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# Variation of Fruit Characteristics of *Pistacia spp.* Pollinated by Different Hybridization Pistachio Types in Manisa-Yunt Mountain Area in Turkey

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## Özet

### Manisa-Yunt Dağı Bölgesinde Farklı *Pistacia* Türleri ile Tozlanan Bazı Antepfıstığı Tiplerinin Meyve Özelliklerinin Değişimi

Bu çalışmada, 1999 ve 2001 yılları arasında Ege Bölgesinin Manisa-Yunt Dağı yöresinde farklı *Pistacia* türleri (*P. vera*, *P. atlantica* ve *P. terebinthus*) ile kontrollü tozlanan ve serbest tozlanan bazı Beyaz (Topan ve Söbü) ve Kırmızı (Çatlayan Kırmızı ve Alyanak) antepfıstığı tiplerinin kabuklu meyve ve iç özellikleri (uzunluk, genişlik, kalınlık, ağırlık, çıtlama ve boş meyve oranı vb.) saptanmıştır. Genellikle Beyaz tiplerin Kırmızı tiplerden daha büyük irilikte ve ağırlıkta olduğu görülmüştür. Bununla beraber, çıtlama oranı Kırmızı tiplerde diğerlerinden daha yüksek olmuştur. Ayrıca, genellikle *P. vera* ile yapılan tozlamalar sonucu elde edilen meyveler, diğer tozlamalar ve serbest tozlamadan elde edilenlerden daha üstün özelliklere sahip olmuştur.

**Anahtar Sözcükler:** Antepfıstığı, *Pistacia* türleri, tanımlama, kabuklu meyve ve iç özellikleri.

## Introduction

Turkey is one of the worldwide major pistachio producer countries. Pistachio production and export have increased considerably in the last 20 years (Emeksiz and Şengül, 2001). Although pistachio production is concentrated mainly in the Southeastern Anatolia, different *Pistacia spp.* are spread in other regions. Aegean Region where wild naturally distributed, is one of the important *Pistacia spp*.

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genetic resources of Turkey. The majority of *Pistacia* trees (especially *P. atlantica* and *P. terebinthus*) and their natural hybrids are present in the Yunt Mountain area in Manisa province of Aegean Region. There is a rather large population top-worked on wild rootstocks. According to the statistical data taken from State Instıtute of Statistics (SİS), there are 949.125 pistachio trees, 548.000 of which are bearing and 401.125 are non-bearing. Pistachio production is reported as 485 tons in the Yunt Mountain (Anonymous, 2001). The climate of this area is not quite suitable for pistachio growing as opposed to South East Anatolia. Since sum of the summer temperatures is usually insufficient for completion of kernel development and shell splitting of *Pistacia* fruits, nut yield is usually low in this area. However, pistachio nuts obtained from the top-worked trees in the Yunt Mountain are being used for fresh nut consumption and the confectionery industry. Turkey exports a certain amount of pistachios as green kernels. Green kernels due to high chlorophyll content, is an important visual quality characteristic for the pistachio processing industry. The pistachio nuts of trees grown on high land produce greener kernels than those of low land trees (Kaşka, 1995). The Yunt Mountain area is located at an altitude of approximately 800 meters above sea level. As a result of this situation, the kernels are green.

The pistachio production of the Aegean Region has long been suffering from insufficient pollination due to inadequate number of male trees in the orchards. The orchards in the Yunt Mountain area are established with naturally grown *P. atlantica* and *P. terebinthus* rootstocks and are not in proper design orchards. These orchards are pollinated by male *P. atlantica* and *P. terebinthus* trees scattered in neighbouring fields. Therefore, pollination varies by year and orchard and the production of blank nuts is high.

