Ministry of Education and Science of Ukraine
Black Sea Universities Network

ODESA NATIONAL UNIVERSITY OF TECHNOLOGY

International Competition of Student Scientific Works

BLACK SEA SCIENCE 2022

PROCEEDINGS

ODESA, ONUT 2022

Ministry of Education and Science of Ukraine

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Odesa National University of Technology

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Proceedings of International Competition of Student Scientific Works «Black Sea Science 2022» contain the works of winners of the competition.

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INTRODUCTION

International Competition of Student Scientific Works “Black Sea Science” has been held annually since 2018 at the initiative of Odesa National University of Technology (formerly Odesa National Academy of Food Technologies) with the support of the Ministry of Education and Science of Ukraine. It has been supported by Black Sea Universities Network (the Association of 110 higher education institutions from 12 countries of the Black Sea Region) since 2019, and by Iseki-FOOD Association (European Integrating Food Science and Engineering Knowledge into the Food Chain Association) since 2020.

The goal of the competition is to expand international relations and attract students to research activities. It is held in the following fields:

- Food science and technologies
- Economics and administration
- Information technologies, automation and robotics
- Power engineering and energy efficiency
- Ecology and environmental protection

The jury includes both Ukrainian and foreign scientists. In the 4 years that the competition has been held, the jury included scientists from universities of 24 countries: Angola, Azerbaijan, Benin, Bulgaria, China, Czech Republic, France, Georgia, Germany, Greece, Israel, Italy, Kazakhstan, Latvia, Lithuania, Moldova, Pakistan, Poland, Romania, Serbia, Slovakia, Switzerland, Turkey, USA.

At the same time, every year the geography has expanded and the number of foreign jury members has increased: from 46 jury members representing 25 universities from 12 countries in 2018, to 73 jury members of the 46 universities from 19 countries in 2022.

More than a thousand student research papers have been submitted to the competition from both Ukrainian and foreign institutions from 25 countries: China, Poland, Mexico, USA, France, Greece, Germany, Canada, Costa Rica, Brazil, India, Pakistan, Israel, Macedonia, Lithuania, Latvia, Slovakia, Romania, Kyrgyzstan, Kazakhstan, Bulgaria, Moldova, Georgia, Turkey, Serbia.

The interest of foreign students in the competition grew every year. In 2018, the students representing 15 institutions from 7 countries have submitted 33 works. In 2021 the number of submitted works increased to 73, authored by the students of 40 institutions from 18 countries.

The competition is held in two stages. In the first stage, student research papers are reviewed by members of the jury who are experts in the relevant fields. In the second stage of the competition, the winners of the first stage have the opportunity to present their work to a wide audience in person or online.

All participants of the competition and their scientific supervisors are awarded appropriate certificates, and the scientific works of the winners are included in the electronic proceedings of the competition. Every year the competition receives a large number of positive responses from Ukrainian and foreign colleagues with the desire to participate in the coming years.

1. FOOD SCIENCE AND TECHNOLOGIES

IMPROVEMENT OF RYE-WHEAT BREAD TECHNOLOGY BY APPLYING SUSPENSION NANO SUPPLEMENT

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Abstract. *Due to improving the rye-wheat bread technology with the functional and technological properties of suspension nanodrains supplements the samples of baked rye-wheat bread with a mass fraction of suspension nanodrains supplement 0.1%; 0.15% is used for the research; 0.2% by weight of raw materials, which is introduced in the form of a fatty suspension when kneading the dough in the technological process of rye-wheat bread. To determine the organoleptic (on a 5-point scale, taking into account the weighting coefficient of each indicator), technological, physico-chemical (titrated acidity, mass of moisture content, specific volume, porosity), microbiological (microbial contamination: mesophilic aerobic and optional anaerobic microorganisms (KMAFanM, CFU / g), the presence of bacteria of the Escherichia coli group (BGKP (coliforms), 0.001 g), detection of Staphylococcus aureus, Proteus and other pathogenic microorganisms (pathogenic microorganisms, including bacteria of the genus Salmonella 25 d), etc.), structural and mechanical (elasticity,%; modulus of elasticity E, Pa; shrinkage, %,) indicators are used generally accepted and standard methods.It is found that the introduction of suspension nanoadrains supplement in the amount of 0.1%; 0.15%; 0.2% by weight of raw materials helps to improve the organoleptic quality of rye-wheat bread, gas-holding capacity and loosening of the dough, reducing the duration of fermentation of dough masses by (10±4,0) minutes and aging of semi-finished dough products by (15±2,0) minutes (due to the ability of CNS nanoparticles to intensify biochemical processes).*

It is found that the highest rates were characterized by bread samples with a mass fraction of suspension nanodrains supplements of 0.1%.

Adding a suspension nanodrains supplements to the recipe of rye-wheat bread increases the specific volume by 1.18-1.22 times, the porosity of the crumb by 1.28-1.32 times, the yield of the finished product by 5-6%; reduces crumbs by 1.42 times. During the regulated shelf life, the process of reducing the porosity, shape stability and specific volume of bread slows down compared to the control.

