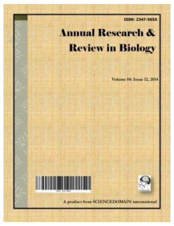

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Assessment of Genetic Diversity for the Properties Related to the Quality of Hexaploid Bread Wheat (SeriM82 / Babax) under Drought Stress

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Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

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ABSTRACT

In order to study the diversity of related characteristics of bakery quality in 167 bread wheat genotypes (SeriM82 / Babax), along with their parents, were evaluated based on two replications. The measured traits including protein content, zeolite sediment volume, bread volume, moisture content, grain hardness, water absorption, wet gluten, gluten index, gluten elasticity, Sodium dodecyl sulfate (SDS) sedimentation volume and quantitative trait of 1000 seed weight according to standards International. After analysis of variance, the data of the experiments and the comparison of the meanings were performed using multivariate methods, cluster analysis and factor analysis, genotyping grouping and the relationship between the variables (traits). The result of variance

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showed that genotype was significant for protein, bread volume, wet gluten, gluten index, sedimentation of sodium dodecyl sulfate and 1000 grain weight at 1% level. Factor analysis from 11 traits examined, 4 factors with 60% variance, the first factor with variance of 27.48% including traits of protein content, zeolite sediment volume, bread volume, moisture content and water absorption, the second factor with variance of 4.8% Includes wet gluten characteristics, gluten elasticity, SDS sedimentation volume, third factor with 10.16% variance, including seed hardness and gluten index, and fourth factor with variance of 9.85% of 1000 seed weight. The results of factor coefficient evaluation indicate the importance of protein content traits, zeolite sediment volume, bread volume, moisture content and water absorption in selection of suitable genotypes for drought conditions. Based on cluster analysis (intra-group variance algorithm), genotypes were divided into eight groups, the fifth group had high baking quality and could be used in breeding programs to improve the quality of baking.

Keywords: Bread wheat; quality of bakery; gluten index; grain hardness; bread size; factor decomposition; inbred line.

1. INTRODUCTION

Common wheat (*T. aestivum* L.) is one of the most important food grains in the world (http://faostat.fao.org). First, after grinding, it becomes flour and later becomes products such as bread, noodle [1,2,3,4]. Finally, the grain quality and qualitative traits are under genetic and environment control. Climatic conditions and crop management such as fertilizer level, infection of pests and pathogens, harvest conditions, storage as flour, flour preparation method, dough preparation method and cooking conditions affect the final quality of wheat [5]. Wheat bakery value in cultivars and lines is dependent on the amount of gluten they contain. Glutenin proteins include gliadins and gluthenes, and the two components constitute nearly 80% of wheat protein. The amount of protein in the grain depends on the cultivar, climatic conditions and abiotic stresses (drought and salinity) [6,7]. Wheat protein content of more 13% in final production is satisfactory. Wheat protein content higher than 13% was reported as a satisfactory final product, whereas protein content lower than 11% was regarded as a poor product.

Researchers showed that in low dry temperature, both protein content and gluten quality are important in determining the quality of baking [8]. Due to this, the environment affects the expression of protein content. The amount of protein is a quantitative trait that is commonly characterized by a complex genetic system and heavily influenced by environmental factors. Other Researchers showed that by ignoring the environmental effects and genetic effects on protein content, the interaction of genotype in the environment seems to be negligible [9]. Therefore, the main effects especially climate and nitrogen are on the protein concentration of the peripheral raw grain [9,10]. Glutenins play a more important role in the quality of bakery and differences between the cultivars. And the relationship between glutenin to gliadin ratio and gluten elasticity has been reported as negative. The presence of diversity in glutenin to gliadin ratio, and gluten elasticity has significant effects on rheological properties (physical properties including elasticity properties and resistance of dough) of gluten and gluthenine [11]. The role of the environment and climatic conditions in determining the quality of the baking is very significant. In an experiment performed, average content of protein has been reported as 10.9 under aqua conditions and 12.4 under rainfed conditions that increasing the amount of nitrogen in the grain normally leads to an increase in grain with a glass section, the volume of sediment, gluten content and strength of dough [12]. The grain protein value is the result of two parameters: 1. Grain growth, which is mainly controlled by the genotype and 2. Transfer of nitrogen and its accumulation in the grain which are mainly controlled by the amount of nitrogen used. The protein content of the grain depends entirely on low molecular weight glutenin (LMW) [13]. Drought stress plays an important role in determining the quality of wheat [14]. In general, moisture stress increases the protein concentration. Due to the inverse relationship between yield and protein, it reduces the yield [4]. In addition, drought limits the green leaf area and the ability of the plant to remove dry matter during the grain filling leading to less starch to grow in the grain and then higher protein concentration [15,16]. Drought often leads to a reduction in grain yield and size and reduces the grain quality by reducing the grain filling [15]. Eivazi et al. [17] have reported a reduction in values of the traits of gluten and glutenin index and an increase in the grain protein content, gliadin, grain hardness index, Falling Number and water absorption rate by flour under salinity and drought stress conditions. Gupta et al. [18] stated that 20% of diversity in bread qualitative properties can be justified by protein content. Given that wheat breeding programs have focused mainly on new and high yield and abiotic stress resistant species, now the necessity to identify high quality cultivars and genotypes in wheat is one of the most important goals. For this purpose, this experiment was conducted to examine the genetic diversity of the baking quality of the bread wheat inbred lines and their grouping in relation to the qualitative traits related to baking properties against desirable conditions and drought stress to be used by wheat breeders in order to improve qualitative characteristics and use in breeding programs.

