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THE COMPARISON OF ANTIOXIDANT COMPOUNDS AND MINERAL CONTENT IN SOME POMEGRANATE (*Punica granatum* L.) GENOTYPES GROWN IN THE EAST OF TURKEY

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ABSTRACT

In recent times, pomegranate has been one of Turkey's most important commercial fruit crops for consumption and export. In this study, the chemical composition of pomegranate (*Punica granatum* L.) fruits grown in the central area of Bitlis province (Eastern Turkey) was investigated. For this purpose, total phenolic content, ascorbic acid content, total anthocyanin and antioxidant activity and minerals content were evaluated. The highest total phenolic contents were determined in 13BIT1 (6477.78 mg gallic acid equivalents 100 g^{-1} fresh matter). The highest ascorbic acid was determined in 13BIT2 of pomegranate genotype (60.78 mg 100 g^{-1}). Radical scavenging activity (DPPH) were determined between 13BIT18 (78.15) to 13BIT1 (31.49). Total anthocyanin of genotypes was measured between 13BIT19 (156.03) to 13BIT17 (55.37), respectively. The highest mineral compositions of the pomegranate genotypes were 998.00% N, 301.00 mg 100 g^{-1} P, 1708.61 mg 100 g^{-1} K, 55.21 mg 100 g^{-1} Ca, 116.79 mg 100 g^{-1} Mg, 5.1 mg 100 g^{-1} Fe, 1.91 mg 100 g^{-1} Cu, 0.41 mg 100 g^{-1} Mn and 1.20 mg 100 g^{-1} Zn, respectively. The results indicate that pomegranate genotypes have an important value of health and nutrition for the human.

Key words: pomegranate genotypes, minerals, phenolics, Eastern Turkey

INTRODUCTION

Pomegranate (*Punica granatum* L.) is from Punicaceae family, the only species in Punica genus in *Punica granatum* L., all forms of formations are of the same species [Levin 2006]. Pomegranate (*Punica granatum* L.) is a perennial plant that develops in a shrub form and has a strong root system.

Pomegranate homeland is known mainly in Iran, South and South East of Turkey, the Middle East, the Caucasus and North India [Lye 2008, Ünal 2011]. In particular, its successful adaptation to the Mediterranean climate has produced a widespread in different countries thus originating different regional geno-

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types throughout the centuries [Ferrara et al. 2011]. Pomegranate has been planted and farmed over the whole Anatolia since age-old times [Ercisli 2004, Orhan et al. 2014] and the commercial cultivation of pomegranate is confined to Mediterranean, Aegean and South East Anatolia regions in Turkey [Ercisli et al. 2007, Ozgen et al. 2008].

Genetically, it is a very dense crown with a very shallow and often branched. The flowers are hermaphrodite and have a large fruit, spherical, slightly flattened from the top. Pomegranate is a tropical and subtropical climate plant. Pomegranate with high adaptability can be grown in limited temperate regions in temperate climatic regions [İkinci 2007].

Pomegranate juice contains important phenolic substances. Gallil type tannins, especially delphinidin, cyanidin, pelargonidin 3-glycoside and 3,5-diglycoside anthocyanins, ellagic acid and its derivatives are important components of antioxidant activity [Miguel et al. 2004].

Phenolic compounds are substances that contribute to the color and sensory properties of many fruits, vegetables and beverages. Research which is conducted in recent years has shown that phenolic compounds commonly found in plant products are very useful compounds for health reasons due to their antioxidant activities. Epidemiologic studies have shown that phenolic-rich foods have positive effects such as inhibiting many diseases, including cardiovascular diseases and cancer, including diseases, and delaying aging [Gil et al. 2000, Aviram et al. 2004]. Antioxidant activity of phenolic compounds; free radicals and hydrogen atoms or electrons, and inactivating certain enzymes [Tsao et al. 2003, Balasundram et al. 2006].

Chemical properties of pomegranate juice are affected by factors such as fruit variety, growing area, soil structure, climatic conditions, maturity status, and cultural practice. Accordingly, pomegranate juice contains vitamins, minerals, sugars, phenolic compounds, organic acids and so on. variations in terms of chemical composition were revealed by many researchers [Gil et al. 2000, Poyrazoglu et al. 2002, Melgarejo et al. 2006].

