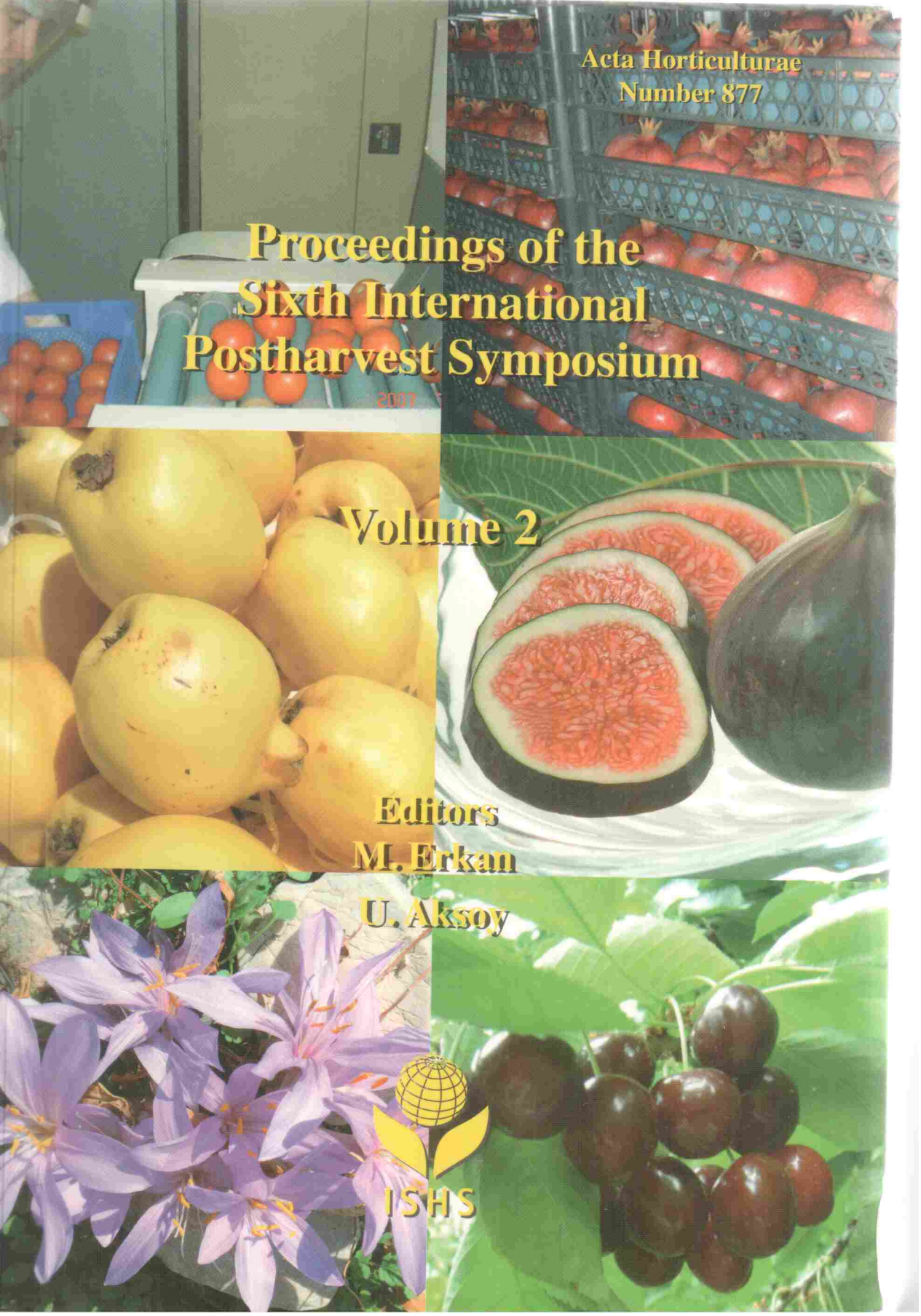


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Changes in Quality Parameters of 'Satsuma' Mandarin during Fruit Development and Their Relationship with Optimum Harvest Maturity