2. MATERIALS AND METHODS

2.1 Field Experimental Designs

In order to identify related to qualitative traits in drought tolerance on 167 pure recombinant line (RILs) derived from wheat SeriM2 (KavKaz / Buho // Kalyansona / Bluebird) and (Bow / NAC // VEE / BJY / 3 / COC) Babax. In this experiment, 167 recombinant inbred lines with SeriM82 and Babax parents were planted at the research station of Yazd Agricultural and Natural Resources Research Center in the form of alpha-lattice (13×13) design with two replications and under two drought and normal conditions for 2 years. Crop operations included preparation of land, planting in autumn and maintenance stages including fertilization and irrigation. during the experiment, using Time Domain Reflectometery (TDR) moisture meter, moisture content in root zone under drought stress conditions was measured at 25% of relative humidity and under normal conditions at 50%.

2.2 Quality Trait Measurements

And after the end of the growing season in spring, 200 gm of seed was harvested from the experimental plot and the quantitative trait of 1000-grain weight was measured, and after grinding the samples, qualitative traits included protein content, Zeleny sedimentation volume, bread volume, moisture content, water absorption rate, wet gluten, gluten index, gluten elasticity, grain hardness and SDS sediment volume were measured according to the standards of International Association for Cereal Science and Technology. To determine the protein content of flour, Zeleny sediment volume, bread volume, grain hardness and water absorption, NIR PERTEN 8600 was used. To measure gluten, from 10 grams of flour without bran, after washing starch with gluten washer and centrifuging gluten at 6000 rounds per minute, based on the gluten passage from the net to the back, the amount of wet gluten, dry gluten, gluten index, and elasticity index were obtained. The volume of sediment was measured using 1 gram of flour and adding Sodium Dodecyl Sulphate Solution and the amount of sediment was determined.

2.3 Data Collection and Analysis

Data analysis for measured traits was performed based on alpha-lattice design and quantitative and qualitative traits were compared by the least significance difference method (LSD). For grouping genotypes, multivariate cluster analysis (cluster) method was used and for the role of qualitative traits in the amount of changes made in each factor, factor analysis was used. Statistical analysis was performed using software SAS, cluster analysis and factor analysis using Stat grapgics method [19].

