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***Research Article***
*(Araştırma Makalesi)*

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**Anahtar sözcükler:** Melezleme, yeni çeşit, sofralık zeytin, Gemlik, Memecik, toplam fenol

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# Determination of table olive characteristics of new olive varieties obtained by crossbreeding of Gemlik and Memecik variety*

## Gemlik ve Memecik melezlemesi ile elde edilen yeni zeytin çeşitlerinin sofralık özelliklerinin belirlenmesi

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## ABSTRACT

**Objective:** The objective of this study was to investigate the physical and chemical characteristics of 10 hybrid type table olives obtained as a result of a national level hybridization program in the Olive Research Institute.

**Material and Methods:** The samples selected from Memecik x Gemlik and Gemlik x Memecik combinations, which came to the pre-elimination stage in the project, were evaluated in terms of table olives characteristics. These products were obtained in four olive seasons. Olives were subjected to some physical and chemical tests and analyzes. The main olive processing techniques (green split olive, natural turning black olives and Spanish style green olives) were applied to test the suitability of the cultivar candidates to processing techniques.

**Results:** The olive variety candidates, GM 41, GM 39, MG 11 and MG 5 attracted more attention than the main varieties of the cross breeding project, “Memecik” and “Gemlik”, in terms of some table olive characteristics like high flesh/pit ratio and the number of olive fruits per kilogram. Especially, The variety, GM 41 was found to be significantly important candidate for the natural black olive processing because of having high number of olives per kilogram.

**Conclusion:** As a result of this study, it was concluded thata the hybrid variety candidates, MG5 and MG13 were found to be promising in terms of table olive characteristics and registered as HAYAT and ARSEL, respectively.

## ÖZ

**Amaç:** Bu çalışma, Zeytincilik Araştırma Enstitüsünde yeni zeytin çeşitlerini elde etmek amacıyla 1990 yılında ulusal düzeyde gerçekleşen bir melezleme programı sonucunda elde edilen melez çeşit adaylarından öne çıkan 10 adayın sofralık özelliklerini tespit etmek amacıyla yapılmıştır.

**Materyal ve Yöntem:** Projede ön eleme aşamasına gelen Memecik x Gemlik ve Gemlik x Memecik kombinasyonlarından seçilen bireyler, sofralık zeytin özellikleri açısından değerlendirilmiştir. Dört zeytin sezonunda sezonunda ürün elde edilmiştir. Zeytinlerde bazı fiziksel ve kimyasal analizlere yapılmıştır. Çeşit adaylarının işleme tekniklerine uygunluğunu test etmek için ana işleme tekniklerinde (yeşil çizik zeytin, doğal yuvarlama siyah zeytin ve İspanyol tipi yeşil zeytin) uygulanmıştır.

**Araştırma Bulguları:** GM 41, GM 39, MG 11 ve MG 5 zeytin çeşidi adayları, "Memecik" ve "Gemlik" çeşitlerine göre yüksek et / çekirdek oranı ve kilogram başına zeytin sayısının yüksek olması ile sofralık zeytin özellikleri açısından dikkat çekmiştir.

Özellikle GM 41, doğal siyah zeytin üretiminde kilogram başına düşen zeytin sayısının yüksek olması nedeniyle çok önemli olacaktır.

**Sonuç:** Çalışma sonucunda MG5 ve MG11 melez çeşit adayları sırasıyla “HAYAT” ve “ARSEL” isimleri ile adlandırılarak tescil edilmiş ve zeytin sektörüne sunulmuştur.

## INTRODUCTION

Table olives are traditional fermented products of the Mediterranean countries, but nowadays table olive production and consumption have spreaded all over the world. Approximately 97% of world olive tree and olive production belongs to Mediterranean countries. The main olive producer countries are Spain, Italy, Greece, Türkiye, Tunisia, Portugal and Morocco (Anonymous, 2020).

The olive fruit is a drupe which has a bitter component (oleuropein). It has a lower sugar content (2.6-6%) as compared with other drupes (12% or more) and higher oil content (12-30%) depending on the harvest time and variety.

There are a large number of olive varieties (93) grown in Türkiye. Gemlik, one of the most common Turkish olive cultivar, accounts for the majority of olive production in the Marmara Region (Northwest of Türkiye), and suits best for processing natural black olives. This olive variety is private with its thin skin, small pit and high oil content (25-30%). Average size of the fruit of the Gemlik variety corresponds to 230-330 fruits per kg and its flesh/pit ratio is between 7/1 - 9/1.

Also, one of the other most common Turkish olive variety, Memecik, constitutes the major part of the olive production in the South Aegean Region. Memecik cultivar is suitable for Spanish style or ripe olive processing. Memecik variety, with an average size of 230-290 fruits/kg has high oil content (25-27%). The synonyms of Memecik olive cultivar are Taş arası, Aşıyeli, Tekir, Gülümbe. The origin of variety is Mugla province. It has an oval fruit structure and large fruit. Flesh / pit ratios vary between 6/1 and 8/1. It is most suitable for Spanish-style green and Californian-style black olive production methods for export.

Olive fruits should have some properties to be consumed as table olive. The size of the fruit is important for presentation and so for consumption. Olives weighting between 3 g and 5 g are considered medium sized, while those over 5 g are considered to be the large ones. Fruits that are more or less in spherical shape are usually best sold, and some elongated ones are also appreciated. The pit should easily separated from the flesh. Flesh/pit ratio should be at least 5/1. The skin of the fruit should be fine, additionally be elastic and resistant to blows and to the action of alkali and brine.

Table olives are one of the most popular fermented foods in Türkiye. This crossbreeding programme which focused specifically on table olives was initiated in 2011. The new table olive genotypes to be released should be adapted to modern growing systems, industrial processing methods (appropriated fruit pitting, ideal fermentation control and low environmental pollution) and should meet consumer demands (fruits with good size, proper shape, high flesh/pit ratio, good texture and colour, and ease in releasing the pit) (Garrido et al., 1997; Lavee, 2008; Rallo et al., 2011).

Türkiye is a country that has 93 registered olive varieties. Making a standard production with using appropriate processing techniques is possible with the use of raw materials with the above-mentioned criteria.

A crossbreeding program at the national level was initiated in 1990 in Olive Research Institute to obtain new varieties that could meet the standard raw material requirements. In the framework of the crossbreeding program, 10 hybrid individuals with superior characteristics in terms of agronomic and technological characteristics were selected by pre-selection.

