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The Effects of Fruit Development and Physico-Chemical Changes on the Optimum Harvest Maturity in Some Astringent Persimmon Cultivars

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Abstract

In this study, physical and chemical changes during fruit development of pollination constant astringent 'Eylül' persimmon genotype and 'Hachiya' persimmon variety were examined and optimum harvest time was determined under Dörtyol-Hatay conditions that have a Mediterranean climate. Fruit samples were taken from persimmon trees from grafted onto *Diospyros lotus* rootstock. Fruit weight, width and length, flesh firmness, skin and flesh color, total soluble solids (TSS) and titratable acidity (TA) content, pH value and TSS/TA ratio were analyzed on samples from June to ripening. Fruit samples were picked up at fortnight interval in the time of fruit development. Fruit weight of 'Eylül' persimmon genotype and 'Hachiya' persimmon variety were reached 96.35 g and 259.84 g, respectively, on 215th day after full bloom (DAFB). Flesh firmness was reduced in the time of fruit growth and achieved to an acceptable limit, while h° values of fruit skin color was decreased in the time of the fruit growth period. Our data shown that fruit skin color especially hº value, fruit flesh firmness, TSS and TSS/TA ratio were significant criteria in determining harvest maturity. Optimal harvest maturity period lay between 155–170th DAFB for 'Eylül' persimmon genotype and between 170–185th DAFB for 'Hachiya' persimmon variety in Dörtyol-Hatay conditions. According to the obtained findings, it was determined that 'Eylül' persimmon genotype reach optimal maturity between the second or the third weeks of October and mid or end of October were the optimum harvest maturity time for 'Hachiya' persimmon variety in order to provide storage long time and transport fruit at optimum commercial maturity and quality.

Keywords: Persimmon, astringent, fruit growth, quality, harvest date.

Bazı Buruk Trabzon Hurması Çeşitlerinde Optimum Hasat Olgunluğuna Meyve Gelişiminin ve Fiziko-Kimyasal Değişimlerin Etkileri

Öz

Bu çalışmada, Akdeniz iklimine sahip Dörtyol-Hatay koşullarında yetiştirilen meyve et rengi kararlı ve buruk (PCA) 'Eylül' Trabzon hurması genotipi ve 'Hachiya' Trabzon hurması çeşidinin meyve gelişimi sırasındaki fiziksel ve kimyasal değişimleri incelenmiş ve optimum hasat zamanı belirlenmiştir. *Diospyros lotus* anacına aşılanan Trabzon hurması ağaçlarından meyve örnekleri alındı. Haziran ayından olgunlaşmaya kadar alınan meyve örneklerinde meyve ağırlığı, genişliği ve uzunluğu, et sertliği, kabuk ve et rengi, suda çözünebilir toplam kuru madde (TSS) ve titre edilebilir asit (TA) içeriği, pH değeri ve TSS/TA oranı analizleri yapılmıştır. Meyve örnekleri, meyve gelişimi sırasında iki haftada bir alınmıştır. Tam çiçeklenmeden sonraki (TÇS) 215. günde 'Eylül' Trabzon hurması genotipi ve 'Hachiya' Trabzon hurması çeşidinin meyve ağırlıkları sırasıyla 96.35 g ve 259.84 g'a ulaşmıştır. Meyve büyümesi döneminde meyve eti sertliği azalarak kabul edilebilir sınıra ulaşırken, meyve kabuk rengi h° değerleri azalmıştır. Verilerimiz, derim olumunu belirlemede meyve kabuk rengi özellikle h° değeri, meyve eti sertliği, TSS ve TSS/TA oranının önemli kriterler olduğunu göstermiştir. Optimal derim olum dönemi, Dörtyol-Hatay koşullarında yetiştirilen 'Eylül' Trabzon hurması genotipi için TÇS 155–170 günler ve 'Hachiya' Trabzon hurması çeşidi için TÇS 170–185 günler arasındadır. Elde edilen bulgulara göre, uzun süre depolamak ve meyveyi optimum ticari olgunluk ve kalitede taşımak için en uygun hasat olgunluk zamanı 'Eylül' Trabzon hurması genotipi için Ekim ayının ikinci ve üçüncü haftası ve 'Hachiya' Trabzon hurması çeşidi için Ekim ortası ve sonu arasında olduğu belirlenmiştir.

Anahtar Kelimeler: Trabzon hurması, buruk, meyve gelişimi, kalite, derim olum zamanı.

