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Показатели хлебных палочек на основе пшеничной, ржаной муки и порошков крупноплодных и мелкоплодных сортов томатов

Indicators of bread sticks based on wheat, rye flour and powders of large-fruited and small-fruited varieties of tomatoes

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Аннотация. *В статье представлены результаты определения показателей качества композитных смесей, полуфабрикатов и хлебных палочек на основе пшеничной муки первого сорта, ржаной сеяной муки в соотношениях 70 и 30 частей; 80 и 20 частей и порошков томатов крупноплодных и мелкоплодных сортов в дозировке 1–9 % от массы смеси муки. Отмечалось увеличение титруемой кислотности композитных смесей, теста и выпеченных изделий при увеличении количества порошков из томатов и незначительные изменения набухаемости изделий. Суспензия порошков крупноплодных и мелкоплодных томатов активировала процессы газообразования, что позволило совершенствовать процесс тестоведения. Достоверных различий между показателями качества образцов смесей и хлебных палочек при использовании порошка из крупноплодных или мелкоплодных томатов, а также при разных соотношениях пшеничной и ржаной муки, но с одинаковыми дозировками обогатительной добавки не наблюдалось. Предложено использовать порошок томатов крупноплодных сортов в количестве 7 % для активации дрожжей при получении хлебных палочек функционального назначения.*

Ключевые слова: порошок томатов, хлебные палочки на основе биологических разрыхлителей, функциональные продукты питания

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Abstract. *The article presents the results of determining the quality indicators of composite mixtures, semi-finished products and bread sticks based on wheat flour of the first grade, sifted rye flour in ratios of 70 and 30 parts; 80 and 20 parts and powderes of large-fruited and small-fruited varieties of tomatoes at a dosage of 1–9 % by weight of the flour mixture. An increase in the titratable acidity of composite mixtures, dough and baked products was noted with an increase in the amount of tomato powders while the wettability of products remained virtually unchanged. A suspension of powderes of large-fruited and small-fruited tomatoes activated the processes of gas formation, which made it possible to improve the dough process. No significant differences were* *found between the quality indicators of samples of mixtures and bread sticks when using powder from large-fruited or small-fruited tomatoes, as well as at different ratios of wheat and rye flour, but with the same dosages of enrichment. It is proposed to use the powder of large-fruited varieties of tomatoes in the amount of 7% for the activation of yeast in the production of functional bread sticks.*

Key words: tomato powder, bread sticks, biological leavening agents, functional foods

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Introduction. Domestic and foreign scientists focus on the feasibility of using secondary resources for the production and processing of agricultural products to expand the range of targeted nutrition products. The positive effect of the introduction of vegetable and fruit processing products on the nutritional and energy value of flour products, quality indicators of finished products and on some technological stages of its production has been proven. The introduction of research results into production contributes to solving the issues of complete processing of fruit and vegetable raw materials in places of their storage or canning [1–3].

Of great importance in the nutrition of a modern person are bakery products with low humidity, therefore, the development of recipes for these products in order to give them a functional orientation has a high scientific and practical potential [4–6].

Our choice of an enriching ingredient for making bread sticks was influenced by the results of experimental studies, which indicate a fairly high content of amino acids, enzymes, sugars, organic acids, dietary fibers, pectins and mineral salts in fresh tomatoes. Many phenolic acids and carotenoids of tomatoes have a pronounced antioxidant activity; therefore, they have a protective effect against oxidative stress [7]. High amylase activity was noted in tomatoes, which can affect the fermentation process and the quality indicators of finished flour products [8].

Tomato powder obtained using various types of drying also contains significant amounts of proteins, sugars, fats, carotenoids, dietary fibers, organic acids, and mineral elements [9–12].

The search for scientific literature data to substantiate the research topic revealed a number of publications that present the results of determining the effect of tomato powder on fermentation processes and quality indicators of bakery and confectionery products. The authors noted the positive effect of certain dosages of tomato powder on the organoleptic and physicochemical properties of crackers, shortbread biscuits, gingerbread, and bakery products, and also determined the optimal stages for adding enriching additives [13–17].

