Turkish Journal of Agriculture and Forestry

Volume 47 | Number 4 Article 2

8-28-2023

Chemical and biochemical advantages of the 'Hicaznar' pomegranate variety over 'Katina' and 'Suruc' varieties grown in the same ecology

BEKİR EROL AK

DİCLE ROZA SAYİNER

İBRAHİM HALİL HATİPOĞLU

BİRGÜL DİKMETAŞ

Turkish Journal of Agriculture and Forestry

http://journals.tubitak.gov.tr/agriculture/

TÜBİTAK Research Article

Turk J Agric For
(2022) 46: 427-435
© TÜBİTAK
doi:10.55730/1300-011X.3099

Chemical and biochemical advantages of the 'Hicaznar' pomegranate variety over 'Katina' and 'Suruç' varieties grown in the same ecology

Bekir Erol AK*, Dicle Roza SAYINER, İbrahim Halil HATİPOĞLU, Birgül DİKMETAŞ
Department of Horticulture, Faculty of Agriculture, Harran University, Şanlıurfa, Turkey

Received: 09.07.2021 • **Accepted/Published Online:** 21.07.2022 • **Final Version:** 28.08.2022

Abstract: Pomegranate cultivation has spread to various parts of the world. Pomegranate has been grown almost anywhere in the world, mostly in Iran, India, China, Turkey and the United States. 'Hicaznar', 'Katina' and 'Suruç' pomegranate varieties were used as materials in this study. Analyses of antioxidants, sugars, anthocyanins, organic acids, and colourless phenolic compounds in the juices of these fruits were performed by HPLC and DPPH methods. According to our findings, the highest antioxidant capacity was found in 'Hicaznar' variety (19.42 mmol trolox L^{-1}). 'Hicaznar' variety had high sugar composition in terms of glucose, fructose, and total sugars while the sucrose content was high in 'Suruç' variety. For anthocyanin analysis, 'Hicaznar' variety contained higher levels of delfinidin-3.5-diglycoside, cyanidin-3.5-diglycoside, pelargonidin-3.5-diglycoside, cyanidin-3-glycoside, pelargonidin-3-glycoside, and cyanidin-pentoside than those of 'Katina' and 'Suruç' varieties. 'Hicaznar' variety also contained higher malic and L-ascorbic acid. 'Hicaznar' variety had colourless phenol content. The results show that; 'Hicaznar' variety contained higher quality parameters in respect to human health than those of other varieties grown under the same ecological conditions.

Key words: Antioxidant, anthocyanin, organic acid, phenol, physicochemical properties, pomegranate (*Punica granatum* L.)

1. Introduction

Cultivation of the pomegranate dates back to ancient times according to archaeological studies in Asia Minor (Anatolia). It is a tropical and subtropical plant, therefore latitudes of 27°–40° in the Northern and Southern Hemispheres, enables better development in warm ecology, warm winters, and hot rainy summers. Anatolia is located within the borders of the homeland of pomegranate. Extremely rich genetic resources of pomegranate occure in this region naturally. The pomegranate varieties have different properties including from sweet to sour, from red to yellow, from small fruit to large fruit or from hard core to soft seed (Kurt and Sahin, 2013).

Demand for pomegranate and pomegranate products has increased rapidly with the discovery of positive and therapeutic properties on human health in recent studies. Pomegranate and its processed products have started to be consumed in high amounts especially in Europe, Russia, Far East and the USA. In particular, 'Hicaznar' pomegranate variety due to its high organoleptic properties has been used extensively in the pomegranate gardens established in recent years. Most of this production was carried out in the Mediterranean region (Ozguven et al., 1997; Ak et al., 2013).

Being popular in the market in recent years, pomegranate has reached an important position in the world food agenda thanks to its commercial importance. Because the studies on pomegranate have increased, the growing technique, food technology, usage possibilities, storage conditions and suitability for storage, suitability for shipping to the market, and methods have been the subject of scientific studies. With the rapid development and innovation of pomegranate culture; the positive effects of pomegranate in terms of human health with increased area of cultivation and varieties, our local varieties have taken great parts in foreign markets. This study was carried out in local pomegranate varieties commonly grown in Turkey, Şanlıurfa. Some biochemical antioxidants, sugars, anthocyanins features among cultivars were determined to differentiate the cultivars in terms of quality parameters.

2. Materials and methods

2.1. Material

'Hicaznar', 'Katina' and 'Suruç' pomegranate varieties were used as materials in this study. The correct fruits that were obtained during the harvest period were delivered to the laboratory for the analyses.

* Correspondence: beak@harran.edu.tr

2.1.1. Hicaznar

This variety has the highest market value due to its dark skin and aril colour (Figure 1). It has a long shelf life. Storage life is also long and resistant to physical damages. It is among the varieties that have been kept for the longest time. It can be stored in plastic bags for up to 3 months even under ordinary conditions. In addition to these positive features, the negative aspects are the colour problem in some areas, the taste is close to sour, the seeds are hard and the arils are small. In this variety, the fruit size is medium high (350.67 g), the fruit shape is flat (1.21) the peel and arilcolour is claret red, the skin thickness (2.64%), the aril yield is medium (54.6%), the fruit juice yield is low-medium (36.2%). Average acidity was determined as 1.8% in 'Hicaznar' variety (Yilmaz, 2007).

