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Quality characteristics of some durum wheat varieties grown in Southeastern Anatolia Region of Turkey (GAP)

Türkiye'nin Güneydoğu Anadolu Bölgesi'nde (GAP) yetiştirilen bazı durum buğdayı çeşitlerinin kalite özellikleri

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ABSTRACT

The purpose of this study was to determine the physical (length, width, thickness, equivalent diameter, sphericity, hardness, thousand-kernel weight, hectoliter weight, color), technological and physicochemical (water absorption capacity, ash, protein, gluten, gluten index, sedimentation (SDS), Glutograph-E values) quality characteristics of wheat varieties grown in Southeastern Anatolia Region of Turkey (GAP). In the study, some durum wheat varieties such as Burgos, Svevo, Güneyyıldızı, Sarıçanak 98, Zenit and Massimo were investigated. Significant differences (P≤0.05) were observed among wheat varieties in terms of physical characteristics such as hardness, thousand kernel weight, hectoliter weight, kernel size (length, width, thickness, equivalent diameter), sphericity, Hunter-color (L*, a* and b*) values. Also, statistically significant differences were found between the wheat varieties in terms of protein, ash, gluten, gluten index, SDS sedimentation, water absorption capacity, stretching (extensibility) and relaxation (elasticity) characteristics. The quality characteristics results and differences in quality characteristics between wheat varieties can be important in terms of product processing processes such as cooking, soaking, kneading, drying.

Key Words: GAP, Durum wheat, Technological, Physicochemical, Quality

ÖZ

Bu çalışmanın amacı Türkiye'nin Güneydoğu Anadolu Bölgesinde (GAP) yetişen bazı durum buğdaylarının fiziksel (uzunluk, genişlik, kalınlık, eşdeğer çap, küresellik, sertlik, bin tane ağırlığı, hektolitre ağırlığı, renk), teknolojik ve fizikokimyasal (su absorpsiyon kapasitesi, kül, protein, gluten, gluten indeksi, (SDS) sedimantasyon, Glutograf-E değerleri) gibi kalite özelliklerini belirlemektir. Çalışmada Burgos, Svevo, Güneyyıldızı, Sarıçanak 98, Zenit ve Massimo gibi bazı makarnalık buğday çeşitleri incelenmiştir. Buğday çeşitleri arasında sertlik, bin tane ağırlığı, hektolitre ağırlığı, tane boyutu (uzunluk, genişlik, kalınlık, eşdeğer çap), küresellik, Hunter-renk (L *, a * ve b *) değerleri gibi fiziksel özellikler açısından önemli farklılıklar (P≤0.05) gözlenmiştir. Ayrıca buğday çeşitleri arasında protein, kül, gluten, gluten indeksi, SDS sedimantasyon, su absorpsiyon kapasitesi, gerilme (uzayabilirlik) ve gevşeme (elastikiyet) özellikleri açısından istatistiksel olarak anlamlı farklılıklar bulunmuştur. Kalite özellikleri sonuçları ve buğday çeşitleri arasındaki kalite karakteristiklerindeki farklılıklar pişirme, ıslatma, yoğurma, kurutma gibi ürün işleme prosesleri açısından önemli olabilir.

Anahtar Kelimeler: GAP, Durum buğdayı, Teknolojik, Fizikokimyasal, Kalite

Introduction

Wheat is still the most important crop in the world, with a total annual production of 736 million tons in 2018. In the same year, China, India, Russia, USA, Canada, Ukraine, Australia, Turkey and Kazakhstan are the world's largest wheat producer countries with the production of 131447224, 99700000, 72136149, 51286540, 31769200, 24652840, 20941134, 20000000 and 13944108 tones, respectively (FAO, 2019). According to the archeological studies, wheat was found in various countries of the Middle East, it is presumed that wheat was already being cultivated thousands of years before Christ, first in the ‘’fertile crescent’’ as Karacadağ in Mesopotamia, later spreading to West Europe. Southeastern of Anatolia which locates in the fertile crescent, is the origin and one of the gene sources of the wild wheat and einkorn (Heun et al., 1997). Although wheat is grown in all regions of Turkey, Central Anatolia Region and Southeastern Anatolia Region, are two important regions in wheat breeding (Özberk et al., 2005).

Wheat is one of the major sources of protein and energy for the human population throughout the world. It supplies about 19% of the calories and 21% of the protein to the world’s population (Ali, 2017). The main reason why wheat has such a wide range of product is that it is produced in many regions and that the products such as bread, pasta, bakery, couscous, biscuits and bulgur are produced from wheat.

Important quality factors in wheat and flour standards are the hectoliter weight, thousand grain weight, color, glassy grain ratio, kernel hardness, ash content, protein content, gluten content and sodium dodecyl sulfate (SDS) sedimentation value. Grain hardness is generally influenced by different environmental, physical and chemical factors such as protein, the hardness of grain, kernel size, water-soluble pentosans, moisture content and lipid content (Turnbull and Rahman, 2002).

