PHYSICO-CHEMICAL CHARACTERISTICS OF POMEGRANATE ACCESSIONS FROM THE KURDISTAN REGION, IRAQ

**Saadatian M.[[1]](#footnote-1)\*, Paiza A.A., Kanar S.F., Pershang Y.N.,**

**Hewen A.H. and Silaw M.E.**

Soran University, Faculty of Education, Department of General Science, Soran, Kurdistan Regional Government, Iraq

**Abstract:** Some physico-chemical properties of ten pomegranate accessions collected from different districts in the Kurdistan region of Iraq were investigated in this paper. Accessions showed variability in all traits except total phenolics and antioxidant capacity. Considerable changes in the characteristics studied were found and valuable pomological traits were observed. Cluster analysis showed the homonyms between some pomegranate accessions. Principle component analysis reported that the component describing the greatest variability and also positively correlated with fruit weight, total aril weight, total peel weight, volume of juice, total soluble solids (TSS), fruit length, fruit diameter, pH, aril length, and 100-seed fresh weight, but negatively correlated with titratable acidity (TA). Fruit weight was firmly correlated with total aril weight, total peel weight, volume of juice, TSS, aril length, 100-seed fresh weight, fruit length and fruit diameter. The volume of juice was correlated with TSS, aril length, 100-seed fresh weight, fruit length, fruit diameter and it was observed that with an increase in the fruit size, the volume of juice increased as well. The correlation between total phenolic compounds and antioxidant capacity was not observed. The associations found among physical and chemical traits suggest that consumers should use large fruits with large arils so that they have more juice. Thus, ‘Choman’, ‘Raniyeh’ and ‘Halabja’ were juicier than other accessions.

**Key words:** physical properties, accessions, fruits, antioxidant, phenolic compounds.

**Introduction**

Pomegranate (*Punica granatum* L.) has a highly distinctive fruit and it is the individual from two species belonging to the *Punicaceae* family (LaRue, 1980). *Punica granatum* L*. (Punicaceae)* is one of the oldest domesticated fruit trees that people have been consuming for a long time. With respect to numerous organic product species, pomegranate fruit is a significant natural product for human wellbeing as a result of its rich cancer prevention activity and high polyphenol content (Hernandez et al., 1999). The most plentiful phytochemicals in pomegranate juice are polyphenols, including the hydrolyzable tannins called ellagitannins framed when gallic acid binds with a sugar to shape pomegranate ellagitannins, otherwise called punicalagins (Singh et al., 2002). The red color of juice can be ascribed to anthocyanins, for example, delphinidin, cyanidin, and pelargonidin glycosides (Hernandez et al., 1999). For the most part, an expansion in juice pigmentation happens in natural product aging (Hernandez et al., 1999). Contrasted with the pulp, the unpalatable pomegranate peel contains as much as three times of the aggregate sum of polyphenols (Singh et al., 2002), including condensed tannins (Ben-Nasr et al., 1996), catechins, gallocatechins and prodelphinidins (Morton, 1987).

The pomegranate tree normally develops up to 4‒6 m, has numerous spiked branches, as proven by trees at Versailles, France, known to be more than 200 years of age. The leaves are polished and spear molded, and the bark of the tree turns dark as the tree ages. The blooms are large, red, white, or variegated and have a tubular calyx that turns into fruits (LaRue, 1980). Pomegranate originated in the area of Iran, and has been developed since old circumstances all through the Mediterranean district and northern India. Today, it is broadly spread all through the Middle East and Caucasus district, north and tropical Africa, the Indian subcontinent, Central Asia, the drier parts of Southeast Asia, and parts of the Mediterranean Basin (Chidambara-Murthy et al., 2002)*.*

Kurdistan is a local point of source for pomegranate and has suitable condition more than any place that pomegranate growth. Neighborhood pomegranates are various and adjusted to various natural states of Kurdistan climate. The pomegranates have been developed using traditional techniques for many years ago and can be used for various purposes; namely, protection from infections, irritations, cold, and dry season. Furthermore, it can be used for modern procedures like natural juice production. Accordingly, the losses in genetically arranged assortment in crop species because of commercialization have driven the need to protect the current genetic sources. The principle objectives of this study were: a) to portray and analyze pomegranate that developed in 10 locations of Kurdistan, and b) to decide the fluctuation inside characters utilized as a part of morpho-pomological and chemical compound examinations.