2.1.2. Katina (Siverek)

Katina variety is widely grown around Karacadağ, which is an important area for the Southeastern Anatolia region of Turkey. Fruit size is large (516.88 g), fruit shape (1.18), skin colour is 30% red on yellow ground, aril colour is dark pink, skin thickness is thin (2.58 mm), aril yield is high (67.5%), juice yield is high (48.8%), coarse-aril (47.74) (Figure 1). In 'Katina' variety, the average acidity rate is 1.37%, the core hardness is medium. The productivity status of this variety is high. Cracking in fruits is low. The tree of the 'Katina' variety shows strong growth. Katina pomegranate variety is a Turkish variety that received a geographical indication with the name 'Katina Siverek Pomegranate' in Şanlıurfa, where it is widely grown, in 2020.

2.1.3. Suruç

'Suruç' variety is grown in the Southeastern Anatolia region of Turkey historically which is based on the hanging gardens of Babylon. The type of 'Suruç', which appeals to the palate with its thin skin can be shown as the best table pomegranate varieties in the world. (Figure 1). In studies,

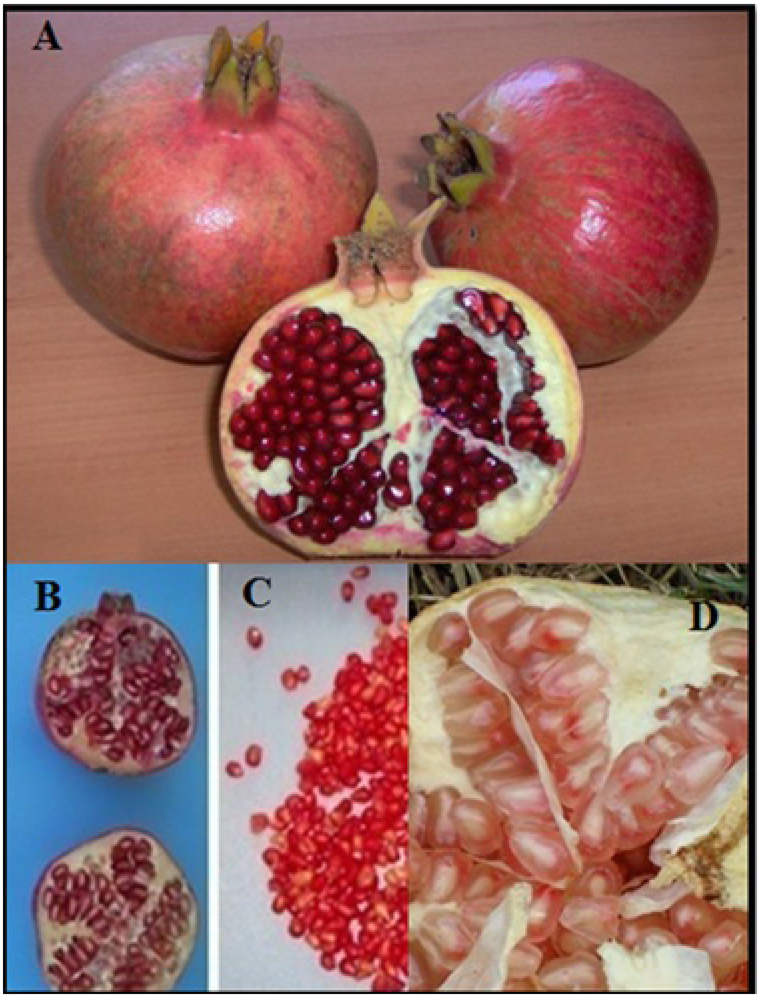


Figure 1. A: Fruits of the 'Hicaznar' pomegranate variety B: Fruits of the 'Katina' variety C: Arils of the 'Katina' variety D: A fruit of the 'Suruç' variety.

it has been shown that the 'Suruç' variety is resistant to many diseases. In a garden where cultivation is carried out under optimum conditions, the aril of pomegranate is approximately 700–1000 g. Approximately 2 to 3 t of product is obtained per acre. It has been observed that the aril of this variety can reach up to 1.5 kg and the product is started to be taken at the age of 3. Since the 'Suruç' variety is an effective fruit against cancer, it is a variety that has a special customer in European markets. 'Suruç', a Turkish variety, received a geographical indication in 2020.

2.2. Methods

Antioxidant determination, sugar analysis, anthocyanin, and organic acid determinations and analysis of colourless phenolics of three different pomegranate varieties were performed.

2.2.1. Determination of antioxdant capacity

DPPH method was used to determine the antioxidant activity in pomegranate juices. Using DPPH (2,2, diphenyl 1-picry-hydrazyl), which measures the free radical blocking capacity, and the change of the reaction occurring in methanol against time, UV-Vis (Agilent-Cary 60) at 515 nm was established according to the measurement in the spectrophotometer (Brand-Williams et al. 1995; Kelebek et al., 2009). According to these data, the absorbance values were calculated with trolox (10–100 mmol L^{-1}) standard slope chart and the results were expressed in mmol L^{-1} trolox. The absorbance values were calculated by trolox (10–100 mmol L^{-1}) standard slope chart and the results were expressed in TEAC (Trolox Equivalent Antioxidant Capacity-Trolox Equivalent Antioxidant Capacity)/100g.