The established microbiological parameters of rye-wheat bread using 0.15% suspension nanodrains supplements for 36 hours meet the requirements of regulatory documentation and indicate its high sanitary-microbiological characteristics.

The recipe was developed and the technological scheme of rye-wheat bread production was developed with the introduction of 0.15% suspension nanoadditive.

The recipe and the technological scheme of rye-wheat bread production is developed with the usage of 0.15% suspension nanoadrains supplements.

The scientific novelty is to study the effect of suspension nanodrains supplements on the organoleptic and microbiological properties of experimental samples of rye-wheat bread, including the storage term.

The practical significance is that its results can be used to develop technologies for the rye-wheat bread production with improved quality, safety and extended shelf life.

Key words: *formulation, suspension nanodrains supplements, functional-technological properties, quality.*

I. INTRODUCTION

One of the directions of development of innovative bakery products technologies is the usage of food additives-enrichers and improvers that allow to adjust the functional and technological properties of flour - the main raw material of flour products; to increase consumer properties and to prolong the preservation of freshness of finished products [1-5].

Bread makes up a significant share of the daily ration of Ukrainians [1-3], so its quality must meet all medical and biological requirements. These indicators depend on a number of factors, the main of which is the quality of the main and additional raw materials used in the production of bread [2-4]. The industry processes up to 50% of the total volume of flour with reduced properties [3], large bakeries use non-stop technology, which has a number of disadvantages, including those that affect the quality of bread [4].

In recent years, technologies with the use of various food supplements have been developed to form the necessary functional and technological properties of flour and dough masses. The need for these innovations is due to:

- the spread of single-phase accelerated methods of dough preparation;
- instability of the quality of flour and raw materials;
- expanding the range of flour products;
- improving the quality of finished products;
- increasing the nutritional value of flour products;
- increasing resistance to microbial and oxidative spoilage;
- extending the shelf life of flour products [6].

Improvers are natural or synthetic substances that are introduced into the recipe of bakery products and allow to regulate the functional and technological properties of raw ingredients (especially flour) and dough. They are used to intensify the technological process of bread production, enhance the aroma and color of the finished product, improve the structure and properties of the crumb. Today an important task in the bakery industry is the search for non-traditional raw materials, the structural components of which will not only intensify the biotechnological processes of flour production, but also improve the chemical composition and quality of finished products, have an economic effect. The intensity of biotechnological processes in bread production depends on the quality of rye and wheat flour, rye sourdough and yeast used. The quality of rye sourdough depends on many factors, but to a greater extent on the composition of the nutrient medium in which the cultivation of this semi-finished product. One of the ways to improve the composition of the nutrient medium for the cultivation of rye yeast is the introduction of biologically active supplements [2, 3, 5].

Therefore, to improve the technology of flour products, in particular, bakery, of practical interest is the use of supplement-improvers, supplement-concentrators, biologically active supplements, including nanometer size. This contributes to the improvement of biotechnological indicators of the quality of sourdough, rye-wheat dough, intensification of the technological process, improving the quality of flour products. The urgency and expediency of the paper is due to the lack of long-term bakery products on the Ukrainian market that do not contain chemical preservatives, insufficient satisfaction of the population's needs in bread products for therapeutic and prophylactic purposes [4, 5]. Therefore, in modern conditions, solving the problem of preserving the quality and consumer properties of rye-wheat bread in the process of sale and storage is relevant, and the search for areas that provide high quality organoleptic, technological, microbiological and physico-chemical indicators is an important task.

II. LITERATURE ANALYTICAL REVIEW

To improve the functional and technological properties in the bakery products production used food supplements of various origins: modified starches, enzymes, seeds, bran, whey and other improvers [14-17].

The authors [17, 18, 20-39] have made a significant contribution to the development of innovative technologies and the formation of the range of bakery products in the market.

Analytical review of literature sources [13-17] reveals a positive effect of dairy supplements on the properties of the dough and the quality of bread. Milk and dairy products contain complete proteins, milk fat and sugar. The most promising protein used in baking bakery products is skimmed milk powder and whey powder. But due to the high cost of these raw materials, their usage becomes economically impractical.

Valuable for bread products are products of soybean processing, sunflower seeds and cotton [39]. Soy flour contains up to 50% protein and 5-6% minerals. Soy protein has a valuable amino acid composition. Soybeans contain: 0.22% calcium, 0.69% phosphorus, 2.09% potassium and other minerals [15, 19, 29, 30, 33]. But 80% of soy is a genetically modified product. Therefore, the use of soy flour has some caveats.

Algae and chickpea technologies are known to improve the quality of bread [2, 3, 24, 25], but they have a negative effect on quality: dough elasticity, moisture and acidity of the crumb, shape stability, yield of the finished product.

