

This paper reports a study into different ways of applying a highly effective technology for making yeast-free bread from wheat flour of the highest, first, and second grades by the accelerated method. The dough mechanical loosening technology was used, which makes it possible to reduce the time to prepare the high-quality dough and bake bread. This study has confirmed that the mechanical loosening technique makes it possible to make high-quality yeast-free bread by an accelerated method without fermentation and proving. Such a technique reduces the time of dough preparation by 3 times, improves the rheological properties of the dough, and reduces baking time by 2 times, as well as improves the quality of bread from flour of the highest, first, and second grade. The results showed that the safety indicators of yeast-free bakery products prepared from flour of the highest, first, and second grade meet the norms established by TR TC 021/2011 of the Technical Regulations of the Customs Union "On Food Safety". In terms of microbiological indicators, the results demonstrated that during storage for 5 days QMAFAnM ranged as follows: in yeast-free bakery products from flour of the highest grade – from $1.2 \cdot 10^2$ to $1.8 \cdot 10^2$ CFU/g. In the yeast-free bakery products from flour of the first grade – from $1.5 \cdot 10^2$ to $2.1 \cdot 10^2$ CFU/g; in the yeast-free bakery products from flour of the second grade – from $1.9 \cdot 10^2$ to $3.2 \cdot 10^2$ CFU/g. In addition, bacteria of the *E. coli* group were found on all yeast-free bakery products. Thus, applying the highly effective technology of the accelerated dough preparation could significantly improve the quality of bread, reduce the time of baking, and reliably ensure that useful properties are maintained

Keywords: yeast-free bread, wheat flour, technology, accelerated method, dough, mechanical loosening

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DEVISING TECHNOLOGY OF THE ACCELERATED METHOD FOR MAKING YEAST-FREE BAKERY PRODUCTS FROM WHEAT FLOUR

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1. Introduction

Basic bread baking processes involve the kneading and fermentation of a formulation dough mixture. When kneading, the components are mixed, the mixture is subjected to mechanical processing and saturation with air bubbles, moisture exerts a hydrolytic effect on the dry components of the mixture, a spongy dough frame is formed. They are the most complex both in the nature of colloidal, biochemical, microbiological transformations, and the physical-mechanical structural changes occurring during dough preparation and in terms of their mecha-

nization and automation. Every year, the range of bread and bakery products increases but their cost does not decrease. This is because the cost of electricity, labor, etc. increases at bakery enterprises. A given technology involving the accelerated method for making yeast-free bakery products from wheat flour helps improve the production and quality of the resulting product. The accelerated technology of dough preparation for making various product ranges of the yeast-free bakery from wheat flour improves quality, reduces the technological process, enhances labor productivity, and increases the socio-economic indicators of bakery enterprises.

In this regard, it is a relevant task to make yeast-free bakery products from wheat flour based on the accelerated dough preparation technology, contributing to improving the quality and reducing the technological process.

This study reports a devised technology for the accelerated method for making yeast-free bakery products from wheat flour using a kneading machine for mechanical loosening. A given dough preparation technique speeds up the process of preparing the yeast-free dough and reduces the time of baking bread and bakery products; the range of yeast-free bakery products will also be expanded.

2. Literature review and problem statement

Work [1] states that the production of bread and bakery products is one of the main trends in the food industry. It accounts for 15.3 % of the total food industry output. The greatest demand by the population is for bread and bakery products from wheat flour of the first grade, rye bread, and products from wheat flour of the highest grade. Therefore, it is necessary to expand the range of bakery products prepared from wheat flour of the highest, first, and second grades.

Paper [2] provides information on the benefits of wheat. Wheat is one of the main sources of calories in the daily human diet. The optimal chemical composition and structure of the food matrix from whole wheat grains can help prevent and reduce the risk of chronic diseases. During the study, it was found that it is necessary to devise an accelerated technology for making yeast-free bread from wheat flour. In work [3], it was also suggested that, in addition to the effects of dietary fiber, the synergistic effect of some bioactive compounds helps protect health and maintain the normal functioning of the body. Therefore, it is necessary to use flour from high-quality wheat varieties to increase the range of yeast-free bakery products.