Vitreousness and kernel size are important in durum wheat quality (Dziki and Laskowski, 2005). The gluten quality of wheat, which is related to the suitability for food processing, is commonly evaluated by sodium dodecyl sulfate sedimentation value and gluten index (GI) tests (Sakin et al., 2011a; 2011b). The thousand kernel weight, which is one of the quality criteria, is affected by the environmental factors and is closely related to variety of wheat kernel. Protein is an important quality criterion in wheat and has a positive effect on the vitreousness (Hansen and Poll, 1997).

Although there were some studies about the quality characteristics of wheat, there are limited studies concerning characteristics of some widely those durum wheat varieties grown in South-Eastern Anatolia Region of Turkey. Hence, this research aims to determine the technological and physicochemical quality characteristics of some wide durum wheat varieties grown in South-Eastern Anatolia Region of Turkey (GAP).

Materials and Methods

Materials

Zenit, Svevo, Sarıçanak 98, Güneyyıldızı, Burgos and Massimo varieties were used in this study due to the most grown varieties in the Southeastern Anatolia Region of Turkey. They were obtained from GAP International Agricultural Research and Training Center (Diyarbakır, Turkey). Before conducting experiments, the samples were manually cleaned to remove foreign materials and broken kernels. The 6 kg of each cleaned wheat variety was used for experiments. Some quality measurements were carried out using 3 kg of each wheat samples milled on a standard laboratory roller mill (Serttaş Makina Lim. Sti. İstanbul, Turkey) to pass through a 180 µm screen to obtain flour. The remaining 3 kg of each wheat variety was used for kernel quality analyses. One kg of wheat kernels and 1 kg of their flours were used for each run analysis. All testing was carried out in triplicate. The moisture content (%) of Zenit, Svevo, Sarıçanak 98, Güneyyıldızı, Burgos and Massimo wheats used in this study were found to be

9.10±0.04, 9.47±0.02, 9.36±0.05, 9.60±0.06, 10.05±0.03 and 9.73±0.04, respectively.

Methods

Physical quality tests

The average dimensions (L: length, W: width and T: thickness in mm) of wheat kernels were measured by a digital micrometer (Mitutoyo No. 505-633, Japan). The equivalent diameters (D_e) and sphericities (ϕ_s) of grains were calculated by using Eqs. 1 and 2 (Mohsenin, 1986).

$$D_e = (LWT)^{1/3} \quad (1)$$

$$\phi_s = (LWT)^{1/3} L^{-1} \quad (2)$$

Thousand-kernel weight (TKW) in dry bases (d.b.) was determined according to the procedure of Williams et al. (1983). The 20 g of cleaned unbroken kernels of each sample was weighed, counted the kernels in 20 g sample, and then converted to thousand kernel. The TKW (g, d.b.) of *e*ach sample for each wheat variety was calculated by Eq.3.

$$TKW(g, d.b.) = \frac{TKW(100-M)}{100} \quad (3)$$

where, M is the moisture content (%) and TKW is the thousand-kernel weight (g, d.b.).

Hectoliter weight was obtained with a Shopper chondrometer equipped with a 250 mL cylinder (the result was reported kg hl^{-1} without reference to the moisture content) (TS EN ISO 7971-2, 2009).

Kernel hardness (%) was determined according to the method of AACC method 39.70.02 with Near Infrared Reflectance spectroscopy (NIR) (FOSS 2500F, Denmark). The calibration of NIR apparatus for hardness was performed by AACC Method 39-10.01 (AACC, 2000; Famera et al., 2004).

The color of wheat and their flour samples was evaluated by measuring the L* (100 = white; 0 = black), a* (+, red; -, green) and b* (+, yellow; -, blue) values using a Hunter-Lab Color Quest XE (HCL-405) spectrophotometer (Hunterlab, USA).

Chemical quality tests

Moisture contents of the samples were determined by oven-drying at 130 °C using the AACC method no 44-15A (AACC, 2000). The flour samples (3 g) were measured into glass weighing bottles and placed in a laboratory dryer for 3 h. The samples were dried at 130 °C to constant weight. After cooling, the samples were weighed, and the moisture contents were calculated.

Ash contents of the samples (%, d.b.) were determined by AACC International Method no 08-01.01 at 900 °C (AACC, 2000). The flour samples were measured into ash dishes in amounts of 3-5 g. Then samples were placed in a muffle furnace at 900 °C. They were incinerated until light gray ash was obtained. After cooling, the samples were weighed, and the ash contents were calculated.

Protein contents of the samples (%, d.b.) were assayed using the Kjeldahl procedure (Nx5.7) by AACC method no 46-10 (AACC, 2000).