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Abstract

The objective of this study was to determine quality changes of the 'Satsuma' mandarin cultivar growing in Dörtyol and Samandağ districts of Hatay province in Turkey. The research was carried out in 2003-2004. Fruits were obtained from trees which were grafted on Sour Orange rootstock. Fruit width, length and weight, skin color (L*, *h*°), fruit juice, total soluble solid (TSS), titratable acidity (TA), juice pH and TSS/TA were measured on fruit samples in similar size that were collected from trees from June to ripening. Samples were taken at 7 to 15 days interval during fruit development. Data indicated that skin color especially *h*° value of CIE L*a*b*, fruit juice, TSS and TSS/TA were important criteria in determining optimum harvest maturity. This period lays between mid-October (177-185 days after full bloom) for 'Satsuma' mandarins in Dörtyol and Samandağ.

INTRODUCTION

Of the 17.8% of citrus production and 28% of mandarin production of Turkey 90.26% is comprised by 'Satsumas' in Hatay region (Anonymous, 2007). Mandarin production becomes intense in Dörtyol, Erzin, İskenderun and Samandağ districts of Hatay province located in the Eastern Mediterranean region of Turkey.

Although quality standards may vary insignificantly between countries, Turkish standards, the standards of Common Market States (OECD) and USA (Arizona) specifies for mandarins that the juice ratio must not be below 33% of the fruit in weight, TSS/TA ratio must be at least 6:1 and must be 8:1 at full maturity, color must be typical in general for all varieties and in addition, in case of green color exceptions, at least 1/3 of skin in 'Clementine' and 'Satsuma' mandarins and 2/3 in other varieties must have the typical color (Anonymous, 1973, 1980, 1995; Wardowski et al., 1986). Harvest maturity of citrus is generally determined based on juice content, TSS and TSS/TA ratios (Pekmezci, 1979; Dündar, 1988). Gündüz (1993) reported that TSS/TA ratio is taken under consideration in citrus export and Austria is very careful on this matter and also, this ratio should be 6:1 in 'Clementine' and 'Satsuma'. Karaçalı (1983) determined TSS/TA ratio as 5.7 on 19 October for 'Satsumas' grown in İzmir. Pekmezci (1983) determined TSS/TA ratio as 5.44 in the middle of November under Adana conditions and Urgun (1997) determined TSS/TA ratio as 6.47-7.93 for 11 varieties and clones at the end of November. According to these data, the fact that these values were determined as 10.01 and 11.21 under Dörtyol conditions within the same period indicates the advantage of Dörtyol region from the point of view of TSS/TA (Uysal, 2001). It was reported that the fruits should achieve 75% of the color specific to the variety and TSS/TA ratio should be 6.5 and more in mandarins (Arpaia and Kader, 2006). It was reported that juice ratio is 43.90% and TSS/TA ratio is 8.28 in 'Satsuma' mandarins growing in Adana province (Tuzcu, 1990; Kaplankıran, 2007).

The aim of this study is to determine the harvest maturity to be used in relation with the changes in the quality parameters during the growth of the fruits of 'Satsuma' mandarins.

MATERIALS AND METHODS

This study was carried out in the years of 2003-2004 in Hatay condition's Dörtyol (36º09'E; 36º51'N, altitude 9 m) and Samandağ (35º59'E; 36º05'N, altitude 18 m) districts and 'Owari Satsuma' mandarins were obtained from trees grafted on Sour Orange rootstock and planted 7×7 m in the orchard.

Fruit samples were collected after June drop and physical and chemical analyses were performed on fruit samples. Fruit width (mm) and fruit length (mm) were measured on 5 fruits from 5 different branches from 3 different trees each time at approximately 15 days intervals and fruit weight (g) was measured. Skin color L* and *h*° angle value, juice content (%), TSS content (%), TA (in % as "g citric acid/100 ml juice"), TSS/TA and pH were determined on the samples.