3. RESULTS AND DISCUSSION

3.1 Analysis of Variance of Traits

Analysis of variance of quantitative and qualitative traits showed that 1000-grain weight, protein content, bread volume, wet gluten, gluten index and SDS sediment volume at 1% level were significantly different. these indicates the high genetic diversity and the difference between the genotypes examined (Tables 1,2). The traits' mean comparison showed that the protein content of the genotypes was very different. Analysis of variance of the traits examined (Table 1,2) shows a significant difference between genotypes for traits like protein percentage, gluten index, gluten elasticity; SDS sedimentation volume and 1000-grain weight which indicates high phenotypic diversity among genotypes. Naghafian et al. [20] in an experiment on wheat cultivar concluded that among the cultivars the traits like grain protein percentage, SDS sedimentation volume, water absorption percentage, Zeleny sediment volume and grain hardness showed a significant difference at 1% level, indicating the difference among the cultivars. Akbari Rad et al. [21] by studying a population of wheat genotypes under normal condition, most of the traits related to the quality of the baking were reported significant at 1% level. Motaghi et al. [22] by studying a population of wheat genotypes under drought and normal conditions showed that some of the traits of the quality of the bakery such as gluten index, wet gluten, bread volume and protein percentage were reported significant at 1% and 5%. Khodarahmi et al. [23] by performing an experiment on five wheat cultivars in a diallel design and examining their qualitative traits concluded that the effect of drought stress on the traits of protein percentage, SDS sedimentation volume, wet gluten content, 1000-grain weight and Hectoliter weight was significant at 1% level. The effect of genotype on all traits except for moisture percentage, Zeleny sediment volume and wet gluten was significant. When moisture stress affect wheat, the protein polymerization stage begins quickly, even earlier than normal state in the grain [24]. In addition, drought limits the green leaf area and the ability of the plant to remove dry matter during the grain filling causes less starch for the grain growth, resulting in higher protein concentration [15]. Therefore for the reasons mentioned, the heritability calculated is private heritability. Heritability expresses how much diversity is caused by genetic factors. Among the studied traits, the protein percentage, water absorption rate, wet gluten, gluten index and SDS sedimentation volume had the highest heritability and the traits of Zeleny sediment, grain hardness, bread volume and moisture percentage had the lowest heritability. Some researchers consider the percentage of protein as due to incremental effects [25]. High private heritability of the traits of water absorption rate, wet gluten, SDS sedimentation volume and protein percentage indicate the increasing importance of genes' incremental effects on the genetic control of these traits. Hence, the choice for such traits in the early generations will be successful. The traits that have high heritability are less affected by the environment. Also, the traits of hardness index, Zeleny sediment and bread volume had low heritability. The researchers have reported an increase in the protein content, gliadin, grain hardness and water absorption percentage under drought and salinity stress [17]. The researchers in their studies concluded that environmental changes usually have an important effect on wheat qualitative properties [26].

In general, the existing differences between the heritability of quantitative traits in an environment can be due to the difference in the number of genes controlling these traits. As the number of genes controlling the trait is greater, the genes have smaller effects, are more affected by the environment, and heritability is reduced.

3.2 Correlation between Traits

The correlation of traits under drought conditions (Table 3) shows that the percentage of protein has a positive and significant correlation with Zeleny sediment volume, bread volume, moisture content, grain hardness, wet gluten, SDS sediment volume and water absorption rate, and with the traits of gluten elasticity, gluten index and 1000-grain weight correlate negatively and insignificantly. In an experiment on wheat cultivars, Najafian. [19] concluded that the traits like grain protein percentage, SDS sedimentation volume, water absorption percentage, and Zeleny sedimentary volume had a positive and significant correlation with each other, but had a positive and insignificant correlation with grain hardness. It is natural that by increasing the amount of protein in the grain, the gluten content of the flour dough is also increased, and the percentage of water absorption is also influenced by the amount of gluten. By increasing the percentage of protein, the amount of water absorption is also increased under all conditions (increasing the amount of nitrogen fertilizer).

In many studies, it has been shown that the grain hardness increases the percentage of water absorption in the dough because the starch damage increases when ground, damaged granules increases and absorption of water increases. Massoudi Far et al. [27] by performing an experiment on the cultivar Kuhdasht concluded that the percentage of protein was positively and significantly correlated with Zeleny number, water absorption percentage; dry gluten percentage and gluten index. The use of correlation between breeding traits is of great importance. Because in cases where a trait in a plant has low heritability, we can use the traits that have high heritability and correlated with that trait indirectly in the selection. The correlation of different traits with the protein percentage indicates the importance of these traits as a selection criterion. Then, it is concluded that in order to improve the percentage of protein in wheat genotypes under all conditions (normal and drought stress), the traits of zeleny sediment volume, wet gluten, gluten index SDS sediment volume, and gluten elasticity are more important than other traits.