However, earlier scientific articles did not consider the use of tomato powder from large-fruited and small-fruited varieties of tomatoes in the production of bread sticks based on a mixture of wheat-rye flour. This fact determined the purpose of the study - to determine the feasibility of obtaining bread sticks based on composite mixtures of wheat flour of the first grade, seeded rye flour and various dosages of powders from large-fruited and small-fruited tomato varieties.

Materials and methods. The following raw materials were used in the experimental work: wheat flour of the first grade (STB 1666-2006 “Wheat flour. Specifications”), seeded rye flour (GOST 7045-2017 “Rye flour. Specifications”), pressed yeast (GOST 171-2015 “Yeast bakery pressed. Specifications"), table rock salt (STB 1828-2008 "Edible rock salt. Specifications"), sugar (GOST 33222-2015 "White sugar. Specifications"), sunflower oil (GOST 1129-2013 " Sunflower oil. Specifications"), drinking water (SanPin 2.1.4.1074-01 "Drinking water. Hygienic requirements for water quality of centralized drinking water supply systems. Quality control"), tomato powders (GOST 32065-2013 "Dried vegetables. General specifications ").

Composite mixtures and finished products were evaluated for compliance with the requirements of STB 1910-2008 “Grain products. Composite mixes. General specifications” and GOST 28881-90 “Bread sticks. General technical conditions ".

In accordance with GOST 27558-87 “Flour and bran. Methods for determining color, smell, taste and crunch” carried out an organoleptic evaluation of flour and composite mixtures, using

GOST 27493-87 “Flour and bran. Method for determining acidity by mash” and GOST 9404-88 “Flour and bran. Moisture Determination Method” to determine the physical and chemical indicators of the quality of flour and composite mixtures (acidity and moisture content). To study the quality of dried tomato powder, we were guided by GOST 28561-90 “Fruit and vegetable processing products. Methods for determination of solids or moisture”.

In the course of a model experiment, the gas-forming ability of yeast was studied in the presence of different dosages of fortifying additives, and the effect of tomato powder on the gas formation of pressed yeast was determined at different periods of storage of biological baking powder [18].

Experimental work was carried out on four variants of composite mixtures:

- Option 1 - the ratio of wheat flour of the first grade and seeded rye 70 and 30 parts, powder of large-fruited tomato varieties in the amount of 1.0–9.0% of the total mass of wheat and rye flour;

- Option 2 - the ratio of wheat flour of the first grade and seeded rye 70 and 30 parts, powder of small-fruited tomato varieties in the amount of 1.0–9.0% of the total mass of wheat and rye flour;

– option 3 – the ratio of wheat flour of the first grade and seeded rye 80 and 20 parts with the addition of powder of large-fruited varieties of tomatoes in dosages of 1.0–9.0% of the total mass of flour.

- Option 4 - the ratio of wheat flour of the first grade and seeded rye 80 and 20 parts with the addition of powder of small-fruited varieties of tomatoes in dosages of 1.0–9.0% of the total mass of flour.

The obtained data were compared with the results of determining the quality indicators of control samples, including wheat and rye flour in the amount of 70:30 parts and 80:20 parts.

The approved recipe was chosen as the basis for improvement [19]. The composition of the control samples of bread sticks of the first and second variants of the experiment included (per 100 grams of flour mixture): wheat flour of the first grade (80 g or 70 g); seeded rye (20 g or 30 g); salt (2 g); sugar (2 g); pressed baking yeast (5 g); sunflower oil for lubrication and water by calculation. Powder of large-fruited or small-fruited tomatoes was added to the test samples in accordance with the research options in the amount of 1–9 g by weight of the flour mixture. To obtain a powder, chopped tomatoes were dried in a TauRo oven at a temperature of 90 °C, then ground in an ML-1 laboratory mill, followed by sieving through a sieve for wheat flour of the first grade.

Based on the data of the model experiment on the study of the gas-forming ability of yeast and the data of previous studies [13], an improved method of dough management was envisaged compared to the traditional one [20]. The process included pre-activation of the yeast suspension with tomato powder at 30 °C. for 15 minutes. Then the remaining components were added to the yeast suspension with the powder, the dough was kneaded with a moisture content of 37%, left to rest for 10 minutes at a temperature of 20 ° C, rolled out, molded semi-finished products and left in a proofer for 30 minutes at a temperature of 30 °C.

