# Relationships of Fruit Characteristics of Rosehips (*Rosa canina* L.) Grown in Bolu City Center

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**ABSTRACT:** Rosehip (*Rosa* spp.) is one of the most used non-wood forest products. It is an essential source of antioxidants and vitamin C besides having a wide range of uses in folk medicine and the marmalade industry. Therefore, for many years, researchers have made efforts to find the superior genotypes of this fruit. In previous studies, classical breeding methods were used in the evaluation of the data and more modernist approaches were given little attention. In this study, fruit characteristics and their relationships of rosehip genotypes growing in Bolu city center were determined by using more modernist analysis methods (Clustering, PCA) and correlation analysis. As a result of the study, while fruit weight was positively correlated with fruit size, it had a negative correlation with the fruit flesh ratio. In cluster analysis, genotypes were collected in two different groups, and PCA analysis supported this result. Results of the study proved that multivariate analysis has come to the fore as a highly effective method for evaluating genetic resources. Furthermore, the G-5 genotype stood out with its fruit weight and size.

**Keywords:** Rosehip, *Rosa canina* L., PCA, correlation, multivariety analysis

## Bolu İli Şehir Merkezinde Yetiştirilen Kuşburnuların (*Rosa canina* L.) Meyve Özellikleri Arasındaki İlişkiler

**ÖZET:** Kuşburnu (*Rosa spp.*) en çok kullanılan odun dışı orman ürünlerinden biridir. Meyvesi, halk hekimliğinde ve marmelat endüstrisinde geniş bir kullanım alanına sahip olmasının yanı sıra önemli bir antioksidan ve C vitamini kaynağıdır. Bu nedenle, araştırmacılar uzun yıllar bu meyvenin üstün genotiplerini bulmak için çaba harcadılar. Bu çalışmalarda verilerin değerlendirilmesinde klasik yetiştirme yöntemleri kullanılmış ve daha modernist yaklaşımlara çok az önem verilmiştir. Bu çalışmada Bolu il merkezinde yetişen kuşburnu genotiplerinin meyve özellikleri ve ilişkileri daha modernist analiz yöntemleri (Kümeleme, PCA) ve korelasyon analizi kullanılarak belirlenmiştir. Çalışma sonucunda meyve ağırlığının meyve büyüklüğü ile pozitif yönde ilişkili olduğu tespit edilirken, meyve eti oranı ile negatif korelasyona sahip olduğu görülmüştür. Küme analizinde genotipler iki farklı grupta toplanmış ve PCA analizi bu sonucu desteklemiştir. Çalışma sonucunda meyve ağırlığı ve büyüklüğü ile G-5 genotipinin öne çıktığı görülmüştür. Ayrıca kümeleme ve PCA gibi analizlerin seleksiyon ıslahı çalışmalarında verilerin değerlendirilmesinde başarılı bir şekilde kullanılabileceği değerlendirilmiştir.

**Anahtar kelimeler:** Kuşburnu, *Rosa canina* L., PCA, korelasyon, Bolu

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## INTRODUCTION

Rosehip (Rosa spp.) belongs to the genus Rosa of the Rosaceae family of the order Rosales. Turkey has approximately 25% of rosehips that grow in the world (Kutbay and Kılınç, 1996; Türkben, 2003; Ercişli and Güleryüz, 2005).

Rosehip is a plant in the form of a shrub that can grow up to 0.5-4.0 m with an upright, and pending form varies according to its species. Its trunk and branches can have more or fewer thorns. Rosehips are deciduous. Thorns of plants are generally curved, very few, and straight. The glabrous leaves with 5-11 leaflets, 2–4 cm long, are in the form of an egg or ellipse. The edges of the leaves are straight or piled, serrated, light bluish-green. The flowers are light red, pink, yellow, cream or white, gathered in single or umbrella-like clusters. Its flowers have five sepal and five petal leaves. The sepals are in the shape of a round or elongated egg, and the ends are folded back later, and it is poured later according to the type or remains on the fruit. The outer part of the fruit is hairy or glabrous depending on the species, and the inner part of the fruit is more or less hairy; It contains many seeds and can generally remain on the plant in winter (İlisulu, 1992; Türkben, 2003).