Physicochemical and technological quality tests

Water absorption capacity (WAC) of wheats was determined by the method described by Hayta (2002). Wheat samples (10 g) was poured into 30 ml of water in the centrifugal tubes. They were kept in the water bath at 75 °C for 20 min and then centrifuged (Sigma2-16 PK, Germany) at 4000xg for 10 min. After draining the sample, water absorption capacity value was calculated by the Eq.4:

$$Water\ absorption \left(\frac{g\ water}{g\ wheat}\right) = \frac{W2-W1}{W1} \quad (4)$$

where, W_2 is the weight (g) of wheat sample after centrifugation and W_1 is the initial weight (g) of wheat sample.

Gluten index (GI) and wet gluten content of the samples were determined using Glutomatic system ((Perten Instrument AB, Huddinge, Sweden) of

AACC methods of 38-11 and 12.02 (AACC, 2000).

SDS (Sodium dodecyl sulphate) sedimentation value of the samples were measured by using AACC method no 56-70 in mL (AACC, 2000).

Glutograph-E values shear time (stretching (STR), s, extension) and relaxation (RX) (elasticity)(BU) was carried out by Glutograph-E device (Brabender- GmbH & Co. KG, Duisburg, Germany) according to the method of Alamri et al. (2009).

Statistical analysis

The data obtained were subjected to analysis of variance (ANOVA). Whenever the differences were significant ($P \leq 0.05$), Duncan's multiple range test was applied to determine the homogeneous groups. Each analysis was performed in triplicate.

Results and Discussion

The results of physical, technological, and physicochemical quality characteristics of wheat varieties were given in Tables 1-3 and discussed in detail below. It was determined that wheat variety was all statistically significant ($P \leq 0.05$) in terms of all investigated quality characteristics.

Physical characteristics of wheat varieties

Dimensions (length, width, thickness, equivalent diameter) and sphericity

The mean dimensions and sphericity results of each wheat variety were given in Table 1. As seen in the Table 1, there are statistically significant differences ($P \leq 0.05$) between the wheat varieties in terms of physical quality characteristics such as size (length, width, thickness, equivalent diameter) and sphericity. It also indicated that the mean length of the Burgos, Svevo, Güneyyıldızı, Sarıçanak 98, Zenit and Massimo wheat are 7.85, 6.98, 6.30, 7.38, 7.81 and 5.96 mm, respectively. The Burgos was the longest while the Massimo was the shortest one. On the other hand, the widest one is Svevo (3.95 mm), while the narrowest one is Zenit (3.16 mm). The wheat variety with the highest thickness value was Sarıçanak 98 with a value of 3.32 mm and the lowest one was Zenit (2.98 mm). Similarly, Svevo wheat variety had the highest mean equivalent diameter (4.47 mm). The sphericity (ϕ_s)values of wheats were found as between 0.53 and 0.66. Massimo variety had the highest sphericity value (0.66) while Zenit had the lowest value (0.53). In a study conducted in 16 varieties of durum wheat cultivars grown in Southern Italy, the length, width and thickness range values were found as 6.39-7.83 mm, 2.17- 3.31 mm and 2.66- 3.05 mm, respectively (Troccoli and Di Fonzo, 1999). In another study for 5 different wheat cultivars grown in Turkey, the length, width, thickness, equivalent diameter and sphericity range values were found to be 6.24-7.43 mm, 2.71- 3.30 mm, 2.62-3.06, 3.57- 4.11 mm and 0.53-060, respectively (Kalkan and Kara, 2011). The sphericity of 5 different wheat cultivars were found to be in the range of 0.48-0.65 (Tabatabaeefar, 2003).

Table 1. Physical characteristics of wheat varieties[1]

Variety	TKW (g)	HLW (kg hl^{-1})	L (mm)	W (mm)	T (mm)	D_e (mm)	ϕ_s	Hardness (NIR, %)
Burgos	53.19^{b} (±0.06)	83.30^{b} (±0.03)	7.85^{a} (±0.07)	3.21^{c} (±0.02)	3.10^{b} (±0.02)	4.27^{a} (±0.03)	0.54^{b} (±0.03)	67.10^{a} (±0.02)
Svevo	49.50^{c} (±0.04)	83.08^{c} (±0.04)	6.98^{c} (±0.01)	3.95^{a} (±0.01)	3.25^{a} (±0.02)	4.47^{c} (±0.04)	0.64^{a} (±0.02)	58.50^{d} (±0.04)
Güneyyıldızı	47.18^{a} (±0.02)	83.10^{a} (±0.06)	6.30^{b} (±0.09)	3.36^{c} (±0.03)	3.01^{b} (±0.01)	3.99^{b} (±0.02)	0.63^{b} (±0.01)	55.70^{b} (±0.01)
Sarıçanak 98	48.21^{d} (±0.05)	84.38^{d} (±0.02)	7.38^{d} (±0.02)	3.45^{b} (±0.02)	3.32^{c} (±0.02)	4.39^{d} (±0.06)	0.59^{a} (±0.02)	66.50^{c} (±0.05)
Zenit	50.77^{c} (±0.04)	81.75^{c} (±0.04)	7.81^{c} (±0.01)	3.16^{a} (±0.01)	2.98^{a} (±0.02)	4.19^{c} (±0.03)	0.53^{a} (±0.01)	69.50^{d} (±0.04)
Massimo	53.82^{d} (±0.05)	84.71^{d} (±0.06)	5.96^{d} (±0.03)	3.35^{b} (±0.07)	3.01^{c} (±0.02)	3.92^{d} (±0.05)	0.66^{a} (±0.02)	72.20^{c} (±0.05)

