Technological properties of triticale-hemp flour

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Abstract. Technology for producing composite triticale-hemp flour was designed. Cannabis seeds are of high nutritional value: they contain essential fatty amino acids (EFAs), vitamins A, D, E and group B, trace elements (calcium, iron, sodium), and dietary fiber. The possibility of co-grinding the triticale-hemp mixture for the first time was shown, which allowed us to develop the technology of triticale flour enriched with essential fatty acids ω-3 (linolenic acid) and ω-6 (linoleic acid). The total yield of triticale-hemp flour was quite high and amounted to 73.9% with an ash content of 1.26%. With the introduction of 10% hemp seeds into the grinding mixture in the obtained baking triticale-hemp flour, the fat content increased by 3.9 times, and the protein content by 20.5%. Indicators rheological properties of the test of triticale and triticale-hemp flour are at a low level. The time of formation and stability of the test according to the pharynograph increased by 2.5 and 3 minutes accordingly, the valorimetric score increased by 16 EVal. against the background of a slight decrease in dilution of the test by 15 EF. The use of hemp seeds contributed to a marked improvement in the physical characteristics of the triticale-hemp flour dough. In terms of organoleptic characteristics, bread made of composite triticale-hemp flour enriched with polyunsaturated fatty acids turned out to be comparable to bread from varietal triticale flour. The volumetric yield of bread baked from triticale-hemp flour (367 cm³) was 107 cm³ higher than that of bread from the control triticale flour (260 cm³).

1. Introduction
Many of the grain processing products based on wheat flour make up a significant share in people’s diet. However, the chemical composition of food products obtained, based on traditional technologies, is characterized by insufficient balance in nutritional value and biological effectiveness [1,2].

In this regard, it is necessary to develop food products with increased nutritional value on a grain basis by adding oilseeds (hemp). Cannabis seeds are of high nutritional value, while they contain essential fatty amino acids (EFA), vitamins A, D, E and group B, trace elements (calcium, iron, sodium), and dietary fiber. Only soy contains similar nutritional value, while the quality of proteins in hemp seeds is much higher: they are similar in composition to human blood proteins. In addition, hemp seeds are an environmentally friendly product, since they do not use herbicides on hemp crops - this plant, due to its viability, perfectly copes with diseases and pests [3,4].
A characteristic feature of hemp seeds is a high fat content of 32.5 to 51.5% with a polyunsaturated fatty acid content (ω-3, ω-6 family) of 40 to 50% and a high protein content of 20 to 30% with a well-balanced amino acid composition. The ratio of polyunsaturated essential fatty acids (EFA) ω-3 (linoleic acid), ω-6 (linolenic acid) in oil obtained from hemp seeds is one of the most optimal for the human body and is recommended for use by people suffering from cardiovascular diseases and nervous system disorder [5,8].

The need to enrich triticale flour with polyunsaturated fatty acids is due to the fact that -3 and ω-6 fatty acids are not synthesized in the human body due to the lack of an enzyme system [6,7].

2. The purpose of the study
The purpose of the study is to develop a method for producing composite flour of high biological value from a mixture of non-traditional species, both grain raw materials (triticale) and oilseeds (hemp).

To achieve this goal, studies were carried out to develop a technological scheme for producing composite triticale-hemp flour, laboratory grinding of a mixture of triticale and hemp seeds and a control sample of triticale grains was carried out. The process of coarse formation of intermediate grinding products of the composite triticale-hemp mixture was studied and the quality indicators of the obtained samples of triticale-hemp flour and a control sample of triticale flour were determined.