Rosehip has become fruit in demand by consumers in recent years having natural antioxidants beneficial to human health (Su et al., 2005). Rosehip fruits contain minerals, carotenoids, tocopherol, bioflavonoids, fruit acids, tannin, pectin, amino acid, and essential oils (Çınar and Çolakoglu, 2005).

Rosehip grows naturally in a wide range of regions, including the Caucasus, Central, and Western Asia, Europe, Iraq, Northwest Africa, and the northern and western parts of Iraq and Iran, north Afghanistan, Kashmir, Pakistan, and the former Commonwealth of Independent States (Ilisulu, 1992). Rosehip plant is highly adaptive to various climate and soil conditions. Because of this characteristic, the plant can be seen in a wide-ranged area in Turkey (Ercişli and Güleryüz, 2005).

Genetic material diversity is an excellent resource that could contribute to future rose hip breeding programs aimed at the most desirable traits, such as high yield, fruit characteristics, bioactive compounds, and resistance to disease and pests.

Even though there are plenty of studies on fruit and plant characteristics of rosehips, most of them were on physicochemical characteristics (Sanderson and Fillmore, 2010; Yıldız and Çelik, 2011 Ekincialp and Kazankaya, 2012; Ersoy and Özen, 2016) and some of them were on nutritional ingredients (Türkben et al., 2005; Ercişli, 2007; Kerasioti et al. 2019; Rovná et al., 2020). Although there are academic studies on rosehip, almost no studies examine the relationships of fruit characteristics. In this study, we determined the relationships of some base characteristics of rosehip genotypes naturally grown in the city center of Bolu.

## MATERIALS AND METHODS

### Material

The rosehip genotypes used for relationship analysis in this study were obtained from the city center of Bolu. The genotypes were ungrafted and naturally grown.

### Pomological analysis

Fruit length (FL) and fruit width (FWH) were measured by a 0.001 mm sensitive digital hand caliper. Fruit weight (FW) and fruit flesh weight (FFW) were weighed by a 0.001 g sensitive scale. pH was measured with a table-type pH meter. Total soluble solids (TSS) was determined by a hand refractometer. Titratable acidity (TA) was measured with the titration method (İpek and Balta, 2020). Fruit flesh ratio (FFR) was calculated with the equation of 'FFW/FWx100' while the fruit shape index (FSI) was calculated with the equation of 'FWH/FL'.

**Statistical analysis**

The ANOVA test was performed to determine the variance between genotypes in terms of fruit characteristics, and significant variants were indicated with different letters. Correlation, cluster, and principal component analysis were performed to determine relationships of features. The R Studio statistical software was used in the analysis and data visualization. The package 'corrplot' (Wei and Simco, 2017) was used to perform correlation analysis, and the package 'ggplot2' (Wickham, 2016) was used for PCA.

