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Using the GlutoPeak Tester in Determining the Quality Characteristics of Some Bread Wheat Varieties

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ABSTRACT
This study aims to determine the physical, chemical and technological, rheological properties of 10 registered bread wheat varieties developed by Bahri Dağdaş International Agricultural Research Institute and their quality status in bread analysis and GutoPeak analysis. At the same time, it aims to investigate the relationships between physical, chemical, technological, rheological, and bread analyses with GlutoPeak quality parameters and to reveal the potential of the varieties. In the study, some quality parameters and significance levels between varieties were determined. Also, the results obtained from the GlutoPeak analysis are explained by comparing them with other quality parameters. Protein ratio, wet gluten, and Zeleny sedimentation values were found to be highly correlated with GlutoPeak AM, BEM, AGGRE, PM, GPRT, GW, and GWA. In addition, it was determined that there was a high correlation between harmonograph water absorption and GlutoPeak AGGRE, AM, BEM, GGLT, GPRT, GW, GWA, and PM values. Autograph W value was positively correlated with GlutoPeak AM, BEM, PM, GPRT, GGLT, GW, GWA, and AGGRE values and negatively correlated with PMT. The results obtained in terms of the examined characteristics in this study show that some varieties stand out in terms of different quality characteristics. With the results of this study, it was determined that the GlutoPeak device can detect the quality of wheat flour with fewer samples and in a short time, therefore, GlutoPeak analysis will be useful in variety development and similar studies in bread wheat.

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Bazı Ekmeklik Buğday Çeşitlerinin Kalite Özelliklerinin Belirlenmesinde Glutopik Test Cihazının Kullanılması

ÖZET
Bu çalışmanın amacı Bahri Dağdaş Uluslararası Tarımsal Araştırma Enstitüsü Müdürlüğü tarafından geliştirilen tescilli 10 ekmeklik buğday çeşidinin bazı fiziksel, kimyasal ve teknolojik, reolojik özellikleri ve ekmek analizleri ile Glutopik analizlerinde kalite durumlarının tespit edilmesidir. Aynı zamanda fiziksel, kimyasal, teknolojik, reolojik ve ekmek analizlerinin, Glutopik kalite parametreleri ile arasındaki ilişkilerin araştırılması ve çeşitlerin potansiyellerinin ortaya konulması amaçlanmıştır. Araştırmada, bazı kalite parametreleri ve çeşitler arasında önemlilik düzeyleri belirlenmiştir. Ayrıca, Glutopik analizinden elde edilen sonuçlar diğer kalite parametreleri ile kıyaslanarak açıklanmıştır. Protein oranı, yaş gluten ve Zeleny sedimentasyon değerlerinin Glutopik AM, BEM, AGGRE, PM, GPRT, GW ve GWA ile yüksek ilişkili olduğu tespit edilmiştir. Bunun yanında farinograf su absorbsiyonu ile Glutopik AGGRE, AM, BEM, GGLT, GPRT, GW, GWA ve PM değerleri arasında yüksek bir korelasyon olduğu belirlenmiştir. Alveograf W değerinin Glutopik AM, BEM, PM, GPRT, GGLT, GW, GWA ve AGGRE değerleri ile pozitif düzeyde önemli, PMT ile negatif seviyede önemli ilişkili olduğu tespit edilmiştir. Bu çalışmada incelenen özellikler yönünden elde edilen sonuçlar, farklı kalite özellikleri bakımından bazı

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çeşitlerin öne çıktığını göstermektedir. Bu çalışmanın sonuçları ile Glutopik cihazının, az örnekle ve kısa sürede buğday unu kalitesini tespit edebileceği, bu sebeple Glutopik analizinin ekmeklik buğdayda çeşit geliştirme ve benzeri çalışmalarda faydalı olacağı belirlenmiştir.

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INTRODUCTION

Wheat is one of the most produced cereals in Türkiye due to its high adaptability, meeting a significant part of the daily calories and protein required for human nutrition and being a staple food (Kün, 1996). In parallel with the increasing population, the demand for wheat is also increasing. Türkiye is one of the countries with the highest annual grain consumption per capita. In Türkiye, wheat consumption per capita was 179.4 kg on average in the 2018-2019 period (Güneş & Turmuş 2020). In developed countries, wheat consumption per capita is behind the level of developing countries (FAO, 2020). In Türkiye, where wheat is consumed approximately 2.5 times the world average as human food, it is a necessity that the wheat is of high quality. In determining the quality of wheat, primarily physical properties are taken into account. Hectoliter weight and thousand kernel weight are the most basic analyses in determining wheat quality and are widely used for selection in breeding studies. The parameters commonly used to determine bread wheat quality are Zeleny sedimentation value, protein content, gluten index, wet gluten, and dry gluten values. Many processes such as agricultural applications, genetic structure, milling, and baking processes contribute to the final product quality of wheat (Güçbilmez et al., 2019). Gluten is the main storage protein that defines the baking quality of wheat by providing water absorption capacity, viscosity, and elasticity to the dough (Wieser, 2007). Gliadin and glutenin protein are two components of gluten that form the gluten network during dough development and determine dough strength (Sharma et al., 2020). The appropriate combination of the two gluten components affects the visco-elastic properties of the dough and eventually the quality of the final products. Since gluten is the main determinant of quality in wheat, gluten content was used as one of the criteria in the selection of varieties and determining the baking quality of flour samples in the breeding program (Güçbilmez et al., 2019). Various quality testing procedures such as allograph, chronograph, and cooking tests continue to be applied at present to characterize wheat for different end uses (Huen et al., 2018). Rheological measurements such as chronographs and micrographs are widely used to evaluate the gluten strength of dough and the overall baking functionality of wheat flour (Wang et al., 2017). However, such rheological analyses and baking quality tests are often labor-intensive and time-consuming (Bouachra et al., 2017). In such cases, analyses with shorter durations may be more useful. GlutoPeak test has started to be used as a rapid quality test that requires fewer samples and measures the properties of gluten aggregation, especially gluten strength and aggregation rate (Huen et al., 2018). Studies have shown that GlutoPeak parameters can be used to differentiate wheat flours based on gluten aggregation and dough rheological properties (Marti et al., 2015).

