Journal of Engineering and Applied Sciences 13 (Special Issue 10): 8300-8309, 2018
ISSN: 1816-949X

Spelta as Raw Material for Food Industry and Peculiarities of its Processing

[1]S.A. Leonova, [1]E.V. Badamshina, [2]E.P. Meleshkina, [3]A.L. Weber, [1]O.Y. Kaluzhina, [2]I.S. Vitol, [1]A.A. Chernenkova and [1]D.T. Gaifullina
[1]Bashkir State Agrarian University, 50-Let Oktyabrya 34, 450001 Ufa, Russia
[2]All-Russian Scientific Research Institute of Grain and Products of its Processing Branch, "V.M. Gorbatov Federal Research Center for Food Systems" of the Russian Academy of Sciences, Moscow, Russia
[3]Omsk State Agrarian University Named after P.A. Stolypin, Omsk, Russia

Abstract: The physico-chemical, technological properties and chemical composition of 3 varieties and 12 breeding lines of speltawere studied and compared with wheat. All the samples studied are characterized by a high grain unit with a mass of 1,000 grains while the grain glassiness and hardness values are at an average level. We noted very high indices of the mass fraction of gluten (35.9-39.5%) and protein (13.57-16.85%), however, the quality of gluten is very low. Most of the spelta samples studied showed low falling number which makes it possible to use the flour from it in breadmaking only in combination with wheat flour. An increased protein content (13.55-16.83%), total sugar (3.15-4.88%) and fat (2.42-3.19%) in the samples studied, as well as a high content of vitamin C and beta-carotene. The recipes and technological parameters of flour, flakes, bread and biscuit on the basis of spelta were developed.

Key words: Spelta, wheat, quality, breeding lines, chemical composition, hydrothermal processing, bread, biscuit, flakes, micronization

INTRODUCTION

Currently in the Russian Federation there is Government Order No. 1873-p of October 25, 2010 "On the Fundamentals of the State Policy of the Russian Federation in the Field of Healthy Nutrition of the Population for the Period to 2020".

Expected results of implementation of the state policy in the field of healthy nutrition are among others: providing 80-95% of the domestic market resources for the main types of food raw materials and food products at the expense of domestic products.

Increase in the share of production of mass consumption products enriched with vitamins and minerals including bulk varieties of bakery products as well as dairy products-up to 40-50% of the total production.

The relevance of this research is its focus on the above-mentioned expected results, since, the research is carried out on domestic varieties and breeding lines of spelta and wheat, the purpose of which is to obtain mass food products-flour, cereal flakes, bakery products-enriched with vitamins, minerals and other nutrients.

Spelta (*Triticum dicoccum*) or eincorn-is the progenitor of all modern varieties of wheat. Interest in it increases as in an ecologically pure culture, superior to wheat in terms of protein content, unsaturated fatty acids, fiber, B vitamins. Grain is larger than wheat grain in the ear it is covered with a dense layer of chaff that protects it from adverse weather conditions (rains, drought) from all kinds of pollution and even from radioactive radiation. But this dense coating of the grains complicates the threshing and peeling of the grain during processing.

For a very long time, spelta was almost forgotten, mainly due to its low yield and processing difficulties. By the middle of the twentieth century, small areas of spelta remained only in Bashkiria, Chuvashia and some areas of the North Caucasus. Interest in it was revived in connection with the emergence of the trend of functional nutrition. Abroad, spelta is also gaining popularity as a dietary product of healthy nutrition. Biskup *et al*. (2017) note that ancient cereals such as spelta are becoming more and more in demand in Europe. Rapp also attests to the growing attention to this culture from consumers, farmers, millers and bakers (Rapp *et al*., 2017).

Speltais an excellent raw material for obtaining high-quality flour but in terms of baking qualities this grain crop is much inferior to wheat. However, spelta unlike wheat, completely retains its nutritional value when making flour from it (Biskup *et al*., 2017). The prote in

Corresponding Author: S.A. Leonova, Bashkir State Agrarian University, 50-Let Oktyabrya 34, 450001 Ufa, Russia

content in the baking flour is up to 30% more than in normal wheat. Also, speltahas a higher content of iron, protein and B vitamins than ordinary wheat.

Gluten-free grains do not cause allergies and indigestion, so, it can be recommended to patients suffering from celiac disease. Due to the low content of gluten, people with gluten allergies can include bread and cereal from speltain their diet. Slovak scientists argue that in alternative medicine, speltais used in the diet of people suffering from neurodermatitis and other allergic diseases. According to recent studies such components of speltaas phytic acid and alkylresorcinols, help maintain blood glucose levels at an acceptable level. At the same time, the researchers give a clear preference to whole grain products (Biskup *et al*., 2017).

Spelta due to the slow absorption of carbohydrates, reduces the feeling of hunger and helps to cope with excess weight. Spelta flour is characterized by low water absorption capacity and a high ratio of the elasticity of the test to extensibility. By "Strength" it refers to the weak. By its technological properties, it comes close to flour made from hard wheat and in quality it exceeds wheat flour. Therefore, spelta flour is a valuable food raw material for use in food industry, public catering and trade for the production of flour composite mixtures, bakery, confectionery and pasta. Crucial for evaluating the quality of grain as a raw material for flour and cereals industry is its technological, flour, cereal and baking properties.

