

۲۴ **correlation between antioxidant activity and total phenolic content ($r = 0.957$). These data**
۲۵ **demonstrated that cultivar is the main parameter that determines the chemical**
۲۶ **composition and antioxidant activity in pomegranates and this provides important**
۲۷ **knowledge on how to make the best use of the pomegranate cultivars evaluated.**

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۲۹ INTRODUCTION

۳۰ Pomegranate (*Punica granatum* L.) belongs to the Punicaceae family and is one of the
۳۱ important commercially fruit, which extensively cultivated in many tropical and subtropical
۳۲ regions (Sarkhosh et al, 2006). Iran is one of the major important pomegranate producers and
۳۳ exporters in the world, and its total production was 670,000 tons in 2005 (Anonymous, 2005).
۳۴ The fruit is either consumed directly or processed into various products such as juice, jams,
۳۵ syrup and sauce (Al-Maiman and Ahamad, 2002).

۳۶ Pomegranate juice has become more popular because of the attribution of important
۳۷ biological actions (Lansky et al., 1998). These biological actions have been attributed to the high
۳۸ level of antioxidant activity (Gil et al, 2000). Phenolic acids, anthocyanin and ascorbic acid,
۳۹ either alone or in combination, are responsible for the antioxidant activity of pomegranate
۴۰ (Scalzo et al, 2004).

۴۱ In spite of various pomegranate cultivars grown (more than 760 original, wild and
۴۲ decorative cultivar) in different regions of the Iran, few published results on the properties of the
۴۳ cultivars in the literature are available (Mousavinejad et al., 2009). Therefore, the aim of the
۴۴ present study was to analyze and compare the chemical characteristics and antioxidant activity of
۴۵ eight pomegranate cultivars grown in Iran.

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57 MATERIALS AND METHODS

58 Eight pomegranate cultivars were studied: ‘Shirin Pust Ghermez’, ‘Shirin Dane Ghermez
59 Ferdows’, ‘Malas Save’, ‘Malas Yazdi’, ‘Torsh Shahvar Kashmar’, ‘Torsh Shahvar Ferdows’,
60 ‘Khazar Bajestani’ and ‘Dom Amberoti’. Commercially ripe fresh fruits were harvested in
61 September 2009 from different mature trees (14-year-old) randomly selected to represent the
62 population of the plantation from the Agricultural Research Center of the Yazd province, Iran.
63 Fruits for each cultivar were manually peeled and, by using a manual device with a pedal for
64 pressing the arils, the juice passed through a perforated plate and the seeds and pulp remained on
65 the plate. Four replicates were used for each analysis and each replicate indicating five
66 pomegranate fruits. All reagents, solvents and standards were of analytical reagent grade.

67 The pH was measured with a digital pH meter ([Metrohm 601](#)). The titrable acidity (TA)
68 was determined by titration to pH 8.1 with 0.1 M NaOH solution and expressed as g of citric acid
69 per 100 g of juice ([AOAC, 1984](#)). The total soluble solids (TSS) were determined with a digital
70 refractrometer ([Erma, Tokyo, calibrated using distilled water](#)). Ascorbic acid was determined by
71 employing the method described by [Ruck \(1963\)](#) and results were expressed as mg per 100 g of
72 juice. The total anthocyanins content was determined with the pH differential method ([Giusti and](#)
73 [Wrolstad, 2001](#)) and results were expressed as mg cyaniding-3-glucoside 100 g of juice. The
74 amount of total phenolics was measured at 760 nm by the Folin-Ciocalteu reagent ([Singleton and](#)
75 [Rossi, 1965](#)). The results were expressed as mg gallic acid equivalent in 100 g of juice.
76 Antioxidant activity was assessed according to the method of [Brand-Williams et al. \(1995\)](#).

77 Data were analyzed by Statistical Analysis System (SAS) software Version 9.1 using
78 analysis of variance (ANOVA) and differences among means were determined for significance
79 at $P < 0.05$ using Tukey’s test.

