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ARAŞTIRMA MAKALESİ **RESEARCH ARTICLE**

The effect of kaolin application on yield and fruit quality in some walnut cultivars

Kaolin uygulamasının bazı ceviz çeşitlerinde verim ve meyve kalitesine etkisi

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ABSTRACT

This study evaluated the effects of kaolin applications on yield and fruit quality in several walnut genotypes grown in Yayladağı/Hatay, Türkiye. The genotypes included Bilecik, Şebin, Yalova 1, Yalova 3, Yalova 4, Tokat 1, Malatya 1, 77H-1, and Kaplan 86. Trees were treated with 6% and 3% kaolin on June 1 and June 15, respectively. The maximum temperatures recorded during the field experiment were 31.1°C, 36.5°C, 41.8°C, and 38.8°C for June, July, August, and September, respectively. The study found that nut shape, nut size, shell roughness, resistance to cracking, and kernel venation traits less influenced by environmental conditions were not affected by kaolin dosage. Although the weight of kernel increased with kaolin doses, no clear effects on average nut weight were observed. Nut weight varied among genotypes; the control treatment of Tokat 1 had the lowest nut weight at 8.50 g, while the highest nut weight was recorded in the control plots of Kaplan 86 at 24.55 g. The kaolin application doses had varying effects on the oil and protein content of the cultivars. The lowest oil proportion, 50% for Yalova 1, was obtained from control plots, while the highest oil proportion, 64.8%, was found in kaolin-treated Tokat 1 fruits. The highest protein content, 23.88%, was found in kaolin-treated 77H-1 fruits, whereas the lowest protein proportion, 16.59%, was recorded in the control plots of Tokat 1. In addition, walnuts treated with kaolin had fuller kernels, while control plants produced darker and weaker kernels.

ÖZET

Bu çalışma, Hatay Yayladağı ilçesinde yetiştirilen Bilecik, Şebin, Yalova 1, Yalova 3, Yalova 4, Tokat 1, Malatya 1, 77H-1 ve Kaplan 86 ceviz genotiplerinde kaolin uygulamasının verim ve meyve kalitesine etkisini belirlemek amacıyla gerçekleştirilmiştir. Bitkilere 1 Haziran ve 15 Haziran tarihlerinde %6 ve %3 oranında kaolin uygulanmıştır. Denemenin yürütüldüğü bahçede hava sıcaklığı kaydedilmiş, maksimum sıcaklıklar Haziran, Temmuz, Ağustos ve Eylül ayları için sırasıyla 31,1°C, 36,5°C, 41,8°C ve 38,8°C olmuştur. Çalışmada, meyve şekli, meyve boyutu, kabuk pürüzlülüğü, kabuk sertliği ve iç cevizde damarlanma gibi çevresel koşullardan daha az etkilenen özelliklerin kaolin uygulamasından etkilenmediği görülmüştür. Kaolin uygulaması iç ceviz ağırlığını artırmakla birlikte, kabuklu ceviz ağırlığı üzerinde belirgin bir etki gözlenmemiştir. Meyve ağırlığı çeşitler arasında farklılık göstermiştir. En düşük meyve ağırlığı Tokat 1 çeşidinin kontrol grubunda 8,50 g olurken, en yüksek meyve ağırlığı Kaplan 86 çeşidinin kontrol grubunda 24,55 g olarak belirlenmiştir. Kaolin uygulamasının ceviz çeşitlerinin yağ ve protein içeriği üzerine etkisi farklı olmuştur. En düşük yağ oranı (%50) Yalova 1 çeşidinin kontrol grubundan elde edilirken, en yüksek yağ oranı (%64,8) Tokat 1 çeşidinin kaolin uygulanmış meyvelerinden elde edilmiştir. En yüksek protein içeriği (%23,88) kaolin uygulanmış 77H-1 meyvelerinden, en düşük protein içeriği (%16,59) Tokat 1 çeşidinin kontrol grubu meyvelerinde saptanmıştır. Ayrıca, kaolin uygulanmış meyvelerde iç cevizler daha dolgun olurken, kontrol bitkilerinden elde edilen iç cevizler daha koyu ve daha zayıf olmuştur.

