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Research article

Variation of Correlation Coefficients of Some Quality Parameters of Bread Wheat Grown in Different Conditions[a]

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ABSTRACT

This study was carried out in the central land of Bahri Dağdaş International Agricultural Research Institute in 2017-2018 with 64 bread wheat varieties in rainfed and irrigated conditions according to the randomized blocks experimental design with 2 replications. In the trial, correlation coefficients of thousand kernel weight, protein content, test weight, Zeleny sedimentation, grain hardness, alveograph, farinograph and mixograph parameters were determined. Correlation analysis was carried out to determine the changes in the examined quality parameters in the study under different growing conditions. Correlation coefficients that were similar or different according to the conditions were determined in the examined quality parameters. In rainfed and irrigated conditions, positive correlations were determined between Zeleny sedimentation and mixograph peak height (0.447**,0.3569**), mixograph peak width (0.5054**,0.5725**) alveograph energy value (0.559**, 0.7278**) and farinograph development time (0.3661**, 0.4249**), respectively. Negative significant correlation was found between alveograph (G) and alveograph (P/L) ratio (-0.802**, -0.7765**). Positive correlation (0.5656**, 0.5484**) was found between farinograph water absorbtion and grain hardness (SKCS). Negative significant corelation was determined between mixograph peak area and farinograph softening degree in 12th minute (-0.528**, -0.5279**).

Keywords: Bread wheat, Alveograph, Farinograph, Mixograph, Correlation.

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Araştırma makalesi

Farklı Koşullarda Yetiştirilen Ekmeklik Buğdayların Bazı Kalite Parametrelerinin Korelasyon Katsayıları Değişimi

ABSTRACT

Bu çalışma 2017-2018 yılında Bahri Dağdaş Uluslararası Tarımsal Araştırma Enstitüsü merkez arazisinde 64 ekmeklik buğday çeşidi ile kuru ve sulu koşullarda tesadüf blokları deneme desenine göre 2 tekerrürlü olarak yürütülmüştür. Denemede bin tane ağırlığı, protein oranı hektolitre ağırlığı, Zeleny sedimantasyon, tane sertliği, alveograf, farinograf ve miksograf parametrelerinin korelasyon katsayıları belirlenmiştir. Çalışma kapsamında incelenen kalite parametrelerinin farklı yetiştirme koşullarındaki değişimlerinin belirlenmesi amacıyla korelasyon analizi yapılmıştır. İncelenen kalite parametrelerinde koşullara göre benzer ya da farklılık gösteren korelasyon kat sayıları tespit edilmiştir. Buğday çeşitleri farklı koşullarda yetiştirildiğinde reolojik hamur özelliklerde ekstrem durumlar hariç koşulların etki derecesinin düşük olduğu ve çeşidin genetik yapısıyla ilgili olduğu anlaşılmaktadır. Çeşitlerin fiziksel kalite özelliklerinin diğer kalite parametrelerine göre farklı yetiştirme koşullarından daha fazla etkilendiği tespit edilmiştir.

Anahtar Kelimeler: Ekmeklik buğday, Alveograf, Farinograf, Miksograf, Korelasyon

Introduction

Wheat is the most produced and consumed product among cereals and it is the most important plant in our general economy as well as in the food sector. Due to the climate changes that have occurred in recent years, there has been a significant decrease in wheat cultivation areas and production. Bread wheat has strategic importance for human life since ancient times, and it is expected that the world population will exceed 9.7 billion (Anonymous 2018a) and Turkey's population will exceed 105 million (Anonymous 2018b) in 2050. It is predicted that the demand for wheat will increase by 2% every year in parallel with the population growth in the world (Alexandratos and Bruinsma 2012). World wheat cultivation area is 218.543071 ha, production is 771.718579 tons and grain yield per decare is 353.12 kg. In Turkey, wheat cultivation area is 7.662273 ha, production is 21.500 000 tons and yield per decare is 280.60 kg (Anonymous 2017). Wheat is very effective in our diet (Demirbaş and Atış 2005), approximately 49.9% of the total energy taken from herbal foods, 54.3% of protein intake and 7.1% of oil are provided from cereals and cereal products in our country. The most important issue is the development of varieties with high yield and quality traits in breeding studies. Factors such as the genetic structure of the new varieties, the climate and soil characteristics of the region, the applied cultural processes, diseases and pests cause differences in yield and quality characteristics.The yield and quality level of bread wheat varies depending on the variety x environment interaction (Souza et al., 2004). Genotype is the most important factor in obtaining high grain yield and quality product in plants. Therefore, breeding programs are focused to develop productive and high quality varieties. In order to achieve the breeding goals, the relations of the studied traits with each other, the effect of one on the other or the effect of another trait must be known very well. (Kurt Polat et al. 2015). In order for the breeding programs carried out in terms of yield and quality traits to be more successful, the direct and indirect interactions of the traits should be separated from each other by examining in detail. Therefore, for a successful breeding program, the degree of direct and indirect interaction between yield, yield elements or quality characteristics should be distinguished from each other and revealed in detail (Aykut Tonk et al. 2017; Güngör et al. 2017). In this study, the quality performances of bread wheat varieties grown under different conditions were determined, and the correlation coefficients of farinograph, alveograph and mixograph parameters, which are rheological properties, were determined according to the growing conditions. In this study, it was aimed to determine the quality performances of bread wheat varieties grown under different conditions and to evaluate the correlation coefficients of the rheological properties of farinograph, alveograph and mixograph parameters according to growing conditions.