The data were analyzed as a completely randomized block design by ANOVA using SAS software of SAS Institute, Cary, N.C. (SAS, 1990) and mean separation was performed by Tukey's Multiple Range test at $p<0.05$ level using SAS's Proc GLM procedure.

RESULTS AND DISCUSSION

In 'Satsuma' mandarin cultivars, flowering completed in the 3rd week of April in the years of 2003 and 2004 in Dörtyol and Samandağ regions. In 'Satsuma' mandarins growing in 2003 in Dörtyol, fruit width was 29.95 mm on 80th days after full bloom (DAFB). Then, it increased and reached to 37.89 mm on 110th DAFB and then, 54.03 mm on 230th DAFB. In 2004, fruit width was 35.63 mm on 110th DAFB. Then, it increased similar to the previous year and reached 64.24 mm on 230th DAFB. In 'Satsuma' mandarins growing in 2003 in Samandağ, fruit width was 31.68 mm on 80th DAFB. Then, it increased and reached to 42.09 mm on 110th DAFB and then, 57.16 mm on 185th DAFB. In 2004, fruit width was 37.05 mm on 110th DAFB. Then, it increased and reached to 50.63 mm on 215th DAFB (Fig. 1).

Fruit grown in Dörtyol in 2003, have a length of 27.70 mm on 80th DAFB and increased to 33.99 mm on 110th DAFB and 44.56 on 230th DAFB. In 2004, fruit length was 32.86 mm on 110th DAFB and increased similar to the previous year to 52.89 mm on 230th DAFB (Fig. 1). Fruit grown in Samandağ in 2003, have a length of 29.80 mm on 80th DAFB and increased to 38.39 mm on 110th DAFB and 47.95 on 185th DAFB. In 2004, fruit length was 37.05 mm on 110th DAFB. In 2004, the fruit length was 33.14 mm on 110th DAFB and increased to 39.72 mm on 215th DAFB (Fig. 1). Similar to our findings, Özsan and Bahçecioğlu (1970), Akgül (1991), Matyar (1992), Urgun (1997), Uysal (2001) and Temiz (2005) reported that width and length of the fruit increased in the growing process.

In fruits grown in Dörtyol in 2003, fruit weight was 18.33 g on 80th DAFB and increased to 33.45 g on 110th DAFB and to 87.78 g on 230th DAFB. In 2004, fruit weight was 31.64 g on 110th DAFB and then, increased to 82.36 g on 230th DAFB. For those which were grown in Samandağ region in 2003, fruit weight was 16.21 g on 80th DAFB and increased to 36.54 g on 110th DAFB and to 92.73 g on 185th DAFB. In 2004, fruit weight was 30.30 g on 110th DAFB and then, increased to 79.61 g on 215th DAFB (Fig. 2). Özsan and Bahçecioğlu (1970) reported that fruit weight of 'Satsuma' mandarin varies depending on years under Dörtyol conditions and the average of the findings obtained in 2 years is 97.10 g. Uysal (2001) reported that this value ranges between 94.81 and 109.08 g. Akgül (1991) determined that fruit weight of 'Satsuma' mandarin grown under Çukurova's ecological conditions and grafted on different rootstocks ranges between 83.31 and 116.75 g. Matyar (1992) found this interval as 101.03-182.44 g on 9 'Satsuma' clones and Urgun (1997) as 82.30-142.98 g on 11 clones.

Fruit grown in Dörtyol in 2003, have a juice content of 39.86% on 125th DAFB and then, increased to 44.00% on 230th DAFB. In 2004, this content was 37.50% on 110th DAFB and then, increased to 42.25% on 125th DAFB and to 54.00% on 230th DAFB. Fruit grown in Samandağ in 2003, have a juice content of 44.79% on 125th DAFB and then, increased to 55.70% on 185th DAFB. In 2004, this content was 44.32% on 110th

DAFB and then, increased to 44.07% on 125th DAFB and to 58.26% on 215th DAFB (Fig. 2). Akgül (1991) determined that juice content of 'Satsuma' mandarin grown under Çukurova's ecological conditions and grafted on different rootstocks ranges between 35.39 and 44.64%. Matyar (1992) found this interval as 37.78-45.35% on 9 'Satsuma' clones and Urgun (1997) as 42.90-47.23% on 11 clones.

