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A Research on Determining the Most Suitable Harvest Maturity of the Kiwifruits (*Actinidia Deliciosa* cv. Hayward) Harvested at Different Time Intervals

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Abstract: This research was carried out to investigate regional maturity characteristics and to determine the suitable criteria for the best harvest time of the kiwifruits in Çanakkale - Umurbey conditions for short time storage. For this purpose kiwifruits harvested at 10 day intervals from November 15th to October 25th, from the vines that was planted as kiwifruit cv. Hayward. Two years results showed that there were important differences in different criteria; % total soluble solid content, fruit firmness and affective evaluation tests, which were carried out to determine maturation and also in other criteria, % Total Soluble Solid Content (%TSSC), titrable acidity and fruit firmness tests, analyzed to determine the proper harvest maturity. According to the results, the proper harvest time was when the fruit weight was approximately 48-49 mm; the fruit length, approximately 63-64 mm; soluble solids % 8-8,5 and fruit firmness 8,5-9,5 kg/cm^2 for the kiwifruit cv. Hayward in Umurbey conditions.

Key Words: Kiwifruit, Development, Maturity, Quality

Introduction

Turkey is one of the rare land which has different microclimates and ecologies with its geographical and climatic situation. In addition to the many fruits grown, determination of the species in different ecologies that are not cultivated in the country, has been accelerated as a result of seeking new tastes. For this reason adaptation studies were started on kiwifruits in the late 80's and growing kiwifruits showed a rapid development in the commercial gardens established with having positive results. But the important effects of ecology on development and quality of fruits require local studies about kiwifruits. Also the studies on marketing and quality must be carried out besides the studies about growing. Various negative consequences after short time storage in the fruit harvested early or late could be removed as a result of determining the best maturity time when the fruits might reach the suitable maturity quality.

It was reported that changes in the weights and the dimensions of the fruits kept on until harvesting in the preceding studies. But the fastest increase on the dimensions occurred in the first 100 days following blooming. Different researchers pointed out that changes in the weight, size and acidity did not give effective results to determine the harvest maturity (Crisisto *et al.*, 1984; Kaynaş *et al.*, 1998; Kaynaş *et al.*, 1999). Harman *et al.*, (1982), determined that the acidity increased in the period of ripening, reduced this increase when the fruits reached ripening period, total carbonhydrates increased continuously, starch/sugar ratio could be a good parameter for maturity. Starch breakdown was related to climatic factors so this property was not reliable for Kiwifruits in some locations. It was reported that breakdown speed of starch under 10°C was faster than the maturity development speed (Karaçalı, 1990).

Percent total soluble solid content of the fruits increased rather slowly until the development of the fruits completed. Many researchers determined that changes in the total soluble solids showed parallelism with the changes in % soluble solid content of the fruits and also expressed that % total soluble solid content and fruit firmness was generally the most suitable parameters for kiwifruits (Weet, 1979; Harman, 1981; Harman *et al.*, 1982; Crisisto *et al.*, 1984; Scott *et al.*, 1986; Mc Donald *et al.*, 1982; Mitchell *et al.*, 1992; Quadretti *et al.*, 1996; Papadopoulous *et al.*, 1997; Kaynaş *et al.*, 1998; Kaynaş *et al.*, 1999). Reid (1985), determined that a % Total Soluble Solid Content rate of 6,25% was sufficient for harvest maturity from the researchs carried out in various regions in New Zelland where the leading kiwi producer country. Also Asami *et al.*, (1988), expressed that, the most suitable harvest time was the period when the % Soluble Solid Content was less than 7%. Walton *et al.*, (1990), determined that ripening of the fruits was changed in the gardens established at different altitudes in California. Thorp (1984), found that the diameters of the fruit sampled at 6.2% Total Soluble Solid Content and the fruits kept waiting until late harvest time did not differ significantly based on his studies carried out for 2 years. Kaynaş *et al.*, (1999), determined that the changes in the fruit firmness, total soluble solid content and total sugar content could be used as maturity parameters; the most suitable values would be 6-7 kg/cm^2 fruit firmness, 7-8% Total Soluble Solid Content and 8-9% total sugar content for short time storage period (3 months) and 7-8 kg/cm^2 fruit firmness, 6.5%-7.5% total soluble solid content 7-8% total sugar content for long time storage period (6 months), in the researches carried out with cv. Hayward in Yalova, Turkey.