There is confusion and lack of information about cultivars in this area. Characterization is important to obtain true information on existing germplasm and to standardize the production. Although Turkey has rich pistachio populations, too many pomological studies related to desirable nut and kernel characteristics have not been conducted (Balta, 2002). Ak (1992) has reported the effects of artificial pollination with different *Pistacia spp*. pollen on nut and kernel quality characteristics of Kırmızı, Siirt, Bilgen, Ohadi and Vahidi pistachio varieties grown in Ceylanpınar State Farm in the Southeastern region. No investigation has been made on fruit characteristics of pistachio cultivars and types grown in the Yunt Mountain area. The objective of

this study was to characterize Topan, Söbü, Çatlayan Kırmızı and Alyanak pistachio types, pollinated naturally or artificially with *P. vera*, *P. atlantica*, *P. terebinthus,* in the Yunt Mountain area of Turkey.

**Material and Method**

This investigation was carried out in the villages of Küçük Belen and Akçaköy of the Yunt Mountain of Manisa province in Turkey. Plant material consisted of *P. atlantica*, *P. terebinthus*, male and female trees of *P. vera* in this study. Female pistachio types were identified by the local name. In the first year (1999), Topan, Söbü, Çatlayan Kırmızı and Alyanak types and in the second year (2000), Beyaz, Alyanak and Çatlayan Kırmızı were used due to biennial production. Also Topan and Söbü were only used in the third year of this study (2001). These pistachio types were pollinated artificially with male *P. vera*, *P. atlantica* and *P. terebinthus*. Average 100 fruit samples at harvesting time (first week of september) were collected from each pollination combination. Pomological evaluation was done according to the pistachio descriptors of International Plant Genetic Resources Instıtute (IPGR) (Anonymous, 1997). Observed characteristics are as follows:

**(i) Nut**: length (mm), width (mm), thickness (mm), split nuts (%), blank production (%), 100 nut weight (g), number of nuts in 100 g **(ii) Kernel**: length (mm), width (mm), thickness (mm), 100 kernel weight (g), kernel dry weight/nut dry weight x 100 (kernel percentages).

All the data obtained from this study were analysed statistically by using SPSS statistical programme.

**Results and Discussion**

In 1999, 2000 and 2001, nut and kernel characteristics of Topan, Söbü, Çatlayan Kırmızı and Alyanak pistachio types pollinated with different *Pistacia spp.* and open pollination in the Yunt Mountain area are shown in Table 1, 2, 3, 4, 5 and 6, respectively. In the evaluation of data on nut and kernel length, it was seen that Topan and Söbü had generally higher values than Alyanak and Çatlayan Kırmızı. The effects of different pollinizers on nut length were not significant. However, the highest nut length (21.23 mm) was obtained in open pollination in 1999 (Table 1) and pollination with *P. atlantica* (19.36 mm) in 2000 (Table 3) and pollination with *P. terebinthus* (18.96 mm) in 2001 years (Table 5). Besides, similar results were also obtained in kernel length (Table 2, 4 and 6).

Table 1. Nut characteristics of pistachio types pollinated with different *Pistacia spp*. or open pollinated in Yunt Mountain area in 1999.

