входять харчові добавки зі статусом GRAS. Комплексний хлібопекарський поліпшувач складається з функціональної основи – білої фармакопейної глини та активної частини – ферментних препаратів Alphamalt VC 5000 та Новамі 1500MG, мальтодекстрину, лецитину знежиреного з соняшнику, яблучного пектину, сухої пшеничної клейковини та аскорбінової кислоти. Доведено технологічну ефективність використання комплексного хлібопекарського поліпшувача «Мінеральна Свіжість Супер» у кількості 1,5 % до маси борошна для уповільнення черствіння хліба пшеничного виготовленого за прискореної технології.

Визначено закономірності впливу комплексного хлібопекарського поліпшувача «Мінеральна Свіжість Супер» на якість хліба пшеничного. Встановлено, що внесення його в тісто призводить до збільшення питомого об'єму виробів, покращання формостійкості, пористості та зменшення в тричі тривалості бродіння, а саме – до 20 хв.

Доведено, що вироби з доданням комплексного хлібопекарського поліпшувача «Мінеральна Свіжість Супер» краще зберігають свіжість, що підтверджено збільшенням загальної деформації м'якушки, меншим підскоринковим шаром та меншою кількістю прошарків повітря у м'якушці виробів. Відмічено більше накопичення декстринів та бісульфітзв'язуючих речовини у виробах у разі використання комплексного хлібопекарського поліпшувача «Мінеральна Свіжість Супер», що вказує на гальмування процесів черствіння виробів та покращання споживчих властивостей.

Результати досліджень доводять доцільність використання комплексного хлібопекарського поліпшувача «Мінеральна Свіжість Супер» у технології хліба пшеничного для подовження тривалості його свіжості до 72 год зберігання в не упакованому вигляді

Ключові слова: комплексний хлібопекарський поліпшувач, хліб пшеничний, черствіння, підскоринковий шар, зв'язана волога

1. Introduction

Improving the competitiveness of bread and bakery products necessitates the extension of their product range. To this end, manufacturers of bakery products employ accelerated technologies, nutritional supplements, alternative raw materials [1]. However, consumers are not satisfied with consumer properties, namely, the taste, flavor, as well as fast staling of bakery products manufactured using accelerated technologies [2].

To improve consumer nutritional properties of baked products, manufactures in the course of the technological process prolong the duration of dough fermentation, use sponge dough, sourdough, chilled semi-finished products, nutritional supplements and alternative raw materials [3].

For the simultaneous adjustment of flour quality, for maintaining the technological process and ensuring the prolonged freshness of bakery products, manufacturers are advised to use integrated bread baking improvers [4].

The range of integrated bread baking improvers is very wide, depending on the effect of their action [5]. In general, integrated bread baking improvers consist of such ingredients as oxidizers and gluten-reducing restorers, enzymes,

emulsifiers, food additives or ingredients with specific effect. All components in an integrated bread baking improver are carefully selected based on their activity and synergic effect among them [7]. Integrated bread baking improvers act over the entire technological process, which is why they are developed to solve specific tasks.

Scientists from the National University of Food Technologies (Ukraine) have developed the integrated bread baking improver "Mineral Freshness Super" to prolong the freshness of bread and bakery products manufactured using accelerated technologies [8]. Its composition includes nutritional supplements, of the GRAS status, that is, they are safe, which is a priority under current conditions [8].

Bread and bakery products, when stored, undergo a deterioration in nutritional properties, due to the transformation of the products' biopolymers. Specifically, the transition of starch from the amorphous state into crystalline, and the loss of part of water by proteins. The result is the lost flavor, worsened taste, crumb of the products becomes fragile, hard, that is, the process of staling occurs [2].

The developed integrated bread baking improver "Mineral Freshness Super" ensures better quality of products baked using accelerated technologies. However, it is a relevant task to explore the effectiveness of its application in order to slow the loss of nutritional properties by bread and bakery products during storage.

2. Literature review and problem statement

Integrated bread baking improvers are used to adjust the baking properties of flour, to intensify the technological process, stabilize quality indicators of baked goods, to improve their quality when using accelerated technologies [9]. These are the multicomponent mixtures that consist of a functional base, throughout which the active component is evenly distributed. In addition, integrated bread baking improvers are applied for making frozen semi-finished foods and products [9, 10], to inhibit staling processes, and to extend the range of bread and bakery products. Development of integrated bakery improvers involves both scientists, aimed to solve actual problems, and commercial organizations that represent the market of ingredients and food additives for the bread-baking industry. The range of integrated bakery improvers is very wide and they are grouped based on their effect. To improve nutritional properties of bakery products, it is recommended to use integrated bread baking improvers, intended to prolong the freshness of bakery products.

