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# Features of biotechnological processes of bread production enriched with inulin-containing raw materials

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**Abstract.** Bread takes a leading place in the diet of all socio-demographic groups of the population, therefore, it should have not only high taste, but also significant nutritional value. Vitamin B, starch, dietary fiber, and minerals are daily supplied with bread to the human body. However, bread has a deficiency of vitamin C, iron, calcium, pectin, and other functional components. This involves enriching bread with various additives with functional properties. However, the introduction of various fillers ambiguously affects the biochemical processes of the development of yeast cells, fermentation and maturation of the test, baking processes, which largely depends on the chemical composition of the additive. This paper presents the rationale for the use of inulin-containing raw materials - powder from Jerusalem artichoke tubers in the production of yeast bread. The effect of the powder on the biotechnological processes of dough formation, quality indicators and nutritional value of the finished bread, staling processes is investigated. The results of the work made it possible to create new types of bread with high consumer properties, containing inulin, an increased amount of fiber and pectin and minerals that have prophylactic properties, including diabetes.

## 1. Introduction

Currently, the development of the baking industry is focused on the scientific support of its development. The issues of forming a “healthy diet” fully apply to bread and bakery products, which involves expanding the range of bread with high nutritional value [1].

The demand for such bread is constantly increasing, the production market has great potential for growth. The issue of expanding the range of bread for preventive purposes, the use of enriching additives is relevant, especially in ecologically unfavorable areas.

As such an additive, it is supposed to use inulin-containing raw materials in the formulation of bread - powder from Jerusalem artichoke tubers.

Jerusalem artichoke (*Helianthus tuberosus L.*) is a perennial tuberous vegetable plant of the aster family.

The predominant component of Jerusalem artichoke is a valuable carbohydrate - inulin [2-5].

Inulin has a diverse beneficial effect on the human body, but its main feature is that, getting into the gastrointestinal tract, it splits into fructose and fructose chains, which are able to regulate blood sugar



levels, which is an important factor in the prevention of such a serious disease as diabetes mellitus [2,3,5].

In addition to inulin, pectin and fiber predominate in the carbohydrate composition of tubers.

Pectin substances have the ability to bind in the human body and remove heavy metals, radionuclides, other toxic and chemical elements that come from food, as well as regulate the intestinal microflora [2,3,5].

Fiber stimulates the contractility of the intestinal wall, boosts the process of cleansing the body of harmful elements, undigested food.

Due to the presence of a valuable carbohydrate composition, Jerusalem artichoke tubers have prophylactic properties and serve as raw materials for the production of inulin, pectin, inulin-pectin concentrate, intended for the treatment and prevention of diabetes mellitus [4,6].

In addition to the carbohydrate complex, Jerusalem artichoke tubers contain essential amino acids, a high amount of B vitamins, and ascorbic acid. A characteristic feature of the chemical composition of tubers is the balance in macro and microelemental composition. It contains up to 12 mg % iron, up to 30 mg % magnesium, up to 500 mg % zinc, etc. [2-5].

Jerusalem artichoke tubers are a vegetable raw material and have no contraindications for use for children and adults.

The purpose of the work is to develop formulations of wheat and rye-wheat bread enriched with inulin-containing raw materials - powder from Jerusalem artichoke tubers. To study the effect of the powder on the biotechnological processes of the production of yeast dough from wheat and rye-wheat flour, the quality indicators of baked bread.

## 2. Materials and methods

The objects of study were Jerusalem artichoke tubers powder obtained by vacuum-pulsed drying of tubers, yeast dough prepared using traditional technology, yeast dough with Jerusalem artichoke tubers powder, baked bread.

Yeast dough (control sample) was prepared by the random method according to traditional technology: yeast and salt were dissolved in warm water (40 ° C), sifted wheat flour (or a mixture of rye and wheat) was gradually added, and the dough was kneaded. The dough was left for fermentation for 2-2.5 hours (depending on the type of flour) at a temperature of 30 ° C. During the fermentation, a warming was carried out. Bread was formed from ripened dough, set to proof (1 hour), then baked.

Jerusalem artichoke powder was combined with wheat flour or a rye-wheat flour mixture (from 5 to 30% of the total mass of flour), then the dough was kneaded, as described above. The safety of raw materials used for the production of bread, consistent with the requirements of regulatory documentation.

In the work, the effect of the powder on the fermentation process of the dough, the quality indicators of the finished bread, the speed of staling were investigated.