3. The subject matter of the study
The subject matter of the study are samples of a commercial consignment of triticale grains from the 2018 crop grown in the Rostov Region, and a commercial consignment of hemp seeds grown in the Republic of Mordovia. Quality indicators of the initial batch of triticale and hemp seeds are presented in table 1.

| Source product | The chemical composition of triticale grains and hemp seeds |
|----------------|----------------------------------------------------------|
| Triticale grain | Starch,% 66,7  Protein% 11,27  Fat% 1,63  Cellulose, % 1,9  Humidity% 12,3 |
| Hemp seeds     | Starch,% 5,1  Protein% 24,42  Fat% 35,18  Cellulose, % 15,06  Humidity% 5,1 |

4. Materials and methods
Studies to determine the baking properties of composite triticale-hemp flour of high biological value were carried out at the Department of Grains, Bakery and Confectionery Technologies, Moscow State University of Food Production, and at the Department of Storage, Processing and Commodity Technology of Plant Products, Federal State Budgetary Educational Establishment of Higher Education Agricultural University - Moscow Agricultural Academy named after K. A. Timiryazev. Peeling of the initial triticale grain was carried out on a Satake laboratory universal grain husk (Japan). Grinding mixture of husked triticale grain and hemp seeds was conducted in laboratory mills MLP-4 with cut rollers and MLP-4 with micro rough rollers.

The standard methods used to analyze the main indicators of the obtained triticale-hemp flour are the following: ash - according to GOST 27494-2016, humidity - according to GOST 9404-88, protein according to GOST 10846-91, fat according to GOST 29033-91, quantity and quality of gluten according to GOST R 31699-2012, determination of water absorption and rheological properties according to GOST ISO 5530-1-2013, test laboratory baking and evaluation of the quality of triticale flour bread - according to the method of state variety testing of crops (1988).

5. Discussion of the results
The first stage of the research presented peeling of the initial triticale grain carried out with the removal of 15.1% of the seed, fruit membranes and, partially, the aleurone layer. Triticale membranes have better sorption ability than endosperm. Given this circumstance, the initial triticale grain was
peeled in order to minimize the loss of polyunsaturated fatty acids and protein contained in hemp seeds when receiving wheat-hemp bread flour.

At the second stage of the research, we ground the initial composite wheat-hemp mixture, consisting of 90% peeled triticale grain and 10% hemp seeds, into baking flour. Unlike traditional baking mills, hydrothermal treatment of triticale grains was not used, because moistened grains absorb sorbent fat contained in hemp seeds worse. The technological scheme of grinding consisted of 4 torn and 3 grinding systems. The grinding regime in torn systems was characterized by the extraction of large-dun products and flour in the first torn system of 50.9%, in the second torn system - 39.3% and in the third torn system - 61.4%. The total yield of hemp and wheat flour in torn systems amounted to 17.7%.

The grinding regime of the intermediate products of the initial mixture on grinding systems to obtain triticale-hemp flour was characterized by extraction on the 1st grinding system in the amount of 69.9%, on the 2nd grinding system - 63.4% and on the 3rd grinding system - 71.4%. The total yield of wheat-triticale flour on three grinding systems was 56.2%. The total yield of wheat-triticale flour on torn and grinding systems amounted to 73.9%, considering the removed shells with preliminary peeling of the initial triticale grain. The quality indicators of the processed products of the initial grain of triticale and triticale-hemp grinding mixture are presented in table 2. The table shows the introduction of 10% hemp seeds with the initial grinding mixture. It was possible to increase the fat content in the baking triticale-hemp flour, mainly due to polyunsaturated fatty acids, by 3.9 times, and protein content by 20.5%. In addition, triticale-hemp flour is characterized by increased ash content, due to the fact that particles of shells during grinding of triticale-hemp mixture fell into the flour.

| Product name          | Humidity% | Ash content,% | Fat content,% | Protein content,% | Content of crude gluten,% | Quality of raw gluten, FDM | Fall number, sec. |
|-----------------------|-----------|---------------|---------------|-------------------|---------------------------|---------------------------|------------------|
| Triticale Flour       | 14,0      | 0,71          | 1,17          | 11,2              | 16,8                      | 67                        | 128              |
| Triticaleo-hemp flour | 13,8      | 1,55          | 4,58          | 13,5              | 18,8                      | 70                        | 113              |
| Triticale-hemp bran   | 11,3      | 5,00          | -             | -                 | -                         | -                         | -                |