The biological value of bread is small, but when consumed in the amount of 500 g of flour of the first or higher grades, the body receives from 21 to 64% of the daily requirement of vital amino acids. Baked bread without improvers does not contain such essential amino acids as lysine, methionine, leucine, isoleucine, phenylalanine, threonine, tryptophan and valine. Person almost completely covers the needs of iron through bread products (receives a significant proportion of manganese and phosphorus). A significant disadvantage of the mineral complex of bread is the low content of calcium and its unfavorable ratio with phosphorus and magnesium. Bread does not contain enough potassium, chromium, cobalt and some other elements. Therefore, increasing the mineral value is also an urgent problem [15, 16, 29, 30].

Analysis of recent research and publications [19, 20, 27-39] has shown that improving bread production technology is necessary to create an innovative product with specified functional and technological properties, because the consumption of such bakery products can increase the biological, physiological and nutritional value of various rations. Flour products are polyphase dispersed systems. Stabilizers are used to increase their stability (especially during technological processing and storage). A promising direction is the use of nanodrains supplementgs with stabilizing action [6, 39].

However, the use of bread improvers and food supplements in bread technology must meet sanitary, medical and biological requirements. In this regard, it is important to introduce into the recipe of the flour product (for example, rye-wheat bread) suspension nanoasupplements (SNS) - to form the necessary functional and technological properties of flour and dough and improve the consumer properties of the finished product. This is due to the ability of SNS nanoparticles to create sufficiently stable polyphase dispersed systems (including emulsions, suspensions) due to the "Pickering effect"; high ζ-potential 34… 44 mV; structural and mechanical stability factor associated with the complexing and electrostatic action of SNS nanoparticles, which leads to the spatial structuring and stabilization of polyphase dispersed systems of dough masses. In addition, the SNS is characterized by complex action: antioxidant, bacteriostatic, hydrating, thickening, water- and fat-retaining, fat- and water-binding properties [7-9, 11, 12, 38].

III. OBJECT, SUBJECT AND METHODS OF RESEARCH

In order to improve the technology of bakery products, participants of the educational-research-production cluster "Complete nutrition: energy-efficient production, storage and marketing" formulated a task - to work out a recipe for rye-wheat bread, which would contain ingredients to improve the quality of finished products.

Requirements for the product were: extended shelf life, esthetics, high biological, physiological and nutritional value.

Subject of research - suspension nanodrains supplements (in the form of fat suspension), samples of baked rye-wheat bread with a mass fraction of suspension nano supplements 0.1%; 0.15%; 0.2% by weight of the prescription mixture.

The object of research is the technology of rye-wheat bread.

Research methods: experimental research, organoleptic, microbiological and microscopic.

In the process of performing experimental work, standard and generally accepted research methods are used [7, 12].

The method of experimental research is used to confirm theoretical positions in practice.

Organoleptic research methods are used to confirm the expected results of organoleptic quality indicators of the finished product.

Microbiological and microscopic studies are performed to confirm the safety of the finished product during the guaranteed shelf life (36 hours).

The mass fraction of moisture is determined by thermogravimetric method of drying a portion of bread to constant weight at constant temperature. The yield of bread product - by weight. The study of the adhesive strength of the dough is based on the method of uniform separation from the steel surface. The acidity of the dough and bread is determined by titrimetric method. The structural and mechanical properties of the dough are investigated using a Brabender farinograph; the maximum shear stress is on the Labor penetrometer. IBE (microbiological indicators) were determined by: KMAFanM - according to GOST 10444.15, Escherichia coli bacteria - according to GOST 30518, Staphylococcus aureus - according to GOST 10444.2, pathogenic microorganisms, including bacteria of the genus Salmonella - according to DSTU according to DSTU ISO 6579: 2006 GOST 10444.12. The presence of bacteria was determined according to GOST 10444.15-94, GOST 10444.8-88, GOST 29185-91.

To assess the organoleptic characteristics of bread, a scale is compiled taking into account the weights and scores of the products. The analysis of bread samples is carried out by the Tasting Commission of the Department of Food Technology, Light Industry and Design of the Ukrainian Academy of Engineering and Pedagogy and the Tasting Commission of the Department of Technical and Logistics of the National Academy of the National Guard of Ukraine.

The use of such a wide range of methods determines, firstly, a fairly high validity and reliability of the results, and secondly, forms a rich array of primary scientific material, so the conclusions and results are objective.

IV. RESULTS

Scientists of leading universities of Ukraine within the cooperation of the educational-research-production cluster "Nutrition: energy efficient production, storage and marketing", which includes the Ukrainian Engineering and Pedagogical Academy and the National Academy of the National Guard of Ukraine, developed an innovative product - bread rye-wheat, which contains a functional ingredient - a suspension nano supplements. It is an supplement-improver based on double iron oxide (FeO Fe2O3), which has great potential and carries a wide range of new functional and technological properties and promising technological applications. It should be noted that most nanomaterials used in food products occupy an intermediate position between nano- and microstructures. Thus, the diameter of DNA is 12 nm, liposomes 30 ... 10000 nm, amylopectin 44 ... 200 nm, cubosomes 500 nm, nanosensors <1000 nm. Nanobiotechnology is one of the most actively developing areas of modern nanoscience and in recent years has attracted more and more attention from researchers in various fields of chemistry, physics, biology, biochemistry, medicine and engineering. Nanobiotechnology can potentially affect many aspects of food technology. Food safety and quality, means of delivery of biologically active components, new materials for pathogen detection and environmental protection are the main areas of application of nanomaterials in food products [7-9, 11, 12, 38].