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INTRODUCTION

Thirty walnut species have been identified in the Juglans genus, with *Juglans regia* L. notable for its production, consumption, and superior fruit quality. It is also known as the Persian walnut, English walnut, or Anatolian walnut (Şen, 2011). Although walnuts are produced in large quantities in countries such as China, the USA, and Iran, Türkiye holds an important position among major walnut-producing countries, with in-shell walnut production of 360,000 tons (Anonymous, 2024). Walnuts can be grown almost everywhere in Türkiye, except in areas with extreme climate conditions (Sütyemez, 2001; Bayazıt & Caliskan, 2018).

Although the walnut is a fruit species used in various industries, its primary production purpose is its rich nutritional content, especially protein, fat, and fatty acids. It contains 15-30% protein, 55-77% fat, and about 1.5-3% ash (Muradoğlu, 2005; Rabrenovic et al., 2011). Walnuts are important in vegetarian diets due to their high biological quality and easily digestible protein. One of the most significant components of walnuts is their fat content. Walnut oil contains 72% polyunsaturated fatty acids (59% linoleic, 13% linolenic), 18% monounsaturated fatty acids (oleic acid), and 10% saturated fatty acids (palmitic, stearic) (Bayazıt & Sümbül, 2012; Aryapak & Ziarati, 2014).

Although walnuts are a species resilient to various ecological conditions, high summer temperatures in July, August, and September cause kernel darkening. Tefek (2016) also reports that summer temperatures above 35°C cause kernel browning. While this issue is frequently observed in the Mediterranean region, which has significant walnut populations, in recent years, due to climate change, summer temperatures have been above average in other regions with temperate climates.

Sunburn is a physiological disorder caused by environmental factors such as high temperature, light, and radiation, resulting in yield and quality losses in fruit cultivation. Exposure to high temperatures, intense light, and direct sunlight affects the fruit surfaces of some species, including walnuts, apples, pears, pomegranates, and citrus. Depending on the severity of the damage and the specific species or cultivar, the affected fruits may drop. This condition reduces the visual appeal and marketability of the fruits, leading to economic losses (Yazıcı & Kaynak, 2007).

The prediction that summer temperatures will further increase as a result of global warming makes it necessary to adopt cultural measures against high temperatures in fruit cultivation. For this purpose, overhead sprinkling for plant cooling, shading with various covering materials, and the application of kaolin to reflect light and reduce temperature are commonly used.

Kaolin is a light-reflecting clay mineral that has undergone various processes. It is a completely natural, white, non-porous, and non-abrasive material with the aluminosilicate formula ($Al_4Si_4O_{10}(OH)_8$), and is specially formulated to be water-dispersible. It is widely used in fruit cultivation in many countries to increase resistance to environmental stresses such as sunburn (Glenn et al., 2002; Daniel et al., 2005; Lo Verde et al., 2011). Additionally, it has been reported to reduce insect damage (Glenn et al., 1999) and prevent the emergence of diseases (Glenn et al., 1999; Puterka et al., 2000).

In recent years, the timing of late spring frosts has shifted as a consequence of climate change. In temperate regions where walnut cultivation is practiced, these frosts have begun to occur in the second half of April and even into May. For this reason, walnut cultivation has also expanded into the mid-to-high altitude areas of the Mediterranean region, which possesses a subtropical climate. In both temperate and subtropical walnut production areas, the significant rise in summer temperatures necessitates the use of shading and reflectors like kaolin to protect the trees from the scorching effects of the sun.

