

Research article

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Effect of low-temperature fermentation and beet powder on the quality of bakery products

Iryna M. Rusina^{1*}, Iryna M. Kolesnik², Alitsiya I. Guzevich³

^{1,3} Grodno State Agrarian University (28, Tereshkova St., Grodno, 230008, Belarus)

² Yanka Kupala State University of Grodno (3/1, Dovatora Lane, Grodno, 230012, Belarus)

¹ rimih_2010@mail.ru

² kolesnik_irina@inbox.ru

³ aliciya_ivanovna@mail.ru

*Corresponding author

Abstract. The article analyses the quality indicators of composite mixes, doughs and bakery products based on first-grade wheat flour and beetroot powder in doses of 3-11% of the flour weight. Straight and low-temperature fermentation methods were used to obtain the bakery products. With an increase for additive, an increase in the titratable acidity of the composite mixtures was observed, the amount of raw gluten decreased while its elasticity was improved. The enriching powder did not have a significant effect on the physic-chemical characteristics of the dough and finished products obtained by the straight method. The quality indicators of the samples prepared under cold fermentation conditions at a temperature of +5 °C and a duration of 20 hours were slightly lower. It was observed that after 18 hours of the experiment, the increase in the acidity of the dough was slower and by the 20th hour it was completely fermented. These data are consistent with the results obtained in the course of a model experiment to study the dynamics of fermentation. The product that was chosen as the best according to the tasting results was the one that included 7 % of table beet powder from the mass of wheat flour. By reducing the sugar dosage in the recipe of this sample by 50 % and resting the dough before fermentation, its consumer properties were improved.

Key words: beetroot powder, bakery products, low-temperature fermentation, functional foods

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Научная статья

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Влияние низкотемпературного брожения и порошка столовой свеклы на качество булочного изделия

Ирина Михайловна Русина¹, Ирина Михайловна Колесник², Алиция Ивановна Гузевич³

^{1,3} Гродненский государственный аграрный университет (28, ул. Терешковой, Гродно, 230008, Беларусь)

² Гродненский государственный университет им. Янки Купалы (д. 3/1, пер. Доватора, Гродно, 230012, Беларусь)

¹ rimih_2010@mail.ru

² kolesnik_irina@inbox.ru

³ aliciya_ivanovna@mail.ru

*Автор, ответственный за переписку

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Аннотация. В статье проанализированы показатели качества комpositных смесей, теста и булочных изделий на основе пшеничной муки первого сорта и порошка столовой свеклы в дозировках 3–11% от массы муки. При получении сдобы использовали безопасный и низкотемпературный способы брожения. С увеличением количества обогатительной добавки наблюдалось повышение титруемой кислотности комpositных смесей, количество сырой клейковины уменьшилось при одновременном улучшении ее упругости. Обогатительный порошок не оказывал значительного влияния на физико-химические характеристики теста и готовых изделий, полученных безопасным способом. Показатели качества образцов, приготовленных в условиях холодного брожения при температуре +5°C и продолжительности 20 часов, были незначительно ниже. Выявили, что после 18 часов эксперимента прирост кислотности теста снизился, а на 20 часу оно выбродило полностью. Эти данные согласовываются с результатами, полученными в ходе модельного эксперимента по изучению динамики брожения. Наилучшим по результатам дегустации было выбрано изделие, включающее 7 % порошка столовой свеклы от массы пшеничной муки. При снижении дозировки сахара в рецептуре этого образца на 50 % и проведении отлежки теста перед брожением улучшились его потребительские свойства.

Ключевые слова: порошок корнеплодов столовой свеклы, хлебобулочные изделия, низкотемпературное брожение, функциональные продукты питания

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Introduction. In recent years, there has been renewed interest in the production of bakery products using low-temperature fermentation, but in terms of innovative technologies, such methods of dough production remain insufficiently studied.