**Materials and Methods**

Plant preparation

Pomegranate fruits of accessions were harvested from pomegranate orchards located in the ‘Choman’, ‘Soran’, ‘Hewler’, ‘Sidakan, ‘Barzan, ‘Raniyeh’, ‘Halabja’, ‘Kerkuk’, ‘Harir’, ‘Balakayati’, in the Kurdistan region of Iraq. They were brought to the laboratory of the General Science Department of the Faculty of Education of Soran University, in 2016. Ripe fresh fruits were picked from different mature trees randomly (by a completely randomized design of four trees per a sample of ten fruits per replications) selected to represent the population of the plantation.

Physical properties: Harvested fruits were sorted according to their size, uniformity, shape and weight. All fruits were first flushed with tap water before the peel, pulp and seed fractions were carefully separated. The peel and the pulp were separated manually after fruit fresh weight and fruit density determination.

Fruit fresh and aril weights were determined by weighting the fruits in the air on a precision digital balance (Mettler AJ50) with an accuracy of 0.0001 g. Then peel thickness, aril and fruit lengths and diameter were measured by a digital caliper with 0.01 mm accuracy. Aril, juice and seed weights were measured as above. Fruit juice extraction content was measured manually. Then the fruit juice was analyzed for total phenols and antioxidant activity.

Chemical analysis: Total soluble solids (°Brix) in the juice were determined with a digital refractometer (ATAGO RX-5000) at 20°C, calibrated using distilled water. Titrable acidity was estimated by juice titration with 0.1 N NaOH to the titration end point of pH 8.3, monitored with a pH meter (Labtron) and expressed as citric acid content (mg/100ml). For pH determinations, the samples were homogenized and measured with a pH meter (Labtron).

Total phenolic content (TPC)

TPC was determined by the Folin-Ciocalteau technique as described by Singleton et al. (1999) with minor adjustments, as indicated by colorimetric oxidation/decrease response of phenols. The polyphenol extraction was completed using 10 ml of 85% methanol added to 1g of fine powder of pomegranate. To prepare 250 μl of concentrate, 250 μl of sterile refined water was used, and after that 2.5 ml of the Folin-Cicalteau reagent and 2 ml of sodium carbonate 7.5% were added. The samples were shaken for 1.5 to 2 hours. The absorbance of tests was estimated at 765 nm by a PG Instruments T80+ UV/VIS spectrophotometer. Gallic acid was utilized for a regulation curve. Results were expressed as mg GAE/100 g FW.

Total antioxidant capacity

The antioxidant properties were estimated by the scavenging of 2, 2-diphenyl-2-picrylhydrazyl hydrate (DPPH) radicals as per Brand-Williams et al. (1995) with minor adjustments. The purple color intensity of DPPH solution decays and the change of absorbance were followed spectrophotometrically (PG Instruments ltd – T80 + UV/VIS) at 517 nm. Quickly, a 0.15 mM solution of DPPH in methanol was prepared. Then, 2 ml of this solution was added to 1 ml of methanol concentrates of pomegranate natural products. The substance of the tubes was blended and taken after to remain for 30 min and absorbances were determined at 517 nm. The antioxidant properties were communicated as the level of free radical scavenging. The inhibition rate for each sample was figured as follows:

% inhibition = 100 (A0 – Ax)/A0, where A0 is the absorbance of a DPPH blank and Ax is the absorbance of juice solution.

Statistical analysis

Investigation of variance, correlation, principle component analysis (PCA) and cluster dendograph were performed using the SAS (variant 9.2) program. LSD values were computed at p≤0.01.