| Pollinizer Type | P. vera | P. atlantica | P. terebinthus | O. pollination | Mean |
|---|---|---|---|---|---|
| | | | **Length (mm)** | | |
| Topan | 21.39 | 21.15 | 21.14 | 21.57 | 21.31 a* |
| Söbü | 21.63 | 21.33 | 21.23 | 21.80 | 21.49 a |
| Alyanak | 20.14 | 19.88 | 19.45 | 19.97 | 19.85 b |
| Ç. Kırmızı | 21.13 | 20.89 | 21.55 | 21.61 | 21.29 b |
| Mean | 21.07 n.s | 20.81 | 20.84 | 21.23 | |
| | | | **Width (mm)** | | |
| Topan | 12.66 | 12.82 | 12.56 | 12.65 | 12.67 a** |
| Söbü | 12.53 | 12.61 | 12.63 | 12.59 | 12.58 a |
| Alyanak | 10.92 | 10.98 | 10.63 | 11.06 | 10.89 c |
| Ç. Kırmızı | 11.59 | 11.58 | 11.08 | 11.67 | 11.47 b |
| Mean | 11.92 n.s | 11.99 | 11.72 | 11.99 | |
| | | | **Thickness (mm)** | | |
| Topan | 10.88 | 11.03 | 10.86 | 10.86 | 10.91 n.s |
| Söbü | 10.87 | 10.90 | 10.59 | 10.63 | 10.75 |
| Alyanak | 10.55 | 10.75 | 10.19 | 11.09 | 10.64 |
| Ç. Kırmızı | 10.63 | 10.40 | 9.80 | 10.79 | 10.40 |
| Mean | 10.73 n.s | 10.77 | 10.36 | 10.84 | |
| | | | **100 nut weight (g)** | | |
| Topan | 80.87 | 67.42 | 62.77 | 82.27 | 73.33 n.s |
| Söbü | 62.48 | 70.46 | 72.62 | 88.74 | 73.57 |
| Alyanak | 63.88 | 56.64 | 60.35 | 70.32 | 62.80 |
| Ç. Kırmızı | 80.72 | 61.60 | 66.49 | 76.35 | 71.29 |
| Mean | 71.98 ab* | 64.02 b | 65.56 b | 79.42 a | |
| | | | **Number of nuts in 100 g** | | |
| Topan | 105.00 | 112.13 | 143.00 | 126.67 | 121.69 b* |
| Söbü | 164.99 | 134.89 | 142.64 | 119.17 | 140.42 ab |
| Alyanak | 155.12 | 178.17 | 172.65 | 150.00 | 163.98 a |
| Ç. Kırmızı | 138.39 | 176.04 | 153.82 | 138.62 | 151.71 a |
| Mean | 140.87n.s | 150.31 | 153.03 | 133.61 | |
| | | | **Splitting percentage (%)** | | |
| Topan | 6.66 | 0.00 | 0.00 | 1.25 | 1.98 n.s |
| Söbü | 0.00 | 0.00 | 0.00 | 5.93 | 1.48 |
| Alyanak | 14.11 | 0.00 | 2.07 | 7.81 | 6.00 |
| Ç. Kırmızı | 5.50 | 0.28 | 3.74 | 0.83 | 2.59 |
| Mean | 6.57 n.s | 0.07 | 1.45 | 3.95 | |
| | | | **Blank nut percentage (%)** | | |
| Topan | 67.00 | 85.00 | 84.50 | 46.50 | 70.75 ab** |
| Söbü | 94.00 | 90.00 | 75.00 | 39.50 | 74.62 a |
| Alyanak | 72.00 | 82.00 | 75.00 | 65.00 | 73.50 a |
| Ç. Kırmızı | 70.00 | 61.00 | 57.00 | 64.00 | 63.00 b |
| Mean | 75.75 a** | 79.50 a | 72.87 a | 53.75 b | |

[a,b,c]: mean seperation, within columns, by Duncan's multiple range test. [*] significant 5 %, [**] significant 1 %, ns not significant.

Similarly, Crane and Iwakiri (1980) reported that the effects of pollen sources on nut and kernel length were not found significant in Kerman cultivar.

The largest nuts and kernels were obtained from white coloured types especially in Topan. The nut and kernel width values did not differ significantly according to the pollinizer: with *P. vera*, *P. atlantica*, *P. terebinthus* and open pollination. The same case was also put forward by Crane and Iwakiri (1980) and Ak (1992).

Table 2. Kernel characteristics of pistachio types pollinated with different *Pistacia spp*. or open pollinated in Yunt Mountain area in 1999.