[1]Means followed by the different letters within the column are significantly different at P≤ = 0.05. ϕ_s: Sphericity, TKW:Thousand kernel weight, HLW:Hectoliter weight, L:Length , W:Width, T:Thickness, D_e:Equivalent diameter.

Kernel size uniformity is very important in wheat milling industry, especially in cleaning, conditioning, debranning or grinding processes. High-quality durum wheat is expected to have larger kernels with hard and vitreous endosperm in order to obtain semolina with higher yield and brightness (Dziki and Laskowski, 2005). Kernel shape (Lenght, width, thickness, and diameter) may depend- not only on wheat genus or species but also on wheat variety and agro-climatic conditions. It is evident from the physical data that Burgos, Svevo, Güneyyıldızı, Sarıçanak 98, Zenit and Massimo wheats were of adequate kernel size for semolina milling, flour milling, bread, pasta, and bulgur processing.

Thousand kernel weight (TKW)

The thousand kernel weight of grains is important to give an idea of grain weight, fullness, slenderness, kernel size, grain yield and flour production. It varies depending on the conditions of growing and climatic, species and varieties. In the same type such as bread or durum wheat, usually the weight of a thousand grains is inversely proportional to the amount of protein, with the amount of starch. Thousand grain weight is higher in hard wheat than in soft wheat (Ünal, 2003).

In this study, thousand-kernel weight values showed a significant difference (P≤0.05) between wheat varieties with values varying from 47.18 (g) (Güneyyıldızı) to 53.82 (g) (Massimo) (Table 1). Massimo variety yielded a high thousand-kernel weight value. Thousand kernel weight was found as highest in Massimo wheat while was lowest that of Güneyyıldızı wheat variety. The differences observed in thousand kernel weight among wheat varieties and genotypes may be due to the differences in the genetic make-up of the varieties. Results are comparable with the earlier findings of Szumilo et al. (2010), Aktaş et al. (2011), Sayaslan et al. (2012), and Öztürk et al. (2017) who reported thousand kernel weight ranges of 25.90-51.40 g, 28.90-40.80 g, 42.30-56.20 g, and 31.40-47.10 g, respectively, for different wheat varieties. Thousand kernel weights of durum wheats are higher than other wheat varieties (Finney et al., 1987; Morris, 2004; Sissons, 2004).

Hectoliter weight

One of the factors that are based on the quality classification of wheat is the weight of hectoliter and the higher the weight, the greater the amount of dry matter and thus the flour yield (Manley et al., 2009). It depends on the grain size, shape, hardness or softness and density. Hectoliter weight may vary depending on genetic structure, environmental conditions, and cultural practices (Protic et al., 2007).

The analysis of variance of the hectoliter weight is showing in Table 1. Hectoliter weight of Massimo (84.71 kg hl^{-1}) was significantly (P≤0.05) higher than the other five varieties. This was followed by Sarıçanak 98 (84.38 kg hl^{-1}), Burgos (83.30 kg hl^{-1}), Güneyyıldızı (83.10 kg hl^{-1}), Svevo (83.08 kg hl^{-1}), and Zenit (81.75 kg hl^{-1}) variety (Table 1). Hectoliter weight up to 82.00 kg hl^{-1} is classified as very good wheat varieties (Diepenbrock et al., 2005). According to the Turkish Wheat Standard, wheat varieties with hectoliter weight higher than 78.00 kg hl^{-1} are first class wheat (Anonymous, 2001). Six wheat varieties in this study showed good values in terms of hectoliter weight. The hectoliter values of this study are comparable with the results of the study reported by Yağdı (2004), Aydın et al. (2005), Szumilo et al. (2010), Aktaş et al. (2011), Kılıç et al. (2012), Migliorini et al. (2016) and Öztürk et al. (2017). Based on the above results, it can be predicted that all the above wheat varieties with their relatively high hectoliter weight have the potential for good semolina, bulgur and couscous yield on milling. Hectoliter weights of durum wheats are higher than other wheat varieties (Finney et al., 1987; Morris, 2004; Sissons, 2004).

