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DETERMINING THE MODES OF TECHNOLOGICAL OPERATIONS IN THE PRODUCTION OF EINKORN WHEAT BREAD MADE OF FROZEN DOUGH AND ENRICHED WITH JERUSALEM ARTICHOKE FLOUR

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Abstract. Einkorn wheat is a grain crop characterized by the ability not to accumulate heavy metals from the soil. Besides, it is rich in selenium. Jerusalem artichoke is rich in inulin. From the combination of these two types of flour (einkorn wheat and Jerusalem artichoke), bread can be produced for people for who suffer from type 2 diabetes. It is proved that consuming bread enriched with Jerusalem artichoke for two months every day significantly reduces the glycaemic index of patients suffering from type 2 diabetes. To provide these patients systematically with fresh bread, the bread dough freezing technique is suggested. We have studied how the storage time of dough enriched with a flour mix (100% einkorn wheat flour and Jerusalem artichoke flour) in the frozen state influence the modes of the main technological operations in the production of bread made of frozen dough, namely, defrosting, the time of increasing the temperature of the dough up to the operational level, the duration of the final fermentation and of baking. It has been established that the storage time of the dough in the frozen state reduces the duration of defrosting (which differs by 91 min. from that of the reference sample). However, there is a reverse effect, too, for the rise of the temperature of the dough to the operational level and for the final fermentation. The duration of the two above-mentioned operations is determined simultaneously. It is 5 min. more, compared with the reference sample. It has been established that the storage time of frozen dough does not affect the duration of baking. By the organoleptic indicators, the bread from the frozen dough is very similar to the reference sample.

Key words: einkorn wheat, Jerusalem artichoke, freezing, defrosting, final fermentation, baking.

ВСТАНОВЛЕННЯ ТЕХНОЛОГІЧНИХ РЕЖИМІВ ВИРОБНИЦТВА ХЛІБА ІЗ ЗАМОРОЖЕНОГО ТІСТА ІЗ ОДНОЗЕРНЯНКИ, ЗБАГАЧЕННОГО БОРОШНОМ ТОПІНАМБУРА

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Анотація. Досліджено вплив тривалості зберігання хлібного тіста в замороженому стані, збагаченого борошняною сумішшю однозернянки та топінамбура, на режими основних технологічних операцій при виробництві хліба, а саме: дефростація, час підвищення температури тіста до робочої, тривалість остаточної ферментації та час випікання. Встановлено, що при збільшенні тривалості зберігання тіста в замороженому стані має місце зменшення часу його дефростації, порівняно з контрольним зразком. Зазначено, що час ферментації тіста, що піддавали заморожування протягом 1–8 днів, спочатку має тенденцію до зменшення, а зі збільшенням тривалості зберігання замороженого тіста до 15 днів – збільшується. Встановлено, що тривалість зберігання збагаченого хлібного тесту в замороженому стані не впливає на тривалість випікання. За органолептичними показниками хліб із замороженого тіста близький до контрольного.

Ключові слова: борошно, однозернянка, топінамбур, збагачена борошняна суміш, заморожування, дефростація, остаточна ферментація, випікання.

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Introduction. Formulation of the problem

Freezing technology is only implemented industrially after the requirements have been studied specified for the raw materials, freezing temperatures, the storage time of frozen bread dough, defrosting, dough temperature rise, final fermentation, and changes in yeast viability that are related to the properties of the dough. The need for new methods and for new frozen dough products is a key issue for any research made when the freezing technology is applied in bread production.

Analysis of recent research and publications

Placing the dough into cooling conditions is a prerequisite for specific changes in it. They depend on