At the present time, the following sorts of spelta are selected by breeders of Russia: Runo (glumal), Alkoran (glumal), Gremme (hulless). Alkoran and Runo are cultivated in the Southern Regions of Russia and Gremme variety in the Middle Volga Region with a more severe climate. Domestic breeders continue to select spelta and create varieties adapted to different climatic conditions. Recent studies have shown that the quality of spelta more than other crops is variable under the influence of external conditions (Kohajdova and Karovieova, 2008; Iunikhina, 2015; Biel *et al*., 2016).

It should be noted that, despite a significant amount of research on the properties of spelta and products based on it, most of them refer to speltaas cereal raw materials. One research is known which describes the effect of the addition of flour from speltaon the properties of corn extrudates (Biel *et al*., 2016). Significantly less studied are the technological properties of spelta as raw materials for obtaining bakery and confectionery products. As Vivart notes with co-authors, the baking properties of spelta in particular the rheological properties of the test have not been practically studied (Wiwart *et al*., 2017). The work in this direction is carried out by Czech researchers who analyzed 11 samples of flour from spelta and its mixtures with wheat flour on a Mixolab instrument and noted the good rheological properties of all samples. There is little information on the use of spelta in confectionery products-the sources we found belong to the field of home cooking or restaurant business but there have been no serious scientific studies on this subject with the exception of a number of works on cookie technology (Kyptova *et al*., 2017).

Obviously, there are not enough results related to specific varieties and climatic zones of the growth of crop; Methods and parameters of hydrothermal processing of grain before grinding are not specified.

That is why the purpose of this study was to study the technological properties of Russian varieties and breeding lines of spelta, the regimes for processing them into flour and cereal flakes and to optimize the dosage of spelta flour in the bread and biscuit formulations.

MATERIALS AND METHODS

The research was carried out in the analytical Laboratory of the Chishminsky selection center for plant growing of the Bashkir Scientific Research Institute of Agriculture in the laboratories of the Department of Technology of Catering and Processing of Plant Raw Material of the Bashkir State Agrarian University and in the Laboratory of Quality of the All-Russian Grain Research Institute.

The material for research was three varieties of spelta, grown in the LLC "Black Bread" of the Tula Region in 2014 as well as 12 lines of the spelta in the collection of the All-Russia Institute of Plant Industry named after Vavilov who underwent an ecological test at the Chishminsky Selection Center, the harvest of 2015-2016.

Sampling and allocation of samples were carried out in accordance with State Standard 13586.3-83; The moisture content of the grain was determined in accordance with State Standard 13586.5-93; Grain unit according to State Standard P 54895-2012; Weight of 1,000 grains according to State Standard 10842-89; Grain glaasiness according to State Standard 10987-76; Ash content according to GOST R 51411-99; Quantity and quality of gluten according to State Standard P 54478-2011; Falling number in accordance with State Standard 27676-88 on the device PchP-99; Protein content-by Kjeldahl method-according to State Standard 10846-91; Hull content according to state standard 10843-76. The length of the seeds was determined by a caliper in 50 replicates and the width and thickness according to the results of the sieve analysis. Hardness

was determined by the granulometric method according to the methods of the All-Russian Scientific Research Institute of Grain and products of its processing.

RESULTS AND DISCUSSION

According to organoleptic indicators, the grain of all varieties and breeding lines corresponded to State Standard 10967-90 methods for determining smell and color. The color is amber-yellow, the smell is not musty, not moldy, characteristic of a normal grain. The taste is characteristic of the grain with no off-tastes. The moisture content of the grain was in the range of 7.8-8.9%.

At the initial stage, some technical characteristics of the speltavarieties were investigated: Runo, Alkoran and Gremme, compared with the generalized characteristic of soft wheat and wheat of Vatan variety. The first two varieties of spelta were glumal, the latter-hulless (Fig. 1). Technical characteristics in comparison with wheat are given in Table 1.

The comparison of the properties of spelta was carried out with generalized data on the quality of wheat obtained in the All-Russian Research Institute of Grain and Products of its Processing as well as with wheat of the variety Vatan, approved for use in the Republic of Bashkortostan.

The high hull content of speltais noted, at the level of 25-31%. According to linear dimensions, the hulless spelta is noticeably smaller than the peeled glumalvarieties. Alkoran (spelta) is the largest but its polygon is the most extended polygon, i.e., it is the least leveled. Gremme's hulless variety is clearly smaller but it is more leveled in comparison with the glumal varieties Runo and Alkoran. The grain unit of the glumal varieties in the collapsed form is slightly lower than that of the hulless. By mass of 1,000 grains and size, the glumal varietyAlkoran is allocated. This variety is distinguished by its high hardness, 84% while the grain glassiness of the Runo variety is only 51% and the hulless Gremme is 74%. The protein content in the Alkoran variety was 1.5 times higher than in the other two varieties and was 18% which is also significantly higher than the corresponding indicator for wheat.