Hardness values

Hardness is among the physical features that effectively determine endues quality of wheat. The hardness values of all wheat varieties used in this study are shown in Table 1. The mean hardness values of Burgos, Svevo, Güneyyıldızı, Sarıçanak 98, Zenit and Massimo wheat varieties were found to be 67.10, 58.50, 55.70, 66.50, 69.50 and 72.20 (NIR hardness), respectively. The results are in agreement with the results of the studies made by Maghirang and Dowell (2003), Arif et al. (2007), Hruskova and Svec (2009) and Öztürk et al. (2017) for different durum and hard wheat cultivars with a range of 52-89, 50-60, 38-58, and 50.00-64.50 (NIR, %). for different wheat varieties with a range of (%). According to Hruskova and Svec (2009), the scales of the relative wheat harness (%) are classified as follows; extra hard (higher than 84), very hard (73-84), hard (61-72), medium hard (49-60), medium soft (37-48), soft (25-36), very soft (13-24) and extra soft (lower than 12), respectively. Svevo and Güneyyıldızı are medium hard wheats while Burgos, Sarıçanak 98, Zenit and Massimo are hard wheats according to this hardness scaling.

The hardness values of all wheat varieties were high because they are all durum wheat varieties. A significant difference was obtained between wheat varieties (P≤0.05). The hardness values of durum wheats are higher (Aalami et al., 2007) than that of Bread wheats due to hard endosperm and vitreousness. Grain hardness is normally affected by different environmental, physical, and chemical factors like kernel protein (El-Khayat et al., 2003), vitreousness, kernel size, water-soluble pentosans, moisture content and lipid content (Turnbull and Rahman, 2002). Previous studies had indicated that milling performance of the kernel was related to the size of the kernel, hardness. Kernels with high protein content are generally assumed to yield more semolina than either starchy or piebald kernels. Hard kernels are also considered to have a positive effect on the color and cooking quality of pasta, couscous, and bulgur.

Hunter CIE color values (L, a* and b*)*

Wheat grains are generally white, light yellow, yellow-red, amber and brown. The color of wheat is very important for wheat products. The color values (L*, a* and b*) of wheat varieties were shown in Table 2 and significant differences (P≤0.05) was obtained between wheats and their flours. The brightness (L*) value of grains was highest in Sarıçanak 98 with a value of 53.50 and lowest in Zenit with a value of 44.02. The a* values of Burgos, Svevo, Güneyyıldızı, Sarıçanak 98, Zenit and Massimo wheat varieties were found to be 5.97, 7.27, 6.87, 7.40, 6.47 and 7.89, respectively. The b* that one of the most important quality characteristics for pasta, bulgur and other wheat products were found as 14.96 (Burgos), 17.72 (Svevo), 16.94 (Güneyyıldızı), 20.24 (Sarıçanak 98), 16.24 (Zenit) and 19.89 (Massimo). The highest in b* value was found in Sarıçanak 98 wheat grain while the lowest one was in Burgos wheat grain.

Table 2. Hunter CIE color values of different wheat varieties and their flours[1]

Variety	Wheat			Flour		
	L*	a*	b*	L*	a*	b*
Burgos	47.78[b] ±0.04	5.97[a] ±0.04	14.96[a] ±0.02	84.43[cd] ±0.02	-2.00[e] ±0.16	16.26[b] ±0.05
Svevo	53.18[e] ±0.06	7.27[d] ±0.03	17.72[d] ±0.06	84.80[d] ±0.03	-2.17[d] ±0.08	16.42[bc] ±0.13
Güneyyıldızı	48.02[c] ±0.08	6.87[c] ±0.02	16.94[c] ±0.04	84.09[c] ±0.06	-2.39[c] ±0.14	18.35[d] ±0.15
Sarıçanak 98	53.50[f] ±0.02	7.40[e] ±0.01	20.24[f] ±0.08	84.38[cd] ±0.07	-1.57[f] ±0.09	14.17[a] ±0.03
Zenit	44.02[a] ±0.07	6.47[b] ±0.05	16.24[b] ±0.07	82.92[a] ±0.03	-2.51[b] ±0.13	18.89[e] ±0.05
Massimo	52.84[d] ±0.03	7.89[f] ±0.06	19.89[e] ±0.05	83.45[b] ±0.06	-2.85[a] ±0.07	17.85[c] ±0.02

[1]Means followed by the different letters within the column are significantly different at *P≤0.05*.

Concerning the color of the flour, the significant difference (P≤0.05) was detected among most of the flour samples (Table 2). The color of the flour samples was bright where L* values exceeded 85 for all of them due to bran removal and high starch content. The a* values flours of all varieties were changed from positive values to negative values due to bran removal and pigments. The b* values were also changed when the flour obtained from the same wheat. The b* values of flours of Svevo, Sarıçanak 98 and Massimo wheats decreased while that of Burgos, Güneyyıldızı and Zenit wheats increased due to bran and characteristics of variety. The yellowish color of durum wheat and semolina flour made from it is due to a carotenoid pigment called lutein, which can be oxidized to a colorless form by enzymes present in the grain. The most important carotenoids found in wheat are lutein and lutein-fatty acid esters from xanthophy and ß-carotene from carotenes (Fortmann and Joiner, 1978).