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Introduction

Persimmon fruits (*Diospyros kaki* L.) are either astringent or non-astringent during the maturity. In the world, the production of astringent persimmon cultivars is the more common than non-astringent varieties. Generally, the storage and shelf life of astringent persimmons are

shorter than non-astringent cultivars. Weight loss, losses of fruit flesh firmness and fungal disorders are postharvest quality losses that limit the market value and storage life of persimmons (Çandır et al., 2010). Astringent persimmon fruits very quickly softening and increase weight losses in the shelf life. Even in the branch of the tree is a quick softening. Harvested astringent persimmons do not consume immediately because of the very high tannin. Furthermore in astringent persimmons, the problems like short shelf life, short marketing period and various factors (changes in the skin and flesh of fruit, losses of fruit flesh firmness and weight loss etc.) decrease its marketing value. Moreover, there is still need of enough research to be done especially 'Eylül' persimmon genotype. Commercially persimmons storage is not in controlled atmosphere in Turkey. Storage is still in cold stores and common storages. In general, it is necessary to know the period of maximum fruit size and highest level of fruit quality. Knowing this will help to increase yield and quality. In addition, the harvest of the products in these periods will increase the income of the producers originating from the high yield and quality, will meet the demands of the domestic and foreign markets and enable people to consume quality products. However, these periods may vary depending on the variety, the cultural processes and the ecology of the region. For this reason, it is necessary to determine the most optimal harvest maturity periods for varieties in different ecologies. The wide variation during the harvest season is due to climatic and ecological differences between the growing regions in persimmon fruit growth, quality and maturity. It is very important to estimate the fruit size and to determine the times of the growth stages (Godoy et al. 2008) for yield management and fruit quality in the export and domestic market. Different quality characteristics of persimmon cultivars determining volatile compounds, chemical and physical composition and have been studied (Forbus et al., 1991; Senter et al., 1991; Taira, 1996; Ertürk et al., 2003; 2004; Çandır et al., 2008; 2009; 2010; Özdemir et al., 2014). The accuracy of maturity and the ability to measure are essential for consumer satisfaction and efficient marketing.

In order to determine the optimal harvest dates of a fruit, it is necessary to monitor fruit growth, changes in physical and chemical properties, and use various ripeness indices. In order to determine the most appropriate harvest dates of a fruit, it is necessary to analyse fruit growth and changes in physical and chemical properties (Çandır et al., 2009). However, there are limited studies on maturation stages of persimmon varieties grown in the Mediterranean Region of Turkey. Toplu et al. (2011) determined that physical and chemical changes during fruit development of non-astringent 'Fuyu', 'Jiro', 'O'Gosho' and 'Hana Fuyu' persimmons. According to the obtained findings, it was determined that non-astringent persimmons grown in east Mediterranean region reach optimal maturity on 185th date after full bloom (DAFB). Pollination variant non-astringent (PVNA) 'Vainiglia', 'Kaki Tipo', 'Harbiye' and 'Amankaki' persimmon cultivars were determined that physical and chemical changes during fruit development and optimum harvest maturity in Dörtyol-Hatay ecological conditions by Toplu et al. (2020). According to the obtained findings, in the Eastern Mediterranean Region, the optimum harvest time in PVNA group persimmon varieties, along with fruit flesh firmness, were reached the variety of acceptable skin color in the 'Amankaki' cultivar occurred after 155th DAFB and in other varieties after the 185th DAFB.

The aim of this study is to determine the effects of fruit development and physico-chemical changes in the quality parameters on the optimum harvest maturity of PCA 'Eylül' astringent persimmon genotype and PCA 'Hachiya' astringent persimmon variety grown in Dörtyol-Hatay conditions in the Mediterranean climate.

Materials and Methods

Fruit and Rootstock Material

This study was carried out in Dörtyol-Hatay conditions (36º 09' E, 36º 51' N, altitude 9 m) districts and 'Eylül' astringent persimmon genotype and 'Hachiya' astringent persimmon variety were obtained from 15 year–old trees grafted on *Diospyros lotus* rootstock and planted 5 m x 6 m *spacing under drip irrigation system with fertilizer regime* in orchard. Dörtyol-Hatay

province has a hot-dry summers and mild-rainy winters. The average temperature and precipitation for years have not been significantly different between years, but the average annual temperature is 19.1 °C and the annual rainfall is 950 mm, soils are generally sandy (sandy: 646 – 693, loamy: 245 – 270 and clay: 64 – 70 g kg^{-1}) and alkaline (pH 7.8) in the orchard of the research. Eylül' persimmon is a local and astringent with recipient colors genotype and 'Hachiya' astringent persimmon variety, which production has become widespread in east Mediterranean region of Turkey. In the persimmon production region where the experiment was conducted, farmers start the season with 'Eylül' astringent persimmon genotype followed by 'Hachiya' astringent persimmon variety.

