AcademicPres

Available online at www.notulaebotanicae.ro

Print ISSN 0255-965X; Electronic 1842-4309

Not Bot Horti Agrobo, 2012, 40(1):247-252

Notulae Botanicae Horti Agrobotanici Cluj-Napoca

Some Fruit Characteristics of Iranian Cornelian Cherries (*Cornus mas* L.)

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Abstract

Although the Cornelian Cherry is widely grown in the north-eastern areas of Iran, it is not recognized as an important fruit crop as are many other fruit species. Large variability has been observed in all morphological and chemical compositions under study. Fruit weight varied from 1.499 to 3.29 g, whereas seed weight ranged from 0.249 to 0.425 g. The average lengths of fruits were between 15.22 and 22.31 mm, and the average widths of them were between 10.26-16.3 mm. The content of ascorbic acid ranged from 240-360 mg/100 g fresh weight. The total soluble solids and total acidity were 5-12.5% and 0.43-1.86% respectively. Grouping of Cornelian Cherry accessions based on 5 factors was performed and were divided into three sub-clusters. The results obtained from this study might be helpful for Cornelian Cherry breeders trying to develop new genotypes and varieties.

Keywords**:** correlation, nutritional properties, physical properties, principle component

Introduction

Cornus (belongs to the family *Cornaceae*) is a very large genus which comprises forty species of shrubs and trees native to Central and Southern Europe and parts of Western Asia. Most species are ornamentals. Only a few species are grown for their fruits, chief among which is the Cornelian Cherry (*Cornus mas* L.) (Brindza *et al*., 2007; Ercisli, 2004b). It is a deciduous shrub, or small tree, from 5 to 8 m high and grows up to an altitude of 1400 m (Klimenko, 2004; Otakar *et al*., 2010). Iran has great agricultural potential because each region of the country can support the cultivation of different kinds of crops.

In Iran, Cornelian Cherry trees are spread in east parts of the country (East Azerbaijan and Qazvin provinces). In these regions, 99% of Cornelian Cherry crop is harvested from open pollinated seedlings of wild genotypes. Because the plants are open pollinated, they vary widely in terms of productivity and fruit characteristics, such as size, shape, color, flavor and nutritional value. The high genetic diversity obtained from seed multiplication of Cornelian Cherry for centuries. Thorough evaluation of the genetic resources of the native genotypes is essential for selecting most useful genotypes for future breeding programs designed to introduce traits such as hardiness and disease resistance from wild genotypes into cultivated varieties (Ercisli *et al*., 2008).

Consumer interest in health foods has increased market demand for high quality fruits such as the Cornelian Cherry (Ercisli, 2004b). Cornelian Cherry cultivation is slowly growing throughout the world, not only because it bears delicious and nutritious fruits, but also because it is an attractive ornamental plant, and is among the first to blossom in spring (Ercisli, 2004b). The fruit is olive shaped, 10-20 mm, pink, yellow or red external colour and, in general, sweet-sour taste (Yilmaz *et al*., 2009a). The fruits are very valuable for fresh consumption and for processing to produce syrups, juices, and jam (Brindza *et al*., 2007) spirits and other traditional products (Otakar *et al*., 2010). Fruits, leaves, flowers and bark are utilized in traditional and modern medicine to cure many disorders (Ercisli, 2004a; Seeram *et al*., 2002). The astringent fruit is a good treatment for bowel complaints and fevers, and also used in the treatment of cholera. The flowers of this plant are used in the treatment of diarrhoea (Demir and Kalyoncu, 2003). Fresh Cornelian Cherry fruits contain twice as much ascorbic acid (vitamin C) as oranges. Furthermore, fruits are rich in anthocyanins, organic acids and tannins (Hassanpour *et al*., 2011; Sara *et al*., 2008; Seeram *et al*., 2002; Tural and Koca, 2008). The Cornelian Cherry is becoming a more popular crop because of recent advances in breeding superior varieties which have an attractive colour, low tannin content, and high sugar content (Brindza *et al*., 2007; Karadeniz, 2002). Studies by Guleryuz *et al*. (1996) revealed that the characteristics of the fruit ranged from 2.907 to 3.906 for fruit weights, 5.950 to 10.707 for flesh/seed ratio, 11.5% to 16.8% for TSS, 43.78 to 76.75 mg vitamin C per 100 g, 2.215% to 4.690% for total acidity (as malic acid), 3.0242 to 7.168 TSS/acid ratio, 4.220 to 9.960 for sugar and 2.024% to 5.664% for reducing sugar, respectively. Also Cornelian Cherry wood, because of its hardness, is used in the production of furniture, jewels, musical instruments and various hand-crafted products (Brindza *et al*., 2007).

