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Pomological and Chemical Properties of Some Walnut Genotypes in Central Anatolia

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Abstract: This study was carried out to determine some pomological and chemical characteristics of Bilecik, Yavuz, Sebin walnut cultivars and Yerli genotype grown in Kırşehir, Turkey. Characteristics of walnut such as nut weight, kernel weight, nut width, nut height and nut diameter and some kernel features were investigated. The results revealed that the average weight of fruit ranged from 17.33 g (Yavuz) to 12.83 g (Sebin), the nut width from 37.63 mm (Yavuz) to 31.33 mm (Yerli), the nut height from 52.25 mm (Yavuz) to 41.07 mm (Yerli), and the kernel percentage from 46.07% (Bilecik) to 49.43% (Yavuz) The highest oil content was detected in Yavuz cultivar (63.20%), while the lowest value was obtained from Bilecik cultivar with 53.90%. Contrary to fat content, the highest protein content was detected in the Bilecik cultivar. When the data obtained are evaluated, it is understood that Yavuz and Şebin walnut varieties are suitable for Central Anatolia conditions.

Keywords: Walnut (*Junglas regia* L.), cultivars, nut, kernel characteristics, Central Anatolia

Bazı Ceviz Genotiplerinin Orta Anadolu Koşullarındaki Pomolojik ve Kimyasal Özellikleri

Öz: Bu araştırma Kırşehir ekolojik koşullarında yetiştirilen Bilecik, Yavuz, Şebin ceviz çeşitleri ve Yerli ceviz genotipinin bazı pomolojik ve kimyasal özelliklerinin saptanması amacıyla gerçekleştirilmiştir. Kabuklu ve iç ceviz ağırlığı, kabuklu meyve eni, boyu, çapı gibi bazı özellikler ölçülmüştür. Ortalama kabuklu ceviz ağırlığı 17.33 g (Yavuz) ile 12.83 **g** (Sebin) arasında değişirken, iç ceviz oranı %46.07 (Bilecik) ile %49.43 (Yavuz) arasında değişmiştir. Meyve eni 37.63 mm (Yavuz) ile 31.33 mm (Yerli), meyve boyu 52.25 mm (Yavuz) ile 41.07 mm (Yerli) arasında dağılım göstermiştir. %63.20 ile en yüksek yağ oranı Yavuz çeşidinden elde edilirken, en düşük değer %53.90 ile Bilecik çeşidinden elde edilmiştir. Yağ oranlarının aksine en yüksek protein oranı Bilecik çeşidinde belirlenmiştir. Elde edilen veriler değerlendirildiğinde Yavuz ve Şebin ceviz çeşitlerinin Orta Anadolu koşulları için uygun olduğu anlaşılmaktadır.

Anahtar kelimeler: Ceviz (*Junglas regia* L.), çeşitler, kabuklu ceviz, iç ceviz özellikleri, Orta Anadolu

1. Introduction

Walnut (*Juglans regia* L.), one of the oldest cultivated plant in the world and grown naturally nearly in all areas of Turkey, is an important fruit crop for Turkey (Sen, 1986; Asma, 2012).

The shelled walnut production of the world is estimated as 3.462.731 tons in a year. China is the main producing country, accounting for 46.3% of the world production with 1.602.373 tons USA (518.002 tons; 15%), Iran (445.829 tons; 12.88%), Turkey (212.807 tons; 6.20%) Mexico (125.758; 3.8%), Ukraine (102.740 tons; 3%) are some of the significant walnut producers (Anonymous, 2017).

Turkey has notably good walnut cultivars. Breeding programs have been launched over the last 40 years to develop new cultivars with uniform fruit quality and high yield (Bayazıt et al. 2016).

Turkey is a rich country in terms of walnut genetic resources compared to other countries. The new walnut cultivars have been improved by breeding programs in Atatürk Central Research Institute, Yalova, Turkey in 1971 (Şen, 1980).

Several selection studies mainly about fruit qualities have been conducted on walnuts in Turkey to improve walnut cultivars (Olez, 1971; Sen, 1983; Celebioglu et al., 1988; Sen and Beyhan, 1993; Ferhatoglu, 1993; Akca and Sen, 1995; Askin and Gun, 1995; Koyuncu and Askin, 1995; Koyuncu and Askin, 1999; Sutyemez, 1998; Bayazıt, 2000; Keles et al. 2014; Akça et al. (2015). A number of walnut cultivars have been developed as a result of those breeding programs. Sebin, Yalova 1, Bilecik, Yalova 3, Kaman 1, Yalova 4, Sen1, Sen 2, Kaman 5 and Yavuz are the most important walnut cultivars for Turkey. In recent years, Maraş 18, Sütyemez 1, Akça 1, Akça 2 varieties have been improved and their production is getting widespread day by day. Today, walnut breeding studies are carried out in different Universities and Research Institutes of Turkey. At the same time, some foreign walnuts varieties such as Fernor, Chandler, Franquette are also cultivated.