Further studies of the properties of the spelta were continued on the breeding lines while the study involved only hulless samples as more technological for subsequent processing.

Table 2 presents the physico-mechanical characteristics of the breeding lines which predetermine the grain's milling properties. A particularly important characteristic is hardness. Of all the indicators to be determined, hardness alone is a genetically determined feature that reflects the structural and mechanical propertie (Leonova, 2013).

Analyzing the data presented in Table 2, one can conclude that the selection samples of the spelta also possessed a sufficiently high mass of 1,000 grains: from 55.8-61 G in grain unit (754-770) G/L. According to the hardness index, the grain of spelta refers to soft hard-grained wheat of the 2nd class (medium-hard). There is evidence that due to the high mass of 1,000 grains, spelta is used as a donor in the process for improving the harvesting properties of wheat (Xie *et al*., 2015).

Fig.1: Appearance of the grain of the variety (from left to right): spelta Runo, spelta Alkoran, hulless spelta Gremme

Table 1: Technical characteristics of spelta in comparison with wheat

	Spelta variety				
Quality indicators	Runo (glumal)	Alkoran (glumal)	Gremme (hulless)	Wheat (generalized data)	Wheat vatan
Linear dimensions (mm)					
Length	7.4	7.8	6.5	4.8-8.0	6.3
Width	3.1	3.3	3.0	1.6-4.0	2.1
Thickness	2.8	3.0	2.8	1.5-3.3	2.2
Weight 1,000 grains (g)	37.1	52.6	37.6	20-40	36.0
Grain unit, g/L (grain)	510	443	804	740	765
Kernel	750	795	804	740	765
Hull content (%)	24.8	31.0	0	0	0
Grain glassiness (%)	51	84	74	60	51
Proteincontent (%)	13.0	18.2	12.1	12.0	12.6

Table 2: Physical and mechanical properties of spelta grain

Breeding lines (No.)	Weight of 1000 grains (g)	Grain unit (g/L)	Grain glassiness (%)	Hardness(%)
1	59.5	755	44	21.00
2	61.0	760	61	18.00
5	60.3	757	45	19.50
9	58.9	759	46	20.00
10	60.5	767	47	18.50
14	55.8	757	43	20.50
17	56.7	758	43	20.50
18	57.2	754	40	19.50
39	58.0	755	40	18.00
101	58.5	759	44	19.50
102	59.0	770	45	18.10
111	56.6	755	46	20.05

The basic norm of the indicator of the grain unit for wheat in the Republic of Bashkortostan, according to State Standard 54895-2012 is 750 g/L. From Table 2, it can be seen that most of the breeding lines studied had a higher than average grain unit. The higher the grain unit, i.e., the bulk weight of the grain, the greater is its mass per unit volume and therefore, it contains more useful substances. Other things being equal, a higher yield of flour is obtained from high-grain grains, so, the grain unit can serve as one of the approximate indicators of flour-grinding grain evaluation.

According to the literature data, the mass of 1,000 grains positively correlates with size, hardness, grain density, so, it affects its milling properties. The higher the mass of 1,000 grains, the higher the yield of flour.

It can be seen from the data obtained that the highest grain glassiness is observed in lines 2, 10 and 102. The best is line No. 2, the remaining samples have a slightly lower index but also belong to the high-glassy ones. Glassy grain gives a greater yield of flour than mealy, therefore, hardness has a direct relationship with the grain-milling properties of grain and is one of the main indicators of the selection of the regime of hydrothermal processing in preparation for grinding. When grinding glassy grains it is easier to extract endosperm and the resulting flour has increased consumer properties.

Hardness like grain glassiness is an indicator of the physico-mechanical properties of the grain and consequently, the milling properties directly depend on it. The value of hardness is that this property is a variety and is inherited genetically. Earlier we created a mathematical model for assessing grain quality in the selection process (Leonova, 2013), described by the regression equation:

$$Y = 0.130X_1 - 0.387X_2 \quad (1)$$

Where:

Y = The yield of flour
X_1 = The mass of 1000 grains
X_2 = Hardness

The maximum permissible value of hardness which is 18.5% is also justified. This value of hardness, provided that the grain glassiness is not lower than 40%, the mass of 1,000 grains is not lower than 38 g and the grain unitis not <750 g/L will provide a yield of flour of standard quality at the level of 70%. All breeding lines corresponded to the specified requirements for grain glassiness, grain unit and mass of 1,000 grains at the same time only four samples had hardness below 18.5%-lines Nos. 2, 10, 39, 102.

All of the above indicators primarily determine the yield of flour and only ash determines its quality. Basic conditions for grain of wheat entering into processing, according to the ash index on absolutely dry matter are 1.97%. Increased ash content in grain deteriorates the quality of finished products. Basic conditionsfor speltahave not been developed, however, it is known that it has a higher ash content. This is confirmed by our data as well-the ash content in the samples of speltavaries from 2.05-2.78% while the lines No. 2, 10 and 102 which we have identified have lower values of 2.05, 2.06 and 2.09%, respectively. Line No. 39 has a high ash content which gives grounds to exclude it from further research, as the ash content of the resulting flour during its processing will also be high.