**Results and Discussion**

According to data, differences among accessions for all the traits were significant at the 1% level (p≤0.01). Mean comparison properties (Table 1) showed that ‘Choman’ accessions reached the highest values of fruit weight, total aril weight, and total peel weight, seed fresh weight, fruit length and fruit diameter. ‘Harir’ accessions reached the highest values of peel thickness and aril length. Peel thickness varied from 1.3 mm to 3.6 mm, and the average values of peel thickness share in pomegranate fruits between 4.2% and 5.9% were reported (Martinez et al., 2012). The vast majority favor pomegranate fruits with thin peel since they have less waste and are simple to separate (Radunic et al., 2015). Also, 100-seed fresh weight, pH and TSS/TA reached the highest values in ‘Halabja’ in comparison to other accessions. The TSS/TA proportion is a quality factor that is critical for assurance of taste and harvest time. According to the results, TSS/TA values varied from 4 (‘Balakayati’) to 6.34 (‘Halabja’). The TSS/TA ratio for Italian pomegranate was in the range of 5.4 to 37.7 (Cristofer et al., 2010) and for Spanish pomegranate between 37.4 and 56.9 (Martinez et al., 2006). According to Table 1, the lowest and highest TA contents were observed in ‘Halabja’ (1.8%) and ‘Sidakan’ (2.2%) with ‘Balakayati’ (2.2%) accessions respectively. TSS varied between 8.7 and 11.3%. The volume of juice differed significantly from 34 ml (‘Soran’) to 135 ml (‘Raniyeh’). Juice quality is incredibly impacted by cultivar and type of extraction method as the extraction of juice using a blender is more different than when using mechanical methods (Rajaseker et al., 2012).

Table 1. Mean comparison of different fruit characteristics in ten pomegranate accessions.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Accessions | Fruit weight  (g) | Total aril weight  (g) | Total peel weight  (g) | Peel thickness (mm) | Volume of juice (ml) | pH | TA (total acidity)  (%) | TSS (total soluble solids) (%) |
| Choman | 418.6a | 230.67a | 148.10a | 3b | 127.3a | 3.63b | 1.8de | 11.1ab |
| Raniyeh | 376.0b | 198.33b | 96.87bc | 2.6bc | 135a | 3.47c | 1.8cd | 11bc |
| Halabja | 361b | 220.33a | 97.23bc | 1.3e | 134a | 3.79a | 1.8e | 11.3a |
| Harir | 355.4bc | 179.00c | 110.43b | 3.6a | 126.6a | 3.1d | 2b | 10.3e |
| Kerkuk | 333.7c | 110.67e | 97.67bc | 2.3bc | 126.6b | 3.6b | 1.9c | 10.8cd |
| Sidakan | 254.5d | 136.33d | 67.67d | 1.3e | 91b | 2.83e | 2.2a | 8.7g |
| Barzan | 253.1d | 121.17e | 84.43c | 1.8d | 73.3c | 3.48c | 1.9c | 10.9bcd |
| Balakayati | 224.1e | 78.67f | 55.30d | 1.3e | 56.6d | 2.83e | 2.2a | 8.9g |
| Hewler | 191.1f | 75.00f | 53.93d | 2.8b | 57d | 3.52bc | 1.8e | 10.7d |
| Soran | 169.5f | 59.67g | 60.98d | 3.6a | 34e | 3.6b | 2b | 10f |
| Accessions | TSS (total soluble solids)  (%) | Taste index (TSS/TA) | Aril length (mm) | Aril diameter (mm) | Seed fresh weight (g) | 100- seed fresh weight  (g) | Fruit length (mm) | Fruit diameter (mm) |
| Choman | 11.1ab | 6.12ab | 9b | 4b | 3.9a | 6.4e | 88.3a | 100a |
| Raniyeh | 11bc | 6.07b | 9.3ab | 4.3ab | 2.1bcd | 7.3c | 87.6ab | 87.6b |
| Halabja | 11.3a | 6.34a | 8.3c | 4.6a | 2.5b | 8.8a | 85.3ab | 87b |
| Harir | 10.3e | 5.1d | 9.6a | 4.6a | 1.4e | 7.2c | 86ab | 85.3b |
| Kerkuk | 10.8cd | 5.7c | 7.3e | 4.3ab | 1.8cde | 6.7d | 84.3b | 85.3b |
| Sidakan | 8.7g | 3.9f | 7.6de | 4b | 1.6de | 5.9f | 75.3d | 76.3c |
| Barzan | 10.9bcd | 5.8c | 8.3c | 4.6a | 1.8cde | 8b | 79c | 75.6c |
| Balakayati | 8.9g | 4f | 6f | 2.66c | 1.32e | 4.5f | 66.3f | 65.6d |
| Hewler | 10.7d | 6.1ab | 8cd | 4.3ab | 1.23f | 5.2g | 68.6ef | 68d |
| Soran | 10f | 5d | 7.6de | 4.3ab | 2.4bc | 6.1f | 70e | 65.3d |

