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THE EFFECT OF REGION ON NUT AND BIOCHEMICAL TRAITS OF MINCANE HAZELNUT CULTIVAR

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Abstract: This study investigated the effect of region on the nut and biochemical traits in Mincane hazelnut cultivar. The study was carried out in the Trabzon (Black Sea Region) and Sakarya (Marmara Region) districts, in 2021 and 2022. The material of the study consisted of the nut of Mincane hazelnut cultivar grown in both regions. Depending on regions, nut weight ranged from 1.89 (Black Sea) to 2.14 g (Marmara), while kernel weight ranged from 0.96 (Black Sea) to 1.06 g (Marmara). The nuts obtained from the Black Sea region yielded the highest total phenolics (118.1 mg 100 g^{-1}). Marmara region's nuts had the highest total flavonoids (8.1 mg 100 g^{-1}) and antioxidant activity (1027.8 and 738.1 µmol 100 g^{-1} according to DPPH and FRAP assays, respectively). The results demonstrated the significance of the growing region on the investigated nut and biochemical traits and the superiority of the Marmara region on many quality traits.

Keywords: *Corylus avellana*, Antioxidant, Phenolic, Kernel weight, Nut size

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1. Introduction

The hazelnut is one of the most important nut species. Approximately 1.1 million tons of hazelnuts are produced on 1 million hectares (ha) in the world. Türkiye is leads the world in hazelnut production, with 665 thousand tons on an area of 734 thousand ha. Italy, USA, Azerbaijan are other important hazelnut producers (Anonymous, 2022a). The Black Sea Region has the most suitable ecological conditions for hazelnut cultivation in the Türkiye (Serdar and Demir, 2005; Ercisli et al., 2011). Hazelnut is cultivated in the area up to 80 km inland and up to 1000-1200 m altitudes in the region. The cultivation zones are classified as old and new production zones (Karadeniz et al., 2009). Tombul, Palaz, Çakıldak, Mincane, Foşa and Kalınkara cultivars are common grown in the old production areas, whereas Çakıldak, Mincane, Foşa and Karafındık cultivars are grown in the new production areas.

Hazelnut is essential in human nutrition and health, with high nutritional value thanks to being rich in fat, protein, vitamins, carbohydrates, minerals, fatty acids, phenolics, and antioxidants (Cosmulescu et al., 2013). It promotes human health and reduces the risk of many chronic diseases such as cancer, diabetes, neurodegenerative and inflammatory, especially cardiovascular diseases (Contini et al., 2011; Di Nunzio, 2019). Hazelnut also lowers the risk of heart disease and the adverse effects of hypertension due to the mono and polyunsaturated fatty acids it contains (Yücesan et al., 2010).

Many factors such as genetic structure (Balta et al., 2006), ecology (Amaral et al., 2010; Karakaya, 2022), technical and cultural practices (irrigation, fertilization, pruning etc.) (Bak and Karadeniz, 2021), harvest time (Cristofori et al., 2015), storage conditions (Turan and İslam, 2018), altitude and orchard direction (Bostan, 2003; Beyhan et al., 2011; Kul, 2020) affect the chemical composition of hazelnut. In particular, ecological conditions impact primary and secondary metabolites (Bacchetta et al., 2013; Mezni et al., 2018). Phenolics, flavonoids, and antioxidants in Çakıldak vary significantly depending on eco-geographic regions (Kul, 2020). Similar phenomena were reported in different hazelnut cultivars (Bacchetta et al., 2018; Karakaya, 2022).

Very few studies have been conducted on the effect of region on the biochemical characteristics of widely grown hazelnut cultivars in Türkiye. These studies include mainly the Tombul, Çakıldak, and Kalınkara cultivars (Bostan, 2003; Kul, 2020; Karakaya, 2022). No studies evaluated the effects of the growing region on biochemical properties in the Mincane, widely grown in both old and new production areas. The sole research on this cultivar determined the vitamin and mineral content (Açkurt et al., 1999). This study investigated the effect of growing regions on the nut and biochemical traits in Mincane hazelnut cultivar.

