

## Assessment of Nut Quality Traits in Almond Cultivars Grown in Karaman

Emre YILDIRIM<sup>1\*</sup> Yılmaz SESLİ<sup>2</sup>

<sup>1</sup>Karamanoğlu Mehmetbey University, Vocational School of Technical Sciences, Department of Plant and Animal Production, Program of Horticulture, Karaman, Türkiye

<sup>2</sup>Karamanoğlu Mehmetbey University, Department of Construction and Technical Works, Karaman, Türkiye

\* eyildirim@kmu.edu.tr (Corresponding Author)

### Abstract

This trial was conducted in a commercial almond orchard belonging to a grower in Dereköy, Karaman. In this study, the nut characteristics of Ferragnes, Ferraduel, and Bertina cultivars grafted onto NemaGuard rootstock were examined. According to the two-year data obtained, full bloom was observed to occur in the third week of April for the Ferragnes cultivar and in the second week of April for the Ferraduel and Bertina varieties. In terms of nut quality traits, the shell thickness of Ferragnes, Ferraduel, and Bertina almond varieties was determined as 24.73 mm, 24.58 mm, and 24.42 mm, respectively; shell width as 31.49 mm, 31.83 mm, and 35.55 mm; shell height as 37.89 mm, 46.62 mm, and 51.27 mm; shell weight as 3.59 g, 5.07 g, and 11.65 g; and kernel weight as 1.27 g, 1.20 g, and 2.90 g. Kernel ratios were identified as 35.17%, 28.37%, and 25.09%, respectively.

**Key words:** Almond, Adaptation, Yield, Cultivar

## Karaman'da Yetiştirilen Badem Çeşitlerinde Kalite Özelliklerinin Değerlendirilmesi

### Özet

Bu deneme, Karaman Dereköy'de bir üreticiye ait ticari badem bahçesinde yürütülmüştür. Bu çalışmada, NemaGuard anacı üzerine aşıllı Ferragnes, Ferraduel ve Bertina çeşitlerinin meyve özellikleri incelenmiştir. Elde edilen iki yıllık verilere göre, Ferragnes çeşidinde tam çiçeklenmenin nisan ayının üçüncü haftasında, Ferraduel ve Bertina çeşitlerinde ise nisan ayının ikinci haftasında gerçekleştiği görülmüştür. Meyve kalite özellikleri bakımından ise, Ferragnes, Ferraduel ve Bertina badem çeşitlerinde kabuk kalınlığı sırasıyla 24,73 mm, 24,58 mm ve 24,42 mm; kabuk genişliği 31,49 mm, 31,83 mm ve 35,55 mm; kabuk yüksekliği 37,89 mm, 46,62 mm ve 51,27 mm; kabuk ağırlığı 3,59 g, 5,07 g ve 11,65 g olarak tespit edilmiştir. Çekirdek ağırlığı 1,27 g, 1,20 g ve 2,90 g olarak belirlendi. Çekirdek oranları sırasıyla %35,17, %28,37 ve %25,09 olarak belirlendi.

**Anahtar kelimeler:** Badem, Adaptasyon, Verim, Çeşit

### Introduction

Almond (*Prunus amygdalus* Batsch) is an important member of the *Rosaceae* family and is cultivated widely around the world. Turkey, with its suitable climate conditions and broad genetic diversity, has significant potential in almond production. However, determining the phenological and fruit quality characteristics of almond cultivars grown in different ecological regions is of great importance for yield and quality.

Phenological traits describe the growth and development stages of plants, while Nut characteristics include the physical and chemical properties of the fruit. Understanding these characteristics plays a critical role in the selection of suitable cultivars, determination of harvest time, and optimization of cultivation techniques.

Various studies on almond cultivation in Turkey have focused on the adaptation abilities and characteristics of almond cultivars in different regions. For example, a study conducted in Gaziantep examined the nut characteristics of 21 almond cultivars and 6 species. In this study, the flowering times, fruit characteristics, and yield potentials of different cultivars were evaluated (Atlı, 2019).

In another study conducted in the Elazığ region, the soil properties and nutrient element contents of local almond trees were examined. This research reveals the relationship between the growth conditions and soil characteristics of almond trees in the region (Akgün et al., 2019).

These studies contribute to determining the most suitable cultivars for specific ecological conditions, revealing the performance of different almond cultivars. However, given Turkey's vast

geography and microclimatic diversity, specific studies are needed for each region.

In this context, the aim of this study is to identify the nut characteristics of different almond cultivars in Karaman, contributing to the identification of regionally suitable cultivars and the development of almond cultivation in the area.

