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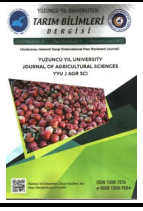

Araştırma Makalesi (Research Article)

Physical and Chemical Fruit Quality Properties of Some Walnut Cultivars and Promising Local Selections Grown Under Plain Conditions in Malatya

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Abstract: This study was conducted between the years of 2017 and 2018 in Battalgazi county of Malatya Province, Turkey, in order to determine fruit quality properties of three walnut cultivars and three local walnut genotypes under plain conditions. For this aim; kernel color and shrinkage, nut height, width and thickness, nut and kernel weights, kernel/nut ratio, shell thickness were detected as physical parameters. Additionally, total oil, protein and ash contents of kernel samples were examined as chemical parameters. Results indicated significant differences in all evaluated parameters of genotypes included in the study. Nut height, width and thickness varied between 37.55 mm - 52.30 mm, 32.61 mm - 42.10 mm, and 30.09 mm - 41.10 mm, respectively. Nut weight varied between 11.22 g and 17.84 g and kernel/nut ratio varied between 43.89 % and 58.13 %. Total oil and protein contents varied between 64.10 - 73.75 %, and 13.50 - 19.66 %, respectively. The study resulted with various values in all evaluated physical and chemical parameters of the cultivars and the genotypes observed. Leading cultivar or genotype depended on different parameters, but according to overall evaluations two of the cultivars and two of the local genotypes were distinguished in terms of their performances under plain conditions. In addition, significant correlations were found between most of the characters examined in the study.

Malatya'da Ova Koşullarında Yetiştirilen Bazı Ceviz Çeşit ve Yerel Ümitvar Seleksiyonlarının Fiziksel ve Kimyasal Meyve Kalite Özellikleri

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Anahtar kelimeler
Meyve kalitesi,
Malatya,
Ova koşulları,
Seleksiyon,
Ceviz.

Öz: Bu çalışma üç ceviz çeşidi ve üç yerel ceviz genotipinin ova koşullarında meyve kalite özelliklerinin belirlenmesi için 2017 ve 2018 yıllarında Malatya'nın Battalgazi ilçesinde yürütülmüştür. Bu amaçla, fiziksel parametreler kapsamında iç rengi ve büzüşmesi, meyve uzunluğu, genişliği, kalınlığı, meyve ve iç ağırlıkları, iç/meyve oranı, kabuk kalınlığı ölçülmüştür. İlave olarak, iç ceviz örneklerinde toplam yağ, protein ve kül miktarları kimyasal parametreler kapsamında ölçülmüştür. Sonuçlar çalışma kapsamındaki genotipler arasında incelenen tüm parametreler açısından önemli farklılıklar ortaya koymuştur. Meyve yüksekliği, genişliği ve kalınlığı sırasıyla 37.55 mm - 52.30 mm, 32.61 mm - 42.10 mm ve 30.09 mm - 41.10 mm arasında değişmiştir. Meyve ağırlığı 11.22 g ile 17.84 g arasında değişirken, iç/meyve oranı, % 43.89 ile % 58.13 arasında değişmiştir. Toplam yağ ve protein içerikleri ise sırasıyla % 64.10 - 73.75 ve % 13.50 – 19.66 arasında değişmiştir. Çalışma sonucunda incelenen çeşitlerin ve yerel genotiplerin değerlendirilen

tüm fiziksel ve kimyasal parametreler açısından önemli seviyede farklı sonuçlar elde edilmiştir. Parametrelere göre öne çıkan genotip farklılık göstermekle beraber, genel değerlendirmelere göre ova şartlarındaki performansları açısından iki çeşit ve iki yerel genotip öne çıkmıştır. Bunun yanında çalışma kapsamında incelenen çoğu karakter arasında önemli seviyede korelasyon bulunmuştur.

1. Introduction

Walnut is the most commonly grown member of Juglans genus (Şen, 1986). This species is also known as Anatolian or Persian walnut all over the world. Its latin name (*Juglans regia* L.) comes from the word "Juglans", which means the fruit of God (Güvenç and Kazankaya, 2019). Walnut is also the most produced nut species which is produced more than 3.5 million tons annually. China was the leading country in 2017 with around 2 million tons of production, and Turkey was the fourth country with its 210 thousands of production (FAO, 2019).

