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Research Article

**EVALUATION OF NAKED EINCORN GRAIN AND FLOUR
TECHNOLOGICAL PROPERTIES**Elena V. Savelyeva¹, Elena E. Zinurova¹, Oksana V. Starovoitova², Olga A. Reshetnik²¹Kazan Federal University, Kremlyovskaya str.420008, Kazan, Russian Federation

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²Kazan National Research Technological University, K Marx str., 68, 420015,
Kazan, Russian Federation**Abstract:**

The article described the kind of wheat *Triticum dicoccum* Schrank - emmer wheat eincorn (*spelta*), belonging to the group of filmy species, and naked grain eincorn obtained from the *Triticum dicoccum* sv. *nadum*, the grain of which is easily removed from an ear, and the plants are characterized by high agronomic traits. They studied the parameters characterizing the morpho-biochemical properties of eincorn grain cultivated in the Republic of Tatarstan: grain size, grain volume, surface area, the weight of 1000 grains, grain nature, grain and flour moisture, specific volume and ash content. The studies have been carried out to identify the characteristics of eincorn and wheat grain starch by comparing the microstructure of crop grains. They determined the presence of starch granules in the grains of eincorn and wheat. These were the granules of two fractions: small and large. The connection between the starch grains and the protein matrix in the naked eincorn is greater in comparison with wheat. It was determined that the content of raw gluten in flour made of naked eincorn is rather large, and its quality is characterized as satisfactorily weak; the data of the autolytic activity of wheat, eincorn flour and the measurement of the number of falls is correlated well with each other; the greatest activity of α -amylases was observed in flour made from the grain of eincorn Runo, the smallest was found in naked eincorn.

The article revealed the regularities of protein-proteinase and carbohydrate-amylase flour complex changes made from the grain of naked eincorn, and the rheological characteristics of the dough were evaluated. The structural and mechanical properties of the dough make it possible to establish that the flour from naked eincorn reduces the dough elasticity and plasticity, while the dough has a low viscosity and high extensibility, which is a necessary condition for the production of bakery, for example, cookies.

The morpho-biochemical properties of grain, protein-proteinase and carbohydrate-amylase complexes presented in the article allow us to substantiate the possibility of flour use from naked eincorn grown in the Republic of Tatarstan during the manufacture of flour products.

Keywords: eincorn grain, naked eincorn, morpho-biochemical properties of grain, protein-proteinase and carbohydrate-amylase complexes of flour, rheological characteristics.

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1. INTRODUCTION:

The creation of healthy food at the modern level with the use of cereals is relevant, taking into account the requirements for chemical composition and biological value. The search and the expansion of the nomenclature among new types of raw materials with a rich chemical composition, the structural components of which will help not only to intensify processes, to save raw materials, but also to increase the nutritional and the biological value of finished products. The use of natural raw materials of vegetable origin during the production of food products allows to improve quality and nutritional value, to expand the range of products, and also use local raw materials rationally.

In this regard, this paper described a poorly used wheat type *Triticum dicoccum* Schrank for the preparation of flour products. It's is emmer wheat eincorn (*spelta*) belonging to the group of filmy species. This type of wheat, once widespread and used for nutrition in the southeast of Russia, is currently cultivated only in some areas of Dagestan, Bashkortostan and it is actively cultivated in Tatarstan recently. Eincorn became popular in India and Italy and was called "the black caviar of cereals".

It is known that eincorn is characterized by its early maturity, unpretentiousness to the conditions of growth, the resistance to frost, drought and disease and by a sufficiently high protein content [1,2]. Eincorn is resistant to environmental contamination and radioactivity, since the grain is densely covered with several layers (chaff). However, the main eincorn drawback in terms of technology is the grain filminess, which is not threshed from the hard scales.

In connection with the mentioned above, it is interesting to study the morpho-biochemical and technological properties of grain and flour from eincorn as an unconventional raw material for the preparation of flour products.