The non-sponge, sponge and accelerated methods are used to obtain wheat bread and bakery products. The most popular areas of low-temperature dough technology are obtaining cooled dough, completely ready for shaping, cooled packaged and unpacked dough pieces for proofing, as well as proofing at low temperatures [1-7].

For example, the effect of prolonged fermentation at low temperatures on the properties of wheat dough was previously studied. The studies revealed a dependence of the quality of finished samples on the duration and temperature of fermentation, which made it possible to ensure the necessary physicochemical and consumer indicators of the product and recommend conducting this stage of dough preparation for 24 hours at a temperature of 5°C, 8-16 hours at 10°C and 8 hours at a fermentation temperature of 15°C [5].

In a comparative analysis of the quality indicators of wheat bread that was molded and not molded before cold fermentation at a temperature of 2-4°C for 10 and 20 hours, the best results were obtained for samples that were not molded before this technological stage [6].

In the process of studying the prospects of using long-term cold proofing for obtaining rich bakery products, several variants of its implementation in a special proofing cabinet at different temperatures and durations of the process were selected. During the research, it was determined that the optimal parameters of long-term cold proofing are a temperature of 5 and 10°C and a duration of 8 and 16 hours, as well as a temperature of 15°C and a time of 8 hours. Such conditions ensured an increase in the degree of accumulation of aromatic substances in rich products. At the same time, long-term cold proofing at a temperature of 5°C was insufficient for the formation of the required amount of these compounds. At a lower temperature for this stage, the porosity, shape stability and other indicators of the test samples worsened in relation to the control [7].

In this regard, we decided to conduct trial baking of rich bun products, not formed before low-temperature fermentation, at a temperature of +5°C and a duration of 20 hours [5-7], and also to introduce beetroot root powder into the recipe, since it is capable of activating the fermentation process and accumulation of flavor compounds. It can be assumed that this will allow obtaining products under conditions of reduced fermentation with good quality indicators, since vegetable powders are phytoactive additives that ensure the regulation of technological

processes, correction of the properties of composite mixtures, semi-finished products and finished products. Their introduction into the recipe of flour products is considered the simplest and most effective technological option for enrichment [8].

In terms of enriching phytoadditives in the production of bakery products, beetroot powder is considered promising, since it contains a large amount of carbohydrates that are easily accessible for fermentation, the betanin of the vegetable has an antioxidant effect, and vitamins and food acids accumulate in significant quantities. The anti-inflammatory, anticarcinogenic, antidiabetic and analgesic effects of beetroot powder have also been previously proven [9-13].

A positive effect of the components of table beet powder on the state of the gluten complex, the rheological properties of semi-finished products and the quality of finished products was noted [14].

The aim of the work is to identify the feasibility of using beetroot powder in the production of bakery products under fermentation conditions at low temperatures.

Materials and methods. To conduct the research the following raw materials were used: first grade wheat flour (STB 1666 - 2006 "Wheat flour. Specifications"), pressed yeast (GOST 171-2015 "Pressed baker's yeast. Specifications"), sugar (GOST 33222 - 2015 "White crystalline sugar. General specifications"), salt (STB 1828 - 2008 "Edible rock salt. Specifications"), margarine (STB 2016 - 2009 "Edible fat and oil products. Margarines and spreads. General specifications"), dry milk (STB 1858 - 2009 "Dry milk. General specifications"), vanillin (GOST 16599 - 71 "Vanillin. Specifications"), drinking water (SanPiN 2.1.4.1074 - 01 "Drinking water. Hygienic requirements for the quality of water in centralized drinking water supply systems. Quality control"), powder of table beetroot (GOST 32065-2013 "Dried vegetables. General specifications").

The developed composite mixtures were determined to comply with the requirements of STB 1910-2008 "Grain products. Composite mixtures. General specifications", and finished products - with the requirements of STB 1007-96 "Bakery products, dietary and enriched. General specifications".

