



# Physical, physicochemical (technological) and chemical characteristics of common bread wheat (*Triticum aestivum* L.) varieties grown in Mardin region of Turkey

## *Türkiye'nin Mardin yöresinde yaygın yetiştirilen ekmeklik buğday (Triticum aestivum L.) çeşitlerinin fiziksel, fizikokimyasal (teknolojik) ve kimyasal özellikleri*

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### ABSTRACT

In this study, the physical (color, grain size, equivalent diameter, sphericity, kernel surface area, kernel volume, thousand kernel weight, hectoliter weight, dry weight and wet weight), physicochemical (technological) (dry volume, wet volume, water absorption capacity, water absorption index, swelling capacity, swelling index, gluten index, Zeleny sedimentation and delayed sedimentation) and chemical (moisture, protein and wet gluten contents) properties of the most grown bread wheat varieties (*Triticum aestivum* L.) (Adana 99, Ceyhan 99, Sagittario, and Dinç) in Mardin region of Turkey during 2018 were compared. Statistically significant differences ( $P \leq 0.05$ ) were obtained between wheat varieties in terms of physical, physicochemical-technological and chemical quality characteristics. It has been determined that thousand kernel weight and hectoliter weight values of wheat varieties which are superior to the wheat varieties in terms of their grain sizes were generally higher than the others. Thousand kernel weight, hectoliter weight, protein, wet gluten, gluten index and Zeleny sedimentation values of wheat varieties were found in the range of 35.48-42.71 g, 77.91-81.00 kg/hl, 11.50-13.25%, 29.04-33.79%, 82.5-89.5 and 26.0-43.5 ml, respectively. The differences in quality characteristics between wheat varieties may be important for the flour producers that produce flour for both industrial and traditional bread (tandoori bread and peksimet, etc.) producers, especially in the Mardin region.

**Key Words:** Wheat, Kernel, Bread, Quality characteristics

### ÖZ

Bu çalışmada, Türkiye'nin Mardin yöresinde 2018 döneminde en çok yetiştirilen Adana 99, Ceyhan 99, Sagittario, ve Dinç buğday çeşitleri olmak üzere 4 farklı ekmeklik buğday (*Triticum aestivum* L.) çeşidinin fiziksel (renk, tane boyutları, eşdeğer çap, küresellik, tane yüzey alanı, tane hacmi, bin tane ağırlığı, hektolitreye ağırlığı, kuru ağırlık ve yaş ağırlık), fizikokimyasal (teknolojik) (kuru hacim, ıslak hacim, su alma kapasitesi, su alma indeksi, şişme kapasitesi, şişme indeksi, gluten indeksi, Zeleny sedimantasyon ve gecikmeli sedimantasyon) ve kimyasal (nem, protein ve yaş gluten miktarları) özellikleri karşılaştırılmıştır. Buğday çeşitleri arasında fiziksel, fizikokimyasal-teknolojik ve kimyasal kalite özellikler açısından istatistiksel olarak önemli farklar ( $P \leq 0.05$ ) bulunmuştur. Buğday çeşitlerinden tane boyutları özellikleri bakımından üstün olan buğdayların bin tane ağırlığı ve hektolitreye ağırlığı değerlerinin de genellikle diğerlerinden yüksek olduğu tespit edilmiştir. Örneklerin bin tane ağırlığı, hektolitreye ağırlığı, protein, yaş gluten, gluten indeksi ve Zeleny sedimantasyon değerleri sırasıyla 35.48-42.71 g, 77.91-81.00 kg/hl, %11.50-13.25, %29.04-33.79, %82.5-89.5 ve 26.0-43.5 ml aralıklarında tespit edilmiştir. Buğday çeşitleri arasındaki kalite karakteristiklerindeki farklılıklar özellikle Mardin yöresindeki gerek endüstriyel gerekse geleneksel bazı (tandır ekmeği ve peksimet vb.) ekmek üreten un üreticileri açısından önemli olabilir.