In this study, the physical and chemical properties of 10 hybrid types, which had the potential for registration according to agronomic characteristics were determined. Gemlik and Memecik olive cultivars were used to compare hybrid characteristics.

## MATERIAL and METHODS

Gemlik and Memecik cultivar olives were used to compare hybrid characteristics. In this study, 10 olive genotypes were evaluated and these are tabulated in Table 1. They obtained from the crosses of Memecik and Gemlik (Turkish cultivars). These trees were planted in 1,5m x 3m distance in olive genotype observation orchard at Kemalpaşa of Olive Research Institute in İzmir- Türkiye. These genotypes were chosen on the basis of having high productivity, large size, high flesh/pit ratio, resistance to diseases and low alternate bearing.

**Table 1.** Olive genotypes and their parents

***Çizelge 1.*** *Melez çeşit adayları ve ebeveynleri*

| | Genotypes | | | | |
|---|---|---|---|---|---|
| **Memecik & Gemlik** | MG5 | MG11 | MG13 | MG22 | MG23 |
| **Gemlik & Memecik** | GM9 | GM19 | GM32 | GM39 | GM41 |

Olives were harvested at the maturity index 1-2 for Spanish style green olives and split green olives, and 5.3 for traditional Turkish style turning black olives suitable for the processing method.

### Table olive processing methods

### Natural green split olive

Olives were harvested in the period of green-yellow and sized. Then they were washed and taken into the polyester tanks after they were split. They were stored in brine that consist of 2% NaCl and 0.2% citric acid during 6 weeks and the brine was changed once per week. After bitter taste was removed, olives were stored in brine consisting of 8% NaCl and 1% citric acid.

### Spanish style green olive

After harvesting in the period of green-yellow and sizing, olives were treated with 1.8 g/100 mL NaOH solution until the alkalinesolution reached 2/3 of the flesh. Then the fruits were washed with tap water for 24 h, brined in 8 g/100 mL NaCl solution, and left to spontaneous fermentation. The acidity level of the olives was balanced at 0.3% by addition of lactic acid. The acidity level of the olives was 0.9-1.2% at the end of the fermentation (Garrido et al., 1997)

### Traditional Turkish-style natural turning black olive

Olives were harvested (5.3 MI) and washed. The olives were transferred into the plastic vessels. 6% salt was added on the olives. The covers of the vessels were tightly closed. The olives were kept in their own water until the end of fermentation. Olive vessels were turned every two days to provide fermentation (Irmak et al., 2017).

### Physical analysis

Number of olives per kilogram and flesh to pit ratio were determined according to official method TS 774 (2003). Fruit weight was calculated by weighing 100 olive fruits. Flesh to pit ratio was calculated by using the ratio of flesh and pit weight of 100 olive fruits. The fruit firmness values were measured with the Mititoyo hardness device (ABD) as milinewton (mN).

### Chemical analysis

pH and acidity analyzes in the fruit were carried out according to TS774 (Anonymous, 2003).

**Reducing sugar analysis**

Olive paste in the amount of 5 g was mixed with 5 ml potassium ferrocyanide (15%) and 5 ml zinc sulfate (30%). This mixture was diluted with 100 ml distilled water and left for a night. Then, it was filtered through filter paper (40 µm pore diameter). A diluted sample of 25 ml and 25 ml of Luff's solution (preparation was described below) was put in the flask and 10 ml of KI (1N) and 25 ml of sulfuric acid (25%) were added. After adding 1 ml starch (1%), the sample was titrated with sodium thiosulphate (0.1 N) (Uylaşer ve Başoğlu, 2000).

To prepare the Luff's solution, the following 3 solutions were prepared separately.

1) 50 g of citric acid was dissolved in 50 ml distilled water.
2) 143.7 g of anhydrous sodium carbonate $Na_2CO_3$ (sodium carbonate) was dissolved in 350 ml of pure water.
3) 25 g of $CuSO_4$ (copper sulfate) is dissolved in 100 ml of water. Then the first and second solutions were mixed carefully. Finally, the third one was added to this mixture and completed to 1 L with distilled water. After a day, the solution was filtered through filter paper.

**Total phenolic content**

Total phenolic content (TPC) were determined colorimetrically using Folin-Ciocalteu reagents according to the method of Catalano et al. (1999) using caffeic acid as standard, with slight modifications. The olive pulp (1g) was mixed with 5 ml of methanol:water 80:20 (v/v). The mixture was centrifugated at 4000 g for 10 min and the methanol phase was decanted and filtered. methanol:water 80:20 (v/v) mixture in the amount of 5 ml was added to the residue and centrifugated at 4000 g for 10 min again. The methanol phase was added over the first solution. The combined filtrate was completed to 10 ml. This filtrate was kept in the dark at ambient conditions. Then 0.1 ml from this filtrate was taken to a 50 ml volumetric flask, 5 ml distilled water, 0.5 ml Folin-Ciocalteau reagent and 1 ml sodium carbonate solution (35%) were added and was completed to 50 ml with distilled water. It was allowed to wait for 120 min in the dark at room temperature. Absorbance was measured at 725 nm using a visible spectrophotometer (Shimadzu 2450). The concentrations were expressed as g of caffeic acid and as g of CAE per 100 g of fresh weight (fw) (Kiai and Hafidi, 2014).

**Sensory analysis**

Hybrid variety candidates were analyzed in terms of color, texture, easy separation of flesh from the pit and total eating quality for the sensory evaluation of table olive characteristics. A 5 point scale was used in the evaluation. The rating was such that 1 indicated the lowest while 5 was rated the highest. Sensory evaluations were carried out by 8 trained panelists on table olives.

## RESULTS and DISCUSSION

One of the most important parameters determining the commercial value of olives in the table olive sector is the number of olives per kilogram, also called calibers. Olives with a low number of olives per kilogram (large olive fruits) are more attractive to consumers. Hence, table olive sector generally prefers medium and large caliber olives. The number of olives per kilogram of candidates is given in (Table 2).

All candidates, except GM19, had larger fruit than their parents. GM32 was found to be the largest olive fruits in the group of Gemlik x Memecik. The others following this were GM41, GM39, GM9 and GM19, respectively.

In the Memecik x Gemlik group olives, the MG22 and MG5 hybrid variety candidates were determined to be larger than both their parents and the other candidates. MG11, MG13 and MG4 followed them.