In fruits grown in Dörtyol in 2003, L* value for fruit skin color was 42.72 on 80th DAFB and then, increased to 46.21 on 110th DAFB and to 67.56 on 230th DAFB. In 2004, L* value for fruit skin color was 48.22 on 110th DAFB and then, increased to 68.45 on 230th DAFB. In the fruits grown in Samandağ in 2003, L* value for fruit skin color was 49.66 on 80th DAFB and then, decreased to 46.23 on 110th DAFB and to 40.76 on 185th DAFB. In 2004, L* value for fruit skin color was 38.74 on 110th DAFB and then, increased to 63.78 on 125th DAFB (Fig. 3).

Fruits grown in Dörtyol in 2003, have a *h*° angle value for fruit skin color of 119.83 on 80th DAFB and then, decreased to 117.89 on 110th DAFB and to 101.25 on 230th DAFB. In 2004, while *h*° angle value for fruit skin color was 118.92 on 110th DAFB, it decreased to 100.72 on 230th DAFB. Fruits grown in Samandağ in 2003, have a *h*° angle value for fruit skin color of116.18 on 80th DAFB and then, increased to 119.00 on 110th DAFB, it decreased to 109.52 on 185th DAFB, In 2004, *h*° angle value for fruit skin color was 124.82 on 110th DAFB and decreased to 99.30 on 215th DAFB (Fig. 3). According to our findings, it was seen that color of the fruit becomes yellow specific to the cultivar at a ratio of 75-80% towards maturity after fruit growth completed according to especially *h*° angle value. Similarly, Akgül (1991) reported that yellow-orange is dominant in fruit skin color of 'Satsuma' mandarin grown under Çukurova's ecological conditions and grafted on different rootstocks in the harvest time. Matyar (1992) and Urgun (1997) reported that dominant fruit skin color is yellow-green according to their results on 9 and 11 clones respectively.

In fruits grown in Dörtyol in 2003, TSS content was 8.00% on 125th DAFB and then, increased to 8.70% on 230th DAFB. In 2004, this content was 7.73% on 110th DAFB and then, became 7.47% on 125th DAFB and increased to 9.73% on 230th DAFB. In the fruits grown in Samandağ in 2003, TSS content was 9.07% on 125th DAFB. Although increases and decreases occurred in this value, it increased to 9.80% on 185th DAFB. In 2004, TSS content was 7.20% on 110th DAFB and increased to 7.45% on 125th DAFB and to 11.60% on 215th DAFB (Fig. 4). Karaçalı (1983) reported that TSS content of 'Satsuma' grown in Izmir is 10.10%. According to Dawes and Martin (1991), this content in 'Silverhill Satsuma' grafted on the Trifoliate grown in New Zeeland ranges between 9.30 and 9.80%. Akgül (1991) determined that TSS content of 'Satsuma' mandarin grown under Çukurova's ecological conditions and grafted on different rootstocks ranges between 9.74 and 11.85%. Matyar (1992) found this interval as 9.27 and 13.47% on 9 'Satsuma' clones and Urgun (1997) as 9.60 and 12.73% on 11 clones. Uysal (2001) reported that this content ranges between 9.65 and 9.75% under Dörtyol conditions.

In fruits grown in Dörtyol in 2003, TA content was 4.44% on 125th DAFB and then, decreased to 1.06% on 230th DAFB. In 2004, TA content was 3.91% on 110th DAFB and then, decreased to 3.85% on 125th DAFB and to 0.90% on 230th DAFB. In the fruits grown in Samandağ in 2003, TA content was 4.96% on 125th DAFB and then, decreased to 1.77% on 185th DAFB. In 2004, TA content was 2.31% on 110th DAFB and then, decreased to 2.24% on 125th DAFB and to 0.90% on 215th DAFB (Fig. 4). Our findings about decrease in TA content are similar to those found by Özsan and Bahçecioğlu (1970), Akgül (1991), Dawes and Martin (1991), Matyar (1992), Urgun (1997), Uysal (2001) and Temiz (2005).