**RESULTS AND DISCUSSION**

In the study, FWs of genotypes varied between 0.67 (G-14) to 1.44 g (G-2), and FFW values were between 0.49 – 0.88 g (Figure 1). FL values were determined between 11.83 - 21.54 mm in G-14 and G-5, respectively. The G-1 genotype had the least FWH (9.33 mm), while the G-6 genotype had the most superior value (11.98 mm) in terms of this feature (Figure 2). FFRs varied by 41.24% (G-10) to 67.32% (G-5), and FSI values were recorded between 1.11-2.02 (Table 1). The features fruit size (FL and FWH) and FW are desired to be as high as possible to attract the farmer's interest to grow them and suitability to mechanical and technological applications (Çelik et al., 2009). The FW and size values of the genotypes in this study were relatively low that previously reported (Yıldız and Çelik, 2011; Ekincialp and Kazankaya; İpek and Balta, 2020) while the results fit and support most of the studies (Türkoğlu ve Muradoğlu 2003, Türkben et al., 2005; Ersoy and Selman Özer, 2016; Doğan and Kazankaya, 2006; Karakuş and Bostan, 2017). There was also a study that showed fewer values than ours (Sanderson and Fillmore, 2010). Considering all these studies, we can suggest that rosehips' fruit properties vary according to species, growing region, climatic and ecological conditions.
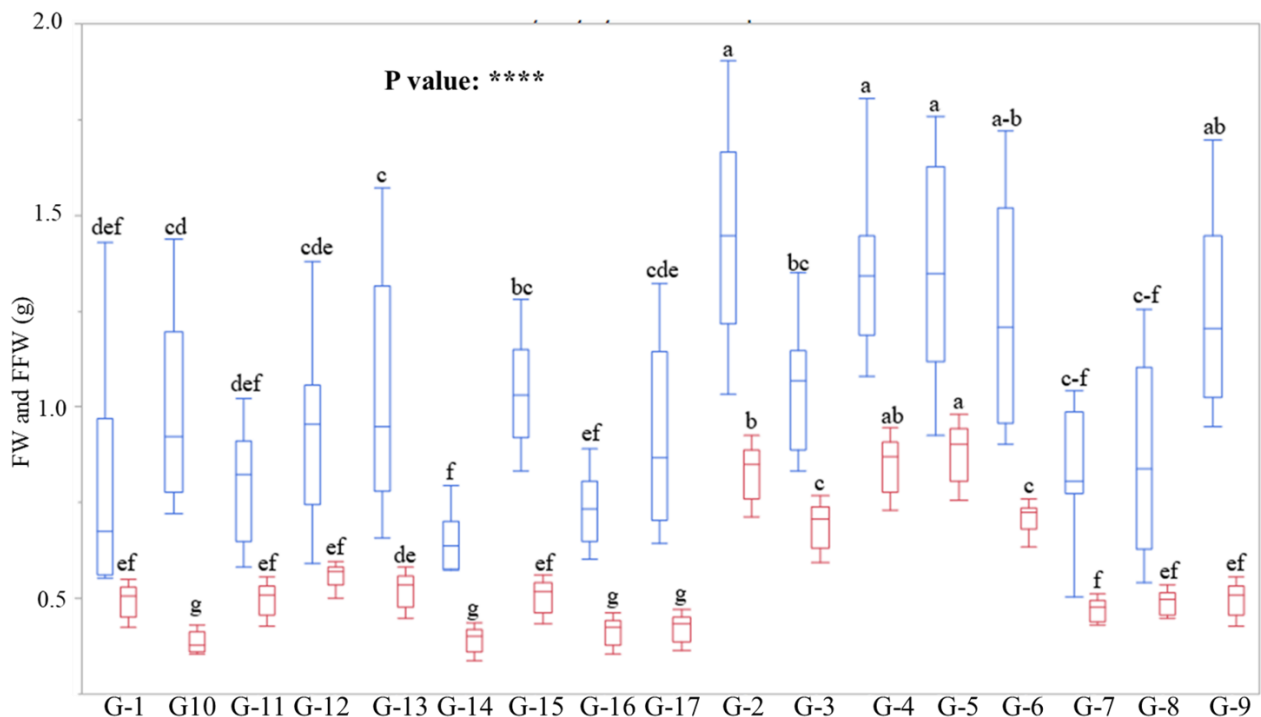


