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Araştırma Makalesi

Comparison of Fruit Quality Characteristics of Çakıldak, Palaz and Tombul Hazelnut *(Corylus colurna* L.*)* Varieties Grown at Different Altitudes of Ordu Province

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ABSTRACT

The hazelnut, which is known to be among the homelands of Anatolia, has been grown in our country for centuries. Hazelnut cultivation in Turkey dates back to ancient times. In the province of Ordu, the hazelnut varieties Çakıldak, Palaz and Tombul are mainly cultivated but other varieties are also grown. This study was carried out between 2022-2023 to determine the effects of altitude and location difference on the fruit characteristics of hazelnut varieties Çakıldak, Palaz and Tombul grown in Fatsa (300 m), İkizce (590 m) and Kumru (400 m) districts of Ordu province. In the study, the lowest average values for nut and kernel fruit weight, nut and shell thickness and kernel size were obtained from trees at 400 m altitude, while the highest values were obtained from trees at 590 m altitude. According to the results, the altitude had a different effect on the weight of the nuts and kernels depending on the variety. While the weight of nuts and kernels increased with increasing altitude in Çakıldak and Palaz varieties, these values decreased in Tombul variety. As a result some fruit quality characteristics of hazelnut varieties grown at different altitudes in Ordu province were found to be different.

Key words: Altitude, Hazelnut, Fruit quality properties, Ordu.

Ordu ilinin Farklı Rakımlarında Yetiştirilen Çakıldak, Palaz ve Tombul Fındık *(Corylus colurna* L.*)* Çeşitlerinin Meyve Kalite Özelliklerinin Karşılaştırılması

ÖZ

Anavatanları arasında Anadolu'nun da olduğu bilinen fındık, asırlardır ülkemizde yetiştirilmektedir. Türkiye'de fındık yetiştiriciliği çok eskilere dayanmaktadır. Ordu ilinde yaygın olarak yetiştirilen fındık çeşitleri çakıldak palaz ve tombul olmakla birlikte diğer çeşitlerle de yetiştiricilik yapılmaktadır. Bu çalışma Ordu ili Fatsa (300 m), İkizce (590 m) ve Kumru (400 m) ilçelerinde yaygın olarak yetiştirilen Çakıldak, Palaz ve Tombul fındık çeşitlerinin meyve özellikleri üzerine rakım ve lokasyon farkının etkisi belirlemek amacı ile 2022-2023 yılları arasında yürütülmüştür. Çalışmada en düşük ortalama kabuklu ve iç meyve ağırlığı, kabuklu meyve ve kabuk kalınlığı ve iç meyve iriliği değerleri 400 m rakımda yetiştirilen ağaçlardan elde edilirken en yüksek ise 590 m rakımda yetiştirilen ağaçlardan elde edilmiştir. Elde edilen sonuçlara göre rakımın çeşitlerin kabuklu ve iç meyve ağırlığına etkisi çeşitlere göre farklılık göstermiştir. Çakıldak ve Palaz çeşitlerinde yükseltinin artmasıyla birlikte kabuklu ve iç meyve ağırlığı artarken, Tombul çeşidinde bu değerler azalmıştır. Sonuç olarak Ordu ilinin farklı rakımlarında yetiştirilen fındık çeşitlerinde bazı meyve kalite özelliklerinin değişkenlik gösterdiği ortaya çıkmıştır.

Anahtar Kelimeler: Fındık, Meyve kalitesi özellikleri, Ordu, Rakım.