Nowadays, interest in functional foods has increased with the increase in the health effects of foods and the awareness of healthy eating [İşleroğlu et al. 2005]. There are many has higher antioxidant activity than other fruit juices due to phenolic compounds [Gil et al. 2000, Seeram et al. 2008]. Pomegranate extracts have antimicrobial and antiviral activity [Vidal et al. 2003, Neurath et al. 2004, Braga et al. 2005, Vasconcelos et al. 2006]. In addition, some clinical trials have shown that the substances of the pomegranate fruit reduce the blood pressure, reduce the low-density lipoprotein (LDL) oxidation significantly [Aviram et al. 2000, Aviram and Domfeld 2001, Aviram et al. 2004, Khan et al. 2007] have shown beneficial effects against Alzheimer's disease [Kim et al. 2002], that chemotherapy reduces side effects of chemotherapy treatment [Sumner et al. 2005], tumor formation and development. It is also reported that in recent years, pomegranate has been classified as a food used in the treatment of AIDS disease and is one of nine plants in Japanese patented medicines [Lansky and Newman 2007].

In a study of macro and micronutrient content and seasonal variation of phenols in the pomegranate and edible parts of pomegranate, it was reported that the content of macronutrient element in the part of the pear-fresh part was lower than that of the pomegranate shell. It has been reported that the order of the macronutrients on both sides is the order of the elements K > N > Ca > P > Mg > Na micronutrient Fe > Zn > Cu > Mn [Mirdeghan and Rahemi 2007].

In this study, certain local genotypes of pomegranate growing in Turkey were analyzed. We determined some pomegranate genotypes as nutrient elements, antioxidant activities and phenolic content of some pomegranate genotypes grown in Bitlis region of Turkey. In addition, the correlation between the biochemical contents of pomegranate genotypes investigated was also determined and related between them. Therefore, we believe that this study will serve as a novel source of germplasm for Turkish and international breeders searching for variations to develop new good commercial varieties.

MATERIAL AND METHOD

Fruits collection. The collection of pomegranate fruits was performed in the years 2015 and 2016, in villages near the central of Bitlis province (Eastern Turkey). The villages were close to each other and had almost the same soil and climate characteristics. Irrigation was done by drip irrigation. Fruits were gathered from mature trees (nearly 30-year-old) located in private little orchards. Every the genotype elected had a similar maturity date rely on their internal and external color and the fruits were harvested when the green color has gone from fruit surface and yellow or red color was appeared. For both years, harvesting time varied from mid-end September to mid-October.

Biochemical analysis. The ascorbic acid content was detected with modified HPLC procedure suggested by Cemeroglu [2007]. Five milliliters of the fruit extracts were supplemented with 2.5% (w/v) metaphosphoric acid (Sigma, M6285, 33.5%), then centrifuged at 6500 rev min^{-1} for 10 min at 4°C. A 0.5 mL sample of the mixture was increased to a final volume of 10 mL with 2.5% (w/v) metaphosphoric acid. Supernatants were filtered with 0.45 μm PTFE syringe filter (Phenomenex, UK). A C18 column (Phenomenex Luna C18, 250 mm × 4.60 mm, 5 μm) was used for the identification of ascorbic acid at 25°C. Ultra-distilled water with 1 mL min^{-1} flow rate and pH of 2.2 (acidified with H_2SO_4) was used as a mobile phase. Spectral measurements were made at 254 nm using a DAD detector. Different standards of L-ascorbic acid (SigmaA5960) (50, 100, 500, 1000, and 2000 ppm) were used for quantification of ascorbic acid readings.

The method of Folin-Ciocalteau reagent has been used to estimate the TPC [Farhan et al. 2012, Zeidan et al. 2015]. 100 μL of each used extract and 0.5 mL of Folin-Ciocalteau (1/10 dilution in water) were mixed with 1.5 mL of Na_2CO_3 (2%). The mixture was incubated in the dark at room temperature for 30 min. The absorbance of the solution was measured at 765 nm using a Gene-Quant 1300 UV-Vis spectrophotometers. The blank was composed of 0.5 mL of selected solvent and 1.5 mL of Na_2CO_3. The results were expressed as milligram of gallic acid equivalent (GAE) per gram extract (mg GAE g^{-1}).

