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Grain quality indicators and their phenotypic variability of ancient varieties of *Triticum aestivum* in the mountains of Uzbekistan

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Abstract. *Ruziyev F, Djabbarov I, Olimjonova S, Niyozov U, Urokov S, Ishankulova D, Bakhadirov U. 2023. Grain quality indicators and their phenotypic variability of ancient varieties of* Triticum aestivum *in the mountains of Uzbekistan. Biodiversitas 24: 5995-6001.* Today, creation of varieties of agricultural crops that are resistant to adverse environmental factors and produce stable crops under the influence of stress factors has become one of the most important issues in the world. In the following years, scientific and research work is being carried out on the wide use of the diversity of its genetic resources in the creation of new varieties of wheat (*Triticum aestivum* L.). In this regard, there are opportunities to use wild, semi-wild and ancient local forms of wheat with high protein and high gluten content to create varieties that meet modern production requirements. Therefore, it is important to evaluate the quality indicators of ancient varieties and the degree of phenotypic variation in the selection of wheat varieties that are resistant to adverse environmental factors, fertile and high-quality. This research work, aimed at researching ancient wheat varieties cultivated by the people living in the mountainous regions of Uzbekistan for many years. According to the research results, the grain quality indicators (grain hardness, diameter of grains, grain quality indicators, rheological properties, etc.) of the ancient wheat varieties distributed in the mountain regions are different. According to the results of the experiment, the grain hardness of the studied ancient wheat varieties is 73-82 µm, grain diameter 2.65-2.71 mm, hectolitre of weight 818.2-838.1±8.7 g/L, vitreousness 62.2-70.3%, gluten content in grain 31.5-34.6%, sedimentation index 64.4-77.2 mL. It was also observed that the phenotypic variability of the quality indicators was different in the wheat varieties that were the object of the study. Differences in the grain quality indicators of ancient wheat varieties are explained by the different effects of climatic parameters, abiotic and biotic factors in the regions where wheat grows. The information presented in the article provides an opportunity to select ancient wheat varieties distributed in the mountainous regions of Uzbekistan as starting sources for the creation of varieties with high nutritional value, resistant to adverse factors.

Keywords: Ancient varieties, Khibit, Khupar, Obi, phenotypic variability, *Triticum aestivum*, Uzbekistan, wheat, Zakhnabad

INTRODUCTION

Twenty percent of the world's food demand is met by the cultivation of wheat (*Triticum aestivum* L.), which is one of the three most common cereal crops in the world (Shahwani et al. 2014). Today, all over the world, wheat is planted on about 220 million hectares, and more than 780 million tons are harvested (Mitura et al. 2023). Further increase in wheat production is mainly due to increased yield and reduced losses due to various stress factors. According to Preiti et al. (2023), only 25-40% of the genetic potential of high-yielding varieties is used under production conditions. Combining high yield with high grain quality has become one of the most important tasks of modern breeding technique today. In this regard, sustainable food security in the face of a rapidly increasing population requires researching varieties cultivated in specific regions for a long time to create productive varieties of staple food crops.

Geographically, one third of the territory of Uzbekistan consists of mountains (Kudratov et al. 2023). Sudden changes in the climate in the mountains, the large-scale impact of stress factors on the diversity of flora (Akramov et al. 2023; Alikulov et al. 2023; Bazarov et al. 2023) and fauna (Nurullayeva et al.2023; Narzullayev 2022; Khalimov 2023; Khalimov et al. 2023; Narzullayev et al. 2023) affected. In addition, there is a high possibility that this condition caused the grain quality indicators to differ among agricultural crops, including wheat varieties, which have been cultivated in the mountain region for a long time. However, the analysis of local and foreign sources showed that there is little information about the wheat varieties that have been cultivated in the mountainous regions of Uzbekistan for a long time, the description and characteristics of their grain quality indicators, the phenotypic variation observed in these varieties, and the possibilities of using them as promising starting sources for productive wheat varieties. The situation indicates that in-

depth fundamental research has not been conducted in this regard.

