International Scholars Journals

Frontiers of Agriculture and Food Technology ISSN 7295-2849 Vol. 7 (3), pp. 001-005, March, 2017. Available online at www.internationalscholarsjournals.org © International Scholars Journals

Full Length Research Paper

Pomological characterisation of different kiwifruit (*Actinidia deliciosa*) cultivars in Adana (Turkey)

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Accepted 09 December, 2016

Kiwifruit production in Turkey has increased very rapidly in recent years due to the high nutritional content, especially of vitamin. The performance and pomological characteristics of seven kiwifruit (*Actinidia deliciosa*) cultivars ('Hayward', 'Bruno', 'Monty', 'Abbott', 'Elmwood', 'Fatma' and 'Tere') were investigated during 2002 to 2007 in the Eastern Mediterranean region, Adana (Turkey). The fruit yield was determined every year from 2002 to 2007, and fruit quality was evaluated between 2002 and 2005. The highest yield per vine was obtained from 'Hayward' and 'Bruno', whereas the lowest yield was from 'Fatma' and 'Monty'. 'Elmwood' had the largest fruit size followed by 'Hayward'. The smallest fruit size was obtained from 'Tere' followed by 'Abbott' and 'Monty'. Vitamin C contents of these cultivars ranged from 78.00 to 52.38 mg ascorbic acid /100 g f.w. Fruit of Elmwood and Monty contained the highest concentrations of ascorbic acid followed by Hayward. For this area, it appears that the 'Hayward' variety is the most productive, has the largest fruit and highest vitamin C content.

Key words: Kiwifruit, *Actinidia deliciosa*, yield, fruit size, vitamin C.

INTRODUCTİON

The kiwifruit (*Actinidia deliciosa*) is one of more than 50 species of Actinidia originating from Southeast China. It was introduced to New Zealand, Europe and USA at the turn of the 19th century. In the 1930's, commercial kiwifruit production began in New Zealand and in 1960 the first kiwifruit exports began in that country. The most important commercial varieties like Hayward, Bruno, Allison were selected from New Zealand. The first commercial kiwifruit orchards were established in Europe and the USA in the late 19th century (Ferguson and Bollard, 1990). Kiwi is a popular fruit and its production has been increasing rapidly in recent years due to its high nutritional value and especially high vitamin C content. World-wide kiwifruit production is about 1,308,424 tonnes (FAO, 2009). Hayward is the most common commercial variety world-wide, especially in Italy, New Zealand and Chile (Cheng et al., 2004). Hayward is grown in many countries because of its distinctive features like high yield, large fruit size and good storage properties (Nishiyama et al., 2004).

Turkish kiwifruit production has increased in recent years and is currently 19,530 tonnes (FAO, 2009). As kiwifruit production has gained attention, studies determining the most suitable areas for cultivation have started and are still in progress today. The studies so far have shown that kiwifruit production can be vary widely, especially in the Black Sea and Marmara regions. The humid valleys of the Mediterranean and the Aegean regions are also suitable for kiwifruit production. The total harvested area of kiwi is 16,295 decares and increasing (TUIK, 2010). In these regions, the most commonly cultivated cultivar is 'Hayward'. Although Hayward is the most dominant cultivar produced in the world market, there are many varieties and selections in the genus Actinidia. Therefore, a wide range in properties such as fruit size, shape, hairiness, flesh color and flavor is observed (Boyes et al., 1997; Ferguson, 1990). Kiwifruit cultivars also have a wide variation in terms of vitamin C content (Ferguson and MacRae, 1991). The cultivated kiwifruit varieties are selections from *A. deliciosa* that have large fruit size. The flesh color is bright green when the fruit ripens. Although chlorophyll breaks down with ripening in many types of fruit species, kiwifruit flesh color

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Table 1. Some pomological characteristics of kiwifruit cultivars (2002-2005).