TA content was determined by pH differential method using two buffer systems – potassium chloride (KCl) buffer (pH 1.0 (25 mM)) and sodium acetate buffer (pH 4.5 (0.4 M)) [Ozgen et al. 2009]. Reaction mixtures were prepared using 0.4 ml of sample with 3.6 ml of corresponding buffers separately and absorbance (A) was measured by a UV–Visible spectrophotometer (UV Chrome TECH CT-8200) at 510 nm and 700 nm. Water was used as the blank for juice samples and absolute ethanol was used as the blank for peel and seed extracts.

$$(A) = (A\ 510\ nm - A\ 700\ nm)\ pH\ 1.0 - - (A\ 510\ nm - A700\ nm)$$

The antioxidant activity was practiced according to the method of Rammal et al. [2013] using free radical DPPH. Increasing concentrations of extracts (0.05, 0.1, 0.2, 0.4, 0.5 mg mL^{-1}) were prepared. 1 mL of each prepared dilution of each extract was added to 1 mL of DPPH reagent. The solutions were incubated in the dark at room temperature for 30 min and the absorbance was measured at 517 nm by a Gene-Quant 1300 UV-Vis spectrophotometer. The DPPH scavenging ability of peels extracts was calculated according to the following equation:

$$\%\ \text{Scavenging activity} = = [(\text{Abs control} - \text{Abs sample}) / \text{Abs control}] \times 100$$

Control was prepared by mixing 1 mL DPPH with 1 mL of selected solvent. The blank was composed of 1 mL of the selected solvent.

Nutrient mineral elements content

Nitrogen content was measured by the Kjeldahl method [James 1995]. In order to determine the mineral contents of (Mn, Cu, Zn and Fe) pomegranate genotypes, samples were burned with a nitric

acid solution, on a hot plaque, at 200°C. Later, the absorbance of the essence was measured by atomic absorbance spectroscopy. The amounts of minerals were measured with a standard curve of every one element. But phosphorus content of the pomegranate essence was analyzed by determining the yellow absorbance, obtained from the Barton reaction, at 680 nm, and comparing the results to a standard curve [James 1995].

Statistical analysis. The study was planned as three repetitions and 10 fruits per repetition. The introductory statistics belonging to analysis and measurement results were offered as average ± standard deviation. In the statistical evaluations, Windows SPSS 20 were used and the differences between the means was evaluated by subjecting to ANOVA variance analysis and determined with Duncan multiple comparison tests ($p < 0.005$).

RESULTS AND DISCUSSION

The ascorbic acid, total phenolic, radical scavenging activity (DPPH) and total anthocyanin content of pomegranate genotypes are given in Table 1. Ascorbic acid contents of the pomegranate genotypes were found to be from 11.12 mg 100 g^{-1} (13BIT1) to 60.78 mg 100 g^{-1} (13BIT2). In terms of total phenol content, the highest value was determined at 13BIT1 variety as 6478.78 mg 100 mL^{-1} and the lowest value was determined at 13BIT17 variety as 891.32 mg 100 mL^{-1}. The highest DPPH content was determined at 13BIT18 variety as (78.15%) and the lowest content was determined at 13BIT1 variety (31.49%). In terms of total anthocyanin content, the highest value was determined at 13BIT19 variety as 156.03 mg 100 g^{-1} and the lowest value was determined at 13BIT17 variety as 55.37 mg 100 g^{-1}.