This study aimed to determine the effects of kaolin application on the yield and fruit quality of walnut genotypes from Türkiye: Bilecik, Şebin, Yalova 1, Yalova 3, Yalova 4, Tokat 1, Malatya 1, 77H-1, and Kaplan 86.

MATERIALS and METHODS

The experiment was conducted in a 14-year-old walnut adaptation plot in the Yayladağı district of Hatay (35° 55′ N, 36° 05′ E; altitude 421 m), which has a Mediterranean climate. The walnut genotypes Bilecik, Şebin, Yalova 1, Yalova 3, Yalova 4, Tokat 1, Malatya 1, 77H1, and Kaplan 86, selected from different regions of Türkiye, were used as research material. The commercial product Surround WP (containing 95% kaolin and 5% spreader-sticker) was used as the kaolin source. The first application was made in the first week of June, when the fruits reached hazelnut size, using a full-dose 6% suspension (6 kg/100 L, Surround WP), followed by a half-dose 3% suspension (3 kg/100 L, Surround WP) in the second half of June. Treatments were applied by spraying the trees with a sprayer. Trees in the control group were sprayed with water. Daily maximum and minimum temperature values of the experimental area were recorded in June, July, August, and September.

To determine the effect of applied kaolin on fruit surface temperature, surface temperatures were measured in fruits that were and were not treated with kaolin. Measurements were taken with an infrared thermometer (Spectrum IR thermometer) on 5 fruits per tree. Data were collected on June 15, July 1, August 1, and September 1, between 11:00 AM and 3:00 PM, during the hottest hours of the day when fruit surface temperature was highest. The average yield per tree (kg) was determined by counting the fruits harvested from each tree individually. The yield per trunk cross-sectional area (g/cm²) was calculated by dividing the yield per tree by the trunk cross-sectional area.

Fruit characteristics were determined in three replications, with 20 fruits per replication. The average weight of in-shell and kernel walnuts (g) was determined using a precision balance with 0.01 g sensitivity. Kernel percentage (%) was calculated using the yield formula for fruits with determined in-shell and kernel weights (Sütyemez, 2001). Shell thickness (mm) was measured at the part of the shell outside the suture. Fruit dimensions (width, length, height) (mm) were measured with a digital caliper sensitive to 0.01 mm, and averages were calculated.

Kernel color was measured using a colorimeter (Minolta CR-300 Chromometer) on 20 fruits per replicate across three replicates and expressed as L*, a*, b*, C, and h. In these values, L* represents brightness (0: black, 100: white), a* indicates the color shift from green to red (positive values: red, negative values: green), b* indicates the shift from yellow to blue (positive values: yellow, negative values: blue), C indicates color intensity, and h indicates the hue angle (0°: red, 90°: yellow, 180°: bluish-green, 270°: blue) (Zerbini and Polesollo, 1984).

The data were analyzed using the Student's *t*-test in the SAS software (SAS, 2005) package.

RESULTS and DISCUSSIONS

In the walnut orchard where the experiment was conducted, air temperature measurements began to be taken from June 10th, when temperatures started to rise. These measurements were carried out daily throughout July, August, and September. The highest temperatures were recorded as 31.1°C on June 19th, 36.5°C on July 24th, 41.8°C on August 3rd, and 38.8°C on September 10th. It was also observed that temperatures exceeded 30°C on all days of July, August, and September (Table 1).

High temperatures and solar radiation during the day cause sunburn damage on the fruit surface, thereby reducing both nutritional and commercial value. The application of kaolin reduced fruit surface temperatures during July, August, and September, when extreme temperatures that could damage the fruit were observed. However, in some genotypes, the temperature values recorded in the control plants were lower than expected compared to those of the kaolin-treated plants. This may be explained by the fact that the trees where the fruits were measured had normal canopy size and therefore remained in the shade. Additionally, there was a prevailing wind blowing from the sea toward the land in Hatay province, especially in the districts of Samandağ, Yayladağı, Defne, and Antakya. It is possible that temperature changes during measurement were also affected by this wind.