Chemical, physicochemical and technological quality characteristics

Ash content

The ash contents of different wheat kernels show significant difference (P≤0.05) among them and varied from 1.35 (%w/w, d.b.) (Zenit) to 1.86 (%w/w, d.b.) (Svevo) (Table 3). This difference may be due to variety, hardness and environment. The ash contents of different wheat genotypes of hard and soft ones from different locations reported as to be between 1.18 and 2.32 (%w/w, d.b.) (Dizlek et al., 2013). According to Codex Alimentarius International Food Standards, the maximum protein content of the whole durum wheat semolina should have been as 2.10 (%w/w, d.b.) (CAIFS, 2019). The ash contents found for the varieties in this study is suitable for the standards and previous studies. Ash is an important chemical constituent for flour quality and is an indicator of flour purity. The ash content of wheat grain has been reported to vary with variety, hardness and environment. Ash content indicates how completely and efficiently the endosperm has been separated from the bran. The ash contents in the endosperm of durum wheats are higher than other wheat varieties (Finney et al., 1987; Morris, 2004; Sissons, 2004).

Table 3. Chemical, physicochemical, and technological quality characteristics of different wheat varieties[1]

Variety	Ash (%w/w, d.b)	Protein (%w/w, d.b)	SDS (ml)	Wet Gluten (%w/w)	Gluten Index (%w/w)	STR Extensibility (s)	RX Elasticity (BU)*	WAC (g water/ g wheat)
Burgos	1.50^{c} ±0.03	16.10^{e} ±0.02	29.00^{e} ±0.04	29.50^{a} ±0.05	96.91^{c} ±0.02	79.00^{e} ±0.13	553.00^{e} ±0.25	2.50^{e} ±0.001
Svevo	1.86^{f} ±0.04	15.15^{d} ±0.03	27.00^{d} ±0.02	30.40^{b} ±0.07	97.87^{de} ±0.03	74.00^{b} ±0.09	547.00^{d} ±0.23	2.42^{c} ±0.002
Güneyyıldızı	1.45^{b} ±0.02	14.70^{c} ±0.02	23.00^{c} ±0.05	36.15^{e} ±0.03	95.11^{b} ±0.02	69.00^{a} ±0.11	535.00^{b} ±0.17	2.37^{b} ±0.003
Sarıçanak 98	1.73^{e} ±0.03	13.85^{a} ±0.05	13.00^{a} ±0.06	35.55^{d} ±0.04	94.36^{a} ±0.04	77.00^{c} ±0.21	532.00^{a} ±0.22	2.47^{d} ±0.005
Zenit	1.35^{a} ±0.06	14.60^{b} ±0.03	13.50^{b} ±0.03	33.15^{c} ±0.07	97.15^{d} ±0.06	78.00^{d} ±0.08	537.00^{c} ±0.09	2.30^{a} ±0.002
Massimo	1.65^{d} ±0.08	16.75^{f} ±0.02	30.50^{f} ±0.04	37.10^{f} ±0.05	98.14^{e} ±0.02	81.00^{f} ±0.06	564.00^{f} ±0.12	2.55^{f} ±0.004

[1]Means followed by the different letter within column are significantly different at P≤0.05. SDS: sodiumdodesilsulphate sedimentation value, WAC: Water absorption capacity.

Protein content

Significant differences (P≤0.05) were observed in the protein contents of all the wheat varieties (Table 3). For instance, among the wheat varieties Massimo had the highest protein content while Sarıçanak 98 had the lowest value. The protein content was found to be 16.10, 15.15, 14.70, 13.85, 14.60 and 16.75 (%w/w, d.b.) for Burgos, Svevo, Güneyyıldızı, Sarıçanak 98, Zenit and Massimo, respectively. These results are in agreement with the results in wheat reported by Sakin et al. (2011a; 2011b), Kılıç et al. (2012), Brennan et al. (2012), Sayaslan et al. (2012), Katyal et al. (2016) and Öztürk et al. (2017). The protein results for the present study are also similar to the results of the study made by Khalaf et al. (2005) for protein contents of some Iraqi and ICARDA selected durum wheat cultivars (11.50-14.76, %w/w, d.b.). According to Codex Alimentarius International Food Standards, the minimum protein content (%w/w, d.b.) of the whole durum wheat semolina should be- 11.5 (CAIFS, 2019).