We used generally accepted organoleptic, physicochemical research methods in accordance with regulatory documentation. The rheological parameters of the test (effective viscosity) were determined on a structuremeter with a velocity gradient from 1 to 435 s<sup>-1</sup>. For the organoleptic evaluation of the finished bread, a 100-point scale was used, taking into account the weight coefficients of each indicator. The staling process of all types of bread was investigated by changing the mass of products during storage (36 hours) and the moisture content in the crumb.

Statistical processing of the results was carried out using the program "Statistic-6.0". When comparing the average values for the two samples and multiple comparing the means, the difference was considered significant at the 95% significance level ( $p < 0.05$ ).

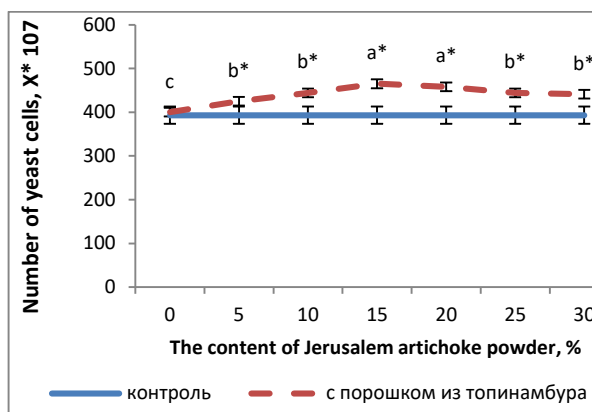
## 3. Research results

In the obtained powder, the content of the most significant functional components was determined. In its composition it contains: inulin (51.1±0.14% of the total amount of carbohydrates), pectin (12.2±0.06% of the total amount of carbohydrates), fiber (2.5±0.011% of the total amount of

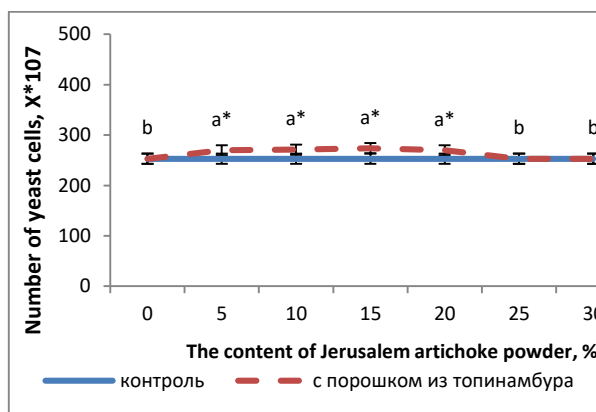
carbohydrates), ascorbic acid ( $18.64 \pm 0.15\%$ ), calcium ( $165.8 \pm 0.75 \text{ mg /\%}$ ), iron ( $9.35 \pm 0.578 \text{ mg /\%}$ ), the energy value of the powder is 274.7 kcal.

The powder is a friable mass of light cream color, with a nutty aroma, light sweet taste. It is insoluble in water; the swelling coefficient is 1:5.

The effect of the powder on the biochemical processes of fermentation of wheat and rye-wheat dough was investigated and analyzed (figures 1, 2).



**Figure 1.** The dynamics of changes in the number of yeast cells in wheat dough with Jerusalem artichoke powder.

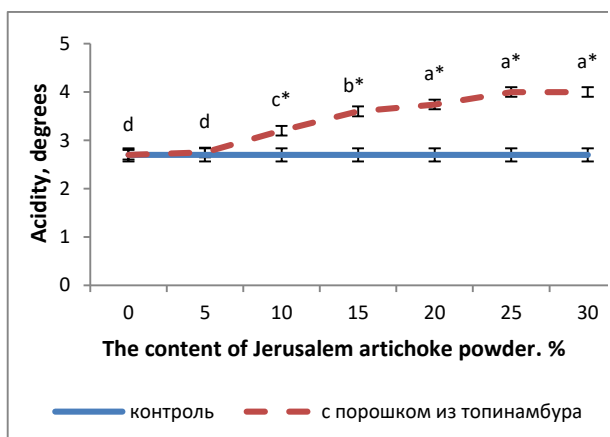


**Figure 2.** Dynamics of changes in the number of yeast cells in rye-wheat dough with Jerusalem artichoke powder.

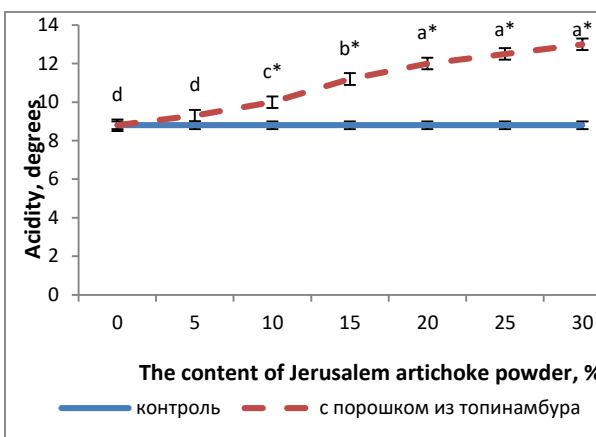
Note: ( $M \pm m$ ) ( $n = 6$ ), letters indicate intergroup differences, \* - difference from control, multiple comparison of means,  $p < 0.05$

