The use of flour from germinated buckwheat in bread recipes

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Abstract. The results of the study of technological properties, chemical composition of buckwheat varieties of the Republic of Bashkortostan, as well as the effect of flour from sprouted buckwheat grain on the quality of wheat bread are presented. According to the nutritional value, in order to obtain buckwheat flour in order to include it in the bread recipe, the Inzer buckwheat variety was selected. The parameters of soaking and germination of buckwheat grain of this variety are optimized and it is shown that due to germination, the physico-chemical parameters of flour and its antioxidant activity are improved. Thus, the expediency of introducing flour from sprouted buckwheat grain into the recipe of wheat bread is proved. The optimal content of flour from sprouted buckwheat grain in the composition of a composite mixture with wheat flour of grade I, which amounted to 10%, providing an improvement in the organoleptic and physico-chemical parameters of bread, was established.

1 Introduction

Human health is influenced by many factors, the most important of which is proper nutrition. In modern society, the trend towards a more balanced and healthy diet is increasing, which is largely realized by the use of products from biologically active raw materials. To create such products, new scientific solutions and technological developments are required. In particular, for the production of a large number of food products, grains of various crops that are at rest are used. At the same time, it is known that when grain germinates, the enzymes contained in it are activated, leading to a change in its chemical composition and nutritional value [1, 11, 13]. Various cereals are used as grain raw materials in the production of food products from germinated grain. and legumes [4-5].

In recent years, domestic producers have shown an increasing interest in buckwheat as one of the important food crops. Buckwheat is used as a fortifier of various food products, both in native and sprouted form. Buckwheat occupies a leading position among grain crops in terms of nutritional value and nutritional value. 100 g of buckwheat contains an average of 68% carbohydrates, 14% protein, 2.5% fat, 12% fiber; the grain of this crop is a source of B, E, PP vitamins, macro- and microelements, essential amino acids, therefore

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products containing buckwheat have a preventive and therapeutic focus and are suitable for nutrition of all population groups [2-3, 7-9, 14] .

Buckwheat breeding is carried out in Bashkortostan, which resulted in the creation of a number of high-yielding and high-tech varieties. The Republic belongs to the main buckwheat-growing regions of the Russian Federation, since this valuable crop is sown annually on an area from 60 to 100 thousand hectares [6]. One of the potential uses of buckwheat is its addition in the form of flour to the recipes of bread, bakery and flour confectionery products. However, the absence of proteins in buckwheat that form the gluten frame of the dough makes it difficult to use buckwheat flour in the production of bread, so it is added to the recipe along with wheat flour [10].

The purpose of the research is to study the technological properties, chemical composition of buckwheat varieties of breeding of the Republic of Bashkortostan, as well as the effect of flour from germinated buckwheat grain on the quality indicators of wheat bread.

2 Materials and methods

The studies used wheat flour of I grade (GOST 26574-2017), buckwheat varieties Agidel, Zemlyachka, Ilishevskaya, Inzerskaya (GOST 19092-92), grown in the Chishminsky breeding center for crop production of the Federal State Budgetary Scientific Institution BNIIS UFITs RAS, buckwheat flour from germinated grain (meeting the requirements TU 9293-005-00932169-96), received at the Department of Catering Technology and Processing of Vegetable Raw Materials of the Federal State Budgetary Educational Institution of Higher Education BSAU.