2. Material and Methods

2.1. Plant Materials

The research was conducted in Trabzon (Black Sea Region) and Sakarya (Marmara Region) provinces, in

2021 and 2022. The material of the study was Mincane hazelnut cultivar grown in the regions. The trial orchard (about 50 years old, 610 m altitude) in the Trabzon was established in the 'Ocak' (8-10 stems per 'Ocak') training system in south direction, and were planted spacing 3 m in the row and 3.5 m between rows. The trial orchard (about 35 years old, 150 m altitude) in the Sakarya was established in the 'Ocak' (9-12 stems per 'Ocak') training system in south direction, and were planted spacing 3.5 m in the row and 4 m between rows. In the trial orchards, technical and cultural practices (except irrigation) were regularly performed. A total of 350-450 g compound fertilizers [N-P-K (12-18-12) + (10 SO_3) + 1 Zn + 0.2 B] and 500-600 g nitrogen (N) were supplied per 'Ocak' in the orchards. Chemical control was performed to against the diseases and pests. Weed control was carried out twice a year and branch thinning was performed in the winter period.

In the Trabzon region, the average annual temperature is 8.9 °C. The warmest month is August (18.1 °C), and the coldest month is January (-1.7 °C). The minimum temperature is between -5.2 °C (January) and 15.1 °C (August). The maximum temperature is from 2.4 °C (January) and 21.4 °C (August). Annual rainfall is 1492 mm and relative humidity is 81%. In the Sakarya region, the average annual temperature is 12.5 °C. The warmest month is August (22 °C), and the coldest month is January (3.2 °C). The minimum temperature is between 0.1 °C (January) and 18.5 °C (August). The maximum temperature is from 6.7 °C (January) and 25.1 °C (August). Annual rainfall is 953 mm and relative humidity is 79% (Anonymous, 2022b).

2.2. Methods

The research was designed according to the randomized blocks experimental design with three replications and three 'Ocak' in each replication. At harvest time (in 10-15 August according to regions and years), approximately 500 g of nut were collected from each 'Ocak'. Harvested nut were naturally dried until the moisture content decreased to 6% after being separated from their husk. Then, the nut and biochemical properties were studied.

Thirty nut were used in nut traits evaluation. Nut and kernel weight were determined using a digital precision balance (Radwag, Poland). The shell thickness, nut and kernel dimensions were measured with a digital caliper (Mitutoyo, Japan). The kernel ratio and nut and kernel size were calculated using the following equation 1, 2 and 3 (Balta et al., 2018a; Guler and Balta, 2020):

$$\text{Kernel ratio} = (\text{kernel weight}/\text{nut weight}) \times 100 \quad (1)$$

$$\text{Nut size} = \sqrt{\text{kernel dimensions (length, width, thickness)}} \quad (2)$$

$$\text{Kernel size} = \sqrt{\text{kernel dimensions (length, width, thickness)}} \quad (3)$$

Total phenolics and total flavonoids were determined by the method of Yılmaz et al. (2019), using a UV-Vis spectrophotometer (Shimadzu, Japan) at 760 nm and 415 nm, respectively. The results for total phenolics and total flavonoids were expressed as mg 100 g^{-1}. The antioxidant activity was detected by modifying the DPPH and FRAP assays previously described by Blois (1958) and Benzie and Strain (1996), reading the absorbances of in the spectrophotometer (Shimadzu, Japan) at 517 nm and 700 nm, respectively. The quantities for DPPH and FRAP were expressed as µmol 100 g^{-1}.

2.3. Statistical Analysis

JMP 14 (trail) statistical software was used in the statistical analysis. Data from two consecutive years were averaged, and the LSD multiple comparison method was used to determine the differences between the means. The PCA analysis was used to examine the interrelations between traits and the growing regions illustrated by a biplot graph (Putra et al., 2020).