Table 1. Analysis of variance for a randomized complete block design under drought stress

Traits	Protein content (%)	Zeleny sedimentation volume	Bread volume	Moisture content (%)	Hardness index	Water absorption rate	Wet gluten	Gluten elasticity	Gluten index	SDS sedimentation volume	Weight of thousand seeds (%)
Block	0.043^{ns}	0.665^{ns}	16.46^{ns}	0.17**	7.39*	0.045^{ns}	0.36^{ns}	0.47^{ns}	8211.7**	20.38^{ns}	0.563^{ns}
Genotype	0.08**	1.367^{ns}	962.4**	0.023^{ns}	1.52^{ns}	0.25^{ns}	11.36**	0.363^{ns}	451.21**	40.1**	10.92**
Erorr	0.055	1.112	338.85	0.019	1.47	0.21	7.64	0.41	256.1	26.61	3.566
C.V%	1.99	3.14	4.06	1.47	2.25	0.75	9.0	43.8	35.6	8.46	4.53

***significant to 1% and *significant to 5% of probability by t test and ^{ns} Non significant*

Table 2. Analysis of variance for a randomized complete block design under nourmal condition

Traits	Protein content (%)	Zeleny sedimentation volume	Bread volume	Moisture content (%)	Hardness index	Water absorption rate	Wet gluten	Gluten elasticity	Gluten index	SDS sedimentation volume	Weight of thousand seeds (%)
Block	0.057^{ns}	1.183^{ns}	461.61^{ns}	1.98**	3.834^{ns}	16.18^{ns}	99.1^{ns}	0.295^{ns}	524.4^{ns}	113.65^{ns}	7.52^{ns}
Genotype	0.04*	2.214^{ns}	2724.7**	0.042^{ns}	2.89^{ns}	9.76^{ns}	15.62**	1.1**	584.27**	4.86**	16.91**
Erorr	0.03	1.99	1864.87	0.041	2.66	9.82	8.06	0.754	318.2	4.484	5.34
C.V%	1.52	4.51	9.63	2.15	3.29	4.95	13.27	40.32	31.03	3.92	5.44

***significant to 1% and *significant to 5% of probability by t test and ^{ns} Non significant*

Table 3. Pearson correlation coefficients between traits studied of recombinant inbred lines under drought stress

Traits	Protein content (%)	Zeleny sedimentation volume	Bread volume	Moisture content (%)	Hardness index	Water absorption rate	Wet gluten	Gluten elasticity	Gluten index	SDS sedimentation volume	Weight of thousand seeds (%)
Zeleny sedimentation volume	0.71**										
Bread volume	0.30**	0.30**									
Moisture content (%)	0.22**	0.32**	0.18**								
Hardness index	0.18**	0.18**	0.11*	0.12**							
Water absorption rate	0.42**	0.45**	0.20**	0.31**	0.26**						
Wet gluten	0.42**	0.35**	0.10^{ns}	0.11*	0.13*	0.12*					
Gluten elasticity	-0.02^{ns}	0.01^{ns}	0.02^{ns}	0.01^{ns}	-0.15**	-0.05^{ns}	-0.01^{ns}				
Gluten index	-0.08^{ns}	-0.08^{ns}	0.001^{ns}	0.03^{ns}	-0.09^{ns}	0.02^{ns}	-0.24**	-0.09^{ns}			
SDS sedimentation volume	0.49**	0.37**	0.13*	0.07^{ns}	0.08^{ns}	0.20**	0.30**	0.01^{ns}	-0.12*		
Weight of thousand seeds (%)	-0.03^{ns}	-0.01^{ns}	-0.08^{ns}	-0.06^{ns}	0.04^{ns}	0.02^{ns}	-0.08^{ns}	0.02^{ns}	-0.01^{ns}	0.02^{ns}	