Within the scope of this study, some physical, chemical, technological, and rheological properties, bread analyses, and quality status in GlutoPeak analyses of 10 registered bread wheat varieties developed by Bahri Dağdaş International Agricultural Research Institute were determined in detail. At the same time, the relationships between the physical, chemical, and technological analyses and the rheological and bread analyses between the GlutoPeak quality parameters were investigated and the potentials of the varieties were tried to be revealed.

MATERIALS and METHODS

In this research, the seeds obtained from the trial carried out in the 2020-2021 period with two replications in randomized blocks experimental design of 10 bread wheat varieties (Bayındır, Bozkır, Şehzade, İkonya, Meke, Selçuklu, Ekiz, Taner, Tuğra and Yavuz) grown in irrigated conditions in Bahri Dağdaş International Agricultural Research Institute Konya/Türkiye land were used as material. To obtain flour from wheat samples in the research, the AACC methods 26-95 and 26-50 were used with slight modifications (AACC, 2000). One kg of cleaned seed was taken, annealed on a moisture basis of 14.5% (w w^{-1}), and then kept for 12 hours, then ground in Yucebaş YM1 (Yücebaş Machinery Analytical Equipment İzmir, Turkey) flour mill.

Physical, Chemical, and Technological Analyzes

The thousand-grain weight of samples was determined according to Williams et al., (2008) with a Pfeuffer Contador brand device (model 75072, Kitzingen/Germany). Test weight was determined according to the standard method of AACCI (No: 55-10.01) (AACCI, 2010). The grain hardness of bread

wheat samples was determined in a NIR (Foss DS2500 F) device calibrated according to AACC 55-31 method using a single kernel characterization system (SKCS; AACC, 2000). Protein ratio was made according to the Dumas method using the LECO FP 528 (Leco Inc, St Joseph, MI) nitrogen determination device (nitrogen ratio x 5.70) by weighing 0.20-0.25 g of ground sample (AOAC 992.23, 2000). Zeleny sedimentation values of flour samples were determined according to ICC (International Association for Cereal Science and Technology) Standard No.116/1 (ICC, 2008). The wet gluten content of the flour samples was determined according to AACC Method No: 38-12A (AACC, 2000). Gluten index values of flour samples were determined according to AACC Method No: 38-12A (AACC, 2000). The time for the wheat starch to lose its viscosity feature was determined by the falling number device (Yücebaş Makine, model 2016-No Y120033 İzmir/Türkiye) according to AACC Method No: 56-81B (AACC, 2000).

Rheological Analyzes

Farinograph analysis was determined by a chronograph device (Farinograf-AT, Brabender Germany) according to ICC Standard Method No: 115/1 (ICC, 2008). Alveograph analysis was made using the Chopin Alveograph (Model Alveograph NG, Chopin, France) device according to the ICC-Standard No:121 method (ICC, 2008). GlutoPeak analyses were performed with a Brabender GlutoPeak device (803400 model, Brabender GmbH&Co KG, Duisburg, Germany). Nine g flour sample was mixed with 9 g distilled water at a speed of 2750 rpm at 36 °C, and the test material was evaluated using the Rapid Flour Check method specified by Wiertz (2018). Measurements made by GlutoPeak were recorded by the device's software program (GlutoPeakR version 2.2.0) and AM (Torque 15 seconds Before Maximum Torque, GPU), BEM (Maximum Torque of Gluten, GPU), PMT (the time passed until the Maximum Torque, sec), PM (Torque 15 sec After Maximum Torque, GPU), GPRT (GlutoPeak Protein Ratio, %), GGLT (GlutoPeak Wet Gluten Value, %), GW (GlutoPeak Energy Value, $x10^{-4}$ J), GWA (GlutoPeak Water Absorption Capacity, % v w^{-1}), AGGRE (Aggregation Energy Value, GPU) values were obtained.

Bread Analyzes

Straight-Dough Bread-Making method (AACC 10-10B) modified according to Turkish style bread was used in bread-making studies. For this, based on 100 g flour, 1.5% g/g table salt, and 3% g/g yeast were added, and then 2 units more water (cc) than the previously determined farinograph values were added and kneaded until a mature dough was formed. The obtained doughs were left to mass fermentation at 30 °C and 70-80% relative humidity 2 times for 30 minutes and at the end of these periods, they were folded and aerated. At the end of this process, the bread dough was given its final shape and left for final fermentation at 30 °C for 55 minutes, and after fermentation, the doughs were baked at 230 °C for 15-20 minutes (Elgün et al., 2014). Bread weights (g) were determined by weighing the bread with laboratory-type scales at least 1 hour after baking (Elgün et al., 2002). Bread volume was measured by the rapeseed displacement method and the bread volumes of each variety were determined in cm^3 (Elgün et al., 2002).

Statistical Analysis

In the evaluation of the data obtained as a result of the study, variance analysis was performed and the mean values of the features with significant differences were grouped according to the LSD (0.05) test. JMP statistics program (version 5.0.1, SAS Institute Inc., USA) was used in data analysis (JMP, 2003).

RESULTS and DISCUSSION

Evaluation of Analysis Findings of Bread Wheat Varieties

The mean square results of the analysis of variance obtained from the analysis results of the quality parameters of 10 bread wheat varieties used in the research are given in Tables 1 and 2, and the mean values and significance groups are given in Tables 3 and 4. As it can be understood from the examination of the tables, the differences between the varieties in all the parameters obtained from the analyses were found to be statistically significant at the level of $P<0.01$.

Evaluation of Findings Related to Physical, Chemical, and Technological Analyzes

In determining the quality of wheat, first of all, its physical properties are taken into account. Thousand-grain weight and test weight are the most basic analyses in determining wheat quality and are widely used for selection in a variety of development studies (Özkaya & Özkaya, 2005).