Nanoparticles of suspension nano supplements have a complex action and high bioavailability to biopolymers, in particular, proteins, carbohydrates. Therefore, they have new functional and technological properties and promising technological applications. Noncovalent adsorption of polymer molecules and H2O dipoles occurs

on the surface of magnetic nanoparticles of suspension nano supplements. The process of adsorption of biopolymer food ingredients and water is determined mainly by ionic, vanderwaals, hydrogen and hydrophobic interactions. These interactions occur between the surface of nanoparticles and adsorbent molecules and entail a change in the free Gibbs energy. The result is the formation of supramolecular ensembles that significantly affect the functional and technological properties of raw materials (eg, flour) and semi-finished products (eg, dough), as well as the quality of finished products [7-9, 11, 12, 38].

In previous studies [7-9, 11, 12, 38] it is found that suspension nanosupplements in the formulation of food products leads to a comprehensive improvement of their consumer and functional-technological properties. Thus, SNS nanoparticles have bacteriostatic and antioxidant properties, promote better digestion of protein components of food, have moisture-, fat-retaining and fat-emulsifying effect, are a source of easily digestible iron, promote metabolic processes.

Table 1 shows the recipes of rye-wheat bread with the introduction of 0.1%; 0.15%; 0.2% of suspension nanosupplements- SNS (in the form of fat suspension) to the weight of raw materials (experiment) and control (bread "Darnytsky").

Table 1 - Recipes for rye-wheat bread "Darnytsky" (control) and rye-wheat bread with the adding of the SNS (experiment)

Title of raw materials	Consumption of raw materials, kg			
	Prototypes (samples) of rye-wheat bread			
	Sample 1 – control	Sample 2 – with 0,1% SNS	Sample 3 – with 0,15% SNS	Sample 4 – with 0,2% SNS
Wheat flour	40,0	40,0	40,0	40,0
Peeled rye flour	60,0	60,0	60,0	60,0
Pressed baker's yeast	0,5	0,5	0,5	0,5
Solt	1,4	1,4	1,4	1,4
SNS fat suspension	–	0,2	0,3	0,4
Total	101,9	102,1	102,2	102,3
The output of bread, %	138,4	143,0	144,1	144,3

For distribution and functioning of nanoparticles of suspension nanosupplements (SNS) by volume of dough mass SNS is introduced in the form of a fat suspension when kneading dough in the technological process of rye-wheat bread in the amount of 0.2 kg; 0.3 kg; 0.4 kg per 100 kg of raw material, equal to 0.1%; 0.15%; 0.2% SNS by weight of raw materials, respectively (see table. 1).

The mass fraction of suspension nanosupplement (SNS in bread is limited by its effect on quality and safety indicators (including organoleptic and microbiological indicators) of the finished product: providing unwanted foreign taste and darkening of bread crumbs with increasing mass fraction of nanosupplements. Previous research has established a massive share of SNS in food systems, which improves the quality of finished products. It is: 0.10%; 0.15%; 0.20% by weight of raw materials [7, 11, 12]. In fig. 1 and 2 is shown prototypes of rye-wheat bread and their organoleptic analysis, respectively.

a b

Fig. 1. Prototypes of rye-wheat bread: a - sample 1 - control, b - sample 3 - with 0.15% SNS

Fig. 1 shows that the prototype of rye-wheat bread with 0.15% SNS has better organoleptic characteristics compared to the control: the correct, oval shape; light brown color of the crumb, which is tender, finely porous, elastic; the surface of the crust - smooth, without swelling, cracks, explosions. This positive effect of the introduction of 0.15% SNS is confirmed by the data of Fig. 2.

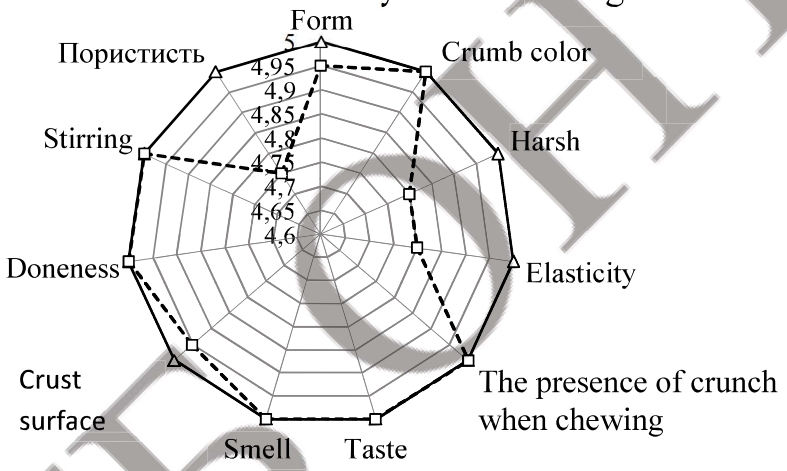

Fig. 2. Organoleptic parameters of samples of bread "Darnytsky" (control) and rye-wheat bread with 0.15% SNS

As can be seen from Pic. 2, the introduction of 0.15% SNS helps to improve the organoleptic quality of rye-wheat bread compared to the control - bread "Darnytsky".