Protein was determined by the Kjeldahl method according to GOST 10846-91, starch according to GOST 10845-98, weight of 1000 grains - GOST 10842-89, nature - GOST 10840-2017, filminess - GOST 10843-76, acidity according to GOST 27493-87, acid number of fat according to GOST 31700-2012, amylolytic activity was determined according to GOST 27676-88. The porosity of bread was determined according to GOST 5669-96, the acidity of bread was determined by the accelerated method according to GOST 5670-96. Buckwheat grain was germinated using two stages: soaking in water for 3 hours and germinating at a temperature of (20 ± 2)°C for 21 hours. A unified bread recipe was taken as the basis [12]. Dough for bread was prepared using a non-dough method using wheat baking flour of the 1st grade (control) and with partial replacement of wheat flour with buckwheat flour from germinated grain in an amount of (10-40)% with a step of 10%, pressed yeast, salt solution and water. Kneading was carried out for 12 minutes and sent to fermentation for 120-150 minutes at a temperature of t=27-28°C and a relative humidity of 75-80% with two knocks until the acidity is not more than 3.0 degrees. Proofing took place in a proofer ShKhL-0.65 at t=35±1°C for 40 min. Baking dough pieces in a baking cabinet ShRL-0.65 for 30-45 minutes at a temperature of 215±5°C.

3 Results and Discussion

Grain of buckwheat varieties of the Bashkir Scientific Research Institute of Agriculture UFITs RAS (Agidel, Zemlyachka, Ilishevskaya and Inzerskaya) 2019, 2020 and 2021 studied in terms of productivity and technological indicators.

The growth and development of buckwheat in 2019 took place in conditions of wet and cool weather: precipitation during the growing season was 132.7 mm, the average air temperature was 17.9°C.

Favorable weather conditions in 2019 significantly increased the growing season of buckwheat plants (the hydrothermal moisture coefficient (HTC) was 0.87. It should be noted that in 2020 and 2021, the plants completed the growing season in 71-87 and 65-72 days, respectively, and in 2019 in 84 - 100 days. In this regard, in 2019, the tested buckwheat varieties formed a high grain yield, in the range from 24.1 to 27.3 q/ha.

The technological properties of the seeds of the studied varieties turned out to be quite high: the weight of 1000 seeds was 31.5-33.8 g, filminess - 19.5-21.7%, grain size - 581-616 g/l.

The growing season of buckwheat in 2020, in general, took place against the background of average air temperatures and an increased amount of precipitation (HTC was 1.2). The rains coincided with the flowering-ripening period of buckwheat, as a result of which pollination of flowers and fruit set were weak, which affected the level of productivity of buckwheat plants and subsequent yields.

At the same time, the formed grain had high technological qualities: with a low filminess (20.3–22.1%) and a high value of the mass index of 1000 grains (28.6–31.0 g), the nature of the grain reached 601–625 g/l.

Table 1. Yield and technological qualities of buckwheat varieties bred by BNIISH UFITS RAS for 2019-2021.

Variety name	Productivity, c/ha	Weight of 1000 grains, g	Nature, g/l	Filminess, %
2019				
Agidel	24.1	30.9	610	19.6
Countrywoman	27.3	31.9	601	19.5
Ilishevskaya	25.7	33.8	581	21.7
Inzerskaya	25.3	31.5	616	19.7
2020				
Agidel	11.8	28.6	625	21.4
Countrywoman	14.7	29.0	607	20.3
Ilishevskaya	12.8	31.0	601	22.1
Inzerskaya	13.5	29.3	621	21.8
2021				
Agidel	7.7	27.6	595	20.3
Countrywoman	6.6	28.9	578	20.5
Ilishevskaya	7.9	30.4	554	22.9
Inzerskaya	7.4	28.8	586	23.2

The growing season of 2021 was characterized by pronounced signs of drought, the average daily temperature was not lower than 21.5 °C, the HTC was 0.4. Especially during the flowering-ripening period, extremely low air humidity was observed, which negatively affected the yield of buckwheat varieties. Nevertheless, the studied varieties of the selection of the Republic of Bashkortostan were bred as drought-resistant, in this regard, the quality indicators of grain, although they were lower than in 2019 and 2020, remained at the level of acceptable limits according to the standard values. Large high-quality grain was obtained: the weight of 1000 grains was 27.6 - 30.4 g, the average film content was 20.3 - 23.2%, and the grain size was 554 - 595 g / l.

The yield of the studied samples in 2020 and 2021 amounted to 11.8 - 14.7 and 6.6 - 7.9 c/ha, respectively, which is 2 - 3.5 times lower compared to 2019.