The organoleptic properties of flour and composite mixtures were studied according to the rules of GOST 27558-87 "Flour and bran. Methods for determining color, smell, taste and crunch", GOST 27493-87 "Flour and bran. Method for determining acidity by chatterbox" and GOST 9404-88 "Flour and bran. Method for determining moisture". The quantity and quality of gluten was determined according to GOST 27839-88 "Wheat flour. Method for determining the quantity and quality of gluten". In accordance with STB 2160-2011 "Bakery products. Acceptance rules, sampling methods, methods for determining organoleptic indicators and weight", GOST 21094-75 "Bread and bakery products. Method for determining moisture", GOST 5670-96 "Bakery products. Methods for Determining Acidity", GOST 5669-86 "Bakery Products. Method for Determining Porosity" assessed the quality indicators of semi-finished and finished wheat bread products.

The enriching phyto-powder was obtained by drying the root crops cut into strips at a temperature of 60°C for 1 hour, then at a temperature of 80°C, followed by grinding in a laboratory mill (LM-1) and sifting.

Taking into account the data from scientific literature, composite mixtures were prepared based on first-grade wheat flour and powder from table beetroots in an amount of 3–11% of the flour weight with a step of 2% [14].

The dynamics of yeast fermentation activity was analyzed in a model experiment in flasks with a sulfuric acid seal [15]. Composite mixtures with 3-9% of beetroot powder and other components according to the recipe were used. Flasks with model mixtures were weighed and placed in a refrigerator, fermentation was carried out at a temperature of +5°C. Gas formation was assessed by the loss of flask mass over 20 hours with intermediate weighings after 14, 16, and 18 hours from the beginning of the experiment.

For improvement, the recipe for the "Venzel" buns [16] was used, including first-grade wheat flour, sugar, yeast, margarine, salt, vanillin, dry milk and water according to calculation.

In the experimental systems, instead of wheat flour, the developed composite mixtures were introduced, including 3-11% of the enriching additive from the mass of flour.

The tests of dough and finished products were conducted in two variants [17, 18]. In the first variant, the traditional method of dough preparation was used, in the second – low-temperature fermentation (Table 1).

Table 1. Technological modes

Technological modes	Experiment 1	Experiment 2
Duration of dough Kneading, min	10	10
Fermentation duration, min	150	1200
Fermentation temperature, °C	32	4
Proofing time, min	45	45
Proofing temperature, °C	40	40
Time Baking time, min	15	15
Baking temperature, °C	180	180

Results and discussion. First-grade wheat flour met the requirements of TNPA, table beet powder had a moisture content of 8.5%, an active acidity of 5.0, and organoleptic indicators that met the requirements of TNPA.

Activation of pressed yeast in the presence of a suspension of table beet powder was previously noted, and it also had a positive effect on fermentation activity determined at a temperature of 30°C for 180 minutes [14]. In this regard, experiments were conducted only under low-temperature fermentation conditions. The dosage of root crop powder in the amount of 11% of the flour weight was not used for the experiment.

The results of determining the gas-forming capacity of yeast in the composite mixtures showed that the total amount of CO₂ in the experimental samples was 1.81–2.80 times higher than in the control, proportional to the amount of added beet powder, which may be due to the presence of a large amount of sugars, free amino acids, minerals and vitamins in the additive, which stimulate gas formation processes (Figure 1).