The shape and size of the grain, as well as the absence of wrinkles and cracks, are the most important physical grain characteristics that affect the thousand-grain weight and directly affect the flour yield (Tyagi et al., 2015). The thousand-grain weight gives information about the endosperm ratio in the seed. Since the endosperm ratios of varieties with a high thousand-grain weight are generally high, flour yields are high (Posner, 2009). Elgün et al., (2001) reported that thousand-grain weights ranged between 26-36 g in soft wheat and 35-46 g in hard wheat. In the study, the mean value of thousand-grain weight was determined as 33.0 g, and this value varied between 27.5 and 41.5 g. The highest thousand-grain weight was obtained from the Ekiz variety (41.5 g), followed by Şehzade (39.9 g), Meke (36.2 g), Bozkır (34.1 g).

Taner (33.0 g) and Bayındır (32.0 g) varieties were found to have average values (Table 3). Aydoğan & Soylu (2017), in a similar study conducted on 14 bread wheat varieties under Konya conditions, found that the thousand-grain weight of the varieties ranged between 30.90 g and 46.46 g and the mean value of the trial was 38.32 g.

The test weight gives information about the unit volume density, shape, and size of the grain. The high test weight value is desirable for bread wheat varieties. The fact that this value is 80 kg hl^{-1} and above is especially desired by the wheat industrialists. Elgün et al., (2001) reported that test weights ranged between 74-82 kg hl^{-1} in soft wheats and 78-82 kg hl^{-1} in hard wheats. The mean value of test weights obtained in the study was determined as 75.8 kg hl^{-1}, and this value varied between 71.9-80.6 kg hl^{-1}. While the Ekiz variety had the highest value with 80.6 kg hl^{-1}, the Bayındır variety had the lowest value (71.9 kg hl^{-1}) (Table 3). Şahin et al., (2017), determined the test weights between 70.97-77.43 kg hl^{-1} and the mean value as 75.18 kg hl^{-1} in the study made on bread wheat varieties.

Many methods have been developed to measure wheat grain hardness and SKCS has been widely used recently. The bread quality of hard wheat is generally high. In general, hard wheats are suitable for bread making and soft wheats are suitable for biscuits (Giroux & Morris, 1998). During the conversion of very hard wheat into flour, energy consumption is high or in very soft wheat, the flour yield is low because it is difficult to separate the bran from the flour (Elgün et al., 2001). The SKCS hardness values obtained in the study were determined as 68.2% on average and this value varied between 44.4-87.2%. In the study conducted by Şahin et al., (2019), it was determined the hardness values of bread wheat genotypes, consisting of 20 varieties and breeding lines, between 29.78 and 87.66%.

Protein ratio is one of the important quality criteria considered in the study. It has been reported that to classify wheat and characterize wheat flour, it is necessary to measure the protein and gluten content together with the sedimentation value for wheat flour characterization (Başlar & Ertugay, 2011). Although the amount of protein is one of the most influential criteria from climatic conditions and agronomic applications (Aktan, 1992), it is one of the most effective parameters in determining the quality of wheat varieties (Williams et al., 1986). Protein ratios obtained from the study varied between 11.7% and 16.8%. Selçuklu variety had the highest protein content with 16.8%, followed by Bozkır (16.0%), Bayındır, İkonya (15.4%) and Yavuz (15.1%). While the protein ratios of Tuğra (14.3%), Meke (14.1%), Taner (13.9%), and Şehzade (13.1%) varieties were low, the protein ratio of the Ekiz variety (11.7%) was determined to be the lowest (Table 3). Egesel et al. (2009) determined the protein ratio between 10.9% and 13.1% in the study they carried out for two years in 10 bread wheat varieties. Şahin et al. (2019) evaluated the quality and technological characteristics of bread wheat genotypes consisting of 20 varieties and lines and found that the protein ratios varied between 12.29-14.10%.

Wet gluten is an elastic substance formed by the gliadin and glutenin proteins in the wheat composition by absorbing water and swelling. The amount of wet gluten helps to determine the gluten quality (gluten structure, flour strength). The fact that the wet gluten ratio is over 28% in the flour to be used in bread making allows the production of good quality dough (Erekul et al., 2005). The wet gluten mean values obtained in the study were determined as 41.6%. This value varied between 32.2-49.2%. While the Selçuklu variety had the highest wet gluten value at 49.2%, wet gluten values of Meke (35.6%), Şehzade (32.6%), and Ekiz (32.2%) varieties were found low (Table 3). In the study of Keçeli & İkikarakaya (2013) conducted for two years on 4 different bread wheat varieties, it was determined the mean value of the wet gluten ratio was 28.0% in the first year and 27.0% in the second year. Okur (2017) reported that for 57 samples milled as flour and whole wheat flour, the mean value of the wet gluten analysis values in red wheat was determined as 34.51 and 28.07%, and the mean value of the wet gluten analysis values in white wheat was determined as 31.27 and 27.08%, respectively.

Table 1. The mean square results of the variance analysis of the glutopic analysis values.
Çizelge 1. *Glutopik analiz değerlerine ait varyans analizi kareler ortalaması sonuçları.*

VS	SD	AM	BEM	PMT	PM	GPRT	GGLT	GW	GWA	AGREE
Variety *(Çeşit)*	9	100.9**	239.8**	566.6**	215.1**	4.1**	36.2**	37706**	44.1**	208915**
Recurrence *(Tekerrür)*	1	0.8	39.2	7.2	1.25	0.061	0.578	460.8	5.832	1828.8
Error *(Hata)*	9	5.35	22.86	13.42	3.47	0.19	1.81	366.13	5.57	9394.04
General *(Genel)*	19									

** (P<0.01), VS: Variation Sources, SD: Degree of Freedom, AM: Torque 15 sec Before Maximum Torque, BEM: Maximum Torque, PMT: Peak Maximum Time, PM: Torque 15 s After Maximum Torque, GPRT: GlutoPeak Protein Ratio, GGLT: GlutoPeak Wet Gluten Value, GW: GlutoPeak Energy Value, GWA: GlutoPeak Water Absorption Capacity, AGGRE: GlutoPeak Aggregation Energy Value