The final stage of the research presents the rheological properties of the dough and the quality indicators of bread from the obtained triticale and triticale-hemp flour determined. The results are presented in tables 3 and 4.

| Product name          | Water absorption,% | Formation time, min | Test stability, min | Dilution of the test, EF. | Valorimetric rating, EVal |
|-----------------------|--------------------|---------------------|---------------------|---------------------------|---------------------------|
| Triticale Flour       | 51,3               | 1,0                 | 0,5                 | 150                       | 36                        |
| Triticaleo-hemp flour | 51,5               | 3,5                 | 3,5                 | 135                       | 52                        |

Indicators of the test rheological properties of triticale and triticale-hemp flour are at a low level. The use of hemp seeds contributed to a marked improvement in the physical characteristics of the
triticale-hemp flour dough. Thus, the formation time and stability of the test according to the pharynograph increased by 2.5 and 3 minutes. accordingly, the valorimetric score increased by 16 EVal. against the background of a slight decrease in dilution of the test by 15 EF. Thus, the dough made from triticale-hemp flour has a higher stability compared to the control to a long mechanized kneading and thus will be more suitable for processing in a production environment.

Bread baked from triticale-hemp flour had a volumetric yield of 367 cm$^3$/100 g of flour, and bread baked from triticale-hemp flour had a volumetric yield of 260 cm$^3$/100 g of flour. The surface of triticale-hemp flour bread is smooth, glossy, the color of the crust is light brown. The surface of triticale flour bread is uneven, with roughness, the color of the crust is dark brown. The crumb of bread from triticale-hemp flour is light with a yellowish tinge, from triticale flour is light with a grayish tint. The crumb porosity of triticale-hemp flour bread is shallow, medium thickness, uniform. Bread from triticale flour is large, uneven, with crumb of medium thickness porosity (Figure 1).

### Table 4. Bakery properties of triticale and triticale-hemp flour

| Quality indicators   | Triticale Flour Bread       | Triticale-hemp flour bread                        |
|----------------------|-----------------------------|--------------------------------------------------|
| Volumetric output    | 260 cm$^3$/100 g.           | 367 cm$^3$/100 g.                                |
| Bread surface        | Rough, bumpy                | Smooth, glossy                                   |
| Bread shape          | Semi-oval                   | Oval                                             |
| Peel color           | Brown                       | Light brown                                      |
| Porosity             | Uneven, medium thickness    | Shallow, uniform, medium thickness               |
| Elasticity           | Elastic                     | Elastic                                          |
| Crumb color          | Light coloured              | Darkish                                         |
| Taste and smell      | Corresponds to triticale flour bread | Nice, specific                                   |

![Figure 1. Appearance of bread and crumb from triticale-hemp flour (left) and triticale (right)](image)

6. **Conclusion**

For the first time, a technology was developed for the production of composite triticale-hemp flour enriched with polyunsaturated fatty acids.

The total yield of triticale-hemp flour was quite high and amounted to 73.9% with 1.26% of ash content.
With the introduction of 10% hemp seeds in the initial grinding mixture, the fat content in the baking triticale-hemp flour increased by 3.9 times, and the protein content increased by 20.5%.

The dough made of triticale-hemp flour has a higher resistance compared to the control to a long mechanized kneading and thus will be more suitable for processing in an industrial environment.

The volumetric yield of bread (367 cm$^3$) when using hemp seeds increased by 107 cm$^3$ compared with a control sample baked from triticale flour.

In terms of organoleptic characteristics, bread obtained from composite triticale-hemp flour enriched with polyunsaturated fatty acids was not inferior to bread baked from varietal triticale flour.

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