Therefore, detailed information about the health-promoting components of more Cornelian Cherry genotypes could lead to a better understanding and an increased consumption of this fruit, including its use in functional foods and as ingredients in pharmaceuticals, nutraceuticals, and medicine.

The objective of this study was to provide information on the status of the genetic resources of the Cornelian Cherry in Iran; its distribution in different parts of the country, and of the characteristics and uses of selected accessions.

Materials and methods

A total of 20 Cornelian Cherry (*Cornus mas* L.) accessions were used in this study. These accessions were selected from Horand (C1-C10) and Kalibar (C11-C20) regions in East Azerbaijan. Approximately 2 kg of ripe Cornelian Cherry fruits per accession were harvested from trees. The fruits were selected according to their uniformity of shape and colour and then transported to the laboratory for further analysis. In totality, 50 fruits in mature status per accession were evaluated for their weight (g), length (mm), width (mm) and other important traits. Fruit juice was analyzed to determination of ascorbic acid, total acidity (TA), total solid content (TSS) and pH. Fruit and Seed weight (g) were measured by a digital balance with a sensitivity of 0.001 g (Scaltec Company, Gottingen, Germany; model SPB31). Fruit length (mm), fruit width (mm), stone width (mm) and stone length (mm) were measured by using a digital vernier caliper with a sensitivity of 0.01 mm (Demir and Kalyoncu, 2003). Flesh/seed ratio (FSR) was calculated by mean fruit weight-mean seed weight/ mean seed weight. TSS was determined by refrectometry of one drop extracted juice of each fruit at 22°C (Kyoto Electronics Manufacturing Co. Ltd., Japan, and Model RA-250HE).TA was determined by diluting each 2 ml aliquot of fruit juice in 20 ml of distilled water and then titrated to pH 8.2 by using 0.1 molar NaOH. The pH value was indicated by pH meter (HBJ-260).

Extraction and measurement of total ascorbic acid

Total ascorbic acid content was determined by the dinitrophenylhydrazine (DNPH) method (Terada *et al*., 1978). Five grams of homogenized fruit tissue was added to 100 mL of a mixture of 6% metaphosphoric acid in 2 mol L^{-1} acetic acid. The mixture was centrifuged at 17000×*g* for 15 min at 4°C and the supernatant was filtered through Whatman filter paper. One millilitre aliquot of the supernatant was mixed with 0.05 mL of 0.2% 2, 6-dichlorophenolindolphenol (DCIP) and the solution was incubated at room temperature for 1 h. After that, 1mL of 2% thiourea in 5% metaphosphoric acid and 0.5 mL of 2% DNPH in 4.5 mol L^{-1} sulfuric acid were added to the solution, and then incubated at 60°C for 3 h. The reaction was stopped by placing the tubes in an ice bath and slowly adding 2.5 mL of cold 90% sulfuric acid. Total ascorbic acid was measured by absorbance at 540 nm using a standard curve. The concentrations were expressed as ascorbic acid on a fresh weight basis, mg per 100 g of fruit.