The weather conditions of the growing season described above, which differ significantly from year to year, had a decisive influence on the chemical composition of the buckwheat grain of the studied varieties (Table 2).

The chemical composition of buckwheat grain varies slightly and depends on the variety. An analysis of the experimental data showed that the protein content varied within 16.21-18.53%, with the minimum content noted in the Ilishevskaya variety 16.21-17.00%, and the maximum content in the Inzerskaya variety 17.98-18.53% . The results of the analysis presented in table 2 indicate the influence of weather conditions on the accumulation of protein in buckwheat. Thus, the hot and dry year 2021 favorably affected the protein content, which was formed at the level of 16.99-18.53%.

The weather conditions of 2020 made it possible to obtain grain with low film content and a fairly high starch content, which is at the level of 69.98-77.95%. The largest amount of starch 76.91-79.83% among all the studied samples was contained in the buckwheat grain of the Inzerskaya variety.

The buckwheat grain of the studied varieties was characterized by a rather high fiber content of 13.7-14.7%. The mass fraction of ash in the studied varieties of buckwheat was 1.7-2.0%, since the ash content characterizes the mineral composition of the grain, the data in table 1 indicate that most of the ash is represented by elements such as phosphorus and magnesium, and to a lesser extent by calcium and iron . In terms of fat content, the studied varieties differ slightly and are at the level of 2.1-2.6%.

Table 2. The chemical composition of buckwheat grain varieties bred by the BNIISH UFITS RAS for the 2019-2021 harvest.

Index	Variety name, year											
	Agidel			Zemlyachka			Ilishevskaya			Inzerskaya		
	2019	2020	2021	2019	2020	2021	2019	2020	2021	2019	2020	2021
Mass fraction, %												
protein	16.63	17.02	17.62	16.74	16.88	16.99	16.21	16.53	17.00	17.98	18.17	18.53
fat	2.2	2.1	2.2	2.6	2.4	2.5	2.5	2.3	2.1	2.4	2.2	2.1
starch	72.83	69.98	67.07	76.74	75.76	72.56	71.88	70.05	69.04	79.83	77.95	76.91
cellulose	14.1	13.7	13.9	14.5	14.0	14.3	13.9	13.8	13.9	14.7	14.5	14.6
ash	1.7	1.8	1.7	1.9	1.8	1.7	2.0	1.8	1.9	1.9	2.0	2.0
Minerals, mg/100 g												
calcium	80	85	81	95	90	87	70	74	69	90	88	90
magnesium	230	233	228	247	245	242	200	203	199	260	255	261
phosphorus	310	317	311	304	300	299	290	292	288	320	324	319
iron	8.08	8.07	8.02	7.99	7.97	8.00	8.01	7.98	7.95	8.31	7.96	8.01

Thus, the most valuable buckwheat variety in terms of nutritional value is Inzerskaya, since the grain of this variety contains more both starch (76.91-79.83%) and protein (17.98-18.53%). Both of these indicators are important both for the flow of technological processes in baking, and for the formation of proper quality and increased nutritional value of bakery products. For this reason, buckwheat grain of the Inzerskaya variety, germinated by the method described below, was used for further research.

The buckwheat grain cleaned from weeds was washed under running tap water at 18 ± 2 °C until the drained water was transparent. Washed buckwheat grain was subjected to soaking at a hydromodulus of 1:3 and kept for 1, 2, 3 hours at a temperature of 20 ± 2 °C. Then, excess water was removed and germinated in a thermostat at a temperature of 25 ± 2 °C until sprouts 3–5 mm long appeared. To determine the optimal soaking time for buckwheat, the germination energy was determined according to GOST 12038-84 after 6, 12, and 18 hours of germination. The effect of soaking time on the change in germination energy after 6, 12 and 18 hours of germination is presented in Table 3.

Table 3. Germination energy of buckwheat grain depending on the duration of soaking and germination.