**Anahtar Kelimeler:** Buğday, Tane, Ekmek, Kalite özellikleri

## Introduction

The fast rise in the world population demands parallel increases in food production, particularly of wheat. Bread wheat (*Triticum aestivum* L.), which is widely grown in many countries, is a major field crop and is therefore of great economic importance. Wheat is a cereal variety of the *Gramineae* family, without husks, with a nearly spherical oval appearance. Wheat grain is rich in carbohydrates, proteins, minerals, trace elements, vitamins, fatty acids, color substances called secondary plant metabolites and phenols. Wheat is a type of cereal that ranks first in human nutrition in the world and is cultivated almost everywhere in the World. According to the 2019 data of FAO, wheat is harvested in an area of 215,901,958 ha with a total annual production of 765,769,635 metric tons in the World. The harvest in Turkey in the same year was 6,831,854 ha and it was 3.2% of the World wheat harvest. The annual production of wheat in Turkey in 2019 was 19,000,000 metric tons (FAO, 2020).

The most common consumption types of wheat are the products such as flour, bread, pasta, semolina, biscuits. Besides the commercial varieties in the World and Turkey, different traditional products are made and consumed by using local wheats. Breads produced using local varieties have become a part of Anatolian culture with the production techniques and tastes specific to the regions. In Anatolia, wheat culture is used as a raw material for many local products such as kadayif, phyllo, lavash, tandoori, kömbe, flat bread, couscous, noodles, bulgur, pasta, and keşkek, which were previously widely used in rural areas and now used in cities (Dizlek and Gul, 2009; Dizlek, 2012; FAO., 2018).

Considering the human nutrition of Turkey, the consumption of bread based on wheat is due to economic reasons and traditional habits. The amount of bread consumption varies according to these habits, and bread continues to be the most commonly consumed food today (Gül et al., 2017). The daily bread consumption was 333 grams in Turkey which is one of the most

consuming countries in the world (Anonymous, 2019).

Mardin is one of the important cities in Turkey according to wheat production area, wheat varieties, the number of flour producing factories and production of local bread types. A total of 2.6 million decares of agricultural land was allocated for cereals and other crops in 2017 in Mardin, and approximately 1.5 million tons of crops were harvested. Approximately 54% of this land was wheat planted and the total production amount was 838,500 tons in 2017 (Anonymous, 2018). The most cultivated wheat varieties in Mardin were Adana 99, Ceyhan 99, Dinç and Sagittario, respectively. (Anonymous, 2018). 41 of 73 food-producing factories in Organized Industrial Zone in Mardin have been produced flour (Anonymous, 2020).

Bread wheat quality is determined by some physical and physicochemical (technological) characteristics. These characteristics are important for both flour producers and bread producers, especially in bread types and production stages. Important quality factors in wheat and flour standards are hectoliter weight, thousand kernel weight, color, ash content, protein content, gluten content, and sodium dodecyl sulphate (SDS) sedimentation value. The physical and physicochemical characteristics (such as density, hectoliter weight, kernel size, thousand kernel weight, color, gluten index, Zeleny and modified Zeleny sedimentation values), the chemical properties (such as moisture, protein, gluten) have been studied extensively in *Triticum aestivum* (Khatkar et al., 2002; Gül et al., 2012; Karaman et al., 2012; Dizlek et al., 2013a, b; Kaplan-Evlice et al., 2016; Şahin et al., 2016; Aydoğan and Soylu, 2017; Gül et al., 2020; Şahin et al., 2020).

In this study, considering the needs of the flour producers in the Mardin Region of Turkey, it was aimed to determine the suitable wheat as a result of the analyzes made from the wheat purchased for commercial flour production and the obtained quality parameters.

## Materials and Methods

### Materials

In this study, Adana 99, Ceyhan 99, Sagittario, and Dinç bread wheat (*Triticum aestivum* L.) varieties, which are mostly grown in 2017/2018 production year at Mardin region, were used as materials. Wheat samples were obtained from Kızıltepe / Mardin Wheat market. Wheat used in the experiments was first cleaned from the foreign materials and broken grains. Cold tempering process (by spraying and mixing method) was applied by adding water according to the amounts specified in AACCI method No. 26-95.01 (AACCI, 2010). After the samples were tempered, they were mixed at 2 hour intervals and after 24 hours they were ground in a laboratory type mill (Serttaş machine Istanbul, Turkey). After milling the samples were sieved to 180 µm particle size.

### Determination of physical characteristics

#### Length, width and thickness of kernels

Randomly selected wheat kernels (100 kernels) were used to measure length (L), width (W) and thickness (T) using a Vernier caliper (Mutitoyo No: 505 -633, Japan).

#### Equivalent diameter

The equivalent diameter,  $D_e$ , was calculated using the Eq. 1 (Mohsenin, 1986).

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

where,  $D_e$ , L, W and T represent the equivalent diameter (mm), length (mm), width (mm) and thickness (mm), respectively.