### Material and Methods

This research was conducted during 2020–2021 in an orchard located in Dereköy, Karaman province, where 6-year-old 'Ferragnes', 'Ferraduel', and 'Bertina' almond cultivars grafted on Nemaguard rootstock were planted at a spacing of 5x5 meters. The geographical coordinates of the orchard are 37.12 latitude and 33.29 longitude, with an altitude of 1218 meters. The cultivation was carried out under the prevailing ecological conditions without irrigation.

### Physical and nut quality traits

Fruit samples were collected from the almond orchard to evaluate physical and nut quality traits. A total of 100 fruits-25 fruits per replicate with 4 replicates per cultivar were randomly selected and evaluated. The samples were evaluated based on the methods of Şimşek (1996), Kuzdere (1999), Balta (2002), Yıldırım (2007), and Gülsoy (2012). The width, thickness, and height of the shelled fruit (mm) were measured using a digital caliper.

**Kernel weight (g):** The inner kernel weights of randomly selected fruits were determined using a precision balance with 0.001 g sensitivity.

**Kernel ratio:** The kernel ratio was calculated for randomly selected fruits from each tree using the following formula:

$$\text{Kernel Ratio (\%)} = (\text{Average kernel weight} / \text{Average shelled fruit weight}) \times 100$$

### Statistical analysis

The data obtained in the study were evaluated using the JMP 8.0 statistical software based on a randomized plot design. The differences between the means were analyzed using the Least Significant Difference (LSD) test at a significance level of  $P < 0.05$ .

## Results

### Fruit width

According to the fruit size measurements in 2019, Ferragnes measured 29.91 mm, Ferraduel 32.46 mm, and Bertina 36.44 mm. Among these, Ferragnes had the smallest fruit width, while Bertina had the largest. In 2020, the widths were 33.07 mm for Ferragnes, 31.20 mm for Ferraduel,

and 34.66 mm for Bertina. These results showed that Bertina had the highest fruit width in both years, while the lowest values were recorded for Ferragnes in 2019 and Ferraduel in 2020 (Table 1).

Variance analysis for fruit width showed that the effects of year, replicate, and year  $\times$  variety interaction were not significant. However, the variety factor was significant at the 5% level.

**Table 1.** 2019–2020 Fruit width (mm)

**Çizelge 1.** 2019–2020 Meyve genişliği (mm)

Years	2019	2020
Ferragnes	29.91 $\pm$ 3.04 b	33.07 $\pm$ 1.31 **
Ferraduel	32.46 $\pm$ 0.40 b	31.20 $\pm$ 2.14 **
Bertina	36.44 $\pm$ 1.65 a	34.66 $\pm$ 1.91 **
Average	32.93	32.98
P-value	0.0081	0.0917

\*Different letters in the same column indicate statistically significant differences (LSD,  $P < 0.05$ ).

\*Aynı sütundaki farklı harfler istatistiksel olarak anlamlı farklılıkları göstermektedir (LSD,  $P < 0,05$ ).

### Fruit thickness

In 2019, the measured fruit thickness values were 26.70 mm for Ferragnes, 28.23 mm for Ferraduel, and 24.81 mm for Bertina. In 2020, the measurements were 22.77 mm, 20.94 mm, and 24.03 mm, respectively. The highest fruit thickness was observed in Ferragnes in 2019 and in Bertina in 2020, whereas the lowest values were recorded for Bertina in 2019 and for Ferraduel in 2020 (Table 2).

Variance analysis revealed that differences in replicate and variety were not significant for fruit thickness, but the effects of year and year  $\times$  variety interaction were significant at the 1% level.

**Table 2.** 2019–2020 Fruit thickness (mm)

**Çizelge 2.** 2019–2020 Meyve kalınlığı (mm)

Years	2019	2020
Ferragnes	26.70 $\pm$ 1.41 ab	22.77 $\pm$ 0.35 b
Ferraduel	28.23 $\pm$ 0.69 a	20.94 $\pm$ 1.05 c
Bertina	24.81 $\pm$ 0.71 b	24.03 $\pm$ 0.99 a
Average	26.58	22.58
P-value	0.0143	0.0016

\*Different letters in the same column indicate statistically significant differences (LSD,  $P < 0.05$ ).

\*Aynı sütundaki farklı harfler istatistiksel olarak anlamlı farklılıkları göstermektedir (LSD,  $P < 0,05$ ).

### Fruit height

In 2019, the fruit height values were 39.44 mm for Ferragnes, 47.35 mm for Ferraduel, and 51.96 mm for Bertina. In 2020, the values were 36.34 mm, 45.89 mm, and 59.59 mm, respectively. Bertina

had the highest fruit height in both years, while Ferragnes had the lowest (Table 3).