٧٠ RESULTS AND DISCUSSION

٧١ Chemical composition

٧٢ The chemical analysis results of the pomegranate cultivars investigated are presented in
٧٣ [Table 1](#). Significant differences ($p < 0.05$) were revealed among the pomegranate cultivars for
٧٤ pH, total soluble solids, titrable acidity, total anthocyanins, ascorbic acid and total phenolics.

٧٥ The pH values varied from 3.16 ('Khazar Bajestani') to 3.99 ('Shirin Dane Ghermez
٧٦ Ferdows') ([Table 1](#)). [Cam et al \(2009a\)](#) reported pH values of some pomegranate cultivars
٧٧ Turkey between 2.82 and 3.81. The level of total soluble solids of eight pomegranate cultivars
٧٨ was within 11.67-15.07, that 'Torsh Shahvar Ferdows' cultivar having the highest amount of
٧٩ total sugars than the other cultivars ([Table 1](#)). In another study, the total sugars values of some
٨٠ pomegranate cultivars growing in Iran were between 10 and 16.5 (°Brix) ([Fadavi et al. 2005](#)).
٨١ The titrable acidity content ranged from 0.33 to 2.44 (mg/100 g) in 'Shirin Dane Ghermez
٨٢ Ferdows' and 'Torsh Shahvar Ferdows' cultivars, respectively ([Table 1](#)). Similar results were
٨٣ also reported by [Fadavi et al. \(2005\)](#).

٨٤ As shown in [Table 1](#), the ascorbic acid content of studied cultivars ranged from 9.91
٨٥ ('Malas Save') to 18.42 ('Malas Yazdi') (mg/100 g). The values of ascorbic acid obtained in the
٨٦ current study are greater than pomegranate juice from 'Ganesh' variety (>10 mg/100 g) reported
٨٧ by [Kulkarni and Aradhya \(2005\)](#). The variation in terms of total anthocyanins content was
٨٨ observed among the pomegranate cultivars (5.72-30.11 mg/100 g). Our results showed the lower
٨٩ total anthocyanins values than the results (8.1-36.9 mg/100 g) reported by [cam et al. \(2009b\)](#).
٩٠ The total phenolics content varied from 295.79 to 916.03 (mg/100 g). The highest level of total
٩١ phenolics was observed in 'Malas Yazdi' and the lowest one in 'Shirin Pust Ghermez'. The total

phenolics for pomegranate fruits were found to be 14.4 and 1008.6 mg/100 g by [Tezcan et al. \(2009\)](#) and 23.7 and 930.4 mg/100 g by [Mousavinejad et al. \(2009\)](#).

Generally, these results indicate that eight cultivars are different in terms of their pH, total soluble solids, titrable acidity, total anthocyanins, ascorbic acid and total phenolics. The chemical composition of pomegranate juice is markedly influenced by many factors such as cultivar type, environmental conditions, nutrition and other agricultural practices. Since all eight pomegranate cultivars used in this study were grown in the same location with using similar agronomic practices, the differences in measured parameters above showed that there was a high genetic heterogeneity within the studied cultivars and also cultivar type which plays an important role in factors.

1.2

1.3 **Antioxidant activity**

As shown in [Table 1](#), the variation in terms of ascorbic acid content was observed among the pomegranate cultivars (18.41-48.85%) and the differences were statistically significant ($p < 0.05$). Antioxidant activity has been reported for seven commercial pomegranate juices from Turkey 10.37–67.46% ([Tezcan et al., 2009](#)) and eight pomegranate juices from Iran 18.6–42.8% ([Mousavinejad et al., 2009](#)). There are differences between the findings of this study and other reports of antioxidant activity. The main reason of these differences is probably that the antioxidant activity in pomegranate juice is specifically affected by the cultivar.