Cultivars	Fruit weight (g)	Fruit length (mm)	Fruit width (mm)	Soluble solid (%)
Hayward	62.67 ab [y]	52.95 bc	42.06 ab	15.73 b
Bruno	56.88 abc	61.03 ab	40.90 abc	13.28 b
Monty	51.52 cb	59.04 abc	37.36 c	13.10 b
Abbott	48.70 cb	59.34 abc	37.27 c	16.08 b
Elmwood	73.30 a	68.40 a	44.02 a	14.06 b
Fatma	51.63 cb	57.41 abc	37.90 c	12.93 b
Tere	40.89 c	47.68 c	37.78 c	19.64 a
Significance	**[z]	**	**	**

[z] **: significant at p<0.01 level; [y] values within the columns followed by unlike letters are significantly different by Tukey's multiple range test at p<0.05.

is green because of the persistant chlorophyll content. Kiwifruit also has many small black seeds (Ferguson, 1991). Long oval fruit shape, brown skin color and short stiff hairs covering the fruit surface are some of the characteristics of kiwifruit (Beever and Hopkirk, 1990). Compared with other commercial fruit species, kiwifruit is extremely high in vitamin C content. It is also rich in terms of carbonhydrates and proteins, as well as important minerals like calcium, magnesium, nitrate, phosphorus, potassium and iron. Besides fresh consumption, kiwifruit is also used in fruit salads, cakes, marmalades and concentrated fruit juice industry. The aim of this study was to investigate some important pomological characteristics of seven different kiwifruit cultivars under Adana growing conditions and determine the most appropriate ones for cultivation.

MATERIALS AND METHODS

The grafted vines were planted in 1996 with 5 x 5 m spacing and standard T – bar training system at the Research Station of Çukurova University, Agricultural Faculty, Citrus Experiment Station, Adana (Latitude, 35° 23′ N; Longitude, 36° 50′ E; elevation 27 m). In this study, Hayward, Bruno, Monty, Abbott, Elmwood, Fatma and Tere cultivars were used as the experimental material; and Matua and Tomuri were used as pollinators. All the cultivars were grafted to kiwifruit seedlings. The kiwifruit cultivars were evaluated under Adana growing conditions from 2002 and 2007. The experimental design was randomized complete blocks design with five replications. In the experimental area, the soil was a clay loam (56% clay, 21% silt and 23% sand containing 13.4% $CaCO_3$), and the soil pH was in the range of 7.29 to 7.37 at a depth of 0 to 90 cm. The electrical conductivity of the soil was 0.21 mmhos/cm. The experimental area had an average temperature ranging between 24.4 and 14.8°C with an average annual rainfall of 497.5 mm. The vines were pruned regularly and irrigated weekly from May to October using a drip irrigation system. The fertilizer was applied in different doses depending on the increasing age of the vines in the years between 2002 and 2007. Nitrogen (N) was applied at a rate of 1 to 1.5 kg/vine (2/3 in mid-February before bud break and 1/3 in mid-May after full bloom), phosphorus (P) was applied at a rate of 600 g to 1 kg/vine (December) and potassium (K) was applied at a rate of 600 g to 1 kg/vine (January).

Iron deficiency was an important factor under our soil conditions and this problem was controlled iron chelates. Every year from 2002 to 2007, the fruit yield of each vine was determined at harvest. The fruit was harvested and weighed at optimum harvesting time (in the beginning and middle of November). Between 2002 and 2005, random samples of 25 fruits from each vine were collected and were ripened at 20 to 25°C for 3 to 4 days for fruit quality analysis. The fruit samples were weighed, and fruit length and width were measured with a digital caliper (Mitutoyo CD-15CPX). The soluble solids content (SSC) was determined with a portable refractometer (FG-103/113) using a few drops of juice. From 2003 to 2005, the concentration of ascorbic acid was obtained according to the Pearson method (1970), using a Shimadzu UV-1208 spectrophotometer. The method relies on oxidation of ascorbic acid with 2.6 dichlorphenol-indolphenol. A standard curve was made for the ascorbic acid content and the concentration of ascorbic acid was read at 520 nm using this standard curve.

A randomized complete blocks design was used with five replicates for each cultivar. Data was subjected to ANOVA and analyzed using MINITAB (v.16, INOVA Inc.) statistical software. Mean comparisons were performed using Tukey's Multiple Range test to examine if differences between cultivars were significant at P<0.05.

RESULTS AND DISCUSSION

Significant differences among cultivars for fruit quality and yield were identified. Yield per vine of kiwifruit cultivars, some important pomological characters and vitamin C of kiwifruit cultivars are given in Table 1 and Figures 1 and 2, respectively.