Methods and Quality Analyses

Fruit samples for both varieties were taken after June drop. Then chemical and physical qualities were analyzed on fruit samples. Fruit length and width (mm) were measured total 150 fruit (labeled 10 fruits from 5 different branches from 3 different trees) using a digital caliper (Mitutoyo absolute digimatic caliper, Japan) on each time at approximately fortnight intervals, every tree have been accepted as a repetition and fruit length and width measurements were made at the same fruits from beginning to end of the sampling. Fruit weight (g) was measured with a laboratory balance (Ohaus Adventurer, ABD) with an accuracy of 0.01 g. Fruit flesh firmness was analyzed with an Effegi penetrometer (Model FT 327) in the force in kilograms according to Çandır et al. (2010) and the results were translated into Newton (N). Fruit skin and flesh color (L* and h°) was assessed using the CIELAB (L* a* b*) color space using a CR-300 Minolta Chroma Meter (Konica Minolta, Osaka, Japan). Total soluble solid (TSS) content was defined in the juice from 10 fruit per replicate with a digital refractometer (Atago Model ATC–1E, Tokyo, Japan) at 20 °C and results were explained as %. Titratable acidity (TA) content was determined (as malic acid equivalent) by potentiometric method. Juice pH value was analyzed by digital pH-meter (Hanna Instruments, HI 2211 pH/ORP meter, ABD). TSS/TA ratio was calculated on the samples.

Statistical Analysis

The study was performed over a two–year period. Data were represented as the mean of 2 experimental years. The data were analyzed using statistical software SAS 9.4 procedures (SAS Institute Inc., Cary, NC., USA) as a "Completely randomized block" design by ANOVA and the mean separation was carry out using Tukey's Multiple Range test at the $p < 0.05$ level and AS's Proc GLM procedure.

Results and Discussion

In 'Eylül' persimmon genotype and 'Hachiya' persimmon variety, flowering was finished between 30 April and 3 May in Dörtyol region during the 2 years of study. The period between the start and end of flowering had generally been 2 weeks. Growth conditions (climate and soil conditions and cultural practices) were similar throughout the two experimental years. There are no significant differences among years at $p<0.05$ level. The period from the days after full bloom to the harvest time, which varies depending on the variety and ecology, is between 120 and 190 days (Mowat and George 1996). Flowering time and flowering periods was similar to those of Antalya (Onur, 1995), which has a similar ecology and was earlier than that of Samsun (Akbulut et al., 2004) and Yalova (Tangu et al., 2004), which have a cooler ecology and a shorter flowering period.

Fruit Length, Width and Weight

Fruit length was 23.01 mm on the 35th DAFB for 'Eylül' persimmon genotype and rose to 49.89 mm on the 215th DAFB and was 31.26 mm on the 35th DAFB for 'Hachiya' persimmon variety and raised to 85.38 mm on the 215th DAFB in Dörtyol-Hatay conditions (Fig. 1 and 2). Fruit width was 25.54 mm on the 35th DAFB for 'Eylül' persimmon genotype and rose to 55.72 mm on the 215th DAFB and was 38.47 mm on the 35th DAFB for 'Hachiya' persimmon variety and increased to 80.92 mm on the 215th DAFB in Dörtyol conditions (Fig. 1 and 2). Fruit weight was 20.76 g on the 35th DAFB for 'Eylül' persimmon genotype and rose to 96.35 g on the 215th DAFB and was 36.12 g on the 35th DAFB for 'Hachiya' persimmon variety and increased to 259.84 g on the 215th DAFB in Dörtyol region (Fig. 1 and 2). Depending on fruit development, cultural practices such as

thinning, fertilizing, irrigation and climatic conditions affect fruit weights. Similar results were described by Toplu et al., (2020).