Table 1. The ascorbic acid, total phenolic, total anthocyanin content and antioxidant activity and of pomegranate genotypes

Genotypes	Ascorbic acid (mg 100 g^{-1})	Total fenolics (mg GAE 100 g^{-1} fresh mass)	Antioxidant activity (%)	Total anthocyanins (mg 100 g^{-1})
13BIT1	11.12 u*	6477.78 a	31.49 v	56.25 u
13BIT2	60.78 a	902.45 u	61.51 j	136.53 g
13BIT3	12.85 s	6003.14 c	39.68 s	72.73 r
13BIT4	49.72 d	1118.57 s	36.57 u	144.78 e
13BIT5	15.25 p	5345.46 e	48.96 p	93.44 n
13BIT6	57.65 b	1366.67 p	76.57 b	152.37 b
13BIT7	17.32 n	4000.47 i	55.75 m	110.32 k
13BIT8	55.58 c	2017.18 n	73.87 d	116.47 j
13BIT9	19.38 l	3570.53 k	60.54 k	64.32 s
13BIT10	36.62 f	3159.02 l	70.54 f	128.31 h
13BIT11	21.45 j	4788.27 g	38.52 t	61.62 t
13BIT12	22.48 i	3902.74 j	69.91 g	150.52 c
13BIT13	23.52 h	2497.68 m	64.65 h	98.29 m
13BIT14	34.55 g	4356.86 h	71.72 e	149.55 d
13BIT15	18.35 m	1453.15 o	62.53 i	78.45 p
13BIT16	20.42 k	5111.75 f	74.61 c	138.62 f
13BIT17	12.15 t	891.32 v	59.86 l	55.37 v
13BIT18	48.68 e	5959.34 d	78.15 a	124.15 i
13BIT19	16.28 o	1245.32 r	50.52 o	156.03 a
13BIT20	60.75 a	6186.42 b	51.52 n	85.56 o
13BIT21	14.22 r	1001.94 t	46.69 r	102.23 l

* There are significant differences ($p < 0.05$) among the cultivars having different letters

In a previous study conducted in Turkey, the ascorbic acid contents were found to be from 14 mg 100 g^{-1} to 69 mg 100 g^{-1} [Ozgen et al. 2008]. In other study conducted in the Riyadh region of Saudi Arabia, the highest ascorbic acid content of pomegranate species was found 18 mg 100 g^{-1} [Al-Maiman and Ahmad 2002]. Özsayın [2012] determined that the ascorbic acid values obtained from the samples of Hicaznarı in Antalya were between 13.2–84.7 mg 100 g^{-1}. Gündoğdu and Yılmaz [2013], found that the content of vitamin C was 12.92 mg L^{-1}, 12.88 mg L^{-1}, 13.47 mg L^{-1} and 12.37 mg L^{-1}, respectively, in the cultivars of Katırbaşı. Li et al. [2006] found 85 mg 100 g^{-1} ascorbic acid in the fruit pulp. Al-Maiman and Ahmad [2002] found that the chemical content of pomegranate fruits was determined. The ascorbic acid levels of the pomegranate fruits examined during the study were determined at different maturity periods. It was reported that the amount of ascorbic acid was 26 mg 100 g^{-1}, 25 mg 100 g^{-1} in the semi-mature period and 18 mg 100 g^{-1} in the full mature period in the unopened period. In Iran, the vitamin C contents of fruit juices of pomegranate varieties were investigated and it was determined that the content of vitamin C in pomegranate fruits varied between 0.09–0.40 mg 100 g^{-1} [Fadavi et al. 2005]. Vicente et al. [2002] found that the content of vitamin C in pomegranate fruits was 50 mg L^{-1} in their research. We have found that the ascorbic acid content is in parallel with the literature we compare with the results we have obtained.

When we look at other studies for total phenolic substance; Gil et al. [2000] reported that the phenolic substance content in pomegranate juice was in the range of 1808–2566 mg GAE L^{-1} Li et al. [2006] determined the total phenolic content of pomegranate pulp as 24.4 mg TA g^{-1}. Turgut and Seydim [2013] determined the total phenolic content of 11 pomegranate varieties and genotypes grown in the Mediterranean Region as 81.515–138.000 mg GAE 100 mL^{-1}. Karaca [2011] determined the total phenolic content of industrial pomegranate juice between 1760.67 and 2513.87 mg L^{-1}. Muhacir-Güzel et al. [2014] studies were carried out from pomfrets and all the work on several pomegranate treatments and the total phenolic content was determined in the range of 1590–3023 mg L^{-1}. In studies investigating changes in the amount of pomegranate juice depending on pomegranate maturation and growth conditions, the total phenolic content was found to be in the range of 158–366 mg 100 mL^{-1}. Tezcan et al. [2009] examined the total phenolic amounts of some commercial pomegranate juice and found their results at a range of 144–10086 mg GAE L^{-1}. It is seen that the results we obtained comparing the results with the ones we have found overlap with the literature. It is thought that the differences can come from the maintenance works such as irrigation and fertilization.