In studies conducted in Italy (Piergiovanni 2013), Turkey (Yıldırım et al. 2020) and USA (Liu et al. 2022), grain quality indicators, including 1000-grain weight, grain glassiness, in ancient wheat cultivars grown in different climates and regions, it is noted that the organic composition of grain, the parameters of dough and bread are different. The authors explained the climatic and genetic reasons that lead to this diversity, and also noted that some grain quality indicators of ancient wheat varieties are better compared to traditionally cultivated varieties, and suggested that they can be used as starting sources for creating high-yielding varieties of wheat in breeding.

Nucia et al. (2021) in their work, while analyzing selection-genetic achievements, noted that as a result of many years of research conducted within the framework of wheat genetics, the difference in bread quality is realized on the basis of genetic diversity in wheat varieties. As the authors noted, the genes affecting wheat grain's technological properties and dough's physical properties are known. In recent years, important information has been collected based on the study of important concepts about mutually complex systems and mechanisms that shape grain properties and determine the quantity and quality of flour produced from it. Ancient varieties that provide full genetic potential, high yield, grain quality, resistant to abiotic and biotic factors, high yield, hardiness and adaptability are always highly evaluated in selection research (Nuraeni et al. 2021). In similar works, improving the adaptability of wheat varieties, strengthening their ability to show maximum productivity in certain environmental conditions dominates among the current directions of breeding. Based on the combination of climatic conditions, it is indicated that the quality of spring wheat prevails in one area, and winter wheat is preferred in another (Bellatreche et al. 2017).

The analyzed data shows the importance of determining the grain quality indicators and their phenotypic variability of the ancient wheat varieties grown in the mountainous regions of Uzbekistan in order to select the sources used as the initial source for wheat selection.

MATERIALS AND METHODS

Study area and plant materials

The selection of sampling stations is based on the differences in wheat field altitude and climatic parameters, including temperature and humidity. The research area is wheat field of Zoxona (Surkhandarya), Gelon (Kashkadarya), Sangardak (Surkhandarya) and Xufar (Surkhandarya), Uzbekistan. A complete description of the sampling station is shown in Figure 1 and Table 1. Figures 2 and 3 show the appearance of wheat fields and grains collected from ancient wheat cultivars studied. Grain samples of old wheat varieties (10 kg per variety) were collected in July 2022 and laboratory analysis was carried out. Laboratory studies were carried out in the laboratories of the Institute of Biochemistry, Molecular Biotechnology and Modern Botanical Research, and the Department of Genetics and Biotechnology of Samarkand State University.

Determination of grain quality indicators

The methods of Manley et al. (2009) and Baasandorj et al. (2015) methods were used to determine grain quality parameters of ancient wheat cultivars, including grain hardness, grain diameter, hectolitre of weight, 1000 grain weight, farinograph mixing value, and grain gluten content.

Grain Hardness (GH) was determined by DO-Corder with an accessory for hardness measurement (Brabender machine). Fifty grams of cleaned wheat grain is ground (200 rounds per minute). A recorder registers the torque value during grinding (Brabender units). In order to extend the measurement scale a special load is used for the power transmission on register paper. Acquired meal is sieved for 3 minutes using 0.140 mm sieve. Sieve threw are weighed. Grain moisture should be 11-13%. The results were summarized using the following formula:

$$\mathrm{GH} = \frac{\text{peak height on hardness tester (B.u.)} + \text{load value (g)}}{\text{0.140 mm sieve threw weight (g)} \times 2}$$

Grain diameter was determined by cutting the grain crosswise into two parts and measuring with a ruler.

The hectolitre of weight was determined using the method of measuring with a spray. In this case, a measure (measuring container) with a nominal capacity of 1 dm was filled with grain and weighed on a balance, then the grain type was summarized by subtracting the weight of the empty container from the result of weighing it with the load.