**Table 2.** The number of olives per kilogram values of new genotype olives and their parents (Number of fruit/Kg)

***Çizelge 2.*** *Melez çeşit adayları ve ebeveynlerinin kilogramdaki tane sayıları (Tane/Kg)*

| **Hybrids** | **1.Year** | **2.Year** | **3.Year** | **Hybrids** | **1.Year** | **2.Year** | **3.Year** |
|---|---|---|---|---|---|---|---|
| GM 9 Y | 180 | 220 | 180 | MG 4 Y | 260 | 260 | 260 |
| GM 9 P | ND | 220 | 180 | MG 4 P | ND | 260 | 260 |
| GM 9 S | ND | 210 | ND | MG 5 Y | 170 | 210 | 180 |
| GM 19 Y | 300 | 200 | 240 | MG 5 P | ND | 210 | ND |
| GM 19 P | 300 | 200 | 240 | MG 11 Y | ND | 220 | 210 |
| GM 32 Y | ND | 160 | 190 | MG 11 P | ND | 220 | 210 |
| GM 32 P | ND | 160 | 190 | MG 11 S | 220 | 220 | 210 |
| GM 32 S | 190 | 150 | ND | MG 13 Y | 240 | 250 | 250 |
| GM 39 Y | 200 | 220 | 200 | MG 13 P | ND | 250 | 250 |
| GM 39 P | ND | 220 | ND | MG 13 S | 240 | 250 | 250 |
| GM 39 S | 200 | 210 | 200 | MG 22 Y | 170 | 220 | 170 |
| GM 41 Y | 180 | 180 | 180 | MG 22 P | 170 | 220 | 170 |
| GM 41 P | 180 | 180 | 180 | MG 22 S | 170 | 220 | 170 |
| GM 41 S | 170 | 180 | 170 | | | | |
| **Parents** | | | | **Parents** | | | |
| Memecik Y | 260 | 260 | 260 | Gemlik Y | 290 | 320 | 280 |
| Memecik P | 260 | 260 | 260 | Gemlik P | 290 | 320 | 280 |
| Memecik S | 260 | 260 | 260 | Gemlik S | 290 | 320 | 280 |

PS: Y-Green, P-Turning colour, S-Black, ND: Not detected

In other studies; Aktan and Kalkan (1999), Şahin et al. (2002), Tuna (2006), Seyran (2009) and Kumral et al. (2009) determined the number of olive per kilogram for Gemlik variety as 286, 257, 265, 298 and 280-320, respectively. When compared to these previous studies, it was seen that the candidates of the hybrid varieties had larger fruits than Gemlik variety.

Flesh / pit ratio

One of the most important criteria that determines the quality characteristics of table olives is flesh /pit ratio. Olives with high flesh/pit ratio are more attractive to consumers. The data for the flesh/pit ratio determined in the first, second and third years for the raw olive samples of the study are presented in Table 3.

It was determined that the flesh/pit ratio of the olives belonging to the hybrid variety candidates varied between 4.86 and 6.86 in Gemlik x Memecik hybrids and 3.98 and 7.29 in Memecik x Gemlik hybrids. The highest flesh/pit ratio of raw olives were found in Gemlik x Memecik hybrid variety candidates. It was found to be 6.9 in GM32. The highest flesh/pit ratio of Memecik x Gemlik variety candidates was determined in MG4 to be 7.29. The lowest values were found in GM19 (Gemlik x Memecik hybrid variety candidate) and MG13 (Memecik x Gemlik variety candidate) to be 4.86 and 3.98, respectively.

Gemlik x Memecik hybrid variety candidates GM32, GM39 and GM41 have the highest flesh/pit ratio while Memecik x Gemlik hybrid variety candidates MG4, MG5 and MG22 are prominent candidates.

The flesh/pit ratio defines the edible ratio of the olive fruit, which is expected to be greater than 5 (Balatsouras, 1995). In table olive varieties, a high flesh-to-pit ratio is a desirable feature (Caballero and Eguren, 1986).

GM32 was identified as a hybrid candidate with the highest flesh rate (6.86 / 1). GM39 and GM 41 followed it. In MG group, MG4 was identified as a hybrid candidate with the highest flesh rate (7.29 / 1). MG5 showed high flesh/pit ratio for 3 years. The flesh/pit ratio of other MG group variety candidates were

lower than that of the parents. In previous studies, it was stated that different flesh/pit ratios could be observed at different harvesting times and as the harvesting time progresses, flesh/pit ratio increases (Kutlu ve Şen, 2011). Dolgun et al. (2010) reported that the flesh/pit ratio for Memecik olive fruits was 4.38. The flesh/pit ratio of all the hybrid variety candidates were found higher than the other studies.

**Table 3.** Flesh / pit ratio values of new genotype olives and their parents

***Çizelge 3.*** *Melez çeşit adayları ve ebeveynlerinin et/çekirdek oranları*

| **Hybrids** | **1.Year** | **2.Year** | **3.Year** | **Hybrids** | **1.Year** | **2.Year** | **3.Year** |
|---|---|---|---|---|---|---|---|
| GM 9 Y | 5.85 | 5.91 | 5.89 | MG 4 Y | 7.29 | 7.29 | 7.12 |
| GM 9 P | ND | 5.91 | 5.89 | MG 4 P | ND | 7.29 | 7.12 |
| GM 9 S | ND | 5.98 | ND | MG 5 Y | 6.27 | 6.32 | 6.34 |
| GM 19 Y | 4.86 | 5.26 | 5.28 | MG 5 P | ND | 6.32 | ND |
| GM 19 P | 5.18 | 5.26 | 5.37 | MG 11 Y | ND | 5.89 | 5.88 |
| GM 32 Y | ND | 6.83 | 6.86 | MG 11 P | ND | 5.89 | 5.92 |
| GM 32 P | ND | 6.83 | 6.86 | MG 11 S | 5.85 | 5.89 | 5.98 |
| GM 32 S | 6.86 | 6.9 | ND | MG 13 Y | 3.98 | 4.14 | 4.36 |
| GM 39 Y | 6.43 | 6.42 | 6.43 | MG 13 P | ND | 4.15 | 4.36 |
| GM 39 P | ND | 6.42 | ND | MG 13 S | 3.98 | 4.19 | 4.45 |
| GM 39 S | 6.51 | 6.51 | 6.51 | MG 22 Y | 7.07 | 6.16 | 6.07 |
| GM 41 Y | 6.12 | 6.08 | 6.12 | MG 22 P | 7.13 | 6.19 | 6.07 |
| GM 41 P | 6.3 | 6.08 | 6.14 | MG 22 S | 7.19 | 6.29 | 6.14 |
| GM 41 S | 6.38 | 6.19 | 6.32 | | | | |
| **Parents** | | | | **Parents** | | | |
| Memecik Y | 6.02 | 5.99 | 6.11 | Gemlik Y | 6.18 | 6.32 | 6.23 |
| Memecik P | 6.08 | 5.99 | 6.11 | Gemlik P | 6.18 | 6.32 | 6.23 |
| Memecik S | 6.14 | 5.99 | 6.24 | Gemlik S | 6.25 | 6.32 | 6.31 |