According to variance analysis, differences in replicate and year  $\times$  variety interaction were not significant, while the year effect was significant at the 5% level and variety differences were significant at the 1% level.

**Table 3.** 2019–2020 Fruit height (mm)

**Çizelge 3.** 2019-2020 Meyve yüksekliği (mm)

Years	2019	2020
Ferragnes	39.44 $\pm$ 1.17 c	36.34 $\pm$ 0.48 c
Ferraduel	47.35 $\pm$ 1.21 b	45.89 $\pm$ 1.36 b
Bertina	51.96 $\pm$ 1.25 a	50.59 $\pm$ 3.63 a
Average	46.25	42.27
P-value	0.0001	0.0004

\*Different letters in the same column indicate statistically significant differences (LSD,  $P < 0.05$ ).

\*Aynı sütündeki farklı harfler istatistiksel olarak anlamlı farklılıkları göstermektedir (LSD,  $P < 0.05$ ).

### Kernel weight

Kernel weight measurements in 2019 were 1.97 g for Ferragnes, 1.14 g for Ferraduel, and 2.94 g for Bertina. In 2020, Ferragnes had 1.27 g, Ferraduel 1.60 g, and Bertina 2.92 g. The lowest kernel weight was observed in Ferraduel in 2019 and Ferragnes in 2020, while Bertina had the highest in both years (Table 4).

According to variance analysis, year and replicate effects were not significant, but variety and year  $\times$  variety interactions were significant at the 1% level.

Statistical analysis of kernel weight by variety showed that, in 2019, the varieties formed three different groups, while in 2020, Ferragnes and Ferraduel were in the same group and Bertina was in a separate group.

**Table 4.** 2019–2020 Kernel weight (g)

**Çizelge 4.** 2019-2020 Meyve iç ağırlığı (g)

Years	2019	2020
Ferragnes	1.97 $\pm$ 0.14 b	1.27 $\pm$ 0.25 b
Ferraduel	1.14 $\pm$ 0.24 c	1.60 $\pm$ 0.21 b
Bertina	2.94 $\pm$ 0.16 a	2.92 $\pm$ 0.13 a
Average	2.02	1.93
P-value	0.0001	0.0001

\*Different letters in the same column indicate statistically significant differences (LSD,  $P < 0.05$ ).

\*Aynı sütündeki farklı harfler istatistiksel olarak anlamlı farklılıkları göstermektedir (LSD,  $P < 0.05$ ).

### Kernel ratio

According to the kernel ratio measurements in 2019, Ferragnes had 36.19%, Ferraduel 27.87%, and Bertina 25.02%. In 2020, the values were

34.16%, 28.87%, and 25.16%, respectively. The lowest kernel ratio in both years belonged to Bertina, while the highest was found in Ferragnes (Table 5).

No significant differences were found for year, replicate, or year  $\times$  variety interaction. However, the variety factor was significant at the 1% level.

**Table 5.** 2019–2020 Kernel Ratio (%)

**Çizelge 5.** 2019-2020 Meyve iç oranı (%)

Years	2019	2020
Ferragnes	36.19 $\pm$ 1.76 a	34.16 $\pm$ 3.79 a
Ferraduel	27.87 $\pm$ 0.75 b	28.87 $\pm$ 0.79 b
Bertina	25.02 $\pm$ 0.92 c	25.16 $\pm$ 0.29 c
Average	29.69	29.39
P-value	0.0001	0.0019

\*Different letters in the same column indicate statistically significant differences (LSD,  $P < 0.05$ ).

\*Aynı sütündeki farklı harfler istatistiksel olarak anlamlı farklılıkları göstermektedir (LSD,  $P < 0.05$ ).

### Discussion and Conclusion

Almond is an important fruit species for Turkey, and there is a need for production planning and increased cultivation. In recent years, scientific studies aiming to achieve this goal have continued. Among these studies, the most critical aspect is adaptation trials to determine suitable cultivars for each region. However, there is still insufficient information about which cultivar should be grown where. Various adaptation and fruit quality studies are ongoing with different almond cultivars in different regions.

With this study, it is aimed to identify suitable almond cultivars for the Karaman ecology, integrate them into production, and thereby contribute economically and scientifically. The fruit physical and quality characteristics of selected almond cultivars were identified during this research.