The weight of 1000 grains was determined by measuring the weight of 50 grains of each variety and evaluating the determined weight by the proportion method.

To determine the amount of gluten in gluten-forming substances (mainly proteins - gliadin and gluten), the method of removing water-soluble substances, as well as starch and bran from the dough with palms (manual method) was used. The resulting gluten was weighed and the percentage of crude gluten relative to the dry milled grain sample was calculated.

Table 1. Sampling site of ancient varieties of *Triticum aestivum* in the mountains of Uzbekistan

Name of ancient varieties	Location	Coordinate	Altitude (m asl.)
Zakhnabad	Zoxona (Surkhandarya)	38°37'03.1"N 67°43'25.1"E	2600
Khibit	Gelon (Kashkadarya)	39°05'03.1"N 67°27'09.0"E	2000
Obi	Sangardak (Surkhandarya)	38°32'46.7"N 67°31'55.5"E	2460
Khupar	Xufar (Surkhandarya)	38°32'13.1"N 67°45'46.3"E	2550

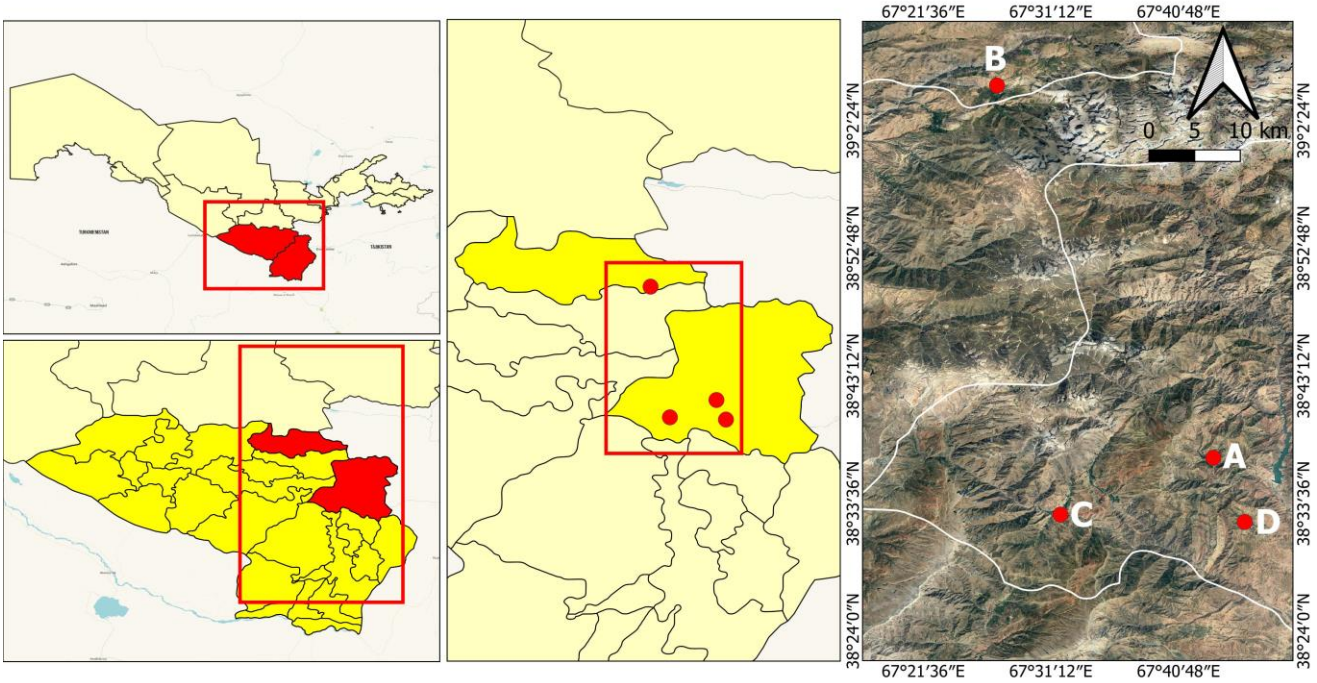

Figure 1. Map of the study area in the mountains of Uzbekistan showing four stations located on wheat field of ancient varieties of *Triticum aestivum* (A. Zoxona, Surkhandarya, B. Gelon, Kashkadarya, C. Sangardak, Surkhandarya, D. Xufar, Surkhandarya)

