Use of powder *Helianthus tuberosus* L. in the production of frozen bread

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**Abstract.** This paper presents the results of studies on the use of powder from Jerusalem artichoke tubers (*Helianthus tuberosus* L.) as a baking additive in the production of frozen bread. Powder from Jerusalem artichoke tubers has a high nutritional value, primarily in terms of inulin content. In addition, a complex of proteins, vitamins, inulin and dietary fiber powder acts as a stabilizer of frozen yeast dough. The paper presents experimental data on the quality of wheat-rye bread baked from frozen dough pieces of long-time, low-temperature storage.

1. Introduction

The production of various types of frozen dough and finished products from them is an actual topic of bakery production all over the world. The technology of shock freezing of dough pieces allows you to get freshly baked products at places of consumption in the shortest possible time. These technologies will help concentrate the laborious process of producing yeast dough and products from it in one place equipped with the necessary equipment - bakeries, food factories in school and medical institutions and to supply secondary food processing facilities with frozen products.

The production of frozen bread has its own technological features. In the process of freezing, storing frozen blanks, defrosting, physical and chemical changes occur in it, leading to a change in the product quality. At all these stages, loss of yeast stability, damage to gluten due to recrystallization of water can occur, which leads to a decrease or loss in the quality of bread, and a deterioration in organoleptic characteristics. When freezing dough, the water contained in it turns into ice crystals, which can destroy the outer shell of the yeast cell [1,2,3,4]. The activity of the yeast during preparation of the frozen test should be minimized, since activated yeast cells undergo autolysis due to metabolic products. When sugar, fat and salts are added, the freezing point of the dough is significantly lower than the freezing point of water. Freezing of the dough begins at a temperature near (-7 °C), some enzymatic and biochemical processes continue to proceed even at a temperature in the center (-10 °C) and almost completely stop at a temperature (-18 °C) [1,2,3,4].

In order to prevent these changes and preserve the quality indicators of finished products, baking improvers are used in this technology. The main builders of the frozen yeast dough are hydrocolloids, which can change the distribution of water in various components of the dough (gluten, starch) and bind water more efficiently, reduce the formation of ice crystals in the dough, and also strengthen the structure of gluten., Guai gum, pectin, inulin, carboxymethyl cellulose and its salt, etc. are mostly used for wheat varieties of bread [3,4].
Jerusalem artichoke (*Helianthus tuberosus L.*) is a valuable food root, widely distributed throughout Russia, including Siberia. Interest in this culture is caused by a unique chemical composition. Jerusalem artichoke tubers in their composition contain a carbohydrate complex, the predominant component of which is inulin, a high content of pectin, fiber. Tuber proteins include all the essential amino acids. Potassium, iron, phosphorus stand out in the mineral composition. The vitamin composition is characterized by a high content of B vitamins, ascorbic acid. Jerusalem artichoke tubers are widely used to obtain inulin-pectin concentrates, powder, flour, and functional syrups [5].

An analysis of the chemical composition of the powder from Jerusalem artichoke tubers (*Helianthus tuberosus L.*) revealed a significant amount of hydrocolloids needed to stabilize the frozen yeast dough. So, 100 g of powder from Jerusalem artichoke tubers, depending on the type and method of drying, contain up to 50-60% of inulin, up to 10-12% of pectin substances, 2.5% fiber, 9% protein substances. These data suggest the possibility of its use not only to increase the nutritional value of bread [6,7], but also as a structuring agent of frozen wheat-rye bread.

Purpose of the work: to study the quality indicators of wheat-rye bread with the addition of Jerusalem artichoke powder, using the technology of deep freezing during long-term low-temperature storage.

Objectives of the study: to determine the physico-chemical, organoleptic quality indicators of defrosted blanks; evaluate the quality of baked products from frozen semi-finished products after 30-90 days of low-temperature storage.

2. Materials and methods
As objects of study, wheat-rye yeast dough and ready-made bread with the addition of powder from Jerusalem artichoke tubers, the optimal dosage of which had been determined in earlier studies, were selected [6,7].

Wheat-rye yeast dough was prepared by the “without leaven” method using traditional technology: the yeast and salt were dissolved in warm water (40 °C), a sifted mixture of wheat and rye flour was gradually added, and the dough was kneaded. It was left for fermentation for 2-2.5 hours at a temperature of 30 °C. In the fermentation process the cutting back was performed. Blanks of 210 g were formed from the ripened dough, proving lasted 15-20 minutes and then shock freezing to a temperature in the center of the products (-18 °C) took place. Next, the blanks were packed into cling film and stored for 30 to 120 days at a temperature (-18 °C). After 30, 60, 90, and 120 days of storage, the blanks were defrosted at a temperature of 25-30 °C and their quality indicators were examined. Next, baking was performed from all samples and the quality of the finished bread was evaluated.