2. STUDY OBJECTS AND METHODS:

Table 1: Characteristics of eincorn and wheat grains

Indicators	Eincorn (Baltasy area)	Runo eincorn	Wheat (the harvest of 2017)
Grain volume, mm ³	25±2	28±4	30±2
Surface area, mm ²	50±2	52±2	58±2
Vitreosity, %	71±3	83±5	52±3
The weight of 1000 grains, g	25-28	32-39	34-38
Nature, g/l	690-715	734-742	777-779
Grain moisture, %	8,0-8,4	9,2-9,4	10,4-10,6
Contents of embryo with a shield, %	3,7-3,9	3,8-4,2	2,6
Endosperm content, %	83-85	86-88	82-84
Ash content of grain, %	2,3	2,5	1,8

The grains of eincorn and wheat were evaluated according to the following indices: moisture content was determined by drying the sample to a constant weight; ash content was determined by ashing via the sample burning in a muffle furnace. The grain vitrification was determined by the transverse cleavages of grains, determining the percentage of vitreous grains from the total number. The grain microstructure was examined using the scanning electron microscope JSM-35C (Jeol, Japan).

Laboratory grinding was carried out via AV-MLP-4 mill. In the flour samples used for the experiments they determined gluten content (washing by hand method), the elastic properties of gluten via IDK instrument, the rheological properties of the flour (elastic and general deformation of dough, the the dough deformation work, elasticity) were evaluated using the alveograph "Chopin" (France), the number of falls on the device (IHP-1-2) and autolytic activity. The moisture content of the flour, the amount of raw gluten, ash content, fiber and fat content were determined by infrared spectroscopy using the "Spectrant-IT" device MO 001-SP-2003. The researches were carried out in the laboratories of Food Production Technology Department at FSBEI HE "Kazan National Research Technological University" and in the Testing Laboratory establishing the safety and the quality of products in Kazan: FSBU "Grain Quality Evaluation Center".

3. RESULTS:

At the initial stage of the work they studied the parameters characterizing the morpho-biochemical properties of eincorn grains: grain size, grain volume, surface area, the weight of 1000 grains, grain nature, grain and flour moisture, specific volume and ash content.

We studied the eincorn grain in Tatarstan (Baltasinsky district), Runo eincorn and wheat (the harvest of 2017). The results of the studies are presented in Table 1.

All determined indicators that characterize the grain are interrelated, are important for wheat and eincorn quality evaluation, determine the technological and physico-chemical properties of grain in the future and, consequently, the possibility of these crops use in the milling industry and for the production of flour products.

The eincorn grain has a longitudinal well-defined groove. The surface of the grain is somewhat rough. The grain is elongated and pointed at the ends (unlike wheat grain). The grain is glassy on the fracture, the color of the grain is light brown.

The value of nature indicator can vary within 10% and depends on the grain size, its density, specific volume, surface condition, humidity and is not a stable sign of culture.

According to the index of vitreousity, the studied eincorn samples can be classified as highly glassy. The greatest value of this indicator was noted in Runo species. At large values of glassiness grain has good milling and technological properties. However, the vitreous index of grain is not stable and can be changed with moistening and the subsequent drying of grain.

In terms of the weight of 1000 grains, the grain of the Runo species is equivalent to wheat, and the eincorn grain (Baltasy region) is somewhat inferior in value to the weight of 1000 grains of wheat. The values of the studied indicator for the eincorn grain correspond to wheat values. The index of 1000 grain weight is unstable and depends on the grain size, its uniformity and correlates with the endosperm content, vitreousness and flour yield.

It is known that the main technological disadvantage of a filmed eincorn is the ear fragility and the grain filminess. After the ripening of plants, the ear decays into separate segments of the ear rod, and the grain is not threshed from the hard scales (films).

In this regard, naked eincorn was studied, provided by FSAEI HVE "Kazan (Privolzhsky) Federal University", the Department of Biochemistry and Biotechnology, obtained from the line of the naked eincorn *Triticum dicoccum* sv. *nadum* [3], the grain of which is easily threshed, and the plants of which are characterized by high agronomic characteristics.

According to the data presented in Table 2, it can be seen that the chemical composition of eincorn refers to high-protein cereals. The flour from the eincorn grain exceeds the flour from wheat in protein content by 5.8-12%, rich in essential amino acids. It is known that the content of valine, leucine, isoleucine, the sum of methionine + cysteine approaches the "ideal" protein in eincorn grain; the speed of these amino acids is more than 90%. By the ratio of tryptophan, lysine and methionine content eincorn can be compared with corn, buckwheat and exceeds millet, rice, oatmeal and pearl barley [4,5,6].

It is important to note that it is possible to wash gluten in the amount of 29.8% and 24.16% by hand from the flour, ground from the Runo and naked eincorn. In this case, gluten can be characterized as satisfactorily weak and be attributed to the IInd quality group. It was not possible to wash the gluten from flour, grinded from eincorn grain (Baltasy region). Due to the absence of gluten in this flour, due to the low content of gliadin and glutenin proteins, the grains of eincorn can be used for preventive nutrition among the population suffering from allergies to gluten.