Yield

Based on a six year period, the highest yield per vine was obtained from Hayward and Bruno cultivars (Figure 1). The lowest yield was found from Fatma and Monty cultivars. Tere, Elmwood and Abbott produced similar yields (kg/vine) and did not show significant differences from each other. These results confirmed the results of Bauckmann (1982), who reported that the highest yield was obtained from Bruno, which gave an average 9.2 kg/plant. Bauckmann (1980) also reported that Hayward was the best cultivar as regards fruit size, yield and flavor. Similar results were reported by Basim and Uzun

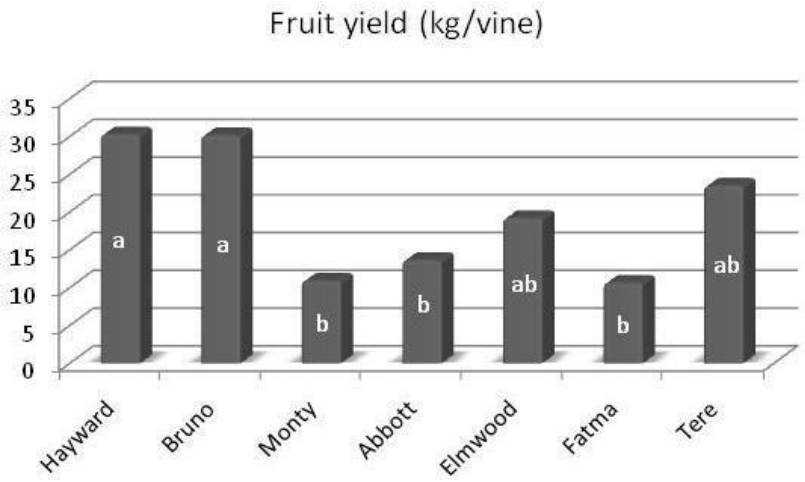

Figure 1. Yield of kiwifruit cultivars per vine (2002 to 2007). Values within the columns followed by unlike letters are significantly different by Tukey's multiple range test at p<0.05.

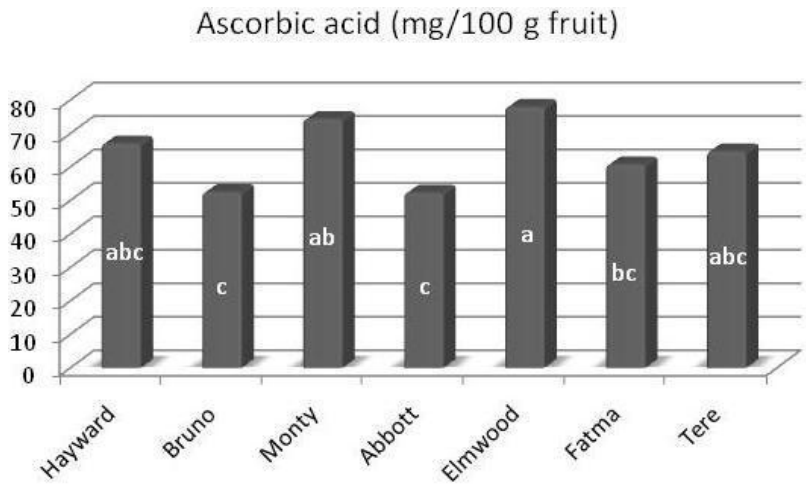

Figure 2. Vitamin C contents in fruit kiwifruit cultivars (2003 to 2005). Values within the columns followed by unlike letters are significantly different by Tukey's multiple range test at p<0.05.

(2003) who found that Hayward produced 38.72 kg/vine in the conditions of the Western Mediterranean region in Turkey. In contrast, Popovic et al. (2002) reported that the lowest yield was from Bruno, followed by Hayward and Abbott, and the highest yield from the Monty cultivar in the conditions of Bar. Lazarevski et al. (1978) reported that, Monty was the best variety as regards fruit yield.