Material and Methods

The trial was carried out in two replications and quality studies were carried out according to the randomized blocks trial design of 64 different bread wheat varieties grown separately in rainfed and irrigated conditions in the Konya-Center location of Bahri Dağdaş International Agricultural Research Institute. Sowing was done with seeds per square meter (550 units/m^2) in rainfed conditions, 3.5 kg/da N and 6.9 kg/da P_2O_5 and 4 kg/da N (total 7.5 kg/da N) were given as top fertilizer. In irrigated conditions, seeds were planted per square meter (450 units/m^2), and fertilization was made with 12 kg/da N and 7 kg/da P_2O_5 together with sowing. For the irrigated conditions, 2 irrigations were made during the growing season. The 1st irrigation (70 mm) was carried out during the stemming period in April and the 2nd irrigation (70 mm) before flowering in May. Annual precipitation amount was 336 mm in the 2017-2018 growing season. Thousand kernel weight and hectoliter weight were determined according to Elgün et al. (2001). Protein content was determined according to AOAC 992.23 (Anonymous 2009), grain hardness was determined according to AACC 55-31 by Near infrared reflectance spectroscopy (FOSS 2500F model Denmark) device calibrated with SKCS (Single Kernel Characterization System). Zeleny sedimentation (ZLN) was analyzed according to the methods of AACC 56-61A (Anonymous 2000). In laboratory studies, wheat samples were annealed according to AACC method 26-95 (14.5% humidity) and ground in a Brabender Junior mill according to AACC method 26-50 (Anonymous 2000). Farinograph analysis was performed with a Brabender AT model (Germany) device according to the AACC 54-21 (Anonymous 2000) method. In Farinograph analysis; Farinograph development time (DDT), farinograph water absorption (WAC), farinograph stability (STB), farinograph 10 th minute degree of softening (DS10), farinograph 12th minute degree of softening (DS12) were determined. Alveograph analysis was determined by Alveo PC device (Chopin France) according to AACC 54-30A method. With Alveo PC device, dough strength (mm) (P), dough elasticity (mm) (L), square root of the amount of air used to inflate the dough (cm^3)(G), the shape ratio of the curd (P/L), the deformation energy of the dough (W) (10^{-4} joules) were calculated (Anonymous

2000). Mixograph analyzes were performed with a 35 g device (National Mfg.Co. Lincoln. NE) according to the AACC 54-40A method and the results were obtained from Mixsmart software (Walker et al. 1997). Envolope analyzes of the mixogram were taken into account and the MTA value from the middle line analyzes was used in the evaluation. Mixograph development time with mixograph analysis (minutes) (MDT), mixograph peak height (%)(MPH), mixograph softening degree (%min-1) (SD), peak width at the end of the analysis (%) (MPW), mixograph peak area (tork) (MPA), mixograph curve total area values (Torque)(MTA) were calculated. The variance and correlation analyzes of the obtained data were performed according to the statistical analysis program (JMP11), and the mean values of the traits with significant differences were grouped according to the LSD (5%) test (Anonymous 2014).

Results and Discussion

The examined parameters were subjected to analysis of variance and the combined analysis results are given in Table 1. The difference between rainfed and irrigated environments was found to be significant for all the parameters studied. The correlation coefficients of the examined traits in rainfed and irrigated conditions are given in Table 3, the changes in correlation coefficients according to the environments in Table 4 are given.

Table 1. Combined analysis of variance of examined traits

Source	DF	TKW	HW	PRT	ZLN	SKCS	MDT	MPH	MSD	MPW	MPA
Conditions (C)	1	223.599**	88.82799**	0.48476	3570.063**	2472.11**	12.87913**	1511.897**	6.0498**	651.5767**	3616.32**
Variety (V)	63	3228.42**	748.1913**	135.605**	1368.89**	1332.89**	374.995**	14137.22**	3071.24**	4250.744**	17489.7**
Recurrence	1	45.9006	5.80082	6.37562	217.563	124.923	2.256	3.251	1.963	2.36	3.412
C*V	63	670.839**	170.1952*	67.6059**	3426.937**	301.874**	56.887**	3265.075**	728.534**	1450.7025**	4157.74**
Error	127	762.939	223.890	48.889	1880.438	2444.044	2.723	1.909	7.780	3.129	2.019
Source	**DF**	**MTA**	**A (P)**	**A (L)**	**A (G)**	**A (W)**	**P/L**	**FDT**	**FWA**	**F(DS10)**	**F(DS12)**
Conditions (C)	1	27117.81**	100**	3106.063*	490.06*	117049.52*	4.671*	484.165**	86.9556**	1216.27**	1245**
Variety (V)	63	2856.36**	6300.98**	78012.43**	1199.32**	704880.48*	42.813**	5697.1*	1683.15**	175150.36**	1558.33**
Recurrence	1	4.32	3.251	2.852	2.698	3.98	2.345	2.51	2.87	3.215	3.631
C*V	63	6164.15**	6088**	4419.93*	630.36	18451.48*	11.039	158.479*	319.16*	7988.73*	438.83*
Error	127	8.762	1.315	3.473	9.364	1.821	5.040	2.245	2.863	1.750	2.152

TKW: Thousand Kernel Weight, HW: Hectoliter Weight, PRT: Protein Content, ZLN: Zeleny Sedimentation, SKCS: Grain Hardness, MDT: Mixograph Development Time, MPH: Mixograph Peak Height, MSD: Mixograph Softening Degree, MPW: Mixograph Peak Width, MPA: Mixograph Peak Area, MTA: Mixograph Total Area, A(P): Alveograph Peak(P), A(L): Alveograph Length (L) A(G): Alveograph (G), A(W): Alveograph Work(W), A(P/L): Alveograph (P/L), FDT: Farinograph development time, FWA: Farinograph water absorption, F(DS10): farinograph softening degree in 10th minute, F(DS12): farinograph softening degree in 12th minute

It was determined that the mean value of a thousand kernel weight of 64 varieties in rainfed conditions examined in terms of quality characteristics was 33.91 g, the difference between the lowest and highest values was 22.38 g, and the standard deviation value was 4.17. It was determined that the thousand kernel weight of the varieties in irrigated conditions was 35.78 g, the difference between the lowest and highest values was 26.05 g, and the standard deviation value was 4.44 (Table 2). According to the analysis of variance, the interaction between varieties and conditions x varieties was significant ($p<0.01$) (Table 1). It was stated that there were differences in thousand kernel weight of the varieties according to the growing conditions and the standard deviation values of the varieties were close to each other in both conditions. Correlation coefficient values of the examined traits are according to rainfed and irrigated conditions respectively, between thousand kernel weight and hectoliter weight (0.6343**, 0.6002**), protein content (-0.487**, -0.305**), alveograph (L) elasticity value (-0.271*, -0.533**), alveograph (G) value (-0.268*, -0.5487**) and alveograph energy value (W) (-0.391**, -0.2994*) were found negative significant (Table 3).