To retain freshness of bread baked from wheat flour, the Austrian company Backaldrin offers manufacturers the paste-like integrated bread baking improver Super XT. It consists of water, emulsifier, and acetic acid [11]. The company recommends using Super XT in the amount from 1.0 to 5.0 % depending on the product, flour quality, and a dough preparation technique. A given improver prevents the condensation of moisture so that products keep softness and freshness; however, to intensify the technological process, the dosage needs to be increased that makes the finished products more expensive [11].

The firm Zeelandia (Netherlands) offers the integrated bread baking improver "Gamma Soft" to extend freshness of bakery products. This improver consists of soy flour, emulsifier, ascorbic acid, enzymes. It is recommended to dose it in the amount from 1.0 to 3.0 % by weight of flour [12]. The disadvantage of this improver is the presence in its composition of soy flour, which is considered to be a source of allergens by nutritionists.

The company Lessaffre (France) recommends using for long-term storage products the integrated bread baking improver "Magimix" with the white label "Magimix with white label" to extend freshness of wheat bread up to 2 months. It contains specially selected monoglycerides and a fermenting complex, which slow down the process of starch retrogradation and accumulate additional amount of dextrins, owing to which crumb of the products would maintain its properties over a certain period [13]. However, the literary sources do not disclose the formulation of a given improver, so it is not clear whether its application would speed up the technological process.

The company IREKS (Germany) offers manufacturers the integrated bread baking improvers "Grand Beta Plus" and "Ireksol" for the prolonged freshness of wheat bread. The former is used in the case of processing wheat flour, which is resistant to dilution, and the latter in the case of processing wheat flour susceptible to considerable dilution. Dosage of these improvers is 0.2...1.5 % by weight of flour [14]. The disadvantage of using these improvers is that they are limited by flour quality.

The firm PURATOS (Belgium) offers the integrated bread baking improver "Soft'r Premium". The improver's formulation includes patented enzymes and emulsifiers made by PURATOS (Belgium), selected based on the technology for extending freshness of bakery products. This integrated bread baking improver is intended to improve the structural and mechanical properties of dough semi-finished products and to maximally prolong freshness of wheat-based products. Prepared packaged products that contain a given integrated bread baking improver retain their freshness and softness up to 10...14 days [15]. The disadvantage is that the producers keep in secret the composition of the integrated bread baking improver, specifically the enzyme complex.

There is a developed integrated bread baking improver for baking wheat bread from wheat flour of the first and second grades with different baking properties [16]. It consists of the functional base, pumpkin flour, and the active part – ascorbic acid, phosphorus calcium, sulfuric acid ammonium. This improver includes in its composition chemical substances that are not GRAS graded and it does not lead to the intensification of the technological process.

To increase the porosity, volume, to obtain a homogeneous elastic crumb and to extend freshness of finished products, an integrated bread baking improver has been developed [17]. It consists of dry wheat gluten, as a functional base, with the active part composed of ascorbic acid, enzyme preparations with amylolytic and pentazanaic activity, and emulsifier. An analysis of the scientific literature has not shown the way this improver affects the staling process of bakery products.

In the case of processing flour that is resistant to dilution, the authors of work [18] suggest using an integrated bread baking improver. A given improver consists of the functional base, buckwheat malt, and the active part – phosphorus calcium, ammonium sulfate. The developed improver is intended to enhance nutritional value and quality parameters for wheat bread.

To prolong freshness of bakery products to 72 h when storing unpacked, the authors of study [19] recommend an integrated bread baking improver. This improver consists of

a composition of dry wheat gluten, an enzyme preparation with amylolytic effect and a mixture of xanthan and guar gums. The developed integrated bread baking improver is intended to extend freshness of bakery products baked according to traditional technologies.

To meet the nutritional characteristics of bakery products, there is a developed integrated bread baking improver with different ferment composition. Its application has a positive effect on water absorption of dough and increases the yield of wheat bread by 1.2 %, as well as prolongs freshness and reduces cost [20].