Such indicators of flour, grinded from eincorn grains, as fiber content, ash content and humidity correlated with the indicators of wheat flour. The fat content in wheat grains made 2.1% on the average, and it was 19.2-22.0% higher in eincorn grain. Eincorn grain is characterized with a high starch content - 60.0-62.4%.

Table 2: Eincorn and wheat grain content

Indicator name	Eincorn (Baltasy region)	Eincorn: Runo species	Naked eincorn	Wheat (the harvest of 2017)
Total protein content, %	16,2±0,2	15,4±0,3	16,5±0,2	14,5±0,2
Quantity of gluten, % - «Infraskan» - manual method	- Not washed	30,4±0,2 29,8	34,2±0,5 24,16	30,6±0,4 30,6
Quality of gluten, IDK, conventional units.	-	95	92	70±2
Fiber content in DIA, %	1,2	1,4	1,3	1,4
Ash content, %	2,1	2,1	2,1	1,8
Fat content, %	2,6	2,6	2,7	2,1
Starch content, %	60,2±0,3	62,4±0,3	60±0,2	56±0,2
Humidity, %	8,3±0,3	10,8±0,1	9,3±0,1	9,5±0,2

In the work they carried out the studies to identify the characteristics of naked eincorn and wheat starch by comparing the microstructure of crop grains.

Figure 1 shows photographs of the naked eincorn and wheat microstructure obtained by electron microscopy. It was established that by shape the starch grains of the studied cultures are rounded and immersed in a protein matrix. The grains of wheat contain much more starch grains, their size is about 50 microns, while the size of small starch grains is 5-10 microns. The average size of starch grains is 10-35 microns. It is important to note that the relationship of starch grains with a protein matrix in naked eincorn grain is greater than that of wheat.

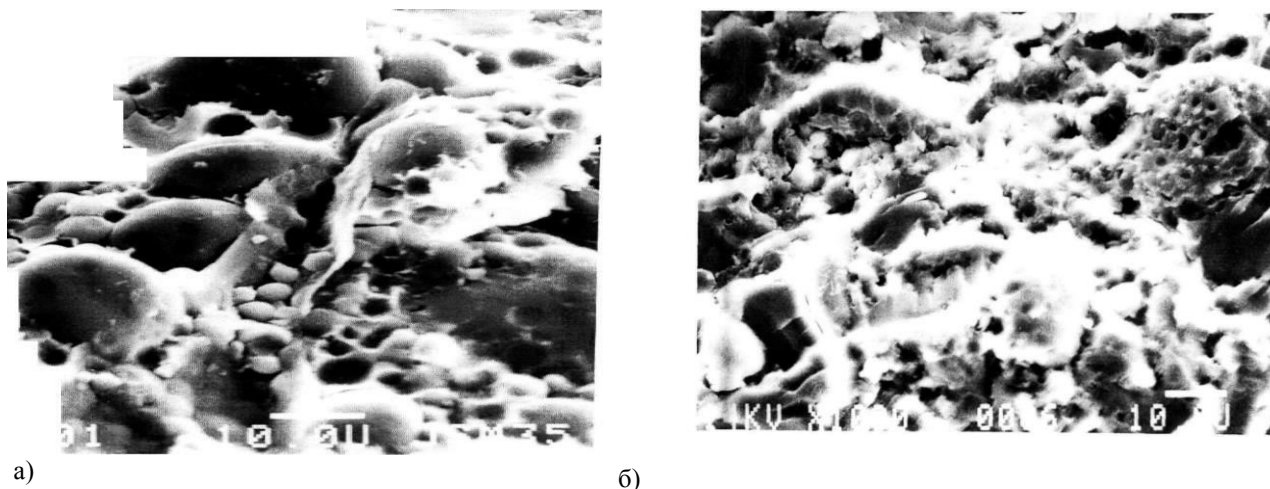


Figure 1. Grain microstructure (transverse cleavage): a - wheat, b - naked eincorn

The degree of starch grain damage during the processing of grain into flour, the size and the ratio of various fractions in general, as well as the relationship of starch grains with proteins determine the grain technological properties. Grain attack by enzymes depends on the mechanical damage of starch grains and their size. During swelling the largest changes experience large and medium-sized starch grains, small ones swell to a lesser extent.