The diphenyl-1-picrihydrazyl (DPPH) radical quenching capacity method is described in detail below. That is a commercially available stable organic nitrogen radical (Brand-Williams et al., 1995; Sanchez et al., 1998; Huang et al., 2005). DPPH radical scavenging capacity analysis methods are widely used to determine the antioxidant activity of natural extracts (Mot et al., 2011). In this method, the proton transfer reaction to DPPH free radical by the antioxidant causes a decrease in absorbance at 517 nm. This stage is based on monitoring the absorbance with a spectrophotometer in the visible area until it stabilizes (Albayrak, 2010). This method is described as a simple, fast, and suitable method for tracking the radical scavenging activity of multiple samples, suitable for the resolution of different samples. However, its sensitivity to light, oxygen, and pollution creates limitations in the use of this method (Mot et al., 2011). To 100 mL of sample extract, 2 mL of 0.1 mmol L^{-1} DPPH (in methanol) was added. After 10 s of shaking, the absorbance at 517 nm was measured following incubation for 30 min in the dark. The results are expressed as mg TEAC/100 g dry matter (Ali et al., 2008; Okan et al., 2013).

2.2.2. Organic acid, sugar and L-ascorbic acid determination

Analyses of sugar and organic acids in pomegranate juices were made following the modification of Kelebek et al. (2011, 2013). For the analysis, 0.3 g of freeze-dried samples were added to 5 mL of 5 mmol L^{-1} sulfuric acid solution then mixed in a mixer for 30 min under nitrogen gas and filtered through 0.45 μm filters. The resulting extract was directly injected into Agilent 1260 model DAD and HPLC with RID detector and the amount of organic acid and sugar in the samples were determined. 5 mmol L^{-1} sulfuric acid solution was used as the carrier phase and the flow rate was adjusted to 0.5 mL min–^{1}. The external standard method was used to determine the sugar concentrations in the samples. For this purpose, calibration solutions of 5 different concentrations were prepared from sucrose, glucose and fructose standards, HPLC analyses were performed, and the amount of sugar was determined using these curves by creating calibration curves from the obtained data. Organic acid concentrations were determined using the same method, using citric, malic, and L-ascorbic acid standards.

2.2.3. Anthocyanin determination

The amounts of total anthocyanin and delfinidin-3.5-diglycoside, cyanidin-3.5-diglycoside, pelargonidin-3.5-diglycoside, cyanidin-3-glycoside, pelargonidin-3-glycoside, cyanidine-pentoside in the juices of pomegranate fruit were analyzed by HPLC method (Lee and Wrolstat, 2004; Turfan, 2008; Kelebek et al., 2009).

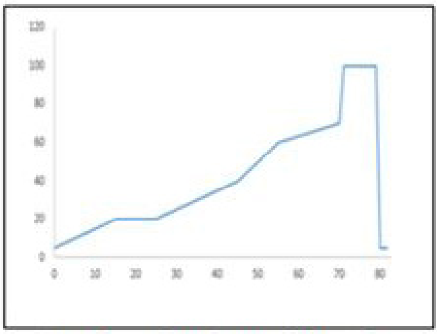
2.2.4. Analysis of phenolic compounds

High performance liquid chromatography (LCDAD-ESI-MS/MS) with Agilent brand 6430 model Triple Quadrupole mass spectroscopy (Agilent Technologies, Palo Alto CA-USA) was used to identify and determine the phenolic compounds. Analyzes of phenolics and anthocyanins were applied in the method of Kelebek and Şelli (2011 and 2013) with changes at various stages.

In the first step; pomegranate juice samples were passed through 0.45 μm membrane filters and injected into LCMS/MS. Analyzes were performed with 3 replications. In the second step; freeze-dried samples (0.4 g) were taken and 5 mL of methanol/water (80/20; v/v) was added and extracted at 250 rpm for 30 min. At the end of this period, the solvent was removed and the same processes were repeated with new solvent. In the identification of phenolic compounds, retention times, DAD spectra, and LC-MS/MS analyses obtained by injection of standard substances were performed (Kelebek et al, 2010).

Whether the peaks of phenolic compounds contain impurities or not was determined by comparing the spectrum obtained for the sample with the spectrum of the standard substance (Figure 2).

Duration (Minutes)	% A	% B
0	95	5
10	85	15
15	80	20
25	80	20
45	60	40
55	40	60
70	30	70
71	0	100
79	0	100
80	95	5
82	95	5



Time dependent change of phase B

Figure 2. Time and change with time used in HPLC analysis of phenolic compounds.

The exact overlap of these spectra with each other is evaluated as an indication that the detected phenolic compound peak does not contain any impurities. Identification of compounds was carried out in negative mode using LC-MS/MS. Negative mode phenol acids, flavanols and flavonols have been identified. In the study, capillary temperature was selected as 400 °C, capillary voltage-3V, nebulizer gas flow 1.75 L/min, dissolution gas flow 1 L/min and spray voltage 5 kV. In the study, scanning was carried out in the mass range of 100–2000 amu. In order to determine the amounts of phenol compounds, a solution of five different concentrations was prepared for each standard substance and calibration curves were created for each compound by injecting them into HPLC. The amounts of the compounds were also determined from these curves. In the analysis; C18 ODS (25 × 4.6 mm × 5µ) column, 20 µL injection, water/formic acid (95: 5, v/v) and methyl alcohol/formic acid (95/5, v/v), 0.5 mL/min flow rate, 360 and 520 nm wavelengths were used. A diode array detector is used as the detector type.