To obtain high-quality and well-assimilated food products, a complex of biochemical properties of grain plays a crucial role: the content of basic nutrients, microelements, vitamins and the activity of enzymes that break down high molecular weight biopolymers of grain to simpler substances. Table 3 and 4 show the results of the determination of the chemical composition and biochemical properties of the studied breeding lines.

Very high indices of the mass fraction of gluten (35.9-39.5%) and protein (13.57-16.85%), significantly exceeding the usual values for wheat were noted. At the same time, the quality of gluten of most samples corresponds only to group 3 which is unacceptable for batches intended for processing into baking flour. The lines chosen by us from the set of physical and mechanical properties, like a number of others had 2, a satisfactory weak, quality group of gluten.

It should be noted that most of the lines studied had higher than average enzyme activity, indicating that the baking properties were low that is it can only be used in breadmaking with wheat flour. The optimum falling number for wheat is in the range from 200-300 sec. The greatest number of studied breeding lines did not enter this interval. The maximum falling number, i.e., the minimum enzymatic activity was noted in the lines under the numbers: 2 (192 sec), 10 (180 sec), 14 (192 sec), 102 (171 sec), 111 (189 sec). The smallest falling number, i.e.,

Table 3: Indicators of the protein-proteinase and carbohydrate-amylase complex of the grain of spelta in the harvest of 2015-2016

Breeding lines, No.	Gluten: Quantity (%) 2015	Gluten: Quantity (%) 2016	Gluten: Quality group 2015	Gluten: Quality group 2016	Mass fraction of protein (%) 2015	Mass fraction of protein (%) 2016	Mass fraction starch (%) 2015	Mass fraction starch (%) 2016	No. of falls (sec) 2015	No. of falls (sec) 2016
1	42.1	37.2	2 satisfactory weak	3 unsatisfactory weak	13.57	14.68	67.87	66.90	127	132
2	41.2	39.0	2 satisfactory weak	2 satisfactory weak	13.55	16.85	69.47	68.57	162	192
5	40.8	38.0	3 unsatisfactory weak	2 satisfactory weak	14.62	13.57	69.19	68.16	127	126
9	40.1	35.9	2 satisfactory weak	3 unsatisfactory weak	13.19	14.89	68.35	66.16	62	107
10	40.1	39.2	3 unsatisfactory weak	2 satisfactory weak	14.69	16.92	67.99	65.80	130	180
14	42.3	36.2	3 unsatisfactory weak	2 satisfactory weak	14.83	15.56	67.96	64.86	96	192
17	44.9	37.4	2 satisfactory weak	3 unsatisfactory weak	15.48	14.76	65.41	63.71	62	115
18	43.8	36.5	2 satisfactory weak	3 unsatisfactory weak	13.46	14.79	69.43	67.52	66	138
39	40.1	38.6	3 unsatisfactory weak	2 satisfactory weak	13.67	15.05	69.55	68.76	120	145
101	43.8	36.8	2 satisfactory weak	2 satisfactory weak	15.17	15.57	67.94	66.84	62	119
102	44.5	39.5	3 unsatisfactory weak	2 satisfactory weak	14.57	16.83	67.55	66.73	162	171
111	41.5	37.0	2 satisfactory weak	2 satisfactory weak	14.00	15.71	68.55	66.85	302	189
Vatan wheat	26.4	23.8	2 satisfactory weak	2 satisfactory weak	12.47	12.66	66.94	67.15	258	272

Table 4: Content of some chemical substances in the grain of the breeding lines of spelta

Breeding lines (No.)	Mass fraction of sugar (%)	Fraction of total cellulose (%)	Mass fraction of fat (%)	Massfraction mass of of ash (%)
1	3.57	264.00	2.98	2.52
2	3.16	2.62	2.52	2.05
5	4.98	2.61	2.75	2.35
9	4.42	2.25	3.00	2.40
10	4.43	2.51	3.05	2.06
14	4.84	2.83	3.22	2.78
17	4.33	3.69	3.19	2.15
18	3.15	3.42	2.42	2.22
39	4.00	2.81	2.45	2.72
101	3.78	3.62	2.53	2.38
102	3.64	4.81	2.56	2.10
111	4.30	3.44	2.52	2.45
Vatan wheat	3.31	1.53	1.44	1.99

increased enzymatic activity was noted in the lines under the numbers: 1 (132 sec), 5 (126 sec), 9 (107 sec), 17 (115 sec), 18 (138 sec), 101 (119 sec).

Thus, lines Nos. 2, 10 and 102 for a combination of the quantity and quality of gluten, the protein content and the falling number are able to provide bread of standard quality without the addition of wheat flour and improvers. The mass fraction of starch in all samples indicates a high content of endosperm which in turn is an indirect sign of a potentially high yield of flour.

The content of sugar, fiber and fat in spelta samples of the 2016 was also studied (Table 3). For comparison, similar indicators were determined in the grain of soft wheat of Vatan variety (Table 4).

According to our data an increased content of total sugar (3.15-4.98%) is noted in the grain of spaelta which exceeds the average values for wheat by more than 2 times. Together with the high activity of alpha-amylase described by us, sugar will provide favorable conditions for yeast nutrition and as a result, produce high-quality bread andbakery, keeping them fresh and increasing shelf life.