The quality of grain and flour was evaluated by the state of the protein-proteinase and carbohydrate-amylase complexes. During the evaluation of the protein-proteinase complex, the quality and quantity of gluten were determined (Table 3). By the content of gluten, eincorn is close to the strong wheat, but the quality limits its use in the production of a number of flour products.

Table 3: Gluten quantity and quality

Flour samples	The amount of crude gluten, %	Elastic properties of gluten, units of the device IDK-1	Quality group	Gluten characteristics
Eincorn	30,4±4	103±4	III	unsatisfactory weak, low elastic, darkening in air
Naked eincorn	34,3±2	92±2	II	satisfactorily weak
Wheat	30,0±2	70±2	I	good, elastic

According to the data from the Table 3, we can conclude that the content of raw gluten in eincorn flour is quite high, its quality is characterized as unsatisfactory weak, poorly elastic and darkening in air.

The quality of naked eincorn gluten takes an intermediate position between wheat and the filmy eincorn. The quality of its gluten is characterized as satisfactorily weak. Wheat flour with similar quality indicators is often used in the production of flour products.

The flour from the naked eincorn is white with a grayish tinge. The mixed dough from it darkens

quickly, which indicates the presence of polyphenols. This fact is interesting from the point of view of eincorn use in functional nutrition. It is known that phenolic compounds have biological activity and a beneficial effect on a human body [7,8,9].

The state of the carbohydrate-amylase complex depends on the activity of enzymes, primarily on α -amylase, and on the degree of starch granule damage. Two methods were used to evaluate the carbohydrate-amylase complex: the method determining the "fall number" and the method determining the autolytic activity of flour. The data of the studies are presented in Figure 2.

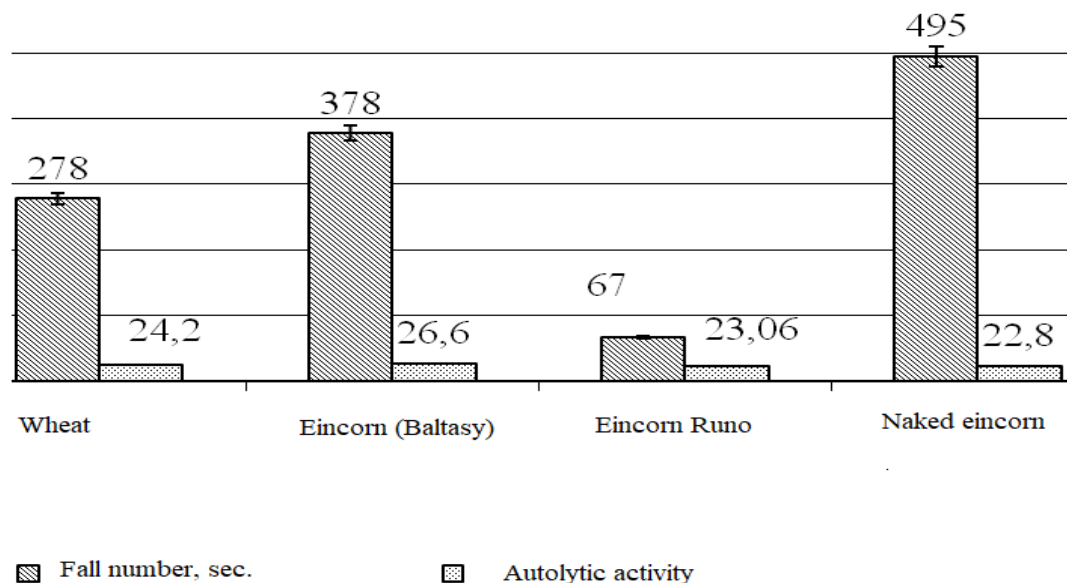


Figure 2. Evaluation results: the state of carbohydrate-amylase grain complex

The lowest values of the "falling number" index were noted in naked eincorn flour. Depending on the activity of α -amylase, the suspension of flour and water gives the paste with different viscosities. It is known that the smaller the "number of falls", the more active α -amylase. For the flour with good baking properties, the "falling number" should be at least 185 seconds, and autolytic activity should be not less than 10-20%. In general, the data of wheat flour and pollen flour autolytic activity and the measurement of the number of drops correlate well with each other. The highest activity of α -amylase was observed in Runo eincorn flour, the smallest one was observed in naked eincorn.