3. Results

3.1. Antioxidant capacity (mmol trolox L^{-1})

Findings for the 'Hicaznar', 'Katina' and 'Suruç' varieties are summarized (Table 1 and Figure 3). The antioxidant capacity of the varieties we used was determined by the DPPH method. 'Hicaznar' variety had the highest antioxidant capacity (19.42 mmol trolox L^{-1}). This was followed by 'Katina' (9.76 mmol trolox L^{-1}) and 'Suruç' (4.70 Mm trolox/L). In the statistical analysis, the averages of the three varieties in both 5% and 1% comparisons were placed in different groups from each other.

Table 1. Antioxidant capacity of pomegranate juices (mmol L^{-1} trolox/L).

Antioxidant capacity	AVERAGE** mmol L^{-1} trolox
Hicaznar	$19.42 \pm 0.41^{a*}$
Katina	9.76 ± 0.05^{b}
Suruç	4.70 ± 0.01^{c}
AVERAGE	11.29
LSD(% 5)	0.476
LSD (%1)	0.721

*: The difference between the averages with different letters on the same column is statistically significant ($p < 0.05$ and $p < 0.01$).**: It is the average of 3 replicates.

3.2. Sugar composition (g/L)

Sucrose, glucose, fructose, and total sugar contents of pomegranate varieties were given in Table 2 and Figure 4. 'Suruç' variety had the highest value (2.10) in terms of sucrose, followed by 'Katina' with (1.66) and 'Hicaznar' with (0.74) value. If a ranking is made in terms of glucose content; 'Hicaznar' with (42.75), 'Katina' with (33.49) and 'Suruç' with (32.23). 'Hicaznar' variety had the highest value (44.50). It was determined that only the 'Hicaznar' variety had differed significantly from those of the other varieties. Cemeroglu et al. (2004) determined some composition elements in pomegranate juices obtained by pressing with their skins from 120 different samples obtained from different regions. He stated that the average glucose ratio in the composition of pomegranates is 64.8. However, the values obtained in this study were found to be lower. On the other hand, similar results are valid for fructose.

3.3. Anthocyanin compounds (mg/L)

Anthocyanin compounds such as; delfinidin-3.5-diglycoside, cyanidin-3.5-diglycoside, pelargonidin-

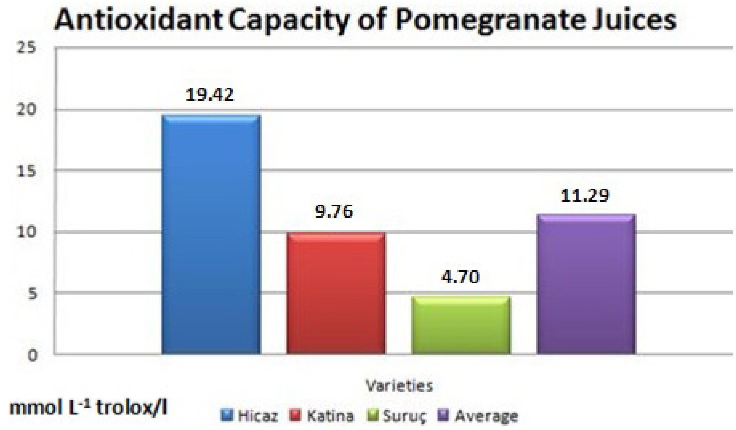


Figure 3. Antioxidant capacities of varieties.

Table 2. Sugar compositions of pomegranate juices (g/L).

	Hicaznar	**Katina**	**Suruç**	**LSD (% 5)**	**LSD (% 1)**
Sucrose	0.74 ± 0.04^{c}	1.66 ± 0.05^{b}	2.10 ± 0.59^{a}	0.080	0.121
Glucose	42.75 ± 0.38^{a}	33.49 ± 0.61^{b}	32.23 ± 7.19^{b}	0.833	1.262*
Fructose	44.50 ± 0.44^{a}	35.22 ± 6.53^{b}	36.16 ± 0.48^{b}	0.759	1.150*
Total	87.99 ± 0.83^{a}	71.32 ± 1.14^{b}	69.56 ± 13.12^{b}	1.636	2.479*
G/F	0.96 ± 0.00^{a}	0.92 ± 0.03^{b}	0.91 ± 0.01^{b}	0.008	0.012

*: Classification is made according to LSD %1. The difference between the averages bearing different letters in the same row is statistically significant ($p < 0.05$ and $p < 0.01$)

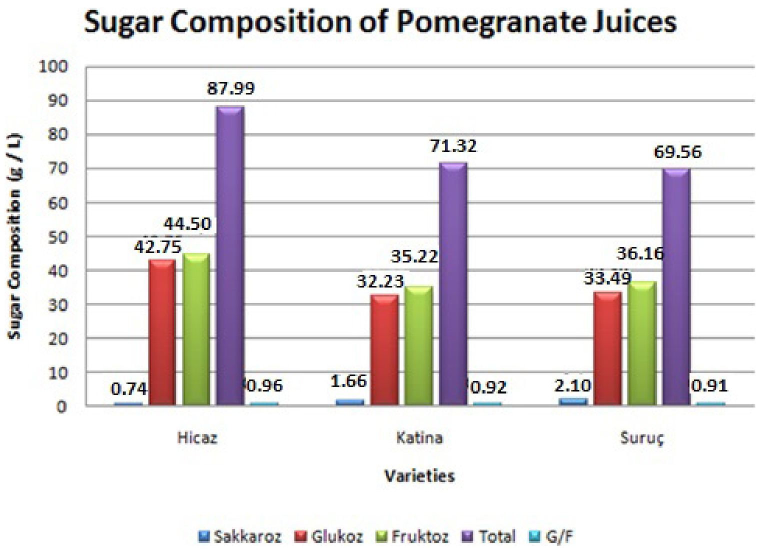


Figure 4. Comparison of different sugar ratios in different pomegranate varieties.