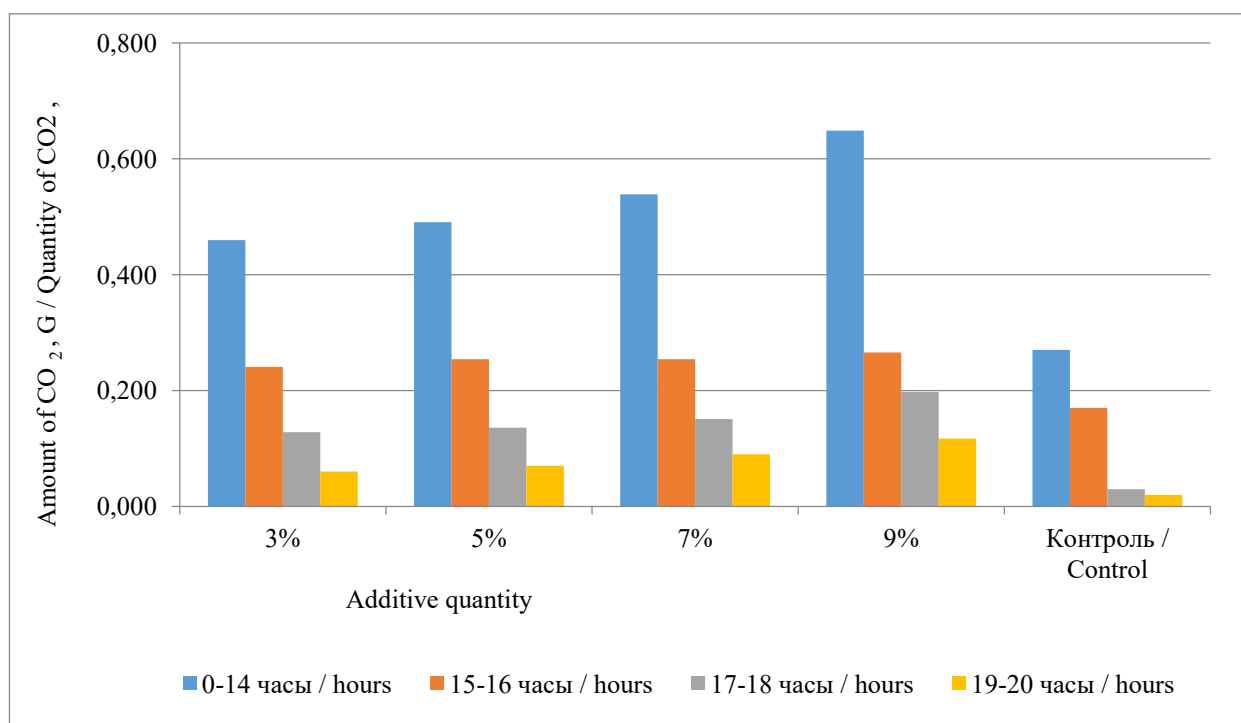


Figure 1. Evaluation of the gas - forming capacity of yeast under low - temperature fermentation conditions in a mixture of beet root powder

Analyzing the results by the periods of weighing the flasks, we note the highest rate of gas formation at the second stage, during the 15-16th hours of fermentation. It was 0.120-0.133 g/hour in the experimental samples and 0.085 g/hour in the control. Then, a uniform step-by-step slowdown of the process was observed, which is explained by the consumption of easily accessible sugars of flour and powder. Considering that even in the experimental sample with a minimum amount of additive, after 14 hours of observation, the amount of released carbon dioxide was higher than in the control after 20 hours, we can say that there is a reserve for reducing the total fermentation time of the dough.

Next, we analyzed the quality indicators of composite mixtures based on first-grade wheat flour and beetroot powder. We decided to expand the range of additive application from 3-9% to 3-11% of the flour weight.

The components of the mixture were uniform in size; the taste and smell of table beet were felt at powder dosages of 5-11% of the flour mixture. In the process of studying the quality indicators of composite mixtures (Table 2), an increase in titratable acidity and a decrease in humidity were noted with an increase in the amount of enriching additive in the sample. The mass fraction of raw gluten decreased with its simultaneous strengthening in proportion to the increase in the content of root crop powder.