The mass fraction of cellulose is also quite high which is understandable, since, this index correlates well with ash content. In terms of product functionality, high fiber content is not a drawback, since, fiber is a dietary fiber that according to the theory of adequate nutrition, must be present in food without fail. The mass fraction of fat is also slightly higher than in wheat.

The results obtained are in many ways consistent with the latest data of domestic and foreign researchers. Thus, in the research of the scientists of the Athenian National Technical University it was noted that in spite of the fact that flour from speltahas a higher protein content, it has some properties of the main fractions of wheat protein (Frakolaki *et al.*, 2018).

There is also an earlier work by Czech researchers who studied 10 varieties of spelta in comparison with soft wheat and found statistically significant differences in protein content -0.5% higher than wheat as well as fiber content-an average of 0.35% higher (Moudry and Dvoracek, 1999).

French scientistsalso found that the spelta differs from wheat by a higher protein content (15.6% versus 14.9% in wheat), increased fat content (2.5 and 2.1%, respectively). There were no significant differences in the content of starch and sugar (Escarnot *et al.*, 2012).

Thus, the results obtained clearly demonstrate the essential differences between spelta and wheat. The grain of the studied breeding lines is large, high-grain unit but has an increased ash content. Hardness and grain glass in essare at an average level. Spelta is very high in protein and gluten but the quality of the latter is very low. Only a few samples were assigned to group 2 of quality, the rest-to group 3. The activity of alpha-amylase is quite high; The content of sugars is twice as high as that of wheat.

According to the set of indicators of structural, mechanical and biochemical properties, three breeding

lines of spelta were selected which are recommended for further study with the goal of creating baking variety.

Further, using the example of the lines identified by us, studies were carried out that made it possible to develop parameters for preparing spelta grains for grinding, taking into account its quality.

In milling production, the variable parameters of the hydrothermal processing are the moisture content of the grain before its way to Ibreak system, the temperature and duration of the binning. Hydrothermal processing is a complex multifactorial problem, the solution of which is some what simplified when the grain is cold-conditioned-in this case, only the moisture content of the grain and the duration of the process are of primary importance.

It is known that the zone of technological optimums for wheat is the moisture content in the range of 14.5, ..., 16% which corresponds to the second critical region of the water sorption isothermal grain: it is in this range of moisture that essential transformations of all grain properties occur and the loosening of the endosperm is intensively developed.

For spelta, the zone of technological optimums has not been established, therefore, before carrying out the basic studies, it was necessary to determine the parameters of the hydrothermal processing which to the greatest extent ensure the yield and high quality of spelta flour.

Laboratory grinding of the grain of the breeding lines No. 2, 10, 102 at the МЛп-4 mill with cold conditioning was carried out. The time of binning was varied -3; 6; 9; 12; 15 h and the grain moisture before grinding in the range of 13.0-16.5% in 0.5% increments.

The obtained results on the effect of the hydrothermal processing parameters on yield and quality of flour are shown in Fig. 2 and 3, respectively. Based on the data obtained by us, the optimal time for 12 h of binning was chosen which ensures the maximum yield of flour.

Based on the obtained data, the optimum time of 12 h of binningis established which ensures the maximum yield of flour, at a moisture content of grain directed to I.D., 14.0%. After the optimal parameters of Hydrothermal Processing (HTP) for the cold conditioning were established, grinding of the grain of spelta was carried out and then the quality of the received spelta flour was evaluated.

The flour was analyzed according to the following parameters: grind size, color, quantity and quality of gluten, falling number, acidity and ash content of flour (Table 5).

Table 5: Parameters of quality of spelta flour obtained with optimized parameters of hydrothermal processing

Parameters	Meaning
Fineness of grinding (%) residue on silk screen No. 27	1.5
Color, standard units	26.7
Moisture (%)	14
Mass fraction of gluten (%)	35.7
Quality of gluten, units IDK, group	67/ I
Falling number (sec)	187
Acidity (°)	5.5
Ash content (%)	0.74

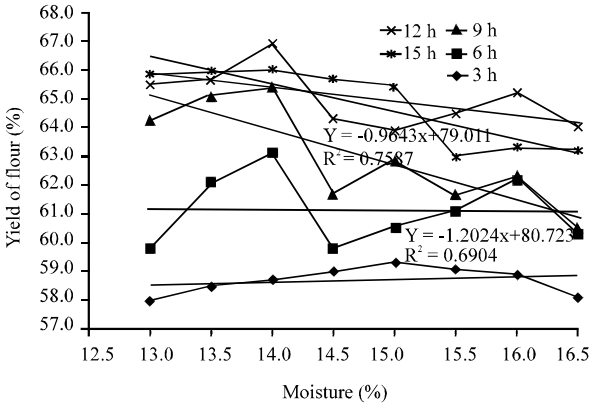

Fig. 2: The yield of spelta flour, depending on the time of binning and the moisture content of the grain of spelta, directed to Edr