Sheets with blanks were placed in a ShKhL-065 SPU laboratory electric oven and baked for 10–12 minutes at a temperature of 200–210 °C.

Results and Discussion. The quality indicators of wheat flour of the first grade and seeded rye met the requirements of TNLA.

The resulting powders of large-fruited and small-fruited tomatoes did not differ in organoleptic characteristics and had an orange color, taste and smell characteristic of tomatoes. The moisture content of the powder from large-fruited tomatoes was 11.3%.

In appearance, the composite mixtures were quite homogeneous. With an increase in the amount of enrichment additive, the color changed from light cream to cream with a red tint, and the taste and smell of dried tomatoes also increased. With an increase in the dosage of tomato powders in all variants of the mixtures, a decrease in moisture content and an increase in titratable acidity were observed (Table 1), which is due to the high content of food acids and other compounds of an acidic nature in tomatoes.

Table 1 Indicators quality composite

Indicator	Quantity additives, %					
	1	3	5	7	9	Control
Option 1						
Humidity, %	11.6±0.2	11.0±0.2	10.5±0.3	10.1±0.3	10.4±0.3	11.8±0.2
Acidity , degrees	7.6±0.2	8.9±0.2	10.5±0.2	10.6±0.2	12.3±0.3	3.9±0.2
Option 2						
Humidity, %	11.6±0.2	11.2±0.2	10.7±0.3	10.0±0.3	9.8±0.3	11.8±0.2
Acidity, degrees	7.6±0.2	8.7±0.2	9.9±0.2	10.9±0.2	12.7±0.3	3.9±0.2
Option 3						
Humidity, %	11.0±0.2	10.8±0.2	10.6±0.3	10.1±0.3	9.9±0.2	11.7±0.2
Acidity , degrees /	7.3±0.2	7.8±0.2	8.3±0.2	9.9±0.2	12.3±0.3	3.8±0.2
Option 4						
Humidity, % /	11.5±0.2	11.3±0.3	10.8±0.2	9.9±0.3	9.7±0.2	11.7±0.2
Acidity , degrees	7.0±0.2	7.9±0.2	8.3±0.2	10.1±0.2	12.5±0.4	3.8±0.2

A comparative analysis of the indicators showed that for all research options there was no significant difference between the moisture content of the samples with equal amounts of enrichment additives. The values of titratable acidity were higher when 30% rye flour was used in mixtures. There were no significant differences in the values of this indicator between samples with the same dosages of tomato powder of large-fruited and small-fruited varieties.

It was possible to wash off gluten from all test samples of composite mixtures, which belonged to quality group II, its elasticity decreased insignificantly with an increase in the dosage of the enrichment additive. An increase in the spread ability of the dough ball was recorded with an increase in the mass fraction of tomato powders in all compiled variants of composite mixtures by 0.33–0.50 cm, while there was no clear dependence of changes in this indicator on the tomato variety.

In order to improve the dough process, an assessment was made of the possibility of pre-activation of yeast by a suspension of tomato powders. The process of switching yeast enzyme systems from respiratory to fermentative metabolism proceeds more rapidly in a small amount of nutrient medium that is optimal in composition [21]. In our experiment, powder from large-fruited or small-fruited tomato varieties was added to an aqueous suspension of yeast. The tube was closed with a Meisl lock and thermostated at 30°C for 15 minutes. The results obtained at this stage showed an increase in gas formation when using powder from large-fruited tomatoes by 2.41–3.00 times, and when powder from small-fruited tomatoes is added to the medium, by 5.12–5.74 times relative to the control. At the same time, the amount of carbon dioxide released proportionally increased with an increase in the amount of tomato powder from 1% to 9% relative to the mass of flour. At the stage of further 60-minute fermentation in the presence of flour mixtures, an excess of the total amount of released CO_2 in terms of 1 gram of yeast was recorded in comparison with the control by 1.16–2.52 times in the first version of the composite mixture; 1.32–1.87 times in the second variant; 1.25–2.20 times in the third; 1.09–2.11 times in the fourth version of the composite mixture (Figure 1).