Table 2 shows the results of organoleptic analysis of experimental samples of rye-wheat bread.

Table 2 - Organoleptic parameters (in points) of experimental samples of rye-wheat bread

Characteristics	Prototypes of rye-wheat bread			
	Sample 1 – control	Sample 2 – with 0,1 % SNS	Sample 3 – with 0,15 % SNS	Sample 4 – with 0,2 % SNS
From	4,8±0,1	4,9±0,1	5,0±0,1	5,0±0,1
Crust surface	4,9±0,1	5,0±0,1	5,0±0,1	5,0±0,1
Taste	5,0±0,1	5,0±0,1	5,0±0,1	5,0±0,1
Smell	5,0±0,1	5,0±0,1	5,0±0,1	5,0±0,1
Crumb color	4,6±0,1	5,0±0,1	5,0±0,1	4,9±0,1
Crumb porosity	4,7±0,1	5,0±0,1	5,0±0,1	5,0±0,1
Crumb elasticity	4,7±0,1	4,9±0,1	5,0±0,1	5,0±0,1
Crumb harsh	4,7±0,1	5,0±0,1	5,0±0,1	5,0±0,1

From the data of organoleptic analysis, the rational amount of suspension nanosupplements (SNS) - 0.15% by weight of raw materials.

Fig. 3 presents the technological indicators of experimental samples of rye-wheat dough, which shows that the humidity and acidity of the dough with the introduction of 0.15% suspension nanosupplements (SNS) meet the requirements of regulatory documentation. Improves gas holding capacity and loosening of the dough.

Table 3 - Technological indicators of the experimental sample of rye-wheat dough

Rye-wheat dough index	Prototypes of rye-wheat dough	
	Sample 1 – control	Sample 3 – with 0,15 % SNS
Moisture of the dough%	47,0±2,4	48,4±2,4
The acidity of the dough beg.,°	6,9±0,3	6,1±0,3
The acidity of the dough end.,°	7,8±0,4	7,1±0,3
Duration of dough fermentation, τ·60 s	55±5,0	45±5,0
Duration of dough aging, τ·60 s	60±3,0	45±2,0
Shear stress limit, Pa	445,0±22,0	494,0±23,7
Adhesion strength (steel), kPa	2,5±0,2	1,9±0,1
Plastic viscosity, kPa ·s (while γ=0,02 s^{-1})	7,0±0,3	9,2±0,4

This reduces the duration of fermentation of dough masses by (10±4,0) minutes and aging of dough semi-finished products by (15±2,0) minutes compared to the control due to the ability of nanoparticles of suspension nanosupplements (SNS) to intensify biochemical processes.

Also compared to the control increases: the maximum shear stress in 1.12 times; plastic viscosity 1.3 times (due to the ability of the SNS to form solvate and lipid complexes and stronger moisture and fat content in the structure of the product); decreases the adhesive strength (to steel) by 1.3 times (due to the reduction of free moisture in the dough by increasing the water holding capacity of the dough under the action of suspension nanosupplements).

In addition, the evaluation of the quality of experimental samples of rye-wheat bread was performed on physico-chemical parameters (Table 4).

Table 4 - Physico-chemical and technological parameters of experimental samples of rye-wheat bread

Rye-wheat bread index	Prototypes of rye-wheat bread	
	Sample 1 – control	Sample 3 – with 0,15 % SNS
Moisture of bread, %	47,5±2,4	48,0±2,4
Acidity of bread,°	7,5±0,4	7,2±0,3
Specific volume of bread, sm^3/g	1,8 ±0,1	2,2 ±0,1
Porosity of bread, %	58,0±2,9	75,4±4,0
Losses during heat treatment,%	9,8±0,4	3,7 ±0,1
Bread output, %	138,4±2,1	144,1±2,5

As can be seen from table. 4, moisture and acidity of bread using 0.15% suspension nanosupplements (SNS) meet the requirements of regulatory documentation. At the same time in rye-wheat bread from the SNS increases: the

specific volume of 1.18-1.22 times, the porosity of the crumb 1.28-1.32 times (due to the intensification of biochemical processes), the yield of 5-6 %; losses during heat treatment are reduced by 5-6% compared to the control (due to the stabilizing and water-holding capacity of the suspension nanosupplement).

According to the results of research, a technological scheme for the production of rye-wheat bread with the introduction of a suspension nanosupplement - SNS (Fig. 3). A distinctive feature of the new technology is the introduction of SNS in the form of a fatty suspension when kneading the dough.

The following rational technological parameters are determined: when kneading the dough, a portion of sourdough is mixed with yeast suspension, sugar-salt solution and water. Then add wheat flour and SNS fat suspension.