PS: Y-Green, P-Turning colour, S-Black, ND: Not detected

### Physical and chemical characteristics of table olive candidates

### Fruit firmness value (mN)

One of the most important criteria that determine the quality characteristics of table olives is the value of the fruit firmness. It is important that the texture of the tissue should be strong and durable because it protects the structure against the applied processing methods. The data on the fruit firmness values determined in the first, second and third years for the raw olive samples are presented in Table 4 thru6.

It was determined that the fruit firmness values of the olives belonging to the hybrid candidates were varied between 15.5 and 30.75 mN in Gemlik x Memecik hybrids and between 15.12 and 45.27 mN in Memecik x Gemlik hybrids. The fruit firmness values of the raw olives were determined in GM 39 green olives and in MG4 as 30.75 and 45.27 mN, respectively. The lowest values were found in GM32 black olives and MG13 black olives as 15.5 and 15.12 mN, respectively. GM32, GM39 and GM41 had the highest fruit firmness values while MG4, MG5 and MG22 were outstanding candidates. In general, an increase in maturity index results in a decrease in fruit firmness. Another factor that affects fruit firmness is the processing. As seen from Table 4 thru 6, the hardness of the fruit decreases with processing.

In order to determine the table olive characteristics of hybrid candidates, they were evaluated according to the the results of processing techniques applied in our country; such as split (Table 4), Spanish style (Table 5) and turning black olives (Table 6).

**Table 4.** Fruit firmness values of new genotype olives and their parents processed as split olive (mN)

***Çizelge 4.*** *Melez çeşit adayları ve ebeveynlere ait çizme zeytinlerin sertlik değerleri (mN)*

| | Raw | Processed | | |
|---|---|---|---|---|
| **Hybrids** | | **1.Year** | **2.Year** | **3.Year** |
| GM 9 Y | 27.51 | 17.07 | 19.78 | 20.07 |
| GM 19 Y | 28.85 | 17.03 | 18.66 | 20.28 |
| GM 19 P | 25.71 | 16.22 | 18.36 | 19.14 |
| GM 39 Y | 29.78 | 17.64 | 19.44 | 20.75 |
| GM 41 Y | 23.32 | 18.25 | 18.19 | 19.55 |
| GM 41 P | 21.58 | 17.56 | 17.23 | 18.34 |
| MG 4 Y | 44.95 | 24.22 | 26.86 | 25.82 |
| MG 5 Y | 36.17 | 26.63 | 24.54 | 24.22 |
| MG 11 Y | 27.35 | 21.83 | 21.67 | 20.12 |
| MG13 Y | 25.52 | 21.06 | 22.33 | 18.49 |
| MG 22 Y | 37.47 | 18.54 | 21.14 | 20.73 |
| MG 22 P | 28.11 | 17.73 | 19.05 | ND |
| **Parents** | | | | |
| Gemlik Y | 25.64 | 17.25 | 20.12 | 20.5 |
| Memecik Y | 30.18 | 25.92 | 25.61 | 23.28 |

PS: Y-Green, P-Turning colour, S-Black, ND: Not detected

**Table 5.** Fruit firmness values of new genotype olives and their parents processed according to the Spanish style (mN)

***Çizelge 5.*** *Melez çeşit adayları ve ebeveynlere ait İspanyol tipi işlenmiş zeytinlerin sertlik değerleri (mN)*

| | Raw | Processed | | |
|---|---|---|---|---|
| **Hybrids** | | **1.Year** | **2.Year** | **3.Year** |
| GM 9 Y | 27.51 | 19.2 | 20.65 | 17.52 |
| GM 19 Y | 28.88 | 19.35 | 19.23 | 18.39 |
| GM 39 Y | 29.91 | 18.71 | 22.34 | 16.15 |
| GM 41 Y | 23.32 | 18.18 | 18.87 | 17.55 |
| MG 4 Y | 44.49 | 25.92 | 26.17 | 23.1 |
| MG 5 Y | 33.97 | 26.42 | 26.94 | 24.17 |
| MG11 Y | 27.35 | 24.12 | 21.34 | 19.23 |
| MG 13 Y | 25.52 | 24.52 | 20.49 | 17.48 |
| MG 22 Y | 37.47 | 24.64 | 20.52 | 18.85 |
| **Parents** | | | | |
| Gemlik Y | 25.64 | 17.19 | 20.27 | 18.37 |
| Memecik Y | 30.18 | 28.92 | 24.61 | 21.83 |

PS: Y-Green, P-Turning colour, S-Black, ND: Not detected

**Table 6.** Fruit firmness analyses of new genotype olives and their parents processed as turning black olive (mN)

***Çizelge 6.*** *Melez çeşit adayları ve ebeveynlere ait yuvarlama zeytinlere ait sertlik değerleri (mN)*

| | Raw | Processed | | |
|---|---|---|---|---|
| **Hybrids** | | **1.Year** | **2.Year** | **3.Year** |
| GM 32 S | 17.12 | 13.52 | 14.11 | ND |
| GM 39 S | 20.15 | 13.64 | 16.55 | 13.97 |
| GM 41 S | 19.95 | 15.25 | 15.71 | 14.45 |
| MG 11 S | 18.83 | 13.18 | 16.48 | 13.58 |
| MG 13 S | 16.44 | 15.14 | 15.81 | 13.14 |
| MG 22 S | 17.28 | 13.41 | 15.62 | 13.25 |
| **Parent** | | | | |
| Gemlik S | 16.47 | 14.23 | 15.65 | 13.24 |

PS: Y-Green, P-Turning colour, S-Black, ND: Not detected

Fruit hardness is an important organoleptic characteristic for table olives (IOC, 2014). In fact, a nonappropriate fruit texture can be one of the main reasons for rejection by the consumer. In addition, a lack of fruit hardness may cause high economic losses to the processing industry because of difficulties in fruit pitting and stuffing after lactic fermentation (Fernandez et al., 1997). Among the green olives, especially the MG group olives came forward in terms of fruit firmness. The measurements made indicated that the texture of the raw olive was firm at the green stage however it weakened with maturation. It was seen that the harvesting time should be different according to each processing method.