Table 2. Quality indicators of composite mixtures

Indicator	Control	Amount of additive, %				
		3	5	7	9	11
Humidity, %	12.6±0.2	12.3±0.2	11.1±0.2	10.7±0.3	10.5±0.3	9.1±0.3
Acidity, °	3.4±0.2	3.5±0.2	3.9±0.2	4.2±0.2	4.5±0.3	4.9±0.3
Mass fraction of crude gluten, %	29.3±0.3	29.0±0.4	28.4±0.3	27.6±0.6	26.8±0.5	26.2±0.5
Gluten quality, IDK units	86.9±0.5	86.8±0.5	85.7±1.0	84.8±0.8	82.7±0.6	80.8±0.7

The obtained results are consistent with previously identified dependencies and indicate a positive effect of vegetable powder on the physicochemical properties of composite mixtures [19]. Strengthening of gluten occurs due to compaction of the dough under the influence of hemicelluloses, pectin substances, mineral compounds and food acids of the additive. It can be assumed that with low-temperature fermentation this fact will not have a negative effect on the quality of the products.

Based on the obtained results, trial baking of buns was carried out using different dosages of beetroot powder.

When analyzing the quality indicators of the first fermentation variant of the dough, we noted the difference between the experimental systems and the control only in color and smell; the structure and plasticity did not change (Figure 2).



Figure 2. Appearance of experimental test variants: 1 – control; 2-6 – 3-11% beet powder

An increase in the acidity of the dough at the end of fermentation was recorded according to the increase in the amount of enrichment additive in the mixture (3.6-6.1 degrees), which indicates a higher activity of microorganisms in its presence and a higher acidity of the enrichment powder.

All baked samples had a pleasant taste and aroma, with an increase in the amount of enriching powder, a pleasant beet flavor intensified, at maximum dosages of the additive (7 and 9%) they resembled the taste of the Borodinsky rye-wheat brewed bread. The color of the crumb and crust of the buns changed as the dosage of the powder increased. The products were well

baked, the crumb was not sticky, had developed and uniform porosity, a slight roughness was observed on the surface with an increase in the amount of root crop powder to 7-11% of the flour weight (Figure 3).



Figure 3. Appearance of products according to the first research option: 1 – control; 2-6 – 3-11% bet powder

When studying the physicochemical indicators, an increase in the titratable acidity of the products was noted, while porosity and moisture remained virtually unchanged in relation to the control sample (Table 3).

Table 3. Quality parameters of the first test method

Indicator	Control	Amount of additive, %				
		3	5	7	9	11
Humidity, %	38.8	39.8	39.7	38.6	39.2	38.9
Acidity, °	3.0	3.2	3.5	3.6	3.9	4.4
Porosity, %	68.3	70.7	70.9	69.5	69.2	69.0

At the next stage of the experimental work, buns of the control and experimental samples were baked under conditions of dough fermentation at a temperature of + 5°C, for 20 hours with periodic analysis of the titratable acidity of the dough. A decrease in the intensity of the increase in titratable acidity was noted after 18 hours of fermentation, and after 19 hours the dough was completely fermented and there was no alcohol smell.

Comparing the results of the assessment of the titratable acidity of the dough after the completion of the fermentation stage, one can note an insignificant decrease in the indicator in relation to the previous experiment conducted under conditions of straight fermentation (3.6-6.1 degrees and 3.5-5.8 degrees, respectively, for the first and second variants of the studies).

In terms of organoleptic characteristics, the samples of the second variant of the study were slightly inferior to the products of the previous experiment with the same dosages of powder in the recipe. It was noted that when the additive in the system was increased to 9 and 11%, the porosity was uneven and finer, there were bursts, but the crumb was not sticky. In terms of taste and smell, the buns did not differ from the products of the previous variant of the study (Fig. 4).



Figure 4. External appearance and cross-sectional view of products obtained using the low temperature fermentation method: 1 – control; 2-6 – 3-11% beet powder

In the process of determining the physicochemical parameters, an unreliable decrease in the moisture content of the buns and an increase in titratable acidity were revealed, which differs slightly from the results of the previous experiment (Table 4).

The porosity of the products did not decrease significantly compared to the previous experiment. No positive or negative dynamics of this indicator change was noted with an increase in the dosage of the additive in the mixture, but the best results were shown by products with the introduction of 5 and 7% of powder.