Table 2. The mean and standard deviation values of the examined traits according to the conditions

	Rainfed conditions						Irrigated conditions					
Traits	**Mean**	**Std Dev**	**Sum**	**Minimum**	**Maximum**	**Difference**	**Mean**	**Std Dev**	**Sum**	**Minimum**	**Maximum**	**Difference**
TKW	33.91	4.17	4340.58	22.87	45.25	22.38	35.78	4.44	4579.8	24.46	50.51	26.05
HW	75.18	2.26	9623.33	65.87	79.39	13.52	74	1.98	9472.53	68.62	77.37	8.75
PRT	13.94	1.00	1784.5	11.97	16.68	4.71	14.03	1.02	1795.64	11.39	16.25	4.86
ZLN	51.21	8.14	6555	32.00	70.00	38.00	43.74	9.00	5599	24.00	66.00	42.00
SKCS	54.81	7.11	7015.23	36.59	76.68	40.09	61.02	9.92	7810.76	42.84	86.64	43.80
MDT	3.84	1.44	491.28	1.84	8.00	6.16	3.39	1.16	433.86	1.67	7.20	5.53
MPH	65.57	9.3	8392.6	46.67	90.92	44.25	60.71	7.11	7770.47	43.85	82.15	38.3
MSD	9.88	3.99	1265.14	1.07	21.15	20.08	10.19	3.75	1304.5	3.28	21.63	18.35
MPW	9.83	5.61	1257.93	2.77	28.95	26.18	6.64	3.67	849.51	2.59	18.58	15.99
MPA	122.39	32.00	15665.2	64.06	195.67	131.6	98.63	26.14	12625	54.38	191.29	136.91
MTA	340.32	42.32	43560.5	228.13	450.63	222.5	319.73	30.73	40925.7	230.16	417.32	187.16
A(P)	64.98	17.53	8318	32.00	111	79.00	66.23	15.4	8478	37.00	110	73.00
A(L)	87.34	25.04	11180	43.00	186	143	65.31	18.3	8360	33.00	132	99.00
A(G)	20.55	2.91	2630	14.60	30.3	15.70	17.78	2.44	2275.8	12.80	25.5	12.70
A(W)	203.52	65.5	26050	72.00	400	328	160.75	52.11	20576	63.00	335	272
A(P/L)	0.84	0.45	107.68	0.17	2.58	2.41	1.11	0.47	142.26	0.41	2.94	2.53
F(DT)	10.82	5.90	1384.68	2.37	19.58	17.21	8.07	4.69	1032.62	2.00	19.59	17.59
F(WAB)	59.07	3.15	7560.4	50.00	66.00	16.00	60.23	2.42	7709.6	52.7	67.4	14.70
F(DS10)	27.42	27.08	3510	10.00	171	111.0	31.78	35.7	4068	12.00	163	151.0
F(DS12)	73.33	42.78	4400	18.00	228	210.0	96.74	46.66	6772	22.00	218	196.0

TKW: Thousand Kernel Weight, HW: Hectoliter Weight, PRT: Protein content, ZLN: Zeleny Sedimentation, SKCS: Grain Hardness, MDT: Mixograph Development Time, MPH: Mixograph Peak Height, MSD: Mixograph Softening Degree, MPW: Mixograph Peak Width, MPA: Peak Area, MTA: Mixograph Total Area, A(P): Alveograph (P), A(L): Alveograph (L) A(G): Alveograph (G), A(W): Alveograph (W), A(P/L): Alveograph (P/L), FDT: Farinograph development time, FWA: Farinograph water absorption, F(DS10): farinograph softening degree in 10th minute, F(DS12): farinograph softening degree in 12th minute

Similar correlations were found between the examined traits and the thousand kernel weight in both conditions. Aydoğan and Soylu (2017) found a positive significant correlation (0.6173*) between thousand kernel weight and hectoliter weight in a parallel study. It was observed that the protein content and alveograph (L) elasticity value increased with the decrease in thousand kernel weight, and likewise, the alveograph energy value increased with the increase in the alveograph (P) resistance value (Table 3). The negative effects that may occur due to environmental conditions also affected the correlation coefficient values, but some quality parameters did not change depending on the genetic characteristics of the variety.

Hectoliter weight is the weight of grains in unit volume and has a commercial importance as it is an indicator of flour yield (Elgün et al. 2001). In rainfed conditions, the mean value of hectoliter weight was 75.18 kg, the difference between the lowest and the highest value was 13.52 kg, and the standard deviation value was 2.26. In irrigated conditions, the mean value of hectoliter weight was 74.00 kg, the lowest and the highest value difference was 8.75 kg, and the standard deviation value was 1.98 (Table 2). As a result of variance analysis, the interaction between varieties ($p<0.01$) and varieties x conditions was found to be significant ($p<0.05$) (Table 1). Considering the correlation coefficients between rainfed and irrigated conditions interms of hectoliter weight; mixograph development time (-0.304*, -0.2849*), mixograph peak width (-0.388**, -0.3335**) and mixograph total area (-0.357**, -0.2979*) were found to be negatively significant (Table 3). Şahin et al. (2019) in their study with 20 genotypes, found a significant negative correlation of 5% between hectoliter weight and Zeleny sedimentation (-0.270), mixograph development time (-0.329) and mixograph peak width (-0.326). In both conditions, as the hectoliter weight decreased, mixograph development time, peak width and area values increased. The change in thousand kernel weight and hectoliter weight from the physical properties of the grain affects the protein quality and causes changes in the kneading processes of the dough. When the environmental conditions are different, it can be said that the change in the physical properties of the grain affects some dough parameters less and this is due to the trait of variety (Table 3).

Table 3. Correlation coefficients of the examined traits according to the conditions