| Pollinizer Type | P. vera | P. atlantica | P. terebinthus | O. pollination | Mean |
|---|---|---|---|---|---|
| | | | **Length (mm)** | | |
| Topan | 14.53 | 14.21 | 14.45 | 16.06 | 14.81 b** |
| Söbü | 17.23 | 17.75 | 16.03 | 16.93 | 16.98 a |
| Alyanak | 15.13 | 14.03 | 13.50 | 15.73 | 14.59 c |
| Ç. Kırmızı | 15.77 | 15.11 | 16.46 | 16.15 | 15.87 b |
| Mean | 15.67 n.s | 15.27 | 15.11 | 16.22 | |
| | | | **Width (mm)** | | |
| Topan | 7.59 | 7.28 | 6.92 | 7.91 | 7.42 b* |
| Söbü | 8.65 | 8.81 | 7.88 | 8.48 | 8.45 a |
| Alyanak | 8.08 | 8.78 | 7.22 | 7.98 | 8.01 ab |
| Ç. Kırmızı | 8.30 | 7.76 | 7.85 | 8.09 | 8.00ab |
| Mean | 8.16 n.s | 8.15 | 7.47 | 8.12 | |
| | | | **Thickness (mm)** | | |
| Topan | 7.24 | 6.92 | 5.80 | 6.67 | 6.65 b* |
| Söbü | 8.13 | 7.88 | 7.54 | 7.24 | 7.69 a |
| Alyanak | 8.00 | 8.73 | 7.01 | 8.59 | 8.08 a |
| Ç. Kırmızı | 8.57 | 8.17 | 6.76 | 8.25 | 7.93 a |
| Mean | 7.98 a* | 7.92 a | 6.77 b | 7.68 ab | |
| | | | **100 kernel weight (g)** | | |
| Topan | 38.10 | 26.53 | 27.50 | 37.86 | 32.49 c* |
| Söbü | 55.65 | 55.44 | 37.55 | 46.55 | 48.79 a |
| Alyanak | 38.64 | 32.75 | 30.98 | 46.65 | 37.25 bc |
| Ç. Kırmızı | 49.84 | 45.47 | 39.28 | 45.06 | 44.90 ab |
| Mean | 45.56 n.s | 40.04 | 33.83 | 44.03 | |
| | | | **Kernel percentage (%)** | | |
| Topan | 47.04 | 38.83 | 43.75 | 45.85 | 43.86 b* |
| Söbü | 89.31 | 78.87 | 51.66 | 52.82 | 68.16 a |
| Alyanak | 60.21 | 57.82 | 51.16 | 66.27 | 58.86 ab |
| Ç. Kırmızı | 64.71 | 78.28 | 60.34 | 61.05 | 66.09 a |
| Mean | 65.32 n.s | 63.45 | 51.73 | 56.50 | |

[a,b,c]: mean seperation, within columns, by Duncan's multiple range test. [*] significant 5 %, [**] significant 1 %, ns not significant.

The highest nut thickness was found in Alyanak among Red types and in Topan among White types. It was seen that the nuts of Red types were higher in thickness than others. In kernel thickness, similar results were also observed.

Table 3. Nut characteristics of pistachio types pollinated with different *Pistacia spp*. or open pollinated in Yunt Mountain area in 2000.

| Pollinizer Type | P. vera | P. atlantica | P. terebinthus | O. pollination | Mean |
|---|---|---|---|---|---|
| **Length (mm)** | | | | | |
| Beyaz | 20.13 | 19.98 | 19.86 | 19.85 | 19.95 a** |
| Alyanak | 18.78 | 18.98 | 18.97 | 18.60 | 18.83 b |
| Ç. Kırmızı | 18.93 | 19.13 | 18.81 | 18.58 | 18.86 b |
| Mean | 19.28 n.s | 19.36 | 19.21 | 19.01 | |
| **Width (mm)** | | | | | |
| Beyaz | 11.28 | 11.41 | 11.21 | 11.47 | 11.34 a** |
| Alyanak | 10.83 | 10.39 | 10.94 | 11.20 | 10.83 b |
| Ç. Kırmızı | 10.40 | 10.24 | 10.15 | 10.12 | 10.22 c |
| Mean | 10.84 n.s | 10.68 | 10.77 | 10.93 | |
| **Thickness (mm)** | | | | | |
| Beyaz | 10.07 | 10.07 | 10.07 | 10.00 | 10.05 b** |
| Alyanak | 10.63 | 10.80 | 10.85 | 10.81 | 10.77 a |
| Ç. Kırmızı | 9.73 | 9.93 | 9.59 | 9.31 | 9.64 b |
| Mean | 10.14 n.s | 10.27 | 10.17 | 10.04 | |
| **100 nut weight (g)** | | | | | |
| Beyaz | 100.01 | 100.22 | 95.74 | 102.65 | 99.65 a** |
| Alyanak | 90.56 | 89.13 | 91.83 | 86.71 | 89.55 b |
| Ç. Kırmızı | 86.14 | 84.88 | 80.48 | 76.58 | 82.01 c |
| Mean | 92.24 n.s | 91.41 | 89.35 | 88.65 | |
| **Number of nuts in 100 g** | | | | | |
| Beyaz | 103.75 | 101.67 | 106.66 | 99.58 | 102.91 c** |
| Alyanak | 114.58 | 116.51 | 112.50 | 121.57 | 116.28 b |
| Ç. Kırmızı | 120.00 | 122.50 | 129.17 | 134.17 | 126.45 a |
| Mean | 112.78 n.s | 113.56 | 116.11 | 118.44 | |
| **Splitting percentage (%)** | | | | | |
| Beyaz | 6.11 | 0.00 | 5.24 | 15.45 | 6.70 n.s |
| Alyanak | 2.25 | 0.54 | 0.92 | 0.00 | 0.93 |
| Ç. Kırmızı | 1.56 | 5.18 | 22.10 | 4.59 | 8.36 |
| Mean | 3.31 n.s | 1.91 | 9.42 | 6.68 | |
| **Blank nut percentage (%)** | | | | | |
| Beyaz | 38.05 | 49.80 | 42.07 | 40.16 | 42.51 b** |
| Alyanak | 53.05 | 78.86 | 71.01 | 76.87 | 69.94 a |
| Ç. Kırmızı | 69.33 | 56.13 | 52.47 | 51.97 | 57.47 a |
| Mean | 53.47 n.s | 61.59 | 55.18 | 56.33 | |

