Study of bakery mixture characteristics during storage and grain bread quality based on it

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Abstract. The technologies of bakery production with the use of multi-component ready-made bakery mixtures are considered to be perspective for developing a wide range of bakery products. In terms of nutrition physiology, it is important that mixtures contain ingredients with useful substances in order to make products with prophylactic and functional orientation. It is acknowledged that characteristics of raw materials can change during the process of storage. That is why this article studies the change in the characteristics of «Chernyaevskaya» bakery mixture based on bioactivated wheat grain during the process of storage and the correlation between the period of storage and the quality of grain bread. As a result, it has been found that after 6 months of storage the titrated acidity of the mixture practically did not change; water-storage capacity, volumetric weight, and angle of repose were increasing. It is certain that after 6 months of storage total bacteria content of the mixture was slightly increasing, water activity and its antioxidant activity decreased. The evaluation of the quality of «Chernyaevskii» bread baked with the use of 6 months stored «Chernyaevskaya» mixture has demonstrated that its quality practically did not change if compared to the bread baked of non-stored mixture. It is recommended to store the bakery mixture during 6 months. Moreover, resource-saving technology of the grain bread based on «Chernyaevskaya» mixture will allow one to use plant raw materials rationally.

1. Introduction
Currently, one of the main directions of the development strategy for the food and processing industry of the Russian Federation for the period till 2030 is the elaboration of innovative agro-food technologies of storage and processing of agricultural products, the production of safe food supplies with functional purposes in order to develop a wide range of high-quality items which can provide human body with vital macro- and microelements.

There are many studies dedicated to the elaboration of new types of foodstuffs including bakery products [1–6]. There are relevant solutions to include in their recipe whole-grain cereals and legumes including bioactivated ones. This will allow one to use plant raw materials rationally, to preserve parts of grain cover in the product, to prevent intensive mechanical impact on it during the process of grinding at a flour mill [7–10]. The use of bioactivated grain during the production process is attributable to its useful
properties: increased vitamin and mineral content in a bioavailable form, increased content of dietary fibers, reduced phytin content [11–14].

One of the main directions of perfecting bread technology is an increasing use of grain bakery mixtures aimed at enhancement of nutritional value and functional characteristics of a product in the recipes. At the Department of technology of bakery, pastry, pasta and grain processing production of Voronezh State University of Engineering Technology there was a developed «Chernyaevskaya» bakery mixture (TS 9195-382-02068108-2016) which consists of dry bioactivated wheat grain, first grade wheat flour, cheese whey, edible salt, ascorbic acid and «Chernyaevskii» bread (TS 9110-384-02068108-2016) based on it. It is known that bakery mixtures are classified as semi-processed goods of long-term storage. Storage duration of raw materials may have an impact on the quality of the product.

2. Objective and objects of research
The purpose of this study is to examine the characteristics of the «Chernyaevskaya» bakery mixture during its storage period and to measure the impact of the storage duration on grain bread quality. The objects of the study are samples of «Chernyaevskaya» bakery mixture No. 1 — at the beginning of storage — and No. 2 — after 6 months of storage, and «Chernyaevskii» bread baked with the use of samples No. 1 and No. 2.

3. Materials and methods
3.1 Examination of the characteristics of bakery mixture
The titrated acidity of the bakery mixture was calculated according to GOST 27493-87, water-storage capacity was measured according to the amount of water being retained during the process of soaking, volumetric weight and angle of repose — according to GOST 28254-2014, water activity with the use of a portable moisture meter RotronicHygroPalm HP23-AW-Set (Switzerland).

3.2 Examination of the grain bread quality
The quality of bread was evaluated 20 hours after baking according to organoleptic indices (appearance, sourdough condition, taste and smell) and physical-chemical indicators (moisture, acidity, porosity) according to GOST 5667-65, GOST 21094-75, GOST 5670-96, GOST 5669-96.

Glycemic index of bakery goods was calculated with a glucometer «Contour TS» (Ascensia Diabetes Care, Germany) after eating a portion of bread (pure glucose) which contained 50g of carbohydrates. 20 volunteers from the students and professors of the University between the ages of 21 and 40 years took part in the study. Exclusionary criteria for participation were body mass index $\geq 25 \text{ kg/m}^2$, blood sugar level on an empty stomach $\geq 6.1 \text{ mmol/L}$, pregnancy, and endocrine pathology. Glycemic index value was calculated basing on the square under the glycemic curve for a tested product which was compared to the square under the glycemic curve for pure glucose and was presented as a percentage.

Both in bread and bakery mixture quantity of mesophilic aerobic and facultative anaerobic microorganisms (QMAFAAnM) was calculated according to GOST 10444.15-94, antioxidant activity was measured by amperometric method with the use of a device ZvetYauza-01-AA (NPO «Chemautomatic»).