several factors: composition, amount of compressed yeast added and yeast strains, freezing temperature, cold storage time, defrosting, and returning to a normal operating temperature (about 26–30°C) [1-7]. Year by year, more and more bread of wholesome and healthy types made of frozen dough is produced [8-10]. It is made of various types of flour (einkorn wheat, chia, oats, barley, Jerusalem artichoke, quinoa, etc.), as well as other materials that make the end products healthy. Einkorn wheat, being rich in protein, is an extremely effective antioxidant and a bioproduct with good healing properties [11]. Not only can it replace modern wheat in the daily diet, but the einkorn wheat is indispensable for people with coeliac disease. Recent studies in this area show that the protein contained in monolayer pressed grain does not cause toxic reactions in patients with coeliac disease [10]. Einkorn wheat food has a positive effect on health because, due to its specific chemical composition, this wheat stimulates the immune system [12-13]. The physical and technological properties of Jerusalem artichoke tuber flour provide the higher quality and slower ageing of bakery products made of it, and higher inulin content makes for its health-improving effect [14-20]. Thus, the Jerusalem artichoke can be viewed as therapeutic, functional, and dietetic food [21-23]. Many believe [24-25] that adding Jerusalem artichoke flour to bakery products improves their physico-chemical and organoleptic properties and slows down their ageing while they are stored. No information has been found on the formula of bread made of einkorn wheat wholegrain flour enriched with Jerusalem artichoke tuber flour, as well as on the technologies of freezing the dough so enriched.

Purpose and objectives. The main objective of this study is to determine how the duration of storage of einkorn wheat and Jerusalem artichoke frozen dough affects the defrosting time; how the duration of storage of the frozen dough affects the time in which the dough temperature rises to the operational level and the final fermentation takes place; how the duration of storage of the frozen dough affects the baking time.

For the purpose, the objectives to be achieved are as follows:

1. Determining the defrosting time for different periods of frozen dough storage.
2. Determining the duration of raising the temperature up to the operational level and to that of final fermentation.
3. Determining the duration of baking.
4. Improving the organoleptic characteristics of the bread quality.

Research Materials and Methods

For experimental work, dough was made from einkorn wheat and Jerusalem artichoke tubers. Standard raw materials were used, both local and imported, approved by the Ministry of Health.

Einkorn wheat dough of type 1850 was provided by *ET TIT Teno Tenev*, its main characteristics being as follows: humidity 12%; ash content 2.3%; acidity 3.7 °H; wet gluten extraction 1.0%. (The amount of the wet gluten was determined by ICC Standarts 106/2.) The Jerusalem artichoke was supplied in the form of flour from *ET CHARODEYTSI*.

Below are the qualitative characteristics of the flour. In appearance, it is a pale beige or cream-coloured powdery product. The taste and smell are typical of a dried product: sweet, without any off-flavour or off-taste; the humidity of the flour is 6.2%; ash content, 5.2%; total sugar (invert), 74.4%; protein, 6.3%. The energy value is 323 kcal/100 g of the product.

The methods of research comply with the Bulgarian State Standards EN 12145-2000, 7169-89, 14431-78, 15335-90 (ash), ISO 712-1997 (humidity), Ordinance No. 23/17.05.01. The characteristics of the flour made of Jerusalem artichoke are determined by the independent laboratory *Bulgarcontrol*.

The compressed yeast is manufactured by *Safmaya*. It is fresh, with shelf life of less than 7 days from the date of manufacture when stored at 0 to +5°C, with moisture content of 70–75% and dough-raising power of no more than 20–22 min.

The kitchen salt and drinking water meet the requirements for bread production. The einkorn wheat of type 1850 and Jerusalem artichoke flour are stored in polyethylene bags (m=2.0 kg), hermetically sealed and placed in cool conditions at 0.4–4°C. The compressed yeast and drinking water are stored in cool conditions at 0–4°C.

The composition: einkorn wheat flour (3000 g), 100%; Jerusalem artichoke flour, 4%; compressed yeast, 4%; kitchen salt, 1.5%; drinking water, 56%.

The doughing of the flour was carried out on a kneading machine Kemper Type SPL for 1 minute at low speed, and for 4 minutes at high speed. The end temperature of the dough is 16 to 18°C. The dough was divided manually, each piece being 200 g. The pieces were shaped into loaves, placed in polyethylene bags intended for freezing, and then vacuumised in a vacuum machine. The dough pieces were frozen at a temperature of –20°C by mechanical refrigeration. The freezing was carried out in the Department of Cereal, Fodder, Bakery, and Confectionery Products Technology, University of Food Technologies of Plovdiv, Bulgaria, with the help of a Fujitsu Freezer.

The frozen dough was stored at –20°C for 15 days. Defrosting, final fermentation, and baking were carried out on the 0^{th}, 1^{st}, 4^{th}, 6^{th}, 8^{th}, 11^{th}, 13^{th}, and 15^{th} day of storing the frozen dough. Two samples were baked on the 0^{th} day: one without freezing (check sample 1), and one frozen and then defrosted (check sample 2).