INTRODUCTION

The Hazelnut is known to belong to the genus *Corylus* of the subfamily *Corylaea* of the family Betulaceae of the order Fagales (Ayfer et al., 1986; Özbek, 1978). The best known species name of hazelnut is Corylus avellana L. The hazelnuts cultivated in our country are called hybrids of *Corylus avellana* and *Corylus maxima*. The Turkish hazelnut is *Corylus colurna* L. (Marangoz, 1999). It is said that the hazelnut originated in Central Asia, the Caucasus and Anatolia, and that the eastern Black Sea region is the place where the hazelnut was cultivated in Anatolia. It is reported that hazelnut shoots were spread by the ancient Greeks from Trabzon to Edremit and Ayvalık and from there via Andalusia to Italy and to European cities fromthe island of . The hazelnut (*Corylus avellana*) is a dwarf, shrub-like, long-lived cultivated plant. In Türkiye, hazelnut growing areas are located between 40-41º latitude and 37-42º longitude. Within these limits, the most ecologically suitable areas are the coasts of the Black Sea. Hazelnut cultivation extends 60 km inland from the Black Sea coasts and up to 750 m altitude (Özbek, 1978; Köksal, 2002). Among the countries where hazelnuts are cultivated, our country is both important in terms of breeding and rich in genetic resources. The wild hazelnut species are distributed over a very wide area from Japan to China, Anatolia, Europe and California and Europe is the region where the wild species have the greatest diversity. Although wild hazelnut species are widespread, the source of crop is the coastal flora of the eastern Black Sea (Özbek, 1978). One of the basic elements of successful fruit cultivation is the selection of varieties suitable for the climate and soil conditions (Steiner and Giuliani, 1995). In the Black Sea region, which has the most suitable ecology for hazelnuts in the world, the highest quality hazelnut varieties in the word are grown. Since the Black Sea region has hilly and sloping land, hazelnut cultivation is practised at different altitudes and it has been reported that altitude and planting age cause significant differences in quality and yield among varieties (Bostan, 1997). Hazelnut is a very important crop in our country and especially in the Black Sea region, where a large part of the population lives on hazelnut. Therefore, the most important objective of hazelnut research is to increase yield and quality. The provinces of Ordu, Giresun, Trabzon, Düzce, Sakarya and Samsun in the Black Sea region, account for 92% of Türkiye's hazelnut production (Demir and Beyhan, 1998). Türkiye's hazelnut production in 2023 is 650.000 tons (Anonymous, 2023b). The hazelnut production in the world is 1.195.732 tons. Türkiye is in first place with a production of 765.000 tons, followed by Italy in second place with a production of 98.670 tons, Azerbaijan in third place with 72.104 tons, and the USA in fourth place with a production of 70.310 tons (Anonymous, 2023a). The most common hazelnut varieties grown in Ordu province are Çakıldak and Palaz, but Tombul, Kalınkara and Sivri varieties can also be found (Balık and Beyhan, 2014). It has been reported that differences in factors such as climatic conditions, cultivar, altitude, location, technical and cultural treatments alter the morphological and anatomical characteristics of the plants (Koyuncu et al., 1997; Karadeniz and Kup, 1997; Cordell et al., 1998; Özbucak et al., 2013). It is known that the temperature decreases by 0.5°C for every 100 meters difference in altitude in the atmosphere. This affects the quality of the fruit (Eser, 1986; Balcı, 2002). Previous studies have investigated the effects of altitude, orientation, number of branches, and number of fruits in the nuts on hazelnut quality characteristics of hazelnuts, but the studies on the effects of different altitudes on fruit quality were insufficient (Faniadis et al., 2010; DiVaio et al., 2013). The aim of this study was to determine the effects of altitude on some fruit characteristics of hazelnut varieties Çakıldak, Palaz and Tombul grown at different altitudes (300, 400, 590 m) (Fatsa, Kumru, İkizce) in Ordu province.

MATERIALS and METHODS

Plant Material

This study was carried out to determine the effects of altitude on some fruit characteristics of Çakıldak, Palaz and Tombul hazelnut cultivars grown at 300, 400 and 590 m altitude in Fatsa, Kumru and İkizce districts of Ordu province in 2022-2023, Nut and kernel weight (g), nut and kernel (length, width and thickness) (mm), nut and kernel size (mm), nut shape index, kernel shape index, shell thickness (mm), kernel percentage (%), percentage of double kernels (%), empty kernel ratio (%), percentage of shriveled kernels (%), percentage of good kernels (%) and fiberiness were determined. The study was carried out on a total of 90 trees of 3 varieties at 3 different altitudes, with 10 trees for each variety at each altitude.

Method

Nut and kernel weight (g): Both nuts and kernels were weighed using a digital scale with 0.01 g measurement accuracy A total of 10 randomly selected nuts were used for nut and kernel weight. (Ayfer et al., 1986; Gülsoy et al. 2019).