The authors of work [21] described the effect of each component in the integrated bakery improvers on the rheological properties of dough and the biochemical and colloidal processes in dough. In addition, they demonstrated their influence on the organoleptic and physicochemical quality parameters of bakery products. The work did not specify the synergistic action of the jointly introduced food additives.

We have designed the integrated bread baking improver "Mineral Freshness Super", recommended to extend freshness of wheat bread baked using accelerated technologies [8].This integrated bread baking improver is characterized by the presence in its composition of food additives, which are GRAS graded, and the comprehensive effect, namely, intensification of the technological process and extending the freshness of finished products. It is advisable to investigate the influence of the developed improver "Mineral Freshness Super" on slowing down the losses of nutritional properties of wheat bread, baked using the accelerated technology under which a fermentation stage lasts 20 minutes, during storage.

3. The aim and objectives of the study

The aim of this study was to substantiate the appropriateness of using the integrated bread baking improver "Mineral Freshness Super" in order to improve nutritional properties of wheat bread.

To accomplish the aim, the following tasks have been set:

– to explore the impact of the integrated bread baking improver "Mineral Freshness Super" on the technological process and quality if bakery products;

– to study the impact of the integrated bread baking improver "Mineral Freshness Super" on the processes of wheat bread staling;

– to explore the impact of the integrated bread baking improver "Mineral Freshness Super" on flavor of bakery products.

4. Materials and methods to study the influence of the integrated bakery improver on consumer properties of wheat bread

4. 1. Examined objects and materials that are used in the experiment

The integrated bread baking improver consists of the functional base, white pharmacopoeial, and the active part, the enzyme preparations Alphamalt VC 5000 and Novamil 1500MG, maltodextrin, sunflower-derived fat-free lecithin, apple pectin, dry wheat gluten, and ascorbic acid.

Bread and bakery products were baked according to formulations that are given in Table 1.

Table 1

Formulations of wheat bread

Formulation components	Amount, kg	
	Wheat bread (control)	Wheat bread «Freshness»
Wheat flour, highest grade	100	100
Pressed baking yeast	3.0	3.0
Kitchen salt	1.3	1.0
Integrated bread baking improver «Mineral Freshness Super»	–	1.5

The composition of the integrated bread baking improver "Mineral Freshness Super" includes:

– functional base: white pharmacopoeial clay supplied by the Ukrainian company Naturalissimo [7];

– active part:

– fermenting drug Alphamalt VC 5000 (5000 SKB/g) supplied by the German firm Muhlenchemie;

– fermenting preparation Novamil 1500MG supplied by the Danish firm Novozymes;

– dry wheat gluten supplied by the Finnish firm Leipurin;

– carboxymethylcellulose supplied by the Ukrainian company Himpostach;

– apple pectin and maltodextrin made in Poland;

– fat-free sunflower-derived lecithin made by the Ukrainian firm BIOLER;

– ascorbic acid made in China.

4. 2. Methods to study the quality of wheat bread with the integrated bread baking improver

To solve the task on studying the impact of the integrated bread baking improver "Mineral Freshness Super" on the technological process and quality of bakery products, we conducted laboratory baking. Dough was prepared by the accelerated technique with a mass fraction of moisture of 43.5 %. We kneaded dough in a two-speed dough-mixer. Dough was aged over 30 min. We processed the dough manually, aging of dough semi-finished products was performed at a thermostat at a temperature of (38±2) °C and relative humidity (78±2) % until ready. The products were baked in a cabinet oven at 220...240 °C.

The quality of bread was estimated based on the physical-chemical (specific volume, shape stability, structural-mechanical properties of crumb) and organoleptic parameters (physical appearance, the surface of the crust structure, porosity structure, taste, smell) [22].

The period over which the products retained freshness was estimated based on a change in the structural and mechanical properties of crumb. We determined its total deformation after 48 h of storage using the penetrometer AP 4/1 [22].

The area of the under-the-crust layer was defined organoleptically based on a change in its rigidity and crumb. A border between the under-the-crust layer and the crumb was highlighted with a marker pen [23].

A microscopic analysis of bakery products was carried out in 4 hours after baking and at the end of storage, that is in 72 hours. The samples were stored unpacked, at a temperature of (20±0) °C. Preparation of the samples was carried out by freezing, lyophilic drying and by spraying, in a vacuum chamber, carbon on a piece of the dried sample. We viewed the samples using the electron scanning microscope IEOLJSMM-200 at a magnification of 1,000 times; we photographed the most important sections.