#### Sphericity

The sphericity ( $\phi$ ) was calculated as a function of the three principal dimensions as shown in Eq. 2 (Mohsenin, 1986).

$$\phi = \frac{(LWT)^{1/3}}{L} \quad (2)$$

where,  $\phi$  is the sphericity of wheat kernels.

### Surface area of kernels

The surface area,  $A_k$  (mm<sup>2</sup>), of the kernels was calculated using the Eq. 3 (Mohsenin, 1986).

$$\text{Kernel surface area}(A_k) = \frac{\pi (WT)^{\frac{1}{2}} L^2}{(2L - (WT)^{\frac{1}{2}})} \quad (3)$$

where,  $A_k$  is the surface area (mm<sup>2</sup>) of kernels.  $\pi$  is the constant.

### Kernel volume

The volume,  $V_k$  (mm<sup>3</sup>), of the kernels was calculated using the Eq. 4 (Mohsenin, 1986).

$$\text{Kernel volume}(V_k) = \frac{\pi (WT)^{\frac{1}{2}} L^2}{6(2L - 3)} \quad (4)$$

where,  $V_k$  (mm<sup>3</sup>) is the volume of kernels.

### Dry weight

One hundred wheat sample was counted and weighed. This value was recorded as dry weight (g).

### Wet weight

One hundred of wheat kernels and fifty ml of water were taken in a graduated cylinder, and after keeping for 16 hours, the wheat kernels were dried with blotter paper and the result was recorded as gram.

### Thousand kernel weight

For the determination of the thousand kernel weight, 500 wheat kernels of wheat samples were weighed and the results were multiplied by 2. Thousand kernel weight values were recorded as grams of dry matter (Elgün et al., 2002).

### Hectoliter weight

The hectoliter weight of wheat samples was measured according to AACCI method no. 55-10.01 and the results were expressed in kg/hl (AACCI, 2010).

### Color

The surface color of wheat kernels was measured using Ultra Scan VIS Color Quest XE

HunterLab (Hunter Associates Laboratory Inc., Reston, VA, USA) after being standardized using Hunter Lab colour standards and 'L\*' (lightness), a\* (redness to greenness) and b\* (yellowness to blueness) values were measured.

#### *Determination of physicochemical-technological characteristics*

Water absorption capacity, water absorption index, dry volume, wet volume, swelling capacity, swelling index, gluten index, Zeleny sedimentation and Delayed sedimentation values of wheat samples were determined according to the methods of Youssef (1978) and Williams et al. (1983).

#### *Water absorption capacity*

The water absorption capacity (WAC) of wheat samples was calculated according to the Eqs. 5 and 6, and the results were recorded as g/kernel. If there is kernels that do not swell;

$$WAC \left( \frac{g}{kernel} \right) = \frac{[(WW-DW) - \left(\frac{DW}{100}\right) * \text{Not swollen kernels}]}{(100 - \text{Not swollen kernels})} \quad (5)$$

If there is no swelling kernels;

$$WAC \left( \frac{g}{kernel} \right) = \frac{WW-DW}{100} \quad (6)$$

where, WAC, DW and WW are water absorption capacity, dry weight, wet weight, respectively.

#### *Water absorption index*

Water absorption index (WAI) of wheat samples was calculated according to the Eq. 7, and the results were recorded as (% w/w).

$$WAI(\%, g/g) = \frac{(\text{Water absorption capacity})}{\text{Dry weight}/100} \quad (7)$$

#### *Dry volume*

50 ml of distilled water was added to 100 ml graduated cylinder and 100 kernels of wheat samples were added. The difference between the final volume and the first volume before wheat was added was calculated, and the result was recorded as ml.

#### *Wet volume*

50 ml of distilled water was added to a graduated cylinder, and 100 kernels of wheat samples were added. After waiting for 16 h, the wheat samples were dried with a paper towel. 100 ml of distilled water was poured into the cylinder and then dried wheat was added. The difference between the final volume and the initial volume before wheat was added was calculated and the result was recorded as ml.

#### *Swelling capacity*

The swelling capacity of wheat samples was calculated according to the Eq. 8 and the result was recorded as ml/kernel.

$$SC \left( \frac{ml}{kernel} \right) = \frac{[(WV-100) - (DV-50)] - \left(\frac{DV-50}{100}\right) * \text{Not swollen kernels}}{100 - \text{Not swollen kernels}} \quad (8)$$

where, SC, WV and DV are swelling capacity, wet volume and dry volume, respectively.