Nut and kernel (length, width and thickness) (mm): Both the nut and kernel were measured with a digital caliper (mm) on randomly selected 10 nuts from each fruit. (Ayfer et al., 1986; Gülsoy et al. 2019).
Nut and kernel size (mm): It was determined using the geometric mean of the length (a), width (b) and thickness (c) values of 10 randomly sampled fruits (Yılmaz, 2005; Gülsoy et al. 2019). Shell and kernel size(mm): = 3√a.b.c
Nut shape index: It was calculated with the following formula by relating the shell length to the average of the shell width and nut thickness (Semiz, 2016).

Nut shape ındex = nut length / [(nut width + nut thickness) / 2]

Kernel shape index: It was calculated using the following formula by relating kernel length to the average of kernel width and kernel thickness (Semiz, 2016).

kernel shape ındex = kernel length / [(kernel width + kernel thickness) / 2]

Shell thickness (mm): Shell thickness was measured on 10 randomly collectedfruit samples using a digital caliper (Ayfer et al., 1986; Gülsoy et al. 2019).
Kernel percentage (%): Kernel percentage is the percentage of kernel weight to nut weight%. Kernel weight percentage % =kernel weight/ nut weight x100
Percentage of double kernels (%): Pertange of double kernels was calculated based on the number of double kernels in 10 randomly selected nuts of each fruit.
Empty kernel ratio (%): It was determined by relating the number of empty fruits out of 100 fruits to the total number of fruits (Gülsoy et al. 2019).

Empty Fruit Ratio (%) = (number of empty fruits / total number of fruits) x 100

Shriveled kernel ratio (%):100 pieces of fruit It was determined by the ratio of the number of shriveled kernel to the total number of fruits (Gülsoy et al. 2019).

Shriveled kernel ratio = (number of shriveled kernel / total number of fruits) x 100

Good kernel ratio (%): It was determined by relating the number of hard (outer) shell completely filled, flawless and intact kernel parts of the broken fruits to the total number of fruits (Ayfer et al., 1986; Gülsoy et al. 2019).
Fibrousness: The condition of the brown fibrous tissue on the kernel surface of the hard shell, which remained adhered to the outer surface of the kernel fruits extracted by breaking the hard shell, was evaluated as fibrousness. The varieties were evaluated as fibrous and non-fibrous according to the fibrous condition of the kernel (Ayfer et al., 1986; Gülsoy et al. 2019).

Statistical analysis

Statistical Analyses Descriptive statistics were expressed as mean and standard error. ANOVA analysis of variance was used to determine if there was a difference between the mean scores of the varieties with respect tothese traits. Following the analysis of variance, Duncan's multiple comparison test was used to determine the differences. The calculations were based on a statistical significance level of 5% and the calculations were performed using the statistical package IBM SPSS Statistics 22 (Düzgüneş et al., 1987). Correlation analysis was performed in the IBM SPSS Statistics 22 statistical program to determine the relationships between the pomological characteristics examined in hazelnuts.

RESULTS and DISCUSSION

According to the results of our study, the lowest average nut weight was found in the Tombul variety (1.79 g) grown at 400 m altitude, while the highest was found in the Tombul variety (3.01 g) grown at 590 m altitude. The highest and lowest average nut length values of the varieties were found in Palaz (15.77 mm) and Tombul (21.59 mm) varieties grown at 590 m altitude,. In the study, the lowest average nut width was recorded for the Tombul variety (16.99 mm) at 400 m altitude and the highest for the Palaz variety (20.63 mm) at 300 m altitude. The lowest average nut thickness was found in the Tombul variety at 400 m altitude (15.24 mm) and the highest in the Tombul variety at 590 m altitude (18.49 mm). In another study conducted at 6 different altitudes between 10 and 500 m in Giresun province, it was reported that kernel width varied depending on altitude and that there was a significant negative correlation between altitude and nut thickness in the Tombul variety (Bostan, 2001). In addition, the shell thickness was determined between the Palaz variety at 400 m altitude (0.96 mm) and the Tombul variety at 590 m altitude (1.24 mm). The lowest average nut and kernel weight was determined at 400 m altitude, while the highest values were obtained at 590 m altitude (Table 1).

Table 1. Some Pomological Characteristics of The Varieties (Averages of 2022-2023).