Process duration, h		Energy of grain germination, %
Soak	Germination	
1	6	48
	12	63
	18	72
2	6	57
	12	73
	18	89
3	6	58
	12	75
	18	94

The highest rates of buckwheat grain germination energy were noted with a soaking time of 3 hours and a germination time of 18 hours.

Sprouted buckwheat grain was dried at a temperature of 50°C to a moisture content of no more than 12%. The dried germinated grain was crushed to a particle size of no more than 0.08 mm. The organoleptic evaluation of the obtained flour was carried out according to GOST 31645-2012. The data obtained are presented in Table 4.

Table 4. Organoleptic characteristics of flour from germinated buckwheat.

Indicators	Requirements GOST 31645-2012	Factual data
Color	Light beige, cream, beige with a grayish tinge	Cream
Smell	Peculiar to buckwheat flour, without foreign odors, not musty, not moldy	Peculiar to buckwheat flour, without foreign odors
Taste	Peculiar to buckwheat flour, not sour, not bitter, without foreign flavors	Peculiar to buckwheat flour, without foreign flavors

The physico-chemical parameters of flour from sprouted buckwheat grains (mass fraction of moisture, acid number of fat, acidity for compliance with the requirements of GOST 31645-2012) were also studied, the data are presented in Table 5.

Table 5. TableCaption.

Name of indicator	Normalized readings GOST 31645-2012	Actual value
Mass fraction of moisture, % no more	12.0	11.5
Acid number of fat, mg KOH per 1 g of fat	15.0	10.2
Acidity, hail, no more	6.0	4.4

The results of the organoleptic and physico-chemical evaluation of buckwheat flour obtained from germinated grain fully comply with the requirements of GOST 31645-2012, which confirms the possibility of its use for the preparation of bakery products.

Interest in buckwheat grain processing products is due to their antioxidant activity, namely the presence of flavonoids in their composition. We have determined the content of flavonoids in flour obtained under laboratory conditions from native and germinated buckwheat grains of the Inzerskaya variety. The results obtained are presented in Table 6.

Table 6. Flavonoid content.

Sample	Content of flavonoids, %
Buckwheat flour from native grain	0.131
Sprouted buckwheat flour	0.135

In buckwheat flour obtained from germinated grain, the content of flavonoids is somewhat higher than in flour from native buckwheat of the same variety, which confirms the feasibility of the germination process.

Based on the experimental data obtained, it was considered expedient to partially replace wheat flour with flour from sprouted buckwheat grains of the Inzerskaya variety in the bread recipe.

The addition of buckwheat flour from germinated grain in different dosages to the wheat bread recipe significantly affected the gluten content and quality of the resulting composite mixture and its amylolytic activity (Figures 1 and 2).

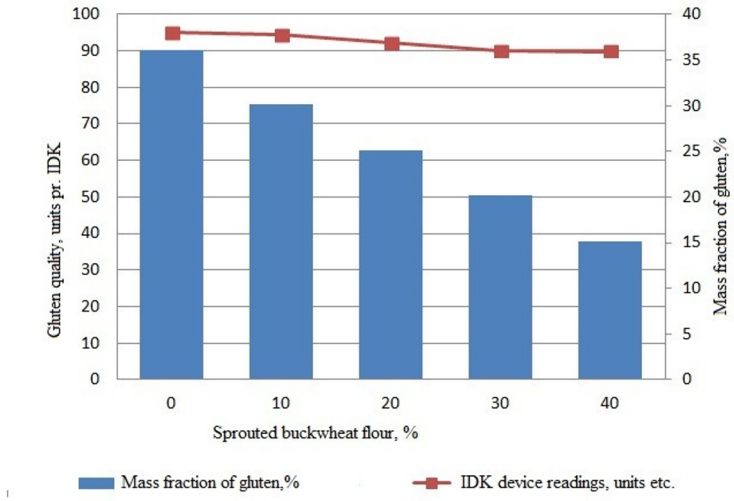

Fig. 1. Effect of buckwheat flour from sprouted grains on the gluten complex.