**Figure 1**. FW (blue boxes) and FFW (red boxes) values of genotypes. Values were given as mean ± std. er.. Different letters indicate significant variance at the level of 0.05
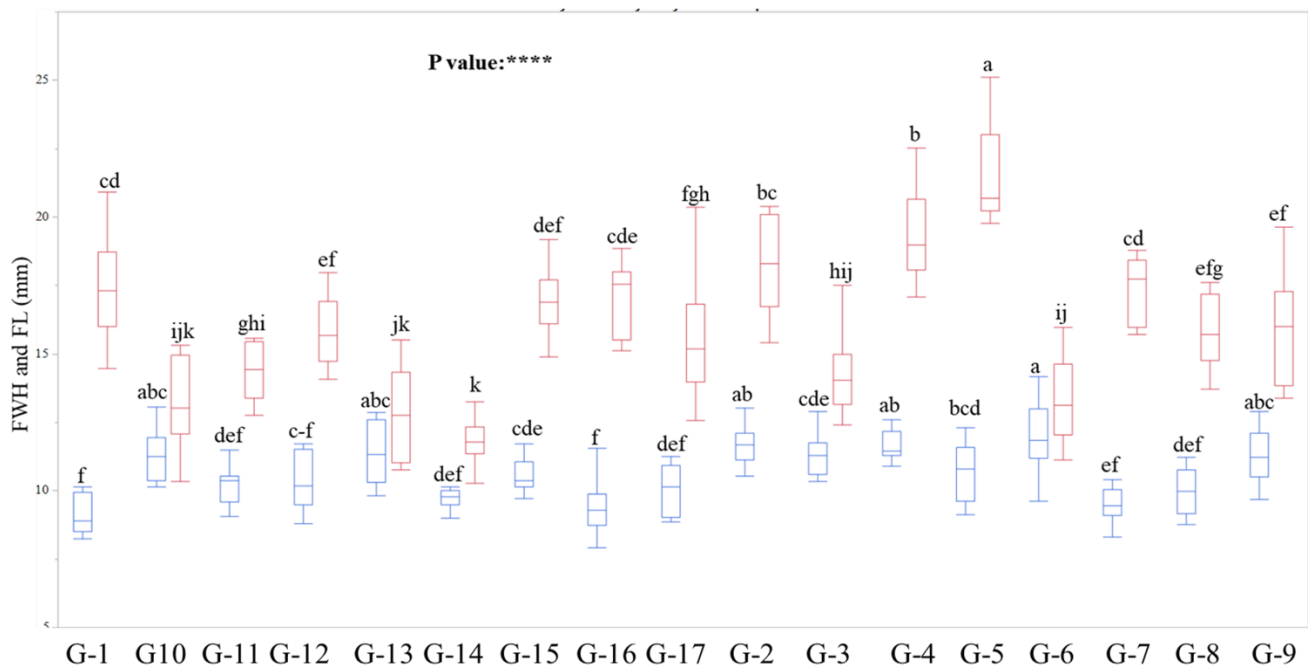
**Figure 2.** FW (blue boxes) FFW (red boxes) values of genotypes. Values were given as mean ± std. er.. Different letters indicate significant variance at the level of 0.05

**Table 1.** The other physical and chemical properties of the genotypes

| Genotype | pH | TSS (%) | TA (g L) | FFR (%) | FSI |
|---|---|---|---|---|---|
| G-1 | 3.88$^s$ | 18.78 ± 0.49 e* | 1.95 ns | 67.01 ± 5.48 a | 1.87 ± 0.04 abc |
| G-2 | 3.93 | 14.04 ± 0.47 h | 1.93 | 59.73 ± 4.34 abc | 1.57 ± 0.03 a-f |
| G-3 | 3.80 | 15.91 ± 0.53 g | 1.91 | 67.11 ± 3.92 a | 1.88 ± 0.64 ab |
| G-4 | 3.95 | 16.85 ± 0.56 fg | 1.98 | 64.00 ± 3.24 ab | 1.66 ± 0.04 a-d |
| G-5 | 3.36 | 23.40 ± 0.78 c | 1.88 | 67.32 ± 4.39 a | 2.02 ± 0.05 a |
| G-6 | 3.58 | 20.50 ± 0.35 d | 1.87 | 59.83 ± 4.13 abc | 1.11 ± 0.03 g |
| G-7 | 3.18 | 29.67 ± 0.79 a | 1.89 | 57.95 ± 4.35 a-d | 1.83 ± 0.05 a-d |
| G-8 | 3.16 | 22.01 ± 0.58 cd | 1.87 | 60.16 ± 5.33 abc | 1.58 ± 0.03 a-f |
| G-9 | 2.25 | 17.78 ± 0.59 ef | 1.80 | 41.58 ± 2.73 e | 1.41 ± 0.06 d-g |
| G-10 | 3.75 | 29.80 ± 0.72 a | 1.87 | 41.24 ± 3.16 e | 1.16 ± 0.03 efg |
| G-11 | 3.52 | 14.04 ± 0.47 h | 1.79 | 64.75 ± 4.51 ab | 1.42 ± 0.05 c-g |
| G-12 | 3.27 | 28.31 ± 0.48 ab | 1.82 | 63.26 ± 4.77 ab | 1.54 ± 0.05 b-g |
| G-13 | 3.55 | 22.46 ± 0.75 c | 1.85 | 54.01 ± 4.57 bcd | 1.14 ± 0.03 fg |
| G-14 | 3.13 | 18.72 ± 0.62 e | 1.79 | 59.83 ± 3.02 abc | 1.20 ± 0.02 efg |
| G-15 | 4.49 | 18.72 ± 0.62 e | 1.92 | 49.70 ± 3.29 cde | 1.61 ± 0.03 a-e |
| G-16 | 3.16 | 27.14 ± 0.90 b | 1.90 | 56.21 ± 4.45 a-d | 1.83 ± 0.07 a-d |
| G-17 | 4.42 | 15.91 ± 0.53 g | 1.80 | 47.84 ± 3.41 de | 1.54 ± 0.05 b-g |