Means of three replicates followed by the same letters were not statistically significant (P≤0.01).

Antioxidant capacity of the studied accessions is shown in Figure 1. According to antioxidant content, ‘Raniyeh’ and ‘Hewler’ accessions showed the highest antioxidant content (85.1% and 87.3% respectively) and ‘Choman’, ‘Harir’ and ‘Halabja’ showed the lowest (75.3%, 74.7% and 77.7%). ‘Kerkuk’, ‘Sidakan’, ‘Barzan’ and ‘Balakayati’ accessions did not show any differences in antioxidant capacity between fruits. According to total phenolic compounds (Figure 2), ‘Soran’, ‘Sidakan’ and ‘Raniyeh’ accessions showed the highest content of phenolic compounds (94, 95 and 90.4 mg/100g respectively) while ‘Harir’, ‘Barzan’, ‘Balakayati’ and ‘Hewler’ accessions showed the lowest content (75.1, 73.2, 74.5 and 71.5 mg/100g). It is interesting that commercial juices had higher antioxidant activity and, on the other hand, experimental juices produced by pressing the arils had a lower activity (Gil et al., 2000). Therefore, it can be presumed that the maintenance of antioxidant potential might be exceedingly affected by preparing techniques. Phenolic compounds are essential for their contribution to sensory attributes, and in addition, they have an extraordinary medical advantage in organic products (Gil et al., 2000).

Figure 1. Antioxidant capacity in eleven pomegranate accessions. Bars with the same letters were not statistically significant (P≤0.01).

PCA (Principal component analysis) was applied to study the characteristics for distinguishing the most important factors of changeability and to portray the connection among the variables (Tables 3 and 4). PCA produced two parts representing a total of 95.3% of variability. The most critical variables incorporated by the first component (81.9% of variability) were TSS/TA, TSS, pH, 100-seed fresh weight, seed fresh weight, aril diameter and peel thickness; while negative correlations were observed in TA, total phenolic compounds and antioxidant capacity. The second part (13.3% of variability) was predominantly related to fruit weight, fruit diameter, fruit length, volume of juice, total aril weight, total peel weight and aril length, while a negative correlation was observed in antioxidant capacity.

Figure 2. Total phenols in fruits of ten pomegranate accessions. Bars with the same letters were not statistically significant (P≤0.01).

The reliance of the variable was determined/obtained by analysis of correlation (Table 2). Although large pomegranates are more delicious to the customer, this will probably be sweetened. A positive correlation was observed between fruit weight and TSS (r =0.85). In addition, there is a positive correlation between fruit weight and other traits: total aril weight (r = 0.79), total peel weight (r = 0.76), volume of juice (r = 0.88), fruit length (r = 0.85), fruit diameter (r = 0.92). TSS was adversely correlated with TA (r = -0.9). Similarly, Melgarejo et al. (2000) found that sour pomegranate contained more TA and less TSS than sweet pomegranate. Total aril weight correlated with total peel weight (r = 0.59), volume of juice (r = 0.84), 100-seed fresh weight (r = 0.56), fruit length (r = 0.72) and fruit diameter (r = 0.79) suggesting that aril weight had a positive relationship with fruit size and juice content. A positive correlation was observed between total peel weight and volume of juice (r = 0.53), aril length (r = 0.57), fruit length (r = 0.68) and fruit diameter (r = 0.88) suggesting that large fruits had more peel than small fruits. Also, there is a positive correlation between volume of juice and fruit length and fruit width (r = 0.81 for both) demonstrating that large fruits might be better for making juice. On the contrary, Jalikop and Kumar (1998) detailed that small fruits are juicer than large fruits. No significant relationships were found between total phenolic compounds and antioxidants with different characteristics that can be of importance to the values for different fruits (Wang et al., 1996).