When we look at other studies related to DPPH (radical scavenging activity); Gil et al. [2000] studied various commercial pomegranate juice samples and found that pomegranate juice has antioxidant activity about 3 times higher than red wine and green tea samples. In another study, activity was determined in vitro using pomegranate seed and seed extracts by the DPPH method. The antioxidant activity of the methanol extract of pomegranate husk was found to be 81% at 50 ppm and 23.2% of the pomegranate methanol extract antioxidant activity at 100 ppm [Singh et al. 2002]. Aviram et al. [1999] measured the antioxidant activity of pomegranate waters by the DPPH method and found the antioxidant activity of pomegranate juice as 50 mmol vit. E L^{-1} as the equivalent of vitamin E. Turfan et al. [2011] on pomegranate juice, the total antioxidant amount was determined as 269–364 mg cyanidin-3-glucoside kg^{-1}. In India, the amount of antioxidants in fruit juice of pomegranate was investigated in a study on pomegranate. In this study, it was reported that the antioxidant activity measured between 13.0–71.2% [Kulkarni and Ardhya 2005].

When we look at other studies for total anthocyanin; Legua et al. [2000] measured the amount of anthocyanin in the fruit growth phase in four different pomegranate clones, and the amount of anthocyanin in mature fruit varied between 186 mg L^{-1} and 271 mg L^{-1}. Aviram et al. [2004] reported that the amount of anthocyanin present in the nard was

121 mg L^{-1}. Gil et al. [2000] reported between 161.9 and 387.4 mg L^{-1}. Mena et al. [2013] found that the content of total anthocyanin in pomegranate juice was found in the range of 109.3 to 182.9 mg cyanidin-3-glucoside L^{-1}. It is seen that our results overlap with the literature if we compare it with the results we find. Differences are thought to be due to applied analysis methods and climate differences.

The N, P, K, Ca and Mg values of pomegranate fruits varied from 101.20 (13BIT20) to 998.00 (13BIT7), 228.42 mg 100 g^{-1} (13BIT1) to 301.00 mg 100 g^{-1} (13BIT2), 501.10 mg 100 g^{-1} (13BIT2) to 1708.61 mg 100 g^{-1} (13BIT13), 20.15 mg 100 g^{-1} (13BIT1) to 55.21 mg 100 g^{-1} (13BIT21), and 26.13 mg 100 g^{-1} (13BIT1) to 116.79 mg 100 g^{-1} (13BIT2), respectively (tab. 2). The micro-mineral contents of pomegranate genotypes are shown in Table 3. Mangan contents of the pomegranate genotypes were found to be from 0.16 mg 100 g^{-1} (13BIT1) to 0.41 mg 100 g^{-1} (13BIT16). In terms of Cu content, the highest value was determined at 13BIT15 variety as 1.91 mg 100 g^{-1} and the lowest value was determined at 13BIT8 variety as 0.16 mg 100 g^{-1}. The highest Zn content was determined at 13BIT16 variety (1.20 mg 100 g^{-1}) and the lowest content was determined at 13BIT6 variety as (0.53 mg 100 g^{-1}). In terms of Fe content, the highest value was determined at 13BIT4 variety as 5.10 mg 100 g^{-1} and the lowest value was determined at 13BIT1 variety as 2.50 mg 100 g^{-1}.