Fruit quality

Fruit size

In the present study, statistical difference in fruit size among kiwifruit cultivars was found (Table 1). Elmwood had the largest fruits followed by Hayward. The smallest fruits were obtained from Tere, followed by Abbott and Monty. Similar results were reported by Nishiyama et al. (2004), who found that Elmwood, Bruno and Hayward had slightly larger fruits than Abbott. A similar trend was found by Popovic et al. (2002), who stated that Monty and Abbott had the smallest fruits. Also, Bauckmann (1982) reported that the largest fruits were obtained from Hayward. In addition, Çelik et al. (2007) reported that the average Hayward fruit mass was found to be 72.28 g.

Fruit length and width

The results in Table 1 show that the differences among

the cultivars in fruit length and width were statistically significant. Elmwood had the greatest fruit length, followed by Bruno, whereas Tere was the shortest, followed by Hayward. Other varieties had similar fruit lengths and did not show significant differences from each other. Within all varieties, Abbott, Monty, Tere and Fatma had the shortest fruits whereas Elmwood had the greatest one followed by Hayward for fruit width. The results obtained in this study regarding fruit length and width was in agreement with a previous report by Popovic et al. (2002). They reported that Bruno had the longest and Monty had the shortest fruit length and also Monty had the smallest and Hayward had the greatest fruit width, averageing 44.12 mm.

Soluble solid content (SSC)

Significant differences in the soluble solid content were identified among the kiwifruit varieties when the averages of the yearly results were analyzed (Table 1). Tere showed the highest SSC, whereas other varieties produced similar SSC and did not show significant differences from each other. Mohammadian and Koldeh (2010) indicated that, there were no significant differences in SSC of Abbott, Allison and Hayward after one month post harvesting time, but at harvest time, Allison and Hayward showed the highest and lowest SSC (9.2 and 6, respectively). Wismer et al. (2005) reported that, SSC of Hayward was 14.5%. In addition, Özcan (1995) mentioned that SSC of Hayward was 15% at ripening time.

Vitamin C

In the present study, the differences among the cultivars in Vitamin C were statistically significant (Figure 1). We found that vitamin C content ranged from 52.38 to 78.00 mg ascorbic acid /100 g f.w. According to previous studies, vitamin C content of the Hayward cultivar was obtained as 65.12 to 102 mg/100 g, at harvest (Cotter et al., 1991; Basim and Uzun, 2003; Guldas, 2003). Fruits of Elmwood and Monty contained the highest concentrations of ascorbic acid, followed by Hayward and Tere, and fruits of Abbott and Bruno contained the lowest amounts. The results obtained in this study regarding vitamin C content are in agreement with a previous report by Ferguson and MacRae (1991). They reported that fruit of Allison and Abbott had the lowest concentrations of ascorbic acid. Nishiyama et al. (2004) indicated that, fruit of Abbott contained the lowest concentration of ascorbic acid and that Hayward cultivated in Japan contained 65.5 mg of ascorbic acid per 100 g fw.

In addition, Popovic et al. (2002) on four kiwifruit cultivar, found that Abbott fruit had the lowest concentration of ascorbic acid. In contrast, Ferguson and MacRae (1991), Popovic et al. (2002), Nishiyama et al. (2004) and Zolfaghari and Sahari (2010) reported that, fruits of Bruno contained the highest concentrations of ascorbic acid. Kauchnatowicz and Nadola (1998) reported that vitamin C content in kiwifruit was 59 mg per 100 g of edible part (Nishiyama et al., 2004). According to a previous study, Latocha (2007) indicated that, the level of vitamin C was not constant and could be affected by growing conditions, such as soil, fertilization, irrigation, temperature and the genotype themselves.

Conclusion

According to the results from this study regarding yield per vine, pomological characteristics and vitamin C content, these cultivars showed differences from each other. Hayward, the most common commercially available cultivar, was found to be the most promising cultivar because of its high yield, large fruit and high vitamin C content. Bruno cultivar is noted for its high yield. The results obtained in this study regarding vitamin C content demonstrated that *A. deliciosa* fruits are excellent sources for vitamin C. In our results, fruit of *A. deliciosa* had a vitamin C content ranging from 52.38 to 78.00 mg ascorbic acid /100 g f.w. When all results are considered, we suggest that Hayward and Bruno are the most successful under the growing conditions of this region.

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