Rainfed condition				Irrigated condition			
Variable	**The dependent variable**	**Correlation**	**Signif Prob**	**Variable**	**The dependent variable**	**Correlation**	**Signif Prob**
HW	**TKW**	0.6343	<.0001	**HW**	**TKW**	0.6002	<.0001
PRT	**TKW**	-0.487	<.0001	**PRT**	**TKW**	-0.305	0.0005
M(DT)	**HW**	-0.304	0.0145	**MDT**	**HW**	-0.2849	0.0214
M(PH)	**ZLN**	0.4477	0.0002	**M(PH)**	**ZLN**	0.3569	0.0035
M(PH)	**SKCS**	0.3455	0.0052	**M(PH)**	**SKCS**	0.4026	0.0009
M(PW)	**HW**	-0.388	0.0016	**M(PW)**	**HW**	-0.3335	0.0066
M(PW)	**ZLN**	0.5054	<.0001	**M(PW)**	**ZLN**	0.5725	<.0001
M(PA)	**HW**	-0.357	0.0037	**M(PA)**	**HW**	-0.2979	0.0159
M(PA)	**ZLN**	0.5941	<.0001	**M(PA)**	**ZLN**	0.7555	<.0001
M(TA)	**ZLN**	0.4554	0.0002	**M(TA)**	**ZLN**	0.5023	<.0001
M(TA)	**SKCS**	0.3563	0.0039	**M(TA)**	**SKCS**	0.3932	0.0012
A(P)	**ZLN**	0.3435	0.0055	**A(P)**	**ZLN**	0.3918	0.0012
A(P)	**SKCS**	0.3999	0.0011	**A(P)**	**SKCS**	0.3891	0.0014
A(P)	**M(PH)**	0.4012	0.001	**A(P)**	**M(PH)**	0.4851	<.0001
A(P)	**M(PW)**	0.4845	<.0001	**A(P)**	**M(PW)**	0.3454	0.0048
A(P)	**M(PA)**	0.4821	<.0001	**A(P)**	**M(PA)**	0.4978	<.0001
A(P)	**M(TA)**	0.4395	0.0003	**A(P)**	**M(TA)**	0.602	<.0001
A(L)	**TKW**	-0.271	0.0306	**A(L)**	**TKW**	-0.533	<.0001
A(L)	**SKCS**	-0.296	0.0174	**A(L)**	**SKCS**	-0.3324	0.0068
A(L)	**A(P)**	-0.522	<.0001	**A(L)**	**A(P)**	-0.3237	0.0085
A(G)	**TKW**	-0.268	0.0323	**A(G)**	**TKW**	-0.5487	<.0001
A(G)	**SKCS**	-0.294	0.0183	**A(G)**	**SKCS**	-0.318	0.0098
A(G)	**A(P)**	-0.532	<.0001	**A(G)**	**A(P)**	-0.3267	0.0079
A(G)	**A(L)**	0.994	<.0001	**A(G)**	**A(L)**	0.9954	<.0001
A(W)	**TKW**	-0.391	0.0014	**A(W)**	**TKW**	-0.2994	0.0154
A(W)	**ZLN**	0.559	<.0001	**A(W)**	**ZLN**	0.7278	<.0001
A(W)	**M(DT)**	0.5185	<.0001	**A(W)**	**M(DT)**	0.5491	<.0001
A(W)	**M(PH)**	0.5338	<.0001	**A(W)**	**M(PH)**	0.4422	0.0002
A(W)	**M(PW)**	0.7567	<.0001	**A(W)**	**M(PW)**	0.6185	<.0001
A(W)	**M(PA)**	0.8266	<.0001	**A(W)**	**M(PA)**	0.8472	<.0001
A(W)	**M(TA)**	0.4841	<.0001	**A(W)**	**M(TA)**	0.5352	<.0001
A(W)	**A(P)**	0.5916	<.0001	**A(W)**	**A(P)**	0.5472	<.0001
A(P/L)	**SKCS**	0.3511	0.0044	**A(P/L)**	**SKCS**	0.3335	0.0066
A(P/L)	**A(P)**	0.8474	<.0001	**A(P/L)**	**A(P)**	0.7853	<.0001
A(P/L)	**A(L)**	-0.764	<.0001	**A(P/L)**	**A(L)**	-0.7516	<.0001
A(P/L)	**A(G)**	-0.802	<.0001	**A(P/L)**	**A(G)**	-0.7765	<.0001
F(DT)	**ZLN**	0.3661	0.0029	**F(DT)**	**ZLN**	0.4249	0.0004
F(DT)	**M(DT)**	0.6918	<.0001	**F(DT)**	**M(DT)**	0.8364	<.0001
F(DT)	**M(SD)**	-0.531	<.0001	**F(DT)**	**M(SD)**	-0.5843	<.0001
F(DT)	**M(PW)**	0.6312	<.0001	**F(DT)**	**M(PW)**	0.7201	<.0001
F(DT)	**M(PA)**	0.5496	<.0001	**F(DT)**	**M(PA)**	0.6006	<.0001
F(DT)	**A(W)**	0.5456	<.0001	**F(DT)**	**A(W)**	0.5188	<.0001
F(WA)	**SKCS**	0.5656	<.0001	**F(WA)**	**SKCS**	0.5484	<.0001
F(WA)	**M(PH)**	0.7175	<.0001	**F(WA)**	**M(PH)**	0.6148	<.0001
F(WA)	**M(SD)**	0.3684	0.0027	**F(WA)**	**M(SD)**	0.2832	0.0223
F(WA)	**M(TA)**	0.6968	<.0001	**F(WA)**	**M(TA)**	0.6535	<.0001
F(WA)	**A(P)**	0.6689	<.0001	**F(WA)**	**A(P)**	0.6992	<.0001
F(WA)	**A(P/L)**	0.4595	0.0001	**F(WA)**	**A(P/L)**	0.5912	<.0001
F(DS10)	**M(SD)**	0.2779	0.0262	**F(DS10)**	**M(SD)**	0.4997	<.0001
F(DS10)	**A(P/L)**	0.379	0.002	**F(DS10)**	**A(P/L)**	0.3253	0.0082
F(DS12)	**ZLN**	-0.407	0.0258	**F(DS12)**	**ZLN**	-0.6213	<.0001
F(DS12)	**M(DT)**	-0.476	0.0079	**F(DS12)**	**M(DT)**	-0.523	0.0013
F(DS12)	**M(PW)**	-0.484	0.0068	**F(DS12)**	**M(PW)**	-0.494	0.0026
F(DS12)	**M(PA)**	-0.528	0.0027	**F(DS12)**	**M(TA)**	-0.5279	0.0011
F(DS12)	**A(W)**	-0.423	0.02	**F(DS12)**	**A(W)**	-0.4846	0.0032
F(DS12)	**A(P/L)**	0.4216	0.0203	**F(DS12)**	**A(P/L)**	0.3426	0.044
F(DS12)	**F(DT)**	-0.687	<.0001	**F(DS12)**	**F(DT)**	-0.6906	<.0001
F(DS12)	**F(DS10)**	0.9074	<.0001	**F(DS12)**	**F(DS10)**	0.9561	<.0001

TKW: Thousand Kernel Weight, HW: Hectoliter Weight, PRT: Protein Content, ZLN: Zeleny Sedimentation, SKCS: Grain Hardness, MDT: Mixograph Development Time, MPH: Mixograph Peak Height, MSD: Mixograph Softening Degree, MPW: Mixograph Peak Width, MPA: Peak Area, MTA: Mixograph Total Area, A(P): Alveograph (P), A(L): Alveograph (L) A(G): Alveograph (G), A(W): Alveograph (W), A(P/L): Alveograph (P/L), FDT: Farinograph development time, FWA: Farinograph water absorption, F(DS10): farinograph softening degree in 10th minute, F(DS12): farinograph softening degree in 12th minute

It was determined that the mean value of protein content in rainfed conditions was 13.94%, the difference between the lowest and the highest value was 4.71%, and the standard deviation value was 1.00. It was defined that the protein content in irrigated conditions was 14.03%, the lowest and the highest value difference was 4.86%, and the standard deviation value was 1.02 (Table 2). According to the analysis of variance, the interaction between varieties and varieties x conditions was significant ($p<0.01$) (Table 1). Although the environmental conditions were different, the mean value of the protein content of the grain was close to each other and therefore the interaction between the conditions was found to be insignificant.