Work [4] gives information about the benefits, harmfulness of bread yeast, and their hydrolysis into monosaccharides. Therefore, it is believed that only monosaccharides can diffuse into yeast cells. However, the preparation of the dough using a given method does not accelerate the fermentation process of the dough; these yeasts can be harmful to human health.

To intensify the process of maturation of semi-finished products after kneading, enhanced mechanical processing of the dough is used during kneading; the related ideas were popular already in the 1920s. At that time, kneading machines of the intensive principle of operation started to be produced. Paper [5] reports the results of a study on the effect of intensive kneading on dough maturation. The results served as the basis for devising a technology for intensive preparation of the dough with a shortened fermentation cycle (Chorleywood technique). The main idea of that technique was that by increasing the mechanical processing of the dough by 4–5 times compared to the standard one, it is possible to intensify and accelerate the process of dough maturation, thereby reducing its fermentation time by 1–1.5 hours.

Works [6–8] report the results of studies into baking yeast. It has been proven that the harm of bakery yeast is extremely serious; its use is fraught with a disruption of metabolic processes, a change in the biochemical composition of the blood, breaking the acid-alkaline balance, and other

negative consequences. In this case, we cannot say that such products are useful for our body. Rather, on the contrary, the harm of baking yeast can lead to irreversible consequences. In this regard, it is necessary to replace baking yeast with useful natural starters or devise effective accelerated technologies.

One of the ways of loosening bakery semi-finished products, excluding the introduction of yeast, is the mechanical way of loosening the dough. According to work [9], there is a known technique of mechanical loosening of the dough by whipping part of it, which involves the following: part of the dough (in a relatively liquid and cold state) is whipped for 5 minutes in a special whipping machine whose design is strong and heavy. After a certain break, the whipped mass is fed into a conventional kneading machine, in which the dough is kneaded, which then arrives for cutting and baking. However, a given method does not fully satisfy the need for production.

According to source [10], manufacturers of bakery products are in dire need of introducing intensive technologies that improve the quality of finished products and their safety. All this suggests that it is advisable to conduct a study into the production of yeast-free, useful, and human health-safe bakery products.

However, those techniques were used only for the preparation of dough from wheat flour and were not widespread in the industry.

Earlier studies addressed the intensification of the process of maturation of semi-finished products after kneading with the use of enhanced mechanical treatment of the dough during kneading. However, none of those techniques eliminated the introduction of yeast into the dough, nor increased the safe shelf life of bread. Many of them even required an increase in the amount of yeast added to the dough.

Based on the literary studies, it turned out that the yeast present in yeast bread negatively affects the entire digestive system of the human body; most of the population prefers yeast-free bread. Therefore, it is necessary to devise an accelerated technology for the preparation of yeast-free dough and expand the range of yeast-free bakery products from wheat flour of the highest, first, and second grades with low cost.

3. The aim and objectives of the study

The purpose of this study is to devise technology for preparing dough from flour of the highest, first, and second grades by an accelerated method through mechanical loosening. That could reduce the baking time and expand the range of yeast-free bakery products of high quality.

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

- to study the quality of flour and prepare the yeast-free dough by an accelerated method through mechanical loosening;
- to study the qualitative indicators of bakery products.

4. The study materials and methods

The main hypothesis of this study assumed that there is a fundamental possibility to expand the range of useful

yeast-free bakery products when applying an accelerated technology involving mechanical loosening of the dough.

The following raw materials were used in the current work: flour of the highest, first, and second grades, table salt “Araltuz”, citric acid, and water.