[a,b,c]: mean seperation, within columns, by Duncan's multiple range test. [*] significant 5 %, [**] significant 1 %, ns not significant.

The effect of pollinizers on kernel width was statistically significant in 1999 and 2000 years ($p<0.05$), and *P. vera* pollen resulted in higher kernel thickness in Red and White pistachio types (Table 2 and 4). These results were parallel to the findings of Crane and Iwakiri (1980) and Ak (1992).

Generally, pollination with *P. vera* increased nut and kernel length, width and thickness in Red and White pistachio types in this investigation. Ak (2001) stated that the weight and sizes of the nut and kernels were increased generally with *P. vera* pollen. Also, nut and kernel size varied according to cultivars by Vargas et al. (1995) and Akkök and Karaca (1995).

Table 4. Kernel characteristics of pistachio types pollinated with different *Pistacia spp*. or open pollinated in Yunt Mountain area in 2000.

| Pollinizer Type | P. vera | P. atlantica | P. terebinthus | O. pollination | Mean |
|---|---|---|---|---|---|
| **Length (mm)** | | | | | |
| Beyaz | 16.63 | 16.54 | 16.53 | 16.80 | 16.62 a** |
| Alyanak | 15.02 | 14.62 | 14.86 | 14.43 | 14.73 c |
| Ç. Kırmızı | 15.52 | 15.28 | 15.30 | 15.41 | 15.37 b |
| Mean | 15.72 n.s | 15.48 | 15.56 | 15.55 | |
| **Width (mm)** | | | | | |
| Beyaz | 7.86 | 8.14 | 7.97 | 8.47 | 8.11 a** |
| Alyanak | 7.73 | 7.51 | 7.36 | 7.07 | 7.41 b |
| Ç. Kırmızı | 7.47 | 7.27 | 7.29 | 7.38 | 7.34 b |
| Mean | 7.69 n.s | 7.64 | 7.54 | 7.64 | |
| **Thickness (mm)** | | | | | |
| Beyaz | 7.48 | 7.56 | 7.49 | 7.46 | 7.50 |
| Alyanak | 7.83 | 7.74 | 7.71 | 7.47 | 7.69 |
| Ç. Kırmızı | 7.65 | 7.62 | 7.45 | 7.32 | 7.51 |
| Mean | 7.65 n.s | 7.64 | 7.55 | 7.41 | |
| **100 kernel weight (g)** | | | | | |
| Beyaz | 43.06 | 44.34 | 41.51 | 46.10 | 43.75 a** |
| Alyanak | 36.55 | 35.71 | 34.62 | 32.31 | 34.79 b |
| Ç. Kırmızı | 38.91 | 36.73 | 35.18 | 35.39 | 36.55 b |
| Mean | 39.51 n.s | 38.93 | 37.10 | 37.93 | |
| **Kernel Percentage (%)** | | | | | |
| Beyaz | 43.04 | 44.25 | 43.36 | 44.93 | 43.89 a* |
| Alyanak | 40.31 | 39.85 | 37.53 | 37.30 | 38.74 b |
| Ç. Kırmızı | 45.25 | 43.44 | 44.21 | 46.35 | 44.78 a |
| Mean | 42.87 n.s | 42.48 | 41.70 | 42.86 | |