#### *Swelling index*

The swelling index of wheat samples was calculated according to the Eq. 9 and the result was recorded as in (% w/w).

$$\text{Swelling index} \left( \%, \frac{w}{w} \right) = \frac{\text{Wet volume} - 100}{\text{Dry volume} - 50} \quad (9)$$

#### *Gluten index*

The gluten index of the samples was determined by the approved AACCI method no. 38-12.02 and the results were found as % (w/w) (AACCI, 2010).

#### *Zeleny sedimentation test*

The Zeleny sedimentation value of the samples was determined by the standard methods of International Association for Cereal Science and Technology (ICC) number 116 (ICC, 2002).

#### *Delayed Zeleny sedimentation test*

Delayed sedimentation values of samples was determined according to the method made by Greenaway et al. (1965). The difference was found by comparing the Zeleny sedimentation value with the Delayed Zeleny sedimentation value. If this difference exceeds more than 5 ml, it

indicates that the wheat has been damaged by sunn pest. Standard hydration time (5 min) in Zeleny sedimentation was extended to 120 min in Delayed Zeleny sedimentation (Dizlek and Islamoğlu, 2015).

#### Determination of chemical properties

##### Moisture content

Moisture content of wheat varieties was determined by the approved AACCI method no.44-15.02 (AACCI, 2010).

##### Protein content

Protein content of wheat varieties was determined by the approved AACCI method no. 46-10.01 using the Kjeldahl method and expressed using the conversion factor  $N \times 5.7$  (AACCI, 2010).

##### Wet gluten

The wet gluten of the samples was determined by the approved AACCI method no. 38-12.02 and the results were found as % (w/w) (AACCI, 2010).

#### Statistical analysis

Analysis of variance (ANOVA) followed by

Duncan's multiple range test were performed using the SPSS 22 (SPSS Inc., Chicago, IL, USA). All the calculations were done at the significance level of  $P \leq 0.05$ . Each analysis was performed in triplicate.

#### Results and Discussion

##### Physical characteristics of bread wheat varieties

Physical characteristics such as length (L), width (W), thickness (T), equivalent diameter ( $D_e$ ), sphericity ( $\phi$ ), kernel volume ( $V_k$ ), kernel surface area ( $A_k$ ), color values ( $L^*$ ,  $a^*$  and  $b^*$ ) of the common bread wheat varieties grown in Mardin region of Turkey were determined to assess their contribution to the quality of the millers in Mardin. The results of these properties were given in Table 1. Length, width, thickness and equivalent diameter are commonly used measures of size. The differences between length, width, thickness, equivalent diameter, sphericity, kernel volume, kernel surface area, color values ( $L^*$ ,  $a^*$  and  $b^*$ ) of wheat varieties were found to be statistically significant ( $P \leq 0.05$ ) (Table 1).

Table 1. Physical characteristics of bread wheat varieties

Variety	L (mm)	W (mm)	T (mm)	$D_e$ (mm)	$V_k$ (mm <sup>3</sup> )	$A_k$ (mm <sup>2</sup> )	$\phi$	Color values		
								$L^*$	$a^*$	$b^*$
Adana99	6.63 $\pm 0.01^d$	3.27 $\pm 0.07^b$	2.97 $\pm 0.03^c$	4.01 $\pm 0.05^{bc}$	21.79 $\pm 0.02^d$	42.43 $\pm 0.04^d$	0.61 $\pm 0.02^b$	56.80 $\pm 0.04^c$	7.45 $\pm 0.07^a$	20.81 $\pm 0.02^d$
Ceyhan99	6.31 $\pm 0.05^b$	3.14 $\pm 0.10^{ab}$	2.84 $\pm 0.01^b$	3.83 $\pm 0.12^{ab}$	19.33 $\pm 0.04^b$	38.77 $\pm 0.02^b$	0.61 $\pm 0.02^{bc}$	54.95 $\pm 0.03^b$	7.23 $\pm 0.04^a$	19.22 $\pm 0.04^b$
Dinç	6.11 $\pm 0.02^a$	3.30 $\pm 0.03^b$	2.91 $\pm 0.02^{bc}$	3.89 $\pm 0.01^{ab}$	20.36 $\pm 0.01^c$	39.85 $\pm 0.03^c$	0.64 $\pm 0.02^c$	54.50 $\pm 0.07^b$	7.54 $\pm 0.03^a$	20.55 $\pm 0.06^c$
Sagittario	6.56 $\pm 0.03^c$	2.99 $\pm 0.10^a$	2.68 $\pm 0.04^a$	3.74 $\pm 0.07^a$	17.84 $\pm 0.03^a$	37.19 $\pm 0.01^a$	0.57 $\pm 0.01^a$	52.78 $\pm 0.05^a$	6.89 $\pm 0.05^a$	16.27 $\pm 0.03^a$

