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Organic Acids and Sugar Compositions of Some Loquat Cultivars (*Eriobotrya japonica* L.) Grown in Turkey

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ABSTRACT

Acidity and sugar contents of loquat fruits are one of the main quality properties for fresh consumption and for processing to juice, jam, marmalades etc. In this study, the main organic acid and sugar profiles of 15 loquat cultivars grown in Turkey were determined. The fruits were harvested at commercial maturity and analyzed without delay. The content of water soluble solids changed between 10.92 (Bassel Brown) and 14.58 °Bx (Champagne de Grasse). Titratable acidity expressed as malic acid ranged from 0.72% (Champagne de Grasse) to 1.25% (Dr.Trabut). The source of 72.31% of titratable acidity was organic acids. The malic acid was the major organic acid. The minimum and maximum levels of organic acids were between 14.96 (Ottowiani) and 26.57 mg kg^{-1} (Uzun Çukurgöbek) for oxalic acid, 40.88 (Kanro) and 89.54 mg kg^{-1} (Ottowiani) for tartaric acid, 368.56 (Champagne de Grasse) and 842.49 mg kg^{-1} (Taza) for malic acid, 6.24 (Gold Nugget) and 14.71 mg kg^{-1} (Sayda) for citric acid, and 10.39 (Madam Maria) and 28.68 mg kg^{-1} (Akko XIII) for succinic acid. Sugars were the main (94.53%) contributor to soluble solids. Glucose was the predominant sugar (6.62%) in fruits. Champagne de Grasse had the highest glucose (7.48%) and fructose (5.45%) content while Gold Nugget had the lowest glucose (5.92%) and Taza had the lowest fructose (3.88%) contents. The results could help to select the cultivar for growing, for fresh fruit consumption or for industrial processing.

Keywords: *Eriobotrya japonica* L.; Loquat; Organic acids; Sugar composition

Türkiye'de Yetiştirilen Bazı Yenidünya Çeşitlerinin (*Eriobotrya japonica* L.) Şeker ve Organik Asit Bileşimi Kompozisyonu

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ÖZET

Asitlik ve şeker kompozisyonu meyve ve sebzelerin taze olarak tüketilmesinin yanında meyve suyu, reçel marmelat gibi ürünlere işlenmesi sırasında dikkate alınan önemli kalite parametrelerindendir. Bu çalışmada Türkiye'de yetiştirilen 15 adet yenidünya çeşidinin temel organik asit ve şeker komposizyonları belirlenmiştir. Meyveler ticari hasat olgunluğuna ulaştığında derilmiş ve bekletilmeden analizler gerçekleştirilmiştir. Suda çözünür kuru madde miktarı 10.92 (Bassel Brown) ile 14.58 °Bx (Champagne de Grasse) arasında değişmiştir. Malik asit cinsinden hesaplanan titre edilebilir asitlik değeri % 0.72 (Champagne de Grasse) ve % 1.25 (Dr. Trabut) aralığında bulunmuştur. Titre edilebilir asitlik % 72.31 oranında incelenen organik asitlerden kaynaklanmıştır. Malik asit baskın organik asittir. İncelenen organik asitlerden; okzalik asit 14.96 mg kg^{-1} (Ottowiani) - 26.57 mg kg^{-1} (Uzun Çukurgöbek), tartarik asit 40.88 mg kg^{-1} (Kanro) - 89.54 mg kg^{-1} (Ottowiani), malik asit 368.56 mg kg^{-1} (Champagne de Grasse) - 842.49 mg kg^{-1} (Taza), sitrik asit 6.24 mg kg^{-1} (Gold Nugget) -14.71 mg kg^{-1} (Sayda) ve süksinik asit 10.39 mg kg^{-1} (Madam Maria) - 28.68 mg kg^{-1} (Akko XIII) arasında değişmiştir. Suda çözünen kuru maddenin % 94.53'ünü şekerler oluşturmaktadır. Glikoz meyvelerde tespit edilen ana şeker olup ortalama % 6.62 oranında bulunmuştur. Champagne de Grasse çeşidi en yüksek glikoz (% 7.48) ve fruktoz (% 5.45) içeriğine sahipken, en düşük glikoz ve fruktoz değerleri sırasıyla Gold Nugget (% 5.92) ve Taza (% 3.88) çeşitlerinde görülmüştür. Sonuçlar yetiştiricilik, taze tüketim ve endüstriyel gıda işlemesi açısından çeşit seçiminde yararlı olacaktır.