[a,b,c]: mean seperation, within columns, by Duncan's multiple range test. [*] significant 5 %, [**] significant 1 %, ns not significant.

Evaluation of splitting percentages for two years in 1999 and 2000, demonstrated that there were no significant differences among

types in respect to pollinizers (Table 1 and 3). Mostly, splitting percentage was low due to influence of water during kernel growth (Kaşka, 1990). In this area, pistachios are largely grown under non-irrigated conditions. Splitting percentages also varied according to the cultivars. Hence, Balta (2002) stated that the percentage of split nuts varied from 66 % to 93% in Siirt pistachio variety. The splitting percentage differed according to the pollinizers in the last year (2001) of this investigation ($p<0.05$) (Table 5). The highest and lowest values were obtained as 30.45 % by *P. vera* pollination and 22.10 % by *P. atlantica* pollination, respectively (Table 5). These findings agreed with those of Ak (1992). On the other hand, these values were rather low due to the differences between ecological conditions. In addition, Ak (1992) and Crane and Iwakiri (1980) reported that there was a positive correlation between kernel weight and splitting percentage. Confirming this, splitting percentages of this study were also low due to low kernel weight.

Percentage of blank nuts showed significant differences according to the pollinizers and types in 1999 ($p<0.01$) (Table 1). In 2000 and 2001, differences were significant statistically according to the types and pollinizers, respectively ($p<0.05$) (Table 3 and 5). In general, percentage of blank nuts were determined less in Çatlayan Kırmızı than in Alyanak. The percentages of blank nuts showed differences according to the years in White types. *P. vera* pollen resulted in lower percentages of blank nuts than other pollinizers in Topan, Söbü and Alyanak types. On the controversy, Çatlayan type gave the best result with *P. terebinthus* pollen. Confirming this, it was reported that the percentages of blank nuts were decreased when pollinated with *P. vera* (Ülkümen, 1945; Ak, 1992). Besides, Hadj-Hassan (1986) pointed out that these percentages changed between 5.6 % and 72.10 % according to the types. In this situation, selection of pollinizers is of great importance. High percentages of blank nut formation were affected by genetic structure, cultural applications and ecological conditions. According to Kaşka (1995), although blank nut formation was a varietical character, it was largely affected by climate, efficiency of pollination, fertilization, irrigation and rootstocks.

The effects of different types and pollinizers on 100 nut weight and number of nuts in 100 g differed according to the years (Table 1, 3 and 5). In pistachio types located in Yunt Mountain area, ıt was seen that White types (Topan and Söbü) produced heavier nuts than other

types.The highest and lowest number of nuts in 100 g were found in Red and White types (Topan), respectively.

Table 5. Nut characteristics of pistachio types pollinated with different *Pistacia spp*. or open pollinated in Yunt Mountain area in 2001.