As for many fruit species, Anatolia is in the origin of walnut (Akça, 2005). This brings a wide range of genetic variation and sources for walnut to be selected according to their desired characteristics in Turkey. Furthermore, the fact that walnut trees had been propagated by seeds until recent decade boosted the wideness of the variation and absence of genetic resources in the area. However, these factors prevented standardization of growing and production which are very important for agricultural marketing needs, especially in exports. Today, almost all of the exported walnuts are produced on standard cultivars which are propagated clonally. For that reason, selection and standardization studies play key role in benefiting the relevant genetic resources. Indeed, most of the superior cultivars used today were obtained by selection in the world and also in Turkey (Çelebioğlu, 1978; Şen, 1980). Today selection studies are still intensively continued (Aslansoy, 2012; Bilgen, 2012; Paris, 2013; Başer et al., 2016; Kazankaya et al., 2017).

Climate, especially temperature, is one of the most important factors influencing performances of cultivars and one of the most significant factors to be considered when deciding a cultivar to be cultivated in a certain area. The traits are expressed under the effects of both the genotypic variations and environmental conditions. For that reason, environment is a determining factor of cultivar performances in a certain area together with genetic background, selection and adaptation studies are of importance. Therefore, determining performances of cultivars and new selections in the areas with different environmental conditions is necessary to obtain a better understanding of cultivars and selections growing habits. As a result this importance, series of studies has been performed to determine different cultivars and new selections under various environments. Bilgin (2015) compared fruit quality attributes of nine different walnut cultivars under the ecological conditions of plain conditions of Menemen county of İzmir Province of Turkey. Similarly, Kaplan (2015) investigated fruit quality characteristics of six local and seven foreign origin walnut cultivars in Niksar county of Tokat Province of Turkey. Asma and Ozturk (1999) evaluated fruit quality performances of different walnut cultivars in Malatya. However, as far as our knowledge no previous studies investigated walnut cultivars and new local selections under plain conditions of Malatya. Even though Malatya Province was the 22nd most walnut producing province of Turkey in 2017 (TUİK, 2019), so is not a primary walnut producing province of Turkey, the province has a wide variety of genetic sources for walnut genotypes and a good potential for walnut production where walnuts are grown under various environments including plain and highland conditions (between the altitudes of 700 meters and 1500 meters above the sea level).

For all those reasons, this study was conducted to evaluate performances of different commonly grown walnut cultivars together with new local selections which are found to be promising because of their fruit quality pre-evaluations under the plain conditions of Malatya Province of Turkey.

2. Materials and Methods

The study was conducted under plain conditions of Battalgazi county of Malatya Province (location: 38°28'00.95"N and 38°21'25.33"E, altitude: 725 m) in the years of 2017 and 2018. Monthly maximum, minimum, mean temperature (°C), and precipitation (mm) of the experimental area recorded during the vegetation period in both of the study years were presented in Table 1 (MGM, 2019).

Table 1. Meteorological records of experimental area

	April		May		June		July		August		September		October	
	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018
MT	11.2	14.3	16.3	17.7	23.1	23.0	27.6	27.6	27.1	27.4	23.2	22.4	14.0	15.2
MMT	26.0	29.0	32.0	32.0	38.0	39.0	41.0	41.0	41.0	39.0	37.0	35.0	26.0	30.0
MNT	-3.0	-1.0	5.0	5.0	8.0	10.0	14.0	12.0	15.0	14.0	8.0	9.0	1.0	-1.0
MP	48.9	5.0	42.8	63.5	0.0	13.1	0.0	0.0	0.0	0.0	2.0	6.2	8.5	31.2

MT: Mean Temperature (°C), MMT: Maximum Temperature (°C), MNT: Minimum Temperature (°C), MP: Monthly Precipitation (mm)

Three walnut cultivars and three local selections which were grown under the plain conditions of Malatya Province were included in the study. The details of the plant genotypes were described in Table 2. The trees of the genotypes were six years old in the first year of the study which were obtained by side grafting of scions on old wild walnut seedling rootstock.

Table 2. Walnut genotypes subjected to assessments

Genotype	Description
Maraş-18	Registered cultivar, origin: Turkey
Chandler	Registered cultivar, origin: United States of America
Bilecik	Registered cultivar, origin: Turkey
S1	Local selected genotype from Kozdere village of Darende county of Malatya Province, Turkey
S2	Local selected genotype from Çörtük village of Darende county of Malatya Province, Turkey
S3	Local selected genotype from Sarıkız village of Hekimhan county of Malatya Province, Turkey

Plants were irrigated as required by using drip irrigation system which was also used for fertigation. No nutritional deficiency and drought symptoms were observed during the study. Weed control, pest and disease management were performed properly.

