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ARAŞTIRMA MAKALESİ

Evaluation of Bread Wheat Genotypes in terms of Quality and Mixograph Parameters in Rainfed Conditions

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Abstract

This study was carried out with 12 different bread wheat varieties in rainfed conditions and in different years (2009-2010, 2010-2011, 2011-2012, 2012-2013, 2013-2014) according to the randomized blocks experimental design with two replications. Mixograph parameters (development time, peak height, degree of softening, total area), protein content, Zeleny sedimentation and grain hardness values were investigated. The 5-year average value range of the examined quality traits; mixograph (development time 1.82-3.51 min, peak height 52.12-68.48%, softening degree 8.08-27.99% and total area 293-362 Nm), protein content 12.62-16.92, Zeleny sedimentation value 32.00-61.50 ml and grain hardness (PSI) was determined as 43.96-69.88%. In terms of mixograph parameters, the year*variety interaction was found to be significant at the 1% level. According to the five-year average values, high values were obtained in Eraybey, Dağdaş-94, Demir-2000 and Gün-91 cultivars in terms of mixograph parameters. It has been determined that the variety and climatic factors play a decisive role in the mixograph parameters, which have an important place in the estimation of wheat quality.

Ekmeklik Buğday Genotiplerinin Yağışa Dayalı Şartlarda Kalite ve Miksograf Parametreleri Açısından Değerlendirilmesi

Öz

Bu çalışma 12 farklı ekmeklik buğday çeşidi ile yağışa dayalı koşullar ve farklı yıllarda (2009-2010, 2010-2011, 2011-2012, 2012-2013, 2013-2014) tesadüf blokları deneme desenine göre iki tekerrürlü olarak yürütülmüştür. Miksograf parametreleri (gelişme süresi, pik yüksekliği, yumuşama derecesi, toplam alan), protein oranı, Zeleny sedimantasyon ve tane sertliği değerleri incelenmiştir. İncelenen kalite özelliklerinin 5 yıllık ortalama değer aralığı; miksograf (gelişme süresi 1.82-3.51 dk, pik yüksekliği %52.12-68.48, yumuşama derecesi %8.08-27.99 ve toplam alan 293-362 Nm), protein oranı %12.62-16.92, Zeleny sedimantasyon değeri 32.00-61.50 ml ve partikül iriliği sayısı (PSI) %43.96-69.88 olarak belirlenmiştir. Miksograf parametreleri bakımından yıl*çeşit interaksiyonu %1 seviyesinde önemli bulunmuştur. Beş yıllık ortalama değerlere göre, miksograf parametreleri bakımından Eraybey, Dağdaş-94, Demir-2000 ve Gün-91 çeşitlerinde yüksek değerler elde edilmiştir. Buğday kalitesinin tahmininde önemli bir yeri olan miksograf parametrelerinde çeşit ve iklim faktörlerinin belirleyici rol oynadığı tespit edilmiştir.

Introduction

Wheat has a greater importance than other agricultural products because it is the raw material source of basic nutrients used in human nutrition all over the world. Wheat is known as the raw material of bread and as the basic nutrient of about 50 countries around the world, with this aspect it meets the nutritional needs of 35% of the total population and 20% of daily calories (Kaya et al., 2015). Turkey's wheat cultivation area in 2017 was 7.6 million ha, production was 21.5 million tons and grain yield was 280 kg/decare, and it constituted 3.5% of the world's wheat cultivation areas (Anonymous, 2018).