Means with different superscripts within a column are significantly different at  $P < 0.05$ . L: length, W: width, T: Thickness,  $D_e$ : equivalent diameter,  $V_k$ : Kernel volume,  $A_k$ : kernel surface area,  $\phi$ : Sphericity

Shape and size is an important physical properties of kernels in heat and mass transfer calculations, screening solids to separate foreign materials, and evaluating the quality of food materials. The shape of a food material is usually expressed in terms of its sphericity. Sphericity is an expression of a shape of a solid relative to that

of a sphere of the same volume. It was determined that the length, width, thickness, equivalent diameter and sphericity of wheat varieties varied between 6.11-6.63 mm, 2.99-3.30 mm, 2.68-2.97 mm, 3.74-4.01 mm and 0.57-0.64. The highest length value was found in Adana 99 wheat variety, while the lowest was found in Dinç

wheat variety. The lowest values in terms of width, thickness, equivalent diameter and sphericity were found in Sagittario wheat variety (Table 1).

The highest width value was found in Dinç wheat variety. The thickness and equivalent diameter of Adana 99 wheat have been found the highest. The highest sphericity value was found in Dinç wheat variety. In a study for 5 different wheat varieties 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 mm, 3.57-4.11 mm and 0.53-0.60, respectively (Kalkan and Kara, 2011). The sphericity of 5 different wheat varieties were found to be in the range of 0.48-0.65 (Tabatabaeefar, 2003). In a study conducted on 16 varieties of wheat grown in Southern Italy, the length, width and thickness range values were found to be 6.39-7.83 mm, 2.17-3.31 mm and 2.66-3.05 mm, respectively (Troccoli and Di Fonzo, 1999). A previous study on some wheat varieties was also showed similar conclusions (Yıldırım and Atasoy, 2020). Kernel size uniformity is very important in wheat milling industry, especially in cleaning, conditioning, debranning or grinding processes. High-quality bread wheat is expected to have larger kernels with vitreous endosperm in order to obtain flour with higher yield and brightness (Dziki and Laskowski, 2005). Kernel shape (Length, 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 wheat varieties in this study were of adequate kernel size for flour milling and bread processing.

Bread wheat kernels are generally white, light yellow, yellow red, amber and brown color. The color of bread wheat is especially important for bread products.  $L^*$  values ranged between 52.78 and 56.80, and Adana 99 variety was found to be brighter than other varieties while there was a significant difference between wheat varieties ( $P \leq 0.05$ ) in terms of  $L^*$  values. There was no statistically significant difference ( $P > 0.05$ )

between wheat varieties in terms of  $a^*$  values. Considering the  $b^*$  values, it can be said that Adana 99, Ceyhan 99 and Dinç wheat varieties are closer to each other and more yellowish, however, it has been determined that Sagittario wheats are darker and reddish than others. Bayrakçı (2008) reported that the  $L^*$ ,  $a^*$  and  $b^*$  values of some wheat varieties varied between 55.24-60.63, 4.90-6.43 and 17.78-21.70, respectively. Yıldırım and Atasoy (2020) was found  $L^*$ ,  $a^*$  and  $b^*$  values between 44.02-53.50, 5.97-7.89 and 14.96-20.24 for 6 different wheat varieties, respectively.

#### *Physicochemical and technological characteristics of wheat varieties*

Average of some physicochemical-technological properties of bread wheat varieties such as average dry weight, wet weight, water absorption capacity, water absorption index, dry volume, wet volume, swelling capacity, swelling index, thousand kernel weight, hectoliter weight are given in Table 2. Considering the results of these properties of the wheats, a statistically significant difference ( $P \leq 0.05$ ) was found between the varieties for all values.