Figure 2. View of wheat field of ancient varieties of *Triticum aestivum* in the mountains of Uzbekistan (A. Zakhnabad, B. Khibit)

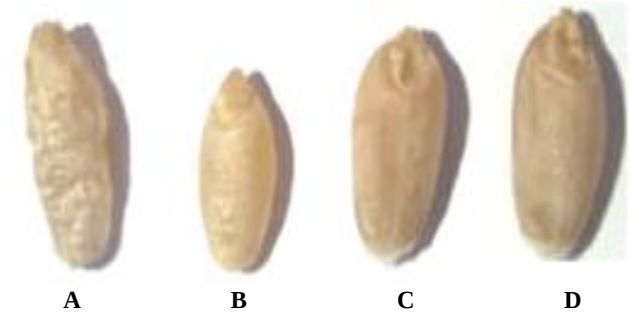

Figure 3. View of grains of ancient varieties of *Triticum aestivum* in the mountains of Uzbekistan (A. Zakhnabad, B. Khibit, C. Obi, D. Khupar)

Evaluation of quality indicators and rheological properties of flour made from grain of ancient varieties

Venturi et al. (2021) method were used to evaluate the quality indicators and rheological properties of flour and dough made from ancient wheat varieties. In evaluating the physical properties of the dough in the varieties, the sedimentation method was carried out in two stages. It is possible to see a clear image of swelling of flour and protein fragments in water as a result of aggregation and disaggregation of gluten proteins in the process of viewing conditions placed in calibrated test tubes filled with water. This process stops after adding the working solution (lactic acid and SDS-sodium) to the test tube. After two times of shaking, the height of the sediment in millimeters is transferred to milliliters according to the formula. Baking

properties were determined by baking sample bread in laboratory conditions. The dough remix method was used to evaluate the physical properties of the dough of the varieties studied in the research.

Evaluation of phenotypic variability

Data recorded for measured traits were subjected to a one-way Analysis of Variance (ANOVA) to test the differences among genotypes at a 5% probability level. The Phenotypic Coefficient of Variation (PCV) is calculated for each trait based on the mean square values obtained from the ANOVA according to the equations given by Johnson et al. (1955) and Acquaah (2012) as follow:

$$PCV = \frac{\sqrt{\sigma_p^2}}{\mu} \times 100$$

Where: σ^2_p: phenotopic variance, μ: mean

RESULTS AND DISCUSSION

Grain hardness and diameter of grains of ancient varieties

As a result of our research, the grain hardness and grain diameter of the ancient wheat varieties grown by the local population in mountainous regions with different heights were determined. The analysis of the results showed that grain hardness and grain diameter are different in ancient wheat varieties (Figure 4). As can be seen from the data of Figure 4, among the ancient wheat varieties studied, the highest index of grain hardness (82 µm) was recorded in Khupar variety, while this indicator was observed to be the lowest (73 µm) in Khibit variety. Grain hardness in Zakhnabad and Obi varieties was equal to 78 µm and 74 µm, respectively. In experiments to determine the diameter of grains of ancient wheat varieties, it was noted that the grain diameter of the studied wheat varieties was between 2.65-2.71 mm. It was determined that Obi variety has the highest grain diameter (2.71 mm). In the remaining varieties, Zakhnabad, Khibit and Khupar, this indicator was recorded to be 2.69, 2.67, and 2.65 mm, respectively. In the scientific notes of a number of local and foreign researchers, it is emphasized that grain hardness and grain diameter indicators are important in the selection of wheat varieties, and the diversity of these indicators is explained by the degree of influence of climatic factors in the mountains. Including Nuttall et al. (2017) reported that grain hardness and functional properties of wheat are affected by changes in temperature and atmospheric CO_2 content. They note that as a result of an increase in the content of CO_2 in the air, the yield can increase up to 36%, but the total grain protein concentration decreases and the change in composition leads to a decrease in functional properties, high temperature stress reduces the ratio of glutenin/gliadin. Also, the change in grain hardness in wheat has a direct effect on the quantity and quality of organic matter in the grain (Pasha et al. 2010).