Wheat is the main raw material in the production of many bakery products, especially bread (Karaoğlu and Kotancılar, 2007), different from other cereal flours, it has some unique features (gluten formation, viscoelastic dough formation, porous and fluffy product with gas holding ability). It has a privileged place among cereals for reasons (Mccarthy et al., 2005; Dizlek et al., 2013). There are 338 registered bread wheat cultivars in Turkey as of 2020 (Anonymous, 2020). The main focus of the wheat breeding program is to develop high yielding wheat varieties that meet grain quality standards. Selection of genotypes with high quality traits and high grain yield is important in breeding programs (Kılıç et al., 2014). Since the quality in wheat genotypes is controlled not by a single gene, but by many genes, many variations occur in the factors affecting the quality. Factors such as genotype, soil structure, climate characteristics are the most important factors affecting wheat quality (Cornish et al., 2006). Protein content, sedimentation value and dough rheological properties are important quality traits that are commonly used. Among the rheology properties, the dough development time, water absorption, stability, peak height and softening degrees provide important information about protein quality. At the same time, the protein quality of wheat endosperm is the most important factor that determines the baking quality of bread, and flours obtained from wheat grains with the same protein content can give very different results during baking due to the quality differences in gluten proteins (Annet et al., 2007). In studies aiming to determine the relationships between chemical and analytical analysis parameters and rheological and technological analysis parameters, it has been revealed that rheological and technological properties cannot be predicted only on the amount of protein (Bushuk et al., 1969).

It is very important to determine the performance of the varieties with the raw material quality required by the developing flour industry. Mixograph is a device used to analyze the rheological properties of dough (Bağcı, 1998), three important properties of wheat flour can be predicted by using mixograph: optimum kneading time, kneading resistance and protein quality. The peak point is the highest point obtained from the mixograph. The time required to reach this level provides information on the strength of the gluten proteins. After the peak, the mixograph curve begins to decline, the width of the curve and the angle of descending downward indicate the tolerance of the dough against excessive kneading (Bağcı and Şahin 1999). In order to further improve quality, an effective selection parameter in the early generation is required in the wheat quality breeding program. Due to the large number of quality parameters that require examination in the development of wheat varieties, breeding programs use predictive methods to test end use quality. Mixograph is a widely used predictive test with which end use quality of many genotypes can be evaluated in a short time. Dough mixing properties are essential in determining wheat processing and end-use quality. Cereal scientists need to be able to measure and understand the basic mechanical properties of wheat flour doughs. Isaak (2019) indicated that gluten strength is a critical feature of bread wheats and an important factor affecting dough properties and end product quality, as a result of his study, he determined that the use of mixograph for dough mixing was very effective in distinguishing gluten strength.

In this study, some quality characteristics (protein, Zeleny sedimentation, grain hardness) and mixograph parameters (MDT: Mixograph Development Time, MPH: Mixograph Peak Height, MTA: Mixograph Total Area, MSD: Mixograph Softening Degree) of different bread wheat varieties in rainfed conditions were determined in a multi-year study.

Material and Method

This study was conducted with 12 bread wheat varieties (Altay-2000, Bağcı-2002, Bayraktar-2000, Bezostaya-1, Dağdaş-94, Demir-2000, Eraybey, Gerek-79, Gün-91, Karahan-99, Müfitbey, Sönmez-2001) in Konya-Center location of Bahri Dağdaş International Agricultural Research Institute in rainfed conditions according to the randomized blocks experimental design with 2 replications in 2009-2010, 2010-2011, 2011-2012, 2012-2013 ve 2013-2014 growing periods. Protein content, Zeleny sedimentation, grain hardness values (acording to particle size index(PSI)) and mixograph parameters (development time, peak height, degree of softening, total area) were investigated. Annual rainfall was (395, 425, 306.10, 306.30 and 320 mm) in the growing seasons of 2009-2010, 2010-2011, 2011-2012, 2012-2013 and 2013-2014 respectively. In laboratory studies, wheat samples were annealed according to AACC method 26-95 (14.5% humidity) and ground

according to AACC method 26-50 in the Brabender Junior mill (Anonymous, 2010). Protein content according to AOAC 992.23 (Anonymous, 2009) by Leco FP 528 analyzer (Leco Inc, St Joseph, MI), grain hardness according to PSI (Particle Size Index) by Near infrared reflectance spectroscopy (NIRs) device according to AACC 39-10 method (Anonymous, 2010) and Zeleny sedimentation AACC 56-61A (Anonymous, 2010) were analyzed according to the methods. Mixograph analyzes were performed with a 35 g mixograph device (National Mfg.Co. Lincoln. NE) according to the AACC 54-40A method. The variance analyzes of the data obtained from the trials were made according to the JMP11 statistical analysis program at a significans level of $p<0.05$ (Anonymous, 2014).