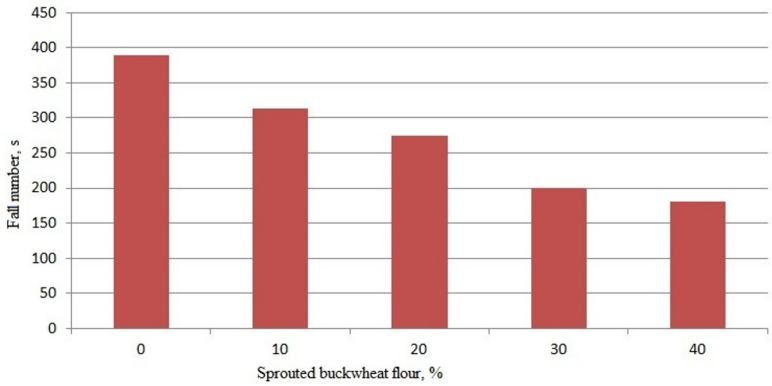

Fig. 2. Influence of the dosage of buckwheat flour from germinated grain on the amylolytic activity of the flour composite mixture.

With an increase in the amount of buckwheat flour from germinated grain in the composite mixture, there was a slight decrease in the quantity and quality of gluten. This dependence can be explained by the fact that flavonoids are highly reactive and form strong bonds with gluten proteins [2].

The research results presented in Figure 2 indicate a decrease in the falling number when buckwheat flour from germinated grain is added to wheat flour of the first grade,

which indicates an increase in the activity of amylolytic enzymes. As a result of the decomposition of starch, the viscosity of the starch paste decreases and the amount of water-soluble substances increases [2].

The next stage of the study was to study the effect of partial replacement of grade I wheat flour with buckwheat flour from germinated grain in an amount of 10-40% on the quality of bread. To determine the optimal ratio of wheat and buckwheat flour from germinated grain, a comparative assessment of the quality of bread obtained from a mixture of wheat and buckwheat flour from germinated grain was carried out. The control was bread made from grade I wheat flour. The developed products were evaluated according to the main organoleptic indicators, scoring for each indicator; the results are shown in Figure 3.

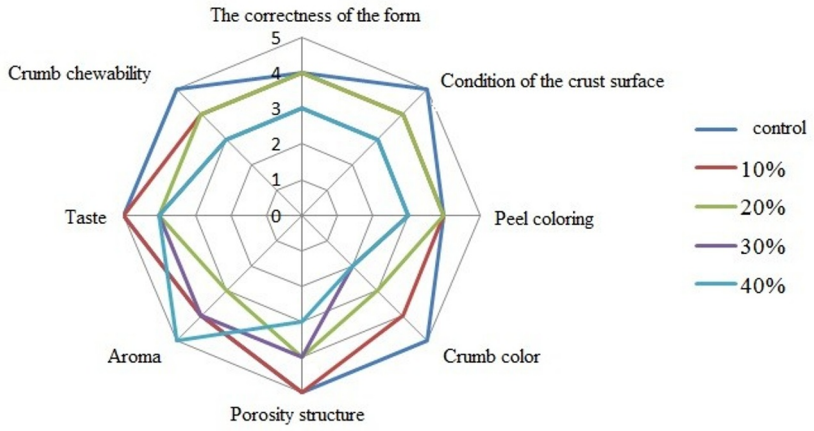

Fig. 3. Organoleptic evaluation of bread samples using flour from germinated buckwheat in the amount of 10-40%.

The results of the organoleptic evaluation of bread with buckwheat flour from sprouted grains indicate that bread with the addition of 10% is close in organoleptic parameters to bread made from grade I wheat flour (control).