In rainfed conditions, Zeleny sedimentation mean value was 51.21 ml, the difference between the lowest and highest values was 38 ml and the standard deviation values were 8.14. In irrigated conditions, Zeleny sedimentation mean value was 43.74 ml, the difference between the lowest and highest values was 42 ml and the standard deviation values were 9 (Table 2). According to the analysis of variance, the interaction between varieties and varieties x conditions was significant ($p<0.01$) (Table 1). In rainfed and irrigated conditions respectively; Positive correlation coefficient values were determined between Zeleny sedimentation and mixograph peak height (0.447**,0.3569**), mixograph peak width (0.5054**,0.5725**), mixograph area (0.5941**, 0.7555**), mixograph total area (0.4554**, 0.5023**) , alveograph (P) resistance (0.3435**, 0.3918**), alveograph energy value (0.559**, 0.7278**) and farinograph development time (0.3661**, 0.4249**). Negative correlation coefficient value was found between Zeleny sedimentation and farinograph softening degree in 12th minute (-0.407*, -0.6213**). In another study, it was determined that there was a positive and high correlation between Zeleny sedimentation value and alveograph energy value (r= 0.709**). Also a positive and high correlation was calculated between Zeleny sedimentation and farinograph water absorption value (r= 0.3811**), and a negative (r=-0. 3013*) correlation was calculated between the softening value (Keçeli et al. 2017). These results are also in line with our findings. In both conditions, the increase in Zeleny sedimentation value affected the rheological paste properties. Significant positive and negative interactions were obtained. As a matter of fact, Konopka et al. (2004) stated that the rheological properties of the dough are more strongly related to the Zeleny test value than the protein content, and our results confirm this situation. The decrease in the Zeleny sedimentation value causes a decrease in the strength and resistance during dough kneading, and with the short kneading time of the dough, the elasticity value increases, that is, dough with low resistance and weak character is obtained. It can be said that Zeleny sedimentation values are not much affected by environmental conditions, but rather related to the genetic structure of the variety.

While hard grain structure is desired for bread quality, material with soft endosperm is preferred in biscuit production (Karaduman et al. 2017). In rainfed conditions, it was defined that the mean SKCS hardness value was 54.81%, the difference between the lowest and the highest value was 40.09% and the standard deviation values were 7.11. It was determined that the mean value of SKCS hardness in irrigated conditions was 61.02%, the difference between the lowest and the highest value was 43.80% and the standard deviation values were 9.92 (Table 2). According to the analysis of variance, the interaction between varieties and varieties x conditions was significant ($p<0.01$) (Table 1). Considering the correlation coefficient values of rainfed and irrigated conditions, with SKCS hardness; mixograph peak height (0.3455**,0.4026**), mixograph total area (0.3563**, 3932**), alveograph (P) resistance value (0.3999**, 0.3891**), alveograph (P/L) ratio (0.3511**, 3335**), farinograph water absorption (0.5656**, 0.5484**) positive significant; alveograph (L) elasticity value (-0.296*, -0.3324*) and alveograph (G) value (-0.294*, -0.318*) was found to be negative significant. In both cases, as the SKCS hardness value increased, that is, as the grain structure became harder, mixograph peak height, total area and alveograph (P) resistance values increased, while alveograph (L) and (G) values decreased. Sönmez and Olgun (2019) investigated the interrelationships of some quality parameters in 6 different bread wheat cultivars grown in dry and irrigated conditions. In the study, the correlation between hardness value and thousand grain weight, hectoliter weight, protein and Zeleny sedimentation in rainfed conditions, and all parameters except Zeleny sedimentation in irrigated conditions were found. Grain hardness is effective on many quality parameters as well as on the classification and processing of the product. Although the genetic basis is effective, environmental conditions affect the hardness value. It was determined that the hardness value in irrigated conditions was higher than in rainfed conditions. This difference is thought to be due to the effect of environmental conditions.

According to the results of the analysis of variance performed on the mixograph parameters examined, the interaction between varieties and varieties x conditions was found to be significant ($p<0.01$) (Table 1). It was determined that the mean value of mixograph development time in rainfed conditions was 3.84 min, the difference between the lowest and highest values was 6.16 min and the standard deviation values were 1.44. It was specified that the mean value of mixograph development time in irrigated conditions was 3.39 min, the difference between the lowest and highest values was 5.53 min and the standard deviation values were 1.16 (Table 2). Considering the correlation coefficient values of rainfed and irrigated conditions, mixograph development time; Alveograph energy value (0.5185**, 0.5491**) and farinograph development time (0.6918**, 0.8364**) were found to be positive, while farinograph softening degree in 12th minute (-0.476**, -0.523**) was found to be negative (Table 3). In this study, a positive correlation (0.5185**) was found between mixograph development time and alveograph energy value, while Cuniberti et al. (2003) similarly found a positive correlation (0.287**) between same parameters.

In rainfed conditions, the mean value of the mixograph peak height was 65.57%, the difference between the lowest and highest values was 44.25% and the standard deviation values were 9.30. In irrigated conditions, the mean value was 60.71%, the difference between the lowest and the highest value was 38.30% and the standard deviation value was 7.11 (Table 2). Correlation coefficient values in dry and wet conditions were respectively with mixograph peak height; Significant positive correlation between alveograph (P) resistance value (0.4012**, 0.4851**), alveograph energy value (W) (0.5338**, 0.4422**), farinograph water absorption (0.7175**, 0.61.48**) detected (Table 3). There was a correlation between mixograph peak height and alveograph energy value (0.5338**) in this study, while Gaines et al. (2006) found a correlation (0.41*) between mixograph peak height and alveograph energy value in a study they conducted to compare the methods used to evaluate gluten quality. These findings are also similar to the results we obtained. In both conditions, the increase in the mixograph peak height significantly improves the rheological properties of the dough. It was determined that the increase in the mixograph peak height in dry conditions was due to the increase in protein content. The increase in the elasticity and strength of the dough causes the increase in the peak height and development time, and accordingly the increase in the energy value. The kneading resistance of the dough is inversely proportional to the degree of softening. As the strength of the dough increases the degree of softening decreases.