Varieties	Altitude	Nut Weight (g)	Nut Length (mm)	Nut Width (mm)	Nut Thickness (mm)	Shell Thickness (mm)
Palaz	Fatsa (300m)	2.57±0.24b	16.14±0.79e	20.63±0.84a	17.66±0.69ab	1.16±0.08abc
Palaz	Kumru (400m)	1.98±0.26de	16.61±0.73e	18.59±0.76bc	15.60±1.41ef	0.96±0.07e
Palaz	İkizce (590m)	2.24±0.26c	15.77±0.73e	19.19±0.81b	17.07±0.82bcd	1.19±0.08ab
Tombul	Fatsa (300m)	2.25±0.12c	17.74±1.11d	18.46±0.54bc	16.48±0.82cde	1.04±0.13de
Tombul	Kumru (400m)	1.79±0.28e	18.47±1.35cd	16.99±0.73d	15.27±1.07f	1.04±0.05de
Tombul	İkizce (590m)	3.01±0.30a	21.59±0.59a	20.41±0.58a	18.49±0.91a	1.24±0.08a
Çakıldak	Fatsa (300m)	2.37±0.21bc	19.15±0.83bc	18.68±0.62b	17.29±1.02bc	1.15±0.07bc
Çakıldak	Kumru (400m)	2.11±0.28cd	19.53±0.77b	17.76±1.68cd	16.13±1.12def	1.05±0.05d
Çakıldak	İkizce (590m)	2.36±0.27bc	19.73±0.67b	18.40±0.74bc	17.29±0.68bc	1.09±0.04cd
Significance		0.000	0.000	0.000	0.000	0.000

The difference between means denoted by the same letter is not statistically important ($p<0.05$)

The lowest average kernel weight values of the varieties were recorded for Tombul (0.98 g) at 400 m altitude and the highest for Tombul (1.61 g) at 590 m altitude. The lowest average kernel fruit width of the tested varieties was recorded forthe Tombul variety at an altitude of 400 m (11.64 mm) and the highest for the Palaz variety at an altitude of 300 m (16.36 mm). The lowest and the highest average kernel length was recorded forthe Palaz (11.10 mm) and the Tombul variety (15.92 mm) at 590 m altitude,. In addition the lowest average kernel thickness was recorded forthe Tombul variety (11.68 mm) at 400 m altitude and the highest for the Palaz variety (14.26 mm) at 300 m altitude (Table 2).

Table 2. Some Pomological Characteristics of The Varieties (Averages of 2022-2023).

Varieties	Altitude	Kernel Weight (g)	Kernel Width (mm)	Kernel Length (mm)	Kernel Thickness (mm)
Palaz	Fatsa (300m)	1.29±0.23bc	16.36±0.74a	11.71±0.65e	14.26±1.23a
Palaz	Kumru (400m)	1.14±0.12cd	14.69±4.01b	12.75±0.59d	13.03±1.13bc
Palaz	İkizce (590m)	1.22±0.06bc	14.99±0.44ab	11.10±1.95e	13.62±0.62ab
Tombul	Fatsa (300m)	1.20±0.19bc	14.36±1.36b	13.50±0.89cd	13.16±1.25bc
Tombul	Kumru (400m)	0.98±0.18d	11.64±0.66c	14.12±1.62bc	11.68±0.98d
Tombul	İkizce (590m)	1.61±0.18a	14.74±0.78b	15.92±0.83a	13.19±0.79bc
Çakıldak	Fatsa (300m)	1.30±0.17bc	14.40±0.86b	15.01±0.88ab	12.90±1.03bc
Çakıldak	Kumru (400m)	1.19±0.17bc	13.73±1.06b	15.64±0.31a	12.46±1.33cd
Çakıldak	İkizce (590m)	1.33±0.07b	14.12±1.09b	15.45±0.85a	13.04±0.77bc
Significance		0.000	0.000	0.000	0.000

The difference between means denoted by the same letter is not statistically important ($p<0.05$)

In the study, the lowest average nut size was recorded forthe Tombul variety at an altitude of 400 m (16.85 mm) and the highest value for the Tombul variety at an altitude of 590 m (20.11 mm). Demir (1997) stated that Turkish hazelnut varieties are the best quality hazelnut varieties in the world, but the nut size is not high compared to foreign hazelnut varieties. The lowest average nut shape index was found in Palaz variety (0.84 mm) at 300 m altitude and the highest in Çakıldak variety at 400 m altitude. In addition the lowest average kernel size was found in the Palaz variety at 300 m altitude (11.99 mm) and the highest in the Çakıldak variety at 590 m altitude (14.53 mm). Among investigated the varieties, the lowest mean kernel shape index was observed in the Palaz variety at 300 m altitude (0.77 mm) and the highest in the Tombul variety at 400 m altitude (1.27 mm). The lowest average kernel percentage recorded forin the Palaz variety at 300 m altitude (50.48%) and the highest average kernel percentage for the Palaz variety at 400 m altitude (57.35%) (Table 3).