Anahtar Kelimeler: *Eriobotrya japonica* L.; Yenidünya; Organik asit; Şeker bileşimi

1. Introduction

Loquat (*Eriobotrya japonica* L.) is a subtropical fruit, belongs the Rosaceae family. It originated from China and it has been widely cultivated for commercial purposes. Currently, the main loquat producers are China and Spain, producing nearly 200 000 and 42 000 tones respectively, followed by Turkey, Pakistan, India, Italy and Brazil. So far, it has been grown more than 30 countries of the world (Caballero & Fernandez 2003; Hasegawa et al 2010; Hussain et al 2011). Beside the fresh consumption, the fruits have been used as one of the main ingredients in various processed foodstuffs such as jam, marmalades, nectar, canned foods, yogurt etc. (Kazunori et al 2007; Hong et al 2008, Temiz et al 2012).

Today, not only taste and price but also health concern, owing to the vital nutrient content of fruits, has great importance on consumer preferences. There have been numerous evidences that the sufficient and balanced consumption of fruits and vegetables can provide protection against various diseases (Cao et al 2009). Along the delicious taste and refreshing flavor, loquat fruits contain a host of active phytochemicals which contribute to health. These compounds have pronounced antioxidant and free radical scavenging agents that could lower the incidence of degenerative diseases such as cancer, arthritis, arteriosclerosis, heart disease, inflammation, brain dysfunction, cardiovascular disease, lung cancer and acceleration of the aging process (Neuhouser et al 2003; Kazunori et al 2007; Xu & Chen 2011).

In fruits, many metabolic changes induce the development of color, texture and flavor. These changes not only increase the consumer acceptability on fruits by establishing the nutritional and sensorial quality but also provide the development of shelf life of the fruit. Variations of organic acid concentrations are one of the examples of these metabolic changes. They are major determinants of fruit taste and flavor which constitutes the organoleptic properties (Ding et al 1997; Cao et al 2009; Chen et al 2009; Xu et al 2010). During ripening, the concentration of organic acids decreases since they are used as a source of energy for respiratory metabolism, and also they may be used as a carbon source for the production of sugars which contributes to the sweetness of the fruit. The main sugars that accumulate during ripening are glucose, fructose and sucrose (Hasegawa et al 2010).

Several studies made on organic acid and sugar composition of loquat cultivars showed that malic acid is the predominant organic acid followed by tartaric, quinic, citric, succinic, fumaric and oxalic acids. Fructose and glucose are the most abundant sugars, and the others are sucrose, maltose and sorbitol (Serrano et al 2003; Tian et al 2007; Amoros et al 2008; Chen et al 2009; Pande & Akoh 2010; Xu et al 2010). Other studies showed that cultivar, ecology, cultivation techniques, harvest date etc. affect these properties (Amoros et al 2003; Freihat et al 2008; Chen et al 2009; Faria et al 2009; Xu & Chen 2011).

Today, many farmers try to cultivate earlier or later maturing fruits species or cultivars in order to increase their economic profit. There are limited number of fruit species when loquats come into the market, thus it provides higher income to growers (Temiz et al 2012). Therefore growers have been attracted by loquats recently. There are more than 50 loquat cultivars which have been cultivated in the world and some of them have been grown in Turkey (Demir 1987; Topuz 1998; Karadeniz 2003; Polat et al 2005). Although a few of them have been studied, there is no study about the evaluation and comparison of the organic acid and sugar compositions of loquat cultivars used in this study. The aim of this study was to determine and compare the organic acid and sugar compositions of fifteen loquat cultivars. The results would be useful for growers and food industry for choosing the appropriate cultivars in their production, and also may provide information for subsequent studies.

2. Material and Methods

The fruits of Sayda, Hafif Çukurgöbek (early), Akko XIII, Uzun Çukurgöbek, Bessel Brown, Ottowiani, Taza and Madam Maria (mid-season), Gold Nugget, Champagne de Grasse, Saint Michel, Victor, Baffico, Kanro, Dr. Trabut (late) cultivars located in Collection Orchard of Batı Akdeniz Agricultural Research Institute in Antalya were used in this study. The fruits were harvested at optimum commercial harvest date in 2011. The fruits were sampled from 15 years old trees which were treated by standard horticultural practices. The samples were transferred to the laboratory immediately.