Mixing is carried out within (12-15) minutes. The dough matures (40-50) minutes at a temperature of (25-28) ° C. The acidity of the ripe dough is (7-8) Neumann's hail.

At the next stage, the dough is divided into pieces of a certain mass, rounded, placed in oiled forms and sent to the oven to stand for 45-50 minutes at a temperature of (30-32) ° C and relative humidity (75-80)%.

Baking of dough blanks is carried out in the oven at 4 temperature zones for 34 minutes: (230–240) oC - 7 minutes, (220–230) oC - 7 minutes, (210–220) oC - 13 minutes, (200–210) oC - 9 minutes.

Cooling and storage of bread after baking is carried out in a granary at a relative humidity of (70-75)% [7,11,12].

The quality of bread is assessed by microbiological safety indicators immediately after production and during the regulated shelf life; as well as the physical and chemical parameters and structural and mechanical properties of bread during storage.

In fig. 4. the technological scheme of rye-wheat bread production with the addition of suspension nanosupplement is presented.

In fig. 5 shows studies of shrinkage and elasticity of experimental samples of rye-wheat bread during the storage.

To determine the quality of rye-wheat bread with the introduction of suspension nanosupplements, the following indicators are studied: the ability of products to harden in terms of stability, specific volume, compressibility, shrinkage, elasticity, porosity, swelling, crumb crumbs.

As can be seen from Fig. 5, on the first day after baking the bread is almost stale; after 24 hours the shrinkage is: for control (3.3 ± 0.1)%, for bread with 0.15% CIS (1.2 ± 0.05)%, in addition, the shrinkage is practically preserved for the first 36 hours, on in contrast to the control, where it increases (2.2 ± 0.1) times. With increasing shelf life, the elasticity of bread samples decreases: after 36 hours for control by (4.5 ± 0.2)%, for bread with 0.15% SNS S only by (1.2 ± 0.05)%, ie much slower . This is due to the water and fat retention capacity of suspension nanosupplements (SNS)