3. Results

The region significantly affected nut and kernel weights, shell thickness, nut width and thickness, kernel width and size, while the effect on kernel ratio, nut length and size, kernel thickness and length traits was insignificant ($P<0.05$). The highest nut and kernel weight (2.14 g and 1.06 g, respectively) were determined in the Marmara region. In contrast, the highest kernel ratio (50.7%) and the thinnest shell (1.07 mm) were obtained from the Black Sea region (Table 1).

The highest values in nut dimensional characteristics were determined in the Marmara region, except for nut and kernel lengths. The nut size ranged from 16.15 mm (Black Sea) to 16.68 mm (Marmara), while the kernel size was determined as 12.57 mm (Black Sea) and 13.05 mm (Marmara) (Table 1).

The region significantly impacted bioactive compounds ($P<0.05$). The nuts grown in the Marmara region possessed the highest bioactive compounds, except for total phenolics. Total phenolics were 105.0 mg 100 g^{-1} in the Marmara and 181.1 mg 100 g^{-1} in the Black Sea, while total flavonoids were 3.0 mg 100 g^{-1} in the Black Sea and 8.1 mg 100 g^{-1} in the Marmara (Table 2).

The DPPH assay determined antioxidant activity as 128.8 µmol 100 g^{-1} in the nuts grown in the Black Sea and 1027.8 µmol 100 g^{-1} in the nuts grown in the Marmara. The antioxidant activity was determined as 152.4 µmol 100 g^{-1} in the nuts obtained from the Black Sea and 738.1 µmol 100 g^{-1} in the nuts of the Marmara region by the FRAP assay (Table 2).

According to principle component analysis, the first two components explained 87.9% of the total variation in the data. PC1 accounted for 72.8% of the total variation and was highly related to nut and kernel weight, shell thickness, nut and kernel dimensions (except for kernel length), bioactive compounds. PC2 was related to nut and kernel length traits, and accounted for 15.1% of the total variation. When evaluated by regions, the Black Sea region grouped with nut length, kernel length, kernel ratio, and total phenolics, while many other traits were grouped with the Marmara region (Figure 1).

Table 1. Mincane hazelnut cultivar's nut traits grown in the Black Sea and Marmara regions

Traits / Regions	Black Sea	Marmara	Significance	LSD (0.05)
Nut weight (g)	1.89 b*	2.14 a	*	0.18
Kernel weight (g)	0.96 b	1.06 a	*	0.09
Kernel ratio (%)	50.7 a	50.0 a	ns	1.32
Shell thickness (mm)	1.07 b	1.23 a	**	0.08
Nut width (mm)	16.27 b	16.94 a	*	0.45
Nut thickness (mm)	14.09 b	15.11 a	*	0.64
Nut length (mm)	18.38 a	18.14 a	ns	1.07
Nut size (mm)	16.15 a	16.68 a	ns	0.55
Kernel width (mm)	12.54 b	13.11 a	*	0.48
Kernel thickness (mm)	11.04 a	11.89 a	ns	0.88
Kernel length (mm)	14.34 a	14.28 a	ns	0.55
Kernel size (mm)	12.57 b	13.05 a	*	0.46

*The difference in between same letters in the same row is statistically insignificant (P<0.05).

Table 2. Biochemical properties of Mincane hazelnut cultivar grown in Black Sea and Marmara regions

Traits / Regions	Black Sea	Marmara	Significance	LSD (0.05)
Total phenolic (mg 100 g^{-1})	181.1 a*	105.0 b	***	15.3
Total flavonoid (mg 100 g^{-1})	3.0 b	8.1 a	***	0.31
DPPH (μmol 100 g^{-1})	128.8 b	1027.8 a	***	72.3
FRAP (μmol 100 g^{-1})	152.4 b	738.1 a	***	182.1

*The difference in between same letters in the same row is statistically insignificant (P<0.05).