Adding 5 - 20% powder to all types of flour increases the fermentation activity of the dough. This is expressed in the quantitative growth of yeast cells: in the wheat dough by 8.1 - 18.8%, in rye-wheat - by 6.6 - 9.2%. With an increase in the amount of powder introduced, the fermentation rate decreases.

The dynamics of the acidity of the test is shown in figures 3 and 4.



**Figure 3.** Acidity of wheat dough depending on the dosage of Jerusalem artichoke powder.



**Figure 4.** Acidity of rye-wheat dough depending on the dosage of Jerusalem artichoke powder.

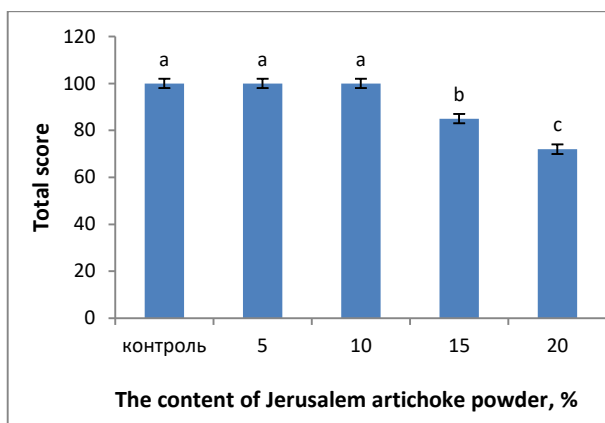
The stability of the test structure was analyzed by changing the effective viscosity, which characterizes the processes of destruction and restoration of the structure of the system.

The study found that when maintaining up to 15% of the powder instead of flour, the value of the effective viscosity of the wheat dough increases by 1.3 times. This indicates the formation of a stronger, more stable structure compared to the control sample. Further, the effective viscosity values are reduced.

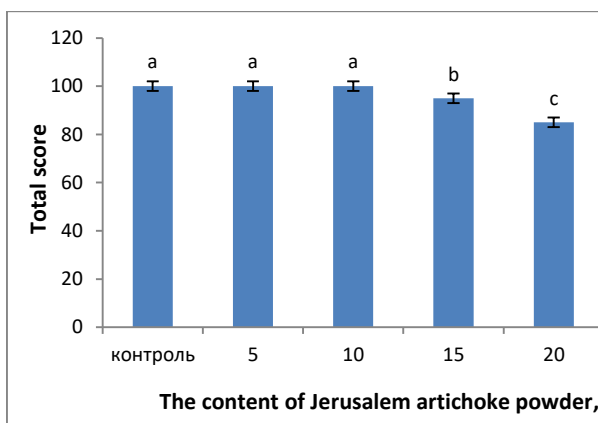
Rye flour has a low gluten content, so the introduction of powder is possible up to 25%, while the value of effective viscosity increases by 1.4 times compared with the control sample.

Of all types of dough, bread was molded and baked, and indicators of finished bread were analyzed.

Figures 5 and 6 show a score for bread.



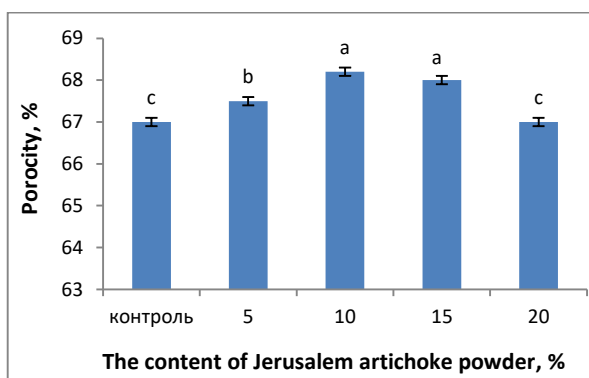
**Figure 5.** Organoleptic evaluation of wheat bread with Jerusalem artichoke powder.