Whipped yeast-free semi-finished products were prepared by mechanical loosening under pressure at an experimental laboratory installation designed at the Department of Technology of Bakery, Pasta, and Confectionery Production, the Voronezh State University of Engineering Technologies (Fig. 1). It consists of the following main components: a whipping chamber; an electric motor; a control panel; a compressor.



Fig. 1. Experimental laboratory installation

The installation works as follows: dough formulation components are fed through a loading hole into the kneading body of the kneading machine of periodic action, which hosts a kneading element in the form of a corolla driven by an electric motor.

At the end of loading, the kneading body of the kneading machine is hermetically closed with a lid; the dough is kneaded for 3–5 minutes at a kneading element's speed of 400–500 min⁻¹. Next, atmospheric air is introduced into the chamber through a nozzle under excessive pressure into the kneading body at a pressure of 0.3–0.5 MPa. At the same time, the semi-finished product continues to be whipped for 3–10 minutes at a frequency of rotation of the kneading element of 9.2 s⁻¹ and is simultaneously loosened.

The dough prepared in this way is a foamy mass with stable physical and chemical characteristics. Upon completion of the whipping process, dough blanks weighing 0.2–0.4 kg are formed through the unloading hole of the kneading machine.

The main advantages of this installation are a wide range of whipping parameters (the frequency of rotation of the kneading element, the amount of pressure of the supplied atmospheric air, the temperature of the water jacket), the smoothness of their adjustment, the possibility of obtaining whipped masses of various compositions. It is also easy to install, design, and maintain.

A given installation quickly loosens the dough before baking to produce a porous product.

The following indicators of the raw materials used and the resulting bread were investigated: organoleptic indi-

cators according to GOST 5667-85, the mass fraction of moisture according to GOST 21094-75, the mass fraction of fat according to GOST 5668-68. The mass fraction of protein was determined by GOST 10846-91. The mass fraction of carbohydrates was determined by GOST 25832-89. The mass fraction of porosity was determined by GOST 5669-96. The acidity content was determined according to GOST 5670-96. In addition, the microbiological indicators were determined on the basis of the following standards: the number of mesophilic aerobic and facultative-anaerobic microorganisms (QMAFAnM) – according to GOST 10444.15-94, the number of bacteria of the E. coli group (coliform bacteria) (BECG) – according to GOST 31747-2012.

5. The results of studying the raw materials and bakery products

5.1. The results of studying the flour quality and making the yeast-free dough by the accelerated method through mechanical loosening

The main stage in the preparation of yeast-free dough mechanically is the whipping up of the semi-finished product under the pressure of compressed air. The qualitative indicators of flour were determined, which are given in Table 1.

Table 1

Quality indicators of wheat baking flour

Indicator name	Flour grade		
	highest	first	second
Color	White	White with a yellowish tinge	White with a grayish tinge
Aroma	Characteristic of wheat flour, without foreign taste, not musty, not moldy		
Taste	Characteristic of wheat flour, without foreign taste, not sour, not bitter		
Crunch	When chewing, there was no crunch		
Whiteness, conditional units of the device RZ-BPL, not less than	64.6	56.2	31.0
Moisture mass share, %	14.3	14.1	14.4
Raw gluten mass share, %	28.0	30.0	29.0
Quality of raw gluten, units of the device IDK	68.0	70.7	65.0
Residue on a sieve from silk fabric according to GOST 4403, not less, %:			
No. 43	3.5	–	–
No. 35	–	1.85	–
No. 27	–	–	1.7
Passing a sieve according to GOST 4403, %:			
No. 43	–	85.0	–
No. 38	–	–	69
Fall number, FN, s	328.0	260.0	201.0
Pest infestation	Not detected		
Acidity, degree	2.6	3.0	4.1

Data in Table 1 show that the flour samples comply with GOST 26574-2017 and are further recommended for baking yeast-free bakery products from it.