The high-quality varieties, determined as a result of breeding trials in Turkey, may not show desired characteristics except for the regions where they are selected. Sometimes some serious problems such as poor fruit quality, inefficiency and frost damage. Thus; Çelebioğlu et al. (1988), Tosun and Akçay (2005) reported that some walnut varieties perform superior in selected places; however, some walnut varieties may perform better in other locations. Similarly, it is not possible to know in advance the performance of the walnut varieties brought from other countries. For this reason, it is necessary to determine suitable walnut varieties for those ecological conditions before planting a walnut orchard, which requires significant labour and cost. Choosing the appropriate walnut varieties is crucially important that ecological conditions effect the yield and fruit quality.

The Turkish Standards Institution established quality criteria of walnut quality for physical nut and kernel properties (Anonymous, 1990; 1991). Nut weight, kernel ratio, nut dimensions, shell shape, kernel weight and other shell properties are some of them.

The chemical composition and fruit quality of some walnut genotypes and cultivars have not been studied in the Central Anatolian Region. The aim of this study was to determine the chemical composition and fruit quality of some significant Turkish walnut genotypes.

2. Material and Method

Among four genotypes, 3 of them are standard cultivars: 'Sebin', 'Bilecik', 'Yavuz', and the other is a promising genotype named as 'Yerli' grown in Kırşehir. Walnut genotypes were grown onto seedling rootstocks and planted at 7 x 7 m in 2008. Fruits of these genotypes were collected from Mucur district of Kırsehir province, which is situated in the Central Anatolia, altitude 1050 meters, in October 2016. The examinations on the eight-year-old trees were carried out for one year. Location, sampling days and storage conditions were same in all genotypes. The kernel samples kept in –18 ^{o}C until the chemical analysis were performed after physical analyses were achieved as quickly as possible. This study was set up with three repetitions for chemical and twenty repetitions for pomological analyses.

Pomological analyses: Fully mature fruits were harvested with three replicates that each replicate contained 20 fruits. The measurement of shell thickness (mm), kernel weight (g), fruit width (mm), fruit weight (g), kernel percentage (%) and fruit length (mm) was achieved. Turkish Standard Institution (TSI) 1275/T1 guidelines were followed to determine the shell breaking, fruit shape, size, shell roughness and fruit shape index (Anonymous, 2010).

The formula used to determine the shape index was as follows; shape index =nut length / (nut diameter + nut thickness) / 2. The evaluation of shape index was defined as sphere and oval shape index, $<$ 1.25 and $\geq$1.25, respectively. Kernels were categorized according to the ratio (%) (kernel weight / nut weight) x100, as followed.

Extra: nut diameter ≥ 27 mm for sphere, nut diameter 26 mm for oval. Class I: nut diameter 24-27 mm for sphere, nut diameter 24-26 mm for oval, class II: diameter 20-24 mm for sphere and oval. Empty, fine, bad and medium terms were achieved according to kernel crinkling.

In addition, Colour Meter CR-300 was used to determine the kernel and fruit shell colours. The value of L* characterises lightness (L* 0 for black, L* 100 for white), whereas a* scale signifies the red/green dimension, with positive values for red and negatives for green. Three diverse spots in each of two samples and two various spots each of three samples of kernel were measured to determine the colour values. The means of measurements were calculated and recorded. In addition, the calculation of hue angle (tan)-1 b*/a*) and chroma [(a*2 + b*2)1/2] was performed.

Total fat content: Hexane in Soxhlet set was extracted to determine the total fat analyses. The content of fat in samples was calculated based on the Akyuz and Kaya (1992) formula:

Total fat (%) = (fat weight (g)/fruit weight (g) in cartridge) x 100.

Crude protein content: Kjeldahl method (N×6.25) was used to determine the content (Jung et al. 2003).

Data analysis: The variance analysis was set up as stated by Steel and Torrie (1980) using SAS (2005). In order to increase the normality values of percentage were transformed (arcsin). The separations of mean were analysed by Tukey test at $p<0.05$ significance level.

3. Results and Discussion

Good kernel quality is desirable and important property for walnut cultivars and production. Nut characteristics of 4 genotypes of walnut are showed in Table 1. Variance analysis revealed that the genotypes were found to be significantly different in all traits.