Fruit samples were collected at harvest maturity from nine trees of each genotype as three replicates (Güneyli and Onursal, 2014). The fruit samples were subjected to physical and chemical quality assessments. As part of physical assessments; kernel shrinkage and color size parameters of nut height (NHE), nut width (NWI), nut thickness (NTH), and shell thickness (STH), weight parameters of nut weight (NWE) and kernel weight (KWE), and kernel/nut ratio (K/N) were assessed. Kernel shrinkage was scored from 1 to 4 according to the classification procedure presented by Özkan (1996). Accordingly, score "1" represented shrinkage rate less than 12.5 % of whole kernel size, "2" represented the shrinkage between 12.5 % and 25 %, "3" represented more than 25 %, and empty nuts were scored as "4". Kernel color was evaluated by using "DFA of California" walnut color scale chart and scored as "Extra Light", "Light", "Light Amber", and "Amber" (Akça, 2009). Size parameters were measured with 0.01 mm digital caliper in mm. Nut and kernel weights were measured with 0.01 g precision scales and kernel/nut ratio were calculated according to the following formula:

$$K/N = \frac{KWE}{NWE} \text{x } 100 \quad (1)$$

As part of the chemical assessments; total oil, total protein and total ash contents kernel samples were investigated. Total oil was detected according to the method described by Anonymous (2000) which includes extraction of oil in Soxhlet extractor with n-hexane (60°C) for 6 h. In order to find total protein content of the samples total N content was detected according to Kjeldahl method,

and multiplied with 6.25 (James, 1995). Total ash was obtained by burning of samples for 24 hours and 6 hours at 200°C and 600°C, respectively (Baymış, 2008).

Results were interpreted according to Duncan's multiple range test ($P \leq 0.05$). Correlations between traits were determined according to Pearson's correlation test. Statistical analyzes were performed by using SPSS 23.0 for Windows software. Two years results of a particular character were evaluated as a whole and compared with each other.

3. Results

Fruit samples of three walnut cultivars and three local promising walnut selections were evaluated for their physical and chemical quality traits. Results of kernel shrinkage and color, size, weight and chemical composition were presented in Table 3, Table 4, Table 5, and Table 6, respectively. The study was resulted with significant differences for all investigated characteristics.

For most of the genotypes kernel shrinkage percentages significantly varied between the years, except Bilecik and S1 genotypes presented almost the same ranges in both years (Table 3). S1 did not forme empty nuts in 2017 but 5 % of its nuts were empty in the second year. S3 produced very high shrinkage performance without empty nuts in the first year of the study, but 20 % of their nuts were empty with higher shrinkage percentages in the second year. Kernel colors of the genotypes were scored as "Extra Light" in S1 and S3, "Light" in Chandler, Bilecik, and S2, "Light Amber" in Maraş-18.

Table 3. Kernel shrinkage percentages and kernel color classifications of the walnut genotypes

KS	Maraş-18		Chandler		Bilecik		S1		S2		S3	
(%)	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018
1	61	47	65	14	19	13	54	60	20	40	95	40
2	23	27	10	33	22	13	33	27	60	20	5	27
3	4	13	20	33	44	27	8	13	10	20	-	13
4	12	13	5	20	15	47	5	-	10	20	-	20
KC	Light Amber		Light		Light		Extra Light		Light		Extra Light	

KS: Kernel Shrinkage, KC: Kernel Color

In terms of nut height Bilecik was the leading genotype in both 2017 and 2018 years with the values of 50.29 and 52.30 mm, respectively. The lowest values for nut height were obtained in S1, S2 and S3 genotypes (37.55, 39.71 and 39.35 mm) in 2017, and S2 (40.00 mm) in 2018 (Table 4). The highest nut width value was obtained in S2 genotype (42.10 mm) in 2017, and in Bilecik and S2 (37.90 and 37.60 mm) genotypes in 2018. The lowest nut width value was obtained in S3 (32.61 mm) in 2017, while except Bilecik and S2 all genotypes were in the lowest significance group in 2018. Nut thickness was highest in Bilecik and S2 genotypes in both years (37.19 and 37.49 mm in 2017, 40.50 and 41.10 mm in 2018, respectively). The lowest nut thickness value was found in S3 genotype (30.09 mm) in 2017, while except Bilecik and S2 all genotypes were in the lowest significance group in 2018. The thickest shell was measured in S2 (1.68 mm), while Bilecik (0.83 mm) presented thinnest shell in 2017. In the second year of the study the highest shell thickness was found in Bilecik and S2 (1.67 mm in both), while Maraş-18, Chandler and S3 genotypes (1.29, 1.22, and 1.32 mm, respectively) were categorized as the genotypes having lowest shell thickness.