The analyses were made on edible parts of the fruit. Water soluble solids of the samples were measured as Brix (°Bx) using a digital refractometer (A. Krüss Optronic GmbH, DR6000 series, Germany) at 25°C. Titratable acidity and pH of the samples were measured using a digital pH meter (WTW Inolab 720, Germany) and digital burette (Brand, Germany) (Cemeroğlu 2007).

For extraction of organic acids, the pulps were mixed with deionized water (1:5), homogenized in ice bath (IKA T 25, Germany) for 1 minute and centrifuged at 5000 rpm (Hettich Universal 32 R, Germany) for 10 minutes at 4°C. Supernatant was filtered through 0.45 µm membrane filter (CHROMAFIL® PET-45/25, Macherey-Nagel, Germany) before injection. The supernatant were analyzed for organic acids by LC 20 AT model HPLC system (Shimadzu Co., Japan) with a diode array detector (DAD, SPD-M20A) (Artık et al 1997). Separation of organic acids was performed on an Inertsil C18 column (5 µm, 250 mm * 4.6 mm, GL Science, Japan). The HPLC elution was carried out at 30°C with isocratic flow of 2% KH_2PO_4, at pH 2.3 adjusted with *o*-phosphoric acid, as mobile phase at a 0.9 mL min^{-1} flow rate and 10 µL injection volumes. The chromatogram was monitored at 214 nm continuously throughout the elution. The calculation of each organic acid was based on the external standard method from the peak area by analytical interpolation in calibration curve and was expressed as mg 100 g^{-1} in fresh weight (FW).

Sugars were extracted from the fruit pulp which was diluted with ultrapure water at a ratio of 1:5. The samples were homogenized for one minute in ice bath, then were centrifuged at 5000 rpm for 10 minutes at 4°C, The sugar contents of fruits were analyzed by LC 20 AT model HPLC system (Shimadzu Co., Japan) with a refractive index detector (RID 10A). Separation of sugar was performed on an Inertsil NH_2 (GL Science, Japan) column (5 µm, 250 mm * 4.6 mm). The HPLC elution was carried out at 25°C with isocratic flow of acetonitril: water (70:30) at a 1.0 mL min^{-1} flow rate and 10 µL injection volumes (Topuz 1998). The calculation of each sugar was based on the external standard method from the peak area by analytical interpolation in a standard calibration curve and was expressed as percentage (%).

Analysis of Variance and Duncan's multiple range test were performed using SAS (SAS version 6.12) to evaluate the significance of differences between the organic acids and sugar compositions of the cultivars ($P<0.05$). The experiment was conducted in randomized design with three replications. The fruits were harvested and pooled from 3 trees. Ten fruits were used for each replication and analyses were carried out in parallel. Data was expressed as means ± standard error (SE).

3. Results and Discussion

The average water soluble solids (SS) content, pH and titratable acidity values for loquat cultivars were given in Table 1. There were large variations for these parameters among the cultivars. The SS contents changed between 10.92 and 14.58 °Bx among the cultivars. The cultivar Bassel Brown had the lowest SS content while Champagne de Grasse had the highest. The pH of the fruits was measured between 3.46 (Uzun Çukurgöbek) and 4.28 (Champagne de Grasse) among the cultivars. The titratable acidity expressed as malic acid was recorded between 0.72% (Champagne de Grasse) and 1.25% (Dr.Trabut). Several studies showed the change in SS, pH and titratable acidity in different loquat cultivars that SS and titratable acidity ranged from 8.97% to 14.0% and from 0.37% to 1.46%, respectively (Özdemir & Topuz 1997; Polat et al 2005; Durgaç et al 2006).

Organic acid and sugar compositions are basic parameters in fruits and the balance between them is very important due to direct effects of them on taste and flavor and hence on fresh consumption, industrial processing such as jam, jelly, canned food etc. production (Topuz 1998; Hasegawa et al 2010). Cultivar, harvest date, ecology, cultivation techniques directly affect these parameters (Amaros et al 2003; Chen et al 2008). The organic acid compositions of loquat cultivars were given in Table 2. The total amount of organic acids showed large

Table 1- The water soluble solids (SS), pH and titratable acidity contents of loquat cultivars

Çizelge 1- Yenidünya çeşitlerinin suda çözünür kuru madde (SS), pH ve titrasyon asitliği değerleri