Fruit grown in Dörtyol in 2003, have a pH value of 2.66 on 125th DAFB and then, increased to 3.09 on 230th DAFB. In 2004, pH value was 2.44 on 110th DAFB. Although increases and decreases occurred in this value, it decreased to 2.38 on 125th DAFB and increased to 2.84 on 230th DAFB. Fruit grown in Samandağ in 2003, have a pH value of 2.61 on 125th DAFB. It generally tended to increase and reached 2.82 on 185th DAFB. In 2004, pH value was 2.65 on 110th DAFB. Although increases and decreases occurred in

this value, it decreased to 2.61 on 125th DAFB and increased to 3.11 on 215th DAFB (Fig. 5).

In 'Satsuma' mandarins grown in Dörtyol in 2003, TSS/TA ratio was 1.80 on 125th DAFB and then, increased to 8.21 on 230th DAFB. In 2004, TSS/TA ratio was 1.98 on 110th DAFB and increased to 1.94 on 125th DAFB and finally, reached 10.88 on 230th DAFB. In 'Satsuma' mandarins grown in Samandağ in 2003, TSS/TA ratio was 1.83 on 125th DAFB and then, increased to 5.54 on 185th DAFB. In 2004, TSS/TA ratio was 3.14 on 110th DAFB and increased to 3.37 on 125th DAFB and finally, reached 13.16 on 215th DAFB (Fig. 5). Karaçalı (1983) reported that TSS/TA ratio of 'Satsuma' grown in Izmir is 5.70. According to Dawes and Martin (1991), this ratio in 'Silverhill Satsuma' grafted on the Trifoliate grown in New Zeeland ranges between 7.20 and 8.40. Richardson et al. (1994) reported for this value on Troyer citrange as 7.00. Akgül (1991) determined that TSS/TA ratio of 'Satsuma' mandarin grown under Çukurova's ecological conditions ranges between 7.01 and 8.54. Matyar (1992) found this interval as 7.75 and 10.38 on 9 'Satsuma' clones and Urgun (1997) as 6.47 and 7.93 on 11 clones.

Uysal (2001) reported that 'Satsuma' mandarins grown under Dörtyol conditions reach maturity criteria specified in the applicable standards (TSS/TA ratio is at least 6:1, 8:1 at full maturity) in the middle of October and at the beginning of November and harvest should not be earlier than the beginning of October (6.45) and the fruits reached full maturity at the beginning of November (7.99) in 1998. For the year 1999, this covered the beginning of October (5.67) and the middle of October (7.56). It is reported that TSS/TA ratio ranges between 5.21 and 7.52 under Izmir conditions on 13 October (Anonymous, 1999). According to the findings about TSS/TA ratio, which is a basic factor in earlier maturity and harvest period, this value ranges between 6.06 and 7.73 under Dörtyol conditions between 6 and 20 October.

CONCLUSIONS

Results of Satsuma mandarins which were grown under Dörtyol conditions are similar to those obtained by Uysal (2001). The fruits reach maturity earlier than those grown under Izmir and Adana conditions. Furthermore, those grown in Samandağ region mature 1-2 days earlier than those grown under Dörtyol conditions. TSS/TA ratio of 'Satsuma' mandarins grown in Samandağ ranges between 6.68 and 8.94 approximately in the middle of October (between 13 and 20 October) in 2004 while this ratio in case of 'Satsuma' mandarins grown in Dörtyol ranges between 4.72 and 6.62. The ratio is 9.59 for those grown in Samandağ while it is 7.58 for those grown in Dörtyol at the end of October. At the beginning of November, the ratio is 10.56 for those grown in Samandağ while it ranges between 7.54 and 9.25 for those grown in Dörtyol.