Fruit Flesh Firmness

Fruit flesh firmness (FFF) was analyzed from the 65th DAFB. FFF tented to decrease in 'Eylül' persimmon genotype and 'Hachiya' persimmon variety. FFF was 78.50 N on the 65th DAFB for 'Eylül' persimmon genotype and decreased to 7.35 N on 215th DAFB and was 83.37 N on 65th DAFB for 'Hachiya' persimmon variety and reduced to 21.83 N on 215th DAFB in Dörtyol-Hatay conditions (Fig. 1 and 2). The softening of the fruit flesh affects and limits the transportation, efficient marketing and storage life of persimmon fruit. FFF is a very important harvest maturity parameter. In persimmons, if FFF is 51-54 N, the period in which this value is obtained can be considered as the optimal harvest time (Harker and Forbes, 1997). In addition, if waiting for optimum maturity, the FFF of the harvest period should not be below at 17.8 N for marketable quality (Crisosto et al., 1995). 'Eylül' persimmon genotype fell below the marketability limit of 17.8 N on 215th DAFB, while 'Hachiya' persimmon variety remained above the marketability limit.

Total Soluble Solid (TSS) Content

Fruit juice was obtained on the 65th DAFB. Although increases and decreases occurred in TSS content of fruit juice, it was 13.87% on 65th DAFB for 'Eylül' persimmon genotype and increased to 23.40% on 215th DAFB and was 16.07% on 65th DAFB for 'Hachiya' persimmon variety and increased to 23.40% on 215th DAFB in Dörtyol conditions (Fig. 1 and 2). A range of minimum maturity of 13–25% for TSS content at harvest is mentioned Onur and Onur (1997), Akça et al. (1999) and Toplu et al. (2011; 2020). Soluble solids of 21–23% at harvest in 'Hachiya' are reported by Crisosto et al. (1995). TSS amount can vary importantly according the individual tree characteristics in the persimmon fruit orchard. Therefore, TSS should be evaluated together with other maturity parameters in determining fruit maturity. It has been reported that the amount of TSS in the fruit should reach 14%, which is the level required for export (George et al., 1994).