Table 1. Monthly variations in fruit surface maximum temperature (°C) values in walnut cultivars
Çizelge 1. Ceviz çeşitlerinde aylara göre maksimum meyve yüzey sıcaklıkları

Cultivars	Application	June	July	August	September	Average
Yalova 1	Kaolin	33.1	29.4	35.3	32.4	32.6
	Control	35.9	31.3	39.7	35.1	35.5
Yalova 3	Kaolin	31.9	30.5	36.3	34.8	33.4
	Control	29.8	29.7	38.4	31.6	32.4
Yalova 4	Kaolin	29.3	29.3	38.7	35.3	33.2
	Control	30.2	32.3	45.0	43.1	37.7
Bilecik	Kaolin	29.0	30.2	35.3	33.0	31.9
	Control	30.5	34.1	36.0	34.5	33.8
Şebin	Kaolin	32.4	32.7	38.9	32.8	34.2
	Control	32.0	30.1	41.7	35.5	34.8
Tokat 1	Kaolin	30.1	31.0	37.3	33.9	33.1
	Control	29.2	30.6	40.7	33.6	33.5
Malatya 1	Kaolin	26.4	29.2	32.5	33.6	30.4
	Control	32.0	31.5	39.0	37.4	35.0
77-H-1	Kaolin	30.3	27.9	36.6	34.2	32.3
	Control	30.7	26.9	38.7	38.1	33.6
Kaplan86	Kaolin	33.9	28.6	41.6	35.5	36.6
	Control	33.7	31.7	44.3	34.0	34.5
	Average	31.1	30.4	38.1	34.9	

Due to differences in plant development among the walnut genotypes included in the experiment, the effect of kaolin application on fruit yield per tree was not clearly observed. This is evident in the Tokat 1, Yalova 4, Yalova 1, and Malatya 1, where the amount of fruit obtained per plant depends on plant development.

The yield per trunk cross-sectional area (TCSA) varied among the walnut genotypes in the experiment; specifically, the Tokat 1, Malatya 1, Yalova 4, and 77H-1 were more productive than the other cultivars (Table 2). Examination of the data showed that kaolin application increased yield in Tokat 1, Malatya 1, and Yalova 4 compared to the control plants. In contrast, for Bilecik, 77H-1, Şebin, and Kaplan 86, the yield per TCSA was higher in the control group. These results support the findings of Kılıç (2014), who reported that the effect of kaolin application on yield and fruit quality varies depending on the cultivar.

Table 2. Effect of kaolin application on yield per tree and per trunk cross-sectional area
Çizelge 2. Kaolin uygulamasının bitki başına ve gövde birim kesit alanına düşen verime etkisi

Genotypes	Yield per tree (kg/tree)		Yield per trunk cross-sectional area (g/cm^2)	
	Kaolin	Control	Kaolin	Control
Tokat 1	3.92^a	7.85^a	17.96^a	15.25^a
Malatya 1	7.06^a	3.55^a	18.44^a	11.76^a
Bilecik	1.54^a	1.89^a	5.81^a	8.86^a
Yalova 1	3.19^a	1.75^a	8.09^a	5.04^a
Yalova 3	2.16^a	3.73^a	7.15^a	6.78^a
Yalova 4	8.12^a	1.53^a	29.25^a	10.25^b
77 H-1	1.14^a	7.27^a	6.38^b	18.28^a
Şebin	1.38^b	2.30^a	6.76^a	9.55 ^{a}
Kaplan 86	1.00^a	1.51^a	3.47^a	10.22^a
Average	3.28^a	3.49^a	11.48^a	10.66^a

As expected, in-shell nut weights in the study varied by genotype. The lowest in-shelled nut weight was found in the kaolin-treated Tokat 1 variety (8.35 g), while the highest was recorded in the kaolin-treated Kaplan 86 cultivar (26.48 g) (Table 2). Kaolin application significantly increased nut weight only in the Malatya 1, while values for the other genotypes were very similar between kaolin-treated and control plants (Table 3).