The content of dextrins was determined by the method of their mass share, based on the capacity of dextrins to settle at different concentrations of ethanol in solution. The examined samples are inactivated by enzymes to free the batch from the water-soluble carbohydrates and fermenting sugars for their better extraction. Dextrins were deposited using the solutions of alcohol of varying concentrations. The further dissolution of removed dextrins involved water and their hydrolysis – a 2 % solution of hydrochloric acid. We determined the amount of glucose in the dextrin hydrolyzate of varying molecular mass according to the method by Wiltheter and Shudl. Based on the determined content of dextrins, we established the mass fraction of dextrins for factions, depending on the mass fraction of dextrins at a different concentration of ethanol [24].

We determined the forms of moisture binding in dough using the thermogravimetric method applying the device derivatograph Q-1000 in the temperature range 20...200 °C at the rate of heating the samples of mass 1.00 g at 1.25 °C/min [24].

The content of aromatic substances in bread was determined based on the number of bisulfite-binding compounds identified in line with the procedure, described in [24].

Results from experimental studys were statistically treated using the standard software Microsoft Office.

5. Results of studying the quality of baked products containing the integrated bakery improver

To estimate impact of the integrated bread baking improver "Mineral Freshness Super" on the technological process and quality of wheat bread "Freshness", we conducted experimental laboratory baking. The obtained results were compared with data obtained when using a sponge-dough-free manufacturing technique. Dosage of the integrated bread baking improver "Mineral Freshness Super" was 1.5 % by weight of flour, duration of dough aging was 20 min. The obtained results were compared with data obtained when using a sponge-dough-free baking technique. Control was the sample without the improver, baked in line with the formulation given above. The study results are in Table 2.

Results from Table 2 show that under a shortened technological process of bread baking, the application of the integrated bread baking improver "Mineral Freshness Super" improves the organoleptic and physicochemical parameters of quality. Using the improver contributes to an increase in the specific volume from 348 cm^3/100 g to 374 cm^3/100 g, that is by 6.9 %; in parallel, there is an increase in porosity, the shape stability of finished goods also improves. The total deformation, in 72 h of storage, in the crumb of products with the improver is 72 penetrometer units, for control – 42 penetrometer units, that is larger by 71 %. The examined improver contributes to lengthening the freshness of baked goods by 54.5 %. The cost of time for fermenting the semi-finished products containing the integrated bakery improver, when compared their manufacturing in line with a traditional technology, is three times less.

Further study addressed examining the effect of the integrated bread baking improver "Mineral Freshness Super" on the processes of staling. Our research dealt with changes in the state of crumb and under-the-crust layer, the accumulation of dextrins, and redistribution of water forms in the products during storage.

Table 2

Effect of the integrated bakery improver on the technological process and quality of products, n=3, p≤0.95

Indicators	Wheat bread "Freshness"	
	Control (no additives)	With the integrated bread baking improver "Freshness +"
Dough		
Moisture mass fraction, %	43.5	
Fermentation duration, min.	210	–
Rest duration, min.	–	20
Aging duration, min.	40	40
Finished products		
Organoleptic indicators:	–	–
shape regularity	Matches the shape	Matches the shape
crust color	Light	Golden to brown
crust surface condition	Rather smooth, single small bubbles, barely visible small short cracks and fractures, glossy	Perfectly smooth, without bubbles or cracks, fractures, glossy
porosity structure	Pores are small, thin-walled, and medium, distributed quite evenly	
flavor	Intense, inherent to bread	
taste	Intense, inherent to bread	
Specific volume, cm^3/100 g	348	374
Shape regularity, h/d	0.41	0.46
Porosity, %	78	84
Acidity, degrees	1.8	1.8
Crumb deformation, general, penetrometer units	–	–
in: 4 hours	96	106
72 hours	42	72
Freshness retention, %	44	68

The difference in the organoleptic indicators for the crumb and crispy crust is the result of processes during baking, when the surface is exposed to higher temperatures than the crumb. During baking, there forms a gradient of relative humidity between the crust and the crumb, which predetermines the redistribution of moisture in the product. This is the cause of crumb softening and crust staling, as well as the formation of a thicker under-the-crust layer during storage. Therefore, it was expedient to investigate the effect of the integrated bread baking improver "Mineral Freshness Super" on the area over which the under-the-crust layer forms (Fig. 1).