1.1

1.2 **Correlation analysis**

A high and significant correlation between total anthocyanins and total phenolic content was determined ($r = 0.712$) ([Table 2](#)). Similar findings have been reported by [Ozgan et al.](#)

115 (2008). Antioxidant activity was positively correlated with the total phenolics ($r = 0.957$), total
116 anthocyanins ($r = 0.655$) (Table 2). These data demonstrated that these components are primarily
117 responsible for the antioxidant activity in all pomegranate cultivars. Feryal et al. (2005) reported
118 a positive correlation between antioxidant activity and total phenolics ($r = 0.93$) in fruits growth
119 in Turkey.

120

121 **Conclusion**

122 In this study, eight pomegranate cultivars were analyzed for various chemical properties
123 and antioxidant activity. Statistically significant differences were observed between pomegranate
124 cultivars investigated in all measured parameters. This indicates that there was a high genetic
125 heterogeneity within the studied cultivars and also cultivar type plays an important role in
126 measured factors. The results provide important information of the chemical properties of
127 pomegranate cultivars which can be useful for developing fruit processing industry, selection of
128 superior desirable pomegranate genotypes for bringing to commercial cultivation. Additionally,
129 the correlation analysis indicates that the total phenolics content contributes significantly to the
130 antioxidant activity of pomegranates. However, there are many other cultivars in Iran, more
131 studies of chemical properties and antioxidant activity are required for them.

132

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Tables

Table 1. pH, total soluble solids (TSS), titrable acidity (TA), ascorbic acid (A), total anthocyanins (TAs), total phenolics (TPs) and antioxidant activity (AA) of eight Iranian pomegranate juice cultivars.

Cultivar ^z	Parameter						
	pH	TSS (°Brix)	TA (g/100 g)	A (mg/100 g)	TAs (mg/100 g)	TPs (mg/100g)	AA (%)
SPG	3.46cd ^y	14.22a	0.49e	17.62a	9.56bc	295.79f	18.41d
SDGF	3.99a	13.85ab	0.33e	17.84a	8.09bcd	332.07ef	22.95d
MS	3.43cd	13.37ab	1.67b	9.91b	6.90cd	710.74b	40.62b
MY	3.52bcd	14.02ab	1.70b	18.42a	30.11a	916.03a	48.85a
TSK	3.93ab	11.67b	2.31a	16.08a	7.63bcd	377.62e	28.09c
TSF	3.58bc	15.07a	2.44a	17.40a	10.32b	645.90c	38.84b
KB	3.16d	13.22ab	1.28c	11.67b	7.20cd	519.59d	29.37c
DA	3.83abc	12.85ab	0.96d	16.96a	5.72d	358.15e	22.07d

^zSPG, 'Shirin Pust Ghermez'; SDGF, 'Shirin Dane Ghermez Ferdows'; MS, 'Malas Save'; MY, 'Malas Yazdi'; TSK, 'Torsh Shahvar Kashmar'; TSF, 'Torsh Shahvar Ferdows'; KB, 'Khazar Bajestani'; DA, 'Dom Amberoti'.

^yMean separation within columns by Tukey's test at $P < 0.05$.

Table 2. Correlation coefficients (r) of pH, total soluble solids (TSS), titrable acidity (TA), ascorbic acid (A), total anthocyanins (TAs), total phenolics (TPs) and antioxidant activity (AA) of eight Iranian pomegranate juice cultivars.

	pH	TSS	TA	A	TAs	TPs	AA
pH							
TSS	-0.152 ^{NS}						
TA	-0.105 ^{NS}	-0.089 ^{NS}					
A	0.453 [*]	0.172 ^{NS}	-0.141 ^{NS}				
TAs	-0.121 ^{NS}	0.211 ^{NS}	0.175 ^{NS}	0.353 ^{NS}			
TPs	-0.385 ^{NS}	0.250 ^{NS}	0.531 [*]	-0.177 ^{NS}	0.712 ^{**}		
AA	-0.303 ^{NS}	0.183 ^{NS}	0.640 ^{**}	-0.159 ^{NS}	0.655 ^{**}	0.957 ^{**}	

^{NS, *, **} Nonsignificant or significant at P = 0.05 or 0.01, respectively.