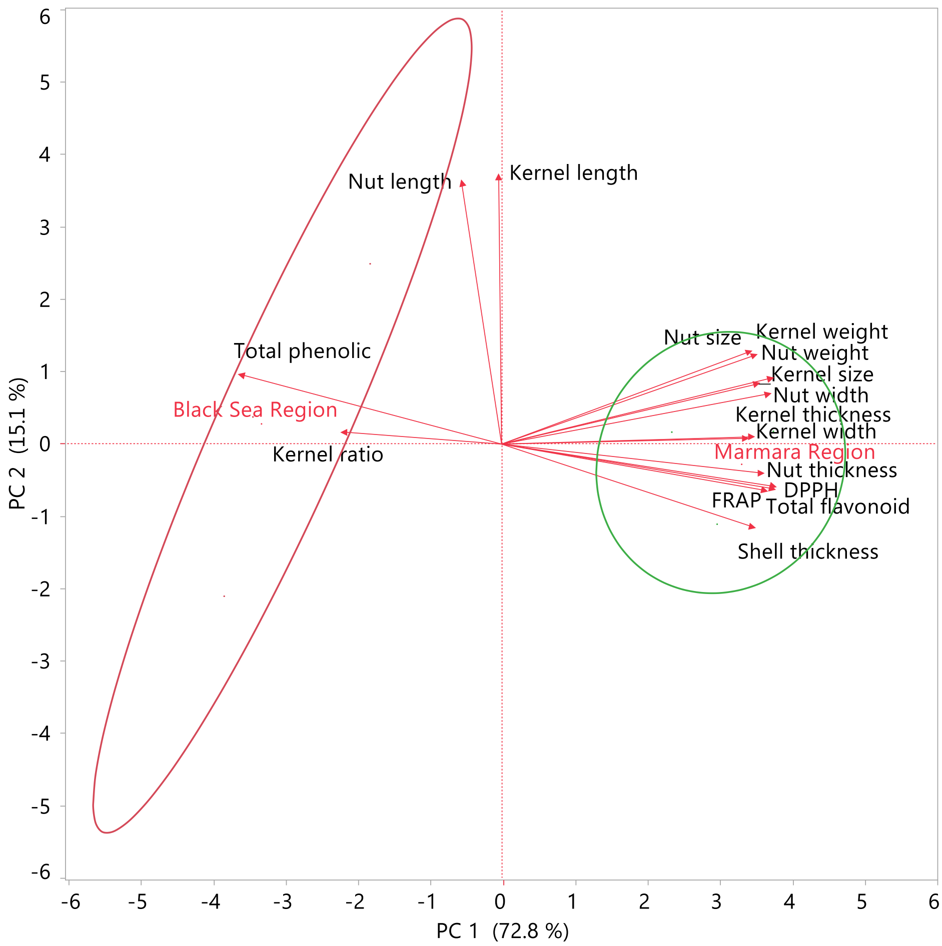

Figure 1. Biplot graph based on nut and biochemical traits of Mincane hazelnut cultivar.

4. Discussion

Nut and kernel weight, shell thickness, and kernel ratio are crucial quality traits in hazelnut (Balta et al., 2018b). Thin-shell and high kernel ratio are desirable in the hazelnut processing industry. Large-sized nut is evaluated for in-shell consumption, while small and medium-sized nut are used in confectionery industry. Many factors such as genotype, variety, ecological conditions, technical and cultural applications (fertilization, irrigation, pruning etc.) are effective on these properties (Beyhan and Demir, 2001; Külahcılar et al., 2018; İslam and Çayan, 2019; Bostan and İsbakan, 2020). In the current study, while region had a significant effect on nut and kernel weight, shell thickness, nut thickness and width, kernel width and size, it had no effect on kernel ratio, nut length and size, kernel length and thickness. Except for kernel ratio, nut and kernel dimensions (length, width, and thickness), no study has been found that investigated the effect of region on other traits in Mincane hazelnut cultivar, and it has been reported that the investigated traits vary significantly depending on the region. The highest kernel ratio and nut dimensions were reported in the west Black Sea region (Köksal et al., 2012). In Kalınkara cultivar grown in Ordu, Samsun, and Sakarya region, the highest nut and kernel weight, shell thickness, kernel ratio, nut and kernel dimensions values were found in Sakarya (Marmara region) (Karakaya, 2022). In the current study, except for kernel ratio, the highest values were recorded in the Marmara region in terms of other traits investigated. Although the highest kernel ratio was found in the east Black Sea region, it was statistically insignificant. Except for kernel ratio, the results obtained for other nut traits similar with the findings of the researchers. The observed differences in terms of kernel ratio could be attributed to environmental conditions, cultivar, cultivation conditions (Balta et al., 2018b; Gülsoy et al., 2019; Karakaya, 2022).