3.5-diglycoside, cyanidin-3-glycoside, pelargonidin-3-glycoside, and cyanidin-pentoside were analyzed. When the total anthocyanin content was examined, it was determined that the 'Hicaznar' variety had 121.36 mg/L, followed by the 'Suruç' variety with 17.15 mg/L. On the other hand, the total anthocyanin in the 'Katina' variety was determined to be 5.41 mg/L^{-1} (Table 3). Aviram et al. (2005) carried out various studies on pomegranate and declared the amount of anthocyanin in pomegranate was 121 mg/L (Du et al., 1970). They indicated the anthocyanins pelargonidin, delphinidin and cyanidin-3-glycoside and 3,5 diglycoside in pomegranate juice. Gil et al. (2000), on the other hand, in a study using HPLC technique, 42% of the anthocyanins in pomegranate juices obtained from arils were Cy-3-glu, 25% Dp-3-glu, 17% Cy-3. It was determined that 5-diglu was composed of 14% Dp-3,5-diglu and 2% Pg-3-glu. They stated that cyanidin 3-glycoside is the main anthocyanin of pomegranate juice with 59.5–128 mg/L. He observed the anthocyanin results obtained by Ozkan (2009) with spectrophotometer and found that the amount of anthocyanin in the protein consisting of a single polypeptide chain in unprocessed water varied between 46 and 405 mg L–1. It has been determined that the dominant anthocyanin in pomegranate juices is Cy-3,5-diglu. 'Hicaznar' variety, which is among the indispensables of the fruit juice industry, was investigated; it has been determined that 56% of the anthocyanins in pomegranate juices are Cy-3,5-diglu and 25% is Cy-3-glu. The remaining 18% was found to be distributed as 9% Dp-3,5-diglu, 4% Dp-3-glu, 3% Pg-3,5-diglu, and 2% Pg-3-glu.

3.4. Organic acid and L-ascorbic acid compounds

The findings of the composition of organic acids made in fruit juices of the 'Hicaznar', 'Katina' and 'Suruç' pomegranate varieties used in the study are given in Table 4. Although there is a statistically significant difference between the varieties in terms of citric acid, it is seen that there is not a big difference (6.08 g/L–7.01 g/L) between the numbers. The lowest value was found in 'Suruç' variety with 0.16 g/L and the highest value was in 'Hicaznar' variety with 0.75 g/L (Figure 5). Again, when the L-ascorbic acid (Vitamin C) values were examined, it was determined that 'Hicaznar' was the highest (53.24 mg/100 mL). These values show that the 'Hicaznar' pomegranate variety is particularly suitable for making pomegranate syrup, while the other varieties are suitable for table use. Cemeroglu et al. (2004) determined some composition elements in pomegranate juices obtained by pressing with their skins from 120 different samples obtained from different regions. It has been determined that the composition elements of pomegranates vary widely between samples. For example, citric acid ranged from 5.47–32.8 g L^{-1} in some samples and the content of citric acid varied between 6.08 and 7.01. These values are in agreement with the findings of Cemeroglu et al. (2004).

The findings obtained in terms of malic acid content are also in agreement. In the 'Hicaznar' variety, which has an important place in the industry, the percentage of organic acid in fruit juice was examined and it was found that 73.9% whereas citric acid and 9.3% was malic acid, 8.9% succinic acid, 7.9% unidentified organic acid and

Table 3. Anthocyanin content of different pomegranate varieties (mg/L).

Anthocyanin contents	Hicaznar	Katina	Suruç	LSD (% 5)	LSD (% 1)
Delfinidin-3.5-diglycoside	6.82 ± 0.01[a]	0.53 ± 0.00[c]	1.35 ± 0.01[b*]	0.016	0.025
Cyanidin -3.5- diglycoside	29.84 ± 0.02[a]	1.75 ± 0.01[c]	4.81 ± 0.02[b]	0.035	0.053
Pelargonidin-3.5- diglycoside	9.30 ± 0.01[a]	0.73 ± 0.01[c]	2.12 ± 0.02[b]	0.027	0.042
Cyanidin-3-glycoside	67.84 ± 0.02[a]	2.07 ± 0.01[c]	7.80 ± 0.02[b]	0.036	0.054
Pelargonidin-3- glycoside	5.28 ± 0.01[a]	0.10 ± 0.00[c]	0.60 ± 0.00[b]	0.013	0.020
Cyanidin-pentoside	2.28 ± 0.01[a]	0.24 ± 0.00[c]	0.46 ± 0.01[b]	0.022	0.033
Total	121.36 ± 0.07[a]	5.41 ± 0.03[c]	17.15 ± 0.06[b]	0.118	0.179

*: The difference between the averages with different letters in the same row is statistically significant ($p < 0.05$ and $p < 0.01$)

Table 4. Citric, malic, and L-ascorbic acid contents of different pomegranate varieties.