Grain quality indicators of ancient varieties

In the course of our research, the main quality indicators of ancient wheat varieties cultivated by the local population in the mountainous regions of Uzbekistan (grain type, 1000 grain weight, farinograph mixing value, gluten content) were determined. The results of the study showed that the grain quality indicators of ancient wheat varieties differ from each other (Table 2). According to the data in Table 3, the hectolitre of weight of the ancient wheat varieties under investigation ranges from 818.2±11.2 g/L to 838.1±8.7 g/L. The maximum indicator according to the type of grain belongs to the Khupar variety, while the minimum indicator was found in the Zakhnabad variety. Grain content of Khibit and Obi varieties was 818.4±9.8 g/L and 828.5±12.1 g/L, respectively. The weight of 1000 grains in the studied ancient wheat varieties was equal to 36.6-39.6 g. The weight of 1000 grains was equal to 39.6±1.4 g in the Obi variety, 36.6±1.5 g in the Khibit variety, and the other two varieties had values within the limits of the above indicators. One of the important quality indicators in the description of wheat grain is the vitreousness of the grain. Among ancient wheat varieties grown in mountain regions, the highest index of vitreousness (70.3±1.1%) was determined in the Obi variety, and the lowest index (62.2±0.9%) in the Zakhnabad variety. Vitrification was equal to 64.0±1.3% and 62.2±0.9% in Khibit and Khupar varieties, respectively. It was observed that the amount of gluten in the grain was from 31.5±0.8% to 34.6±0.6% in the investigated ancient wheat varieties. Among the varieties, the Khupar variety was noted as the richest variety in grain gluten. It was determined that the amount of gluten in the grain is equal to 34.6±0.6%. The amount of gluten in grain in Zakhnabad, Khibit and Obi varieties was 33.5±0.6%, 31.5±0.8% and 32.1±1.0% respectively.

The results of the experiment show that the main quality indicators of ancient wheat varieties grown by local residents in mountain areas are different. The diversity of the indicators can be explained by the different climate indicators in the region, the influence of soil composition and agrotechnologies of care. In the research conducted in the conditions of Zecevic et al. (2014) and Nuttall et al. (2017) in the studies of the diversity of the main quality indicators of wheat grain and the conclusions made regarding the factors influencing their change also confirm the data obtained by us.

Quality indicators of flour made from grain of ancient varieties

It is known that the sedimentation method is widely used in the assessment of heritability of grain quality in wheat breeding and has high accuracy in determining the diversity between varieties. The sedimentation index of the flour is directly related to the physical properties of the dough and the baking properties of the flour. A higher sedimentation index determines the physical properties of the dough and the higher the level of breadiness (Onipe et al. 2015). From the results of experiments on determining the quality indicators of flour made from grains of old wheat varieties, it is clear that the quality indicators of flour