Table 2: Mean square results of variance analysis of some quality values of bread wheat.
Çizelge 2. *Ekmeklik buğdayların bazı kalite değerlerine ait varyans analizi kareler ortalaması sonuçları.*

VS	SD	Thousand Grain Weight *(Bin Tane Ağırlığı)*	Test Weight *(Hektolitre Ağırlığı) (kg hl-¹)*	SKCS Hardness *(SKCS Sertlik) (%)*	Protein Ratio *(Protein Oranı) (%)*	Zeleny Sedimentation *(Zeleny Sedimentasyon)(ml)*	Wet Gluten *(Yaş Gluten) (%)*	Gluten Index *(Gluten İndeks) (%)*	Falling Number *(Düşme Sayısı) (sn)*	Farinograph Water Absorption *(Farinograf Su Absorbsiyonu)*	Alveograph Energy Value *(Alveograf Enerji*	Bread Weight *(Ekmek Ağırlığı) (g)*	Bread Volume *(Ekmek*
Variety	9	44.815**	11.44**	434.329**	4.335**	135.12**	70.8**	251.56**	10060.72*	31.82**	12771.689**	17.05**	1223.7
Recurrence	1	0.722	0.007	0.2668	0.328	6.05	5.398	21.487	1170.45	0.025	897.8	8.039	4.05
Error	9	0.674	0.182	3.908	0.807	1.828	6.594	12.53	130.228	0.512	218.356	0.852	70.72
General	19												

** ($P<0.01$), VS: Variation Sources, SD: Degree of Freedom

Table 3. Mean values of some quality parameters in bread wheat varieties.
Çizelge 3. *Ekmeklik buğday çeşitlerinde bazı kalite parametrelerine ait ortalama değerler.*

Variety *(Çeşit)*	Thousand Grain Weight *(Bin Tane Ağırlığı) (g)*	Test Weight *(Hektolitre Ağırlığı) (kg hl-¹)*	SKCS Hardness *(SKCS Sertlik) (%)*	Protein Ratio *(Protein Oranı) (%)*	Zeleny Sedimentation *(Zeleny Sedimentasyon) (ml)*	Wet Gluten *(Yaş Gluten) (%)*	Gluten Index *(Gluten İndeks) (%)*	Falling Number *(Düşme Sayısı) (sn)*	Farinograph Water Absorption *(Farinograf Su Absorbsiyonu)*	Alveograph Energy Value *(Alveograf Enerji Değeri) (x10-4 J)*	Bread Weight *(Ekmek Ağırlığı) (g)*	Bread Volume *(Ekmek Hacmi) (cm³)*
Bayındır	32.0^{de}±0.	71.9^{g}±0.7	87.2^{a}±1.	15.4^{abc}±0	31.0^{f}±1.0	44.6^{ab}±1	53.2^{e}±4.	507^{ab}±3	70.2^{a}±0.4	389.0^{a}±40.	150^{b}±1.	465^{b}±7.
Bozkır	34.1^{c}±0.	76.3^{cd}±0.	54.5^{e}±2.	16.0^{ab}±0.	46.5^{b}±0.7	45.7^{ab}±1	67.8^{d}±3.	348^{f}±1	65.5^{c}±0.1	214.5^{cd}±19	148^{bc}±0	430^{c}±14
Ekiz	41.5^{a}±0.	80.6^{a}±0.1	76.1^{bc}±4	11.7^{e}±0.2	26.5^{g}±0.7	32.2^{c}±1.	65.7^{d}±2.	435^{d}±5	62.0^{f}±0.4	127.5^{ef}±5.0	146^{c}±1.	439^{c}±5.
İkonya	28.1^{gh}±0.	77.4^{b}±0.2	78.0^{b}±1.	15.4^{abc}±0	40.5^{d}±0.7	45.7^{ab}±1	78.1^{bc}±2.	435^{d}±2	63.7^{de}±0.2	191.5^{de}±7.	148^{bc}±0	465^{b}±7.
Meke	36.2^{b}±0.	75.1^{e}±0.2	45.9^{f}±3.	14.1^{bcd}±0	42.5^{cd}±2.1	35.6^{c}±1.	91.0^{a}±4.	377^{e}±2	62.5^{ef}±1.0	220.5^{c}±16.	148^{c}±2.	469^{b}±1.
Selçuklu	27.5^{h}±0.	72.9^{f}±0.2	78.3^{b}±0.	16.8^{a}±0.3	56.0^{a}±2.8	49.2^{a}±0.	85.3^{ab}±1	532^{a}±2	68.6^{b}±0.1	244.0^{b}±14.	153^{a}±0.	469^{b}±1.
Şehzade	39.9^{a}±0.	76.3^{cd}±1.	44.4^{f}±2.	13.1^{de}±0.	35.5^{e}±0.7	32.6^{c}±5.	85.0^{ab}±5	311^{g}±1	55.6^{g}±0.5	115.5^{f}±10.	141^{d}±1.	410^{d}±7.
Taner	33.0^{cd}±0.	75.5^{de}±0.	76.2^{bc}±1	13.9^{cd}±2.	42.0^{cd}±1.4	43.5^{ab}±3	70.0^{d}±4.	481^{c}±6	65.6^{c}±1.4	282.0^{b}±42.	148^{bc}±1	490^{a}±14
Tuğra	30.9^{ef}±1.	76.9^{bc}±0.	68.5^{d}±0.	14.3^{bcd}±0	44.0^{bc}±1.4	44.5^{ab}±2	78.9^{bc}±4.	482^{bc}±2	62.9^{def}±0.5	157.0^{de}±2.	148^{bc}±1	482^{ab}±2.
Yavuz	29.6^{fg}±0.	75.2^{e}±0.1	72.7^{cd}±0	15.1^{ad}±0.	42.0^{cd}±1.4	42.8^{b}±2.	72.2^{cd}±0.	429^{d}±2	64.4^{cd}±0.8	195.5^{de}±7.	147^{c}±0.	445^{c}±7.
Mean*(Ortalam*	33.0	75.8	68.2	15.0	41.0	41.6	75.0	434	64.1	213.7	147.7	456
CV (%)	2.9	0.6	2.9	6.2	3.3	6.2	4.7	2.6	1.1	6.9	0.6	1.8
$LSD_{0.05}$	2.19	0.96	4.47	2.03	3.1	5.81	8.0	25.8	1.6	33.4	2.1	19.0

CV: Coefficient of Variation, LSD: Least Significant Differences, $^{(de)}$: Different superscripts in the same column indicate statistically significant differences between the means ($P<0.05$).