Lopez et al. (2009) reported that almost all olive varieties contain calcium (362-731 mg/kg) and this leads to the tissue firmness. Also, the salt used during fermentation improves the rigidity of olives (Alvarez et al., 2014).

However, according to the characteristics of the varieties, the decrease in firmness were found to be differantiated. Fruit firmness seems to be an important parameter affecting the shelf-life during storage or sale. The least decrease in firmeness was observed in GM41 (green and pink split olives). In the MG group, even though there were more stringent cross-hybrid candidates, the fruit firmness values decreased more. However, all of the variety candidates in the MG group had higher values than the GM group in terms of fruit firmness.

When the Spanish type olives were examined in terms of fruit firmness, it was determined that the MG group hybrid variety candidates had higher values than GM group candidates.

As for turning black olive processing method, the hybrid candidates had lower fruit firmness values than the green and pink olives when examined in terms of fruit firmness. However, the decrease in fruit firmness was less as compared to green olives.

Sanchez-Gomez et al. (2013) reported a loss in firmness between 35% and 52% during storage period. The losses that occur as a result of the processing methods in the hybrid variety candidates were seen to be compatible with this work.

**Reducing sugar**

Sugars in olive fruits are important because they are the raw material for fermentation during processing. The changes in these compounds affect greatly the processing of olives because their preservation is highly dependent on a strong lactic acid fermentation (Fernandez et al., 1997).

Reducing sugar values of hybrid raw olives are tabulated in Table 7 thru 9. The reducing sugar content of the hybrid varieties were changed between 1.68% and 1.95% in Gemlik x Memecik hybrids and between 1.64% and 2.29% in Memecik x Gemlik hybrids. Reducing sugar values of raw olives were highest in GM41 green olives from Gemlik x Memecik hybrid varieties and 1.95% in green olives and 2.29% in MG13 green olives of Memecik x Gemlik variety candidates. The lowest values were found in Gemlik x Memecik hybrid variety candidates as 1.19% in GM19 pink olives and as 1.64% in MG11 black olives for Memecik x Gemlik variety candidates.

It has been reported that the content of sugar decreased during the ripening stage of olives and the sugar content of processed olives changed according to the type of olive and applied processing method (Kailis and Harris, 2007).

Reducing sugar content in the raw fruit of the Gemlik variety was determined by Ünal and Nergiz (2003), Tuna (2006) and Özdemir (2011) as 1.41% - 1.90%, 2.72% and 2.49% on average, respectively. For Memecik variety, Ünal and Nergiz (2003) found the amount of reducing sugar in raw olive as 1.41% and Kaya et al. (2017) found between 2.20% and 2.75%. The results obtained from the candidates of hybrid varieties were consistent with the previous studies. The reducing sugar content of the hybrid variety candidates appeared to be sufficient to provide fermentation. During the processing of table olives, a drastic decrease was observed in the amount of reducing sugar content and this was consistent with the literature.

**Table 7.** Reducing sugar contents of new genotype olives and their parents processed as split olive (%)
***Çizelge 7.*** *Melez çeşit adayları ve ebeveynlere ait yeşil çizme zeytinlerin indirgen şeker içerikleri (%)*

| | Raw | Processed | | |
|---|---|---|---|---|
| **Hybrids** | | **1.Year** | **2.Year** | **3.Year** |
| GM 9 Y | 1.83 | 0.39 | 0.35 | 0.36 |
| GM 19 Y | 1.77 | 0.35 | 0.33 | 0.34 |
| GM 19 P | 1.71 | 0.41 | 0.35 | 0.39 |
| GM 39 Y | 1.92 | 0.32 | 0.36 | 0.34 |
| GM 41 Y | 1.91 | 0.31 | 0.32 | 0.32 |
| GM 41 P | 1.85 | 0.34 | 0.32 | 0.33 |
| MG 4 Y | 1.78 | 0.38 | 0.29 | 0.36 |
| MG 5 Y | 1.76 | 0.35 | 0.31 | 0.35 |
| MG11 Y | 1.92 | 0.33 | 0.32 | 0.33 |
| MG 13 Y | 2.18 | 0.32 | 0.27 | 0.34 |
| MG 22 Y | 1.88 | 0.34 | 0.28 | 0.32 |
| MG 22 P | 1.84 | 0.35 | 0.25 | ND |
| **Parents** | | | | |
| Gemlik Y | 1.82 | 0.36 | 0.32 | 0.34 |
| Memecik Y | 1.9 | 0.41 | 0.33 | 0.32 |

PS: Y-Green, P-Turning colour, S-Black, ND: Not detected

**Table 8.** Reducing sugar contents of new genotype olives and their parents processed according to Spanish style green olive (%)
***Çizelge 8.*** *Melez çeşit adayları ve ebeveynlere ait İspanyol tipi yeşil zeytinlerin indirgen şeker içerikleri (%)*

| | Raw | Processed | | |
|---|---|---|---|---|
| **Hybrids** | | **1.Year** | **2.Year** | **3.Year** |
| GM 9 Y | 1.83 | 0.27 | 0.31 | 0.35 |
| GM 19 Y | 1.78 | 0.24 | 0.3 | 0.33 |
| GM 39 Y | 1.92 | 0.29 | 0.35 | 0.32 |
| GM 41 Y | 1.91 | 0.32 | 0.37 | 0.33 |
| MG 4 Y | 1.77 | 0.33 | 0.32 | 0.32 |
| MG 5 Y | 1.76 | 0.38 | 0.3 | 0.34 |
| MG11 | 1.92 | 0.35 | 0.32 | 0.35 |
| MG 13 Y | 2.17 | 0.29 | 0.28 | 0.32 |
| MG 22 Y | 1.89 | 0.25 | 0.26 | 0.34 |
| **Parents** | | | | |
| Gemlik Y | 1.82 | 0.27 | 0.32 | 0.35 |
| Memecik Y | 1.9 | 0.32 | 0.3 | 0.32 |