SDS-sedimentation value

Sedimentation value is an important feature that gives information about the gluten quality of wheat flour. Sedimentation value is used to predict the quantity and quality of gluten, as well as to estimate the protein content of wheat with the same gluten quality (Dizlek and Islamoğlu, 2015).

According to the results of variance analysis, the difference between sedimentation value of wheat varieties was found statistically significant (P≤0.05) (Table 3). The higher the volume of sediment, the relatively stronger the gluten proteins are in the sample. When the sedimentation values (SDS) of the varieties were considered, the best varieties were found in Massimo and Burgos wheats with 30.50 ml and 29.00 ml, respectively. The lowest sedimentation value was observed in the Sarıçanak 98 variety with 13.00 ml. Sedimentation values are considered to be poor for 15-20 ml, moderate for 20-25 ml, and suitable for bread making if it is between 25-30 ml (Ünal, 2003). The sedimentation volume of different wheat varieties (durum, hard and soft wheats) varies between 12.0 and 56.0 ml (Sakin et al., 2011b, Kılıç et al., 2012; Sayaslan et al., 2012; Kaya and Akcura, 2014; Katyal et al., 2016 and Pekmez, 2018). It has been determined that types of wheats used in this study have sedimentation value between the range of previous researches.

Wet gluten content

Gluten is a group of proteins found in cereals, especially wheat responsible for the strong structure of the dough. It is closely related to other grain cereals, especially rye, barley, oats, and for this reason these cereals also contain gluten. Gluten, an important indicator of the pasta quality of wheat, is elastic protein showing the suitability of flour for pasta and couscous making. The gluten structure, including the strength of the matrix, is thus an important component of pasta quality. Among the wheat quality components, gluten plays the most important role in determining industrial use, and therefore gluten strength is one of the parameters for classification of wheat for use in bread, cakes, and pasta (Modenes et al., 2009).

When it was considered the wet gluten results of different wheats in Table 3, it was found the values between 29.50 and 37.10 (%w/w). The amount of wet gluten for Sarıçanak 98, Güneyyıldızı and Massimo varieties is higher than 35% and it is a high value. Burgos, Svevo and Zenit varieties are in the gluten group because they are between 28-35 (%w/w). Significant differences (P≤0.05) in the mean of wet gluten were observed among wheat varieties. It is stated that the amount of wet gluten is higher than 35% in wheat with high gluten value, between 28-35 (%w/w) in good wheat, between 20-27 (%w/w) in medium wheat, and less than 20 (%w/w) in wheat with low degree gluten (Ünal, 2003). Similar results for investigation of genotypes for wet gluten traits recognized by several writers (Szumilo et al., 2010; Sakin et al., 2011b; Cristina et al., 2014; Vida et al., 2014).

Gluten index value

The gluten index (GI) is a measurement of wheat protein that provides a simultaneous determination of gluten quality and quantity. Gluten index gives an idea of gluten quality. The gluten index is used to determine whether gluten structure is weak or strong (AACC, 2000).

Gluten index value of flours milled from different wheat varieties ranged from 94.36 ((%w/w) to 97.87 ((%w/w) and showed significantly (P≤0.05) differences between wheats (Table 3). It was determined that the lowest gluten index value in varieties is Sarıçanak 98 with 94.36 ((%w/w). The highest gluten index value is in Massimo variety with 98.14 ((%w/w). As for the gluten index, which somewhat reflects gluten quality, the genotypes had values varying from 21 ((%w/w) to 96 ((%w/w) (Sayaslan et al., 2012). Optimum value for gluten index is between 65 ((%w/w) and 80 ((%w/w). Gluten index value above 80 indicates strong gluten (Migliorini et al., 2016). Six wheat varieties studied had strong gluten because the values of all varieties were higher than 80 ((%w/w). Migliorini et al. (2016) reported that gluten index values of wheat varieties cultivated in Italy, which expresses gluten quality, were found between 57 ((%w/w) and 80.30 ((%w/w) and influenced by the year. The gluten index values of 70 ((%w/w) winter durum wheat genotypes grown between 2010-2012 years were changed between 1.51 ((%w/w) and 96.37 ((%w/w) (Vida et al., 2014)

Glutograph-E values

Glutograph is a device that measures the elongation and elastic properties of wet gluten. The time required for the Glutograph test is approximately 7 minutes. The glutographer 800 BU (Brabender unit) measures parameters such as the elongation or stretching time (STR) required to reach the BU angle and the elasticity (RX) value at 10 seconds. The glutograph test provides information on the extensibility and elasticity of gluten.