Phenolic compounds are secondary metabolites. They are crucial for the determine health benefits and quality of fruits, and influence sensory traits such as taste, aroma, color of foods (Haminiuk et al., 2012). Furthermore, polyphenols are beneficial to human health and play a crucial role in disease prevention. The synthesis of primary and secondary metabolites is influenced by climatic conditions (Bacchetta et al., 2013; Mezni et al., 2018). Phenolic synthesis increased is associated with extreme temperatures, UV radiation, parasite and pathogen damage (de Abreu and Mazzafera, 2005; Del Valle et al., 2020; Ozdemir et al., 2022; Karakaya et al., 2023).

In the current research, the influence of region on bioactive compounds was significant. Except for total phenolics, the highest bioactive compounds values were determined in the Marmara region. Although the influence of region on the vitamin and mineral content of the Mincane hazelnut cultivar has been studied (Açkurt et al., 1999), no research on the influence of the region on bioactive compounds has been conducted. Researchers reported that the vitamin and mineral content varied significantly depending on the region, and the highest vitamin and mineral values determined in the eastern and western Black Sea regions, respectively (Açkurt et al., 1999). Bioactive compounds have been found to differ in Tombul cultivar grown at different altitudes in the same location (Şengül, 2019). Similar findings were reported in the Çakıldak cultivar (Kul, 2020). In the Kalınkara cultivar grown in different regions, the highest total phenolics and total flavonoid were reported in Sakarya (Marmara), and the highest antioxidant was reported in Ordu (Black Sea) (Karakaya, 2022). Also, Solar et al. (2022) reported that phenolics and flavonoids in the Barcelona, Pauetet, Merveille de Bollwiller, Tonda di Giffoni, and Tonda Gentile delle Langhe hazelnut cultivars varied significantly depending on the region. In the current study, except for total phenolics, the highest bioactive compounds values were determined in the Marmara region. Except for total flavonoids, the results obtained for other bioactive compounds differed from the findings of Karakaya (2022). The observed differences could be attributed to environmental conditions, cultivar, cultivation conditions (Yılmaz et al., 2019; Tonkaz et al., 2019).

5. Conclusion

The region significantly influenced the nut traits and bioactive compounds of the Mincane hazelnut cultivar. The Marmara region produced the best results in terms of nut and kernel weight, which are crucial quality characteristics of hazelnut. The Black Sea region had the best kernel ratio and shell thickness. Except for total phenolics, the highest bioactive compounds were determined in the Marmara region. Overall, the best results were found in a Mincane cultivar grown in the Marmara region in many traits. These findings provide essential information for the hazelnut industry and processors in Trabzon and Sakarya, where the Mincane cultivar is widely grown.

Author Contributions

The percentage of the author contributions is present below. The author reviewed and approved final version of the manuscript.

	O.K.
C	100
D	100
S	100
DCP	100
DAI	100
L	100
W	100
CR	100
SR	100
PM	100
FA	100

C=Concept, D= design, S= supervision, DCP= data collection and/or processing, DAI= data analysis and/or interpretation, L= literature search, W= writing, CR= critical review, SR= submission and revision, PM= project management, FA= funding acquisition.

Conflict of Interest

The author declared that there is no conflict of interest.

Ethical Consideration

Ethics committee approval was not required for this study because of there was no study on animals or humans.

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