Average dry weight values were found between 3.69 g and 3.90 g. The average wet weight values were varied between 5.02 g and 5.45 g, with the highest value in Adana 99 (5.45 g) and the lowest value in Sagittario wheat (5.02 g). The water absorption capacities of Adana 99, Ceyhan 99, Dinç and Sagittario wheat varieties were found to be 0.04, 0.03, 0.02 and 0.01 g/kernel, respectively. It was observed that there was a proportional relationship between wet weight and water absorption capacity of wheats.

Dry volume, wet volume, swelling capacity, swelling index, thousand kernel weight and hectoliter weight values were found to be significantly different ( $P \leq 0.05$ ) between wheat varieties. Average dry volume was ranged between the lowest Dinç wheat with 52.0 ml and the highest Ceyhan 99 wheat with 55.5 ml. The wet volume values were found to be close to each other between 104.5 ml and 106.5 ml. Swelling

capacity varied between 1.0 and 3.0 ml/kernel. Sagittario wheat variety was the least swollen,

while Adana 99 was the most swollen wheat variety.

Table 2. Physicochemical characteristics of wheat varieties

Variety	DW	WW	WAC	WAI	DV	WV	SC	SI	TKW	HLW
Adana 99	3.90 ±0.01 <sup>b</sup>	5.45 ±0.06 <sup>bc</sup>	0.04 ±0.001 <sup>c</sup>	0.41 ±0.01 <sup>a</sup>	53.50 ±0.02 <sup>b</sup>	106.50 ±0.03 <sup>c</sup>	3.00 ±0.02 <sup>d</sup>	2.25 ±0.04 <sup>bc</sup>	38.50 ±0.05 <sup>d</sup>	81.00 ±0.03 <sup>d</sup>
Ceyhan 99	3.80 ±0.02 <sup>ab</sup>	5.26 ±0.36 <sup>b</sup>	0.03 ±0.002 <sup>a</sup>	0.40 ±0.02 <sup>a</sup>	55.50 ±0.03 <sup>d</sup>	106.50 ±0.01 <sup>c</sup>	2.50 ±0.01 <sup>c</sup>	1.88 ±0.02 <sup>b</sup>	37.62 ±0.02 <sup>b</sup>	77.91 ±0.01 <sup>a</sup>
Dinç	3.73 ±0.03 <sup>a</sup>	5.18 ±0.09 <sup>ab</sup>	0.02 ±0.005 <sup>b</sup>	0.48 ±0.04 <sup>b</sup>	52.00 ±0.01 <sup>a</sup>	104.50 ±0.04 <sup>a</sup>	2.00 ±0.03 <sup>b</sup>	1.23 ±0.03 <sup>ab</sup>	35.48 ±0.01 <sup>c</sup>	79.69 ±0.04 <sup>b</sup>
Sagittario	3.69 ±0.02 <sup>a</sup>	5.02 ±0.11 <sup>a</sup>	0.01 ±0.003 <sup>d</sup>	0.44 ±0.03 <sup>bc</sup>	54.50 ±0.02 <sup>c</sup>	105.50 ±0.02 <sup>b</sup>	1.00 ±0.02 <sup>a</sup>	1.18 ±0.05 <sup>a</sup>	42.71 ±0.02 <sup>a</sup>	80.24 ±0.02 <sup>c</sup>

Means with different superscripts within a column are significantly different at  $P < 0.05$ . DW: Dry weight (g), WW: Wet weight (g), WAC: Water absorption capacity (g. Kernel<sup>-1</sup>), WAI: Water absorption index (% w/w), DV: Dry volume (ml), WV: wet volume (ml), SC: Swelling capacity (ml. Kernel<sup>-1</sup>), SI: Swelling index (% w/w), TKW: Thousand kernel weight (g), HLW: Hectoliter weight (kg. hL<sup>-1</sup>).

Thousand kernel weight, which gives information about the seed and flour yield of the wheat, was varied between 35.48-42.71 g. Sagittario wheat variety had the highest thousand kernel weight value. Hectoliter weight is an important parameter used in wheat standards and commercial classification of wheats (Ünal, 2002). One of the factors that are based on the quality classification of wheat is the hectoliter weight and the higher the hectoliter 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 of wheat. The difference between the varieties was found to be significant in terms of hectoliter weight ( $P \leq 0.05$ ). The highest hectoliter weight was found to be for Adana 99 with 81.00 kg/hl and the lowest one was found for Ceyhan 99 wheat variety with 77.69 kg/hl. Hectoliter weight up to 82.00 kg/hl has been classified as very good wheat varieties (Diepenbrock et al., 2005). Wheat varieties with a hectoliter weight higher than 78,00 kg/hl were classified as first class wheat according to the Wheat Standard of the Turkish Standard Institute (Anonymous, 2001). Hectoliter weight may vary depending on genetic structure, environmental conditions and

cultural practices (Protic et al., 2007). Four bread wheat varieties in this study showed good values in terms of hectoliter weight and are comparable with the results of the study reported by Aktaş et al. (2011), Kılıç et al. (2012), Türk (2013), Migliorini et al. (2016), and Mutlu and Taş (2020).