The whipped yeast-free dough was prepared at a laboratory installation, at a moisture content of 55–56 %, according to the formulations and modes given in Tables 2–4.

Table 2
Formulations and modes of dough preparation for whipped yeast-free bread from wheat flour of the highest grade

No.	Name of raw material and process indicators	Raw material consumption and process parameters
1	Wheat flour, highest grade, kg	100.0
2	Table salt, kg	1.5
3	Citric acid, kg	0.2
4	Water, kg	As calculated
5	Dough moisture content, %	55 %
6	Stirring time, min	8
7	Whipping time, min	2
8	Air pressure, MPa	0.5
9	Kneading element rotation frequency, min ⁻¹	500

Table 3
Formulations and modes of preparation of dough for whipped yeast-free bread from wheat flour of the first grade

No.	Name of raw material and process indicators	Raw material consumption and process parameters
1	Wheat flour, first grade, kg	100.0
2	Table salt, kg	1.3
3	Citric acid, kg	0.2
4	Water, kg	As calculated
5	Dough moisture content, %	56 %
6	Stirring time, min	10
7	Whipping time, min	1.5
8	Air pressure, MPa	0.5
9	Kneading element rotation frequency, min ⁻¹	450

With the intensive mechanical loosening of the dough, starch grains increase in volume, become looser and are easily exposed to the action of amylolytic enzymes. The linear fraction of starch – amylose, which forms the inner part of the starch grain, hydrolyzes faster than amylopectin, which makes up its outer part and has a branched structure.

An important role in the process of hydrolysis of starch by α -amylase belongs to proteolytic enzymes. Proteases, while carrying out a limited breakdown of proteins, contribute to the release of amylases from the bound state, and also hydrolyze that part of the spare proteins that is firmly bound to the surface of the starch granules, while the access of the enzyme to the substrate is facilitated. Under the action of proteolytic enzymes, the complex structure of the protein molecule is simplified, its ability to swell decreases, and the solubility of proteins increases.

Table 4

Formulations and modes of preparation of dough for bread whipped yeast-free from wheat flour of the second grade

No.	Name of raw material and process indicators	Raw material consumption and process parameters
1	Wheat flour, second grade, kg	100.0
2	Table salt, kg	1.2
3	Citric acid, kg	0.2
4	Water, kg	As calculated
5	Dough moisture content, %	56 %
6	Stirring time, min	6
7	Whipping time, min	0.5
8	Air pressure, MPa	0.5
9	Kneading element rotation frequency, min ⁻¹	400

The main reaction catalyzed by proteolytic enzymes is the hydrolysis of the peptide bond in protein and peptide molecules.

Adding the enzyme preparation GC-106 to the dough with intensive whipping and oxygen saturation of the air increases the solubility of proteins, reduces the ability of the protein molecule to swell, which would provide for a significant increase in foaming of the semi-finished product, a decrease in the specific power per kneading, resulting in reduced energy consumption, increased elasticity of the foam, its stability.

In addition, the action of enzymes (α -amylase and protease) on starch and flour protein when whipped contributes to the intensive formation of substances that predetermine the taste and aroma of bread. At this stage, a series of products of enzymatic hydrolysis of proteins and starch (low-molecular nitrogenous substances, polypeptides, peptides, amino acids, carbonyl compounds) are formed, which are involved in the formation of the taste and aroma of the yeast-free product, as well as melanoid formations that enter the reaction that occurs during bread baking. As a result, melanoidins are formed, giving color to the crust, as well as intermediate and by-products of this reaction, which are also involved in the formation of the taste and aroma of the finished products.

The resulting dough was formed into round shapes of 0.3–0.4 kg.

Baking is carried out in baking ovens with parameters that ensure the optimal technological conditions and baking mode. The duration of baking at a baking chamber temperature of 220–230 °C is 25–30 minutes, depending on the weight of the products.