Table 4. Size parameters results of the walnut genotypes subjected to assessments

GN	Nut Height (mm)		Nut Width (mm)		Nut Thickness (mm)		Shell Thickness (mm)	
	2017	2018	2017	2018	2017	2018	2017	2018
Maraş-18	44.24 bc	45.90 b	35.81 cde	35.70 cde	34.41 d	37.60 b	1.17 c	1.29 c
Chandler	44.15 bc	43.90 bc	36.24 cde	35.30 de	34.91 cd	37.10 b	1.19 c	1.22 c
Bilecik	50.29 a	52.30 a	38.82 b	37.90 bc	37.19 b	40.50 a	0.83 d	1.67 a
S1	37.55 e	43.20 c	37.66 bcd	35.20 e	34.91 cd	36.90 bc	1.22 c	1.49 b
S2	39.71 de	40.00 d	42.10 a	37.60 bcd	37.49 b	41.10 a	1.68 a	1.67 a
S3	39.35 de	43.50 bc	32.61 f	36.00 cde	30.09 e	38.40 b	1.20 c	1.32 bc

Differences between the values of a particular character signed with different letters are significant at $P \leq 0.05$

Chandler cultivar was the leading genotypes for nut weight in 2017 with 16.09 g, whereas no significant differences were found between genotypes in 2018. Nut weight values of Maraş-19, Bilecik, S1, S2, and S3 were significantly higher in 2018 when compared with 2017 values (Table 4). While significant differences in kernel weight were found between the genotypes in 2018, the differences were not significant in the first year of the study. All genotypes presented higher kernel weight value in the second year when compared to their first year results. The highest kernel weight result was found in Maraş-18 (9.22 g) which was followed by Bilecik and S2 genotypes (9.08 and 9.06 g, respectively), and the lowest value was found in S3 genotype (7.98 g) in 2018. The highest kernel/nut ratio was found in S1 (58.13 %) which was followed by S3 (57.05 %), and Chandler and S2 represented lowest values (43.89 and 44.50, respectively) in 2017. All of the genotypes except S1 showed higher kernel/nut ratio value, and the leading genotype was S2 (54.25 %) in the second year of the study.

Table 5. Weight related results of the walnut genotypes subjected to assessments

GN	Nut Weight (g)		Kernel Weight (g)		Kernel/Nut Ratio (%)	
	2017	2018	2017	2018	2017	2018
Maraş-18	15.05 bc	17.84 a	7.12 cde	9.22 a	46.96 ef	51.77 cd
Chandler	16.09 ab	17.38 a	7.27 cde	8.48 bc	43.89 f	48.83 de
Bilecik	12.64 d	17.84 a	6.96 de	9.08 ab	49.44 de	51.50 de
S1	12.29 d	16.83 ab	7.27 def	8.66 bc	58.13 a	51.71 cd
S2	14.74 c	16.65 ab	6.92 de	9.06 ab	44.50 f	54.25 bc
S3	11.22 d	16.07 ab	6.41 e	7.98 bcd	57.05 ab	49.67 de

Differences between the values of a particular character signed with different letters are significant at $P \leq 0.05$

Total oil was highest in S3 (73.75 %) in 2017, but in Bilecik (73.63 %) in 2018. The lowest total oil was found in Chandler (65.73 %) in 2017, whereas except Bilecik all genotypes were in the same statistical group in 2018 (Table 6). S2 genotype gave the total protein values in both of the study years (19.66 % in 2017, and 16.82 % in 2018). The lowest total protein was found in S3 (13.99 %) in 2017, while in Bilecik (13.50 %) in 2018. Bilecik and S2 were the leading total ash content genotypes (2.06 %), and S3 was the lowest (1.72 %) in 2017. On the other hand, the highest total ash contents were found in S2 (1.84 %), and the lowest total ash was found in Maraş-18 (1.58 %) in 2018.