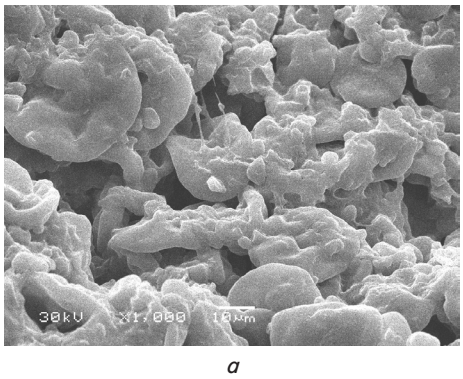
The research results indicate that during storage, when using the developed integrated bakery improver, the under-the-crust layer of wheat bread "Freshness" in 72 h of storage is less than the under-the-crust layer of control product.

Further research involved a microscopic analysis of wheat bread "Freshness" in the process of storage. The research results are given in Fig. 2.

a *b*

Fig. 1. Formation of under-the-crust layer during storage of bakery products after a 72-h storage: *a* — wheat bread (without additives); *b* — wheat bread "Freshness" with the integrated bread baking improver "Mineral Freshness Super"

The structure of crumb in bakery products is characterized by the presence of pores, which are covered by intra-pore walls that creating a spongy frame. The control samples under a microscope clearly demonstrate the layers of air in the intra-pore walls, indicating a decrease in the volume of starch grains due to the formation of the crystalline structure of starch. In the wheat bread "Mineral Freshness Super" with the integrated bakery improver, the crumb consists of a solid mass of proteins, coagulated during baking, in the middle of which are the swollen, partially gelatinized grains of starch.



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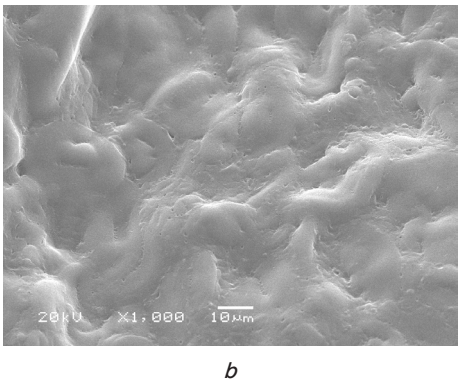

b

Fig. 2. The microstructure of crumb in baked products after a 72-h storage: *a* — wheat bread (without additives); *b* — wheat bread "Freshness" with the integrated bread baking improver "Mineral Freshness Super"

In the process of baking, there occurs the destruction of starch, in addition, along with the integrated bread baking improver "Mineral Freshness Super", the dough receives amylolytic enzymes [25] and maltodextrin; it was expedient to investigate a change in the amount of dextrins in bakery products. We determined the content of dextrins after 4 hours of cooling. The research results are given in Table 3.

Table 3

The content of dextrins in bakery products, n=3, p≤0.95

Samples of bakery products	Content of dextrins by fractions, % to DS*			Total content of dextrins
	amyl-dextrins	erythro-dextrins	malto- and achrodextrins	
Wheat bread (no additives)	0.915	0.386	0.832	2.133
Wheat bread the integrated bread baking improver "Mineral Freshness Super"	1.144	0.415	1.126	2.685

*Note: * – DS – dry substances*

When using the integrated bread baking improver "Mineral Freshness Super", one observes a significant increase in dextrins; thus, the total content of dextrins in control is 2.133 % to DS, and in the product with the improver is 2.685. That is, there is the increase in dextrins by 25.8 % in comparison with control, due to the presence in the integrated bread baking improver of α-amylase, maltogenic α-amylase, and maltodextrin.

The capacity of bread and bakery products to retain freshness is associated with the content of bound water [26]. Therefore, it was necessary to determine the content of bound and free water in the crumb. We determined it using a derivatograph. An analysis of thermogravimetric curves allowed us to acquire the quantitative characteristics of moisture distribution in the crumb of products with additives and on changes in its state in the process of storage (Fig. 3).