The advantage of the accelerated technology is to prepare the dough with a simple formulation without the use of yeast and starter cultures in a matter of minutes. In addition, a given technology does not require proving while reducing the number of devices and equipment used.

5. 2. The results of studying the qualitative indicators of bakery products

Whipped yeast-free bread from wheat flour was packed, after cooling, individually in bags of polyethylene film, approved by the bodies of Gossanepidnadzor of the Russian Federation for contact with food and ensuring the quality, safety, and storage of the product.

The bread was stored at a temperature not higher than 25 °C and a relative air humidity not exceeding 85 %.

Fig. 2 shows the samples of whipped bakery products.

Qualitative indicators of the baked whipped yeast-free bakery products are given in Table 5.

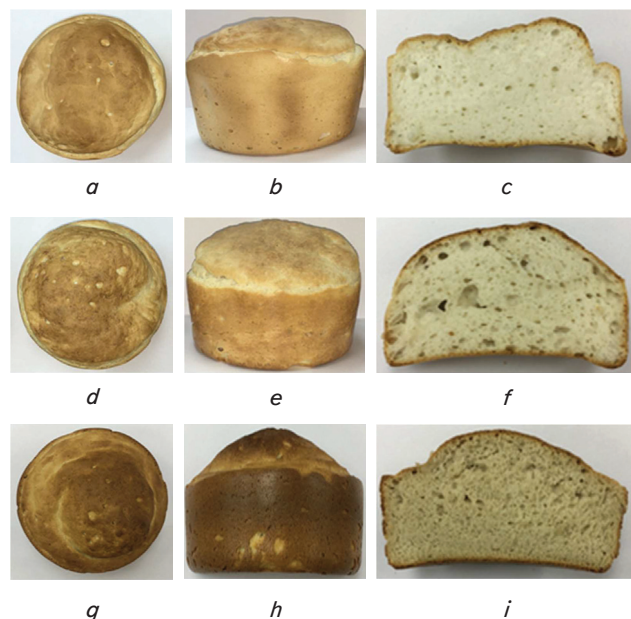


Fig. 2. Samples of whipped bakery products: *a, b, c* – from flour of the highest grade; *d, e, f* – from flour of the first grade; *g, h, i* – from flour of the second grade

Table 5

Qualitative indicators of whipped yeast-free bakery products

Indicator name	Bread from flour of the highest grade	Bread from flour of the first grade	Bread from flour of the second grade
Crumb moisture content, %	47.5	48.4	48.6
Crumb acidity, degree	2.1	2.4	2.8
Porosity, %	75	69	63
Physical appearance:	Characteristic of the bread mold used for baking		
Surface	Smooth, without major cracks and explosions		
Crumb state	Baked, not wet to the touch, without traces of non-mixing, more elastic crumb	Baked, not wet to the touch, without traces of non-mixing, elastic crumb	Baked, not wet to the touch, without traces of non-mixing, elastic crumb
Porosity	Uniform, thin-walled, small homogeneous, without the presence of large pores	Uniform, thin-walled, small, without the presence of large pores	Uniform, thin-walled, uneven medium, without the presence of large pores
Crumb color	White	Light yellow	Light gray
Taste and aroma	Characteristic of this product, without foreign taste		

The chemical composition and nutritional value of yeast-free bakery products are given in Table 6. As a control sample, the results for the bread prepared from the first-grade wheat using bread yeast are given.