Results and Discussion

In the study, it was determined that wheat quality and mixograph parameters of rheological properties were affected by variety and year factors (Table 1).

Table 1. Combined analysis of variance of examined traits

Source of Variation	SD	Protein Content		Particle Size Index		Zeleny Sedimentation		Mixograph Development Time	
Variety	11	63.7450	<.0001**	8298.76	<.0001**	12195.96	<.0001**	39.9778	<.0001**
Years	4	52.7291	<.0001**	777.64	<.0001**	2295.88	<.0001**	9.0814	<.0001**
Recurrence	1	0.2622	0.4181	5.187	0.6632	6.533	0.3013	0.1104	0.205
Variety*Years	44	40.8275	0.0011*	3176.64	0.0003*	5337.11	<.0001**	35.0134	<.0001**
Error	59	23.2673		1570.49		354.46		3.9657	

Source of Variation	SD	Mixograph Peak Height		Mixograph Total Area		Mixograph Softening Degree	
Variety	11	2115.36	<.0001**	45777.54	<.0001**	5396.125	<.0001**
Years	4	4465.74	<.0001**	80239.78	<.0001**	1310.968	<.0001**
Recurrence	1	23.4941	0.0741	131.853	0.376	0.4031	0.7688
Variety*Years	44	1569.52	<.0001**	55559.11	<.0001**	1832.531	<.0001**
Error	59	419.292		9776.19		272.6571	

Table 2. Mean values of the examined quality traits by years

	Protein	Zeleny	MDT	MPH	MTA	MSD	Particle Size Index
2009-2010	14.18	41.71	2.86	53.94	301	22.76	54.89
2010-2011	14.79	44.00	2.99	58.04	359	16.51	56.59
2011-2012	13.90	51.92	3.07	65.48	345	12.54	61.83
2012-2013	15.52	50.50	2.53	65.54	336	15.87	54.99
2013-2014	15.34	52.50	2.35	70.88	374	16.86	57.79
Mean	14.75	48.13	2.76	62.78	342	16.91	57.22

MDT: Mixograph Development Time, MPH: Mixograph Peak Height, MTA: Mixograph Total Area, MSD: Mixograph Softening Degree

Protein Content

Protein content and quality have an important role in determining the rheological properties of the dough and the suitability of the product to be processed for the intended use. The protein content in the study varied according to the varieties in different years. The average protein contents were determined for the years 2009-2010 (14.18%), 2010-2011 (14.79%), 2011-2012 (13.90%), 2012-2013 (15.52%) and 2013-2014 (15.34%) (Table 2). Considering the general averages by years, it was determined that the protein content was higher in 2012-2013, and the lowest value was obtained in 2011-2012. Significant differences were found between the varieties in terms of protein content (1%) and the interaction between years*varieties (5%) (Table 1). The five-year average protein content of the cultivars was determined as 14.75%, the highest value was determined as 16.21% in Dağdaş-94 and the lowest value was 13.45 % in the Gerek-79 cultivar (Table 3). Aydoğan et al. (2018), in a similar study, found that the protein content range of 910 genotypes in the bread wheat advanced yield trial between 2010 and 2015 varied between 11.50% and 15.72%, and the highest rate was obtained in the 2010-2011 growing period. In another study, Naneli et al. (2015) found that the difference between varieties in terms of protein content was significant at the level of 1% in both years, varying between 10.8-13.9% in the first year and 8.2-11.5% in the second year.