Organic acids	Hicaznar	Katina	Suruç	LSD (% 5)	LSD (% 1)
Citric acid (g/L)	6.57 ± 0.07[b]	6.08 ± 0.03[c]	7.01 ± 0.07[a*]	0.119	0.181
Malic acid (g/L)	0.71 ± 0.02[a]	0.50 ± 0.00[b]	0.16 ± 0.00[c]	0.023	0.035
L-ascorbic acid (mg/100 mL)	53.24 ± 1.00[a]	20.54 ± 0.71[b]	19.69 ± 0.67[c]	1.608	2.436

*: The difference between the averages with different letters in the same row is statistically significant ($p < 0.05$ and $p < 0.01$)

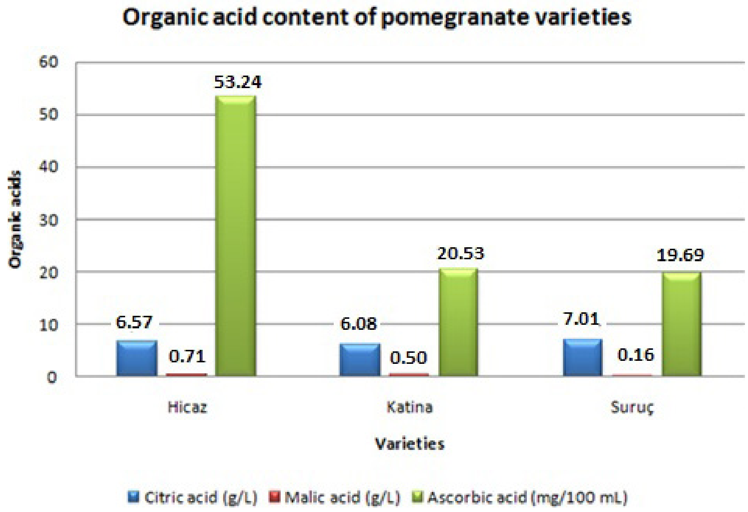


Figure 5. Comparison of organic acid amounts in different pomegranate varieties.

0.12% tartaric acid (Ozkaya, 1988). Saxena et al. (1987) reported that citric acid is abundant in pomegranate, but pomegranate also contains other acids such as malic, oxalic, succinic and tartaric acid. Bodur and Yurdagel (1986) reported that pomegranate is very poor in terms of L-ascorbic acid and the amount in pomegranate concentrate is approximately 12 mg/100 mL. However, this study states that the amount of L-ascorbic acid was very high, especially in the 'Hicaznar' variety. This may be due to the ecological conditions in which the plants are grown. Some components may be high, especially with the introduction of abiotic stress factors due to high temperatures.

3.5. Colourless phenols

The findings of the colourless phenol analysis made in the fruit juice of the 'Hicaznar', 'Katina' and 'Suruç' pomegranate varieties used in the study are given in Table 5. It was observed that levels of hydrolysable tannins B1 (galloyl hexose) and B2 digalloyylhexose in 'Hicaznar' were 4.50 and 2.60 respectively followed by 'Katina' variety with 3.27 and 1.41 values. C1 Ellagic acid, C2 HHDP-Hexose, C3 Ellagic acid hexose, C4 ellagic acid pentose, C5 Elagic acid-deoxyhexose, C6 Galloyl-HHDP-hexose, C7 bis-HHDP-hepose, C8 Digalloyl-HHDP-hexose, and C19 Ellagic acid derivative various values were determined by comparing C20 Galloyl-HHDP-Glucoside of 'Hicaznar', 'Katina' and 'Suruç' varieties. C1 ellagic acid (4.61), C2 HHDP-hexose (4.71), C3Elagic acid-hexose (4.33), Ellagic acid pentose (2.32), C7 bis-HHDP-hexose (77.17), C8 Digalloyl-HHDP-hexose (45.42), C19 ellagic acid derivative (24.23), Galloyl-HHDP-glycoside (15.82) are mostly seen in 'Hicaznar', while C6 Galloyl-HHDP-hexose is highest in 'Katina' with the value (44.53). When the Ellagic tannins are evaluated in total in Table 5, it was determined that the varieties were 'Hicaznar' (220.81), 'Katina' (150.24), 'Suruç' (80.60).

In the Table 5, among the hydroxycinnamic acids, F1 Kaffeic acid hexose, F2 Kaffeic acid hexose derivative, and F3 Kaffeic acid derivative are examined and the 'Suruç' variety has the highest value in terms of hydroxycinnamic acid (18.74); this was followed by the variety 'Hicaznar' with (12.75) and 'Katina' with a value of (10.41). In Table 5, Gallagyl esters D1 Gallagyl-hexose (punikalin) HHDP-Gallagyl-hexose were the highest (7.23) in 'Katina' variety. Later, it was determined that this order was 'Hicaznar' with (6.56), and 'Suruç' variety with (3.76). When D2 (Punicalagin) was examined, it was determined that the highest punicalagin level was in 'Hicaznar' with (53.83), followed by 'Katina' with (42.22) and 'Suruç' with (29.63) respectively.

4. Discussion and conclusion

In this study, antioxidant (DPPH method), sugar (HPLC method), anthocyanin (HPLC method), organic acids (HPLC method) and colourless phenolic compounds found in the juices of the 'Hicaznar', 'Katina' and 'Suruç' pomegranate varieties grown in Şanlıurfa region were determined. According to the findings obtained, it was determined that the 'Hicaznar' variety (19.42 mmol L^{-1} trolox) was 3–5 times more than the other varieties in terms of antioxidant capacity. The varieties used in the study were analysed in terms of sucrose, glucose, fructose, total sugar contents and glucose/fructose ratios. In this respect, it was determined that the highest value in terms of sucrose content was in the 'Suruç' variety, while the 'Hicaznar' variety was found to be statistically

Table 5. Some colourless phenol contents in different pomegranate varieties.