Statistical analysis

Data were subjected to analysis of variance and means were separated by Duncan's multiple range test at $p<0.01$ significance level by SAS (Software Version 9.1 SAS). Correlation between the traits was determined using the Pearson correlation coefficient. Relationships among the accessions were investigated by factor analysis. Correlation and factor analysis were performed by SPSS (Software Version 16 SPSS). Scatter plots of the first 2 factors were created with SPSS (Software Version 16 SPSS) as well. Cluster analysis was done to yield a dendrogram depicting the morphological relatedness of the Cornelian Cherry accessions by SPSS (Software Version 16 SPSS).

Results and discussion

Nutritional properties

The nutritional properties of Cornelian Cherry fruits are given in Tab. 1. TSS values of these 20 accessions ranged from 5% to 12.5%. This value was reported as 2.1% to 24.1% in previous studies (Demir and Kalyoncu, 2003; Ercisli, 2004b; Pantelidis *et al*., 2007; Pirlak *et al*., 2003; Rudkovsky, 1960; Yilmaz *et al*., 2009a). The observed variation could be as a result of different environmental conditions and accession types, since TSS is greatly influenced by these factors (Demir and Kalyoncu, 2003).

The ascorbic acid content varied from 240 to 360 mg/100 g while the other studies showed that it can be ranged from 12.6 to 122 mg/100 g (Demir and Kalyoncu,

Tab. 1. Chemical properties of the Iranian accessions of Cornelian Cherry fruit

Name of samples	TSS [%]	TA	TSS/TA ratio	PH	Vitamin C [mg/100g]	Altitude [m]
C1	10d	1.28f	7.81i	3.12q	324d	980
C2	6.5q	0.93j	6.99k	3.38e	312e	1034
C3	8.1j	1.28f	6.33n	3.36g	240n	1024
C4	10.5c	1.28f	8.20h	3.51b	354b	1039
C5	9.7e	1.71c	5.67o	3.28k	306f	1025
C6	9.1g	1.83b	4.97r	3.07r	276i	1018
C7	6.9o	1.01h	6.83l	3.29j	312e	1065
C8	8.5i	0.75m	11.33d	3.31h	252l	1275
C9	7.5l	1.17g	6.41m	3.27l	360a	919
C10	10d	1.28f	7.81i	3.22m	330c	1278
C11	6.8p	0.96i	7.08j	3.47c	300g	1469
C12	9.6f	1.86a	5.16q	3.2n	294h	1511
C13	11.1b	0.74n	15b	3.37f	246m	1483
C14	9.7e	1.01h	9.60f	3.4d	252l	1450
C15	7.1m	1.33e	5.34p	3.18o	276i	1266
C16	8k	0.96i	8.33g	3.13p	360a	1061
C17	8.7h	0.85k	10.24e	3.27l	276i	986
C18	5r	0.43o	11.63c	3.95a	246m	903
C19	12.5a	0.8l	15.63a	3.30i	264k	1220
C20	7n	1.49d	4.7s	3.29j	270j	1223

Values in the same column with different lower-case letters are significantly different at $p<0.01$.