Table 6. Chemical composition (percent) of walnut genotypes subjected to assessments

GN	Total Oil (%)		Total Protein (%)		Total Ash (%)	
	2017	2018	2017	2018	2017	2018
Maraş-18	67.72 bc	68.89 b	15.36 f	14.59 h	2.03 b	1.58 h
Chandler	65.37 cd	69.90 b	16.45 d	14.12 i	1.91 c	1.73 ef
Bilecik	66.33 cd	73.63 a	16.61 c	13.50 k	2.06 a	1.74 e
S1	69.01 b	69.19 b	16.44 d	15.47 e	1.90 c	1.66 g
S2	64.10 e	70.13 b	19.66 a	16.82 b	2.06 a	1.84 d
S3	73.75 a	69.65 b	13.99 j	15.25 g	1.72 ef	1.71 f

Differences between the values of a particular character signed with different letters are significant at $P \leq 0.05$

Table 7. Correlation coefficients between physical and chemical traits in walnut genotypes

	NWI	NTH	NWE	KWE	K/N	STH	TO	TP	TA
NHE	0.37^{**}	0.54^{**}	0.35^{**}	0.32^{**}	-0.39^{**}	-0.16	0.19	-0.39^{*}	-0.07
NWI		0.80^{**}	0.30^{**}	0.33^{**}	-0.13	0.26	-0.29	0.69^{**}	0.53^{**}
NTH			0.50^{**}	0.56^{**}	-0.13	0.42^{**}	0.11	0.19	-0.05
NWE				0.85^{**}	-0.12	0.36^{*}	-0.05	-0.14	-0.31
KWE					0.40^{**}	0.52^{**}	0.27	-0.27	-0.48^{**}
K/N						0.30	0.62^{**}	-0.40^{*}	-0.48^{**}
STH							0.17	0.11	-0.25
TO								-0.74^{**}	-0.60^{**}
TP									0.69^{**}

*Correlations significant at $P \leq 0.05$, **Correlations significant at $P \leq 0.01$

NHE: Nut Height, NWI: Nut Width, NTH: Nut Thickness, NWE: Nut Weight, KWE: Kernel Weight, K/N: Kernel/Nut Ratio, STH: Shell Thickness, TO: Total Oil, TP: Total Protein, TA: Total Ash

Correlations between the characters investigated as part of the study was expressed by the correlation coefficients presented in Table 7. The coefficients indicated positive significant correlations between fruit sizes and nut and kernel weight. Negative significant correlations were found between nut height with kernel/nut ratio and total protein. Nut thickness, nut and kernel weight were found as positively correlated with shell thickness. Kernel/nut ratio was positively correlated with total oil, whereas negatively correlated with total protein and total ash. Total oil was found as negatively correlated with other chemical compositions characters investigated as part of the study, whereas the correlation between total protein and total ash was in positive way.

4. Discussion and Conclusion

The obtained results indicated a high variation between the genotypes and also significant differences between the years for all characteristics investigated as part of the study. The differences between the results would probably be caused by the different level of fruit load which was higher in 2017 for all genotypes investigated as part of the study and also changes in the environmental conditions. Previous studies reported variable results for the cultivars evaluated in this study which points the significant influence of the environmental conditions on the fruit quality aspects. In studies conducted by Baymış (2008) and Sütyemez (2016), adaptation performances of Maraş-18 and Bilecik cultivars were observed at Nut Research and Application Center of Kahramanmaraş Sütçü İmam University which is located in Kahramanmaraş Province of Turkey at 940 m altitude, lower fruit sizes, similar shell thickness, fruit and kernel weights, but higher kernel/nut ratio values were reported for Maraş-18. The authors indicated similar empty nut but lower shrinkage percentages. The author also investigated chemical composition parameters included in this study and reported lower total oil, higher total protein for both of the cultivars, and higher total ash for Bilecik but similar total ash for Maraş-18. In another study conducted by Akça and Aydın (2005), Bilecik cultivar was investigated in Niksar county of Tokat Province in Turkey at 420 m altitude. Lower empty fruit and shrinkage percentages, fruit sizes, kernel weight and kernel/nut ratio, but similar shell thickness and kernel weight were reported by the authors. Bilgin (2015) evaluated Maraş-18 cultivar at sea level in Menemen county of İzmir Province in Turkey. The author reported lower fruit sizes, shell thickness, kernel and kernel/nut ratio, but similar fruit weight value when compared with the results obtained in this study.

As a result of this study, various impacts of environmental conditions were observed on the cultivars and local selected genotypes when the results of the previous reports and years were comparatively examined. For that reasons, it would be useful to determine the reactions of the cultivars and selected genetic resources against the specific stress factors, especially heat and drought, under both controlled and open-field conditions. When overall quality aspects are evaluated and compared with the cultivars investigated as part of the study, local walnut genotypes, especially the ones selected from Kozdere village of Darende and Sarıkız village of Hekimhan were concluded as promising genotypes for growing under plain conditions. As another result of the study, significant correlations between most of the parameters evaluated. This fact indicates useful information for the breeding studies on the related fruit quality aspects. For those reasons, observation of the correlations between the related traits in wider and segregating populations is suggested for the future studies.

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