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Classification of some superior local apricot genotypes of Iran based on physical and geometrical attributes

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ABSTRACT

In this study some physical and geometrical properties of 11 superior apricot genotypes were determined. These properties such as respiration rate, Mass, fruit dimensions, perimeter, surface area, volume, geometric mean diameter, projected area, shape factor, circularity, compact factor, length to width ratio, length to thickness ratio, and length to mass ratio were measured at harvesting moisture content ranging from 75.19 to 87.67 %. Then the correlation among average values of the attributes was performed and the genotypes were classified using principal component analysis (PCA). The results showed that all the genotypes had significant differences in terms of all the studied attributes (P<0.01). There was a significant and positive correlation between fruit length and weight and fruit length and moisture content. Fruit shape factor and compression factor showed a positive and significant correlation, while these attributes had negative and significant correlations with circularity. This study showed that Iranian apricot genotypes could be discriminated by differences in their geometrical characteristics using principal component analysis. Based on the PCA results, the first two components account for the most of the variation in the data (91%) and five distinct groups were observed. Overall, the results of this study can be beneficial for the design of equipment for harvesting, transportation, separating, packaging, and processing of apricot fruit.

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1- Introduction

Apricot *Prunus armeniaca* .L One of the most important species*Prunus* is cultivated in the world. The continental climate with low temperature changes during winter and hot summers provides suitable conditions for the growth of this tree. Currently, the most important producers of apricots with more than 80% of world production are Turkey, Iran, Italy, Pakistan, France, Spain, America and Morocco. Apricot production in the world in 2021 was about 3578412 tons, among which Iran with the production of 323019 tons accounted for about 9% of the world production [1]. The most fruitful apricot trees in the country, whose fruits are exported in addition to domestic use, are grown in the provinces of East Azerbaijan, Tehran, Khorasan, West Azerbaijan, Semnan, Hamadan, Zanjan, and Central respectively. Apricots have a short harvest season and their storage time is limited even under the best conditions. Therefore, apricot fruit is not only consumed fresh, and in order to supply and deliver this fruit to consumers throughout the year, various processing industries have been developed to process it, and this fruit is dried, frozen, jam, jelly, marmalade, pulp, and fruit juice. is used In addition, apricot kernels are used in the production of oils, benzaldehyde, cosmetics, activated carbon, and fragrances. Apricots are a good source of potassium and beta-carotene. Beta-carotene is a plant pigment that is a precursor of vitaminA It is very useful for preventing many diseases and strengthening the immune system. In the food industry, this pigment is also used as a natural color and strong antioxidant [2].

According to many available sources, Iran is one of the origins of fruit trees, especially fruit trees. Currently, in many countries, very extensive programs are implemented to preserve plant genetic resources, because if these genetic resources are not identified and preserved due to the lack of human awareness, many of them will be unavailable for various reasons, including the replacement of new cultivars or the destruction of natural resources and gardens. Humans will be out forever. Based on the information obtained in our country, this process is widely implemented by gardeners, and based on this, a significant number of valuable genotypes have been identified and collected in a unique collection. Evaluation of these genotypes in order to identify and introduce promising genotypes for different purposes can be an effective step to preserve these valuable genetic resources. On the other hand, due to the sensitivity and perishability of the apricot fruit and the limited harvest time, the waste of this fruit during production is high, and due to the lack of knowledge of producers and processing units about the characteristics and differences of its different cultivars, in most cases, it is a suitable variety for processing or fresh eating. It can't be done and this problem increases product waste. By identifying the country's apricot cultivars and studyingTheir physicochemical, physical, nutritional and sensory properties can be used to identify and introduce suitable cultivars for processing, fresh eating and storage, in this way waste can beIt reduced fruit harvesting and increased production efficiency in transformation industries. Meanwhile, the physical properties of apricots are very important for the design of harvesting equipment and tools, and after harvesting, transportation, storage, cleaning, separation, fruit sorting, and its packaging and processing.

In 2008, Ahmadi et al. investigated some physical and mechanical properties of the fruit, kernel, and pith of Tabrizeh cultivar at different humidity levels. The measurement results of these traits including dimensions, geometric mean diameter, roundness, bulk density, actual density, porosity and weight play a role in

increasing productivity and reducing waste after harvesting this fruit. They showed that in Tabrizeh apricot variety, the fruit had a larger volume, weight and surface area compared to its kernel and core, and the fruit of this variety was spherical in shape [3].

Physical and chemical characteristics of six Turkish apricot fruit samples in 2007 including fruit length and diameter, mass, fruit volume, average diameterGeometry, sphericity, apparent mass, density, porosity, image surface, static and dynamic friction coefficient were studied in different humidities. The researchers stated that the data of this research has a potential application in harvesting, transportation, classification, processing, storage, packaging and other processes related to apricot fruit [2].