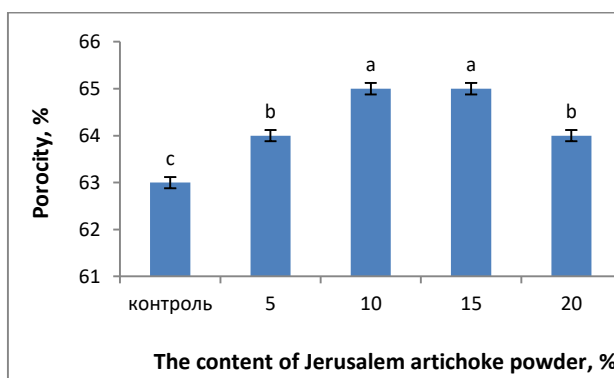
**Figure 6.** Organoleptic evaluation of rye-wheat bread with Jerusalem artichoke powder.

Due to the pronounced taste and smell of Jerusalem artichoke, the introduction of the powder is limited to 5-10-10% by weight of flour, both in wheat and rye-wheat bread.

The effect of the powder on the porosity of the bread is presented in figures 7 and 8.



**Figure 7.** Change in porosity of wheat bread depending on the content of Jerusalem artichoke powder.

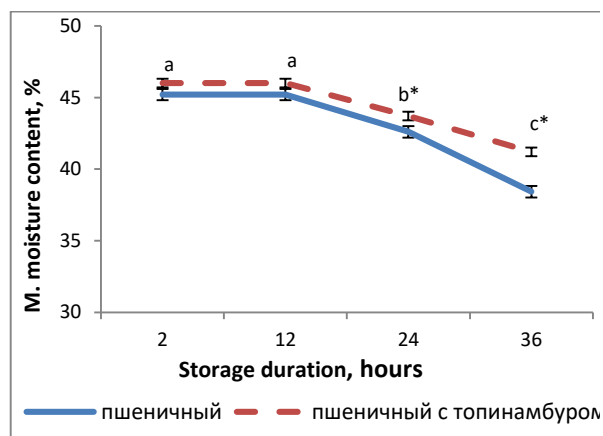


**Figure 8.** Change in porosity of rye-wheat bread depending on the content of Jerusalem artichoke powder.

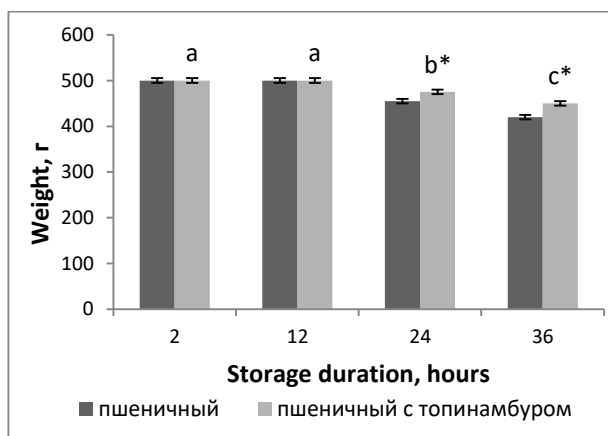
A similar dynamics of changes was obtained by specific volume and shape stability of bread samples.

The optimal recipe composition of new types of bread with Jerusalem artichoke powder was determined using the qualimetric method for determining a comprehensive quality indicator.

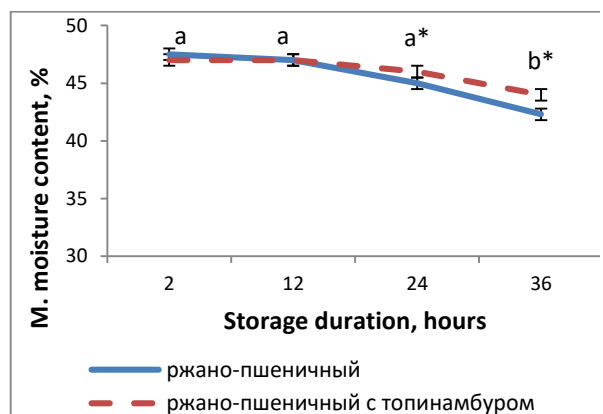
The shelf life of bread, which characterizes its freshness and safety, is 24 hours. We have studied the staling process of new types of bread for 36 hours (taking into account the safety factor) (figures 9-12).