4. Quality parameters of the second test method

Indicator	Control	Amount of additive, %				
		3	5	7	9	11
Humidity, %	38.7	38.7	39.0	39.1	39.2	39.0
Acidity, °	3.3	3.5	3.9	4.1	4.2	4.2
Porosity, %	64.7	65.8	66.2	66.8	64.6	64.5

In the process of tasting all samples using the method of preferential evaluation, the best samples were selected, including 7% of table beet powder from the mass of the first grade wheat flour mixture.

At the final stage of the work, the best sample in terms of quality indicators and taking into account the tasting results, including 7% of table beet powder from the mass of the flour mixture, was made using low-temperature technology. In this case, after kneading, the dough was left to rest for an additional 20 minutes at room temperature, the remaining technological parameters corresponded to the previous experiment. However, sugar was not added to the recipe of one experimental product, and half of the recommended amount was added to the other sample.

In terms of external indicators, the dough without adding sugar rose worse and had a rough surface. The finished products had uneven and fine porosity, a rough surface, and an indistinct taste and smell. In this regard, the quality indicators were not further assessed.



Figure 5. Samples of bread sticks:
1 – control sample; 2 – experimental sample with the addition of 7% powder

When studying the physicochemical parameters of buns, in the recipe of which half the dosage of sugar was added, no significant changes were found in relation to the results of the previous experiment (Figure 5). When half the dosage of sugar was added, the porosity did not decrease (65.2%).

Conclusion. High gas-forming capacity of yeast in the presence of the additive and the presence of compounds in the beetroot powder that improve the physicochemical properties of composite mixtures and finished bakery products make it advisable to use the phytoadditive when producing buns based on low-temperature dough technology. The optimal fermentation period at a temperature of +5 °C is 19-20 hours, in addition, the amount of sugar can be reduced in the recipe and the dough can be left to rest after mixing, which will improve the consumer qualities of the products. The advisability of using beetroot root powder in a dosage of 7% of the weight of first-grade wheat flour is proven by the results of assessing the physicochemical and organoleptic properties and during the tasting analysis.

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INFORMATION ABOUT THE AUTHORS

Iryna M. Rusina – Cand. Sci. (Biol.), associate professor, Department of Technology of storage and processing of plant raw materials, Grodno State Agrarian University, Tereshkova St., 28, Grodno, 230008, Belarus; e-mail: rimih_2010@mail.ru

Iryna M. Kalesnik – senior lecturer, Department of Ecology, Yanka Kupala State University of Grodno, Dovatora Lane, 3/1, Grodno, 230012, Belarus; e-mail: kolesnik_irina@inbox.ru; <https://orcid.org/0000-0001-5365-4751>

Alitsiya I. Guzevich – senior lecturer, Department of Technology of storage and processing of plant raw materials, Grodno State Agrarian University, Tereshkova St., 28, Grodno, 230008, Belarus; e-mail: aliciya_ivanovna@mail.ru

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ИНФОРМАЦИЯ ОБ АВТОРАХ

Ирина Михайловна Русина – кандидат биологических наук, доцент кафедры технологии хранения и переработки растительного сырья, Гродненский государственный аграрный университет, ул. Терешковой, 28, г. Гродно, 230008, Беларусь; e-mail: rimih_2010@mail.ru

Ирина Михайловна Колесник – магистр биологических наук, старший преподаватель кафедры экологии, Гродненский государственный университет имени Янки Купалы, пер. Доватора 3/1, Гродно, 230012, Беларусь; e-mail: kolesnik_irina@inbox.ru; <https://orcid.org/0000-0001-5365-4751>.

Алиция Ивановна Гузевич – магистр технических наук, старший преподаватель кафедры технологии хранения и переработки растительного сырья, Гродненский государственный аграрный университет, ул. Терешковой, 28, г. Гродно, 230008, Беларусь; e-mail: aliciya_ivanovna@mail.ru

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