Table 2. The macro nutreint element content of pomegranate genotypes fruits average of 2015–2016

Genotypes	N (%)	P (mg 100 g^{-1})	K (mg 100 g^{-1})	Ca (mg 100 g^{-1})	Mg (mg 100 g^{-1})
13BIT1	234.25 n*	228.42 v	1347.35 g	20.15 g	26.13 u
13BIT2	347.15 i	301.00 a	501.10 v	43.19 c	116.79 a
13BIT3	148.39 t	230.32 t	998.00 k	45.23 b	28.19 s
13BIT4	229.32 r	300.90 b	1702.11 b	48.26 b	36.46 k
13BIT5	230.32 p	232.33 r	763.12 n	24.29 f	30.26 p
13BIT6	301.00 j	297.60 e	856.33 l	45.33 b	31.29 o
13BIT7	998.00 a	285.40 o	1004.22 j	46.36 b	32.66 n
13BIT8	232.33 o	295.40 g	505.23 u	47.39 b	34.36 m
13BIT9	956.33 b	289.50 m	618.32 r	28.43 e	34.39 m
13BIT10	285.40 m	287.50 n	717.82 o	29.46 e	40.59 g
13BIT11	518.32 g	291.52 k	807.15 m	29.49 e	82.66 e
13BIT12	292.10 l	292.10 j	1649.51 c	30.53 e	37.49 j
13BIT13	300.90 k	293.20 i	1708.61 a	31.56 d	104.73 c
13BIT14	285.40 m	294.30 h	1481.56 e	32.59 d	39.56 h
13BIT15	452.26 h	290.51 l	509.22 t	33.63 d	29.23 r
13BIT16	649.51 e	296.50 f	1387.60 f	34.65 d	41.63 f
13BIT17	717.82 d	233.33 p	1500.22 d	35.68 d	35.43 l
13BIT18	781.56 c	298.70 d	1101.10 i	36.72 c	93.69 d
13BIT19	587.60 f	231.32 s	1202.11 h	37.75 c	38.53 i
13BIT20	101.20 u	299.80 c	703.11 p	38.78 c	115.76 b
13BIT21	156.32 s	229.32 u	604.11 s	55.21 a	27.16 t

* There are significant differences ($p < 0.05$) among the cultivars having different letters

Table 3. Micro mineral content of genotypes 2015–2016

Genotypes	Mn (mg 100 g^{-1})	Cu (mg 100 g^{-1})	Zn (mg 100 g^{-1})	Fe (mg 100 g^{-1})
13BIT1	0.16 v*	0.23 t	0.68 lm	2.50
13BIT2	0.32 e	1.11 s	0.69 l	4.60 b
13BIT3	0.16 t	1.23 r	0.56 s	2.60 v
13BIT4	0.36 c	0.21 u	0.75 i	5.10 a
13BIT5	0.18 p	1.36 o	0.73 j	2.80 s
13BIT6	0.16 u	1.60 i	0.53 t	4.40 d
13BIT7	0.19 o	1.40 l	0.68 m	3.10 p
13BIT8	0.30 f	0.16 v	0.65 p	4.20 f
13BIT9	0.19 m	1.55 j	0.71 k	3.30 n
13BIT10	0.23 h	1.68 f	0.75 i	3.90 h
13BIT11	0.21 k	1.23 p	0.86 h	3.50 l
13BIT12	0.20 l	1.71 e	0.91 f	4.50 c
13BIT13	0.23 i	1.89 b	0.96 d	3.70 j
13BIT14	0.35 d	1.66 h	1.00 c	3.80 i
13BIT15	0.21 j	1.91 a	1.12 b	3.40 m
13BIT16	0.41 a	1.38 m	1.20 a	4.10 g
13BIT17	0.17r	1.48 k	0.72 k	3.20 o
13BIT18	0.27g	1.67 g	0.67 n	4.30 e
13BIT19	0.19 n	1.80 c	0.89 g	2.90 r
13BIT20	0.39 b	1.74 d	0.95 e	3.60 k
13BIT21	0.17 s	1.37 n	0.56 r	2.70 t

* There are significant differences ($p < 0.05$) among the cultivars having different letters