The parameters commonly used to determine the quality of bread wheat are protein ratio, Zeleny sedimentation value, wet gluten, dry gluten, and gluten index values (Menderis et al., 2008). Gluten index value is used to determine gluten quality and it is required to be between 60-90% in bread flour (Elgün et al., 2001). The gluten index values obtained in the study varied between 53.2-91.0%. Make variety had the highest gluten index value with 91.0%, followed by Selçuklu (85.3%), Şehzade (85.0%), Tuğra (78.9%) and İkonya (78.1%). While the gluten index values of Yavuz (72.2%), Taner (70.0%), Bozkır (67.8%), and Ekiz (65.7%) varieties were below the average value, the Bayındır variety had the lowest value with 53.2% (Table 3). Egesel et al., (2009) determined the gluten index value between 14.0 and 77.8% in a study conducted for two years on 10 bread wheat varieties.

The time for the wheat starch to lose its viscosity with the activity of the α and ß amylase enzymes in the flour gives the falling number. The falling number determines the activity of the amylase enzyme in the flour. The value of a falling number over 300 seconds is an indicator of low amylase activity. If amylase is not added to flours with low amylase activity, bread volume becomes low and bread crumbs become dry. The falling number values obtained in the study were determined as 434 seconds on average. This value varied between 311-532 sec. (Table 3). Kara et al., (2020) determined the falling number values of bread wheat between 262.5 and 882.0 sec. in different grain sizes. It was determined that all varieties had low amylase activity in terms of falling number values.

Evaluation of Findings Related to Rheological Analyzes

In determining the quality of wheat for bread making, physical and physicochemical properties do not provide complete and precise information, so it is necessary to determine the rheological properties of the dough. The rheological properties of the dough give information about the visco-elastic structure of the dough. The visco-elastic structure of the dough shows the bread quality. The visco-elastic structure allows the dough to keep its shape. After the deformation formed in the dough by a force applied to the dough, the dough tries to return to its previous state. This is the most important property of dough (Patel & Chakrabarti-Bell, 2013). The visco-elastic properties of the dough can be measured with some devices. One of the devices developed for this purpose is the chronograph. Farinograph determines the amount of water required for the flour to become a normal dough and provides information about the development, stability, and softening degree of the dough (Elgün et al., 2001).

Farinograph water absorption is the amount of water required to be added to the flour to obtain a dough of a certain consistency, and it is desired that the amount of water to be used in bread making is high. High water absorption is a feature desired by bakers. When flours with high water absorption are kneaded, more dough is obtained. The mean values of water absorption values obtained in the study were determined as 64.1% (Table 3). Al-Saleh & Brennan (2012) reported that the water absorption value varied between 56.30% and 64.05% in a study they conducted with bread wheat genotypes under irrigated conditions.

Alveograph energy (W) value is one of the reliable data to reveal the quality of wheat flour and has a key role in the evaluation of the quality of wheat for bread making among all allograph parameters. Abu Hammad et al. (2012) classified the allograph energy values as weak (<100 $x10^{-4}$ J), moderately weak (101-150 $x10^{-4}$ J), moderately strong (151-200 $x10^{-4}$ J), and strong (201-250 $x10^{-4}$ J), and very strong (>250 $x10^{-4}$ J). In the study, the W value varied between 115.5-389.0 $x10^{-4}$ J. While Bayındır variety has the highest W value with 389.0 $x10^{-4}$ J, Yavuz (195.5 $x10^{-4}$ J), İkonya (191.5 $x10^{-4}$ J), Tugra (157.0 $x10^{-4}$ J), Ekiz (127.5 $x10^{-4}$ J) and Şehzade (115.5 $x10^{-4}$ J) varieties had lower than average W values (Table 3). Kristensen et al., (2019) found the W value between 40-293 $x10^{-4}$ J and the mean value of W value as 134.2 $x10^{-4}$ J in their study. According to Pomeranz (1987), the W value of standard flour is around 141 x 10^{-4} J. Some other researchers have suggested that the W value of standard flour is characterized in the range of 160-200 x 10^{-4} J (Bordes et al., 2008). Considering the literature information, it was determined that the W values of the majority of the varieties examined in this study were almost in the standard range or higher.

Evaluation of Findings Related to GlutoPeak Analysis

The gluten qualities of bread wheat varieties must be suitable for the end product.
To determine the gluten quality, information about water absorption, energy value, and tolerance values against kneading is obtained with devices such as micrographs, allographs, chronographs, and stenographs. These methods require large amounts of samples and take a long time. In recent years, it has been stated that the Glutopik device, which gives results in a shorter time with fewer samples, has been used to measure gluten quality (Güçbilmez et al., 2019). GlutoPeak measures the aggregation of wheat gluten proteins in a flour/water slurry under high-speed shearing (Melnyk et al., 2011). Studies show that GlutoPeak parameters can be used to differentiate wheat flour according to gluten aggregation and dough rheological properties (Malegori et al., 2018; Zawieja et al., 2020).

In the research, the mean value of AM (GPU), which is expressed as torque 15 seconds Before Maximum

Torque, was determined as 25.6 GPU, and this value varied between 17.5 and 42.0 GPU (Table 4). Güçbilmez et al. (2019) and Şahin et al. (2020) reported that AM values varied between 14-36 GPU and 19.5-43.8 GPU respectively, in their study of bread wheat flour.