Cultivar	*SS (°Bx)*	*pH*	*Titratable acidity (%)*
Saint Michel	10.95	3.92	0.75
Taza	11.85	3.51	1.21
Dr. Trabut	11.35	3.53	1.25
Gold Nugget	10.93	3.53	1.22
Kanro	11.70	4.26	0.74
Champagne de Grasse	14.58	4.28	0.72
Hafif Çukurgöbek	13.25	3.56	1.21
Victor	11.43	3.83	0.77
Bassel Brown	10.92	3.89	0.76
Sayda	13.68	3.57	1.21
Ottowiani	11.15	3.55	1.10
Madam Maria	11.83	3.87	0.73
Baffico	12.78	3.78	0.83
Akko XIII	11.95	3.72	0.86
Uzun Çukurgöbek	14.18	3.46	1.12
Average	12.17	3.75	0.95

variation and it changed from 464.53 mg 100 g^{-1} (Madam Maria) to 971.86 mg 100 g^{-1} (Taza). We found that 72.31% of the titratable acidity in average originated from the organic acids and this ratio ranged from 64.25% (Madam Maria) to 79.79% (Taza) among the cultivars.

Our results showed that organic acid compositions of the cultivars changed significantly. The cultivars Taza, Sayda and Dr.Trabut had higher organic acids content than other cultivars (Table 2). Malic acid was predominant organic acid as in other studies (Ding et al 1997; Topuz 1998; Amoros et al 2003; Serrano et al 2003; Tian et al 2007; Chen et al 2008; Hasegawa et al 2010), and it was followed by tartaric, succinic, oxalic and citric acids, respectively.

The malic acid levels ranged from 368.56 to 842.49 mg 100 g^{-1} among the cultivars. Taza was the richest (842.49 mg 100 g^{-1}) while Champagne de Grasse was the poorest (368.56 mg 100 g^{-1}) cultivars in malic acid. Researchers found various concentrations in different cultivars such as 250-850 mg 100 g^{-1} by Serrano et al (2003), 129.9-891.2 mg 100 g^{-1} by Chen et al (2008) and 587.97 - 988.05 mg 100 g^{-1} by Hasegawa et al (2010). The ratio of malic acid to total organic acids changed between 76.96% (Akko XIII) and 87.78% (Sayda), and the average was 82.34% which was very close to 83% as previously reported in some varieties by Shaw & Wilson (1981). Besides the genotype, differences in malic acid concentrations could be resulted from ecology, cultivation techniques, harvest date etc.

Table 2- Organic acid compositions (mg 100 g^{-1} FW) of loquat cultivars (means ± SE)

Çizelge 2- Yenidünya çeşitlerinin organik asit bileşimi (mg 100 g^{-1} Taze Ağırlık) (ortalama ± standart hata)

Cultivar	*Oxalic acid*	*Tartaric acid*	*Malic acid*	*Citric acid*	*Succinic acid*	*Total*
Saint Michel	17.50±0.39 gh*	71.99±0.35 e	421.34±0.16 gh	8.57±0.91 ef	14.91±0.17 g	534.35±0.47 k
Taza	16.24±0.21 i	81.01±0.11 c	842.49±0.05 a	14.76±0.14 a	17.36±0.34 fg	971.86±0.29 a
Dr.Trabut	24.29±0.36 b	84.82±0.56 b	779.97±0.83 b	12.45±0.48 bc	27.06±0.25 bc	928.60±0.57 c
Gold Nugget	18.35±0.48 fg	67.72±0.07 fg	718.09±0.05 d	6.23±0.16 g	25.59±0.17 bcd	835.99±0.26 f
Kanro	23.36±0.12 c	40.88±0.04 i	415.71±0.98 h	12.76±0.08 bc	24.36±0.94 cde	517.07±0.61 l
Champagne de Grasse	22.25±0.31 d	55.55±0.12 h	368.56±0.17 i	9.59±0.32 de	21.66±0.81 e	477.61±0.53 n
Hafif Çukurgöbek	19.32±0.31 e	87.98±0.56 ab	753.46±0.81 c	10.08±0.03 de	30.79±0.69 a	901.64±0.77 d
Victor	19.04±0.15 ef	68.66±0.41 efg	424.96±0.79 fgh	9.61±0.05 de	22.51±0.64 de	544.79±0.59 j
Bassel Brown	18.99±0.08 ef	58.60±0.39 h	384.30±0.63 i	6.68±0.11 g	28.71±0.28 ab	497.29±0.33 m
Sayda	19.80±0.28 e	70.11±0.42 ef	832.76±0.57 a	14.71±0.80 a	11.27±0.63 h	948.65±0.71 b
Ottowiani	14.76±0.39 j	89.54±0.75 a	719.53±0.98 d	11.12±0.11 cd	11.75±0.79 h	846.69±0.83 e
Madam Maria	16.74±0.22 hi	65.39±0.58 g	364.93±0.83 i	7.09±0.27 fg	10.38±0.56 h	464.53±0.58 o
Baffico	18.86±0.16 ef	77.51±0.52 d	451.95±0.93 f	10.21±0.94 de	17.39±0.22 fg	575.92±0.75 hi
Akko XIII	18.35±0.29 fg	76.85±0.02 d	445.46±0.95 fg	9.47±0.13 de	28.68±0.71 ab	578.82±0.62 h
Uzun Çukurgöbek	27.24±0.31 a	85.62±0.91 b	683.02±0.92 e	13.92±0.83 ab	18.63±0.45 f	828.42±0.86 g
Average	19.68±3.31	72.15± 13.47	573.77±187.35	10.48±2.78	20.74±6.79	696.82±197.49