Table 3. Combined analysis of variance of examined traits

Varieties	Protein Content (%)					
	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	Mean
Altay-2000	14.34	15.54	14.01	15.88	15.07	14.97
Bağcı-2002	13.85	14.61	12.66	15.23	16.13	14.49
Bayraktar-2000	12.62	13.80	13.62	14.28	14.16	13.70
Bezostaya-1	14.04	14.65	14.57	15.49	16.23	14.99
Dağdaş-94	15.06	16.92	15.18	17.21	16.68	16.21
Demir-2000	13.54	16.01	13.00	15.66	15.14	14.67
Eraybey	14.71	14.25	14.13	15.10	15.69	14.77
Gerek-79	13.12	13.69	13.59	13.02	13.84	13.45
Gün-91	14.73	13.94	13.94	16.69	15.82	15.02
Karahan-99	14.97	14.88	14.58	16.25	15.51	15.23
Müfitbey	15.11	15.17	13.77	15.99	14.99	15.00
Sönmez-2001	14.09	14.10	13.80	15.52	14.90	14.48
Mean	14.18	14.79	13.90	15.52	15.34	14.75
$CV_{(\%)}$	5.36	3.64	4.67	2.54	4.52	
$LSD_{(0.05)}$	1.64	1.20	1.41	0.86	1.49	

Zeleny Sedimentation

Zeleny sedimentation value is one of the most important properties used in determining the gluten quality in bread wheat. The high volume obtained by swelling of the flour particles indicates that the dough can hold water better, and accordingly, the bread volumes are higher. In the study, Zeleny sedimentation value varied in different years. Mean value of Zeleny sedimentation were determined as 41.71 ml in the period of 2009-2010, 44.00 ml in 2010-2011, 51.92 ml in 2011-2012, 50.50 ml in 2012-2013, 52.50 ml in 2013-2014. Considering the general averages by years, the highest Zeleny sedimentation value was obtained in 2013-2014 and the lowest in 2009-2010 (Table 2). Zeleny sedimentation value was found to differ significantly between cultivars and years (1%) and years*cultivars interaction (5%) (Table 1). It is stated that the sedimentation value indicates the amount and quality of gluten, and it is also a method used to estimate the protein amount of wheat with the same gluten quality (Elgün et al., 2001). According to the five-year mean values, the trial mean of the Zeleny sedimentation value of the cultivars was 48.13 ml, the highest value was 61.50 ml in the Eraybey variety and the lowest value was 32.00 ml in the Bayraktar-2000 variety. The difference between the variety means was found to be significant (Table 4). Ozturk and Aydin (2004), in a study in which they determined the sedimentation values under different growing conditions; The values were determined as 32.20 ml in irrigated conditions, 35.70 ml in rainfed conditions, 34.00 ml in early drought stress conditions, 35.00 ml in late drought stress conditions and 37.50 ml in continuous drought stress conditions. Naneli et al. (2015), in their study, they found that the difference between the varieties in terms of Zeleny sedimentation value is significant in both years (1%). They reported that the highest sedimentation values were obtained with 24.2-38.3 ml in Bağcı-2002 variety in the first year, with 25.8-38.2 ml in Bezostaya-1 variety in the second year. The sedimentation values obtained in the study were consistent with similar studies, but the genotype and environmental factors caused wide variations in the sedimentation values.