When the BEM value of the GlutoPeak diagram is examined, the Bayındır variety has the highest BEM value of 89 GPU. Daba et al., (2021) determined the BEM value between 53.5-81.5 GPU, with a mean value of 64.8 GPU in their study.

The PMT value is expressed as the time (sec) from the beginning of the GlutoPeak diagram to the maximum torque. Varieties with strong gluten give lower PMT and higher BEM values, while the opposite is true for varieties with weak gluten (Güçbilmez et al., 2019). In the study, the mean value of PMT was determined as 60.8 seconds, and this value varied between 45.5-87.0 seconds. Wang et al., (2018) stated that the PMT value varied between 41.3 and 92.3 seconds in the GlutoPeak analysis studies on bread wheat.

PM value is measured as the torque 15 sec after maximum torque. Bayındır variety in the study had the highest PM value with 69.5 GPU, followed by Selçuklu (66 GPU), Taner (58 GPU), Yavuz (56 GPU), Bozkır (55 GPU), Tuğra (54 GPU), İkonya (52 GPU), Meke (49 GPU), Ekiz (39.5 GPU) and Şehzade (36 GPU) (Table 4). Daba et al., (2021) are also in agreement with this study in terms of PM value (43.0-67.0 GPU).

In the study, the mean value of GPRT calculated by the GlutoPeak was determined as 13.2%, and this value varied between 10.8 and 15.7%. The Bayındır variety in the study had the highest protein content with 15.7%. Şahin et al., (2020) found the mean of GPRT values as 12.8% in their study on bread wheat.

Table 4. Mean values of GlutoPeak parameters of bread wheat varieties.
Çizelge 4. *Ekmeklik buğday çeşitlerinde glutopik parametrelerine ait ortalama değerler.*

Variety *(Çeşit)*	AM (GPU)	BEM (GPU)	PMT (sn)	PM (GPU)	GPRT (%)	GGLT (%)	GW (x10^{-4} J)	GWA (% v w^{-1})	AGGRE (GPU)
Bayındır	42.0^{a}±14.9	89.0^{a}±1.4	28.0^{g}±0.0	69.5^{a}±2.1	15.7^{a}±0.1	32.4^{bc}±0.6	670^{a}±16.9	72.3^{a}±0.6	2173^{a}±57.1
Bozkır	28.0^{bc}±2.1	68.5^{bc}±0.7	67.0^{bc}±0.0	55.0^{bc}±1.4	13.7^{bc}±0.3	31.6^{cd}±0.0	419^{cd}±8.4	66.4^{b}±0.6	1819^{b}±38.5
Ekiz	17.5^{ef}±3.5	59.0^{cd}±7.1	54.0^{e}±5.7	39.5^{e}±4.9	11.4^{e}±0.6	25.3^{e}±1.9	303^{e}±86.2	60.0^{cd}±2.6	1279^{d}±177.9
İkonya	27.0^{bcd}±4.2	73.0^{b}±5.7	55.5^{de}±13.4	52.0^{cd}±0.7	13.5^{cd}±0.0	32.2^{bc}±1.5	450^{bc}±17.6	64.1^{bc}±0.8	1577^{c}±128.6
Meke	24.0^{cd}±0.7	66.0^{bc}±2.8	80.0^{a}±9.9	49.0^{d}±4.9	12.9^{cd}±0.1	29.8^{cd}±0.6	389^{d}±34.6	63.3^{bc}±1.8	1772^{bc}±26.9
Selçuklu	30.0^{b}±2.9	84.0^{a}±11.3	59.5^{cde}±14.8	66.0^{a}±9.9	14.7^{b}±0.8	35.0^{b}±2.3	631^{a}±35.3	72.9^{a}±6.1	2128^{a}±14.6
Şehzade	16.5^{f}±0.7	51.5^{d}±2.1	87.0^{a}±12.8	36.0^{e}±1.4	10.8^{e}±0.1	23.6^{e}±0.6	212^{f}±26.1	57.9^{d}±0.7	1164^{d}±43.0
Taner	27.5^{bc}±0.7	71.0^{b}±1.4	45.5^{f}±7.8	58.0^{b}±0.7	13.8^{bc}±0.5	38.2^{a}±0.8	474^{b}±69.2	66.8^{bc}±2.4	1768^{bc}±3.8
Tuğra	22.0^{de}±1.4	67.0^{bc}±0.0	69.0^{b}±1.4	54.0^{bc}±1.4	13.4^{cd}±0.1	31.3^{cd}±0.1	401^{d}±0.0	65.1^{bc}±0.2	1567^{c}±75.0
Yavuz	23.0^{cd}±1.4	65.0^{bc}±4.2	62.5^{bcd}±10.6	56.0^{b}±4.2	12.7^{d}±0.6	29.2^{d}±1.9	377^{d}±51.6	66.1^{b}±0.4	1812^{b}±158.1
Ortalama	25.6	69.4	60.8	53.4	13.2	30.8	432.4	65.5	1706
CV (%)	9.0	6.9	6.0	3.5	3.3	4.4	4.4	3.6	5.7
$LSD_{0.05}$	5.2	10.8	8.3	4.2	1.0	3.0	43.3	5.3	219.3

CV: Coefficient of Variation, LSD: Least Significant Differences, $^{(a)}$; Different superscripts in the same column indicate statistically significant differences between the means (P<0.05). AM: Torque 15 sec Before Maximum Torque, BEM: Maximum Torque, PMT: Peak Maximum Time, PM: Torque 15 s After Maximum Torque, GPRT: GlutoPeak Protein Ratio, GGLT: GlutoPeak Wet Gluten Value, GW: GlutoPeak Energy Value, GWA: GlutoPeak Water Absorption Capacity, AGGRE: GlutoPeak Aggregation Energy Value

The GGLT values, which express the wet gluten ratio calculated by the GlutoPeak device, were found to be 30.8% on average. Taner variety had the highest GGLT value with 38.2% followed by Selçuklu (35.0%), Bayındır (32.4%), İkonya (32.2%), Bozkır (31.6%), Tuğra (31.3%), Meke (29.8%), Yavuz (29.8%). 29.2), Ekiz (25.3%) and Şehzade (23.6%) varieties (Table 4). Şahin et al., (2020) found the the mean of GGLT values as 30.5% in their study.