Tab. 2. Physical properties of the Iranian accessions of Cornelian Cherry fruit

Name of samples	Fruit weight (g)	Seed weight (g)	Flesh weight (g)	Flesh/stone Ratio	Fruit length (mm)	Fruit width (mm)	Index (Fruit Length/ Fruit width)	Stone length (mm)	Stone width (mm)	Index (Stone length/ stone width)
C1	3.29a	0.347g	2.94a	8.48b	22.31a	16.3a	1.37d	12.56n	6.36k	1.97k
C2	2.220h	0.299l	1.92f	6.42f	19.62b	13.8e	1.42b	13.46h	6.6h	2.04e
C3	2.331e	0.345h	1.99d	5.76i	18.32e	14.18c	1.29g	13.28i	6.76g	1.96l
C4	2.145k	0.325j	1.82g	5.6j	18.16g	13.66ef	1.33f	13.22j	6.94de	1.90p
C5	2.346e	0.345h	2.001d	5.8h	17.36l	13.48gh	1.29g	12.74m	6.62h	1.92o
C6	2.24g	0.279n	1.96e	7.03d	17.16m	13.4h	1.28g	12.22p	6.12o	2.00j
C7	2.367d	0.249s	2.12b	8.51a	19.02c	14.4b	1.32f	12.2p	6.24m	1.95m
C8	1.671o	0.262q	1.41m	5.38k	17.12n	12.46jk	1.37d	12.22p	6.08p	2.00h
C9	1.499o	0.251r	1.25o	4.97m	15.22s	12.76i	1.19h	11.64q	6.4j	1.82r
C10	1.541p	0.282m	1.26no	4.46p	15.92q	12.08l	1.32f	12.32o	6.3l	1.95m
C11	1.998l	0.416c	1.58j	3.80s	17.56k	12.56j	1.4c	14.94a	7.14b	2.09c
C12	2.272f	0.361f	1.91f	5.29l	18.12h	13.38h	1.35e	14.22c	6.84f	2.08d
C13	2.202i	0.422b	1.78h	4.22q	18.24f	12.88i	1.42b	14.5b	7.5a	1.93n
C14	2.420c	0.343i	2.08c	6.06g	18.36d	13.32h	1.38d	13.64g	6.38jk	2.14b
C15	2.164j	0.266p	1.9f	7.14c	17.6j	13.62fg	1.29g	13.76f	6.16n	2.23a
C16	2.458b	0.319k	2.14b	6.71e	17.88i	13.98d	1.28g	12.7e	6.56e	1.94f
C17	1.965m	0.425a	1.54k	3.62t	16.32p	12.3k	1.33f	14.06e	6.92e	2.03f
C18	1.990l	0.356e	1.63i	4.59o	15.52r	10.26n	1.51a	13.00l	6.96d	1.87q
C19	1.554p	0.271o	1.28n	4.73n	16.32p	11.56m	1.41b	13.14k	6.48i	2.03g
C20	1.892n	0.390d	1.50l	3.85r	16.68o	12.42jk	1.34e	14.16d	7.06c	2.00i

Values in the same column with different lower case letters are significantly different at $p<0.01$

2003; Ercisli, 2004b; Otakar *et al*., 2010; Pantelidis *et al*., 2007; Pirlak *et al*., 2003; Yilmaz *et al*., 2009a, 2009b). Similar results were found by Hassanpour *et al*. (2011). The ascorbic acid content of this study were generally higher than the previous findings (Demir and Kalyoncu, 2003; Ercisli, 2004b; Otakar *et al*., 2010; Pantelidis *et al*., 2007; Pirlak *et al*., 2003; Yilmaz *et al*., 2009a, 2009b). In addition, their ascorbic acid content was higher than other fruits known for their elevated ascorbic acid content, such as strawberries and oranges (46-31 mg per 100 g) (Roberts and Gordon, 2003) and kiwi fruits (29-80 mg per 100 g) (Nishiyama *et al*., 2004).

In this research, titrable acidity varied from 0.43% to 1.86%, while it was ranged from 0.62% to 4.69% in other studies (Demir and Kalyoncu, 2003; Yilmaz *et al*., 2009a, 2009b). TSS/TA ratio ranged from 4.7 to 15.63 while it has been reported between 6.37 and 12.61 by Demir and Kalyoncu (2003).

Physical properties

The fruit, seed and flesh weight, flesh/stone ratio, fruit length, fruit and stone width and stone length, of the studied accessions are given in Tab. 2. There were statistical differences in terms of fruit, seed and flesh weight, flesh/stone ratio, fruit length, fruit and stone width and stone length of among accessions (Tab. 2). Average fruit weight values of Cornelian Cherry accessions ranged from 1.499 g (accession C9) to 3.29 g (accession C1). The seeds weight were varied from 0.249 g (accession C7) to 0.425 g (accession C17); flesh weight from 1.25 g (accession C9) to 2.94 g (accession 1); Flesh/stone Ratio from 3.62 (accession C17) to 8.51 (accession C7); Fruit length from 15.22 mm (accession C9) to 22.31 mm (accession C1); fruit width from 10.26 mm (accession C18) to 16.3 mm (accession C1); stone length from 11.64 mm (accession C9) to 14.94 mm (accession C11); stone width from 6.08 mm (accession C8) to 7.5 mm (accession C13).