Chauhan et al. [1991] reported that K > Na > Ca > Mg > P > Zn > Fe > Cu is the most abundant element in fruit of pomegranate, respectively. Gündoğdu et al. [2017], fruit juices of the pomegranate genotypes varied from 329.123 to 943.684 ppm, potassium content from 93.375 to 985.600 ppm and calcium content from 63.477 to 142.703 ppm. The iron content in the study was 1.337–41.741 ppm, manganese content 0.281–3.346 ppm, zinc content 0.050–0.223 ppm, copper content 0.253–2.388 ppm and magnesium content 38.672–92.948 ppm. The content of oxalic acid in pome fruit juices is 0.017–0.447 g L^{-1}, the content of malic acid is 1.008–2.718 g L^{-1}, the content of citric acid is 0.6161–6.408 g L^{-1}, the content of succinic acid is 0.059–0.396 g L^{-1}, the content of fumaric acid is 0.044–0.882 g L^{-1} and tartaric acid content ranged from 0.029 to 0.094 g L^{-1}. Salma et al. [2001] found that the content of pomegranate Mg was 28.7 mg g^{-1}. Al-Maiman and Ahmad [2002] reported that the contents of K, Na, Mg and Ca of pomegranate fruit were higher than other elements, that the contents of Cu, Zn and Ca were high in pomegranate seeds and K, Na and Fe contents were high in pomegranate juice. Gölükcü et al. [2008] were determined contents of potassium (0.308–1.399%), phosphorus (0.252–0.650%), calcium (0.143–0.281%), magnesium (0.107–0.276%), iron (26.69 mg kg), zinc (15.23–40.26 mg kg), copper (24.03–38.53 mg kg^{-1}) and manganese (6.18–13.12 mg kg^{-1}) between 15 pomegranate genotypes, respectively. Dumlu and Gürkan [2007]

analyzed the nutrient elements in 12 different pomegranate species and they found contents of potassium (250–1200 ppm), calcium (35–326 ppm), magnesium (176–427 ppm) iron (21–46 ppm) and phosphorus (12–43 ppm) in Turkey. Differences are considered to be due to applied analysis methods and climate differences. In this study, the relationship between nutrient elements and other biochemical compounds was found to be statistically positive at P 0.05 between N and Cu. It was determined that there is a strong positive correlation between phosphorus, vitamin C, total antioxidant activity and total anthocyanin, and statistically significant at $P < 0.01$ level (tab. 4).

Table 4. Correlation between nutrients and other bioactive compounds

	P	K	Ca	Fe	Mg	Mn	Cu	Zn	Vitamin C	Total phenolic	DPPH	Total antocyanin
N	0.13	0.03	–0.13	–0.06	–0.05	–0.13	0.26*	0.08	–0.27	–0.01	0.24	–0.11
P		–0.04	–0.20	0.81**	0.46**	0.61**	0.10	0.34**	0.67**	–0.05	0.55**	0.39**
K			–0.13	0.18	–0.07	0.11	–0.02	0.29*	–0.24	0.08	–0.04	0.23
Ca				–0.16	–0.10	–0.12	0.00	–0.17	–0.11	–0.16	–0.10	–0.02
Fe					0.33**	0.60**	–0.12	0.14	0.74**	–0.28	0.51**	0.63**
Mg						0.44**	0.23	0.19	0.51**	0.13	0.11	0.01
Mn							–0.13	0.50**	0.59**	0.10	0.26*	0.39**
Cu								0.38**	–0.17	–0.01	0.42**	0.10
Zn									–0.14	0.13	0.22	0.12
Vitamin C										–0.15	0.38**	0.46**
Total phenolic											–0.16	–0.29
DPPH												0.49**
Total antocyanin (V_{13})												1.0

* $P \leq 0.05$, ** $P \leq 0.01$

CONCLUSIONS

When the biochemical contents of examined pomegranate genotypes are examined; 13BIT2 and 13BIT20 genotypes in terms of ascorbic acid content, 13BIT1 genotype in total phenolic content, 13BIT18 genotype in total antioxidant content and 13BIT19 genotype in terms of total anthocyanin content. When the contents of macro and micronutrients of pomegranate fruits are examined, it is seen that the order is approximately N > K > P > Mg-Ca > Fe > Zn-Cu > Mn. When we look at the correlation between nutrients and other biochemicals in this research, especially P, Fe, and Mn contents, and total anthocyanin ($P \leq 0.01$). In the study, a statistically similar relationship was also found between total antioxidant content and P, Fe, Cu and Vitamin C. As a conclusion of this study, it can be said that pomegranate fruits are a valuable horticultural product, based on their rich and beneficial nutrient composition. Certain growing conditions and cultural management techniques, affecting the nutritional value of pomegranate genotypes, will be the subject of further research projects.

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