This research was carried out to determine the physical and chemical changes in the fruits that reached to ripening period and also to determine the most suitable harvest maturity for short time storage period and the most suitable harvest parameters in Umurbey, Çanakkale.

Materials and Methods

This study was carried out in Çanakkale-Umurbey for two years (1999 and 2000), and 7 years old kiwifruit cv. Hayward orchards were used as material. Harvest was done at 5 different times with 10-day intervals on previously designated plants when they reached 6% Total Soluble Solid Content. The fruit width (cm), (diameter-1 and diameter-2), fruit length (cm), fruit weight (g) were determined of the 10 fruits randomly taken from the orchards in each repetition for each harvest period.

Total Soluble Solid Content (%), titrable acidity (%g citric acid), pH and fruit firmness (kg/cm^2) were also determined on the same fruits during the maturity period. To determine the eatable maturity, fruits were stored at 20°C for 10 days and afterwards Total Soluble Solid Content (%), fruit firmness (kg/cm^2) and sensorial tests were applied to the fruits (1-very bad.... 5-very good).

Total soluble solid content was determined by the rephractometer, fruit firmness by penetrometer, titrable acidity by titration, pH by pH-meter, width and length by digital caliper, weight by sensitive balance. The fruit width expressed the diameter-1 and 2, measured narrow and wide parts of the fruits.

Results and Discussion

The development of the fruits harvested at different periods was summarized in Table1. Fruit weight, diameter-1 and diameter-2 and length were not affected significantly by the harvest periods in 1999 (Table 1). The diameter-1 was 45.07 mm in the first harvest period and reached 46.06 mm in the last harvest period in the second year of the study but increase of the average of the two years was not found significant.

While the increase in the diameter-2 was not found significant based on years, the increase from 49.10 mm to 52.34 between the first and last harvest period was found statistically significant in the results of the mean of the two years. The fruit length reached 65.50 from 63.29 with the effect of 2nd year and showed a significant increase in the last harvest period compared to the first harvest. Fruit diameter-2 and fruit length were found significant at 0.05 level between the harvest periods. But the changes based on the years and the differences found significant only between the first and the last harvest periods, showed a parallelism with the findings by other researchers reporting the fruit weight and size were not the effective variables to determine the best harvest maturity (Crisisto *et al.*, 1984; Thorp, 1984; Kaynaş *et al.*, 1998 and Kaynaş *et al.*, 1999).

The physical and chemical changes of the fruits sampled in different time intervals were shown in Table 2. The Total Soluble Solid Content (TSSC) of the fruits increased linearly in the first, second and also the mean of the two years and differences were determined at 0.01 level between the harvest periods. While TSSC was found 6.61% in the first harvest period, it was reached to 7.65%, 8.45%, 11.10% and 12.62% in the following harvests respectively. The increase in TSSC was found low compared to the first application year. This may be because of the load of the fruits on the vines in the first year was more than that of the second year and also climatic factors. Titrable acidity was found significant at 0.05 level and the mean of the two years also found significant at 0.01 level statistically. Titrable acidity was found 2.0% in the first year and it showed a sudden decrease and then showed a little increase finally changing to the value 1.79% in the last harvest period.