$^s$ statistical analysis was not performed. *Different letters in the same column indicate significant variance in the level of 0.05. ns: not significant

The cluster analysis was performed to determine if the genotypes separate or group together in terms of fruit characteristics. As a result of the analysis, the genotypes were grouped into two main trees. Sub-cluster one (A) had fourteen of the genotypes, while sub-cluster two (B) had three of them (Figure 3). Two-way clustering showed that cluster B separate from A in terms of FWH, FW, FFW, and FL. The mean FWH of A was 10.40 mm while B had 11.35 mm. The average FW of cluster A was 0.94 g while B was 1.37 g. FFW of A was 0.50 g while B had an average of 0.85g. According to this perspective, sub-grouping has occurred in terms of priority of fruit size and weight, and sub-group B had superior values.
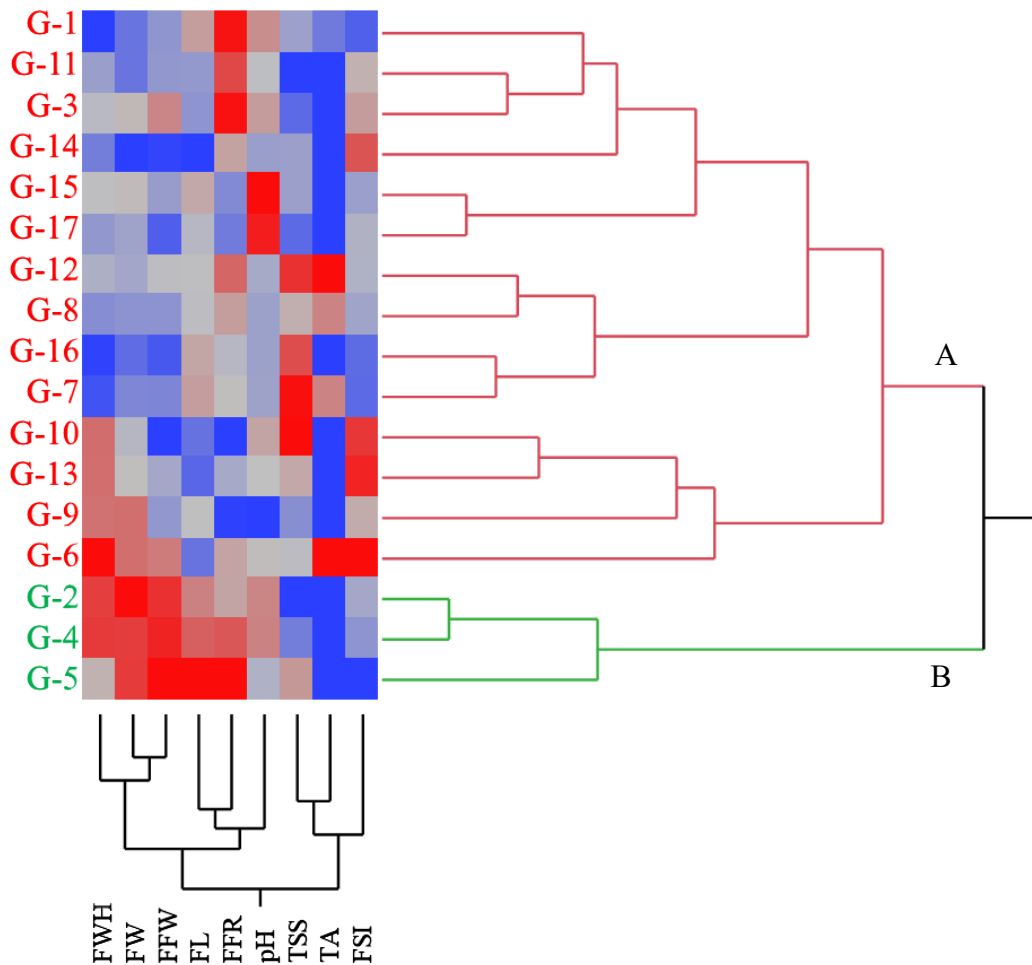