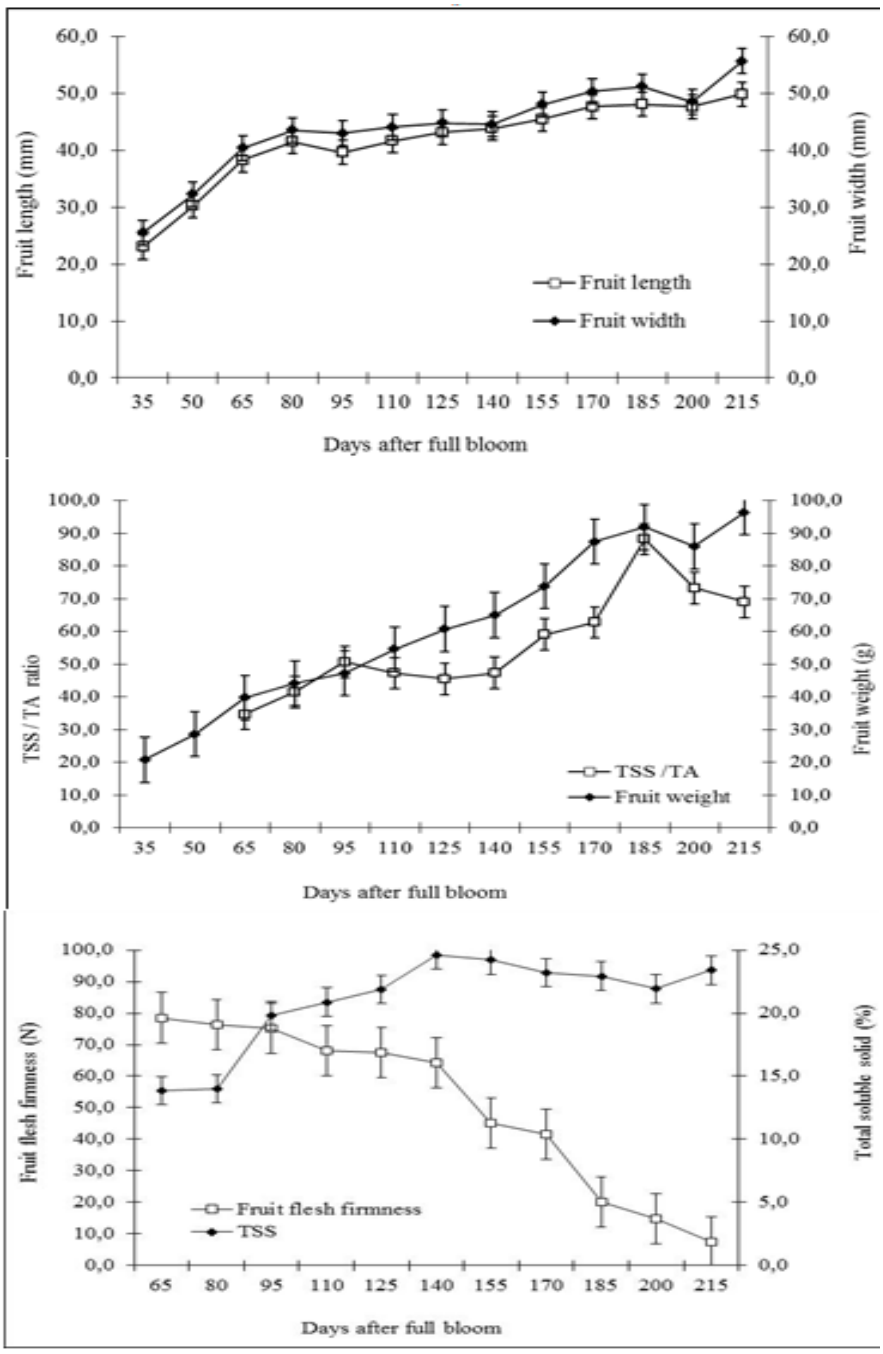

Figure 1. Variations determined in fruit length, width, weight and flesh firmness, TSS content and TSS/TA ratio during fruit development period for 'Eylül' persimmon genotype grown under Dörtyol region. Vertical error bars represent the standard deviation of the mean, and when absent fall within the area of the symbol. Means were obtained from pooling of two-year data with three replicates in each year