Table 6

Chemical composition and nutritional value of yeast-free bakery products

Name of nutrients	Nutrient content per product				Daily need, g/24 hrs.	Satisfaction extent, %			
	Bread – control sample	Bread from flour of the highest grade	Bread from flour of the first grade	Bread from flour of the second grade		Bread – control sample	Bread from flour of the highest grade	Bread from flour of the first grade	Bread from flour of the second grade
Proteins, g	7.45	5.7	6.1	6.7	75.0	9.9	7.6	8.2	8.9
Fat, g	0.7	0.6	0.8	1.1	83.0	0.84	0.72	0.96	1.3
Carbohydrates, g	37.3	42.7	40.6	36.8	365.0	10.22	11.7	11.12	10.1
Dietary fiber, g	2.8	1.2	2.6	4.6	30.0	9.3	4	8.67	15.3
Mineral substances, mg:									
Calcium, mg/100g	23.0	15.6	18.4	22.6	1000.0	2.3	1.56	1.84	2.26
Potassium, mg/100g	128.4	80.3	104.9	140.1	3500.0	3.67	2.3	3.0	4.0
Phosphorus, mg/100g	85.2	52.4	67.7	102.1	1000.0	8.52	5.24	6.77	10.21
Magnesium, mg/100g	30.8	12.3	26.5	41.6	400.0	7.7	3.07	6.63	10.4
Iron, mg/100g	1.7	0.9	1.3	2.2	14.0	12.14	6.4	9.29	15.7
Vitamins, mg:									
B ₁ , mg/100g	0.16	0.11	0.15	0.21	1.5	10.67	7.3	9.81	14
B ₂ , mg/100g	0.05	0.03	0.05	0.08	1.8	2.78	1.7	2.61	4.4
PP, mg/100g	2.5	1.7	2.4	2.5	20.0	12.5	8.5	6.47	12.5

Table 8

Safety indicators of bakery products

Name of indicators, dimensionality	TP TC requirements 021/2011, mg/kg, not exceeding	Whipped bread from flour of the highest grade	Whipped bread from flour of the first grade	Whipped bread from flour of the second grade
Toxic elements				
Lead	0.35	0.10	0.12	0.15
Arsenic	0.15	not detected*	not detected*	not detected*
Cadmium	0.07	not detected*	not detected*	not detected*
Mercury	0.015	not detected*	not detected*	not detected*
Mycotoxins				
Aflatoxin B1	0.005	not detected*	not detected*	not detected*
Deoxynivalenol	0.7	not detected*	not detected*	not detected*
T-2 toxin	0.1	not detected*	not detected*	not detected*
Zearalenones	0.2	not detected*	not detected*	not detected*
Radionuclides, Bq/kg				
cesium-137	40	less than 2.2	less than 1.8	less than 2.8
strontium-90	20	less than 1.4	less than 2.4	less than 2.3
Pesticides				
hexachlorocyclohexane (α , β , γ -isomers)	0.5	not detected*	not detected*	not detected*
DDT and its metabolites	0.02	not detected*	not detected*	not detected*
hexachlorobenzene	0.01	not detected*	not detected*	not detected*
mercury organic pesticides	not allowed	not detected*	not detected*	not detected*
2,4-D acid and its salts, esters	not allowed	not detected*	not detected*	not detected*

Note * – not detected at the sensitivity level of the analysis method

The nutritional value of bakery products is determined by the totality of the properties of bread, in the presence of which the physiological needs of a person in the necessary substances and energy are satisfied. The nutritional value of the product is characterized by its benignity (harmlessness), digestibility, mass fraction of nutrients and physiologically active substances, as well as their ratio, the organoleptic and physiological value.

Data in Table 6 clearly illustrate how using the accelerated method of mechanical loosening makes it possible to make yeast-free bakery products that have a good chemical composition and nutritional value that are not inferior to the indicators of yeast bakery products.

The biological and energy value is given in Table 7; the safety indicators of whipped bakery products – in Table 8.

Table 7

Biological and energy values of whipped bakery products

Product title	Bio-logical value, %	Amino-acid score difference coefficient, %	Energy value, kJ (kcal)
Whipped bread from flour of the highest grade	53.7	47.3	877 (209.5)
Whipped bread from flour of the first grade	60.8	39.2	776 (185.5)
Whipped bread from flour of the second grade	62.4	37.6	702 (167.6)

The biological value of bakery products is an indicator of the quality of food protein, reflecting the degree of compliance of its amino acid composition with the needs of the body in amino acids for protein synthesis.