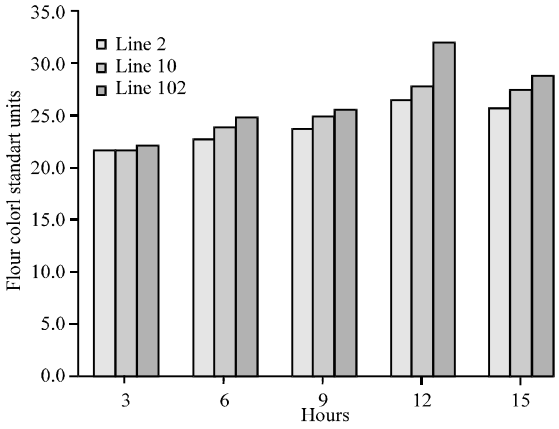

Fig. 3: Influence of the time of binning on the flour color in laboratory grinding

It can be seen from the results of researches that parameters of quality of flour basically corresponded to requirements of the standard for wheat flour of 1 grade.

Further research was devoted to the development of recipes and technologies for obtaining food products from spelta flour. The task was to optimize the bread recipe from a mixture of wheat flour and spelta flour.

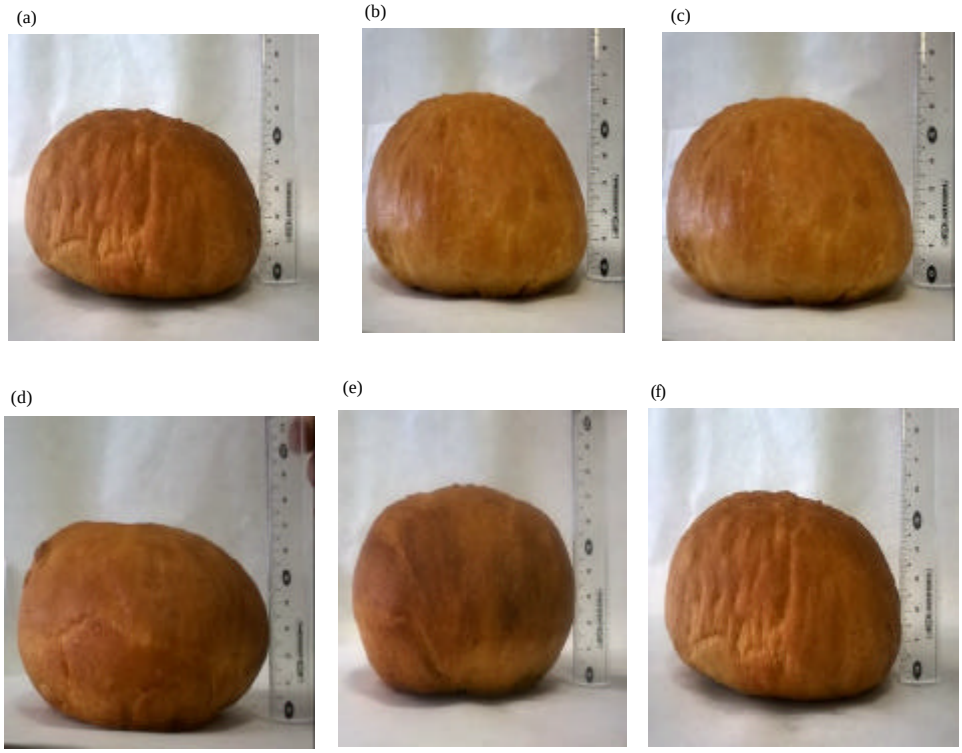

Fig. 4: Appearance of hearth bread from a mixture of wheat and spelta flour: a) control -100% wheat flour; b) 20% spelta flour; c) 40% spelta flour; d) 60% spelta flour; e) 80% spelta flour and f) 100% spelta flour

Table 6: Organoleptic evaluation of bread samples

	Dosage of spelta flour (%)					
Parameters	Control	20 (%)	40 (%)	60 (%)	80 (%)	100 (%)
Shape			Round not vague without press			
Surface			Without major cracks and explosions			
Color	Lightbrown	Golden			Lightbrown	
Crumb condition:	Baked not sticky not wet to the touch, elastic				Baked has a slight stickiness	
Baking thoroughly						
Porosity	Developed, slightly compacted				Developed not compacted	Developed, a bitdense
Kneading		Without lumps and traces of impurities				

Table 7: Physico-chemical parameters of bread samples

	Adding of spelta flour (%)					
Parameters	Control	20	40	60	80	100
Acidity (°)	2.8	2.7	2.8	2.6	2.6	2.8
Porosity (%)	73.6	73.2	72.1	70.6	68.3	67.2
Keeping shape	0.36	0.38	0.38	0.37	0.36	0.36
Volume yield of bread (cm^3)	310	312	310	307	305	302
Moisture of crumb (%)	42.6	43.1	42.7	43.1	42.7	42.2

Hearth bread samples were baked with a ratio of 100: 0-0: 100 of wheat flour and spelta flour in the recipe. Appearance of bread samples is shown in Fig. 4.

The results of the organoleptic and physico-chemical evaluation of bread samples are presented in Table 6 and 7.