Table1: The Physical Changes in the Fruits Harvested in Different Time Intervals

Harvest Time	Fruit Weight (g)			Fruit Diameter-1 (mm)			Fruit Diameter-2 (mm)			Fruit Length (mm)		
	1999	2000	Mean	1999	2000	Mean	1999	2000	Mean	1999	2000	Mean
Harvest I (15th Oct.)	77.5	77.1 b	78.0	43.2	45.1 ab	44.1	48.2	50.0	49.1 b	64.1	62.5 ab	63.3 b
Harvest II (25th Oct.)	81.2	76.7 b	79.0	44.9	44.3 b	44.1	49.7	50.3	49.9 ab	64.3	62.0 b	63.2 b
Harvest III (5th Nov.)	84.1	78.9 b	81.5	43.8	45.3 ab	44.5	51.2	50.5	50.8 ab	64.9	62.9 ab	63.9 ab
Harvest IV (15th Nov.)	83.5	80.4 ab	82.0	43.0	45.5 ab	44.2	51.0	51.4	51.2 ab	64.4	63.0 ab	63.7 ab
Harvest V (25th Nov.)	80.7	88.9 a	84.8	43.5	46.1 a	45.0	52.2	52.5	52.4 a	64.4	66.6 a	65.5 a
LSD	NS	9.74*	NS	NS	1.30*	NS	NS	NS	2.51*	NS	4.20**	2.01*

NS: Not Significant, *: Significant at 0.05 level, **: Significant at 0.01

Table 2: The Physical and Chemical Changes of the Fruits Sampled in Different Time Intervals

Harvest Time	TSSC (%)			Titrable Acidity (g/l citric acid)			PH			Fruit Firmness (kg/cm^2)		
	1999	2000	Mean	1999	2000	Mean	1999	2000	Mean	1999	2000	Mean
Harvest I (15th Oct.)	7.20 d	6.03 c	6.61 e	1.71 a	2.28	2.0 a	3.36 ab	3.54	3.45	11.5 a	10.7 a	11.2 a
Harvest II (25th Oct.)	8.67 cd	6.63 c	7.65 d	1.49 b	1.99	1.74 b	3.35 ab	3.49	3.42	9.5 bc	10.2 a	9.8 a
Harvest III (5th Nov.)	9.83 c	7.07 bc	8.45 c	1.50 b	2.10	1.80 b	3.27 b	3.44	3.36	10.1 ab	9.7 ab	9.9 a
Harvest IV (15th Nov.)	13.27 b	8.93 a	11.10 b	1.53 b	2.30	1.97 b	3.30 ab	3.54	3.42	6.6 c	9.9 a	8.3 ab
Harvest V (25th Nov.)	14.67 a	10.56 a	12.62 a	1.52 b	2.06	1.79 b	3.47 a	3.49	3.48	4.7 c	7.8 b	6.3 b
LSD	1.32**	1.67**	0.70**	0.07**	NS	0.02 *	0.18**	NS	NS	4.66**	1.80*	3.20**

NS: Not Significant, *: Significant at 0.05 level, **: Significant at 0.01

Table 3: The Physical and Chemical Changes in the Fruits Stored in 20°C after Harvest for Consumers

Harvest Time	Fruit Firmness (kg/cm2)			TSSC (%)			Taste Tests (1-5)		
	1999	2000	Mean	1999	2000	Mean	1999	2000	Mean
Harvest I (15th Oct.)	8.41 a	5.97 ab	7.19 a	11.80 c	10.50 d	11.15 d	1.98 c	2.39 b	2.18 c
Harvest II (25th Oct.)	5.19 ab	6.35 a	5.77 ab	13.10 bc	11.21 cd	12.16 c	2.30 bc	2.50 b	2.40 bc
Harvest III (5th Nov.)	5.78 ab	6.25 ab	6.02 ab	14.16 ab	12.26 bc	13.21 b	3.30 ab	2.64 b	2.97 ab
Harvest IV (15th Nov.)	3.60 b	4.44 ab	4.02 ab	15.33 a	13.30 b	14.31 a	3.52 ab	2.63 b	3.07 ab
Harvest V (25th Nov.)	2.02 b	3.78 b	2.90 b	15.56 a	14.03 a	14.79 a	3.56 a	3.14 a	3.35 a
LSD	4.37*	2.45*	2.45**	1.82 *	1.09**	0.98**	1.21**	0.45**	0.66**