		Hicaznar	Katina	Suruç	LSD (% 5)	LSD (% 1)
Hydrolysable tannins						
B1	Galloyil hexose	4.50 ± 0.01[a*]	3.27 ± 0.03[b]	2.31 ± 0.02[c]	0.038	0.057
B2	Digalloyil hexose	2.60 ± 0.01[a]	1.41 ± 0.02[b]	1.01 ± 0.01[c]	0.027	0.042
	Total	***7.10 ± 0.02[a]***	***4.68 ± 0.02[b]***	***3.32 ± 0.01[c]***	***0.039***	***0.060***
Ellagic tannins						
C1	Ellagic acid	4.61 ± 0.02[a]	3.57 ± 0.01[b]	2.98 ± 0.01[c]	0.027	0.042
C2	HHDP-hexose	4.71 ± 0.01[a]	3.64 ± 0.01[b]	3.02 ± 0.02[c]	0.037	0.056
C3	Ellagic acid-hexose	4.33 ± 0.02[a]	3.34 ± 0.02[b]	2.80 ± 0.01[c]	0.032	0.048
C4	Ellagic acid pentose	2.32 ± 0.01[a]	1.75 ± 0.01[b]	1.16 ± 0.01[c]	0.024	0.036
C5	Ellagic acid-deoxyhexose	2.78 ± 0.02[b]	2.98 ± 0.01[a]	2.31 ± 0.01[c]	0.031	0.047
C6	Galloyl-HHDP-hexose	39.42 ± 0.42[b]	44.53 ± 0.28[a]	22.03 ± 0.03[c]	0.585	0.886
C7	bis-HHDP-hexose	77.17 ± 0.08[a]	35.13 ± 0.06[b]	12.06 ± 0.03[c]	0.118	0.178
C8	Digalloyl-HHDP-hexose	45.42 ± 0.19[a]	25.09 ± 0.08[b]	8.84 ± 0.05[c]	0.246	0.373
C19	Ellagic acid derivative	24.23 ± 0.03[a]	17.50 ± 0.02[b]	14.40 ± 0.04[c]	0.058	0.089
C20	Galloyl-HHDP-glycoside	15.82 ± 0.15[a]	12.72 ± 0.03[b]	11.01 ± 0.02[c]	0.175	0.266
	Total	***220.81 ± 0.82[a]***	***150.24 ± 0.46[b]***	***80.60 ± 0.18[c]***	**1.100**	**1.679**
Gallagyl esters						
D1	Gallagyl-hexose (punikalin)	6.56 ± 0.01[b]	7.23 ± 0.02[a]	3.76 ± 0.01[c]	0.031	0.046
D2	HHDP-gallagyl-hexose (punicalagin)	53.83 ± 0.04[a]	42.22 ± 0.02[b]	29.63 ± 0.03[c]	0.061	0.092
	Total	***60.40 ± 0.06[a]***	***49.45 ± 0.04[b]***	***33.39 ± 0.03[c]***	***0.083***	***0.126***
Hydroxycinnamic acids						
F1	Caffeic acid hexose	3.73 ± 0.01[c]	7.75 ± 0.01[a]	6.72 ± 0.02[b]	0.032	0.048
F2	Caffeic acid hexose derivative	4.75 ± 0.01[b]	1.40 ± 0.02[c]	7.15 ± 0.02[a]	0.034	0.051
F3	Caffeic acid derivative	4.27 ± 0.01[b]	1.26 ± 0.01[c]	4.88 ± 0.03[a]	0.033	0.050
	Total	***12.75 ± 0.03[b]***	***10.41 ± 0.03[c]***	***18.740.05[a]***	***0.078***	***0.118***

higher than the other varieties in terms of glucose and fructose and total sugars. When the anthocyanin contents are examined, both as anthocyanin compounds (Delfinidin-3.5-diglycoside, Cyanidin-3.5-diglycoside, Pelargonidin-3.5-diglycoside, Cyanidin-3-glycoside, Pelargonidin-3-glycoside, Cyanidin-pentoside) and total anthocyanin type, 'Hicaznar' was determined to have high values. Organic acids such as citric acid, malic acid and L-ascorbic acid were analysed in the fruit juices of the varieties used in the study. While it was determined that the 'Suruç' variety was higher in terms of citric acid, the analyses revealed that the 'Hicaznar' variety in terms of L-ascorbic acid, was more than twice the vitamin C (53.24 mg/100 mL) found in both 'Katina' and 'Suruç' varieties. Hydrolysable tannins, ellagic tannins, galloyl esters and hydroxycinnamic acids in the fruit juices of the varieties used in the study were also analysed. It was determined that the 'Hicaznar' variety was higher in terms of total hydrolysable tannins and total galloyl esters, while the total ellagic tannins and hydroxycinnamic acids were found to be higher than the other varieties studied. In this study, the characteristics analysed can also affect the ecological and maintenance conditions in which the pomegranate plant is grown. Particularly due to high temperatures and light intensity, some fruit juice components may be high or low, with the effect of abiotic stress factors. As a result, it was determined that the cultivation of the 'Hicaznar' variety would be more suitable when used for consumption as a fruit juice, which was determined to be high in terms of antioxidant capacity, and anthocyanin content. 'Hicaznar' pomegranate variety will be very beneficial for human health by using it in the fruit juice industry, as it is significantly high in L-ascorbic acid.