*, Different letters in the same column indicate significant difference between values at the $P<0.05$ level.

Tartaric acid was the second predominant organic acid in loquat cultivars. The average of tartaric acid quantity was 72.15 mg 100 g^{-1}. Ottowiani had the highest (89.54 mg 100 g^{-1}) whereas Kanro had the lowest (40.88 mg 100 g^{-1}) tartaric acid content. Tian et al (2007) and Chen et al (2008) reported wider variation in tartaric acid content which changed between 24.5 and 99.4 mg 100 g^{-1} in different loquat cultivars. The average oxalic acid content was 19.68 mg 100 g^{-1}, and it was changed between 14.76 mg 100 g^{-1} (Ottowiani) and 27.24 mg 100 g^{-1} (Uzun Çukurgöbek). Tian et al (2007) and Pande & Akoh (2010) reported oxalic acid content between 4.80 and 25.9 mg 100 g^{-1} in loquat cultivars. Citric and succinic acids were found at lower quantities in loquat cultivars. The citric acid content ranged from 6.23 mg 100 g^{-1} (Gold Nugget) to 14.71 mg 100 g^{-1} (Sayda) and the succinic acid content varied between 10.38 mg 100 g^{-1} (Madam Maria) and 28.68 mg 100 g^{-1} (Akko XIII). In contrary to the tartaric and oxalic acids, there are more studies on citric and succinic acids. The reported values changed between 11.91 and 150.14 mg 100 g^{-1} in citric acid (Ding et al 1997; Tian et al 2007; Chen et al 2008; Amoros et al 2008; Hasegawa et al 2010) and between 5.2 and 40 mg 100 g^{-1} in succinic acid in loquats (Ding et al 1997; Amoros et al 2008; Hasegawa et al 2010).

Sugar compositions of loquat cultivars were given in Table 3. Total sugars, contributed 94.53% of water soluble solids in average. Depending on the variety, this ratio ranged from 91.42% (Taza) to 96.23% (Dr.Trabut). The total sugar content was between 10.92% in Bassel Brown, which had the lowest SS content, and 13.91% in Champagne de Grasse, which had the highest SS content. Topuz (1998) reported that total sugar contents of Hafif Çukurgöbek, Uzun Çukurgöbek, Yuvarlak Çukurgöbek, Tanaka, Akko XIII, Gold Nugget and Armudi cultivars changed between 8.48% and 12.07%. The cultivar Champagne de Grasse stands out for its sugar content that it had the highest glucose, fructose, sucrose and maltose contents. The cultivars Madam Maria, Baffico and Uzun Çukurgöbek were other important cultivars for their high sugar contents. In contrary, Gold Nugget,

Table 3- Sugar compositions (%) of loquat cultivars (means ± SE)

Çizelge 3- Yenidünya çeşitlerinin şeker bileşimi (%) (ortalama ± standart hata)