Table 1. Pomological traits of some important Turkish walnut genotypes in the Central Anatolia Region of Turkey

Tablo 1. Bazı önemli Türk ceviz genotiplerinin Orta Anadolu koşullarındaki pomolojik özellikleri

Genotypes	Nut weight (g)	Kernel weight (g)	Kernel ratio (%)
Yavuz	17.33 a	8.56 a	49.43 a
Sebin	12.83 b	6.28 bc	48.93 a
Bilecik	16.66 a	7.67 ab	46.07 a
Yerli	15.54 b	5.69 c	36.69 b
HSD (5%)	2.21	1.58	7.65

The average nut weight changed between 17.33 and 12.83 g. The highest value was obtained from 'Yavuz' (17.33 g) and it was followed by 'Bilecik' (16.66 g) and 'Yerli' genotypes (15.54 g). Kernel weight varied from 8.56 g (Yavuz) to 5.69 g (Yerli). It has been noted that the kernel weight of the Yerli walnut genotypes is lower than others.

Kernel ratio varied according to varieties. Kernel/nut ratio ranged from 49.43% (Yavuz) to 36.69% (Yerli) and were lower than 50% in all genotypes. In walnut genotypes, nut weight and kernel weight were found higher than the results of previous studies in other regions of Turkey (Tosun and Akçay, 2005; Bayazıt and Sumbul, 2012). In contrast, the kernel percentage of the walnut genotypes was low.

Akça and Aydın (2005) determined the nut weight (10.16 and 15.92 g), kernel weight (6.56 and 5.92 g) and kernel ratio (64.80 and 48.56 %) for the Sebin and Bilecik cultivars grown in Tokat province. Our results are also better than outcomes of Baymış (2008) who studied the Sebin and Bilecik cultivars grown in Kahramanmaras

and found nut weight (11.22 g-13.13g), kernel weight (6.33 g-6.11g), kernel ratio (56.41%-46.53%). This could be due to differences in the ecological, cultural practices, tree age and genetic properties of walnut genotypes grown in different areas. As a matter of fact, the kernel ratio of Sebin walnut cultivars in Ankara ecological conditions was reported as 33.98% by Akkuzu and Celik (2001).

Favourable walnut genotypes should have between 0.7 and 1.5 mm of shell thickness (Zhadan and Strukov, 1977). In this research shell thickness of the walnut genotypes varied between 1.42 (Bilecik) and 1.83 mm (Sebin) (Table 2). In the previous adaptation researches, shell thickness was 1.06 mm for the Sebin cultivars and 0.93 mm for the Bilecik variety (Baymış, 2008). Similarly, shell thicknesses of the Sebin walnut variety was reported to be 1.85 mm in the Hatay ecologic conditions (Bayazıt and Sumbul, 2012). As a result of this research, the shell thickness values obtained from the walnut varieties were higher than the values obtained from other researches. Shell thickness is essential for saving kernels from the external effects.

Table 2. Nut characteristics of walnut genotypes
Tablo 2. Ceviz genotiplerinin kabuklu meyve özellikleri

Genotypes	Nut width (mm)	Nut length (mm)	Nut thickness (mm)	Shell thickness (mm)
Yavuz	37.63 a	52.25 a	39.23 a	1.54 b
Sebin	34.11 b	44.44 b	35.31 b	1.83 a
Bilecik	35.40 b	45.42 b	35.85 b	1.42 b
Yerli	31.33 c	41.07 c	33.27 c	1.53 b
HSD (5%)	1.41	2.26	1.92	0.19

The average nut length ranged from 41.07 (Yerli) to 52.25 mm (Yavuz), nut width varied from 31.33 (Yerli) to 37.63 mm (Yavuz), nut height varied from 33.27 (Yerli) to 39.23 mm (Yavuz) in the walnut genotypes (Table 2). The pomological characteristics of walnut genotypes were similar to results of other researchers (Baymış, 2008; Akça and Aydın, 2005; Bayazıt and Sumbul, 2012).

Fruit shape was determined as oval, kernel colour was light yellow and yellow. Kernel removal was easy in the majority of the walnut genotypes.

The best nut is described as a tight seal, clean, strong, thin shell and appropriate weight: from 12 to 18 g. The kernel ought to be removed easily from the shell, the colour should be homogeneously light, clean, and weight 6–10 g or it encompasses weight at least 50% of entire nut. Genotypes powerfully effect the nut and kernel quality, additionally interaction and exposed environment (McGranahan and Leslie 1991; Akça and Ozongun 2004).

The index of fruit shape i.e. fruit length/width ranged from 1.28 to 1.38 in genotypes and the fruit shapes were oval in walnut genotypes (Table 3). Shell roughness was smooth for ‘Sebin’ and ‘Bilecik’, and medium for ‘Yerli’, and was rough for ‘Yavuz’. ‘Sebin’, and ‘Bilecik’ were on ease of shell breaking, but other genotypes were intermediate. The fruits of all walnut varieties in the experiment were included in the extra class.
The percentage of clean yellow kernel should be at least 50% in walnut genotypes according to previous findings. In our study, walnut genotypes had light coloured kernels.