Taking into account all the preliminary experiments, it was decided to conduct test baking for all options for composite mixtures, using preliminary yeast activation.

In the process of assessing the quality indicators of semi-finished products, a change in their color was noted with an increase in the dosage of the powder from light yellow to brown. The dough of all samples had a homogeneous structure and was well kneaded. With an increase in the number of added additives, a slight decrease in moisture content and an increase in the acidity of semi-finished products were noted.

In bread sticks of all experimental variants, no differences were found in organoleptic properties when using equal dosages of powder from large-fruited or small-fruited tomato varieties in the recipe. Depending on the amount of tomato powder added, the color of the products changed from light yellow to brown, and the pleasant taste and smell of dried vegetables intensified. Bread sticks with a dosage of tomato powder of 9% had a sour taste with a barely noticeable bitterness. The shape of the finished samples of the experimental systems was round, without dents, the surface was smooth without swelling, and with a powder content of 9%, its slight inclusions were visualized. A loosened, baked inner part of the products without signs of non-mixing with uniform pores was noted.

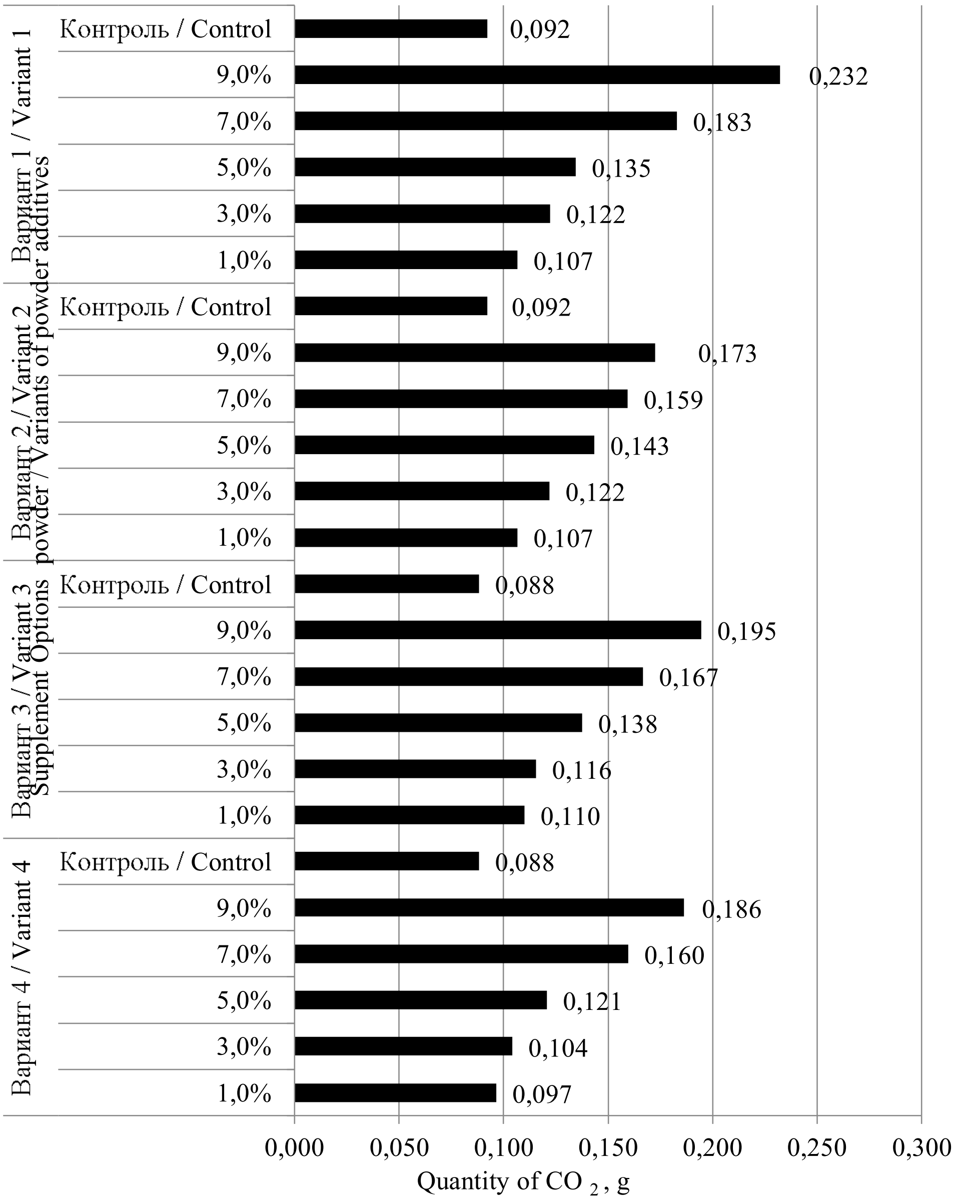

Figure 1 - Formation of CO_2 in recalculation per 1 g yeast V four options composite mixtures

A significant difference in the values of physicochemical parameters of the research options when using equal amounts of powders of large-fruited and small-fruited tomato varieties within the same ratio of wheat and rye flour was not noted (table 2).