4. Results and Discussion
After 6 months of storage of the bakery mixture it was found that titrated acidity of mixture practically did not change; water-storage capacity, volumetric weight, and angle of repose were increasing (table 1). The fact that after the storage the volumetric weight of the bakery mixture increased shows its denser laying in a volume unit, and the increase of angle of repose demonstrates caking of its mass during storage. It is certain that flowability of the samples No. 1 and No. 2 was satisfactory. The total bacteria content in the mixture was slightly increasing (table 2).
Table 1. Change in physical-chemical and physical-mechanical characteristics of the bakery mixture during storage

| Characteristics                              | Indicators for bakery mixture samples |
|---------------------------------------------|---------------------------------------|
|                                             | No. 1          | No. 2          |
| Titrated acidity, deg.                      | 16.0±0.1       | 16.5±0.1       |
| Water-storage capacity, g of water/g of substance | 1.02±0.02     | 1.15±0.02     |
| Volumetric weight, kg/m³                    | 450±10         | 490±10         |
| Angle of repose, deg.                       | 36±2           | 42±2           |

Table 2. Change of total bacteria count, water activity, and antioxidant content in the bakery mixture samples

| Indicators                              | Indicators value for bakery mixture samples |
|-----------------------------------------|---------------------------------------------|
| QMAFAAnM, CFU/g                         | less than 0.3·10⁵                            | 3.0·10⁵|
| Water activity at ambient temperature   | 0.353 at t<sub>a.t.</sub> = 19.12 °C          | 0.308 at t<sub>a.t.</sub> = 21.45 °C |
| Total antioxidant count/100 gDM         | 5.67                                         | 4.54|

After 6 months of storage of the bakery mixture its water activity and its antioxidant activity decreased. The decrease of antioxidant content is associated to the destruction of a number of substances during storage: ascorbic acid, tocopherol, β-carotene.

The evaluation of the quality of bread in 20-hour period after baking revealed that the quality of «Chernyaevskii» bread based on the sample of bakery mixture No. 2 practically did not change its characteristics in comparison to the product baked with the sample of bakery mixture No. 2.

Microbiological bacteria content of grain bread based on bakery mixture sample No. 2 was 13.5 times higher comparing to the product based on sample No. 1. It is explained by a bigger value of this indicator in sample No. 2.

It was established that the largest content of antioxidants was observed in the sample of bread (1.12 mg/100 g DM) baked on the basis of bakery mixture sample No. 1 (figure 1). After 6 months of storage of «Chernyaevskaya» bakery mixture, the acidity activity of a product baked with it decreased on 11.6 %. It is attributable to the reduction of acidic activity during storage.
Table 3. Quality indicators of grain bread based on the bakery mixture samples

| Indicators                                | Indicators value for bakery mixture bread |
|-------------------------------------------|------------------------------------------|
|                                            | No. 1          | No. 2          |
| Appearance:                               |               |               |
| surface                                   | Well-formed, consistent with the baking mould used for cooking |
| colour                                    | Slightly abrasive, without erosion and cracks |
|                                            | Brown         |
| Sourdough condition:                      |               |               |
| porosity                                  | Developed, with empty spaces and lumps |
| Cockiness                                 | Cooked, not clammy |
| Taste and smell                           | Nice, distinct, without foreign taste and smell |
| Moisture, %                               | 47.0±0.5      | 47.0±0.5      |
| Acidity, deg.                             | 4.5±0.1       | 4.7±0.1       |
| Porosity, %                               | 61.5±1.0      | 61.0±1.0      |
| QMAFAnM, CFU/g                            | less than 4.0·10¹ | 5.4·10² |

Figure 1. Change in antioxidant count in bread based on bakery mixture samples No. 1 and No. 2
It was established that the glycemic index of «Chernyaevskii» bread based on bakery mixture sample No. 2 had 2 % lower glycemic index compared to the item based on sample No. 1 (figure 2). It was caused by the reduction of the activity of enzymatic complex, first of all of amylolytic enzymes, of bioactivated grain during the storage period of the bakery mixture on which basis it was prepared (due to its high acidity level 16.0-16.5 deg.).

![Glycemic index of bread baked of bakery mixture samples No. 1, No. 2 and pure glucose](image)

**Figure 2.** Glycemic index of bread baked of bakery mixture samples No. 1, No. 2 and pure glucose

According to the World Health Organisation grain bread regardless of storage duration of a bakery mixture belongs to the category of products with the average glycemic index.

5. Conclusion

On the basis of the carried out research it was established that flowability of the bakery mixture regardless of storage period was satisfactory. Moreover, additional mixing or vibration during storage are not required. After 6 months of storage its titrated acidity practically did not change, water-storage capacity, volumetric weight, angle of repose, and QMAFaM were increasing, water activity and antioxidant content were decreasing. That is why it is recommended to store «Chernyaevskaya» bakery mixture for 6 months. Its application in compliance with mentioned storage duration will allow one to cook bread with organoleptic and physical-chemical quality indicators which practically do no differ from products baked of bakery mixtures that have not been stored.

It was proved that microbiological bacteria content of grain bread based on the 6 months stored «Chernyaevskaya» mixture increased 13.5 times, its antioxidant activity decreased by 11.6% and glycemic index decreased by 2 %.

Moreover, the use of «Chernyaevskaya» bakery mixture in bread bakery technology will allow one to expand a raw material base, rationally use plant raw materials including whole wheat grain, and increase the variety of functional bakery goods.

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