Cultivar	*Glucose*	*Fructose*	*Sucrose*	*Maltose*	*Total*
Saint Michel	6.79±0.72 d*	4.41±0.31 g	0.013±0.003 def	0.132±0.012 cd	11.337±0.14 cd
Taza	6.02±0.82 g	3.88±0.47 k	0.006±0.001 efg	0.105±0.011 de	10.011±0.09 h
Dr.Trabut	6.46±0.92 e	4.06±0.72 j	0.006±0.001 efg	0.111±0.009 cde	10.633±0.11 efgh
Gold Nugget	5.92±0.60 g	4.21±0.71 i	0.012±0.001 defg	0.126±0.012 cde	10.271±0.22 gh
Kanro	6.32±0.63 f	4.53±0.39 f	0.005±0.001 fg	0.114±0.016 cde	10.977±0.23 ef
Champagne de Grasse	7.48±0.73 a	5.45±0.49 a	0.704±0.062 a	0.278±0.023 b	13.906±0.26 a
Hafif Çukurgöbek	6.62±0.95 e	4.57±0.47 def	0.010±0.001 defg	0.114±0.014 cde	11.312±0.32 cde
Victor	5.97±0.50 g	4.34±0.22 h	0.159±0.031 b	0.343±0.028 a	10.812±0.18 defg
Bassel Brown	6.85±0.49 d	4.88±0.62 b	0.011±0.004 defg	0.127±0.012 cde	11.863±0.13 bc
Sayda	6.52±0.82 e	4.58±0.51 de	0.045±0.09 g	0.098±0.08 a	11.193±0.17 cde
Ottowiani	5.99±0.71 g	4.36±0.21 h	0.015±0.002 d	0.131±0.013 cd	10.490±0.21 fgh
Madam Maria	7.42±0.91 a	4.61±0.72 cd	0.015±0.004 d	0.139±0.009 c	12.177±0.24 b
Baffico	7.05±0.99 c	4.91±0.23 b	0.013±0.002 de	0.130±0.014 cd	12.105±0.29 b
Akko XIII	6.61±0.41 e	4.56±0.42 ef	0.025±0.003 c	0.119±0.005 cde	11.315±0.19 cde
Uzun Çukurgöbek	7.27±0.78 b	4.63±0.31 c	0.028±0.004 c	0.111±0.006 cde	12.041±0.16 b
Average	6.62±0.52	4.53±0.38	0.07±0.18	0.15±0.07	11.363±0.97

*, Different letters in the same column indicate significant difference between means at $P<0.05$

Ottowiani and Dr. Trabut had the lowest sugar content. Our results showed that sugar compositions changed significantly from cultivar to cultivar. Glucose and fructose were found predominant sugars while the amount of sucrose and maltose were considerably low. Our results were similar to that of Topuz (1998) and Xu &Chen (2011) that they found glucose and fructose main sugars in loquats. However, several studies reported that sucrose was the dominant sugar (Hirai 1980; Shaw & Wilson 1981; Bantog et al 1999).

The average glucose content was 6.62% among the cultivars. Champagne de Grasse had the highest glucose content (7.48%) while Gold Nugget had the lowest (5.92%). Fructose was the second important sugar for loquats that the content changed between 3.88% (Taza) and 5.45% (Champagne de Grasse). The amounts of glucose and fructose were similar to that of Topuz (1998). However they were higher than the values reported by Xu & Chen (2011) where glucose and fructose contents of 12 loquat cultivars quantified between 30.0 mg g^{-1} and 53.6 mg g^{-1}, and 35.9 mg g^{-1} and 54.2 mg g^{-1} respectively (Xu & Chen 2011). Shaw & Wilson (1981) found that the glucose content of varieties changed from 1.6% to 3.0% while the amount of the fructose ranged from 2.3% to 4.8%. Amount and composition of sugars in loquat generally changed with cultivars, maturation level, cultivation techniques, ecology and also some factors such as amount of fruit per panicle, purple spots, fruit thinning etc. in loquat (Hirai 1980; Cemeroğlu et al 2001; Gariglio et al 2003).

4. Conclusions

The organic acid compositions and sugar profiles of fifteen cultivars were evaluated in this study. The change in these parameters were found statistically important ($P<0.05$). The cultivar Champagne de Grasse has the highest sugar content (13.91%) while Taza stranded out for its malic acid content (842.49 mg 100 g^{-1}). The results may assist breeders to improve the cultivars for based on flavor and taste. And these results may help the industry, food technologist, consumer and growers for choosing the cultivar of interest.

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