Glutograph-E results of wheat samples were given in Table 3. Significant differences (P≤0.05) in stretching (extensibility) and relaxation (elasticity) values from Glutograph-E were obtained between wheat varieties. The stretching (extensibility) and relaxation (elasticity) values of all wheat varieties were found between 69-81 s and 532-564 BU, respectively. The highest extensibility time was found in Massimo wheat variety with a value of 81 s while the lowest one was in Güneyyıldızı wheat with a value of 69 s. The elasticity value of Sarıçanak 98 wheat was the lowest with a value of 532 BU. On the other hand, the highest value of elasticity was found as 564 BU for Massimo wheat. Stretching and relaxation values of 5 different durum wheat varieties were found as in the range of 0-125 s and 417-915 BU (Alamri et al., 2009). Glutograph stretching value and glutograph relaxation value for sixteen durum wheat cultivars grown at Langdon, Minot and Williston, North Dakota, in 2006 were found between 0.10-96.5 s and 150-287 BU, respectively (AbuHammad et al., 2012).

The stretching and relaxation values of bread wheat were found to be 101 s and 564 BU, respectively (Kaplan-Evlice et al., 2016). Stretching and relaxation values of Bread wheats were found to be in the range of 390-811 BU (13-125 s) and 328-679 BU, respectively (Keçeli et al., 2017). In the study of Kaya (2018), the stretching and relaxation values of refined durum wheat were 82.50 s and 534 BU, respectively. Gluten extensibility was higher in wheat samples with native inulin in percentages of 2.5- 7.7 % (571-535 s) than in the control dough (499 s) (Codina et al., 2018).

Water absorption capacity (WAC)

Hydration characteristics of wheat and wheat products such as bulgur, couscous, flour, semolina are important and indicate the physical and chemical alterations occurring during processing (Maskan, 2001). As can be seen in Table 3, water absorption capacity changed significantly (P≤0.05) with wheat variety. This difference may be due to the size of wheat-, variety and hardness. The water absorption capacities of Burgos, Svevo, Güneyyıldızı, Sarıçanak 98, Zenit and Massimo wheats were found to be 2.50±0.001, 2.42±0.002, 2.37±0.003, 2.47±0.005, 2.30±0.002 and 2.55±0.004 (g water/g wheat), respectively. The water absorption capacities of fine bulgur which is a type of durum wheat products at different drying conditions were found to be in the range of 1.96-2.39 (g water/g bulgur) (Kahyaoglu et al., 2010). Hayta (2002) also found the water absorption of pilaf bulgur (made from durum wheat) at different drying conditions to be between 2.33 and 2.56 (g water/g bulgur).

Damaged starch granules exhibit a higher degree of water absorption and greater susceptibility to degradation by amylolytic enzymes than undamaged granules. By their very nature, hard wheat granular products (whole meals and flours) contain a higher percentage of damaged granules than similar products from soft wheat. Water absorption of flour during baking is largely determined by the combination of protein content, starch damage level, and α-amylase activity. Damaged starch hydrates and swells very rapidly and has high water-absorbing capacity (Khan and Shewry, 2009)). Water absorption capacity of durum wheat and flours are important for bulgur, couscous, pasta, noodles processes such as dough formation, cooking, forming, drying etc.

Conclussion

Based on the findings of the study, it was seen that there were differences between the wheat varieties with statistical significance (P≤0.05) in terms of physical, chemical, technological and physicochemical characteristics. The longest, widest, thickest, highest mean equivalent diameter and highest sphericity wheats were found to Burgos, Svevo, Sarıçanak 98, Svevo, Svevo and Massimo while the shortest, narrowest, thinnest, lowest equivalent diameter and lowest sphericity wheats were Massimo, Zenit, Zenit, Massimo, Zenit, respectively. The differences observed in thousand kernel weight among wheat varieties and genotypes may be due to the differences in the genetic make-up of the varieties. Wheat varieties in this study showed good values in terms of hectoliter weight. Svevo and Güneyyıldızı are medium hard wheats while Burgos, Sarıçanak 98, Zenit and Massimo are hard wheats according to hardness scaling. Significant differences (P≤0.05) in color values (L*, a* and b*) were obtained between wheats and their flours. The b* values of flours of Svevo, Sarıçanak 98 and Massimo wheats decreased while that of Burgos, Güneyyıldızı and Zenit wheats increased compared with their wheat kernels due to bran and characteristics of variety. The ash contents of different wheat kernels shown significant difference (P≤0.05) due to variety, hardness and environment. Among the wheat varieties Massimo had the highest protein content while Sarıçanak 98 had the lowest value. When the sedimentation values (SDS) of the varieties were considered, the best varieties were found in Massimo and Burgos wheats. The amount of wet gluten for Sarıçanak 98, Güneyyıldızı and Massimo varieties was found to be higher than 35% value. Six wheat varieties studied had strong gluten because the values of gluten index of all varieties were higher than 80. The highest extensibility and elasticity were found in Massimo wheat variety. Water absorption capacity changed significantly (P≤0.05) with wheat variety due to size of wheats, variety and hardness. Knowing the quality characteristics of wheat varieties may facilitate the processing of products to be obtained from these wheats.

Conflict of Interest: The authors declare that they have no conflict of interest.

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