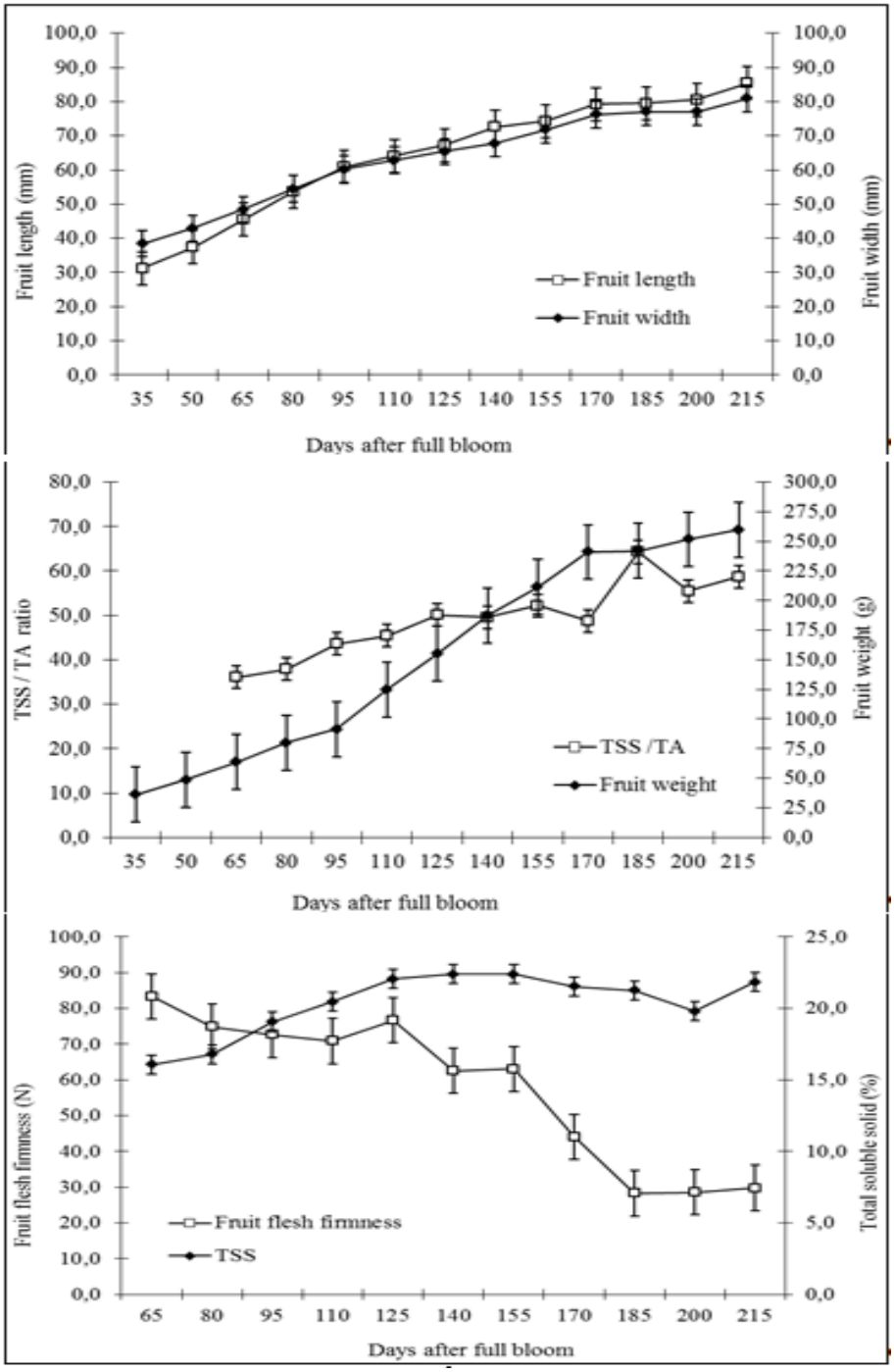

Figure 2. Variations determined in fruit length, width, weight and flesh firmness, TSS content and TSS/TA ratio during fruit development period for 'Hachiya' persimmon variety grown under Dörtyol region. Vertical error bars represent the standard deviation of the mean, and when absent fall within the area of the symbol. Means were obtained from pooling of two-year data with three replicates in each year