PS: Y-Green, P-Turning colour, S-Black, ND: Not detected

**Table 9.** Reducing sugar contentsof new genotype olives and their parents processed as turning black olive (%)
***Çizelge 9.*** *Melez çeşit adayları ve ebeveynlere ait yuvarlama zeytinlerin indirgen şeker içerikleri (%)*

| | Raw | Processed | | |
|---|---|---|---|---|
| **Hybrids** | | **1.Year** | **2.Year** | **3.Year** |
| GM 32 S | 1.56 | 0.31 | 0.28 | T.E. |
| GM 39 S | 1.83 | 0.22 | 0.31 | 0.32 |
| GM 41 S | 1.81 | 0.21 | 0.29 | 0.32 |
| MG 11 S | 1.65 | 0.25 | 0.38 | 0.35 |
| MG 13 S | 2.07 | 0.22 | 0.36 | 0.34 |
| MG 22 S | 1.77 | 0.24 | 0.33 | 0.31 |
| **Parent** | | | | |
| Gemlik S | 1.72 | 0.35 | 0.38 | 0.34 |

PS: Y-Green, P-Turning colour, S-Black, ND: Not detected

### Total phenolic content

Total phenol content values showed variation among the genotypes as shown in Table 10, 11, 12.

It was determined that the total phenolic compound values of the olives belonging to the hybrid variety candidates were varied between 319 and 678 CAE mg / 100g in Gemlik x Memecik hybrids and between 411 and 603 CAE mg / 100g in Memecik x Gemlik hybrids. These variations in the total phenolic contents in raw olives could be due to variety or to their degree of maturation.

**Table 10.** Total phenolic compound content of new genotype olives and parents processed as green split olives (mgCAE/100g)

***Çizelge 10.*** *Melez çeşit adayları ve ebeveynlere ait yeşil çizme zeytinlerin toplam fenolik madde miktarları (mgCAE/100g)*

| | **Raw** | **Processed** | | |
|---|---|---|---|---|
| **Hybrids** | | **1.Year** | **2.Year** | **3.Year** |
| GM 9 Y | 640 | 395 | 405 | 343 |
| GM 19 Y | 484 | 286 | 291 | 282 |
| GM 19 P | 446 | 268 | 284 | 257 |
| GM 39 Y | 427 | 288 | 301 | 224 |
| GM 41 Y | 448 | 287 | 312 | 221 |
| GM 41 P | 428 | 275 | 307 | 245 |
| MG 4 Y | 592 | 376 | 355 | 321 |
| MG 5 Y | 553 | 342 | 348 | 294 |
| MG11 Y | 445 | 305 | 296 | 284 |
| MG 13 Y | 434 | 266 | 261 | 228 |
| MG 22 Y | 453 | 271 | 283 | 252 |
| MG 22 P | 437 | 263 | 272 | ND |
| **Parents** | | | | |
| Gemlik Y | 370 | 189 | 226 | 239 |
| Memecik Y | 387 | 196 | 245 | 277 |

PS: Y-Green, P-Turning colour, S-Black, ND: Not detected.

**Table 11.** Total phenolic compound content of new genotype olives and parents after processed according to Spanish style green olive (mgCAE/100g)

***Çizelge 11.*** *Melez çeşit adayları ve ebeveynlere ait İspanyol tipi yeşil zeytinlerin toplam fenolik madde miktarları (mgCAE/100g)*

| | **Raw** | **Processed** | | |
|---|---|---|---|---|
| **Hybrids** | | **1.Year** | **2.Year** | **3.Year** |
| GM 9 Y | 640 | 402 | 387 | 317 |
| GM 19 Y | 484 | 397 | 293 | 286 |
| GM 39 Y | 427 | 303 | 294 | 264 |
| GM 41 Y | 448 | 317 | 303 | 251 |
| MG 4 Y | 592 | 369 | 351 | 322 |
| MG 5 Y | 553 | 376 | 346 | 287 |
| MG11 Y | 445 | 293 | 301 | 289 |
| MG 13 Y | 434 | 291 | 279 | 277 |
| MG 22 Y | 453 | 296 | 285 | 238 |
| **Parents** | | | | |
| Gemlik Y | 370 | 175 | 277 | 254 |
| Memecik Y | 387 | 194 | 295 | 285 |

PS: Y-Green, P-Turning colour, S-Black, ND: Not detected

**Table 12.** Total phenolic compound content of new genotype olives and parents processed as turning black olive (mgCAE/100g)
***Çizelge 12.*** *Melez çeşit adayları ve ebeveynlere ait zeytinlerin toplam fenolik madde miktarları (mgCAE/100g)*

| | **Raw** | **Processed** | | |
|---|---|---|---|---|
| **Hybrids** | | **1.Year** | **2.Year** | **3.Year** |
| GM 32 S | 358 | 341 | 281 | ND |
| GM 39 S | 407 | 376 | 361 | 354 |
| GM 41 S | 417 | 385 | 376 | 362 |
| MG 11 S | 446 | 417 | 345 | 385 |
| MG 13 S | 409 | 382 | 339 | 374 |
| MG 22 S | 413 | 412 | 335 | 391 |
| **Parent** | | | | |
| Gemlik S | 344 | 338 | 340 | 308 |

PS: Y-Green, P-Turning colour, S-Black, ND: Not detected

Visioli and Galli (1995) found that the phenolic content of olive was 50-800 mg / kg. Piga et al. (2005) showed that the total phenolic content of the olive varieties of Semidana and Kalamata were between 306 and 550 mg / kg. Aktaş (2013) determined the total amount of phenolic compond as 103.2-452.4 mg GAE / 100 g in Gemlik cv. Lanza et al. (2013) found that the total amount of phenolic compound in olives of Itrana ranged from 110-239mg CAE/100 g.

The total amount of phenolic compound in all GM and MG group olives from hybrid variety candidates was found to be higher than their parents (Table 10, 11, 12). This indicates that the hybrid variety candidates are rich in phenolic compounds.

Irmak (2010) found that the total amount of phenolic compound in Gemlik, Ayvalık, Memecik and Domat olives were 274.9, 250.8, 208.2 and 189.8 mg CAE / 100g, respectively.

According to the Irmak's study (2010) it was seen that regarding the total phenolic compound, there were more losses in lye-treated olives. The use of alkaline in Spanish-type process is also consistent with the findings in the literature that lye accelerates the loss of phenolic compound.

It was also stated that the fermentation process influences the change of the concentration of phenol in olives. As shown in the results, total phenols varied between the de-bittering methods of fermentation. The compounds which are formed as a result of hydrolysis of oleuropein are considered as a factor which act in decreasing the total amount of phenolic compound (Brenes et al., 1995).