The results of this study on shelled nut weight are consistent with previous research. However, differences in the measured weight and size of shelled nuts in some cultivars may be due to cultural practices, tree age, ecological conditions, and the number of fruits per tree. Additionally, fruit weight in a given variety is influenced by cultural practices especially irrigation and fertilization as well as genetic structure. Kaolin application significantly increased shelled nut weight only in the Malatya 1, while the difference was not significant in other genotypes. Similarly, Ertan et al. (2009) reported that applying kaolin at 3% and 6% rates, two to four times, increased fruit yield and quality in figs. Schupp et al. (2002) found that three kaolin applications in May, June and July-August prevented sunburn in two apple cultivars, but fruit size was reduced when the application was made in July-August.

Kernel weights also varied among walnut genotypes. As with nut weight, the lowest kernel weight was observed in the control fruits of the Tokat 1 (4.30 g), while the highest kernel weight was found in the kaolin-treated nuts of the Kaplan 86 (10.49 g). The effect of kaolin application on kernel weight, which was the primary objective of the study, differed among cultivars. In the Tokat 1, Malatya 1, and Yalova 4, kaolin application significantly increased kernel weight compared to the control. Kaolin application increased kernel weight in all cultivars except Bilecik (Table 3).

The kernel percentage, a key criterion for determining the characteristics of walnut fruits, also varied among cultivars. The highest kernel percentage was obtained from kaolin-treated Tokat 1 fruits at 57.59%, while the lowest value was recorded in the control fruits of Kaplan 86 at 35.97%.

Table 3. Effect of kaolin application on fruit characteristics of walnut cultivars.
Çizelge 3. Kaolin uygulamasının ceviz çeşitlerinin meyve özelliklerine etkisi

Genotypes	**Nut weight (g)**		**Kernel weight (g)**		**Kernel percentage (%)**	
	Kaolin	**Control**	**Kaolin**	**Control**	**Kaolin**	**Control**
Tokat 1	8.35^{a}	8.50^{a}	4.72^{a}	4.30^{b}	57.59^{a}	50.57^{b}
Malatya 1	19.16^{a}	17.44^{b}	10.27^{a}	9.38^{b}	53.61^{a}	53.81^{a}
Bilecik	14.73^{a}	15.42^{a}	6.44^{a}	6.82^{a}	43.61^{a}	44.15^{a}
Yalova 1	14.95^{a}	14.26^{a}	6.01^{a}	5.61^{a}	40.31^{a}	39.03^{a}
Yalova 3	12.35^{a}	13.19^{a}	5.75^{a}	5.73^{a}	46.60^{a}	43.63^{a}
Yalova 4	11.40^{a}	9.61^{a}	4.75^{a}	2.94^{b}	41.53^{a}	30.58^{b}
77 H-1	14.31^{a}	14.28^{a}	4.76^{a}	4.72^{a}	33.25^{a}	33.12^{a}
Şebin	16.81^{a}	16.41^{a}	7.83^{a}	7.66^{a}	46.60^{a}	46.73^{a}
Kaplan 86	26.48^{a}	24.55^{a}	10.49^{a}	8.86^{a}	38.66^{a}	35.97^{a}
Average	15.39^{a}	14.85^{a}	6.78^{a}	6.22^{b}	44.64^{a}	41.95^{b}

Measurement results for fruit dimensions were consistent with in-shell nut weights, with the lowest values observed in Tokat 1 and the highest in Kaplan 86 (Table 4). Kaolin application significantly increased nut width, length, and height only in the Malatya 1 genotype; in the other walnut genotypes, these values were very similar in both kaolin-treated and control plants.