Table 3. Some pomological characteristics of the varieties (averages of 2022-2023).

Varieties	Altitude	Nut Size (mm)	Nut Shape Index (%)	Kernel Size (mm)	Kernel Shape Index (%)	Kernel Ratio (%)
Palaz	Fatsa (300m)	18.05±0.48bc	0.84±0.06e	11.99±0.84c	0.77±0.02e	50.48±2.14c
Palaz	Kumru (400m)	16.86±0.64e	0.98±0.05d	13.11±0.51b	0.93±0.15d	57.35±1.78a
Palaz	İkizce (590m)	17.25±0.73de	0.87±0.03e	13.42±0.77ab	0.78±0.04e	54.63±1.23ab
Tombul	Fatsa (300m)	17.53±0.52cd	1.02±0.08cd	13.65±0.86ab	0.98±0.07cd	53.16±2.46bc
Tombul	Kumru (400m)	16.85±0.51e	1.15±0.02a	13.86±0.52ab	1.27±0.34a	54.25±2.90ab
Tombul	İkizce (590m)	20.11±0.62a	1.11±0.06ab	13.97±2.69ab	1.14±0.15ab	53.29±1.85bc
Çakıldak	Fatsa (300m)	18.35±0.62b	1.07±0.11bc	14.05±0.57ab	1.10±0.07bc	54.93±6.45ab
Çakıldak	Kumru (400m)	17.74±0.37cd	1.15±0.05a	14.16±0.32ab	1.21±0.16ab	56.19±4.08ab
Çakıldak	İkizce (590m)	18.44±0.56b	1.11±0.05ab	14.53±0.63a	1.14±0.10ab	56.33±3.50ab
Significance		0.000	0.000	0.000	0.000	0.002

The difference between means denoted by the same letter is not statistically important ($p<0.05$)

Regarding fibrousness, all varieties (Çakıldak, Palaz and Tombul) were evaluated as non-fibrous. In addition, no double kernel (twin fruit) was observed in the varieties in terms of double kernel percentage. The. empty kernel percentage was not observed in all varieties and was determined as 100% full. The proportion of the good interior was determined as 100% for all varieties. The good kernel ratio was found to be 100% in all varieties. When the percentage of shriveled kernels of the varieties at different altitudes was examined, all varieties were good and no shriveled kernels were observed (Table 4).

Table 4. Some Pomological Characteristics of The Varieties (Averages of 2022-2023).

Varieties	Altitude	Double Kernel Ratio (%)	Empty Kernel Ratio (%)	Good Kernel Ratio (%)	Shriveled Kernel Ratio (%)	Fibrousness
Palaz	Fatsa (300m)	0	0	100	0	non-fibrous
Palaz	Kumru (400m)	0	0	100	0	non-fibrous
Palaz	İkizce (590m)	0	0	100	0	non-fibrous
Tombul	Fatsa (300m)	0	0	100	0	non-fibrous
Tombul	Kumru (400m)	0	0	100	0	non-fibrous
Tombul	İkizce (590m)	0	0	100	0	non-fibrous
Çakıldak	Fatsa (300m)	0	0	100	0	non-fibrous
Çakıldak	Kumru (400m)	0	0	100	0	non-fibrous
Çakıldak	İkizce (590m)	0	0	100	0	non-fibrous