It was determined that the mean value of mixograph softening degree in rainfed conditions was 9.88%, the difference between the lowest and highest values was 20.08% and the standard deviation value was 3.99. It was defined that the mean value of the mixograph softening degree in irrigated conditions was 10.19%, the difference between the lowest and highest values was 18.35% and the standard deviation values were 3.75 (Table 2). In rainfed and irrigated conditions, a significant positive correlation was found between mixograph softening degree and farinograph water absorption (0.3684**, 0.2832*), and again between farinograph softening degree in 10th minute (0.2779*,0.4997**). A negative significant correlation was found between mixograph softening degree and farinograph development time (-0.531**, -0.5843**) (Table 3). Since strong doughs have the capacity to absorb more water during kneading, their development time is also longer. As strong doughs absorb more water during kneading, their rising times will be longer. If the protein quality is low in doughs obtained from weak flours, damage occurs in the gluten networks due to the resistance during kneading and accordingly the degree of softening increases.

In rainfed conditions, the mean value of the mixograph peak width was specified as 9.83%, the difference between the lowest and the highest value was 26.18% and the standard deviation values were 5.61. In irrigated conditions, the mean value of the mixograph peak width was determined as 6.64%, the difference between the lowest and the highest value was 15.99% and the standard deviation value was 3.67 (Table 2). Considering the correlation coefficient values examined in rainfed and irrigated conditions, a positive significant correlation was found between mixograph peak width and farinograph development time (0.6312**,0.7201**). A negative significant correlation was determined between mixograph peak width, farinograph softening degree in 12th minute and hectoliter weight (-0.484**,-0.494**, -0.388**) (Table 3). In a study by Ohm and Chung (1999), 12 hard winter wheats were analyzed in terms of mixograph parameters, and the difference between cultivars was found to be statistically significant at the ($p<0.01$) level in terms of mixograph peak width and height parameters. In strong flours, the dough shows resistance during kneading and when this resistance continues until the end of the analysis, the peak width increases. In weak flours, the dough resistance decreases towards the end of the analysis, and the peak width decreases due to the decrease in dough resistance.

Mixograph peak area means that the distance between the highest and lowest values of the peak and includes the development time of the dough, the peak height and the softening value. It was determined that the peak area was high in strong flours and low in weak flours, while the average value was 122.39% in rainfed conditions, the difference between the lowest and highest values was 131.60% and standard deviation values were 32. It was determined that the average value of the mixograph peak area in irrigated conditions was 98.63%, the difference between the lowest and the highest value was 136.91% and the standard deviation values were 26.14 (Table 2). In rainfed and irrigated conditions, positive significant corelations coefficients were found between mixograph peak area and alveograph (P) resistance (0.4821**,0.4978**), alveograph energy value (W) (0.8266**,0.8472**), farinograph development time (0.5496**, 0.6006**). Negative significant corelation was determined between mixograph peak area and farinograph softening degree in 12th minute (-0.528**, -0.5279**) (Table 3). Sahin et al. (2019) found a significant correlation (1%) between alveograph energy value (W) and mixograph MPW (0.485), MPA (0.728), MTA (0.619). As dough resistance, development time and energy value increase, the peak area increases; As the softening degree elongation ability increases, decrease in the peak area is observed.

Alveograph resistance (P) value is related to dough hardness or elasticity, the higher this value, the harder the dough is. Bakers do not prefer hard doughs because kneading times are long and they generally use it as a blend. Bakers do not prefer hard doughs because of their long kneading times and generally use them in flour mixtures. It was determined that the average of alveograph (P) resistance in rainfed conditions was 64.98, the difference between the lowest and the highest value was 79 and the standard deviation was 17.53. In irrigated conditions, the mean value of alveograph (P) resistance was 66.23, the difference between the lowest and the highest value was 73, and the standard deviation values were 15.40 (Table 2). As a result of variance analysis, the interaction between varieties ($p<0.01$) and varieties x conditions ($p<0.05$) was significant (Table 1). Considering the values of the correlation coefficients in rainfed and irrigated conditions, positive significant correlations were found between alveograph (P) and alveograph energy value (0.5916**,0.5472**), alveograph (P/L) ratio (0.8474**,0.7853**) and again positive significant correlations were determined between alveograph (P) and farinograph water absorption (0.6689**,0.6992**), and SKCS hardness (0.3999**, 0.3891**). In another study, Bettge et al. (1989) find positive correlation (0.253**) between hardness and alveograph (P) value in hard wheats. Negative significant correlation were found between alveograph (P) and alveograph (L) elasticity value (-0.522**, -0.3237**), alveograph (G) value (-0.532**, -0.3267**) (Table 3). If the alveograph (P) resistance value is high, it causes an increase in the energy value, (P/L) ratio, water absorption, and grain hardness values; if it is low, the elongation and elasticity values increase.

Alveograph elasticity (L) value is the measurement of the extensibility of the dough, and it was defined that the mean value in rainfed conditions was 87.34, the difference between the lowest and the highest value was 143 and the standard deviation values was 25.04. In irrigated conditions, the mean value of alveograph elasticity (L) was 65.31, the difference between the lowest and the highest value was 99 and the standard deviation values were 18.30 (Table 2). Analysis of variance was significant between varieties ($p<0.01$) and the interaction between varieties x conditions ($p<0.05$) (Table 1). Considering the correlation coefficients in rainfed and irrigated conditions; A positive significant correlation was determined between the alveograph (L) elasticity elongation value and the alveograph (G) value (0.994**,0.9954**). A negative significant correlation was found between alveograph (L) elasticity value and alveograph (P/L) ratio (-0.764**,-0.7516**). A negative correlation was determined between alveograph (L) value and TKW (-0.271*) (Table 3) and a similar result (-0.16**) was obtained from a research conducted by Bordes et al. (2008). With the increase in dough extensibility, resistance values decreased.

Alveograph (P/L) ratio express the balance between dough hardness and extensibility. If this ratio is greater than 1, the dough is expressed as hard, if it is less than 1, it is expressed as soft. Alveograph P/L ratio being 1 indicates that the resistance and elongation ability are equal. In this research, the mean value of alveograph P/L in rainfed conditions is 0.84, the difference between the lowest and the highest value is 2.41 and the standard deviation values are 0.45. In irrigated conditions, the mean value of the alveograph (P/L) ratio was 1.11, the difference between the lowest and the highest value was 2.53 and the standard deviation was 0.47 (Table 2). According to the variance analysis results, the interaction between varieties ($p<0.01$) and varieties x conditions was found to be insignificant (Table 1). Considering the correlation coefficients in rainfed and irrigated conditions, a positive significant correlation was determined between the alveograph (P/L) ratio and the farinograph water absorption value (0.4595**, 0.5912**). Again, positive significant correlations were found between alveograph (P/L) ratio and farinograph 10 min softening value (0.379**,0.3253**) and farinograph softening degree in 12th minute (0.4216*,0.3426**) (Table 3). A positive significant correlation was found between farinograph water absorbtion with alveograph (P) and (P/L) value (0.6689**,0.4595**) (Table 3) and a similar finding (0.89*, 0.84*) was determined by Konopka et al. (2004). In this study, a positive correlation (0.5656**) was found between F(AW) and SKCS, while a similar correlation (0.763**) was obtained in another study (Hruska et al. 2006).