Bread with the addition of buckwheat flour in an amount of 10-20% had a smooth surface with single small bubbles, without cracks and undermining, golden brown in color, with well-developed crumb porosity, pleasant taste and smell, with uniform and barely noticeable inclusions of buckwheat flour. When buckwheat flour was added in an amount of 30%, the organoleptic properties noticeably worsened, the crust became bumpy, rough, with noticeable, but not large cracks. The bread crumb of this sample had a grayish-brown color, due to the presence of buckwheat flour, and a dense, uneven porosity structure.

Next, the physico-chemical parameters of products with different contents of buckwheat flour from germinated buckwheat were determined; the results are presented in Figure 4.

The obtained results show that the addition of buckwheat flour from germinated grain to the bread recipe instead of grade I wheat flour in the amount of 10% improves the performance of the finished product: the specific volume increases to 4.13 g/cm^3 and the porosity to 72% compared to control 4, 08 g/cm^3 and 70%, respectively. Buckwheat flour, due to the content of sugars, vitamins and minerals in it, which are additional nutrition for yeast, intensifies the dough fermentation process [1].

With an increase in the content of buckwheat flour in the recipe, the moisture content of the crumb slightly increased. The acidity of bread from a mixture of wheat and buckwheat remained at the standard level, which has a positive effect on the consumer value of bakery products with the addition of buckwheat flour.

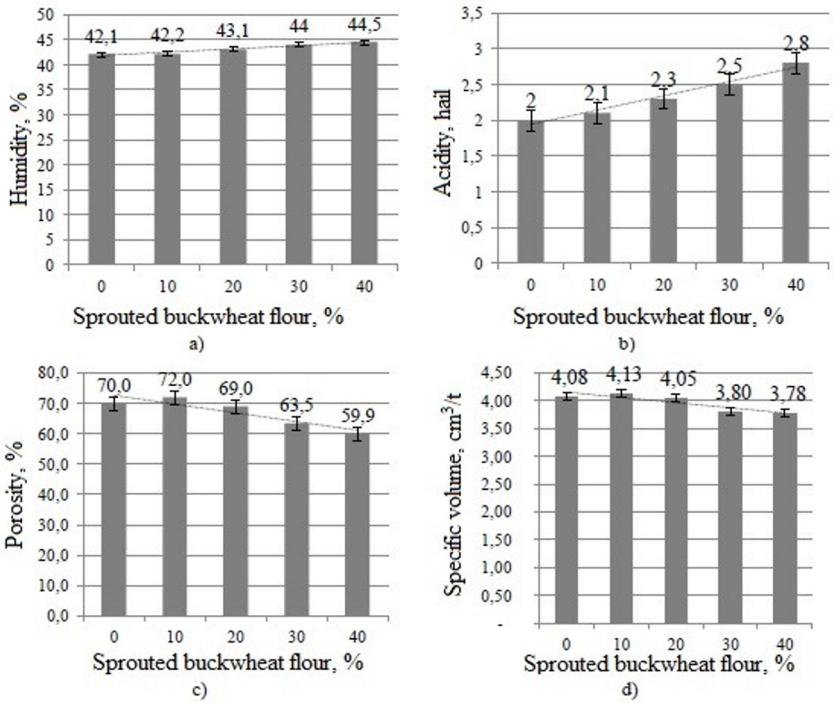

Fig. 4. Physical and chemical indicators of bread samples with partial replacement of wheat flour with buckwheat flour from germinated grain: a) humidity; b) acidity; c) porosity; d) specific volume.

An increase in the dosage of buckwheat flour from sprouted grains over 20% led to a decrease in bread quality indicators. The specific volume of products and their porosity decreased; the crumb became mushy and sticky. Based on this, the dosage of buckwheat flour from germinated grain in the amount of 10% was chosen as acceptable, at which the best organoleptic and physicochemical parameters were observed.

4 Conclusion

The conducted studies made it possible to carry out a comparative characterization of 4 varieties of buckwheat bred in the Republic of Bashkortostan (Agidel, Zemlyachka, Ilishevskaya, Inzerskaya) harvested in 2019-2021. according to the yield and a complex of physico-chemical indicators, including the mineral composition, and to establish the influence of the conditions of the growing season on these indicators.