Comparing the study we conducted withthe studies in the literature; Beyhan (2000) reported that the nut weights of the hazelnut cultivars Tombul, Palaz, Sivri, Kalınkara, Local Hazelnut and Hanım vary between 1.02- 1.07 g and their kernel rate is between 50.9-53.0%. Islam et al. (2005) conducted a study in Ordu province between 1999 and 2001 and found that the kernel percentage of the hazelnut varieties Tombul, Palaz, Çakıldak varied between 43.08% - 65.48%, the nut size between 15.02 - 20.39 mm, the nut weight between 1.37 - 3.64 g, the shell thickness between 0.69 - 1.56 mm and the kernel weight between 0.76 - 1.75 g. In a study in the Çarşamba district of Samsun, Semiz (2016) determined the nut weights of hazelnut varieties and types to be 2.14 g (Çakıldak), 1.93 g (Palaz) and 1.89 g (Tombul). In addition, the researcher recorded the shell thickness between 0.74 mm (Kuş Hazelnut-1) and 1.29 mm (Palaz-1) and the kernel weight between 0.79 g (Kuş hazelnut-1) and 1.46 g (Çarşamba Tip-1) and the nut size between 15.08 mm (Giresun Karası-2) and 18.62 mm (Çarşamba Tip-2) and the kernel size between 11.89 mm (Kuş Hazelnut-1) and 15.86 mm (Giresun Karası-1). Gülsoy et al. (2019), study in Ordu, in hazelnut cultivars grown in different locations, the average nut weight was between 1.52 g (Çakıldak -350 m) and 2.92 g (Kara -350 m), kernel weight was between 0.80 g (Sivri -350 m)-1. 47 g (Kara -350 m), kernel percentage between 46.88% (Sivri -350 m)-55.52% (Çakıldak -350 m), shell thickness between 0.94 mm (Yağlı -350 m)-1.29 mm (Kara -800 m), nut size between 14.27 mm (Sivri -350 m)-18.67 mm (Kara -350 m). In addition, they evaluated the varieties in 2 groups as fibrous and non-fibrous in terms of fibrousness. The Çakıldak, Yağlı, Palaz and Sivri varieties were evaluated as non-fibrous and the Kara variety as fibrous. In a study conducted in

the Harkköy region in the Karakaya Basin of the Tirebolu district of Giresun province, Karadeniz et al. (2020) determined the nut weight of the genotypes to be between 1.63-2.40 g, the kernel weight between 0.90-1.18 g, the kernel percentage between 44.91-56.27%, the shell thickness between 1.12-1.52 mm and nut size between 16.64-17.29 mm. Comparing the data obtained in our study with the studies conducted in previous years, it can be seen that they are either similar or have better values. It is thought that the difference in similarity or superiority of the genotypes could be due to both genetic structure and environmental factors. It is known that the physical and chemical characteristics of fruit species are influenced by factors such as climate and soil conditions of the region where they are grown, technical and cultural treatments, harvest time, fruit yield and fruit ripening time (Drogoudi et al., 2009; Caliskan and Polat, 2012). It has been reported that hazelnuts grown at different altitudes differ from each other in terms of fruit quality factors and that fruit characteristics vary considerably depending onnutritional conditions and altitude (Karadeniz and Bostan, 2004). In a study conducted to determine the effects of geographical region and climate on hazelnut yield and variety performance, it was found that climate and soil characteristics and average yield values vary according to altitude and distance from the coast (Baldwin et al., 2001).