The average fruit weights reported by others ranged from 0.55 to 9.2 g in Turkey, Slovakia and Serbia (Brindza *et al*., 2009; Demir and Kalyoncu, 2003; Ercisli, 2004b; Pirlak *et al*., 2003; Sandra *et al*., 2010; Turhan *et al*., 2007; Yilmaz *et al*., 2009a, 2009b). One of the significant breeding goals for the Cornelian Cherry is to have larger fruits and attractive fruit characteristics such as flesh/seed ratio, taste etc. (Demir and Kalyoncu, 2003). Therefore, it could be suggested that future breeding program should be primarily focused on fruit weight increase, as a characteristic that has the highest direct correlation with mesocarp weight (Bijelic *et al*., 2007).

Average flesh/seed ratio was varied from 3.62 to 8.51. However, this value was reported to be between 2.05 to 12.62 in Turkey and Serbia (Demir and Kalyoncu, 2003; Ercisli, 2004b; Pirlak *et al*., 2003; Sandra *et al*., 2010; Turhan *et al*., 2007; Yilmaz *et al*., 2009b). The result indicates that the fruit types used in this study were within normal limits.

In the selected accessions, fruit length and width varied from 15.22 to 22.31 mm and 10.26 to 16.3 mm, respec-

Tab. 3. Correlation coefficients among physical properties in Cornelian Cherry genotypes

Variable	1	2	3	4	5	6	7	8	9	10
1-Fruit weight	1	0.24 ns	0.99**	0.68**	0.87**	0.8 ns	0.03 ns	0.13 ns	0.02 ns	0.16 ns
2-Seed weight	-	1	0.09 ns	-0.53**	0.08 ns	-0.13 ns	0.38**	0.75**	0.83**	0.03 ns
3-Flesh weight	-	-	1	0.77**	0.88**	0.83**	-0.02 ns	0.03 ns	-0.9 ns	0.16 ns
4-Flesh/stone Ratio	-	-	-	1	0.68**	0.78**	-0.25 ns	-0.42**	-0.59**	0.14 ns
5-Fruit length	-	-	-	-	1	0.86**	0.11 ns	0.09 ns	-0.07 ns	0.22 ns
6-Fruit width	-	-	-	-	-	1	-0.41**	-0.09 ns	-0.24 ns	0.15 ns
7-index	-	-	-	-	-	-	1	0.33**	0.35**	0.06 ns
8-Stone length	-	-	-	-	-	-	-	1	0.74**	0.52**
9-Stone width	-	-	-	-	-	-	-	-	1	-0.18 ns
10-index	-	-	-	-	-	-	-	-	-	1

*, **: Correlation coefficient is significant at $p<0.05$ and $p<0.01$ respectively. ns: Non-significant.

Tab. 4. Eigen values and cumulative variance for 5 factors resulted from factor analysis

	Component				
	1	2	3	4	5
Fruit weight	0.964**	-0.058	0.151	0.033	-0.028
Seed weight	0.066	0.144	0.938**	0.073	0.000
Flesh weight	0.977**	-0.079	0.018	0.023	-0.031
Flesh/stone Ratio	0.777**	-0.148	-0.565**	0.009	-0.092
Fruit length	0.950**	0.013	0.032	0.077	0.101
Fruit width	0.865**	-0.399	-0.119	-0.058	0.113
Index	0.043	0.832**	0.274	0.215	-0.098
Stone length	0.031	0.038	0.832**	0.463	-0.009
Stone width	-0.084	0.185	0.935**	-0.182	-0.015
Index	0.149	-0.162	0.023	0.918**	-0.005
TSS	0.041	-0.049	0.019	-0.018	0.966**
TA	0.156	-0.867**	-0.010	0.049	0.053
Vitamin C	0.157	-0.453	-0.123	-0.602**	0.003
TSS/TA	-0.153	0.831**	0.043	-0.059	0.479
pH	-0.242	0.710**	0.268	-0.188	-0.427
Eigen value	5.295	3.268	1.988	1.418	1.376
% of variance	35.297	21.789	13.256	9.452	9.172
Cumulative variance %	35.297	57.086	70.341	79.793	88.965