At the first stage of moisture removal from the samples of bread, one observes a significant loss of it. In this temperature interval, free moisture, the moisture contained in macro- and micro capillaries, and the immobilized water, are removed . The total amount of this moisture in the samples of products is as follows: for control, over the first day of measurements, it is 18.21 % by the total mass of water in the products; in the sample with the integrated bread baking improver "Mineral Freshness Super", it is 18.84 % by the total mass of water in the product. At day four of storing the products, the moisture content of these forms of binding in control increases by 2.11 % by the total mass of water in the products, and in the product with the integrated bread baking improver "Mineral Freshness Super" it is 0.34 % by the total mass of water in the product.

The second and third intervals of temperatures correspond to the endothermic peak, that is, the endothermic processes occur over these ranges, which might be associated with the removal of moisture at a considerable binding energy, obviously, of osmotically and adsorption-bound water. Fig. 3 shows that the amount of osmotically bound moisture in the products with the improver is higher relative to control sample by 2.37 % by the total mass of water in the product. After four days of storage the amount of osmotically-bound moisture in bread with the integrated bread baking improver is somewhat reduced, but is still higher than in control. The amount of adsorption-bound water in products over the first day of storage and after four days of storage is almost the same.

The fourth interval of temperatures corresponds to the removal of chemically-bound water. The results of analysis

show that the amount of this water in samples increases but it is very small, compared with other forms of water binding.

In the course of our study, it was established at the end of storage that the samples of products demonstrated a tendency towards a decrease in the osmotically- and adsorption-bound moisture and a decrease in free water and in the moisture in microcapillaries, but such a decrease occurs to a lesser extent with the integrated bread baking improver.

To solve the next task, we investigated the impact of the integrated bread baking improver "Mineral Freshness Super" on the aroma of wheat bread.

The composition of the integrated bread baking improver includes enzymes with an amylolytic effect, which positively affect the accumulation of aromatic substances in bread, namely carbonyl compounds [27].

We studied the influence of the integrated bread baking improver on the content of carbonyl compounds in finished products applying a method by R. R. Tokareva and V. A. Kretovich; the results are given in Table 4.

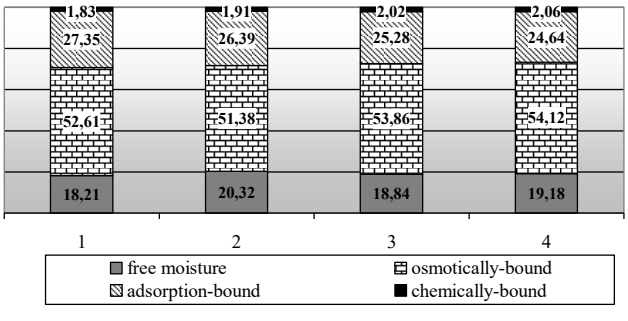

Fig. 3. Changes in the forms of moisture binding in the examined samples during storage, %: 1, 3 – in 24 h; 2, 4 – in 72 h; 1, 2 – wheat bread without additives; 3, 4 – wheat bread with the integrated bread baking improver "Mineral Freshness Super"

Table 4

Content of bisulfite-binding substances, mg-equiv./100 g of bread, n=3, p≤0.95

Region of taking a sample	Wheat bread (no additives)	Wheat bread with the integrated bread baking improver "Mineral Freshness Super"
In 4 hours		
Crumb	7.3	9.8
Crust	15.5	23.1
In 24 hours		
Crumb	6.2	8.4
Crust	13.8	22.1
In 48 hours		
Crumb	5.4	7.6
Crust	10.1	16.4
In 72 hours		
Crumb	3.1	4.3
Crust	6.3	8.7

Thus, when adding the integrated bread baking improver "Mineral Freshness Super", the content of bisulfite-binding compounds in the products increases, compared with control, by 1.2...1.6 times, regardless of the length of storage. An increase in the content of carbonyl compounds in the finished products with additives correlates with the improvement in coloration of the crumb and in the flavor of bread.

6. Discussion of results of using the integrated bread baking improver "Mineral Freshness Super" in the formulation of wheat bread

Underlying the development of integrated bakery improvers is their directed action, achieved owing to a varied composition. Their composition includes a variety of ingredients provided by baking industry, as well as food additives. That predetermines a wide range of integrated bread baking improvers that could differ in the mechanism of action, the intensity of effect, and essentially by the targeted action, which is achieved by the combination of components. That is why formulations for integrated bread baking improvers are given in the scientific literature only in the form of a list of components that they are made from.