Acknowledgements

This project is supported by University of Harran. The authors are grateful to Scientific Council of University, Assoc. Prof. Dr. Murat Dikilitaş (Harran University, Agriculture Faculty) and Prof. Dr. Michelle Wirthensohn (School of Agriculture, Food & Wine Plant Research Centre, South Australia) who have checked this paper. Also, İbrahim Halil Hatipoğlu is sponsored via a fellowship from the Council of Higher Education 100/2000 doctorate program.

References

Ak BE, Sakar E, Korkmaz S (2013). Pomegranate cultivation in the Southeast. Mardin Journal of Food Agriculture and Livestock 3: 27-34 (in Turkish with abstract in English).

Albayrak S, Sagdic O, Aksoy A (2010). The methods used to determine the antioxidant capacity of herbal products and foods. Erciyes University Journal of Science, Institute 26(4): 401-409.

Ali S, Kasoju N, Luthra A, Singh A, Sharanabasava H et al. (2008). Indian medicinal herbs as sources of antioxidants. Science Direct Food Research 41: 1-15.

Aviram M, Roseblant M, Gaitini D (2005). Pomegranate juice improves carotid artery health and lowers blood pressure in patients with carotid artery stenosis. Herbal Gram 65: 28-30.

Bodur I, Yurdagel U (1986). A research on the changes that occur during cold storage of pomegranate concentrate as frozen and with chemical additives. Ege University Engineering Faculty Journal 4 (2): 11-27.

Brand-Williams W, Cuvelier ME, Berset C (1995). Antioxidative activity of phenolic composition of commercial extracts of sage and rosemary, LWT-Food Science and Technology 28: 25-30.

Cemeroglu B, Yemenicioglu A, Ozkan M (2004). Composition of fruits and vegetables, 1st Fruit and Vegetable Processing Technology (Ed: B. Cemeroğlu), Baskent Klise Printing House1: 1-188 (In Turkish).

Du CT, Wang PL, Francis FJ (1970). Anthocyanins of pomegranate. Journal of Food Science 40: 417-418.

Gil MI, Tomas-Barberan FA, Hess-Pierce B, Holcroft DM, Kader AA (2000). Antioxidant activity of pomegranate juice and its relationship with phenolic composition and processing. Journal of Agricultural and Food Chemistry 48: 4581-4589.

Huang D, Ou B, Prior RL (2005). The chemistry behind antioxidant capacity assays. Journal of Agricultural and Food Chemistry 53: 1841-1856.

Kelebek H, Selli S, Canbas A, Cabaroglu T (2009). HPLC determination of organic acids, sugars, phenolic compositions and antioxidant capacity of orange juice and orange wine made from a Turkish cv. Kozan, Microchemical Journal 91: 187-192.

Kelebek H, Canbas A, Jourdes M, Teissedre PL (2010). Characterization of colored and colorless phenolic compounds in Öküzgözü wines from Denizli and Elazig regions using HPLC-DAD–MS. Industrial Crops and Products 31 (3): 499-508.

Kelebek H, Selli S (2013). Identification of phenolic compositions and the antioxidant capacity of mandarin juices and wines. Journal of Food Science and Technology 51 (6): 1094–1101, doi:10.1007/s13197-011-0606-7.

Kelebek H, Selli S (2011). Determination of volatile, phenolic, organic acid and sugar components in a Turkish cv. Dortyol (*Citrus sinensis* L. Osbeck) orange juice, Journal of the Science Food and Agriculture 91: 1855-1862.

Kurt H, Sahin G (2013). A Agriculture, Geography Study: Pomegranate in Turkey (*Punica granatum* L.) agriculture. Marmara Geographical Journal 27: 551-574.

Lee J, Wrolstad RE (2004). Extraction of anthocyanins and polyphenolics from blueberry processing waste. Journal of Food Science 69 (1): 564-573.

Mot CA, Dumitrescu SR, Sarbu C (2011). Rapid and effective evaluation of the antioxidant capacity of propolis extracts using DPPH bleaching kinetic profiles, FT-IR and UV-VIS spectroscopic data, Journal of Food Composite and Analysis 24: 516-522.

Okan OT, Varlibas Oz HM, Deniz I (2013). Antioxidant analysis methods and some non-wood herbal products that can be used as antioxidant source in the Eastern Black Sea Region. Kastamonu University Journal of the Faculty of Forestry 13 (1): 48-59.

Ozguven AI, Cetiner S, Ak BE, Yilmaz C (1997). Studies on adaptation of different pomegranate varieties in Southeastern Anatolia Region (Second Research Period). Çukurova University Faculty of Agriculture 192 (112): 29.

Ozkan M (2009). Some chemical properties of the major pomegranate varieties grown in Turkey. Ankara University, Scientific Research Project Accelerated Project Final Report No: 08H4343004 (In Turkish).

Ozkaya H (1988). Analytical food quality control. Ankara University Faculty of Agriculture 1086: 43-46.

Saxena AK, Manan JK, Berry SK (1987). Pomegranades; postharvest technology, chemistry and processing, Indian Food Packer 41(4): 43-60.

Turfan O (2008). Changes in anthocyanins during production and storage of pomegranate juice concentrate. Ankara University, Institute of Science, Department of Food Engineering, Master's Thesis, Ankara, 154p (in Turkish with abstract in English).