The frozen dough pieces were defrosted in a refrigerator at 4°C until the cryoscopic point was reached. Then, they were placed in the fermentation chamber, where a working temperature of 26°C and a relative humidity of 80% were to be reached under the

same conditions, for final fermentation. Baking was carried out in a Salva oven at 180°C.

Results of the research and their discussion

Determining the dependence of defrosting time on the duration of storage of einkorn wheat and Jerusalem artichoke dough in the frozen state. The duration of defrosting the dough made of einkorn wheat enriched with Jerusalem artichoke flour has been determined as depending on the time of its storage in the frozen state. The results are presented in Fig. 1

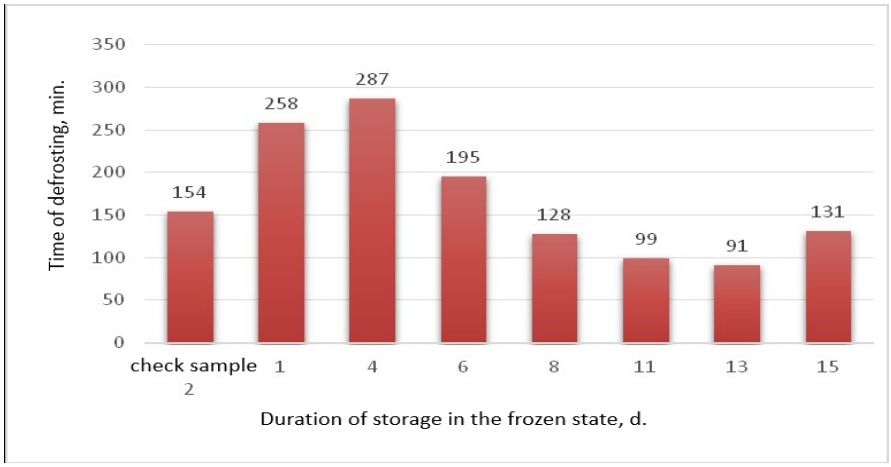

Fig. 1. Dependence of the defrosting time of einkorn wheat dough enriched with Jerusalem artichoke tuber flour on the duration of its storage in the frozen state.

The time of defrosting einkorn wheat dough enriched with the Jerusalem artichoke flour ranges from 91 to 287 min. The general tendency is that, until the 4th day of storage, the duration of defrosting increases significantly (287 min, as compared to check sample 2), whereas the difference between the 4th day of storage and the check sample 2 is 133 min. This increase may be due to fluctuations of the air temperature in the freezing chamber, when the growth of crystals in the dough takes place. After the 4th day of storage, up to the 13th day, there is a progressive decrease in the duration of defrosting, which, on the 13th day, is 91 min – it is 63 min. shorter than defrosting check sample 2. This may result from the temperature change in refrigerating conditions, as well as from the increasing and decreasing crystal size.

Determining how the time of raising the temperature of the dough up to the operational level and the time of the final fermentation depend on the duration of storage of frozen einkorn wheat dough enriched with Jerusalem artichoke flour.

The two steps follow defrosting the dough: raising the dough temperature to the operational level (26°C), and the final fermentation. They cannot be dissociated from each other, as bread yeast begins growing when the temperature of the dough is above 16°C. So, the two operations are hardly separable. The results obtained are presented in Fig. 2.