** Significant factor loading (values above 0.50).

tively while in other similar studies it ranged from 12.05 to 29.9 mm and 7.43 to 23.51 mm, respectively. The actual values is dependent on the experiment region (Brindza *et al*., 2009; Demir and Kalyoncu, 2003; Ercisli, 2004b; Pirlak *et al*., 2003; Sandra *et al*., 2010; Turhan *et al*., 2007; Yilmaz *et al*., 2009b). The accession C9 with the lowest shape index value (1.19) had the most round fruit. The highest fruit shape index was found in the accession C18 (1.51) with longest fruit, while in other similar studies the fruit shape index ranged from 1.18 to 2.35 (Demir and Kalyoncu, 2003; Sandra *et al*., 2010; Turhan *et al*., 2007).

Average seed length and width varied from 11.64 to 14.94 mm and 6.08 to 7.5 mm, respectively while Brindza *et al*. (2009) has reported that seed length and width was between 10.16 and 15.49, 5.14 and 7.10 for Cornelian Cherry. The accession C18 had the most round seed, or the lowest seed shape index value (1.87). The highest seed shape index, (the longest seed) was found in the accession C15 (2.23).

The variation of fruit weight, seed weight, flesh/stone ratio, fruit length, fruit width, TSS, pH, TA and ascorbic acid contents in Cornelian Cherry fruits could be result of heterozygote nature of seed propagated accessions and the effect of different environmental conditions where the accessions grown. The analyses of the physicochemical characteristics of Cornelian Cherry accessions in this work demonstrated that the twenty accessions are different in terms of their fruit weight, seed weight, flesh/stone ratio, fruit length, fruit width, and TSS, pH, TA and ascorbic acid contents. The accession C1 had high fruit weight, fruit length, fruit width and flesh weight. The other promising accessions are C9 for its less stones length, C8 for its less stones width, C13 for its smaller stones, higher TSS content, TSS/TA ratio and TA content, C18 for its for higher pH and accession C16 for its higher ascorbic acid content. These six accessions may be especially useful in developing cultivars with greater agronomic potential.

Correlation coefficient for different physical parameters showed that significant positive correlations existed among most of the traits (Tab. 3). There were significant positive correlations between fruit weight, flesh weight, flesh/stone ratio and fruit length; seed weight, stone length and width ($p<0.01$), whereas a significant negative correlation existed between seed weight and flesh/stone ratio; flesh/stone ratio and stone length, stone width ($p<0.01$). It was observed that there was no apparent correlation between fruit weight and fruit width. Therefore, it is not possible to sort out Cornelian Cherry trees with weighted fruits according to the fruit width.

Factor analysis showed that the first fifth Principle component explained 35, 22, 13, 9.5 and 9% of the variation respectively, making a total of 89% (Tab. 4). Among the studied variables tested, the fruit weight, flesh weight, flesh/stone ratio, fruit width and length, were highly correlated with factor 1. The highly correlated variables with factor 2 were TSS/TA and pH. The highest correlation with factor 3 was calculated from seed weight, seed width

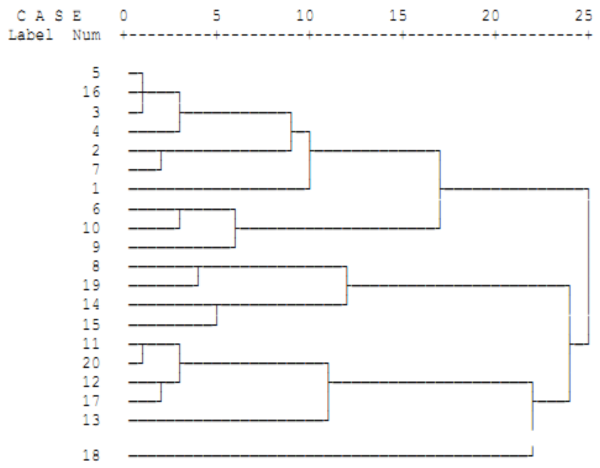

Fig. 1. Dendrogram of grouping 20 Cornelian Cherry accessions based on 5 main factors and Ward's method