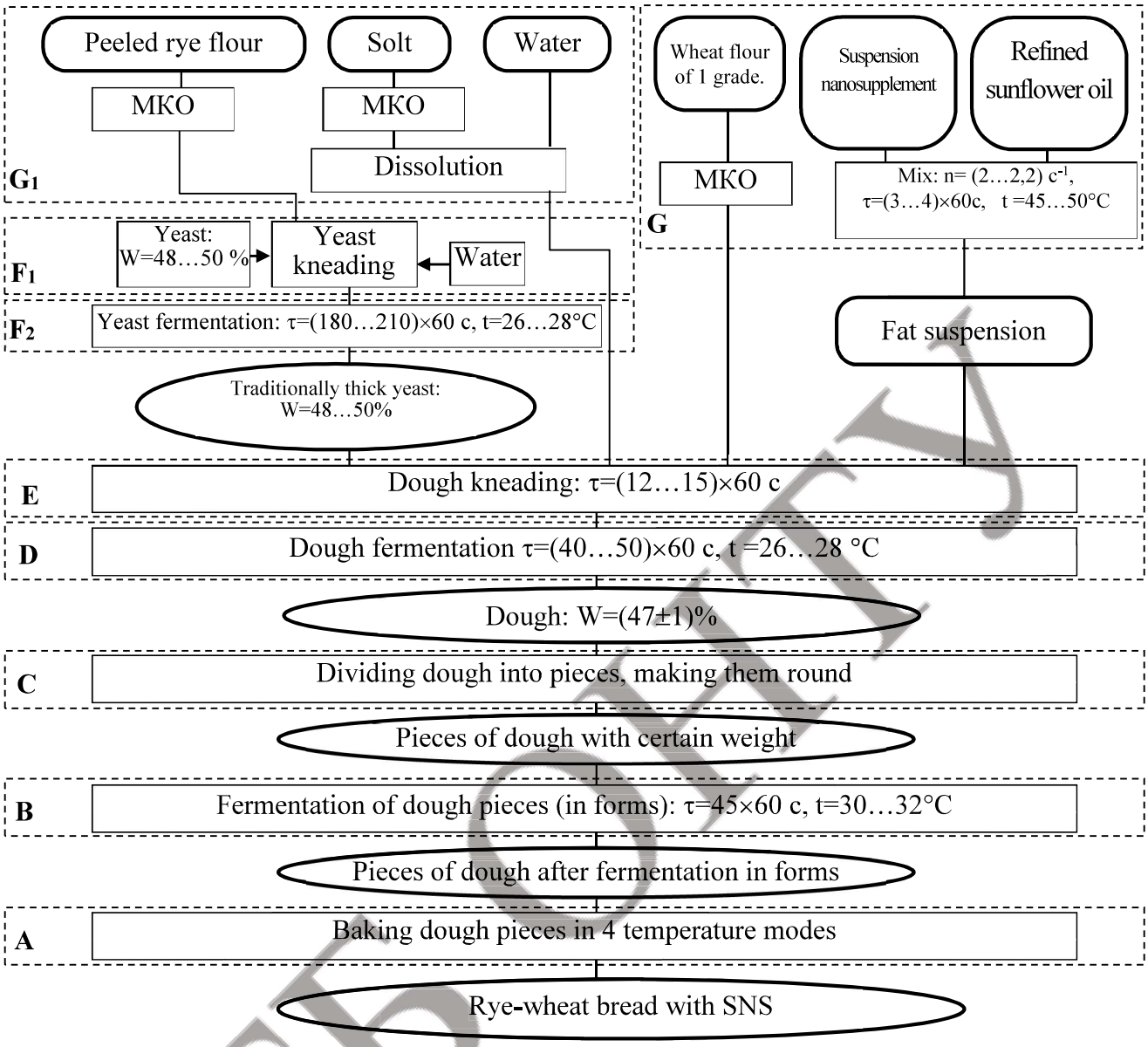

Fig. 4. Rye-wheat bread with SNS production technological scheme: D, E, F_1, F_2, G_1, G_2 – subsystems of the bread production technological scheme

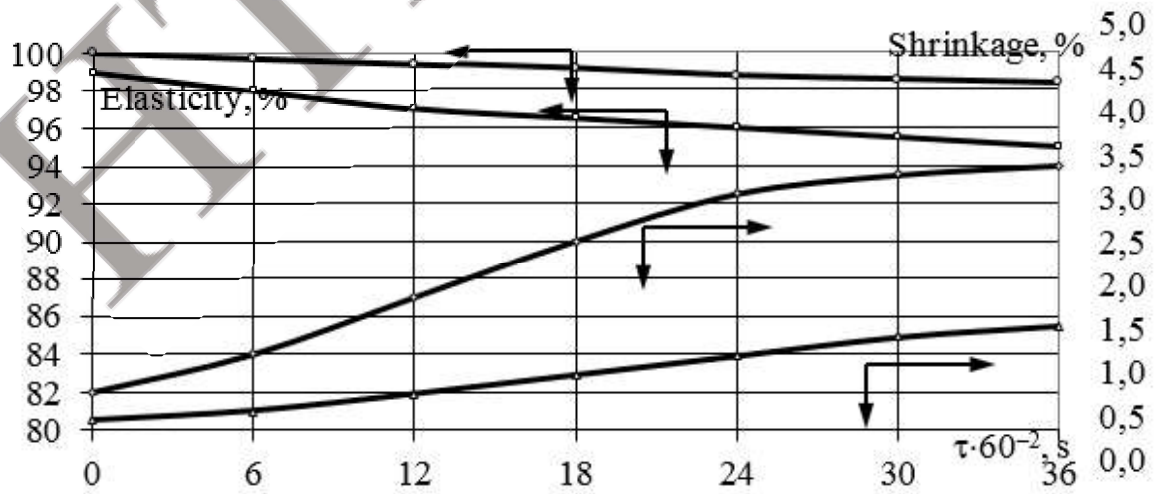

Fig. 5. Elasticity and shrinkage of experimental samples of rye-wheat bread: sample 3 - with 0.15% SNS, - sample 1 - control, - sample 3 - with 0.15% SNS, - sample 1 - control

In fig. 6 shows studies of shape stability, porosity and specific volume of experimental samples of rye-wheat bread during storage.

From the data of fig. 6 it is showed that changes in the porosity of rye-wheat bread with 0.15% SNS correspond to trends in specific volume and stability. The introduction of suspension nanosupplements (SNS) slows down the reduction of these indicators during the regulated shelf life: porosity, stability and specific volume of bread from 0.15% SNS compared to control increases by 4.3-4.7%, 1.6-1, 7 times and 1.8–2.4 times, respectively (due to the ability of the SNS to clusterize and steric stabilization of the food system).

For a more in-depth study of the process of hardening of rye-wheat bread, the indicators of swelling and crumbliness of the crumb are determined (Table 5), which shows that the ability to harden bread with 0.15% SNS is much lower than in the control sample, traditionally produced enterprises of the industry.