***significant to 1% and *significant to 5% of probability by t test and ^{ns} Non significant*

3.3 Effect of Drought Stress on Traits

Qualitative properties of wheat have been influenced by their genotype, environment and interactions. And due to the complexity of environmental stresses, such as drought, on wheat bakery features, their detailed study is not possible [28,16]. Researchers have reported a reduction in the traits of gluten and glutenin index and an increase in the grain protein content, gliadin, grain hardness index, falling number, and water absorption rate by flour under salinity and drought stress conditions [17]. The researchers reported that aqua stress at the grain filling stage in nine bread wheat genotypes reduced the yield, 1000-grain weight and grain thickness, and the average protein content of the grain was increased from 11.64% to 12.83%. They also stated that in areas where occurring end-of-season aqua stress is common, It is more likely that early genotypes have more stable grain quality [25]. Given that under stress conditions during grain filling period, reducing starch storage in the grain due to the significant reduction in the frequency of starch synthesis enzymes under stress conditions and consequently the loss of protein / starch ratio leads to an increase in protein content per unit volume [29]. It can be argued that simultaneous utilization of tolerant genotypes from the stem and grain carbohydrate sources during stress would cause less uptake of the grain starch storage and, consequently, maintain a ratio of protein to starch. Of course, due to the acceptable yield of tolerant genotypes under stress conditions, the amount of protein production per unit area of these genotypes may not only reduce, but also show the relative increase. On contrary, the inability of sensitive genotypes in sufficient and timely utilization of the stem photosynthetic stored materials has caused extensive use of the grain starch storage and then an increase in the ratio of protein to starch percentage. The little effect of drought stress on the traits of grain hardness and water absorption percentage by flour in different genotypes has been observed in the experiments. It has been reported that the higher protein content of the flour causes increase stretchability of the dough. They stated that 28% of changes related to the bread qualitative properties were justified by the amount of protein [30]. The researchers have reported an increase in gluten percentage under stress conditions [31]. However, in the present experiment, not only the gluten percentage of tolerant genotypes failed to increase under stress conditions, but also it was faced with a slight reduction, which was due to high correlation of gluten and protein levels is justifiable, because most of gluten is composed of two protein groups of glutenins and gliadins, and these two groups constitute about 40% of the total protein content of flour [32]. Due to the similarity of the decreasing trend of gluten quality in all three groups' genotypes under drought stress conditions, it seems that stress tolerance and/ or sensitivity had a little effect on the descending trend of gluten index of different genotypes in terms of optimum conditions to stress, but other environmental factors associated with stress may lead to a general reduction in gluten index. Reduced quality of gluten under stress conditions, following the sharp increase in the synthesis of gliadin protons, has been reported against the slight reduction in the accumulation of the grain gliadin proteins [18,33]. Wheat cultivars with high baking quality sediment content in SDS extraction and high strength of high molecular weight glutenins has been mentioned. Therefore, reduced sediment volume of different groups under stress conditions can be due to general reduction of protein storage of glutenin as one of the heavy glutenins under stress conditions, although definite comments in this regard require more detailed studies [34].

3.4 Factor Analysis on Traits

To determine the appropriate number of factors, the number of factors with eigenvalues greater than one was selected and used to form the factor coefficients' matrix, because eigenvalues are obtained from the correlation matrix of the variables and the factor having an eigenvalue less than one compared to other primary factors justifies fewer changes of the total data. For better and more rational interpretation, factor coefficients greater than 0.5 have been considered as a significant factor. Eigenvectors are shown in four factors (Table 4). The largest factor coefficients among the coefficients of each factor represent a trait or traits that play the most role in that factor. Therefore, according to the variable related to the factor coefficients, the factors can be named. When the traits are found together in a factor and have the same factor load, they are correlated, if the load sign is positive, the correlation is positive and if the sign is negative, the correlation is negative. Under drought stress conditions, four factors had eigenvalues higher than one, In which the first four factors justify a total of 59% of total data changes, and 11 traits examined showed 7 traits with a high common rate of 0.550 (Table 4). In the first factor, traits protein percentage, Zeleny sediment volume, bread volume; moisture percentage and water absorption rate had eigenvalues of 0.621, 0.701, 0.544, 0.640, and .688, respectively, all of them had positive coefficients named as the flour quality factor. In the second factor, traits like of wet gluten, gluten elasticity and SDS sedimentation volume had eigenvalues of -0/729, 0/652 and -0/607 named as the quality factor of the dough. The third factor had traits of hardness index and gluten index with eigenvalues of 0/690 and -0/794 named as the quality factor of bread and 1000-grain weight was in fourth factor.