The main purpose of the integrated bread baking improver "Mineral Freshness Super" is to provide nutritional properties for bread baked from wheat flour, produced using an accelerated technology. Its proposed composition is intended to intensify the technological process, namely a three-fold decrease in its duration. In addition, the result of the synergistic effect of the improver's components is the improvement of nutritional properties.

In the course of our study into effect of the integrated bread baking improver "Mineral Freshness Super" on the technological process and quality of bakery products we have established a decrease in the duration of the technological process and an increase in the specific volume of bakery products. That relates to the use in the composition of the improver of the enzyme with an amylolytic effect, maltodextrin, which contributes to an increase in gas-generating and sugar-generating capacity. Prolonged freshness is due to the introduction, together with the integrated bread baking improver, of moisture-retaining supplements, specifically maltodextrin, carboxymethylcellulose, apple pectin, which, during storage of products, keep the osmotically and adsorption-bound moisture [28]. In addition, maltodextrin is a water-soluble hydrocolloid, which increases the degree of retention of moisture and forms a three-dimensional grid, which inhibits the interaction between gluten and starch, resulting in slower retrogradation of starch [29, 30].

While studying the impact of the integrated bread baking improver "Mineral Freshness Super" on the staling processes of wheat bread, we determined its effect on the state of the crumb and under-the-crust layer. It was established that the use of the integrated bakery improver reduces the formation of an under-the-crust layer, improves the structure of crumb when the wheat bread "Freshness" is stored for 72 hours without packaging.

The result of action of the developed improver is an increase in low-molecular dextrins, namely maltodextrins and achrodextrins by 35.3 %. Given this, there is the slowing down of staling process of baked goods due to the formation of a three-dimensional grid by low-molecular dextrins, which prevents the interaction between gluten and starch, as well as the release of moisture by starch.

The redistribution of moisture is predetermined by the aging of biopolymers and their release of water, which is distributed in micropores, formed during storage. That relates to the structure of porosity – microphotography shows that

products with the integrated bread baking improver demonstrate a well-developed porosity, with thin walls.

An analysis of forms of moisture binding in the samples of bakery products with the integrated bread baking improver gives reason to believe that a slowdown in the process of staling occurs. It is associated with a lower content of free moisture, moisture in macro-and microcapillaries at the beginning and in the process of storage and with an increase in the amount of osmotically-bound moisture [31, 32]. This correlates with data on determining the total deformation of crumb depending on the content of dextrins.

While addressing the task on the impact of the integrated bread baking improver "Mineral Freshness Super" on the content of carbonyl compounds in the crumb and crust of baked products, it was found that their content increases. This is due to the fact that the composition of the integrated bread baking improver contains enzyme preparations with amylolytic effect, maltodextrin, dry wheat gluten, which speed up the process of resting and releasing more carbonyl compounds. An increase in the content of bisulfite-binding compounds is also explained by that the composition of the integrated bread baking improver "Mineral Freshness Super" includes maltodextrin, which, along with the slowing of staling, accelerates the process of fermentation.

Therefore, the use of the integrated bread baking improver "Mineral Freshness Super" contributes to the prolonged freshness of bakery up to 72 h when stored unpacked.

However, still unclear is the impact of the integrated bread baking improver "Mineral Freshness Super" on the mechanism of moisture loss by products during storage.

Further research into this area will address the establishment of impact of the integrated bread baking improver "Mineral Freshness Super" on the biological activity, the degree of digestion of proteins from bread products, as well as the selection of packaging materials to store them.

7. Conclusions

1. It was established that the use of the integrated bread baking improver "Mineral Freshness Super" in the amount of 1.5 % by weight of flour when using an accelerated technology leads to an increase in specific volume, improves shape stability and porosity, and shortens the process of fermentation to 20 min.

2. The application of an optimal dosage of the integrated bread baking improver "Mineral Freshness Super" prolongs storage to 72 hours, stored unpacked. This is confirmed by an increase in the total deformation of the crumb by 70 % compared with control. In addition, there is a decrease in the under-the-crust layer and the number of air layers in the products' crumb, as well as an increase in the amount of accumulated dextrins in products by 25 % compared with control.

3. It was established that using the integrated bread baking improver "Mineral Freshness Super" increases the amount of bisulfite-binding compounds by 34...49 % compared with control, which positively affects the flavor of wheat bread, which is removed to a lesser extent compared with control in the process of storage.

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