The shell and kernel of all the walnut varieties in the experiment were light coloured. The biggest reason for this is that the temperate climatic conditions prevail in the experiment area, and there are no high summer temperatures.

Table 3. Fruit quality traits of some important Turkish walnut genotypes in in the Central Anatolia Region of Turkey

Tablo 3. Bazı önemli Türk ceviz genotiplerinin Orta Anadolu koşullarındaki meyve kalite özellikleri

Genotypes	Fruit Shape Index	Nut shape	Shell roughness	Shell breaking	Size
Yavuz	1.38	Oval	Rough	Intermediate	Extra
Sebin	1.30	Oval	Smooth	Ease	Extra
Bilecik	1.28	Oval	Smooth	Ease	Extra
Yerli	1.31	Oval	Medium	Intermediate	Extra

Fruit skin L* value had the lightness value of 59.71 for 'Sebin' (Table 4). Fruit skin a* values indicating red colour, was the highest for 'Yerli' (11.35), while it was the lowest for 'Sebin' (10.25). The maximum hue angle value (*ho*, the higher values are the clearer) was obtained from 'Yerli' (59.29). Chroma values (C, the lower values are more density) were found highest for 'Yerli' (22.31) genotype.

Table 4. Fruit shell colour traits of some important Turkish walnut genotypes in the Central Anatolian Region of Turkey

Tablo 4. Bazı önemli Türk ceviz genotiplerinin Orta Anadolu koşullarındaki sert kabuk renkleri

Genotypes	L	a	b	C	H
Yavuz	50.30 c	11.09 a	18.09 ab	21.23 ab	58.39 ab
Sebin	59.71 a	10.25 a	16.35 b	19.31 b	57.78 b
Bilecik	56.05 b	10.57 a	17.36 ab	20.34 ab	58.56 ab
Yerli	52.24 c	11.35 a	19.20 a	22.31 a	59.29 a
HSD (5%)	2.74	1.25	2.10	2.40	1.29

The value of kernel L* was the least for 'Bilecik' (45.23). The kernel a* values indicating red colour, had the highest for 'Sebin 86' (13.93). C and *ho* values had the highest for 'Bilecik' (28.68 & 64.61, respectively) (Table 5).

Table 5. Fruit kernel colour traits of some important walnut genotypes of Turkey in the Central Anatolian Region

Tablo 5. Bazı önemli Türk ceviz genotiplerinin Orta Anadolu koşullarındaki iç ceviz renkleri

Genotypes	L*	a*	b*	C	H
Yavuz	40.62 a	10.99 c	21.86 b	24.53 b	62.99 a
Sebin	39.33 a	13.93 a	24.53 ab	28.35 a	59.88 a
Bilecik	45.23 a	12.06 b	25.95 a	28.68 a	64.61 a
Yerli	44.14 a	11.19 bc	25.23 ab	27.71 a	64.33 a
HSD (5%)	7.80	0.99	3.49	2.75	6.35

In this study, chemical properties of walnuts were also determined. For chemical composition (Fat and protein content), the significant level of differences was observed among genotypes. Table 6 shows the highest protein quantity (20.08%) in Bilecik, the value of it was the lowest in Yavuz (17.11%). The values of protein indicate parallel results with the literatures (Koyuncu and Askin, 1995; Bayazit and Sumbul, 2012).

Table 6. Fat and protein ratios of walnut genotypes
Tablo 6. Ceviz genotiplerinin yağ ve protein oranları

Genotypes	Fat (%)	Protein (%)
Yavuz	63.20 a	17.11 b
Sebin	60.40 a	18.45 ab
Bilecik	53.90 b	20.08 a
HSD (5%)	5.46	2.48

Fat contents of the sample (%) were in the range of 53.90–63.20. Yavuz had the highest fat contents. Kahraman (2006) reported oil content in walnut genotypes was 51.70–72.80% and protein content was 15.61–27.50%, respectively (Table 6).

4. Conclusions

Climate characteristics and features of fruit qualities of four walnut genotypes were found high in Kırsehir province. Especially, compared to other research results, the shell and kernel weights of 'Sebin' walnut cultivar were relatively high. In addition, the yield per tree was higher in 'Sebin' walnut compared to other genotypes. Kernel percentage is very important for quality parameters. The 'Yerli' walnut genotype, grown for many years in the region, has larger fruits. But the low kernel percentage is the disadvantage of this genotype.

Walnut plants are able to be damaged thanks to late spring frost specifically in central and eastern Anatolia regions of Turkey. It was seen that late spring frosts were not effective in walnut varieties in this study.

In conclusion, 'Bilecik' and 'Sebin' genotypes can be suggested to be the best choice for fruit quality traits in the Kırsehir province in Central Anatolia Region of Turkey.

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