| Pollinizer Type | P. vera | P. atlantica | P. terebinthus | O. pollination | Mean |
|---|---|---|---|---|---|
| | | | **Length (mm)** | | |
| Topan | 18.31 | 19.19 | 19.25 | 19.21 | 18.99 n.s |
| Söbü | 19.16 | 18.09 | 18.67 | 18.62 | 18.63 |
| Mean | 18.71 n.s | 18.64 | 18.96 | 18.91 | |
| | | | **Width (mm)** | | |
| Topan | 12.26 | 12.85 | 12.81 | 12.74 | 12.66 |
| Söbü | 12.42 | 12.22 | 12.57 | 12.54 | 12.43 |
| Mean | 12.34 n.s | 12.53 | 12.69 | 12.64 | |
| | | | **Thickness (mm)** | | |
| Topan | 10.31 | 10.05 | 10.38 | 10.41 | 10.29 |
| Söbü | 10.51 | 9.96 | 10.27 | 10.29 | 10.26 |
| Mean | 10.41 n.s | 10.00 | 10.33 | 10.35 | |
| | | | **100 nut weight (g)** | | |
| Topan | 83.13 | 80.55 | 88.22 | 87.79 | 84.92 |
| Söbü | 89.03 | 77.72 | 83.88 | 84.78 | 83.85 |
| Mean | 86.08 | 79.13 | 86.05 | 86.29 | |
| | | | **Number of nuts in 100 g** | | |
| Topan | 123.26 | 124.81 | 114.03 | 114.35 | 119.11 n.s |
| Söbü | 117.31 | 131.82 | 119.95 | 119.04 | 122.03 |
| Mean | 120.29 n.s | 128.32 | 116.99 | 116.70 | |
| | | | **Splitting percentage (%)** | | |
| Topan | 32.26 | 2.71 | 25.09 | 14.77 | 18.73 n.s |
| Söbü | 28.54 | 12.33 | 2.17 | 12.81 | 13.96 |
| Mean | 30.45 a* | 7.51 b | 13.62 | 13.78 ab | |
| | | | **Blank nut percentage (%)** | | |
| Topan | 56.85 | 91.06 | 74.72 | 68.85 | 72.87 n.s |
| Söbü | 39.34 | 74.44 | 94.99 | 64.59 | 68.34 |
| Mean | 48.09 b* | 82.74 a | 84.85 a | 66.71 ab | |

[a,b,c]: mean seperation, within columns, by Duncan's multiple range test.[*] significant 5 %, [**] significant 1 %, ns not significant.

Generally, no significant differences were found among pollinizers in terms of 100 nut weight and number of nuts in 100 g (Table 1, 3 and 5). Pollen obtained from different sources, may not have the same effect on nut characteristics (Crane and Iwakiri, 1980; Hadj-Hassan, 1986, Pontikis, 1989). In the trees pollinated with *P. vera,* 100 nut weights were generally higher than those pollinated with the other two species. According to Ak (2001*), P. vera* pollen produced the heaviest nuts when compared to the other pollen sources. Besides,

the highest and lowest number of nuts in 100 g were obtained in pollinated trees with *P.terebinthus* and *P. vera*, respectively.

Significant differences were found on the effects of pistachio types on 100 kernel weight in 1999 and 2000 (Table 2 and 4). Kernel weights were higher in White types than Red types. Alyanak had the lowest kernel weight in all years of this investigation. Although the effects of pollinizers on 100 kernel weight were not significant in three years, usage of *P. vera* pollen resulted with heavier kernels than the other two species or open pollination (Table 2, 4 and 6). Similarly, Riazi and Rahemi (1995) reported that greater kernel weight of Kalleh-ghuchi resulted from pollination with *P. vera*. Moreover, Ak (2001) obtained larger and heavier kernels by the pollination with *P. vera* pollen.

Table 6. Kernel characteristics of pistachio types pollinated with different *Pistacia spp*. or open pollinated natural pollination in Yunt Mountain area in 2001.