It was determined that the mean value of alveograph swelling index (G) in rainfed conditions was 20.55, the difference between the lowest and the highest value was 15.70 and the standard deviation value was 2.91. In irrigated conditions, the mean value of the alveograph (G) was 17.78, the difference between the lowest and the highest value was 12.70, and the standard deviation values were found to be 2.44 (Table 2). As a result of variance analysis, the interaction between varieties ($p<0.01$) and varieties x conditions was found to be insignificant (Table 1). Considering the correlation coefficient values in rainfed and irrigated conditions, a negative significant correlation was found between alveograph (G) and alveograph (P/L) ratio (-0.802**, -0.7765**). At the same time, a negative correlation (-0.268*) was found between the alveograph G value and the TKW value (Table 3), while a similar correlation (-0.16**) was also defined by Bordes et al. (2008).

The balance between the resistance and the extensibility of the dough caused an increase in the water holding capacity of the flour, and the increase in the dough's extensibility caused an increase in the softening values. The alveograph energy (W) value reflects the balance between dough resistance (P) and extensibility (L). In rainfed conditions, the mean value of alveograph energy was (W) 203.52, the difference between the lowest and the highest value was 328 (W) and the standard deviation value was 65.5. In irrigated conditions, the mean value of alveograph energy was 160.75 (W), the difference between the lowest and the highest value was 272 (W), and the standard deviation values were 52.11 (Table 2). As a result of variance analysis, the interaction between varieties ($p<0.01$) and between varieties x conditions was found significant ($p<0.05$) (Table 1). In rainfed and irrigated conditions, positive significant correlation was found between alveograph energy value and farinograph development time (0.5456**, 0.5188**), negative significant was determined correlation between alveograph energy value and farinograph softening degree in 12th minute (-0.423*, -0.4846**) (Table 3). A positive correlation (0.559**, 0.7278**) was found between the alveograph (W) value and the Zeleny value in both conditions (Table 3), and similar results (0.906**) were also supported by Payne et al. (1988). The increase in the energy value causes the dough strength to be good and the development time of the dough will increase, as well as a decrease in the softening values. Higher values for alveograph (W) and (G) values results in bigger dough bubble owing to balanced elastic and extensibility features (Indrani et al. 2007). In both growing conditions, the alveograph energy value also increases depending on the increase in the resistance of the dough to kneading, otherwise, as the dough development times shorten, the degree of softening increase. It has been observed that environmental conditions are effective in the changes in dough resistance.

It was determined that the average of farinograph development time in rainfed conditions was 10.82 min, the difference between the lowest and the highest value was 17.21 min and the standard deviation value was 5.90 min. It was defined that the mean value of farinograph development time in irrigate conditions was 8.07 min, the difference between the lowest and the highest value was 17.59 min. and the standard deviation value was 4.69 (Table 2). According to the correlation coefficient values in dry and wet conditions, a negative significant correlation was found between farinograph development time and farinograph softening degree in 12th minute (-0.687*,-0.6906**) (Table 3). Şahin et al. (2019), determined a significant correlation of 5% ($p<0.05$) between farinograph development time and mixograph peak width (0.357), and mixograph total area (0.394). In the same study, they determined a significant correlation of 1% ($p<0.01$) between farinograph development time and alveograph W value (0.736), alveograph (Ie) (0.747), mixograph development time PT (0.625), and mixograph TINT (0.668).

In rainfed conditions, the average value of farinograph softening degree in 10th minute was 27.42 min, the difference between the lowest and the highest value was 111 and the standard deviation was determined to be 27.08 values. In irrigated conditions, the mean value of farinograph softening degree in 10th minute was 31.78 min, the difference between the lowest and the highest value was 151 min and the standard deviation value was 35.70 min. (Table 2). When the correlation coefficient values were examined in rainfed and irrigated conditions, farinograph softening degree in 10th minute and farinograph softening degree in 12th minute (0.9074**,0.9561**) were found to be significant. In another study similar to these results, a negative correlation ($r=-0.878$) was found between the degree of dough softening and development times (Linina et al. 2014).

In rainfed conditions, the mean value of farinograph softening degree in 12th minute was 73.33, the difference between the lowest and the highest value was 210 and the standard deviation was 42.78 values. In irrigated conditions, farinograph softening degree in 12th minute was 96.74, the difference between the lowest and the highest value was 196, and the standard deviation value was found to be 46.66. The increase in the softening degree of the 10th and 12th minutes of farinograph indicates that the kneading resistance of the dough is weak.

The average of farinograph water absorption value in rainfed conditions was 59.07%, the difference between the lowest and the highest value was 16 and the standard deviation value was found to be 3.15. It was determined that the mean value of farinograph water absorption in irrigated conditions was 60.23, the difference between the lowest and the highest value was 14.70 and standard deviation values were 2.42 (Table 2). A positive significant correlation was found between farinograph water absorbtion with alveograph (P) and (P/L) value (0.6689**,0.4595**) (Table 3) and a similar finding (0.89*, 0.84*) was determined by Konopka et al (2004). In this study, a positive correlation (0.5656**) was found between F(AW) and SKCS, while a similar correlation (0.763**) was obtained in another study (Hruska et al. 2006).