The gluten index (GI) is a measurement of wheat protein that provides a simultaneous determination of gluten quality. The gluten index is used to determine whether gluten structure is weak or strong (AACCI, 2010). When the gluten index values were examined, the highest value was found in Adana 99 variety with 89.50% and the lowest value was found in Dinç wheat variety with 82.50% (Table 3). Menderis et al. (2008) reported that if the gluten index value of wheat was less than 63%, gluten quality was low, between %63-80 gluten quality was medium, between %80-96 gluten quality was good, and higher than %96, gluten quality was grouped as having very strong quality. According to this grouping, all varieties have been found to be in the good protein group wheats. In addition, it has been determined that the variety of bread wheats used in this study had gluten index value between the range of previous studies (Migliorini et al., 2016; Kaplan-Evlice et al., 2016).

Table 3. Chemical characteristics of bread wheat varieties

Variety	Moisture (%, w/w)	Protein (%, w/w)	Wet gluten (%, w/w)	Gluten index (%, w/w)	Zeleny Sedimentation (ml)	Delayed Sedimentation (ml)
Adana 99	8.85 ±0.01 <sup>a</sup>	11.50 ±0.05 <sup>a</sup>	29.04 ±0.03 <sup>a</sup>	89.50 ±0.06 <sup>d</sup>	26.00 ±0.02 <sup>a</sup>	35.50 ±0.15 <sup>a</sup>
Ceyhan 99	9.00 ±0.02 <sup>b</sup>	12.90 ±0.04 <sup>c</sup>	33.65 ±0.05 <sup>c</sup>	88.50 ±0.03 <sup>c</sup>	38.50 ±0.04 <sup>c</sup>	55.50 ±0.22 <sup>c</sup>
Dinç	9.70 ±0.03 <sup>d</sup>	12.20 ±0.03 <sup>b</sup>	31.50 ±0.04 <sup>b</sup>	82.50 ±0.01 <sup>a</sup>	30.50 ±0.05 <sup>b</sup>	38.00 ±0.04 <sup>b</sup>
Sagittario	9.65 ±0.01 <sup>c</sup>	13.25 ±0.02 <sup>d</sup>	33.79 ±0.01 <sup>d</sup>	85.00 ±0.02 <sup>b</sup>	43.50 ±0.07 <sup>d</sup>	58.00 ±0.07 <sup>d</sup>

Means with different superscripts within a column are significantly different at  $P < 0.05$ .

Zeleny sedimentation test is the measurement of the settling amount of the swollen particles in a certain time in the suspension prepared with flour and lactic acid solution according to the gluten amount and quality. It 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 İslamoğlu, 2015). In wheat with high gluten content and good quality, the particles can be swollen too much due to decrease in their density and slower the settling to the bottom. Thus, the sedimentation value could have been higher. The proteolytic enzymes that sunn pest (*Eurygaster* spp.), *Aelia* spp. and *Nysius huttoni* leaved on the wheat grain cause the gluten proteins to break down under appropriate conditions. As a result of proteolytic enzyme activity, gluten is broken down and delayed Zeleny sedimentation value is lower than Zeleny sedimentation value. As the difference increases, it is understood that the sunn pest, *Nysius huttoni* damage also increases.

The lowest Zeleny sedimentation and delayed sedimentation values were determined in Adana 99, the highest Zeleny sedimentation and delayed sedimentation values were determined in Sagittario wheat variety, and statistically significant differences ( $P \leq 0.05$ ) were found between the varieties. It has been reported that those with a sedimentation value of 15 ml or less are weak, between 15-24 ml are medium, between 25-36 ml are good and with 36 ml and above have very good gluten quality (Elgün et al., 2002). According to this classification, it is seen that all wheat varieties have good and very good

gluten quality. Türk (2013) reported that Zeleny sedimentation and delayed sedimentation values of 12 different wheat varieties was varied between 21.33-41.00 ml and 27.67-54.00 ml, respectively. 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 Zeleny sedimentation volume of different wheat varieties varied between 12.0 and 56.0 ml (Menderis et al., 2008; Kılıç et al., 2012; Kaya and Akcura, 2014; Katyal et al., 2016; Keçeli et al., 2017; Pekmez, 2018).