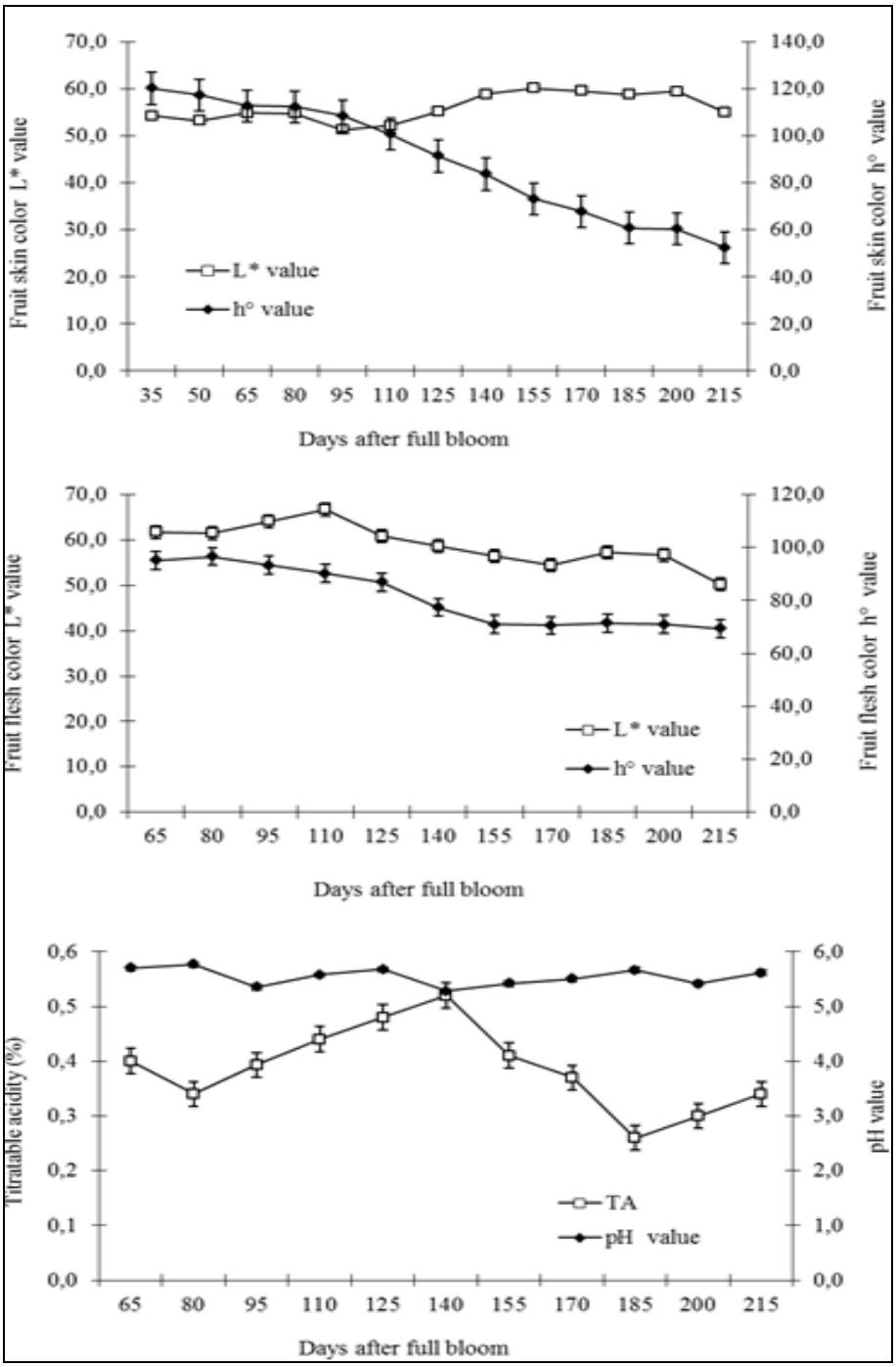

Figure 3. Variations determined in L* and hº value of fruit skin and flesh color, titratable acidity content and pH value during fruit development period for 'Eylül' persimmon genotype grown under Dörtyol region. Vertical error bars represent the standard deviation of the mean, and when absent fall within the area of the symbol. Means were obtained from pooling of two-year data with three replicates in each year