The energy value of bread characterizes its digestible energy, that is, that proportion of the total energy of the chemical bonds of proteins, fats, and carbohydrates, which can be released in the process of biological oxidation and used to ensure the physiological functions of the body. We determined the content of amino acids per 100 g of the product, the biological value of the products, and the indicators ASDC – the coefficient of difference in the amino-acid composition, as well as the energy value of the whipped bakery products.

The results have shown that bakery products made from flour of the highest, first, and second grades do not contradict the established norms of TR TC 021/2011 of the Technical Regulations of the Customs Union “On Food Safety”.

The prepared samples of whipped yeast-free bread were analyzed for microbiological contamination for 5 days.

Our study has shown that the content of QMAFAnM ranged in the whipped bread from the highest wheat grade from $11.2 \cdot 10^2$ to $1.8 \cdot 10^2$, in bread from the first grade – from $1.5 \cdot 10^2$ to $2.1 \cdot 10^2$, in the sample of bread from the second grade – from $1.9 \cdot 10^2$ to $3.2 \cdot 10^2$. The analysis of the whipped yeast-free products for the presence of bacteria of the E. coli group in the product and on its surface and the causative agents of potato disease of bread has revealed their absence during the entire storage period.

Summarizing the above, we can conclude that the recommended shelf life of the studied whipped yeast-free bread from flour of the highest, first, and second grades is up to 5 days.

6. Discussion of results of studying the yeast-free bakery products

In order to obtain the dough without fermentation before cutting, new accelerated technology was used in this work, which makes it possible to quickly intensify the colloidal and biochemical processes that occur during dough preparation. The fundamental difference between a given technology and existing analogs is the creation of assortments of yeast-free bakery products from wheat flour of the highest, first, and second grades of improved quality and reduced technological process.

The positive effect of mechanical action in the process of kneading on the speed and quality of wheat dough was confirmed by a study reported in [9]. A series of works in the field of kneading theory, calculation of operating parameters of dough mixing machines, as well as experimental studies into the specificity of processes at intensive kneading, were performed at the Ukrainian State University of Food Technologies [11, 12]. Based on those works, several fundamentally new

dough kneading machines were designed. However, those machines have considerable drawbacks: they increase energy costs, reduce the yield of the product, increase the cost of bread, etc.

An analog in designing innovative equipment and devising technology of bakery products with a reduced production cycle is the installation created by the scientists at the Voronezh State Technological University of Engineering Technologies (VSUIT). In our work, the dough was made using such an installation. A given technique has made it possible to completely eliminate the process of dough fermentation and proofing (consequently, the related equipment: dough mixing machine, barrels, fermentation tanks, proofing cabinet), to abandon the use of pressed yeast during kneading.

The amount of the optimal mechanical impact on the dough when it is kneaded is undoubtedly influenced by the baking properties of flour. Flour dough with strong gluten requires more intensive processing; on the contrary, flour with weak gluten has a less strong mechanical effect on the dough during kneading. Therefore, at the beginning of the experiment, the quality of flour was investigated. And, accordingly, the dough was prepared with a moisture content of 55–56 %. Formulations and modes of dough preparation for yeast-free bakery products from flour of the highest, first, and second grades, given in Tables 2–4, have been devised. Next, the qualitative indicators of the yeast-free bakery products made were investigated. The organoleptic, physical-chemical, microbiological indicators, as well as biological and energy values of yeast-free bakery products, were analyzed.

The results have shown that yeast-free bakery products meet the established standards and requirements of TR TC 021/2011. It was also found that the technique of making the yeast-free dough by mechanical loosening under pressure at an experimental laboratory installation makes it possible to reduce the duration of the manufacturing process of bakery products from 3 to 6 hours, improve labor productivity by 2–3 times, increase the yield of bread by 14–18 %, and improve the organoleptic performance of the finished product.