Table 4. Effect of kaolin application on fruit size characteristics in walnut cultivars
Çizelge 4. Kaolin uygulamasının ceviz çeşitlerinin meyve ebatlarına etkisi

Genotypes	Fruit width (mm)		Fruit length (mm)		Fruit thickness (mm)	
	Kaolin	Control	Kaolin	Control	Kaolin	Control
Tokat 1	26.82^{a}	27.00^{a}	33.58^{a}	33.31^{a}	29.35^{a}	29.28^{a}
Malatya 1	40.35^{a}	38.8^{b}	44.04^{a}	41.37^{b}	43.38^{a}	41.33^{b}
Bilecik	34.87^{a}	35.33^{a}	42.82^{a}	42.45^{a}	36.24^{a}	36.60^{a}
Yalova 1	35.24^{a}	34.54^{a}	43.01^{a}	42.08^{a}	37.14^{a}	35.97^{a}
Yalova 3	32.10^{a}	31.95^{a}	41.55^{a}	41.43^{a}	33.47^{a}	33.53^{a}
Yalova 4	32.27^{a}	31.70^{a}	43.47^{a}	41.99^{b}	36.09^{a}	35.56^{a}
77 H-1	35.67^{a}	35.77^{a}	45.53^{a}	45.23^{a}	38.55^{a}	38.18^{a}
Şebin	34.93^{a}	35.07^{a}	43.07^{a}	42.49^{a}	36.57^{a}	36.88^{a}
Kaplan 86	43.96^{a}	43.80^{a}	58.32^{a}	56.17^{a}	48.79^{a}	48.05^{a}
Average	35.13^{a}	34.89^{a}	43.93^{a}	42.95^{b}	37.73^{a}	37.26^{a}

The kernels from kaolin-treated plants were lighter in color than those from control plants. In kaolin-treated plants, both the L value and the b value (indicating yellow color) were higher. Higher L and b values were observed in the kernels of the Tokat 1, Malatya 1, Bilecik, Şebin, and Yalova 3 cultivars compared to other genotypes. However, no clear relationship was found with the a values. Therefore, it is suggested that L and b values should be used as preferred color parameters in walnuts. The +a value may indicate darkening and should be kept as low as possible. In this respect, the high L and b values and low a value of the Malatya 1 genotype, resulting in lighter-colored kernels, were consistent with subjective observations.

Table 5. L, a*, b* color values of walnut kernels
Çizelge 5. İç ceviz L, a, b* renk değerleri*

Genotypes	L		a*		b*	
	Kaolin	Control	Kaolin	Control	Kaolin	Control
Tokat 1	45.32^{a}	43.19^{a}	12.51^{a}	12.30^{a}	26.39^{a}	24.61^{a}
Malatya 1	43.82^{a}	46.39^{a}	11.46^{a}	11.36^{a}	28.05^{a}	26.70^{a}
Bilecik	41.93^{a}	38.34^{a}	13.33^{a}	12.96^{a}	24.41^{a}	22.77^{a}
Yalova 1	39.60^{a}	30.93^{a}	13.46^{a}	13.17^{a}	23.92^{a}	19.16^{a}
Yalova 3	43.29^{a}	41.41^{a}	12.93^{a}	12.19^{a}	26.17^{a}	24.27^{a}
Yalova 4	31.94^{a}	20.85^{b}	12.15^{a}	9.90^{b}	19.15^{a}	11.16^{b}
77 H-1	39.56^{a}	35.52^{a}	11.41^{a}	11.39^{a}	22.02^{a}	20.39^{a}
Şebin	40.03^{a}	38.61^{a}	13.98^{a}	13.65^{b}	26.71^{a}	24.18^{b}
Kaplan 86	32.19^{a}	29.25^{b}	12.21^{a}	12.43^{a}	19.22^{a}	18.97^{a}
Average	39.74^{a}	36.05^{b}	12.60^{a}	12.15^{b}	24.00^{a}	21.36^{b}