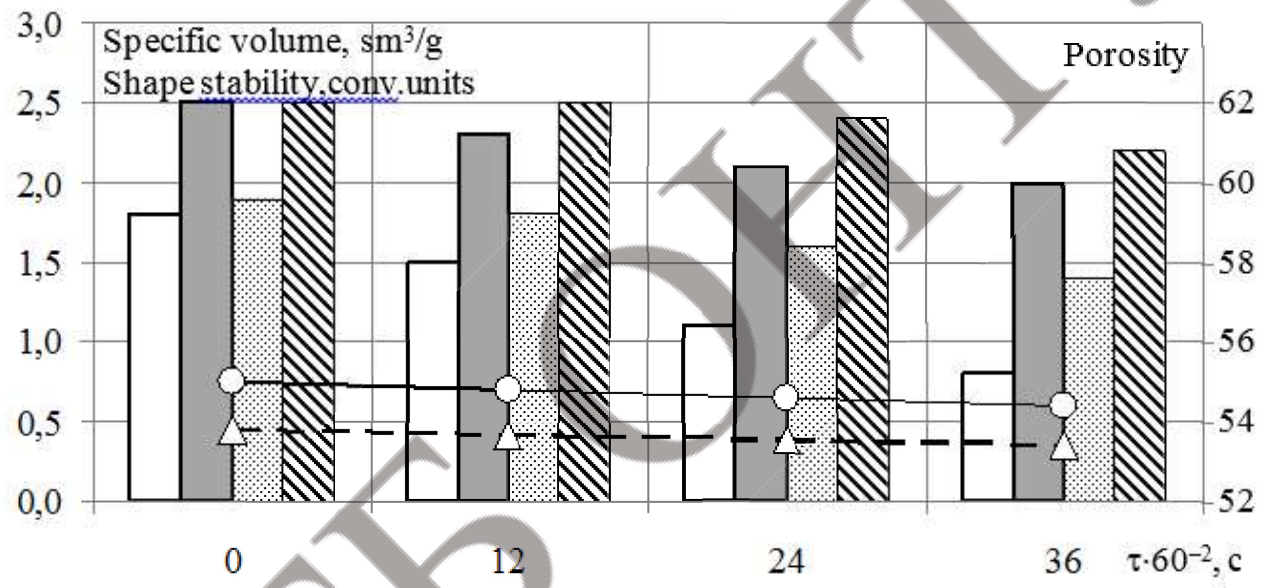

Fig. 6. Specific volume, form stability and porosity of the rye-wheat bread samples while storing: ▭ – specific volume.

Sample 1–control, - specific volume of sample 3 - with 0.15% SNS, - porosity of sample 1-control, - porosity of sample 3 - with 0.15% CIS, - shape stability of sample 1-control, - shape stability of sample 3 - with 0.15 % SNS

Table 5 - Quality indicators of experimental samples of rye-wheat bread (36 hours of storage)

Index	Prototypes of rye-wheat bread	
	Sample 1 – control	Sample 3 – with 0,15 % SNS
Compressibility, penetrometer units	29,0 ± 1,4	36,0 ± 1,8
Swelling of the crumb, %	249,0 ± 12,0	305,0 ± 12,0
Crumb harsh, %	16,9 ± 0,8	11,9 ± 0,6

The safety of bread using suspension nanosupplement (SNS) is evaluated by microbiological indicators. The research results are given in table. 6.

As can be seen from table. 6, microbiological indicators of rye-wheat bread using 0.15% suspension nanosupplement during the regulated shelf life (36 hours) comply with regulatory documentation and indicate its high sanitary-microbiological characteristics.

Table 6 - Microbiological indicators of rye-wheat bread with 0.15% SNS (after 36 hours of storage)

Characteristics	Standart	Bread with 0,15 % SNS
KMAFAnM, KUO / g	No more $1,0\times10^3$	$0,9\times10^2$
Yeast CFU / g	No more 1,0×10	4,0
BGKP (coliforms)	Not allowed in 0.1 g	Not found
Pathogenic m / o, including bacteria of the genus Salmonella	Not allowed in 25,0 g	Not found
CFU molds / g	No more 5,0×10	10

V. CONCLUSIONS

1. The technology of rye-wheat bread production with the introduction of suspension nanosupplements has been improved. A distinctive feature of the new technology is the adding of SNS to the form of a fat suspension when kneading the dough.

2. It is found that the introduction of suspension nanosupplements in the amount of 0.15%; from the mass of raw materials contributes (compared to control) to improve: organoleptic quality of rye-wheat bread; gas holding capacity and dough loosening; reduction of the duration of fermentation of dough masses by (10±4,0) minutes and aging of dough semi-finished products by (15±2,0) minutes (due to the ability of SNS nanoparticles to intensify biochemical processes); increase the ultimate shear stress by 1.12 times and plastic viscosity by 1.3 times and reduce the adhesive strength (to steel) by 1.3 times (due to the structure-forming ability of the nanoparticles of the supplements and the water-holding capacity of the dough under the action of SNS).

3. It is determined that in rye-wheat bread from the SNS (compared to the control) increases: the specific volume of 1.18-1.22 times, the porosity of the crumb 1.28-1.32 times (due to the intensification of biochemical processes) , yield by 5-6%; losses during heat treatment are reduced by 5-6% (due to the stabilizing and water-holding capacity of the suspension nanosupplements).

4. It is proved that the introduction of SNS slows down the process of hardening of rye-wheat bread in the process of regulated shelf life - 36 hours (compared to control): inhibits the reduction of elasticity and shrinkage of bread; increases: porosity, shape stability and specific volume of bread from 0.15% SNS by 4.3-4.7%, 1.6-1.7 times and 1.8-2.4 times, respectively; compressibility and swelling of bread crumbs in 1.22-1.24 times; reduces crumb crumbs by 1.42 times (due to the SNS 's ability to cluster and sterically stabilize the food system).

5. It is established that according to organoleptic indicators, safety indicators, conditions and terms of storage the new product meets the requirements of regulatory documentation.

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