Particle Size Index (PSI)

Particle size index is one of the important factors in determining the quality and it is also used in the classification of flours. It determined that the flour yield of hard wheat was higher than that of soft wheat, the protein amount of wheat passed to flour with a much less loss during milling, and the content of water absorption and bread volume was higher. (Elton ve Greer, 1971). It has been measured in terms of grain hardness (Particle size index) and values close to 100 express the grain softness, although the hardness and softness depend on the variety, it is affected by the climate conditions. The hardness values (PSI) of the varieties for years were determined as 54.89% in 2009-2010, 56.59% in 2010-2011, 61.83% in 2011-2012, 54.99% in 2012-2013 and 57.79% in 2013-2014. The lowest hardness value was 54.89% in 2009-2010 and the highest hardness value was 61.83% in 2011-2012 (Table 2). Significant differences were found in the grain hardness value between cultivars and years (1%), years*cultivars interaction (5%) (Table 1). According to the five-year averages, Bayraktar-2000 was in the soft group with 69.89% and Dağdaş-94 variety in the hard group with 43.96% (Table 5). Şahin et al. (2013) determined that the hardness value (PSI) varied between 27 and 73 % in 314 genotypes during the 2011-2012 growing period, and the mean grain hardness value (PSI) was 52.50%. In a similar study, Aydoğan and Soylu (2015) determined the mean hardness value of bread wheat varieties as 50.89% in rainfed conditions. In the same study, grain hardness value changed between 41.27% and 64.82% and it was reported that the difference between the conditions was significant.

Table 4. The mean value of Zeleny sedimentation of the examined varieties according to years

Varieties	Zeleny Sedimentation (ml)					
	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	Mean
Altay-2000	43.5	53.5	52.0	59.0	57.5	53.1
Bağcı-2002	51.0	42.0	70.5	58.0	56.5	55.6
Bayraktar-2000	31.0	32.0	32.0	32.5	32.5	32.0
Bezostaya-1	47.5	48.0	45.5	60.5	68.5	54.0
Dağdaş-94	32.5	33.0	31.0	33.0	31.0	32.1
Demir-2000	39.0	45.5	39.5	63.0	65.5	50.5
Eraybey	53.0	55.0	67.5	59.5	72.5	61.5
Gerek-79	37.5	46.5	33.5	34.5	34.0	37.2
Gün-91	51.5	50.0	62.0	47.0	54.0	52.9
Karahan-99	49.0	56.5	69.5	68.0	64.0	61.4
Müfitbey	29.0	31.5	51.5	45.0	54.0	42.2
Sönmez-2001	36.0	34.5	68.5	46.0	40.0	45.0
Mean	41.71	44.00	51.92	50.50	52.50	48.13
$CV_{(\%)}$	6.35	5.96	5.24	3.88	1.88	
$LSD_{(0.05)}$	6.68	6.59	4.05	4.23	4.27	

Table 5. Mean values of particle size index of the examined varieties according to years

Varieties	Particle Size Index (PSI) %					
	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	Mean
Altay-2000	70.91	63.92	70.00	59.25	56.35	64.09
Bağcı-2002	55.87	57.50	63.00	55.72	55.50	57.52
Bayraktar-2000	75.50	68.69	75.00	65.17	65.05	69.88
Bezostaya-1	45.02	57.35	54.00	47.75	55.04	51.83
Dağdaş-94	40.08	42.50	38.00	39.99	59.23	43.96
Demir-2000	47.38	58.72	59.00	60.15	51.46	55.34
Eraybey	56.50	48.50	59.00	61.52	65.60	58.22
Gerek-79	70.25	70.30	76.00	61.52	64.63	68.54
Gün-91	40.79	50.65	59.00	49.41	56.11	51.19
Karahan-99	72.30	60.00	83.00	65.70	58.37	67.87
Müfitbey	42.23	45.34	54.50	47.83	49.23	47.82
Sönmez-2001	41.86	55.62	51.50	45.83	56.92	50.34
Average	54.89	56.59	61.83	54.99	57.79	57.22
$CV_{(\%)}$	6.18	5.71	4.64	6.51	4.10	
$LSD_{(0.05)}$	11.41	6.94	14.14	7.76	13.34	