The expected increase in titratable acidity was recorded with an increase in the amount of tomato powder added to the recipe and a decrease in the moisture content of bread sticks of all research options. Titratable acidity was higher in samples of the first and second research options due to the addition of more rye flour. These data are consistent with the results of the analysis of composite mixtures and semi-finished products. The titratable acidity exceeded the normalized acidity according to TNLA, however, for products containing tomato additives, an increase in the value of this indicator is allowed.

Table 2 - Indicator's quality bread sticks

Indicator	Quantity additives, %					
	1	3	5	7	9	Control
Option 1						
Humidity, %	10.1±0.2	9.8±0.2	9.2±0.2	9.0±0.2	8.4±0.2	10.0±0.2
Acidity, degrees	7.3±0.2	8.6±0.2	9.8±0.2	10.1±0.2	11.8±0.3	3.9±0.2
Swelling coefficient	1.020± 0.05	1.020± 0.05	1.020± 0.04	1.035± 0.06	1.013± 0.04	1.090± 0.05
Option 2						
Humidity, %	10.0±0.2	9.4±0.2	9.1±0.2	8.9±0.2	8.3±0.2	10.0±0.2
Acidity, degrees	7.2±0.2	8.4±0.2	9.5±0.2	10.5±0.2	12.1±0.3	3.9±0.2
Swelling coefficient	1.021± 0.04	1.022± 0.04	1.022± 0.05	1.036± 0.05	1.014± 0.04	1.090± 0.05
Option 3						
Humidity, %	10.0 ±0.2	9.2 ±0.2	9.0 ±0.2	8.8 ±0.2	8.6 ±0.2	9.9±0.2
Acidity, degrees	6.9±0.2	7.3±0.2	8.0±0.2	9.2±0.2	11.8±0.3	3.8±0.2
Swelling coefficient	1.020 ± 0.04	1.025 ± 0.04	1.022 ± 0.05	1.029 ± 0.05	1.015 ± 0.03	1,100± 0.04
Option 4						
Humidity, %	10.1 ±0.2	9.4 ±0.2	9.1 ±0.2	8.9 ±0.2	8.7 ±0.2	9.9±0.2
Acidity, degrees	6.7±0.2	7.3±0.2	8.0±0.2	9.5±0.2	11.9±0.4	3.8±0.2
Swelling coefficient	1.019 ± 0.03	1.021 ± 0.04	1.027 ± 0.05	1.033 ± 0.05	1.010 ± 0.03	1,100± 0.04

The swelling coefficient did not change in proportion to the amount of the added additive, which is explained by a gradual increase in the amount of pectin substances when making large dosages of the additive, and on the other hand, by a decrease in the content of proteins of prolamin and glutelin fractions of flour in composite mixtures. The best results in this indicator were obtained for samples containing concentrations of enrichment powders of 5 and 7% by weight of flour.