**Figure 3.** Two-way clustering of genotypes in terms of fruit characteristics according to Ward's method

In the study, correlation analysis was performed to determine the relationships between fruit characteristics. Correlation analysis showed that FWH had positive relationships with FW (r=0.82), FFW (r=0.57) and, FSI (r=0.51). FFR was negatively related to FWH (r=-0.23). FL had a negative correlation with FSI and a positive correlation with FFW. TSS was negatively related to FFW (r=-0.32). None of the characteristics were statistically related to pH and TA. All correlations have been shown in Figure 4.
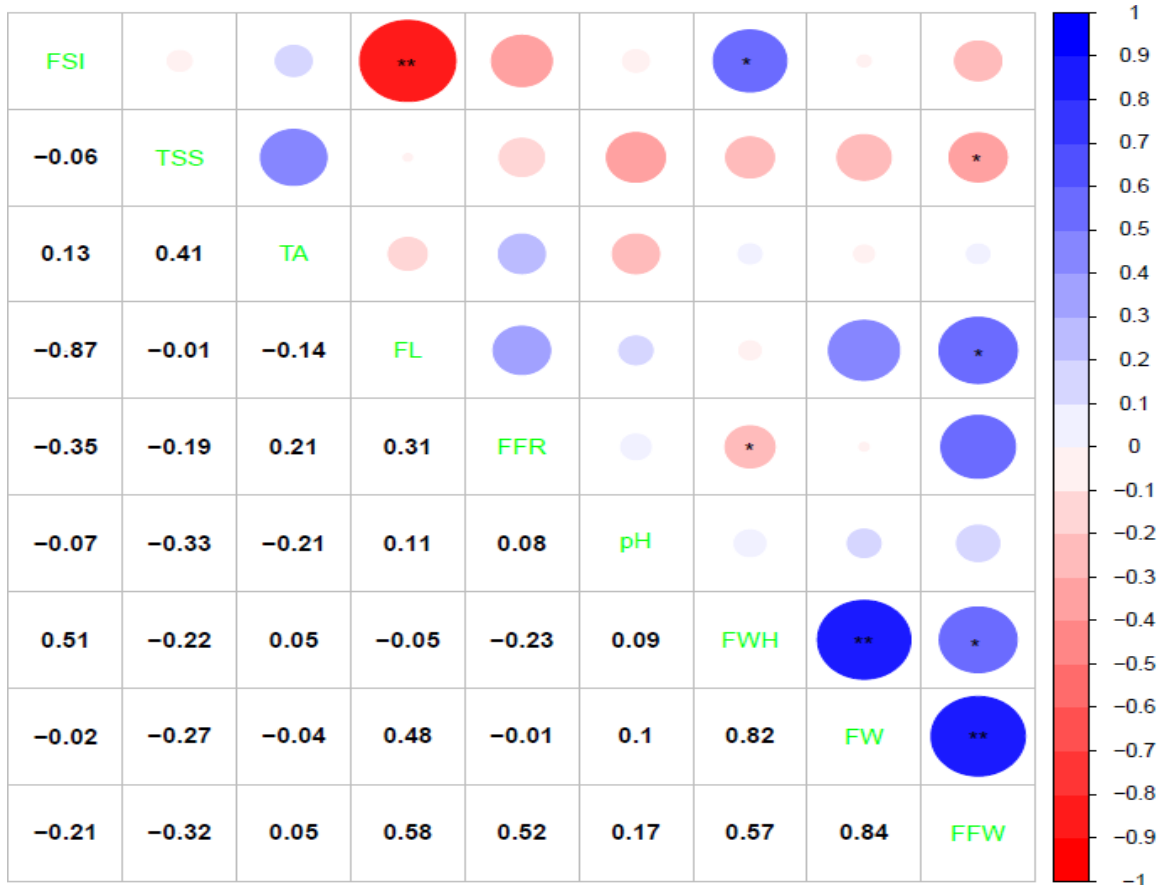
**Figure 4.** Pearson's correlations of fruit characteristics of rosehip. *indicates significance at 0.05, and ** indicates significance at 0.01
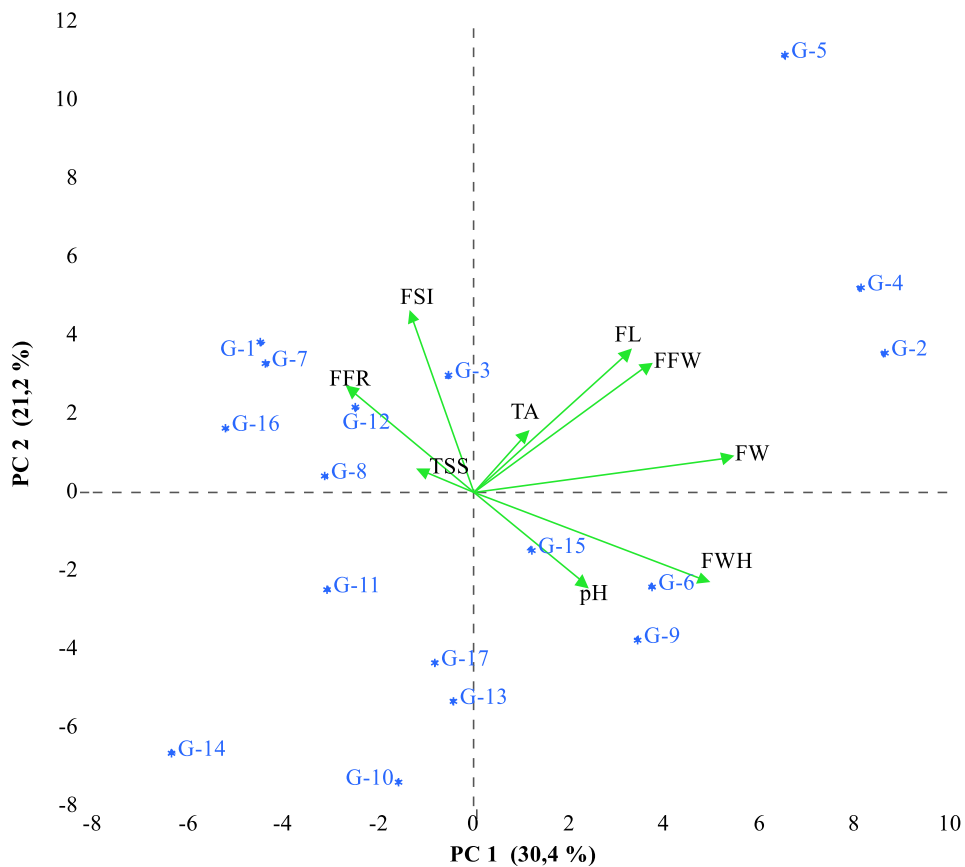