Mixograph Development Time

The advantage of the mixograph device compared to other rheological dough devices is that it can analyze rapidly with 35 g of flour and in a short time such as 8 minutes and is used in breeding programs. During the kneading of the dough, a curve occurs, and in this curve, many parameters such as dough development time, peak height, softening degree, peak area, peak width and total area values are obtained. In the research, the mean values of mixograph development time of the varieties for years were determined as 2009-2010 (2.86 min), 2010-2011 (2.99 min), 2011-2012 (3.07 min), 2012-2013 (2.53 min), 2013-2014 (2.35 min). The five-year mean values of mixograph development time of the varieties in the study varied between 1.82 and 3.51 minutes. It was determined that the highest development time was 3.07 min in 2011-2012 and the lowest development time was 2.35 min in 2013-2014 (Table 2). In terms of mixograph development time, a significant difference (1%) was found between varieties, years and years*varieties (Table 1). According to the five-year average values, the highest development time was obtained in Eraybey variety with 3.51 minutes, and the lowest value was obtained in the Gerek- 79 variety with 1.82 minutes (Table 6). Significant positive correlation was found between mixograph development time and Zeleny sedimentation (Table 10). Aydoğan et al. (2018) found that the mixograph development time of 910 genotypes of the bread wheat advanced yield trial between 2010 and 2015 varied between 1.10 and 6.00 minutes. Şahin et al. (2013), in a similar study, determined that the average development time of mixograph was 3.2 minutes, the lowest value was 1.1 and the highest value was 11.4 min.

Table 6. Mean value of mixograph development time of the examined varieties according to years

Varieties	Mixograph Development Time (min)					
	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	Mean
Altay-2000	3.36	4.27	2.67	2.68	2.48	3.09
Bağcı-2002	3.16	3.10	2.55	2.47	2.43	2.74
Bayraktar-2000	3.66	3.98	1.82	4.32	3.65	2.48
Bezostaya-1	3.97	3.23	3.30	2.61	2.55	3.13
Dağdaş-94	1.94	1.88	3.22	2.88	1.72	2.33
Demir-2000	1.77	2.16	2.55	1.88	1.49	1.97
Eraybey	4.49	3.49	3.59	2.61	3.40	3.51
Gerek-79	1.44	1.85	2.66	1.50	1.64	1.82
Gün-91	3.11	3.69	2.37	2.18	2.45	2.76
Karahan-99	2.92	3.33	4.78	3.52	2.65	3.44
Müfitbey	2.92	2.92	3.94	2.13	2.25	2.83
Sönmez-2001	1.58	2.05	3.47	1.64	1.56	2.06
Mean	2.86	2.99	3.07	2.53	2.35	2.76
CV(%)	3.45	5.12	5.86	4.88	3.31	
LSD(0.05)	0.84	0.52	0.39	1.62	5.09	

Mixograph Peak Height

It is the point at which the curve reaches its maximum height from the beginning of the dough kneading. In the research, the average mixograph peak height values of the varieties for years; 2009-2010 (53.94%), 2010-2011 (58.04%), 2011-2012 (65.48%), 2012-2013 (65.54%) and 2013-2014 (70.88%) were determined. The five-year average mixograph peak height of the cultivars varied between 52.12-68.48%, the highest peak height was obtained in 2013-2014 with 70.88%, and the lowest peak height was obtained in 2009-2010 with 53.94% (Table 2). In terms of peak height value, significant differences were found between varieties, years and years*varieties (1%). According to the five-year average values, the highest value was obtained in Dağdaş-94 variety with 68.48%, and the lowest value was obtained in Altay-2000 variety with 58.64% (Table 8). The increase in the mixograph peak height in bread wheat is an indication of a better gluten resistance. The mixograph peak height increases in wheat with a hard grain structure. Significant positive correlation was determined between mixograph peak height and protein content (Table 10). Aydoğan et al. (2019) determined that the mixograph peak height in bread wheats varied between 69.15-79.34%, the trial average was 74.25%, the highest value was in Konya-2002 and the lowest value was in Pehlivan variety. Mao et al. (2013) generally stated that the development times of strong doughs are long and the peak values are high. Aydoğan et al. (2019) stated in a study they conducted with bread and durum wheat that the peak height of the mixograph was higher in bread wheat, and this height was due to the high gluten resistance.