Based on the results of the tasting, samples were selected, including 7% of the powder of large-fruited and small-fruited tomatoes, using the ratio of wheat and rye flour - 70 and 30 parts (Figure 2).

1 2 3

Figure 2 - Samples of bread sticks: 1 - control sample (a mixture of 70 and 30 parts of wheat and rye flour), 2 - a mixture of 70 and 30 parts of wheat and rye flour and 7% tomato powder of large-fruited tomatoes, 3 - a mixture of 70 and 30 parts of wheat and rye flour and 7% tomato powder of small-fruited tomatoes

Given the higher economic feasibility of using powder from large-fruited tomatoes, in further studies we used wheat and rye flour in a ratio of 70 and 30 parts and powder from large-fruited tomatoes. During the storage of bread sticks of this variant at a temperature not exceeding 25 °C, in plastic bags for 15 days, there were no signs of damage and deterioration of the organoleptic characteristics of the products.

In order to assess the effect of tomato powder components on the parameters of viability and fermentation activity of used pressed baker's yeast with different storage times from the date of production, a model experiment was carried out in which the proportion of budding cells, the proportion of dead cells and the degree of activation by a suspension of tomato powder were determined. Two samples of pressed yeast were used, stored at +4 °C for 10 days from the date of manufacture (option 1) and 45 days (option 2, the last day of the expiration date set by the manufacturer). At the first stage, a sample of yeast (3 g) was suspended in water with large-fruited tomato powder added in an amount of 7% of the calculated flour weight. The flasks were closed with a Meisl lock and kept for 15 minutes in a thermostat at +30° C. A yeast suspension without flour was used as a control sample. At the second stage, a wheat-rye mixture (70:30) was added to the existing suspensions, and cultivation continued for another 60 minutes, periodically weighing the flasks. The repetition of the experiment is 3-fold.

A microscopic study of the physiological state of baker's yeast in "crushed drop" preparations stained with methylene blue showed that at the initial time, the proportion of dead cells in the large square of the Goryaev chamber (n = 15) in the studied samples with different storage periods was 5.38–6 .81% (Table 3) and χdid not differ statistically when comparing the shares by method ^{2} (p = 0.685). The proportion of budding cells was 16.14% in the suspension of variant 1 and 7.02% in variant 2; differences between the variants are significant at p = 0.046 (Table 3). The lower content of budding cells in the second sample may be due to the longer storage period from the date of production.

Table 3 – Yeast viability assessment

Yeast suspensions	Time, minutes	Parameters	
		Proportion of dead cells, %	Proportion of budding cells, %
Control 1	0	6.81	16.14
	15	5.94	15.72
Control 2	0	5.38	7.02
	15	5.13	8.80
Option 1	15	5.52	15.34
Option 2	15	4.89	9.53

After the completion of the 15-minute first stage of the experiment - activation of yeast under anaerobic conditions without flour - the microscopic picture indicated that the proportions of dead cells and budding cells in the control samples of both variants did not change statistically significantly compared to the initial values (p > 0.6) , no differences were found between the control suspensions themselves (p >0.4). In yeast suspensions of both variants with the addition of tomato powder, no differences were also observed (p > 0.6) both in comparison with the initial state and in comparison, with the corresponding 15-minute control (table 3). It can be concluded that during the observation period under anaerobic conditions of cultivation in both suspensions at the stage of preliminary activation, yeast cells retained viability, but did not multiply. Accordingly, it can be assumed that, regardless of the duration of storage of baker's yeast, the adaptation and restructuring of metabolism to fermentation processes occurred at a sufficient level.

Analyzing the total amount of carbon dioxide released during the monitoring of the suspensions in terms of 1 gram of yeast, it was found that in both variants of the experiment, the addition of tomato powder to the flour mixture led to the activation of fermentation: 3.13 times compared to the control in the first sample and 2.82 times in the second (Figure 3). At the first stage of fermentation - with the addition of powder from large-fruited tomatoes, without flour - gas formation in all flasks was insignificant. Statistically significant differences between the two samples, as well as between the sample and the corresponding control, were not found (Z -test in the Mann-Whitney test took values from 0.21 to 1.53 at p >0.1).