**Sensory evaluation**

Hybrid variety candidates were analyzed in terms of color, texture structure, easy separation of flesh from the stone and total eating quality for the sensory evaluation of table olive characteristics. A 5 point scale was used in the evaluation. The rating was such that 1 indicated the lowest while 5 was rated the highest (ilk sayfalarda yazıldığı şekilde yazalım (Table13, 14). Some hybrid variety candidates softened. For some hybrid variety candidates, separating flesh from the stone were found to be difficult and they received low scores. GM41, GM 39, MG5 and MG13 scored high in terms of overall eating quality. When evaluated with their other characteristics, these were decided to be variety candidates. At the end of the 12-months storage, the candidates were ranked according to their sensory scores and evaluated together with the other characteristics of the prominent candidates and it was decided to register these olive variety candidates to be presented to the table olive sector.

**Table 13.** Sensory analysis values of MG hybride candidates

***Çizelge 13.*** *MG melez adaylara ait duyusal analiz değerleri*

| Hybrids | Color | Texture | Flesh pit seperation | Total eating quality |
|---|---|---|---|---|
| MG 4 S | 4 | 3 | 2 | softened |
| MG 4 Sp | 4 | 3 | 2 | 4 |
| MG 5 S | 4 | 3 | 3 | 4 |
| MG 5 Sp | 4 | 3 | 3 | 4 |
| MG 11 S | 4 | 4 | 3 | 4 |
| MG 11 Sp | 4 | 4 | 4 | 4 |
| MG 11 T | 4 | 4 | 4 | 4 |
| MG 13 S | 4 | 4 | 2 | 4 |
| MG 13 Sp | 4 | softened | 3 | softened |
| MG 13 T | 4 | 4 | 3 | 4 |
| MG 22 S | 4 | 4 | 4 | 4 |
| MG 22 Sp | 4 | softened | 4 | softened |
| MG 22 T | 4 | 4 | 4 | softened |

S; Black olive Sp; Split olive T; Turning black olive.

**Table 14.** Sensory analysis values of GM hybride candidates

***Çizelge 14.*** *GM melez adaylara ait duyusal analiz değerleri*

| Hybrids | Color | Texture | Flesh pit seperation | Total eating quality |
|---|---|---|---|---|
| GM 9 S | 4 | 3 | 2 | 4 |
| GM 9 Sp | 4 | Softened | 2 | Softened |
| GM 19 S | 4 | 4 | 4 | 4 |
| GM 19 Sp | 4 | Softened | 4 | Softened |
| GM 19 T | 4 | 4 | 4 | Softened |
| GM 32 S | 4 | 4 | 4 | 4 |
| GM 32 Sp | 4 | 4 | 3 | 4 |
| GM 32 T | 4 | 4 | 3 | Softened |
| GM 39 S. | 4 | 4 | 4 | 5 |
| GM 39 Sp | 5 | 5 | 3 | 5 |
| GM 39 T | 4 | 4 | 3 | 3 |
| GM 41 S | 4 | 4 | 4 | 5 |
| GM 41 Sp | 4 | 4 | 3 | 4 |
| GM 41 T | 5 | 5 | 4 | 5 |

S; Black olive Sp; Split olive T; Turning black olive.

## CONCLUSION

In this study, raw and processed olives of 10 table olive variety candidates obtained from a cross-breeding programme in Olive Research Institute evaluated for their suitability as table olive cultivar. Suitable genotypes were selected according to the physical, chemical and sensory properties of olives and their suitability for different processing methods. Fruit size and flesh/pit ratio, resistance to softening and shelf-life were identified to be deterministic characteristics for the commercial value of table olives.

The overall evaulation of findings as a result of 4 year study, it was concluded that MG 5, MG 11, GM 39 and GM 41 hybrids had more suitable characteristics as table olive varieties. GM 41, GM 39, MG 11 and MG 5 olive variety candidates attracted more attention than “Memecik” and “Gemlik”, which are

main varieties of cross breeding project, in terms of table olive characteristics like high flesh/pit ratio and number of olives per kilogram.

According to research findings, especially GM 41 stands out with its high flesh/pit ratio and caliber. For this reason, this variety can be considered as an alternative for the table olive sector and can be used especially in the production of black table olives.

The hybrid variety candidates MG5 and MG13 were found promising in terms of table olive characteristics and registered as HAYAT and ARSEL, respectively.

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## REFERENCES

Aktan, N. & H. Kalkan, 1999. Sofralık Zeytin Teknolojisi. Ege Üniversitesi Basımevi, İzmir, 122pp.

Aktaş, A.B., 2013. Chemical Characterization of 'Hurma' Olive Grown in Karaburun Peninsula. Izmir Institute of Technology, (Unpublished) Master of Science Thesis, İzmir, 95 pp.

Alvarez, D.M.E., A. López & A.L. Lamarque, 2014. Industrıal improvement for naturally black olives productıon of Manzanılla and Arauco cultivars. Journal of Food Processing and Preservation, 38: 106. DOI.org/10.1111/j.1745-4549.2012.00751.x.

Anonymous, 2003. TS/774 Sofralık Zeytin Standardı. Türk Standartları Enstitüsü, Ankara, 10s.

Anonymous, 2020. International Olive Council.(Web page: www.internationaloliveoil.org) (Date accessed: February, 2021).

Balatsouras, G.D., 1995. Table Olives: Cultivars, Chemical Composition, Commercial Preparations, Quality Standarts, Packing, Marketing. Agricultural University of Athens, Athens, Greece.

Brenes, M., L. Rejano, P. Garcia, A.H. Sanchez & A. Garrido, 1995. Biochemical changes in phenolic compounds during Spanish-style green olive processing. Jounal of Agricultural and Food Chemistry, 43: 2702-2706.

Caballero, J.M. & J. Eguren, 1986. Agronomic Characteristics of a World Collection of Olive Cultivars. Olea, No: 17, 83 pp.

Catalano, L., I. Franco, De Nobili M., & L. Leita, 1999. Polyphenols in olive oil mill waste waters and their depuration plant effluents: A comparison of the folin-ciocalteau and HPLC methods. Agrochimica, Vol XL111, N. 5-6.

Dolgun, O., G. Ozkan & B. Erbay, 2010. Comparison of olive oils derived from certified organic and conventional agricultural methods. Asian Journal of Chemistry, 22 (3): 2339-2348.