Table 7. Mean value of mixograph peak heights of the examined varieties according to years

Varieties	Mixograph Peak Height (%)					
	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	Mean
Altay-2000	46.99	53.58	61.69	63.78	67.14	58.64
Bağcı-2002	52.52	55.72	69.10	72.26	73.50	64.62
Bayraktar-2000	44.91	47.85	47.50	53.24	67.12	52.12
Bezostaya-1	46.25	60.80	67.56	62.14	71.00	61.55
Dağdaş-94	59.00	68.00	73.79	66.17	75.46	68.48
Demir-2000	59.67	61.84	71.89	70.00	75.00	67.68
Eraybey	61.26	57.76	60.50	65.79	74.72	64.01
Gerek-79	58.48	58.07	59.50	60.00	62.50	59.71
Gün-91	60.67	63.10	60.00	69.81	74.00	65.52
Karahan-99	47.85	51.88	75.32	66.21	67.01	61.65
Müfitbey	56.47	59.55	69.95	69.27	73.50	65.75
Sönmez-2001	53.23	58.37	69.00	67.79	69.56	63.59
Mean	53.94	58.04	65.48	65.54	70.88	62.78
CV(%)	1.41	5.29	2.01	2.62	2.24	
LSD(0.05)	1.28	6.55	2.86	3.73	7.48	

Mixograph Softening Degree

The gluten reveals the viscoelastic properties of wheat flour dough and is important in determining the bread quality of different wheat varieties (Holme, 1966). In addition to the high development time of the dough, it is desired that the degree of softening is low. Mean of mixograph softening values by years were determined as 2009-2010 (22.76%), 2010-2011 (16.51%), 2011-2012 (12.54%), 2012-2013 (15.87%) and 2013-2014 (16.86%). According to the five-year average values, the mixograph softening value of the varieties varied between 8.08% and 27.99%, and the highest softening value was obtained in 2009-2010 with 22.76% and the lowest average value was obtained in 2011-2012 with 12.54% (Table 2). In terms of mixograph softening value, significant differences (1%) were found between varieties, years and years*varieties (Table 1). According to the five-year means, the highest softening value was obtained in Dağdaş-94 variety with 27.94%, and the lowest value was obtained in Karahan-99 variety with 11.01% (Table 8). A dough that decreases the mixograph softening degree is stronger. Negative significant correlation was determined between mixograph softening degree and Zeleny sedimentation (Table 10). Aydoğan et al. (2010) stated that a low degree of softening is an indication that gluten networks are strong and that the dough will show strong resistance to pallets.

Table 8. Mean values of mixograph softening degree of the examined varieties by years

Varieties	Mixograph Softening Degree (%)					
	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	Mean
Altay-2000	14.9	10.76	8.99	10.29	12.73	11.53
Bağcı-2002	16.24	13.07	10.74	14.05	17.86	14.39
Bayraktar-2000	13.55	6.47	5.43	5.84	9.11	13.08
Bezostaya-1	12.68	12.73	15.85	12.78	14.66	13.74
Dağdaş-94	36.54	31.85	14.52	33.5	23.54	27.99
Demir-2000	37.72	25.25	16.92	17.3	22.69	23.97
Eraybey	8.39	11.39	8.53	11.07	11.81	10.24
Gerek-79	45.52	22.61	18.33	22.5	19.65	25.72
Gün-91	19.63	13.33	10.62	13.03	19.63	15.25
Karahan-99	15.18	10.83	8.81	10.93	9.33	11.01
Müfitbey	16.08	14.36	9.11	14.2	21.75	15.1
Sönmez-2001	36.76	25.52	22.6	25	19.58	25.89
Mean	22.76	16.51	12.54	15.87	16.86	16.91
$CV_{(\%)}$	2.21	4.99	6.11	4.5	5.19	
$LSD_{(0.05)}$	4.73	7.16	2.03	2.92	4.12	