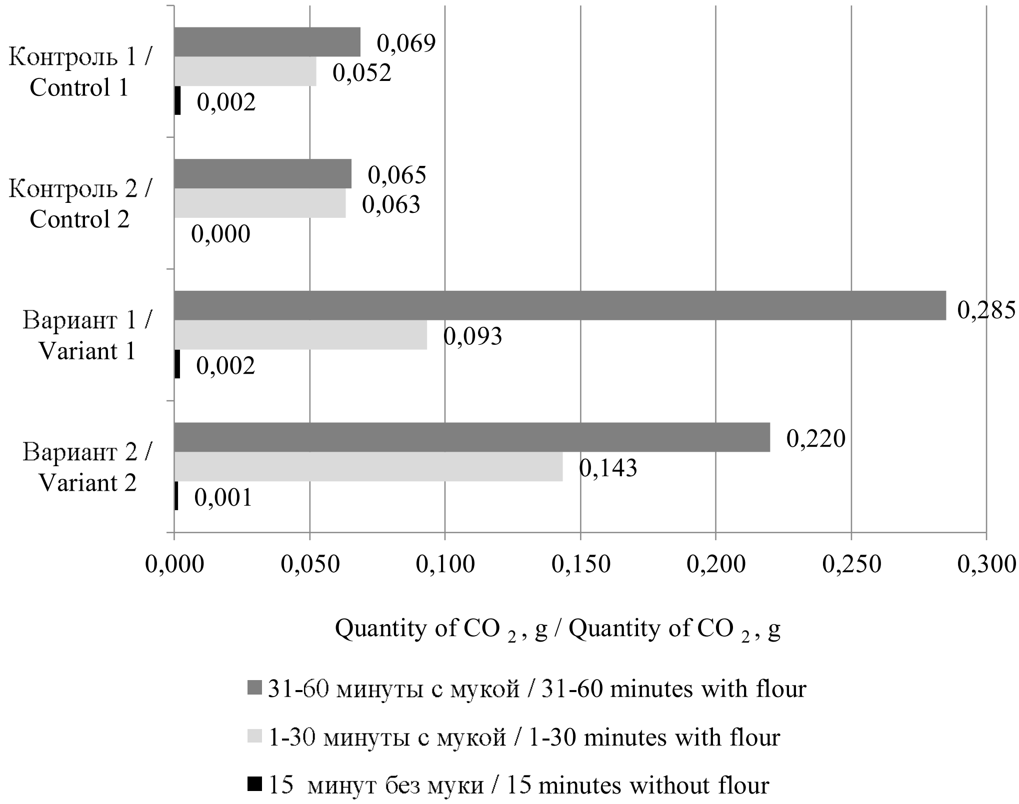

Figure 3 - CO_2 generation during activation of baker's yeast with different storage times

At the second stage, after adding a mixture of wheat and rye flour (70:30), already in the first 30 minutes of observation, activation of the process by 1.78–2.26 times was noted in comparison with control flasks; while more gassing occurred in sample 2 (with a longer storage period). In the next 30 minutes, the fermentation rate increased even more ($p < 0.05$): in sample 1, it exceeded the control by 4.15 times, and in sample 2, by 3.37 times.

Thus, the addition of tomato powder to the flour mixture made it possible to significantly intensify gas formation even in a baker's yeast sample at the expiration date.

Conclusion. The results of a significant pre-activation of pressed baker's yeast with a suspension of tomato powder substantiated the feasibility of test baking bread sticks with enrichment powder under conditions of reduced resting and proofing periods. Significant amounts of mono- and disaccharides, amino acids, carotenoids, high amylase activity of tomato powder contribute to an increase in the gas-forming ability of yeast. The prospect of using powder of large-fruited and small-fruited tomatoes in the production of bread sticks at a dosage of 7% by weight of a mixture of wheat-rye flour in a ratio of 70 and 30 parts is justified by good quality indicators of composite mixtures, semi-finished products and finished products, as well as the results of tasting. Tomato powder activates pressed baker's yeast at the limit of its shelf life, which is of great technological importance and can be the basis for reducing the dosage of yeast added to the recipe under certain production conditions.

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