According to a set of indicators, primarily nutritional value, for the production of buckwheat flour in order to include it in the bread recipe, the Inzerskaya buckwheat variety was selected. The parameters of soaking and germination of buckwheat grain of this variety are optimized and it is shown that as a result of germination, the physicochemical parameters of flour and its antioxidant activity are improved. Thus, the expediency of introducing flour from germinated buckwheat into the recipe for wheat bread has been proved.

The optimal content of flour from germinated buckwheat grain in the composition of the composite mixture with grade I wheat flour was established, which was 10%, which provides an improvement in the organoleptic and physico-chemical parameters of bread.

References

1. E.A. Zernaeva, D.A. Shansharova, A.N. Bondarenko, *Development of bread technology using flour from sprouted crops*, Food. Ecology. Quality: Proceedings of the XIII International Scientific and Practical Conference, 434-437 (2016)
2. E.A. Kuznetsova, E.V. Klimova, L.V. Shayapova, E.G. Shuvaeva, A.N. Fesenko, Production of powder from buckwheat husks - a way to create waste-free high-performance technologies, Scientific and production journal "Grain legumes and cereals", **1**, **37**, 69-75 (2021)
3. L. Kozubaeva, S. Esin, A. Zakharova, The use of buckwheat extrudate in the production of bread, Bread products, **6**, 49 (2011)
4. S.A. Leonova, E.V. Pogonets, Technology of cereals from germinated triticale grain, Technology and commodity science of innovative food products, **6**, **41**, 58-63 (2016)
5. S.A. Leonova, O.F. Nuretdinova, M.Z. Fazylov, Technology for obtaining a national cereal product from germinated oats with the addition of apples, Khleboprodukty, **9**, 52-53 (2015)
6. F.F. Magafurova, V.V. Khusnutdinov, Productivity and technological qualities of grain of various varieties of buckwheat in the conditions of the Cis-Ural zone of the Republic of Bashkortostan, Proceedings of the Ufimskogo scientific center of the Russian Academy of Sciences, **3-6**, 34-36 (2018)
7. E.M. Mazurova, A.V. Yatsenko, *Baking properties of a mixture of buckwheat and wheat flour*, Sat. Proceedings of the All-Russian scientific conference of promising developments of young scientists in 3 volumes Youth and science: a step towards success, 317-320 (2017)
8. A.V. Maslov, O.V. Starovoitova, Z.Sh. Mingaleeva, *Influence of a functional additive on the quality of a bakery product. Science, education and innovation for the agro-industrial complex: state, problems and prospects*, Materials of the VI International scientific and practical online conference, Publishing house "Magarin Oleg Grigorievich", Maikop, 502-504 (2020)
9. V.V. Morozov, *Development of bread with flour from green buckwheat*. Materials of the XV All-Russian student conference: A look into the future, Krasnoyarsk, 347-349 (2020)
10. T.A. Nikiforova, I.A. Khon, The influence of buckwheat flour on the preservation of the freshness of bread, Khleboprodukty, **6**, 38-39 (2017)
11. E.I. Ponomareva, N.N. Alekhina, O.B. Skvortsova, Changes in the nutritional value of buckwheat grain during sprouting using ultrasonic treated water, Food technology, **1**, **373**, 30-33 (2020)
12. L.I. Puchkova, Laboratory workshop on the technology of bakery production: textbook. allowance -4th id., revised and additional (GIORD, St. Petersburg, 2004)
13. Yu.R. Rakhmatullina, V.V. Kirdyashkin, O.A. Vrzhesinskaya, V.M. Kodentsova, Accumulation of vitamins B1 and B2 in sprouted grains, Khleboprodukty, **9**, 64-65 (2012)
14. R. Rozylo, D. Dziki, U. Gawlik-Dziki, G. Cacak-Pietrzak, A. Mis, S. Rudy, Physical properties of gluten-free break caused by water addition, Intern Agrophysics, **29**, **3**, 353-365 (2015)