#### *Chemical characteristics of bread wheat varieties*

Significant differences between bread wheat varieties ( $P \leq 0.05$ ) were obtained in terms of moisture content, protein content, wet gluten content (Table 3). Moisture contents of wheats have been varied between 8.85% and 9.70% and the lowest value was found in Adana 99 variety, the highest value was found in Dinç variety with 9.70 %, and any variety of critical moisture level did not exceed 14% (Ünal, 2002). The differences in moisture content of wheat varieties may be due to their different chemical components as well to the shape of kernels, kernel covering structures, pre-harvest climatic conditions and storing conditions. In some studies, this effect was also confirmed that taking attention both to the genetic characters of each variety and the environment including climate and agro-factors during vegetation (Khan et al., 2009).

Bread making quality is highly dependent on the amount and quality of the protein in modern bread wheat varieties. The protein content of the



wheat varies between 6-20% partly depending on the type and variety but mostly depending on the soil and environmental factors of the place where it is grown (Özkaya and Özkaya, 2005). Among the wheat varieties, the highest protein content was found in Sagittario and the lowest in Adana 99. Protein content was found to be 11.50, 12.90, 12.20 and 13.25 (% w/w) for Adana 99, Ceyhan 99, Dinç and Sagittario, respectively (Table 3). These results are in agreement with the results of bread wheats reported by Yağdı (2004), Menderis et al. (2008), Tayyar (2010), Zilic et al. (2011), Kılıç et al. (2012), Şanal et al. (2012), Kaplan-Evlice et al. (2016) and Katyal et al. (2016).

Gluten is a group of proteins, especially wheat, responsible for the strong structure of dough. Gluten, which is an important indicator of the bread quality of wheat, is the elastic protein that shows the suitability of flour for bread making. Among the quality components of wheat, gluten plays the most important role in determining industrial use, and therefore gluten strength is one of the parameters used in the classification of wheat for bread use (Dizlek et al., 2006; Modenes et al., 2009). Wet gluten values have been varied between 29.04-33.79%, and the highest value was found in Sagittario wheat variety (Table 3). Menderis et al. (2008) reported that if the wet gluten content of wheat was less than 20%, gluten quality was low, between 20-27% gluten quality was medium, between 28-35% gluten quality was good, and higher than 35% gluten quality was high. Accordingly, the wet gluten values obtained in this study can be evaluated in the good gluten quality class for all bread wheat varieties. Wet gluten values for different types of bread wheat were found similar to those of this study by some researchers (Yağdı, 2004; Cristina et al., 2014; Kaplan-Evlice et al., 2016).

## Conclusions

Based on the findings of this study, it was seen that there were differences between the wheat varieties with statistical significance ( $P \leq 0.05$ ) in terms of physical, chemical and physicochemical

(technological) quality characteristics. All wheat varieties in this study showed good values in terms of all quality characteristics studied. It has been determined that the all quality values of Adana 99 wheat variety are generally superior among the most grown wheat varieties in the Mardin region of Turkey in 2017/2018. The longest wheat variety was Adana 99, while the shortest was Dinç wheat variety. The lowest values in terms of width, thickness, equivalent diameter and sphericity were found in Sagittario wheat variety. The widest was Dinç wheat variety. The thickness and equivalent diameter of Adana 99 wheat have been found the highest and the highest sphericity value was found in Dinç wheat variety. The  $b^*$  values of Adana 99 was found to be higher than that of other wheat kernels due to bran and characteristics of variety. Sagittario wheat variety was the highest in terms of thousand kernel weight value while Adana 99 was the highest in terms of hectolitre weight value. Swelling capacity of wheat varieties varied between 1.0 and 3.0 ml/kernel. Sagittario wheat variety was the least swollen, while Adana 99 was the most swollen wheat variety. On the other hand, Adana 99 variety had the highest value in terms of gluten index value, while Sagittario variety had the highest value in terms of wet gluten, zeleny sedimentation and delayed sedimentation values. Four wheat varieties studied had strong gluten because the values of gluten index of all varieties were higher than 80. Considering the above analysis results, flour producers will be able to produce flour with better quality flour and suitable flour blends for different traditional breads.

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