The mean value GW was determined as 432.4x10^{-4} J, and this value varied between 212-670x10^{-4} J. The Bayındır variety included in the study had the highest GW value with 670x10^{-4} J (Table 4). Şahin et al., (2020) determined the average GW value as 392.7x10^{-4} J.

GWA values varied between 57.9-72.9 % v w^{-1}. While the Selçuklu variety had the highest GWA value with 72.9 % v w^{-1}, the Şehzade variety had the lowest GWA value with 57.9 % v w^{-1} in the study. Güçbilmez et al., (2019) determined the GWA value in the range of 52.8-67.1% v w^{-1} and found the mean value as 61.9% v w^{-1} in their study on bread wheat flour.

While the mean value of AGGRE obtained from the GlutoPeak data was determined as 1706 GPU, the Bayındır variety gave the highest AGGRE value with 2173 GPU. Daba et al., (2021) found the mean value of AGGRE as 1794.7 GPU in their studies on dough rheological properties and baking quality of wheat.

Evaluation of Findings Related to Bread Analyzes

While the mean value of bread weight obtained in the

study was 147.7 g, this value varied between 141-153 g among varieties. In addition, the mean value of bread volume was 456 cm^3, and this value changed in the range of 410-490 cm^3. Aydoğan (2016) determined the bread weight between 141.6-149.5 g and the mean value as 146.0 g in the study made on bread wheat varieties grown under irrigated conditions. Also, the bread volume was determined between 368-485 cm^3, and the mean value was 452.3 cm^3 in the research.

Evaluation of Relationships Between GlutoPeak Data and Other Quality Parameters

The data obtained by using classical methods in 10 bread wheat varieties were compared with the data calculated by the GlutoPeak method. The correlation coefficients between the GlutoPeak parameters obtained in the study and other parameters, and their statistical significances are given in Table 5.

Table 5. Correlation coefficients between GlutoPeak and other quality analyses (r) (n=10)
Çizelge 5. *Glutopik ile diğer kalite analizleri arasındaki korelasyon katsayıları (r) (n=10)*

	Thousand Grain Weight *(Bin Tane Ağırlığı)* (g)	Test Weight *(Hektolitre Ağırlığı)* *(kg hl-1)*	SKCS Hardness *(SKCS Sertlik)* (%)	Protein Ratio *(Protein Oranı)* *(%)*	Zeleny Sedimentation *(Zeleny Sedimentasyon)* (ml)	Wet Gluten *(Yaş Gluten)* *(%)*	Gluten Index *(Gluten İndeks)* *(%)*	Falling Number *(Düşme Sayısı)* *(sn)*	Farinograph Water Absorption *(Farinograf Su Absorbsiyonu)* (%)	Alveograph Energy Value *(Alveograf Enerji Değeri)* *(x10-4 J)*	Bread Weight *(Ekmek Ağırlığı)* (g)	Bread Volume *(Ekmek Hacmi)* *(cm^3)*
AM	-0.54	-0.76*	0.55	0.66*	0.12	0.66*	-0.52	0.55	0.87**	0.95**	0.70*	0.43
BEM	-0.69*	-0.72*	0.67*	0.72*	0.30	0.77**	-0.36	0.76*	0.93**	0.86**	0.88**	0.58
PMT	0.33	0.29	-0.89**	-0.20	0.27	-0.44	0.81*	-0.71*	-0.77**	-0.74*	-0.53	-0.44
PM	-0.77**	-0.78**	0.62	0.78**	0.44	0.85**	-0.36	0.74*	0.94**	0.85**	0.86**	0.60
GPRT	-0.70*	-0.73*	0.58	0.76*	0.37	0.82**	-0.38	0.69*	0.93**	0.88**	0.85**	0.62
GGLT	-0.69*	-0.50	0.49	0.59	0.56	0.79**	-0.14	0.65*	0.74*	0.67*	0.75*	0.79**
GW	-0.67*	-0.74*	0.67*	0.71*	0.33	0.76*	-0.35	0.78**	0.94**	0.87**	0.89**	0.60
GWA	-0.74*	-0.79**	0.60	0.79**	0.48	0.83**	-0.32	0.74*	0.94**	0.82**	0.89**	0.54
AGREE	-0.67*	-0.83**	0.45	0.79**	0.48	0.74*	-0.26	0.60	0.92**	0.85**	0.86**	0.50

*(P<0.05) significant at 5% level, ** (P<0.01) significant at 1% level AM: Torque 15 sec Before Maximum Torque, BEM: Maximum Torque, PMT: Peak Maximum Time, PM: Torque 15 s After Maximum Torque, GPRT: GlutoPeak Protein Ratio, GGLT: GlutoPeak Wet Gluten Value, GW: GlutoPeak Energy Value, GWA: GlutoPeak Water Absorption Capacity, AGGRE: GlutoPeak Aggregation Energy Value

Relationships Between GlutoPeak Analysis and Physical Analyzes

It was determined that there was a negative significant correlation between thousand-grain weight and BEM (r=-0.69 P<0.05), PM (r=-0.77 P<0.01), GPRT (r=-0.70 P<0.05), GGLT (r=-0.69 P<0.05), GW (r=-0.67 P<0.05), GWA (r=-0.74 P<0.05) ve AGGRE (r=-0.67 P<0.05). A negative significant correlation between test weight and AM (r=-0.76 P<0.05), BEM (r=-0.72 P<0.05), PM (r=-0.78 P<0.01), GPRT (r=-0.73 P<0.05), GW (r=-0.74 P<0.05), GWA (r=-0.79 P<0.01), AGGRE (r=-0.83 P<0.01) were observed. SKCS had a positive significant correlation with BEM (r=0.67 P<0.05) and GW (r=0.67 P<0.05), and a negative significant correlation with PMT (r=-0.89 P<0.01). Güçbilmez et al., (2019) reported that they found a significant correlation (r=0.7607 P<0.01) between BEM value and hardness value in their study. These findings are compatible with Güçbilmez et al., (2019) in terms of the correlations between BEM and hardness value (r=0.7607 P<0.01).