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Table 2. Results of simple correlation analysis for different fruit characteristics of ten pomegranate accessions. |  | Fruit weight | Total aril weight | Total peel weight | Peel thickness | Volume of juice | pH | TA (total acidity) | TSS ( total soluble solids ) | Taste index(TSS/TA) | Aril length | Aril diameter | Seed fresh weight | 100-seed fresh weight | Fruit length | Fruit diameter | Antioxidant capacity | Total phenolics | **\*\***Different significant values (P≤0.01). Absolute linear correlations ≥0.01 are marked in bold. |
| Fruit weight | 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Total aril weight | **0.79\*\*** | 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Total peel weight | **0.76\*\*** | **0.59\*\*** | 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Peel thickness | 0.08 | 0.08 | 0.33 | 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Volume of juice | **0.88\*\*** | **0.84\*\*** | **0.53\*\*** | -0.04 | 1 |  |  |  |  |  |  |  |  |  |  |  |  |
| pH | 0.22 | 0.24 | 0.19 | 0.21 | 0.17 | 1 |  |  |  |  |  |  |  |  |  |  |  |
| TA | -0.30 | 0.34 | -0.23 | -0.14 | -0.33 | -**0.6\*\*** | 1 |  |  |  |  |  |  |  |  |  |  |
| TSS | **0.85\*\*** | 0.45 | 0.35 | 0.14 | **0.47\*\*** | **0.67\*\*** | -**0.9\*\*** | 1 |  |  |  |  |  |  |  |  |  |
| TSS/TA | 0.37\* | 0.40 | 0.26 | 0.14 | 0.40 | **0.68\*\*** | **-0.9\*\*** | 0.69 | 1 |  |  |  |  |  |  |  |  |
| Aril length | **0.51\*\*** | 0.23 | **0.57\*\*** | **0.46\*\*** | **0.53\*\*** | 0.25 | -0.33 | 0.41 | 0.36 | 1 |  |  |  |  |  |  |  |
| Aril diameter | 0.16 | 0.16 | 0.41 | 0.3 | 0.17 | 0.41 | -0.28 | 0.34 | 0.29 | **0.61\*\*** | 1 |  |  |  |  |  |  |
| Seed fresh weight | 0.29 | 0.31 | 0.09 | 0.03 | 0.33 | 0.37 | -0.27 | 0.32 | 0.33 | 0.2 | -0.14 | 1 |  |  |  |  |  |
| 100-seed fresh weight | **0.51\*\*** | **0.56\*\*** | 0.38 | -0.06 | **0.6\*\*** | **0.47\*\*** | -**0.4\*\*** | **0.62\*\*** | **0.52\*\*** | **0.51\*\*** | 0.52 | 0.25 | 1 |  |  |  |  |
| Fruit length | **0.85\*\*** | **0.72\*\*** | **0.68\*\*** | 0.09 | **0.81\*\*** | 0.34 | -0.33 | 0.45 | 0.37 | **0.54\*\*** | 0.30 | 0.24 | **0.62\*\*** | 1 |  |  |  |
| Fruit diameter | **0.92\*\*** | **0.79\*\*** | **0.88\*\*** | 0.18 | **0.81\*\*** | 0.27 | -0.34 | 0.45 | 0.38 | **0.58\*\*** | 0.32 | 0.30 | **0.49\*\*** | **0.85\*\*** | 1 |  |  |
| Antioxidant capacity | -0.45 | -0.37 | -0.34 | -0.06 | -0.37 | -0.18 | 0.16 | -0.23 | 0.16 | -0.27 | -0.13 | -0.27 | -0.31 | -0.2 | -0.38 | 1 |  |
| Total phenolics | -0.04 | -0.02 | -0.1 | -0.09 | -0.01 | -0.06 | 0.21 | -0.15 | -0.19 | -0.12 | -0.19 | -0.10 | 0.06 | 0.03 | -0.06 | -0.04 | 1 |