3.5 Cluster Analysis on Traits

The cluster analysis by intra-group variance method classified the genotypes into eight groups (clusters) in terms of different traits (Table 5). In the first group, 21 genotypes were placed (Table 6). In this group, the mean grain protein content was 12.38%, Zeleny sedimentation volume was 33.52 ml, SDS sedimentation volume was 59.83 ml, grain hardness was 53.67%, wet gluten was 28.30, gluten index 58.19 and bread volume was 478/07. The group was weak in terms of wet gluten, but gluten index was good, and the rest of the qualitative traits were moderate. The second group consisted of 5 genotypes with the qualitative traits of protein content of 12.22%, bread volume of 286.5, Zeleny sedimentation volume of 32.5, moisture content of 9.5%, water absorption rate of 64.7%, wet gluten of 31.5, grain hardness 54.5, gluten index of 32.75, SDS sediment volume of 61.25, gluten elasticity of 1.5, and 1000-grain weight of 39.33. This group in terms of the traits of protein content, Zeleny sediment volume and bread volume was weak and in terms of grain hardness, water absorption rate and wet gluten was good, and the rest of the traits were moderate. The third group had 55 genotypes based on moderate qualitative traits. The fourth group had 24 genotypes with the traits of protein content of 12.35%, at the good level, moisture percentage of 9.42%, water absorption rate of 64.2%, and gluten index of 19.86 as weak and the rest of the traits were moderate. The fifth group was ranked the first in the clustering and 25 genotypes were included in this group. That the traits of the protein content of 12.34%, zeleny sedimentation volume of 33.59, 1000-grain weight of 42.33 g and gluten elasticity were moderate and wet gluten of 33.69, the amount of water absorption of 64.69, the grain hardness of 54.48, the moisture percentage of 9.66, the bread volume of 492.9 and SDS sediment volume of 63.36 were good. But, gluten index of 27.25 was weak. Therefore, the genotypes of this group can be used for breeding programs. The sixth group had 36 genotypes and the protein content of 12.58%, Zeleny sediment volume of 34.58, bread volume of 481.77 and sediment volume of 61.5% were at good level, and the rest were at moderate level except for the gluten elasticity. The seventh group was clustered with 2 genotypes as the last rank because most of the qualitative traits were poor. The eighth group had a genotype and the traits of gluten index of 57.5, gluten elasticity of 2 and zeleny sedimentation volume of 34.5 were at good level and the protein content of 12.25, moisture percentage of 9.5, water absorption rate of 64.35, wet gluten of 30 and SDS sediment volume of 60 were moderate, but the grain hardness of 30 and bread volume of 456.5 were at the low level.

Table 4. Results of factor analysis for traits under drought stress

Traits	Subscription rate	Factors			
		1	2	3	4
Protein content (%)	0.739	**0.621**	**-0.590**	0.052	0.046
Zeleny sedimentation volume	0.712	**0.701**	-0.469	0.016	0.024
Bread volume	0.415	**0.544**	-0.060	-0.093	-0.327
Moisture content (%)	0.445	**0.640**	0.081	0.023	0.166
Hardness index	0.587	0.182	-0.170	**0.690**	-0.222
Water absorption rate	0.545	**0.688**	-0.086	0.242	-0.075
Wet gluten	0.591	0.124	**-0.729**	0.093	0.188
Gluten elasticity	0.671	0.039	-0.099	**-0.794**	-0.168
Gluten index	0.548	0.304	**0.652**	0.001	0.173
SDS sedimentation volume	0.450	0.279	**-0.607**	-0.045	-0.040
Weight of thousand seeds (%)	0.804	-0.013	0.051	0.029	**-0.895**
Relative variance	***	27.48	11.79	10.16	9.85
Cumulative variance	***	27.48	39.27	49.43	59.28

Table 5. Group of genotype frequencies in each group in terms of qualitative traits under drought stress

Cluster	Protein content (%)	Zeleny sedimentation volume	Bread volume	Moisture content (%)	Hardness index	Water absorption rate	Wet gluten	Gluten elasticity	Gluten index	SDS sedimentation volume	Weight of thousand seeds (%)
1	12.38	33.52	478.07	9.50	53.76	64.35	28.30	2.119	58.19	59.83	41.32
2	12.22	32.50	286.50	9.50	54.5	64.70	31.5	1.500	32.75	61.25	39.35
3	12.26	33.12	478.24	9.52	53.78	64.30	30.5	1.267	32.85	60.91	41.86
4	12.39	33.69	467.91	9.42	53.72	64.20	31.02	1.717	19.86	61.23	43.34
5	12.34	33.59	492.92	9.66	54.48	64.68	33.69	1.557	27.25	63.36	41.33
6	12.58	34.58	481.77	9.50	53.70	64.32	30.61	1.157	40.95	61.50	41.19
7	12.15	33.00	463.00	9.60	53.50	64.25	29.25	1.250	39.00	32.00	40.73
8	12.25	34.50	456.5	9.50	30.00	64.35	30.00	2.000	57.50	60.00	39.15