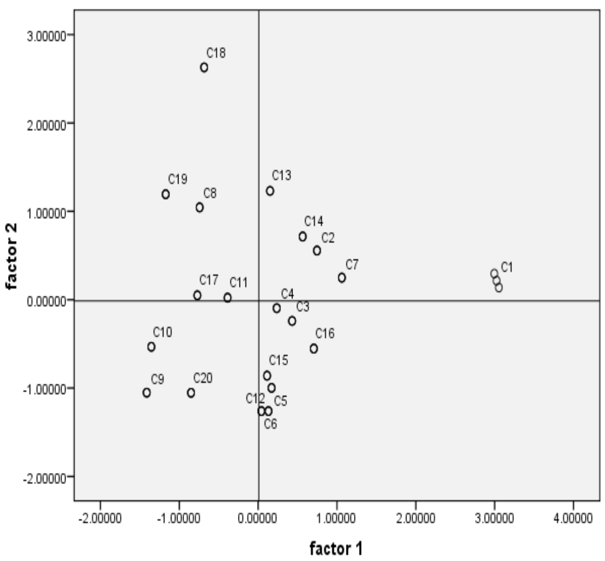

Fig. 2. Factor analysis plot of the first two factors depicting relationship among Cornelian Cherry (cornus mas) accessions established in Iran

and length. The highest correlation with factor 5 was calculated from TSS. The vitamin C was negatively correlated with factor 4. While TSS/TA and pH was positively correlated with factor 2, TA was negatively correlated with factor 2. The PC analysis of Yilmaz *et al.* (2009b) study in Turkey indicated that the first three PC explained 61% of the total variation. Grouping of Cornelian Cherry accessions based on these 5 factors was performed and accessions in distance of 22 were divided into three sub-clusters (Fig. 1).

The distribution of accessions on the factor 1 and factor 2 plots is showed in Fig. 2. Starting from the negative to the positive values of factor 1, the accessions indicated a general increase in the fruit flash weight, length and width, and a decrease in seed weight. Starting from the negative towards the positive values of factor 2, the accessions were characterized by a large seed. The factor analysis provided a simplified classification of the Cornelian Cherry accessions for collection and for breeding. The scatter plot (Fig. 2) also shows geometrical distances among the accessions in the plot that reflect a similarity among them in terms of variables measured. Three groups of related accessions were separated. Group A includes those accessions with a low negative value of factor 1 and intermediate of factor 2 (C9, C10, C11, C17 and C20). Group B consists of seven accessions that corresponded with a high negative factor 2 and a low positive factor 1 value (C3, C4, C5, C6, C12, C15 and C16). Four accessions that have an intermediate positive factor 1 and 2 value are in the third, C group, of related accessions (C2, C7, C13 and C14). For further collection it is sufficient to take just one accession from each of these groups. Based on the position, a small genetic distance is observed between C8 and C19 accessions. The C1 accession can be considered unique. This accession characterized by the large fruit size and small seed size. This is the first report on genetic diversity among Cornelian Cherry accessions in Iran based on morphological markers. As a tool for germplasm biodiversity description, we have used principal component analysis to study correlations among variables and establish relationship among accessions. This method is commonly applied for characterization of biodiversity of genetic resources in such studies (Sarkhosh *et al.*, 2009; Yilmaz *et al.*, 2009b).

Conclusions

This investigation clearly indicates that wide biodiversity occurred among Cornelian Cherry accessions. Fruits differ among themselves in the weight, length, width, ascorbic acid, TSS and TA, etc. The results of the study are helpful for understanding the variability and attempting the selection of superior desirable Cornelian Cherry accessions for bringing to commercial cultivation.

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