Table 3. Specific values, variance and cumulative percent of variances for seven main factors.

|  |  |  |  |
| --- | --- | --- | --- |
| Factors | Specific value | Variance (%) | Cumulative (%) |
| 1 | 493.3 | **81.9** | 81.9 |
| 2 | 80.5 | **13.3** | 95.3 |
| 3 | 10.9 | 1.83 | 97.1 |
| 4 | 6.9 | 1.1 | 98.3 |
| 5 | 3.8 | 0.6 | 98.9 |
| 6 | 2.5 | 0.43 | 99.4 |
| 7 | 2.4 | 0.4 | 99.8 |

Table 4. The variable selected by the factor and explained cumulated proportion of variation for the two eigenvectors.

|  |  |  |
| --- | --- | --- |
|  | Factor 1 (81.9%) | Factor 2 (13.3%) |
| TSS/TA | **1** | 0.00 |
| TSS | **0.97** | 0.10 |
| pH | **0.68** | -0.004 |
| 100-seed fresh weight | **0.52** | 0.40 |
| Seed fresh weight | **0.33** | 0.19 |
| Aril diameter | **0.29** | 0.19 |
| Peel thickness | **0.14** | 0.06 |
| Total phenolics | **-0.19** | 0.04 |
| TA | **-0.98** | 0.05 |
| Fruit weight | 0.37 | **0.88** |
| Fruit diameter | 0.38 | **0.87** |
| Fruit length | 0.37 | **0.80** |
| Volume of juice | 0.40 | **0.78** |
| Total peel weight | 0.26 | **0.77** |
| Total aril weight | 0.40 | **0.73** |
| Aril length | 0.36 | **0.49** |
| Antioxidant capacity | -0.16 | **-0.39** |

Cluster analyses (Figure 3) produced five clusters showing relatedness between accessions ‘Choman’, ‘Raniyeh’ and ‘Halabja’ and ‘Harir’, ‘Kerkuk’, ‘Sidakan’ and ‘Barzan’, ‘Balakayati’ and ‘Hewler’ and ‘Soran’. A high disparity level was found in accessions ‘Choman’ and ‘Kerkuk’, being very heterogeneous among the considered accessions. Groups one and three were highly heterogeneous in comparison with others. In addition, group two that had highly similar fruit weight, total peel weight, volume of juice, fruit length and fruit diameter were similar. In group four, fruit weight, seed fresh weight and fruit diameter were also similar. In group five, total peel weight, pH, aril length, aril diameter, 100-seed fresh weight, fruit diameter and fruit weight were similar too. Fruit weight and size were main factors in grouping of accessions.