Table 6. Number located on each cluster genotypes under drought stress

Cluster	Number genotype
1	1-13-18-19-20-28-31-33-59-81-93-98-99-103-105-119-128-137-148-157-168
2	3-53-54-55-121
3	3-10-17-21-22-23-34-38-39-43-47-58-61-63-64-65-66-67-71-72-74-85-90-91-94-95-97-101-106-109-110-111-114-118-120-125-126-127-130-132-133-134-138-142-143-144-146-151-153-158-159-160-161-164-169
4	5-9-16-30-35-36-40-41-49-56-73-76-79-92-107-108-113-116-117-123-136-139-147-152
5	6-11-24-26-29-37-44-45-46-48-50-60-68-75-87-89-96-102-104-115-135-140-141-162-165
6	7-8-12-14-15-25-27-32-42-51-52-57-62-69-70-77-78-80-82-83-84-86-87-88-100-112-122-129-131-145-150-154-155-163-166-167
7	124-149
8	156

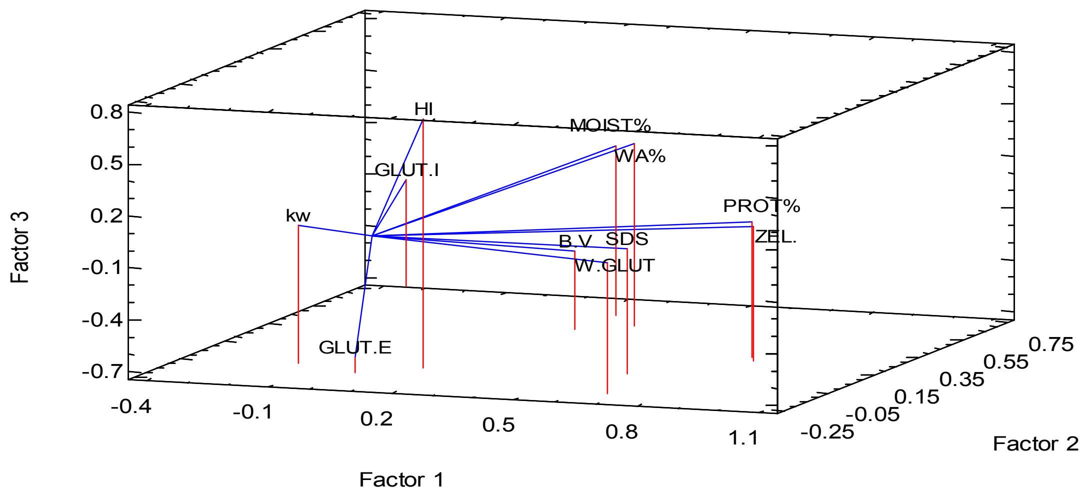

Fig. 1. Triplot analysis of qualitative traits of wheat based on three principle factors

According to the results of this experiment, the genotypes in the fifth group had good quality, and then followed by the sixth, fourth, third, second, first, eighth, and the last (group seven). The results of this experiment showed a good grouping of bread wheat genotypes in relation to qualitative properties associated with bakery features. These results can be used in breeding programs for wheat bread quality and identifying the best genotypes. Three-dimensional 3D plot analysis of the distribution of genotypes based on the traits affecting the first three. The distribution represents the variation among genotypes (Fig. 1). Traits that are in the positive and relative direction with percentage of perineum in drought stress conditions include protein, Zeleny sedimentation volume, SDS sedimentation volume, bread volume and wet gluten. The graph plots lines represent more variance between the views of relevant traits. As well as lower angle showed high correlation among traits.

4. CONCLUSION

Under stress conditions, due to weight loss, which results in a reduction in starch, the protein content and qualitative traits associated with it increase. In analyzing the components, the traits of protein content, bread volume, water absorption, zeleny sedimentation volume and moisture content in the first component were shown to be of high importance in evaluating the quality of the bakery.

Considering that the value and quality of gluten increases the value of bakery. Between protein content and gluten content, there is usually a positive and good relationship. In this research, there was a positive and significant correlation between protein content and bread wheat traits, water absorption, zeleny sedimentation volume, moisture content, grain hardness, wet gluten and SDS sedimentation.

The results of this experiment showed a good grouping of bread wheat genotypes in relation to qualitative traits (protein content, bread volume, water absorption, zeolite sedimentation volume, grain hardness, wet gluten and SDS sedimentation volume) related to bakery characteristics. One can use genotypes in the fifth cluster numbers 6, 11 and 165 in breeding programs for bread wheat bread quality.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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