Adding spelta flour in quantities of 40% or more reduces the volume yield and porosity of the bread. This agrees with the results reported in research (Frakolaki *et al*., 2018). The researchers of the cited work note that bread samples baked using spelta flour showed a decrease in volume, increased crumb density and less attractive external characteristics compared to samples of bread made from wheat flour. The samples were with a darker crust and crumb color due to a higher content of fibers and boltings. At the same time, the researchers note a more developed and pleasant taste and smell of bread with the addition of spelta flour.

In our study, the moisture content of the crumb of the samples under study varies in the range from 42.2-43.1%, all samples correspond to State Standard 27842-88 "Bread

from wheat flour. Technical specifications", the acidity of the crumb of the samples under study varies in the range from 2.6-2.8° which is not significant. Thus, on the basis of a combination of a complex of consumer properties of bread and its biological value which is increased due to the partial replacement of wheat flour with spelta flour, the optimum dosage of spelta flour in the recipe was 40%.

The further experiment was devoted to the possibility of using spelta flour in the biscuit recipe. Biscuit products are known to be extremely demanding in cooking and with the slightest deviations in the recipe and technology they fall off, losing their lush fine-pored structure. At the same time, for flour confectionery products it is important to increase their phytochemical potential, since, they are characterized by a high content of so-called fast carbohydrates.

When optimizing the dosage of spelta flour in the biscuit semi-finished product recipe, a standard recipe was used. Were made products with the addition of spelta flour in an amount of: 3, 6, 9, 12 and 15% to the weight of flour and a control sample without adding spelta flour.

At the initial stage of the study, a tasting evaluation of the manufactured products with various dosages of spelta flour and a control sample (without adding spelta flour) was conducted to identify consumer preferences. As a result of the tasting assessment, it was found that a 9% dosing of spelta flour is optimal and does not reduce the quality of the product being developed. With the subsequent increase in the dosage of spelta flour, the organoleptic characteristics of the biscuit semi-finished product decrease. This is accompanied by a decrease in moisture. In the control sample, the moisture is 27.2% while as the dosage of spelta flour increases, the moisture decreases.

It was determined the amount of vitamins in baking flour and in products with the addition of grape flour at the optimal dosage (9%) and in the control sample without adding ground flour.

It has been established that spelta flour contains vitamin C in the amount of 3.08 mg/g; β-carotene-0.93 mg/g. In the biscuit semi-finished product without the addition of spelta flour, the amount of vitamin C was 0.44 mg/g; β-carotene-0.03 mg/g. In the biscuit semi-finished product with the addition of spelta flour at the optimal dosage, the amount of vitamin C is 1.32 mg/g; β-carotene 0.41 mg/g. Therefore, spelta flour will help to fill the balance of vitamins in the developed products.

The products described above were obtained on the basis of spelta flour. The modern point of view on products of a healthy food assumes introduction in a

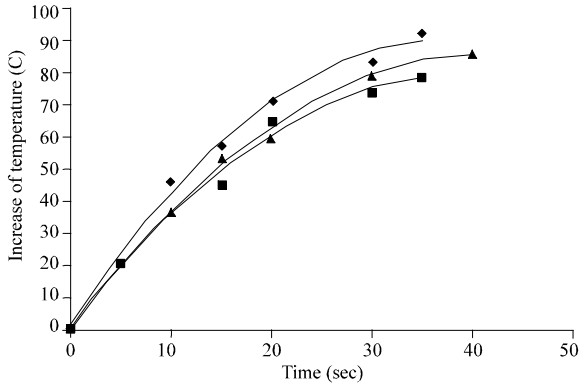

Fig. 5: Increase in the temperature of the spelta grain with the moisture content W_0 = 18% when heated in different modes: 1-E = 23 kW/m^2, Tc = 303°C; 2-E = 11 kW/m^2, Tc = 270°C; 3-E = 0 kW/m^2, Tc = 212°C

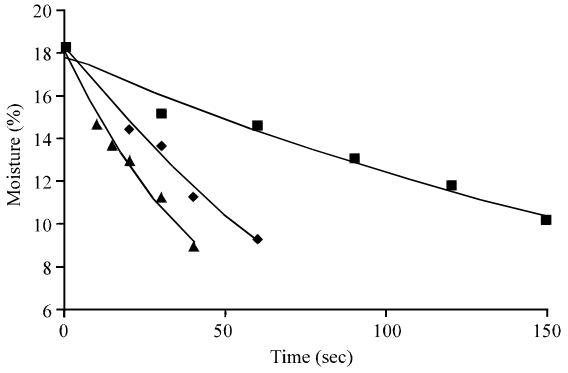

Fig. 6: Change in moisture content of the spelta grains with the initial moisture content W_0 = 18% when heated in different modes: 1-E = 23 kW/m^2, T_{fi} = 303°C; 2-E = 11 kW/m^2, Tc = 270°C; 3 - E = 0 kW/m^2, Tc = 212°C

ration also products on the basis of whole grain. Proceeding from these positions, the All-Russian Research Institute of Grain and Products of its Processing carried out research on the production of cereal flakes from spelta grain with preliminary processing in high-temperature micronization devices. The studies were carried out using the grain of the Runo variety. The grain was moistened, binned, heated and subjected to bruising.