Table 5 (Continued). C and h° color values of walnut kernels
Çizelge 5 (Devamı). İç ceviz C ve h° renk değerleri

Genotypes	C		h°	
	Kaolin	**Control**	**Kaolin**	**Control**
Tokat 1	29.23[a]	27.55[b]	64.55[a]	63.15[a]
Malatya 1	30.32[a]	29.08[a]	67.70[a]	66.39[a]
Bilecik	27.98[a]	26.40[a]	59.72[a]	57.81[a]
Yalova 1	27.60[a]	23.56[a]	59.08[a]	52.26[a]
Yalova 3	29.22[a]	27.26[a]	63.41[a]	61.32[a]
Yalova 4	22.93[a]	15.20[b]	54.96[a]	52.31[a]
77 H-1	25.06[a]	23.61[a]	59.72[a]	58.27[a]
Şebin	30.20[a]	27.91[b]	61.92[a]	58.69[b]
Kaplan 86	22.84[a]	22.79[a]	57.06[a]	55.75[a]
Average	27.26[a]	24.82[b]	60.90[a]	58.44[b]

Total fat content was higher in kaolin-treated plants than in control plants across all walnut genotypes in the experiment; the differences between the means were statistically significant for the Tokat 1, Bilecik, Yalova 1, and Yalova 3. The average total fat content for kaolin-treated plants was 59.83%, compared to 55.06% for control plants. For protein ratios, the values were 19.31% and 18.10%, respectively (Table 6). Lipids and proteins, the primary nutrients in nut species, have been measured in various studies (Kılıç, 2014; Bayazıt & Caliskan, 2018). The values reported by these researchers are consistent with the data obtained in this study. In addition, the positive effect of kaolin on kernel color lightness and oil content may be related to its ability to reduce canopy temperature and solar radiation load. Particle film technology also reflects excess radiation, reduces leaf temperature, and increases photosynthetic efficiency under heat stress conditions (Glenn, 2012). This can contribute to increased lipid biosynthesis and delayed browning of kernel color by reducing oxidative stress.

Table 6. The effect of kaolin application on protein and fat content in walnut cultivars.
Çizelge 6. Kaolin uygulamasının ceviz çeşitlerinde protein ve yağ oranına etkisi

Genotypes	Fat content (%)		Protein content (%)	
	Kaolin	**Control**	**Kaolin**	**Control**
Tokat 1	64.80[a]	58.100[b]	19.09[a]	16.59[b]
Malatya 1	63.80[a]	61.00[a]	19.79[a]	17.86[a]
Bilecik	58.90[a]	54.90[b]	16.92[a]	16.26[a]
Yalova 1	56.10[a]	50.00[b]	19.56[a]	19.56[a]
Yalova 3	59.10[a]	51.90[b]	17.70[a]	18.17[a]
Yalova 4	55.00[a]	51.10[a]	19.86[a]	16.68[a]
77 H-1	60.80[a]	55.60[a]	23.88[a]	21.20[a]
Şebin	58.00[a]	56.50[a]	17.96[a]	17.11[a]
Kaplan 86	62.00[a]	56.50[a]	19.08 [a]	18.69[a]
Average	59.83[a]	55.06[b]	19.31[a]	18.10[b]

CONCLUSIONS

In conclusion, kaolin application did not produce a statistically significant difference in yield across all walnut genotypes, but it significantly improved certain kernel quality characteristics, particularly kernel weight, kernel color lightness (L value), total oil content, and protein ratio. Under Mediterranean climate conditions with high summer temperatures, kaolin application stands out as a sustainable cultural practice for maintaining kernel quality in walnut production.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest between them.

AUTHOR'S CONTRIBUTIONS;

All authors contributed equally for analyses, writing and interpretation of the article. The authors read and approved the final version of the manuscript.

STATEMENT OF ETHICS CONSENT

This article does not require ethical approval as there are no experiments with human or animal subjects.

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