Erol, A., 1979. Muhtelif Olgunluk Dönemlerinde Oksidasyonlu (Ripe Olive) Zeytin Yapımı. Bornova Zeytincilik Arştırma Enstitüsü, Yayın No: S-9, 133 pp.

Garrido, A.F., M.J.F. Diez & M.R. Adams, 1997. Table Olives: Production and Processing. Chapman&Hall, London, 481pp.

Irmak, Ş., 2010. Bazı Sofralık Zeytin Çesitlerinin Polifenol İçeriklerinin Belirlenmesi ve İşleme Tekniklerinin Polifenollere Olan Etkisi Üzerine Bir Arastırma, Sonuç Raporu, TAGEM, Zeytincilik Araştırma Enstitüsü, İzmir, 43 pp.

Irmak, Ş., P. Kadiroglu & S. Ötles, 2017. Evaluation of olive preservation methods on bioactive constituents and antioxidant properties of olive oils, Journal of American Oil Chemistry Society, 94(4): 595-609. DOI. 10.1007/s117460172971-5

Kailis, S.G. & D. Harris, 2007. "Table Olives, 321-330". In: The New Crop Industries Handbook (Eds. S. Salvin, M. Bourke & T. Byrne) RIRDC Publication No. 04/125, Rural Industries Research and Development Corporation, Canberra, Australia, 328 pp.

Kaya, Ü., F. Öztürk Güngör, G. Çamoğlu, E. Akkuzu, Ş. Aşık & O. Köseoğlu, 2017. Effect of defiiit irrigation regimes on yield and fruit quality of olive trees (cv. Memecik) on the Aegean coast of Türkiye. Irrigation and Drainage, 66: 820-827. DOI.org/10.1002/ird.2156

Kiai, H. & A. Hafidi, 2014. Chemical composition changes in four green olive cultivars during spontaneous fermentation. LWT - Food Science and Technology, 57: 663-670. DOI.10.1016/j.lwt.2014.02.011

Kumral, A., F. Başoğlu & İ. Şahin, 2009. Effect of the use of different lactic starters on the mıcrobiologıcal and physicochemical characteristics of naturally black table olives of Gemlik cultivar. Journal of Food Processing and Preservation, 33: 651-664. DOI.org/10.1111/j.1745-4549.2008.00303.x

Kutlu, E. & F. Şen, 2011. Farklı hasat zamanlarının Gemlik zeytin (Olea europea L.) çeşidinde meyve ve zeytinyağı kalitesine etkileri. Ege Üniversitesi Ziraat Fakültesi Dergisi, 48 (2): 85-93.

Lanza, B., M.G. Di Serio & E. Iannucci, 2013. Effects of maturation and processing technologies on nutritional and sensory qualities of Itrana table olives. Grasas Y Aceites, 64 (3): 272-284. DOI.org/10.3989/gya.132112

Lavee, S., 2008. New table olive varieties intended for harvest facilitation. II International Conference on Table Olives. Seville, Spain: Dos Hermanas, 20 pp.

Lopez-Lopez, A., F. Rodriguez-Gomez, A. Cortes-Delgado, A. Montano & A. Garrido-Fernandez, 2009. Influence of ripe olive processing on oil characteristics and composition as determined by chemometrics. Journal of Agricultural and Food Chemistry, 57:5973-8981. DOI: 10.1021/jf901488h.

Özdemir, Y., 2011. Bazı Melez Zeytinlerin Fizikokimyasal Özelliklerinin ve Starter Kültür (*Lactobacillus plantarum*) İlaveli Sofralık Zeytin Fermentasyonuna Uygunluklarının Belirlenmesi. Namık Kemal Üniversitesi, (Basılmamış) Doktora Tezi, Tekirdağ, 134 s.

Piga, A., A. Del Caro, I. Pinna & M. Agabbio, 2005. Anthocyanin and colour evolution in naturally blacktable olives during anaerobic processing. LWT, 38:425-429. DOI.org/10.1016/j.lwt.2004.06.011.

Rallo, L., M. El Riachy & P. Rallo, 2011. "The Time and Place for Fruit Quality in Olive Breeding, 323-348". In: Breeding for Fruit Quality (Eds. M.A. Jenks & J.P. Bebeli). John Wiley & Sons, Inc. Iowa (USA) 400 pp.

Sanchez-Gomez, A.H., P. Garcia-Garcia & A.G. Fernandez, 2013. Spanish-style green table olive shelf-life. International Journal of Food Science and Technology, 48: 1559-1568. DOI.org/10.1111/ijfs.12124.

Seyran, Ö., 2009. Silifke Yaglık, Sarı Ulak ve Gemlik Zeytin Çesitlerinin Meyve Gelisim Sürecinde Gösterdikleri Bazı Fizyolojik, Morfolojik ve Biyokimyasal Degisimler. Mustafa Kemal Üniversitesi, Fen Bilimleri Enstitüsü (Basılmamış) Yüksek Lisans Tezi, Hatay, 129 s.

Şahin, İ., M. Korukluoğlu & O. Gürbüz, 2002. Salamura Siyah Zeytin İslemede Çesit, Maya ve Laktik Starter Kullanımı ve Bazı Katkıların Fermentasyon Süresi ve Ürün Kalitesine Etkilerinin Arastırılması. TÜBİTAK -Türkiye Tarımsal Araştırma Projesi, Bursa, 23 s.

Tuna, S., 2006. Siyah Sofralık Zeytin Fermentasyonunda Alkali ve Enzimatik Yöntemlerin Fiziko-Kimyasal Özellikler Üzerine Etkisi. Uludağ Üniversitesi, Fen Bilimleri Enstitüsü (Basılmamış) Doktora Tezi, Bursa, 86 s.

Uylaşer, V. & F. Başoğlu, 2000. Gıda Analizleri I-II Uygulama Kılavuzu, Uludağ Üniversitesi Ziraat Fakültesi Uygulama Kılavuzu No:9, Bursa, 119s.

Ünal, K. & C. Nergiz, 2003. The effect of table olive preparing methods and storage on the composition and nutritive value of olives. Grasas y Aceites, Vol. 54:71-76. DOI.org/10.3989/gya.2003.v54.i1.280.

Visioli, F. & C. Galli, 1995. Natural antioxidants and prevention of coronary heart disease: the potential role of olive oil and its minör constituents. Nutrition Metabolic Cardiovascular Disease, 5: 306-314.