The influence of the regimes of heating of spelta grain with a moisture content of 18% on the rate of increase in the grain temperature was investigated Fig. 5 (Zverev *et al*., 2016).

The heating of the cereal is accompanied by moisture loss, the degree of which depends on the initial moisture of the product, the regimes and the heating time. Figure 6

Fig. 7: Appearance of the glumal spelta of the Runo variety and products from it: 1) Initial speltagrain; 2) Peeled grain and 3) Flakes

shows the dependence of moisture on heating time at a grain moisture of 18.4% and different heat processing regimes (Zverev *et al*., 2016).

Using the method of high-temperature micronization,it was possible to reduce the cooking time of flakes by an average of 28-30%. The following processing modes are recommended: the heating temperature is up to 90-100°C with initial grain moisture W_0 = 19-22%. Appearance of the flakes obtained is shown in Fig. 7.

CONCLUSION

The complex researches carried out by us made it possible to establish significant differences in the properties of spelta compared to wheat and to develop technological methods for its processing into food products.

Both varieties and breeding lines are better than wheat in a number of respects. Almost all the samples studied are characterized by high grain unit, mass of 1,000 grains while the grain glassiness and hardness values are at an average level. Very high values of the mass fraction of gluten (35.9-39.5%) and protein (13.57-16.85%), significantly exceeding the usual values for wheat were noted but the quality of gluten of the majority of samples corresponds only to 3, unsatisfactory weak group, therefore, three breeding lines are selected, the best in terms of the total technological properties and at the same time having gluten of the 2 quality group. Most of the samples studied showed low faling number which makes it possible to use the flour from it in breadmaking only in combination with wheat flour.

An increased content of protein (13.55-16.83%), total sugar (3.15-4.98%) and fat (2.42-3.19%) in the spelta grain were found which correlates with the latest data from domestic and foreign researches.

The parameters of the hydrothermal processing of the spelta grain during its preparation for grinding are optimized, ensuring the yield of flour of 67.2% at a quality corresponding to the requirements for wheat flour of grade 1.

A high content of vitamin C (3.08 mg/g) and β-carotene (0.93 mg/g) was found in spelta flour which gives additional reasons for its mass use in healthy foods.The optimum dosage of spelta flour added in the recipes of bread and biscuit was established which without compromising the basic characteristics of the products, provides an increase in fiber, vitamin C and β-carotene. The parameters for obtaining cereal flakes from whole grains were developed using the high-temperature micronization method.

REFERENCES

Biel, W., S. Stankowski, A. Jaroszewska, S. Pu¿ynski and P. Bosko, 2016. The influence of selected agronomic factors on the chemical composition of spelt wheat (*Triticum aestivum* ssp. spelta L.) grain. J. Integr. Agric., 15: 1763-1769.

Biskup, I., M. Gajcy and I. Fecka, 2017. The potential role of selected bioactive compounds from spelt and common wheat in glycemic control. Adv. Clin. Exp. Med. Off. Organ Wroclaw Med. Univ., 26: 1013-1019.

Escarnot, E., J.M. Jacquemin, R. Agneessens and M. Paquot, 2012. Comparative study of the content and profiles of macronutrients in spelt and wheat, a review. Biotechnol. Agron. Soc. Environ., 16: 243-256.

Frakolaki, G., V. Giannou, E. Topakas and C. Tzia, 2018. Chemical characterization and breadmaking potential of spelt versus wheat flour. J. Cereal Sci., 79: 50-56.

Iunikhina, E.V., 2015. Improving bakery technologies for healthy diet based on non-traditional raw materials. Master Thesis, Moscow State University, Ioscow, Russia.

Kohajdova, Z. and J. Karovicova, 2008. Nutritional value and baking applications of spelt wheat. Acta Scientiarum Polonorum Technol. Aliment., 7: 5-14.

Kyptova, I., Đ. Konvalina and O.D. Khoa, 2017. Technological and sensory quality of grain and baking products from spelt wheat. Agric. Sci., 2: 46-55.

Leonova, S.A., 2013. Wheat Properties as Raw Material for Food Production. LAP LAMBERT Academic Publishing, Saarbruken, Germany,.

Moudry, J. and V. Dvoracek, 1999. Chemical composition of grain of different spelt (*Triticum spelta*) varieties. Rostlinna Vyroba, 45: 533-538.

Rapp, M., H. Beck, H. Gutler, W. Heilig and N. Starck *et al*., 2017. Spelt: Agronomy, quality and flavor of its breads from 30 varieties tested across multiple environments. Crop Sci., 57: 739-747.

Wiwart, M., A. Szafranska, U. Wachowska and E. Suchowilska, 2017. Quality parameters and rheological dough properties of 15 spelt (*Triticum spelta* L.) varieties cultivated today. Cereal Chem., 94: 1037-1044.

Xie, Q., S. Mayes and D.L. Sparkes, 2015. Spelt as a genetic resource for yield component improvement in bread wheat. Crop Sci., 55: 2753-2765.

Zverev, S.V., O.V. Politukha and P.S. Abramov, 2016. High temperature micronization in production of speltagrain products. Bakery, 11: 48-50.