The safety of raw materials used for the production of bread, met the requirements of regulatory documentation.

In the work, generally accepted organoleptic, physicochemical, instrumental, and statistical research methods were used in accordance with normative documentation. For the organoleptic and instrumental evaluation of defrosted blanks, a 5-point scale was used; for the evaluation of finished types of bread, a 100-point scale was used, taking into account the weight coefficients of each indicator. Statistical processing of the research results was carried out using the “Statistica 6.0” application package, non-parametric criteria were applied. 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
The duration of the shock freezing of a batch of wheat-rye bread blanks was 50 minutes (up to -18 °C). The defrosting of semi-finished products was carried out, according to the recommendations, until the temperature inside the product (+ 10 °C) was reached, the duration was 1.5 hours.

We studied the change in mass, acidity and organoleptic characteristics of defrosted workpieces, compared with freshly made.

Research data are presented in table 1, in figure 1,2.
Table 1. Physico-chemical characteristics of freshly prepared dough pieces.

| Samples                                      | Indicators          | Mass fraction of moisture, % | Acidity, degrees |
|----------------------------------------------|---------------------|------------------------------|-----------------|
| Newly-made semi-finished products ready for freezing |                     | 40.8±0.22                    | 3.31±0.04       |

After long-time low-temperature storage, the changes occurred only with a mass fraction of moisture and slightly – with organoleptic properties (out of the indicators characterizing the quality of the dough pieces) (figures 1, 2).

Changes in the acidity of defrosted blanks during long-term low-temperature storage did not occur.

**Figure 1.** Change in mass fraction of moisture in freshly prepared and defrosted dough pieces (M±m) (n = 6) (letters indicate differences, multiple mean comparisons, Mann-Whitney test, p <0.05).

**Figure 2.** Organoleptic evaluation of the studied samples of dough pieces on a 5-point scale (M±m) (n = 7) (Mann-Whitney test, p <0.05).

Similarly, we studied the effect of long-term low-temperature storage on the quality of baked bread (figures 3-6).

**Figure 3.** Change in the mass of bread samples baked from frozen semi-finished products of long-time storage.

**Figure 4.** Change in the specific volume of bread samples baked from frozen semi-finished products of long-time storage.
Figure 5. The change in acidity of bread samples baked from frozen semi-finished products of long-time storage.

Figure 6. Change in ppm moisture in samples of bread baked from frozen semi-finished products of long-time storage.

(M±m) (n = 6) (letters indicate differences, multiple mean comparisons, Mann-Whitney test, p <0.05).

Figure 7. Overall grade for finished products baked from frozen billets (M±m) (n = 6) Mann-Whitney test, p <0.05).

4. Discussion of the results
As a result of low-temperature storage from 30 to 90 days, almost no changes occur in defrosted dough pieces and bread baked from them. The mass fraction of moisture, of both blanks and finished products, is at the same level as that prepared for freezing. This can be explained by the fact that Jerusalem artichoke powder contains a significant amount of hydrocolloids capable of retaining moisture. Ascorbic acid, which is a part of the powder, helps strengthen the structure of the protein and the binding of moisture in the test.

Changes in data and other indicators slightly occur after 120-day storage of frozen semi-finished products. So, the mass of baked goods decreases by only 5.8%. The mass is lost primarily due to the evaporation of moisture, but at low temperature the loss of the mass fraction of moisture was only 5.5%. Weight loss is accompanied by a slight decrease in the specific volume of products - by 4.2%. The
Acidity of defrosted semi-finished products and finished products does not change even after 120 days of storage.

With an increase in the storage duration of baked samples up to 120 days, the finished products show a decrease in quality by such indicators as appearance, porosity, and color of the crust. The total mark of finished products decreased by 10 points compared to other samples (figure 7).

5. Conclusions
The wheat-rye yeast dough has a weaker gluten than the wheat one, so there are certain difficulties when freezing and obtaining high-quality finished bread. The introduction of Jerusalem artichoke powder into the composition of this type of dough can solve this problem due to the presence of natural hydrocolloids - inulin, pectin, fiber, protein. Dough yeast bread pieces can be stored frozen at a temperature of (-18 °C) for up to 90 days without changing the quality of both the dough itself and the finished bread.

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