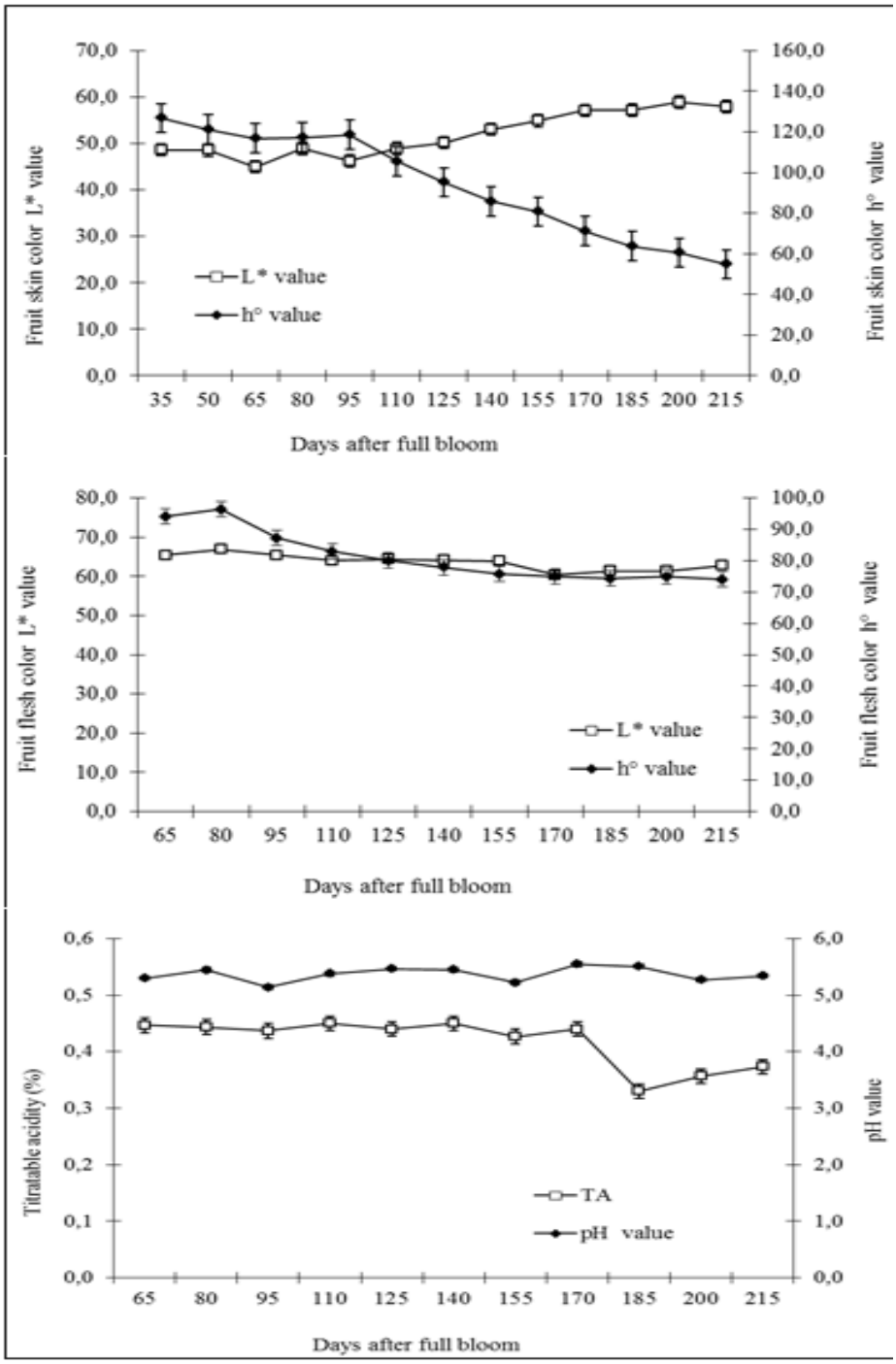

Figure 4. Variations determined in L* and hº value of fruit skin and flesh color, TA content and pH value during fruit development period for 'Hachiya' persimmon variety grown under Dörtyol region. Vertical error bars represent the standard deviation of the mean, and when absent fall within the area of the symbol. Means were obtained from pooling of two-year data with three replicates in each year

Titratable Acidity (TA) Content

Although, TA amount in the form of increases and decreases, TA content was decreased towards maturity. TA amount was 0.40% on 65th DAFB for 'Eylül' persimmon genotype and reduced to 0.34% on 215th DAFB and was 0.45% on 65th DAFB for 'Hachiya' persimmon variety and decreased to 0.37% on 215th DAFB in Dörtyol-Hatay conditions (Fig. 3 and 4).

TSS/TA Ratio

Although increases and decreases were found TSS and TSS/TA during fruit development, TSS/TA ratio was over 30.00 at day for both varieties (Fig. 1 and 2). Toplu et al. (2011; 2020) were reported similar results for TSS/TA rate.

Juice pH Value

Juice pH values were decreased as fruit reached maturity for 'Eylül' persimmon genotype and 'Hachiya' persimmon variety during the study. pH value was 5.71 on 65th DAFB for 'Eylül' persimmon genotype and decreased to 5.62 on 215th DAFB and was 5.30 on 65th DAFB for 'Hachiya' persimmon variety and decreased to 5.34 on 215th DAFB in Dörtyol regions (Fig. 3 and 4).

Fruit Skin and Flesh Color

L* value of fruit skin color was 54.26 on 65th DAFB for 'Eylül' persimmon genotype and increased to 55.10 on 215th DAFB and was 45.65 on 65th DAFB for 'Hachiya' persimmon variety and increased to 57.94 on 215th DAFB in Dörtyol conditions (Fig. 3 and 4). hº value of fruit skin and flesh color was decreased during maturity in 'Eylül' persimmon genotype and 'Hachiya' persimmon variety. hº value of fruit skin and flesh color was 120.19° and 95.13° on 65th DAFB for 'Eylül' persimmon genotype and decreased to 52.49° and 69.33° on 215th DAFB, respectively and was 126.93° and 94.08° on 65th DAFB for 'Hachiya' persimmon variety and decreased to 54.94° and 74.03° on 215th DAFB in Dörtyol conditions (Fig. 3 and 4). It can be said that the turning from green to orange color improved significantly at harvest maturity and color of the skin turned to reddish orange for 'Eylül' persimmon genotype and 'Hachiya' persimmon variety on day 215th DAFB. Fruit skin color is a very good and important criterion in the determination of optimal harvest period of maturity (Kitagawa and Glucina, 1984). The skin brightness of the mature fruit was higher than in it's the case at the beginning. L* value of fruit skin color was raised toward harvest maturity.

Conclusion

The data showed that skin color especially hº value, FFF, fruit size, TSS and TSS/TA ratio were important parameters in the determination of optimal harvest maturity. Based on all data, such a period lies between 155–170th DAFB for 'Eylül' persimmon genotype and between 170–185th DAFB 'Hachiya' persimmon varieties in Dörtyol-Hatay conditions. According to the obtained findings, it was determined that PCA 'Eylül' persimmon genotype grown in east Mediterranean region reach optimal maturity on between the second or the third weeks of October and mid or end of October were the optimal harvest period for PCA 'Hachiya' persimmon variety in order to fruit quality, shipping, efficient marketing and adequate storage life at optimal commercial maturity.

Disclosure Statement

The authors have declared no conflicts of interest for this article.

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