| **Pollinizer Type** | **P. vera** | **P. atlantica** | **P. terebinthus** | **O. pollination** | **Mean** |
|---|---|---|---|---|---|
| | | | **Length (mm)** | | |
| Topan | 15.30 | 14.77 | 16.05 | 16.19 | 15.58 n.s |
| Söbü | 15.92 | 14.52 | 15.61 | 15.71 | 15.44 |
| Mean | 15.61 a** | 14.64 b | 15.83 a | 15.94 a | |
| | | | **Width (mm)** | | |
| Topan | 9.63 | 9.18 | 9.69 | 9.31 | 9.45 |
| Söbü | 9.27 | 9.32 | 9.07 | 9.46 | 9.28 |
| Mean | 9.45 n.s | 9.25 | 9.38 | 9.39 | |
| | | | **Thickness (mm)** | | |
| Topan | 7.82 | 7.33 | 7.42 | 7.94 | 7.63 |
| Söbü | 7.86 | 7.14 | 7.14 | 7.67 | 7.45 |
| Mean | 7.84 a* | 7.23 b | 7.27 b | 7.80 a | |
| | | | **100 nut weight (g)** | | |
| Topan | 49.04 | 44.87 | 50.09 | 50.99 | 48.75 |
| Söbü | 50.16 | 44.56 | 44.57 | 47.43 | 46.68 |
| Mean | 49.60 | 44.72 | 47.33 | 49.21 | |
| **Number of nuts in 100 g** | | | | | |
| Topan | 59.25 | 55.70 | 57.01 | 58.09 | 57.51 n.s |
| Söbü | 57.87 | 58.19 | 53.88 | 56.07 | 56.50 |
| Mean | 58.56 n.s | 56.95 | 55.44 | 57.08 | |

[a,b,c]: mean seperation, within columns, by Duncan's multiple range test. [*] significant 5 %, [**] significant 1 %, ns not significant.

It was seen that nut and kernel weights were lower in Yunt Mountain area than in South-East part of Turkey. Similar differences were also determined in different areas of the same region. Confirming this, Ak (1992) stated that 100 nut weights were found as 102.10 g and

125.00 g in Ohadi cultivar in Ceylanpınar and Gaziantep, respectively. Besides, nut weight values were changed according to the years. 100 kernel weights in Ohadi x *P. vera* combination were determined as 63.00 g and 47.00 g in 1989 and 1990, respectively (Ak, 1992). Nut and kernel weights were changed according to place and year. It resulted due to the differences in ecological conditions. Additionaly, pistachio trees in the Yunt Mountain area are grown under non-irrigated conditions. Also, these characteristics may be influenced by differences in fruit set percentages.

Kernel percentages (kernel/nut x 100) showed significant differences according to pistachio types in 1999 and 2000 ($p<0.05$) (Table 2 and 4). It was seen that kernel percentages in Çatlayan Kırmızı type were higher than in Alyanak type. In White types, kernel percentages varied according to the years. Although the effects of pollinizers on kernel percentages were not found significant statistically in three years, kernel percentages were the highest and lowest in pollination with *P. vera* and *P. terebinthus*, respectively.

In this research work, considerable differences in nut and kernel characteristics of pistachio types grown in this area were determined. Thus, a better and true knowledge about the characters of these types were obtained. Generally, the pomological analysis of the nuts and kernels revealed that pollination of female flowers of Topan variety with *P. vera* pollen produced large and attractive fruits. Pistachios are grown with no irrigation, fertilization or pest control in this area. So, fruit characteristics of pistachios located in Yunt Mountain were lower than the other domestic or foreign pistachio varieties. The pistachio orchards are established with spontaneous rootstocks and pollinated by pollen from the male trees scattered in the neighbouring orchards. Thus, yield per tree varied between years and orchards in this area. Similar situation was observed in the Mediterranean region of Turkey. In order to get nut production, sufficient male trees coinciding with the flowering of female trees need to be planted. In addition to this, when open pollination is not sufficient, artificial pollination can be applied as a temporary solution in this area.

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## Summary

In this study, nut and kernel characteristics (length, width, thickness, weight, splitting, blank nut ratios etc.) of some White (Topan and Söbü) and Red

(Çatlayan Kırmızı and Alyanak) pistachio types pollinated artificially with different *Pistacia spp*. (*P. vera*, *P. atlantica* and *P. terebinthus*) and open pollination were determined in Manisa-Yunt Mountain area of Aegean Region in Turkey between 1999 and 2001. It was seen that nuts and kernels of White types were generally larger and heavier than Red types. However, splitting percentages were higher in Red types than the others. Besides, fruits obtained from *P. vera* pollination had superior characteristics than other combinations or open pollination in general.

**Key words:** Pistachio, *Pistacia spp*., description, nut and kernel characteristics.

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