The rheological properties of the dough largely depend on the state of the flour protein-proteinase and carbohydrate-amylase complex. The proteins of wheat flour are able to form an elastic hydrated gel, affecting the stuctural and mechanical properties of

the dough [10]. Further studies were directed to the study of naked eincorn flour effect on the structural and mechanical properties of the dough.

The objects of the study were the dough samples with the replacement of wheat flour to naked eincorn flour in the following ratios (wheat flour: eincorn flour) 70:30; 50:50; 30:70; 0: 100. The dough from the premium wheat flour was the control element. Using alveograph they determined the following properties of the dough: air pressure limit (P, mm - resistance to deformation) corresponding to the elastic deformation of the dough; extensibility (L, mm or G); baking capacity or the amount of energy spent on a ball inflation before its breaking (W, E.A), and the ratio P/L and the coefficient of elasticity (Ie). The results of the statistical processing of the data obtained on the alveograph concerning the effect of naked eincorn flour on the rheological properties of the dough are presented in Table 4.

Table 4: Influence of flour from naked eincorn on the rheological properties of the dough

Name of indicators	Wheat flour : Eincorn flour				
	control 100:0	sample 1 70:30	sample 2 50:50	sample 3 30:70	sample 4 0:100
Maximum overpressure P, mm	106	76	66	54	45
The averaged value along the abscissa axis at the break point L, mm	89	99	77	63	34
Deformation coefficient G, cm	21	22,1	19,5	17,7	13
Bakery capacity (dough deformation work) W, E.A	356	219	138	87	51
P/L curve shape indicator	1,19	0,77	0,86	0,86	1,32
Elasticity ratio Ie, %	65,7	50,2	37,5	26,3	0

The results of the studies (Table 4) showed that when the amount of eincorn flour was increased, the maximum excess pressure (P) of the sample 2 was reduced in the dough by 37.7%, and in the sample 4 - by 54.5% relative to the control, indicating the dough elasticity decrease. The work on the dough deformation (W), which characterizes the quality of flour and its baking capacity, also decreased. The stretchability (L) of the dough was increased in sample 3, and then decreased with respect to control. The value of the strain coefficient (G) in sample 1 is greater by 5% than in the control, and it is 14.3% less in sample 4 with respect to the control. The elasticity of the dough was decreased with the increasing amount of eincorn flour. The dough elasticity was decreased in the samples due to the fact that gluten is weakened with the addition of eincorn flour, and the speed of the grain swelling process is decreased in eincorn, as the starch grains are immersed in the protein matrix and are associated with it more than in wheat (Figure 1).

The flour from naked eincorn lowered the elasticity and the plasticity of the dough, which leads the dough gas-holding capacity reduction, and, thus, the volume and the porosity of the finished bakery products. However, it is known that in order to make flour confectionery products, for example, good quality biscuits, the dough with low viscosity (low P value) and high extensibility (high L value) is necessary, in contrast to bakery products (the dough with a sufficiently high strength and elongation (high and medium values of P and L). The obtained results of the dough rheological properties make it possible to establish the possibility of naked eincorn flour use made in the Republic of Tatarstan for the production of flour products.

CONCLUSIONS:

Based on the results of grain morpho-biochemical properties analysis, protein-proteinase and carbohydrate-amylase complexes, they explained the possibility of naked eincorn flour use produced in the Republic of Tatarstan for the production of flour products.

SUMMARY:

They studied the morpho-biochemical properties and the microstructure of eincorn grain, grown in the Republic of Tatarstan. The eincorn grain has a longitudinal well-defined groove. The surface of the grain is somewhat rough. Eincorn grain is elongated and pointed at the ends, it is vitreous on the fracture, the grain color is light brown. The presence of starch granules of large and small fractions has been

established in naked eincorn grains. The connection between the starch grains and the protein matrix of naked eincorn is greater in comparison with wheat.

The result of the studies concerning the protein-proteinase and carbohydrate-amylase complexes of eincorn flour: the content of raw gluten in naked eincorn flour is quite large, and its quality is characterized as satisfactorily weak; the data of wheat, eincorn flour autolytic activity and the measurement of the number of falls correlate well with each other; the greatest activity of α -amylases was observed in flour from Runo eincorn, the smallest - in naked eincorn.

The obtained results of the dough rheological characteristics make it possible to establish that the flour from naked eincorn reduces the elasticity and the plasticity of the dough, while the dough has a low viscosity and a high extensibility, which is a necessary condition for the production of confectionery products, for example, cookies.

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