'Satsuma' mandarin fruits should achieve 75% of the color specific to the variety, $h°$ angle value should be 100-110 and lesser, TSS content should be 8% and more, TA content should be 1.25% and less, TSS/TA ratio should be 6.5 and more and juice ratio should be 33% and more in optimal harvest time of mandarins (Anonymous, 1973, 1980, 1995; Pekmezci, 1979; Wardowski et al., 1986; Dündar, 1988; Tuzcu, 1990; Gündüz, 1993; Arpaia and Kader, 2006; Kaplankıran, 2007).

According to the obtained findings, it was determined that 'Satsuma' mandarins grown in Dörtyol and Samandağ should be harvested approximately in the middle of October (between 13 and 20 October). Accordingly, it was determined that 'Satsuma' mandarins grown in Dörtyol and Samandağ regions reach optimal harvest maturity on 177th-185th DAFB.

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Figures

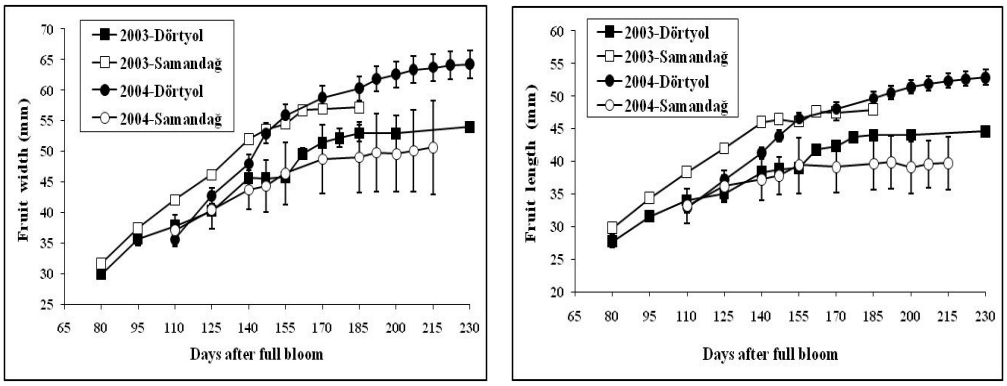


Fig. 1. Variations determined in fruit width and length during fruit development period for 'Satsuma' mandarins grown under Dörtyol and Samandağ conditions in 2003-2004.

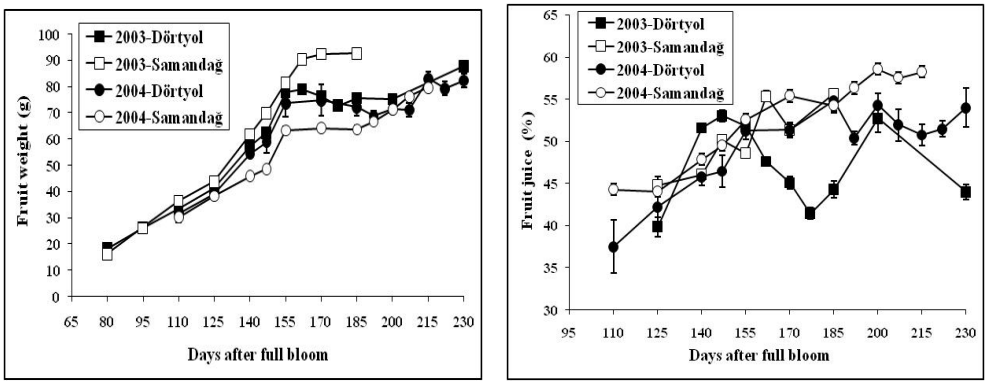


Fig. 2. Variations determined in fruit weight and juice during fruit development period for 'Satsuma' mandarins grown under Dörtyol and Samandağ conditions in 2003-2004.