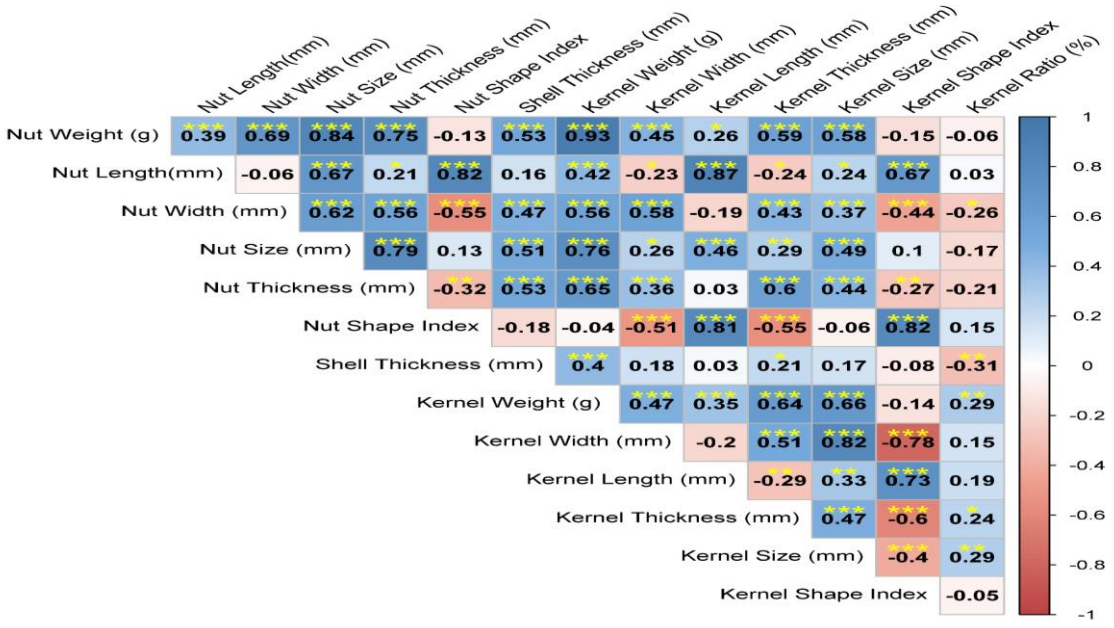

Figure 1 Correlation graph between pomological characteristics of hazelnut cultivars.

In this study, correlation test was performed to determine the relationship between the pomological characteristics of hazelnut cultivars and altitude (Figure 1). As a result of correlation test, nut weight showed high positive correlation with nut width (r=0.69***), nut size (r=0.84***), nut thickness (r=0.75***), kernel weight (r=0.93***). Moreover, nut length showed a high positive correlation trend with nut size (r=0.67***), nut shape index (r=0.82***), kernel length (r=0.87***) and kernel shape index (r=0.67***). İn addition nut width showed a positive correlation trend with nut size (r=0.62***), nut thickness (r=0.56***), Kernel width (r=0.58***), while it showed a low negative correlation trend with nut shape index (r=-0.55***), kernel shape index (r=-0.44***) and kernel ratio (r=-0.26*). Besides nut size tended to be positively correlated with nut thickness (r=0.79***), shell thickness (r=0.51***), kernel weight (r=0.76***), kernel size (r=0.49***). Nut thickness tended to be positively correlated with kernel thickness (r=0.53***), kernel weight (r=0.65***), kernel thickness (r=0.60***), kernel size (r=0.44***), while nut shape index (r=-0.32**) tended to be negatively correlated with kernel shape index (r=-0.27**). Moreover, nut shape index tended to be positively correlated with kernel length (r=0.81***) and Kernel shape index (r=0.82***), while kernel width (r=-0.51***) and kernel thickness (r=-0.55***) were negatively correlated. Shell thickness was positively correlated with kernel weight (r=0.40***) and negatively correlated with kernel ratio (r=-0.31**). Kernel weight tends to be positively correlated with kernel thickness (r=0.64 ***), kernel size (r=0.66*), kernel width (r=0.47 ***). Also kernel width showed positive correlation with kernel size (r=0.82***), while it showed negative correlation with kernel shape index (r=-0.78 ***). Kernel length

showed positive correlation with kernel shape index (r=0.73***) and negative correlation with kernel thickness (r=-0.29**).

CONCLUSION and SUGGESTIONS

Hazelnut cultivation in our country is generally practiced on small plots and in the form of family farms. Hazelnut cultivation directly or indirectly affects 8 million people in the regions (Karadeniz et al., 2020 For this reason, hazelnuts are of great importance both for the region where they are grown and for our country. In Ordu province, many hazelnut varieties can be grown at different altitudes. In the study, the lowest average values for nut and kernel weight, nut and shell thickness and kernel size were obtained from trees at 400 m altitude, while the highest values were obtained from trees at 590 m altitude. According to the results, the altitude had a different effecton the weight of the nuts and kernels depending onthe variety While the weight of nuts and kernels increased with increasing altitude in Çakıldak and Palaz varieties, these values decreased in Tombul variety. It was determined that the best values in terms of yield per decare and fruit quality characteristics of Çakıldak, Palaz and Tombul cultivars were found inorchards at different altitudes in Fatsa, İkizce and Kumru ecosystems in Ordu province in the orchards at 590 m altitude. It was concluded that the quality parameters may increase with increasing altitude. However, more reliable results can be obtained by conducting similar studies consideringmany characteristics such as soil fertility, orientation, variety and cultivation methods in each district. In this study, differences were found between the fruit characteristics of varieties grown at different altitudes. However, longer-term and more detailed studies on the effects of altitude on the fruit quality of the varieties will provide better results.

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Compliance with Ethical Standards

Conflict of interest All authors declare that they have no conflicts of interest

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