change depending on the wheat variety. It can be seen from the data of Table 3 that the sedimentation index of the flours made from the grain of the investigated wheat varieties ranges from 64.4±2.2 mL to 77.2±1.6 mL. The highest value of the sedimentation index (77.2±1.6 mL) was recorded in the Khupar variety, and the lowest value (64.4±2.2 mL) in the Zakhnabad variety. In Khibit and Obi varieties, this indicator was found to be equal to 72.1±1.9 mL and 68.9±2.4 mL. Also, during the experiments, the amount of protein in the flour was studied. According to the results of the experiment, among the ancient wheat varieties, Khibit is the variety with the richest protein content. The amount of protein in flour in this variety is 16.7±1.0%. The amount of protein in Zakhnabad, Obi and Khupar varieties was 16.2±0.8%, 14.3±1.1% and 16.4±0.9%, respectively. In evaluating the quality of flour, its sedimentation index and the ratio of the content of protein are of great importance. The ratio of flour sedimentation index to protein content in ancient wheat varieties under study is from 4.0 to 4.8. It was found that the high value of this indicator belongs to the Obi variety, and the low value to the Zakhnabad variety. As a result of a number of foreign studies aimed at studying the quality indicators of flour made from the grain of ancient wheat varieties (Belcar et al. 2020; Venturi et al. 2021), it was noted that the quality indicators vary by variety. By them, this diversity was explained by the influence of the climate, soil conditions and breeding technology of the region where wheat grows, and the fact that all varieties have only a specific genotype.

Rheological properties of dough of ancient varieties

Given the specific pleasant taste and flavor, as well as color in the case of einkorn, products from ancient wheat varieties are an interesting addition to the assortment of baked goods on offer in bakeries, restaurants and agritourist farms (Belcar et al. 2020). Therefore, during our research, we determined the rheological properties of the dough made on the basis of flour obtained from the grain of ancient wheat varieties. It was observed that the parameters representing the rheological properties of the studied doughs were different (Table 4). When analyzing the cross-section of old varieties and indicators, it was noted that flour strength (250.0±6.4 mL), water absorption (61.4±3.1%) and volume output of bread (946.0±19.3 cm^3) were higher in Khupar variety. These parameters were 220.0±4.7 mL, 60.3±3.0% and 810.0±15.6 cm^3 in the Zakhnabad variety, and 246.0±5.1 mL, 60.5±2.4% and 935.0±21.5 cm^3 in the Khibit variety. According to the data of Table 4, the porosity of the bread core was evaluated as 4.1-4.3 points, and the color of the bread core was evaluated as 4.0-4.3 points in the studied ancient wheat varieties. According to the porosity of the bread core, the Khibit variety and the Khupar variety according to the color of the bread core were noted to be the varieties with the best performance. A number of researchers (Amjid et al. 2013; Venturi et al. 2021) have described the rheological parameters of flour and dough made from ancient wheat varieties in their works, according to them, rheological parameters are one of the important characteristics of the variety.

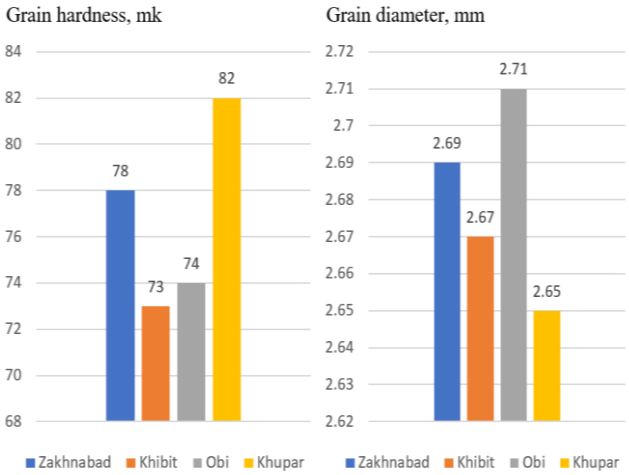

Figure 4. Grain hardness and diameter of grains of ancient varieties of *Triticum aestivum* in the mountains of Uzbekistan

Table 2. Grain quality indicators of ancient varieties of *Triticum aestivum* in the mountains of Uzbekistan (n=5)