**Figure 5.** Distribution of the fruit characteristics and genotypes in the biplot

In the PCA analysis, PC1 described 30.4%, and PC2 explained 21.2% of the data. FW had the highest effect on PC1 (0.57), followed by FL, FWH, and FFW, and these features had almost the same amount of influence (0.42). FSI had a dominant effect on PC2, and it was negative (-0.62). FL was the second with a value of 0.44. As clearly seen in Fig. 5, genotypes 2, 4, and 5 separated into different zone supporting cluster analyses. Sanderson and Fillmore (2010) stated a total of 66% variation in PCA. The difference between various amounts of PCA's is considered to occur due to data set differentiation.

## CONCLUSION

This study was carried out on the rosehip germplasm of the city center of Bolu province. As a result of the study, it was observed that the rosehip genotypes grown in the city center were of medium size and partially competed with the genotypes reported by previous researchers. The genotypes 2, 4, and 5 came to the fore with fruit size and weight, and they were considered valuable material to be evaluated in future studies. Besides, clustering and PCA analyzes were highly useful in determining superior genotypes and clearly differentiated them. In subsequent studies, it was proven that these analyzes could also be used effectively instead of the classical weighted grading method.

### Conflict of Interest

The article authors declare that there is no conflict of interest between them.

### Author's Contıbutions

The authors declare that they have contributed equally to the article.

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