NS: Not Significant, *: Significant at 0.05 level, **: Significant at 0.01

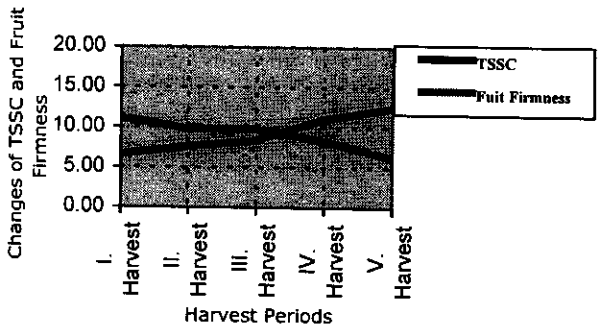

Fig. 1: The Changes of Fruit Fimness and Total Soluble Solid Content of the Kiwifruits Sampled at Different Time Intervals

Neither evident nor effective changes were determined in the fruit juice pH. The uncertain changes in pH showed that pH was not useful for determining the most suitable harvest maturity for kiwifruits.

Based on the results it was determined again that the fruit firmness is effective maturity parameter as TSSC. The fruit firmness was found 11.15 kg/cm^2 at the beginning then it decreased to 6.26 kg/cm^2 in the last harvest period. These findings are in harmony with many researchers who expressed that the TSSC and the fruit firmness were the most effective parameters for determining the most suitable harvest time for kiwifruits (Weet, 1979; Harman, 1981; Harman *et al.*, 1982; Crisisto *et al.*, 1984; Scott *et al.*, 1986; Mc Donald *et al.*, 1982; Mitchell *et al.*, 1992; Quadretti *et al.*, 1996; Papadopoulous *et al.*, 1997; Kaynaş *et al.*, 1998 and Kaynaş *et al.*, 1999). The differences in fruit firmness were significant at 0.01 level between the harvest periods. Evident decreases were observed in fruit firmness in the last two harvests in the first year and the last harvest in the second year (Table 2).

To determine the most suitable maturity for consumers, the fruits harvested in different time intervals were stored in 20°C for 10 days. Generally the fruits harvested in early period could not reach to the high quality maturity for consumers in 10 days (Table 3). The fruit firmness of the fruits stored in 20° C was found quite high in the initial harvests, but the fruits sampled in 4th and 5th harvest period softened. The initial fruit firmness was 7.19 in the first harvest period then 5.77, 6.02, 4.02, 2.90, kg/cm^2 as the harvest period went on in the fruits stored in 20° C for consumers. TSSC was found 11.15% initially and then recorded as 12.16%, 13.21%, 14.31% and 14.79%. While the TSSC of the fruits showed similar values in the last two harvests, it showed significant increases in the first three harvests. The TSSC and fruit firmness was found significant at 0.01 level. A group of 7 people did fruit taste tests on the fruits stored in 20°C for consumers and graded the fruits based on a 1-5 scale. The maturity of the fruits was determined satisfactory after the 3rd harvest period in each year (Table 3). However, the sudden softening with the TSSC reaching to 15.56% value, in the fruits harvested in 4th and 5th harvests of the 1st year, decreased the quality of the fruits. For this reason it was determined that the fruits might reach to excessive maturity values, with delayed harvests in some years and this might decrease the storage life in cold depots.

The fruits sampled in the early harvest periods were found sour and insufficient in quality. Furthermore, it was determined that fruit flesh was not soft enough. However, it was thought that, the quality loss might be seen in the fruits harvested after the 4th harvest period and also storage problems might be seen in the cold depots.

The most suitable harvest time was determined as the 3rd harvest period when the TSSC and fruit firmness intersect in the figure for the kiwifruits cv Hayward grown in Çanakkale, Turkey (Fig. 1). The TSSC was determined sufficient for the short time storage in the fruits harvested at or later than 3rd harvest period. Also, based on the tests, it was found that the fruits reached the limit value of 3 for edible maturity.

As a result of evaluations for two years, the most suitable harvest period was determined as the period when the fruits were 81-82 g in weight, 48-49 mm in diameter and 63-64 mm in width, 8-8.5% in TSSC, 8.5-9.5 in fruit firmness for short time storage in Umurbey-Çanakkale.

Similar studies are needed in the regions where the kiwifruit are grown to determine the most suitable harvest period and parameters.

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