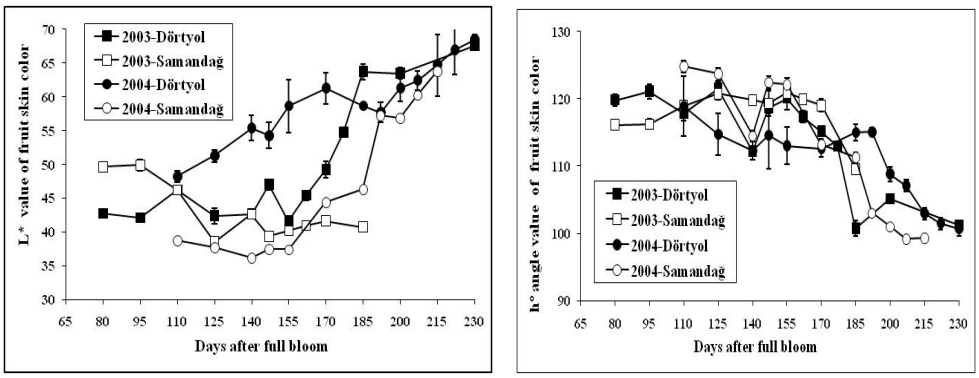


Fig. 3. Variations determined in L* and hº angle value of fruit skin color during fruit development period for 'Satsuma' mandarins grown under Dörtyol and Samandağ conditions in 2003-2004.

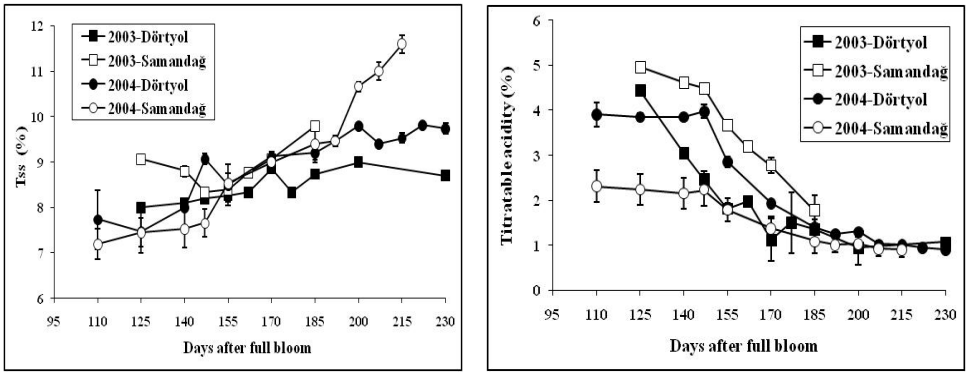


Fig. 4. Variations determined in fruit TSS and titratable acidity during fruit development period for 'Satsuma' mandarins grown under Dörtyol and Samandağ conditions in 2003-2004.

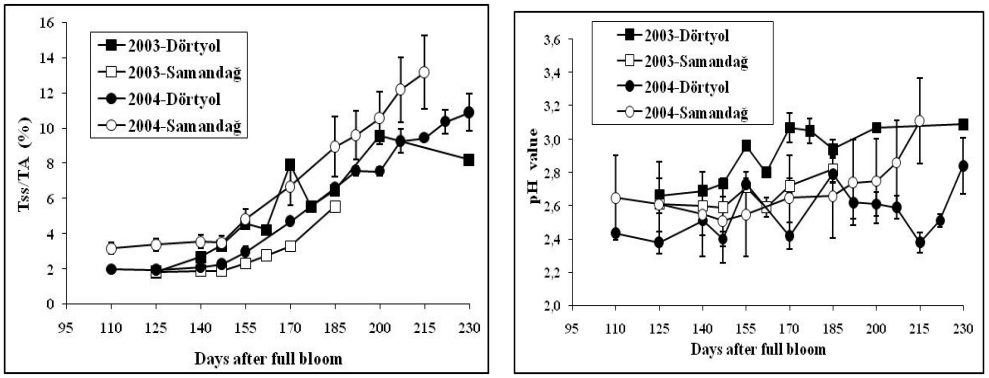


Fig. 5. Variations determined in TSS/TA and pH value during fruit development period for 'Satsuma' mandarins grown under Dörtyol and Samandağ conditions in 2003-2004.