Based on the accelerated dough preparation technology, which makes it possible to exclude yeast from the formulation, reduce the duration of the production process, improve the quality of finished products, increase labor productivity, and increase the socio-economic indicators of bakery enterprises, a new direction in the production of yeast-free bakery products can be developed.

When whipping up the dough components under the pressure of compressed air, an intensive saturation of the semi-finished product with air oxygen occurs. At the same time, the structural and mechanical properties of the dough are improved, its volumetric mass decreases. This is due to a decrease in the number of SH groups and the formation of bonds in the structure of the S-S protein, which contribute to the strengthening of the protein structure, and, accordingly, the foam film. Thus, intensive stirring and whipping of the dough with the saturation of oxygen in the air in the presence of the enzyme preparation GC-106 accelerate the processes of hydrolysis of proteins, while their solubility increases, the foaming of the semi-finished product increases, the formation of substances involved in the reactions of melanoidin formation intensifies, the specific power per kneading decreases.

Consequently, the enzymatic hydrolysis of the main components of flour with a mechanical loosening technique and its intensification could make it possible to make the dough and a bakery product with optimal structural and mechani-

cal properties and full taste and aroma. Reducing the stage of dough fermentation after its kneading before cutting is achieved by intensifying the colloidal and biochemical processes that occur during the preparation of the dough.

The economic effect could be achieved by reducing the duration of the production process from 3 to 6 hours, reducing the number of equipment units by eliminating the processes of fermentation and proofing (kneading machines, barrels, fermentation tanks, proofing cabinet), etc.

The advantages of our technology in comparison with the known ones are:

- a reduction in the production costs due to the exclusion of yeast and the reduction of the technological process;
- an increase in bread yield by 14–18 %;
- an increase in labor productivity by more than 2–3 times, as well as an increase in the income of the enterprise by 2 times.

The difference between a given technology and existing analogs:

- products have high taste consumer properties;
- the products are safe;
- long shelf life of products;
- low cost.

The main disadvantage of the mechanical technique of dough loosening is that reducing the duration of dough preparation leads to insufficient accumulation of substances that give a special taste and aroma to the finished products. Therefore, it is recommended to use special food additives that improve those indicators of bread quality.

7. Conclusions

1. The quality of flour was investigated and the yeast-free dough was made by the accelerated method. The dough was prepared by mechanical loosening under the pressure of compressed air. The study results showed that the quality of flour of the highest, first, and second grades corresponds to GOST 26574-2017 and is recommended for baking yeast-free bakery products. The indicators of raw gluten in flour were as follows: the highest grade – 68.0 units, the first grade – 70.7 units, and the second grade – 65.0 units. Next, the yeast-free dough was obtained according to the developed formulations and modes. Depending on the amount of gluten, the dough was kneaded. Further, the yeast-free dough was obtained according to the devised formulations and modes. Citric acid was added as a flavor since the main drawback of the mechanical technique of dough loosening is the insufficient accumulation of substances that give the characteristic taste and aroma to the finished products.

The accelerated technology of mechanical loosening of dough is practically applied in the preparation of bakery and flour confectionery. Using this technique of dough loosening makes it possible to exclude pressed yeast from the formulation and prepare the dietary varieties of yeast-free bread and flour confectionery products by the accelerated method.

2. The qualitative, organoleptic, physical-chemical, and microbiological indicators, as well as safety indicators have been determined. The results showed that the yeast-free bakery products made from flour of the highest, first, and second grades meet the requirements and norms of TR TC 021/2011 of the Technical Regulations of the Customs Union “On Food Safety”. The biological value in the yeast-free bakery products from second-grade flour was the highest (62.4 %),

and the energy value was higher in the yeast-free bakery products from flour of the highest grade (877 kJ). It was also found that bakery products made from flour of the highest, first, and second grades can be stored for up to 5 days.

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