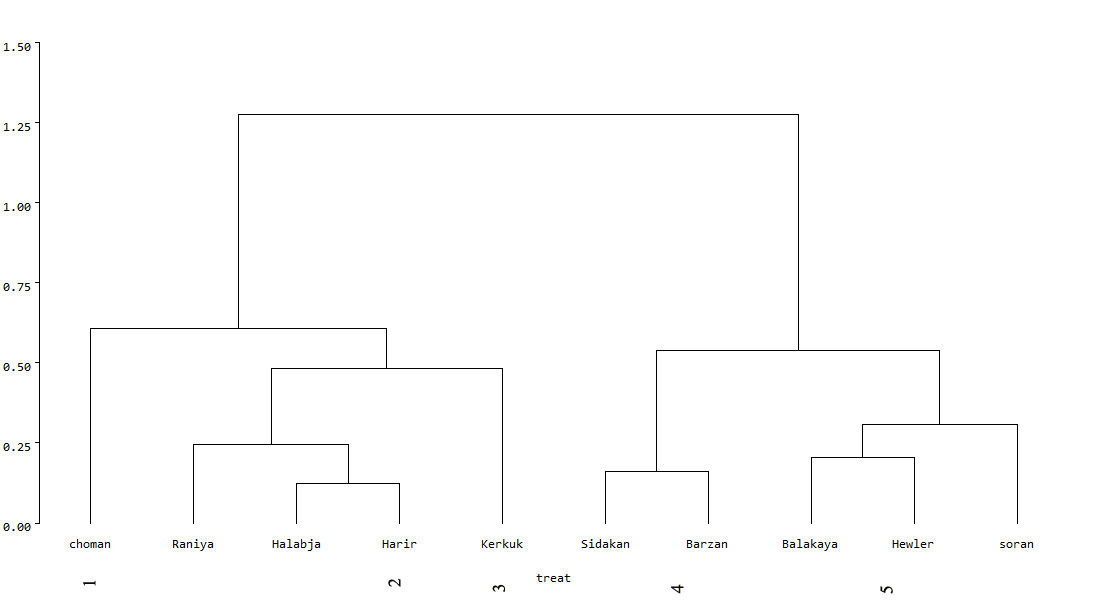


Figure 3. Grouping of ten pomegranate accessions based on fruit

characteristics by the Ward method.

**Conclusion**

We have estimated for the first time the physical and chemical properties of pomegranate accessions from the Kurdistan region of Iraq. All of accessions varied significantly in studied traits. In this study, no significant correlation was found between total phenolic compounds and antioxidant capacity. To obtain more juice from fruits in food industries, fruits and aril size should be considered, and according to this, ‘Choman’, ‘Raniyeh’ and ‘Halabja’ accessions, due to large fruit size, had more juice. Principle component analysis (PCA) indicated that physico-chemical properties of pomegranate fruit were significantly affected by genotype. Also, physical properties had the importance factor in close relationship between accessions. Finally, this study gives us more information about physical and chemical properties in pomegranate and can be useful to producers and breeders that could be profitable for increasing their fruits quality.

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**Saadatian M.[[2]](#footnote-2)\*, Paiza A.A., Kanar S.F., Pershang Y.N.,**

**Hewen A.H. i Silaw M.E.**

Univerzitet Soran, Fakultet za obrazovanje, Odsek za opšte nauke,

Soran, Regionalna vlada Kurdistana, Irak

R e z i m e

U ovom radu istraživane su neke fizičko-hemijske osobine deset genotipova nara prikupljenih iz različitih okruga u regionu Kurdistana u Iraku. Genotipovi su pokazali varijabilnost svih osobina osim ukupnih fenola i antioksidativnog kapaciteta. Utvrđene su značajne promene ispitivanih karakteristika i uočene su značajne pomološke karakteristike. Klaster analiza je pokazala homonime između nekih genotipova nara. Analiza glavnih komponenti je pokazala da je komponenta kojom se opisuje najveća varijabilnost u pozitivnoj korelaciji sa masom ploda, ukupnom masom semena nara, ukupnom masom kore, zapreminom soka, ukupnim rastvorljivim suvim materijama (engl. *total soluble solids* – TSS), dužinom ploda, prečnikom ploda, pH, dužinom semena, i svežom masom 100 semena, ali je u negativnoj korelaciji sa titracionom kiselošću (engl. *titratable acidity* – TA). Masa ploda je u jakoj korelaciji sa ukupnom masom zrna, ukupnom masom kore, zapreminom soka, TSS, dužinom semena, svežom masom 100 semena, dužinom ploda i prečnikom ploda. Zapremina soka je u korelaciji sa TSS, dužinom zrna, svežom masom 100 semena, dužinom ploda, prečnikom ploda i uočeno je da se sa porastom veličine ploda, zapremina soka takođe povećavala. Korelacija između ukupnih fenolnih jedinjenja i antioksidativnog kapaciteta nije uočena. Veze među fizičkim i hemijskim osobinama sugerišu da bi potrošači trebalo da koriste velike plodove sa velikim zrnima kako bi dobili više soka. Stoga su genotipovi ‘Choman’, ‘Raniyeh’ i ‘Halabja’ bili sočniji od drugih genotipova.

**Ključne reči:** fizičke osobine, genotipovi, plodovi, antioksidant, fenolna jedinjenja.

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1. \*Corresponding author: e-mail: mohammad.saadatian@soran.edu.iq [↑](#footnote-ref-1)
2. \*Autor za kontakt: e-mail: mohammad.saadatian@soran.edu.iq [↑](#footnote-ref-2)