Name of ancient varieties	The nature of the grain, g/L	1000 grain weight (g)	Farinograph mixing value (%)	Gluten content (%)
Zakhnabad	818.2±11.2	38.5±1.0	62.2±0.9	33.5±0.6
Khibit	818.4±9.8	36.6±1.5	64.0±1.3	31.5±0.8
Obi	828.5±12.1	39.6±1.4	70.3±1.1	32.1±1.0
Khupar	838.1±8.7	39.0±1.2	62.6±0.7	34.6±0.6

Table 3. Quality indicators of flour made from grain of ancient varieties of *Triticum aestivum* in the mountains of Uzbekistan (n=3)

Name of ancient varieties	Sedimentation (S), mL	Protein (P), %	S:P
Zakhnabad	64.4±2.2	16.2±0.8	4.0
Khibit	72.1±1.9	16.7±1.0	4.3
Obi	68.9±2.4	14.3±1.1	4.8
Khupar	77.2±1.6	16.4±0.9	4.7

Table 4. Rheological properties of dough of ancient varieties of *Triticum aestivum* in the mountains of Uzbekistan (n=3)

Name of ancient varieties	Strength of flour (mL)	Water absorption (%)	Porosity of bread core, sc	Color of breadcore, sc	Volume output of bread (cm^3)
Zakhnabad	220±4.7	60.3±3.0	4.1	4.1	810±15.6
Khibit	246±5.1	60.5±2.4	4.3	4.2	935±21.5
Obi	221±6.0	59.8±2.8	4.1	4.0	940±11.2
Khupar	250±6.4	61.4±3.1	4.2	4.3	946±19.3

Table 5. Phenotypic variability of grain quality indicators of ancient varieties of *Triticum aestivum* in the mountains of Uzbekistan (PCV, %)

Name of ancient varieties	Nature of the grain	Grain protein content	Wet gluten content	Gluten deformation meter	100 g of bread made from it
Zakhnabad	4.8	10.8	15.3	3.8	21.9
Khibit	4.4	9.1	13.4	4.0	15.9
Obi	4.2	10.8	14.8	4.6	27.6
Khupar	4.8	12.2	16.1	3.4	28.5

Phenotypic variability of grain quality indicators of ancient varieties

According to the results of the comparative analysis of the studied varieties during the research, it was found that the technological characteristics of the grain are variable. It was confirmed that the studied varieties have high technological indicators of grain, and on the contrary, some of them have low ones. The variability of grain quality indicators in the studied varieties can be explained by the interaction of such factors as "genotype" and "meteorological conditions of the year". According to the data of Table 5, it can be seen that some varieties have values higher than the norm of the first class wheat in terms of grain nature, grain protein and crude gluten mass fraction in the years that are optimal for grain formation. When analyzing the phenotypic variability of the indicators in the studied ancient wheat varieties, it was found that 4.2-4.8% in grain quality, 9.1-12.2% in grain protein content, 13.4-16.1% in grain gluten content, 3.4-4.6% gluten deformation, and 15.9% bread yield, will be equal to - 28.5%. The variability of grain quality indicators in the studied varieties is divided into stable and moderately variable groups. In this case, the stable group includes the type of grain, the IDK unit, and the middle variable group includes such indicators as the mass fraction of protein in grain, the mass fraction of raw gluten, and the total price of bread. The technological parameters determining grain quality in ancient wheat varieties change not only depending on the genotypic characteristics of the variety, but also depending on the conditions of the year of grain cultivation (Wahyu et al. 2018; Fadli et al. 2021; Nucia et al. 2021).

In conclusion, in the ancient wheat varieties grown in the mountainous regions of Uzbekistan, adaptation to the harsh continental climate and other stress factors of the region is formed for many years. Depending on the seasons and genotypic characteristics of the variety, the value of quality and other parameters in grain and flour and dough of the studied varieties changes. Grain quality parameters and their phenotypic variability of the investigated ancient wheat varieties correspond to other cultivar parameters within the species. The results of the research show that the ancient wheat varieties grown in the mountainous regions of Uzbekistan are a potential source for creating varieties resistant to the effects of stress factors.

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