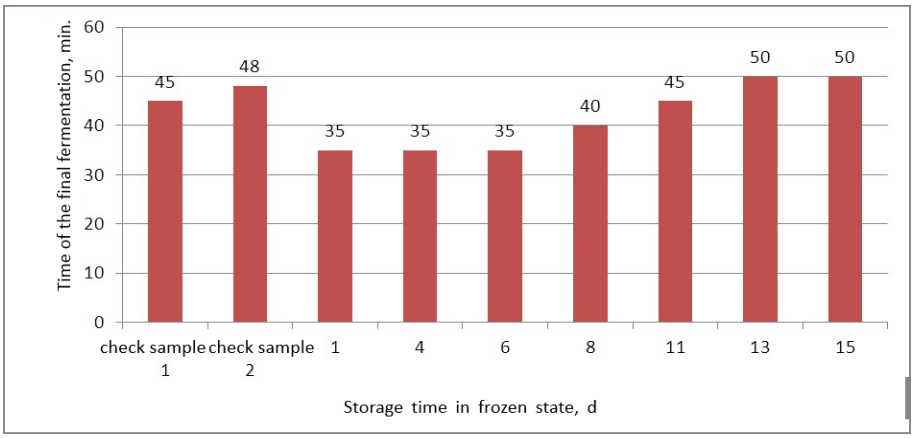

Fig. 2. The effect the duration of storage of frozen einkorn wheat dough enriched with Jerusalem artichoke flour has on how quickly the dough temperature rises to the operational level and the final fermentation takes place.

The general tendency for the einkorn wheat dough enriched with Jerusalem artichoke flour is as follows. The time of the two operations is initially as short as 35 min on the 1st day and remains so up to the

6th day; then, the time of both operations keeps increasing until it is 50 min. on the 13th day, and remains so until the 15th day when the research is over. The shortest duration of the two operations is 35 min (the 1st day), which is 10 min. shorter than that for check sample 1 (45 min).

The initial reduction in the time of the two operations, depending on how long the frozen dough is stored, may be due, on the one hand, to the reduction of the number of living yeast cells, and, on the other hand, to the deterioration of the properties of the dough when it is kept frozen longer.

The effect the duration of storage of frozen einkorn wheat dough enriched with Jerusalem artichoke flour has on the time of baking. The results obtained about how the duration of baking depends on the storage time of the frozen dough, are shown in Fig. 3.

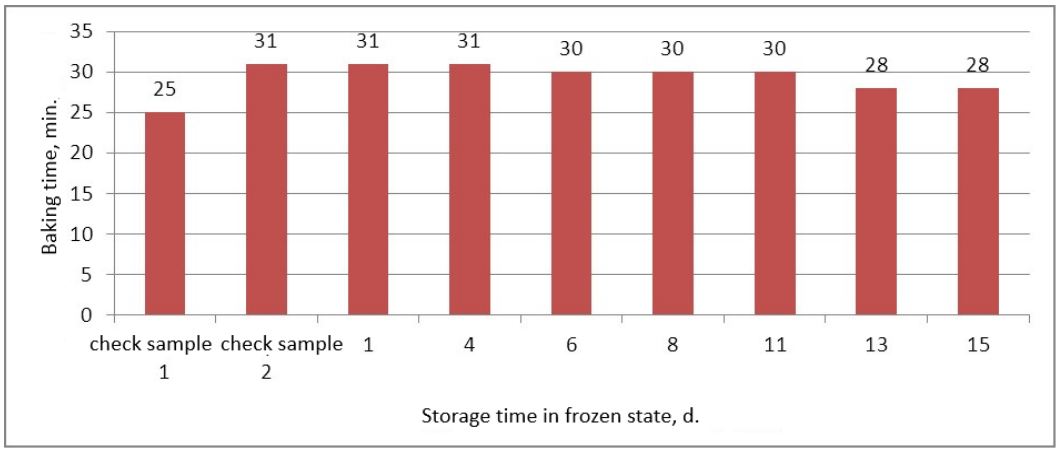

Fig. 3. The dependence of the time of baking on how long einkorn wheat dough enriched with Jerusalem artichoke tuber flour is stored in the frozen state.

First, we see 6 minutes' difference in baking time between check sample 1 (25 min.) and check sample 2 (31 min.). This difference must be due to an increase in the liquid phase of the dough during its freezing. The storage time of the frozen enriched dough does not tell on the time of its preparation till the 4th day (31 minutes as compared to check sample 2). In the periods that follow, the baking time is gradually reduced, until it reaches the lowest point (28 min) on the 15th day. It may be concluded that the storage time of the frozen dough has no effect on the time of baking.

Conclusions

1. The duration of storage of frozen dough made of einkorn wheat enriched with Jerusalem artichoke flour reduces the duration of its defrosting.

2. The storage time of einkorn wheat dough enriched with Jerusalem artichoke flour in the frozen state increases the time in which the temperature of dough rises and its final fermentation takes place, with the longest duration of these two operations on the 15th day.

3. Storing frozen dough does not affect the duration of baking.

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