In different conditions, the correlation coefficients of some of the examined traits changed according to the conditions. A negative significant correlation was found between protein content and hectoliter weight (-0.4638**). Meles et al. (2017) obtained similar results in a study they conducted and found that there was a negative correlation (-0.21*) between protein ratio and hectoliter weight. Positive significant correlations were found between protein content and mixograph peak height, alveograph energy value and farinograph water absorption (0.2868*, 0.3136*, 0.3994*) in rainfed conditions (Table 4). In another study consistent with these results, it was declared that there was a significant correlation (0.43*) between farinograph water absorption and protein content in Canadian wheat samples (Morgan et al., 2000). Negative significant correlations were determined between Zeleny sedimentation value and thousand kernel weight and hectoliter weight (-0.2076*,-0.2485**). A positive significant correlation was found between Zeleny sedimentation value and farinograph water absorption (0.4462**). Also Hruskova et al. (2006) found a positive correlation (0.661) between Zeleny value and farinograph water absorption. A positive significant correlation (0.2868*) was determined between the mixograph peak height and the protein content. Negative significant correlation (-0.3726**) was found between Mixograph total area and thousand kernel weight, positive significant correlation (0.4248**) was found between Mixograph total area and farinograph water absorption. A positive significant correlation (0.249*) was determined between the alveograph (P) resistance value and the mixograph development time. A negative significant correlation was found between alveograph energy value and hectoliter weight and mixograph softening degree (-0.2817*, -0.2875*), a positive significant correlation was found between alveograph energy value and protein content (0.3136*). A positive significant correlation was found between farinograph water absorption and protein content, zeleny sedimentation mixograph total area value (0.3994**,0.4462**0.4248**), again a positive significant correlation was obtained between farinograph softening degree in 12th minute and mixograph softening degree (0.4569*). In irrigated conditions, positive significant correlations were found between mixograph development time and Zeleny sedimentation, alveograph (G) value (0.4089**, 0.298*). Also similar results have been obtained from other studies and Gaines et al. (2006) found a correlation (0.49*) between mixograph development time and sedimantation value in their research. Negative significant correlations were determined between mixograph development time, farinograph water absorption and farinograph softening degree in 10th minute (-0.3775*, -0.5233**) (Table 4). In irrigated conditions, negative correlations were determined between the softening degree of mixograph and Zeleny sedimentation value (-0.3153*), between farinograph water absorption and mixograph development time (-0.3775*), between farinograph water absorption and alveograph (L) elongation ability (-0.3405*). In a similar study, a negative correlation (0.3744**) was found between the degree of mixograph softening and the zeleny sedimentation value (Aydoğan et al. 2022). Significant corelations were determined between alveograph (G) value and protein content (0.3307*), between alveograph (G) value and Zeleny sedimentation (0.3084*), between alveograph (G) value and mixograph development time, mixograph total area (0.298*,0.3103*). Negative significant correlations were obtained between farinograph softening degree in 10th minute and Zeleny sedimentation, mixograph development time, mixograph peak width, total area and alveograph energy value (-0.4966**, -0.5233**, -0.3607*, -0.4204**,-0.3779*). Parallel to these results, Aydoğan et al. (2015) stated that the degree of softening at the 10 th minute was negatively correlated with the zeleny value and dough development time (-0.527, -0.548).

Table 4. Correlation coefficient ratios changing according to conditions

Rainfed condition				Irrigated condition			
Variable	**by Variable**	**Correlation**	**Signif Prob**	**Variable**	**by Variable**	**Correlation**	**Signif Prob**
PRT	**HW**	-0.4638	<.0001	**M(DT)**	**ZLN**	0.4089	0.0007
ZLN	**TKW**	-0.2076	0.0187	**M(SD)**	**ZLN**	-0.3153	0.0105
ZLN	**HW**	-0.2485	0.0047	**A(G)**	**PRT**	0.3307	0.0071
MPH	**PRT**	0.2868	0.0216	**A(G)**	**ZLN**	0.3084	0.0125
M(PA)	**TKW**	-0.3726	0.0024	**A(G)**	**M(DT)**	0.298	0.0159
A(P)	**M(DT)**	0.249	0.0473	**A(G)**	**M(TA)**	0.3103	0.0119
A(W)	**HW**	-0.2817	0.0241	**F(WA)**	**M(DT)**	-0.3775	0.0019
A(W)	**PRT**	0.3136	0.0116	**F(WA)**	**A(L)**	-0.3405	0.0055
A(W)	**M(SD)**	-0.2875	0.0213	**F(DS10)**	**ZLN**	-0.4966	<.0001
F(WA)	**PRT**	0.3994	0.0011	**F(DS10)**	**M(DT)**	-0.5233	<.0001
F(WA)	**ZLN**	0.4462	0.0002	**F(DS10)**	**M(PW)**	-0.3607	0.0032
F(WA)	**M(TA)**	0.4248	0.0005	**F(DS10)**	**M(TA)**	-0.4204	0.0005
F(DS12)	**M(SD)**	0.4569	0.0111	**F(DS10)**	**A(W)**	-0.3779	0.0019

TKW: Thousand Kernel Weight, HW: Hectoliter Weight, PRT: Protein Content, ZLN: Zeleny Sedimentation, MSD; Mixograph Softening Degree, MPW: Mixograph Peak Width, MTA: Mixograph Total Area, A(P): Alveograph Peak , A(L): Alveograph Length A(G): Alveograph , A(W): Alveograph Work (W), F(WA): Farinograph water absorption, F(DS10): farinograph softening degree in 10th minute, F(DS12): farinograph softening degree in 12th minute

Conclusion

In order to develop bread wheat varieties with high quality, breeding of genotypes suitable for different environmental and growing conditions is needed. As a result of the study, similar correlations were obtained in terms of properties examined in irrigated and rainfed conditions in bread wheat, while changes were obtained in correlation of some parameters according to the conditions. Considering the results of the correlation analysis performed in both conditions, it was determined that there was a positive significant correlation between the alveograph energy value and Zeleny sedimentation, farinograph development time and mixograph parameters (development time, peak width, peak height, peak area and total area). While a positive significant correlation was determined between farinograph development time and Zeleny sedimentation value, mixograph development time, mixograph peak width, mixograph area value; a negative significant correlation was determined between farinograph development time and mixograph softening value. Positive significant correlation was found between farinograph water absorption and SKCS hardness, mixograph peak width, mixograph total area, alveograph resistance and alveograph (P/L) ratio. Significant positive correlation was found between Mixograph peak width and Zeleny sedimentation, SKCS hardness value and alveograph (P) resistance value. The relationship between alveograph energy value and protein content, alveograph energy value and Zeleny sedimentation in dry conditions was found to be positively significant. It has been determined that the physical quality characteristics of the varieties are more affected by different growing conditions than other quality parameters. While differences were determined in the correlation values of the quality parameters determined under different conditions, it was observed that some quality parameters were not affected by the growing conditions due to genetic effects. In breeding studies, parameters with strong genetic effects and which do not change with the effect of the environment will be determined, and new genotypes will be included in breeding programs and quality varieties will be obtained.

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Conflict of Interest

No known or potential conflict of interest exist for any author.

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