Mixograph Total Area

The high total area of the mixograph indicates that the gluten structure of the kneaded dough is strong, and the high resistance of the dough to the pallets during kneading causes this area to increase. The increase in mixograph development time and peak height causes an increase in the total area value. In the research, the mean mixograph peak height values of the varieties by years were determined as 2009-2010 (301 Nm), 2010-2011 (359 Nm), 2011-2012 (345 Nm), 2012-2013 (336 Nm) and 2013-2014 (374 Nm) (Table 2). The five-year mean mixograph total area values varied between 293 Nm and 362 Nm, the highest value was obtained in 2013-2014 with 374 Nm, and the lowest value with 301 Nm in 2009-2010. In terms of the mixograph total area value, significant differences were found (1%) between the varieties, years and years*cultivars (Table 1). According to the five-year means, the highest total area among the varieties was obtained in Eraybey variety with 362 Nm and the lowest value was obtained in Bayraktar-2000 variety with 293 Nm (Table 9). With increasing flour strength of the varieties, there was a clear trend to increasing mixograph total area.

Correlation Between Traits

Considering the correlation coefficient of the examined mixograph parameters; Positive correlations were found between mixograph development time and Zeleny sedimentation (0.2187*), again between mixograph development time and particle size index (0.1844*) (Table 10). Positive relationships were determined between mixograph peak height and Zeleny sedimentation (0.3494**), mixograph peak height and protein content (0.3417**). The high peak height of the mixograph is an important feature for bread wheat and shows the strength of the dough. Martinant et al. (1998) stated that there is a significant relationship between mixograph peak height and protein (0.62). A negative significant correlation was

determined between the mixograph peak height and the partial size index (-0.1905*). While positive significant relationships were determined between mixograph total area and Zeleny sedimentation (0.3631**), mixograph total area and protein content (0.2442*), a negative relationship was found between mixograph total area and partial size index (-0.2282*). Negative significant correlations were determined between mixograph softening degree and Zeleny sedimentation (-0.3744**), and between mixograph softening degree and particle size index (-0.3395**).

Table 10. Correlation coefficients between examined traits

Variable	The dependent variable	Correlation	Signif Prob
MDT	Zeleny Sedimentation	0.2187	0.0164
MPH	Zeleny Sedimentation	0.3494	<.0001
MTA	Zeleny Sedimentation	0.3631	<.0001
MSD	Zeleny Sedimentation	-0.3744	<.0001
Protein Content	MPH	0.3417	0.0001
Protein Content	MTA	0.2472	0.0065
Particle Size Index	MDT	0.1844	0.0447
Particle Size Index	MPH	-0.1905	0.038
Particle Size Index	MTA	-0.2282	0.0126
Particle Size Index	MSD	-0.3395	0.0002

MDT: Mixograph Development Time, MPH: Mixograph Peak Height, MTA: Mixograph Total Area, MSD: Mixograph Softening Degree

Conclusion

Quality traits are affected by environment and genotype. The climatic differences between the years played an important role in the emergence of the variety*year interaction. Since quality parameters are highly dependent on genetic and environmental factors, it is inevitable to make evaluations according to existing conditions and to prefer varieties that show little change in quality and yield levels against changing environmental conditions. The chemical properties of some bread wheat varieties, the rheological properties of the dough were examined in rainfed conditions in Konya location, and it was determined that the differences in quality properties were significant between cultivars and years. When evaluated in terms of five-year mean values, it was determined that the quality of Eraybey, Dağdaş-94, Gün-91, Karahan-99 and Müfitbey varieties were high in terms of quality traits. Strong wheat varieties have stronger dough properties. It is thought that the needs of the producers and the flour industry will be met by making quality studies of bread wheat varieties and determining the performance of the varieties by providing more efficient and quality production.

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