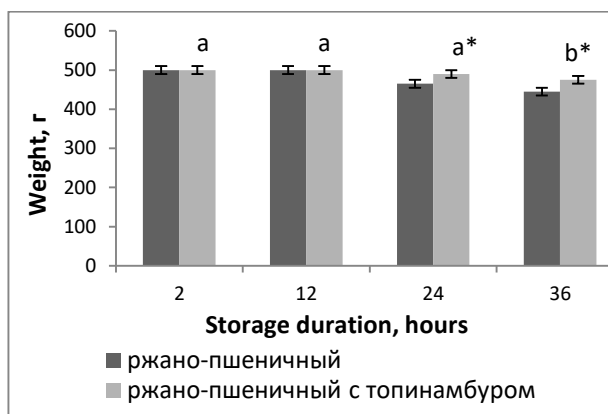
**Figure 9.** Change in the mass fraction of moisture in the crumb of wheat bread during storage.



**Figure 10.** The change in the mass of wheat bread during storage.



**Figure 11.** Change in the mass fraction of moisture of rye-wheat bread during storage.



**Figure 12.** Change in the mass of rye-wheat bread during storage.

Note: (M ± m) (n = 6), different letters indicate intra-group differences, \* - difference from control, p < 0.05

During storage, the moisture mass fraction in the crumb of the control sample of wheat bread decreased by 15%, in the crumb of wheat bread with Jerusalem artichoke powder - by 10.4%. The weight loss of the control sample of wheat bread was 16.0%, wheat bread with Jerusalem artichoke powder - 10.0%.

The content of the mass fraction of moisture in the crumb of the control sample of rye-wheat bread decreased by 13.3%, rye-wheat with powder - 9.1%. The weight loss of the control sample of rye-wheat bread was 11.0%, rye-wheat bread with Jerusalem artichoke powder - 5.0%.

**4. Discussion of results**

Replacing part of the flour with Jerusalem artichoke powder activates the biochemical processes of fermentation and maturation of the yeast dough. Due to the powder in the test, the number of monosaccharides increases, which are an additional nutrient medium for yeast cells [7-8]. Active growth and development of yeast is observed in the test of wheat flour with the introduction of up to 20% of the powder, since the optimum acidity value is formed there. Rye flour in itself has a high acidity. With the introduction of the powder, acidity increases, the number of yeast cells increases less actively than in wheat dough. So, with the introduction of a powder of more than 20%, the acidity of the fermented

wheat dough reaches 4.5 degrees and above, with a norm of 2.8 - 3 degrees. In the rye-wheat test, the acidity reaches 13 degrees, with a norm of 10 -11, which predicts the receipt of poor-quality bread.

The introduction of Jerusalem artichoke powder in the recipe increases the quality characteristics of the bread. In new types of bread with Jerusalem artichoke powder, the porosity, specific volume and shape stability of bread are increased.

It is known that vegetable additives reduce the rate of change of starch when baking bread, the temperature of its gelatinization decreases. Pectin substances, fiber, and inulin have hydrophilic properties [8,9,10]. The presence of these hydrocolloids in the Jerusalem artichoke powder helps to increase the water-holding ability of the dough and finished products, and slows down the staling process. Thus, the weight loss of a new type of wheat bread is lower by 5.2% compared with the control sample, the weight loss of a new type of rye-wheat bread decreased by 6.0%.

## 5. Conclusion

It has been established that the introduction of Jerusalem artichoke powder into the recipe composition of wheat and rye-wheat bread up to 10 -15% of the total flour mass activates the dough fermentation process, creates optimal acidity, which forms a more developed porosity, volume of finished products, slows down the staling process. However, the pronounced taste and smell of Jerusalem artichoke limits the introduction of the powder to 10% of the total mass of flour.

Wheat bread with Jerusalem artichoke powder has a smooth surface with a brown crust, soft, elastic crumb of light gray color, fine developed porosity, pleasant, slightly sweetish taste and aroma of Jerusalem artichoke.

Rye-wheat bread with Jerusalem artichoke powder has a smooth surface with a dark brown crust, soft, elastic crumb of a dark brown color, fine developed porosity, the taste of rye bread, with a light aftertaste and aroma of Jerusalem artichoke, moderately sour.

According to the results of organoleptic evaluation, all types of bread with Jerusalem artichoke powder retained their freshness throughout the entire shelf life.

In addition to a positive effect on biotechnological processes, Jerusalem artichoke powder is a functional additive. It has been experimentally established that all new types of bread contain inulin, which is absent in the traditional one. So, its content in wheat bread was 1.8%, in rye-wheat - 2.1% per 100 g of product. In new types of bread there is an increased content of total protein (by 38.0 and 34.0%), pectin substances (by 16.0 and 20.1%) as well as calcium, phosphorus and other functional components.

This makes it possible to say that bread with Jerusalem artichoke powder has prophylactic properties, including diabetes.

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