Relationships Between GlutoPeak Analysis and Chemical and Technological Analyzes

The correlation coefficients between the GlutoPeak parameters obtained in the study and the chemical and technological parameters and their statistical significance are given in Table 5. No statistically significant correlation was found between Zeleny sedimentation values and GlutoPeak parameters. Positive significant correlations were determined between protein ratio and AM (r=0.66 P<0.05), BEM (r=0.72 P<0.05), PM (r=0.78 P<0.01), GW (r=0.71 P<0.05), GWA (r=0.79 P<0.01) and AGGRE (r=0.79 P<0.01). Positive significant correlations between wet gluten and AM (r=0.66 P<0.05), BEM (r=0.77 P<0.01), PM (r=0.85 P<0.01), GPRT (r=0.82 P<0.01), GW (r=0.76 P<0.05), GWA (r=0.83 P<0.01), AGGRE (r=0.74 P<0.01) values were observed. In addition, a positive correlation was found between gluten index value and PMT (r=0.81 P<0.05). When the protein ratio values of the samples made by the Dumas method and GPRT values were evaluated together; the differences between varieties were determined as significant (r=0.76 P<0.05).

Also, when the samples were compared in terms of wet gluten values; it was determined that the differences between varieties were significant (r=0.79 P<0.01). Positive significant correlations were determined between the falling number and BEM (r=0.76 P<0.05), PM (r=0,74 P<0,05), GPRT (r=0,69 P<0,05), GGLT (r=0,65 P<0,05), GW (r=0,78 P< 0.01), GWA (r=0.74 P<0.05) and negative significant correlations were determined with PMT (r=-0.71 P<0.05). Bouchra et al., (2017) stated the positive significant correlation between AM value and gluten quality, BEM value, and

protein ratio.

Relationships Between GlutoPeak Analysis and Farinograph Analysis

When the correlation coefficients and statistical significance between the glutopic parameters and farinograph water absorption were examined, positive correlations between farinograph water absorption and AM (r=0.87 P<0.01), BEM (r=0.93 P<0.01), PM (r=0.94 P<0.01), GPRT (r=0.93 P<0.01), GGLT (r=0.74 P<0.05), GW (r=0.94 P<0.01), GWA (r=0.94 P<0.01), and AGGRE (r=0.92 P<0.01)) and negative correlations with PMT (r=-0.77 P<0.01) were obtained (Table 4). The chronograph water absorption made with the classical method and GWA were evaluated together and it was determined that the differences between genotypes were significant at the P<0.05 level in both. The mean value of water absorption results made with the classical method was found to be 65.5%, and the average GWA value was determined as 64.1%. Similar to this study, Şahin et al., (2020) and Güçbilmez et al., (2019) reported a significant correlation between the values obtained with both devices at the level of r=0.8280 P<0.01 and r=0.9158, P<0.01, respectively.

Relationships Between GlutoPeak Analysis and Alveograph Analysis

The autograph W value was evaluated with the obtained GlutoPeak parameters. It was determined that there were positive correlations between AM (r=0.95 P<0.01), BEM (r=0.86 P<0.01), PM (r=0.85 P<0.01), GPRT (r=0.88 P<0.01), GGLT (r=0.67 P<0.05), GWA (r=0.82 P<0.01) and AGGRE (r=0.85 P<0.01), and negative correlations with PMT (r=-0.74 P<0.05).

Relationships Between GlutoPeak Analysis and Bread Analyzes

When the correlation coefficients and statistical significance between the GlutoPeak parameters and the technological parameters obtained from the study were examined, positive correlations were found between the bread weight and AM (r=0.70 P<0.05), BEM (r=0.88 P<0.01), PM (r=0.86 P<0.01), GPRT (r=0.85 P<0.01), GGLT (r=0.75 P<0.05), GW (r=0.89 P<0.01), GWA (r=0.89 P<0.01), AGGRE (r=0.86 P<0.01). Also, positive correlations were obtained between bread volume and GGLT (r=0.79 P<0.01) (Table 4).

CONCLUSION

According to the data obtained as a result of the analysis performed with the GlutoPeak device developed to evaluate the gluten quality in bread wheat, the high AM, BEM, PM, and AGGRE values indicate high gluten quality, while the high PMT value indicates late aggregation and weak gluten.

A high correlation between GWA and water absorption values obtained from farinograph analysis (r= 0.94, P<0.01) was obtained. In addition, it was determined that there was a significant correlation between GPRT and protein ratio (r= 0.76, P< 0.01), GGLT and wet gluten (r=0.79, P<0.01), and GW and allograph W value (r=0.87, P<0.01).

Rheological measuring devices such as allograph, chronograph, and stenograph are widely used around the world to determine dough properties and bread-making properties of flour. However, bread wheat breeding studies take a long time (13-15 years). Especially in the F1-F3 stages after crossing, the amount of seeds is low (20-25 g), and breeders are curious about the quality values of the wheat lines they will develop at these stages. Therefore, there is a need for analyzers that provide information about technological analyses using fewer samples. Since 9 g of sample is used in the GlutoPeak device, it is considered to be suitable for this purpose. The use of GlutoPeak device data in breeding stages can provide a scientifically remarkable contribution to breeders in the selection of bread wheat in terms of technological properties. Comparison of GlutoPeak parameters with allograph, farinograph, or chemical analysis in advanced stages or variety trials where the sample amount is high; may be required to make accurate assessments in terms of results. Considering the analysis findings of this study (flour water absorption, flour protein ratio, wet gluten ratio, and dough alveograph energy value [W]), it was concluded that GlutoPeak analysis can be used in variety development and similar studies in wheat because it gives results in a short time with few samples.

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Contribution Rate Statement Summary of Researchers

The authors' contribution to the study is equal.

Statement of Conflict of Interest

The authors have no conflict of interest related to the study.

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