Nut quality analyses showed that in Karaman's ecology, the shelled fruit weight was Ferragnes (3.59 g), Ferraduel (5.07 g), and Bertina (11.65 g); fruit width: Ferragnes (31.49 mm), Ferraduel (31.83 mm), Bertina (35.55 mm); fruit thickness: Ferragnes (24.73 mm), Ferraduel (24.58 mm), Bertina (24.42 mm); fruit height: Ferragnes (37.89 mm), Ferraduel (46.62 mm), Bertina (51.27 mm); kernel weight: Ferragnes (1.27 g), Ferraduel (1.20 g), Bertina (2.90 g); kernel ratio: Ferragnes (35.17%), Ferraduel (28.37%), Bertina (25.09%). In comparison, in Şanlıurfa, the shelled fruit weight was Ferragnes (3.76 g), Ferraduel (3.85 g), Bertina (7.11 g); kernel weight: Ferragnes (3.76 g), Ferraduel (3.85 g), Bertina (7.11 g); kernel ratio: Ferragnes (31.11%), Ferraduel (31.01%), Bertina (24.46%). In Gaziantep, Ferragnes was

4.15 g, Ferraduel 4.21 g, and Bertina 6.29 g for shelled fruit weight (Parlakçı, 2008).

In other regions such as Diyarbakır, Manisa, and Uşak, fruit and kernel weights, fruit dimensions, and kernel ratios varied depending on ecological and cultivation conditions. For instance, in Diyarbakır, the shelled fruit weight ranged from 1.99 to 3.59 g, and kernel ratio from 22.93% to 56.20%.

When the current study is compared with those conducted in other regions, the differences observed in shelled fruit weight and kernel ratios are believed to be due to climatic and cultivation conditions, as well as the use of dry farming in the research area. Nevertheless, the findings are largely consistent with previous studies, especially those from Central and Southeastern Anatolia.

It is considered beneficial to conduct further research in the region regarding rootstock, cultivar, and cultivation practices. Particularly, the adaptation of new late-blooming almond cultivars may be advantageous. Additionally, testing drought-resistant or intensive cultivation-suitable almond rootstocks in regions of Karaman with Mediterranean climate characteristics may yield positive results.

## References

- Akgün TD, Tüfekçioğlu M, Küçük M, 2019. Determination of habitat characteristics of almond trees (*Prunus amygdalus* Batsch) grown in the Elazığ region. *Artvin Çoruh University Journal of Forestry Faculty* 20(1): 1-13.
- Atlı HS, 2019. Determination of Phenological and Pomological Characteristics of Some Almond Cultivars. *Journal of Turkish Agricultural Research* 6(2): 222-229.
- Balta MF, 2002. Research on the Improvement of Almonds (*Prunus amygdalus* L.) in Elazığ Central and Ağın Districts through Selection. PhD Thesis, Yüzüncü Yıl University, Institute of Science, Department of Horticulture, Van.
- Bilgin NA, 2020. Determination of performance of almond cultivars grown in Demirci District of Manisa. *KSU Journal of Agriculture and Nature* 23(1): 44-48.
- Gülsoy E, 2012. Selection of Naturally Growing Almonds (*P. amygdalus* L.) in Yenipazar, Bozdoğan and Karacasu Districts of Aydın. PhD Thesis, Yüzüncü Yıl University, Institute of Science, Department of Horticulture, Van.
- Kuzdere H, 1999. A Study on the Phenological and Pomological Characteristics of Some Almond Cultivars Grown in the Conditions of Ceylanpınar Agricultural Enterprises. MSc Thesis (unpublished), Harran University, Institute of Science, Şanlıurfa.
- Küçük E, 2019. Determination of phenological and pomological characteristics of Ferragnes and Ferraduel almond cultivars grown at different altitudes in Malatya conditions. MSc Thesis, Malatya Turgut Özal University, Department of Horticulture, Malatya.
- Parlakçı H, 2008. Determination of Some Pomological and Chemical Characteristics and Nutrient Content of Various Foreign-Origin Almond Cultivars. MSc Thesis, Harran University, Institute of Science, Department of Horticulture, Şanlıurfa.
- Şimşek M, 1996. A Study on the Improvement of Almonds (*Amygdalus communis* L.) in the Central District and Villages of Kahramanmaraş through Selection. MSc Thesis, Kahramanmaraş Sütçü İmam University, Institute of Science, Kahramanmaraş.
- Şimşek M, Yıldırım H, 2010. A Study on the Selection of Naturally Growing Almond Types in Dicle District. *Selçuk Journal of Agriculture and Food Sciences* 24(4): 9-15.
- Yıldırım AN, 2007. Selection of Almonds (*P. amygdalus* L.) in the Isparta Region. PhD Thesis, Adnan Menderes University, Institute of Science, Department of Horticulture, Aydın.
- Yıldız E, Perdahcı ÇE, 2019. Adaptation of Some Almond Cultivars in Ecological Conditions of Uşak. *Erciyes Journal of Agriculture and Animal Sciences* 2(1): 11-19.