The physical properties of apricot kernel and pith are essential for the design of processing, handling, sorting, breaking and separation equipment. With the increase in humidity, the physical properties of apricot kernels and kernels such as dimensions, roundness, bulk density, volume, weight, limit speed and image surface changed as a function of humidity [4]. Apricot kernel roundness decreased slightly with increasing humidity, while apricot pith roundness increased with increasing humidity. Changes in the degree of porosity of apricot kernel and pith also showed a similar dependence on humidity.

In a research, the qualitative properties including physical, chemical and olfactory properties of early, mid-ripening and late-ripening apricots were investigated and the statistical analysis of the results was used to identify and group similar cultivars and their relationship with ripening time. The results showed that there is a big difference between the cultivars in terms of physical, chemical and odor properties and they are not related to the ripening season. In this research, it was concluded that in the case of apricot, the detailed analysis of the profile of aromatic substances is an efficient tool for classifying genotypes based on the ripening season, and volatile compounds and odor-causing substances can be used as qualitative indicators to select suitable cultivars [5].

The physicochemical, nutritional and geometrical properties of 6 dominant apricot cultivars in the northern regions of Pakistan were investigated. The results showed a significant difference between different apricot cultivars. Some cultivars are suitable for processing and drying due to their high dry matter and sugar content and low moisture content, and on the contrary, some cultivars are suitable for fresh consumption. The results of measuring the geometric properties of cultivars were important for the development of post-harvest mechanization and fruit processing industries. They showed that Mirmalik variety[1] It had the highest average weight, volume, and geometric dimensions and was recognized as suitable for fresh consumption. Other studied cultivars were selected for drying due to the small weight and volume of their fruits. Mirmalik and Nili cultivars[2] Due to the large ratio of pulp to core, they were found suitable for processing and producing products such as jam, marmalade and juice [6].

Examining and comparing the qualitative properties of 20 apricot genotypes in the Czech Republic showed that there is a good correlation between the chemical and physical properties of apricots. This relationship can help to choose the right genotypes with optimal performance. In the continuation of the genotypes using the method Principal component analysis[3] were grouped and the genotypes of each group had similar physical and chemical properties [7].

The effect of two crop years 2010 and 2011 on qualitative properties and bioactive compounds of new apricot cultivars, hybrid cultivars between Iran, Caucasus and Europe and some important cultivars in Mediterranean areas.

[1]-Myrmalik

[2]- Neeli

[3]- Principal Component Analysis (PCA)

Türkiye was investigated. The results showed that the type of variety, crop year and the interaction effect of the variety in the crop year cause considerable and significant changes in the qualitative properties and bioactive compounds of the fruit, but in general, the genotype showed the largest and most significant role among other factors. It was also found that there is a significant positive correlation between the amount of fructose and sucrose with the amount of total phenol. These results can be used to produce apricot cultivars with higher quality and nutritional properties [8].

In 2018, fruitological characteristics and antioxidant properties of organic fruits from 7 different varieties of apricots were investigated in Italy. The storage characteristics of fruits were also investigated for 14 days at 4 degrees Celsius and 90% relative humidity. In general, increasing the phenolic compounds of fruits and berries is very important from the point of view of nutrition, but at the same time, during the storage period, it causes enzymatic browning of the product and reduces its quality. In this research, in different apricot cultivars with different amounts of phenolic compounds, the incidence of enzymatic browning during storage was insignificant, which requires further study. The results of this research show that in order to maximize the quality properties of the product, choosing the right variety is more important than other factors [9].

Considering that the physical properties of apricots are for a better understanding of the behavior of the product during harvesting and after harvesting, such as transportation, sorting, grading, packaging and storage inCold storage plays a very important role in processing operations such as cooling, drying, and mass and heat transfer processes. The purpose of this research was to investigate and determine some important physical and geometric properties of eleven apricot genotypes native to Iran and to prepare a database of these genotypes. In the followingUsing analysis of variance and chemostatistics methods[4], the genotypes were grouped according to these traits. In Iran, so far, there has been a research on the grouping of apricot genotypes using analysis of variance and chemometric methods.Q has not been done.

2- Materials and methods

Top 11 apricot genotypes from the collection of the apricot research garden of the National Horticultural Science Research InstituteAt the Meshkandasht research stationwere preparedThis station, with an area of about 100 hectares, is located in Mashkindasht Karaj, with geographical features of 35.74 north and 50.95 east and with an altitude of 1560 meters above sea level. The soil texture of this area is sandy-clay. The distance of planting trees is 5 x 4 meters and the base type of all cultivars and genotypes is seed.The genotypes used in this research with codesB105, S111, S113, B114, B121, S134, B142, B209, S211, S217 AndR126 were identified. The fruits were transferred to the laboratory immediately after harvesting.Some physical and geometrical properties of apricot fruit from different genotypes were measured with natural fruit moisture as described below.

Fruit weight: using a sensitive scaleSarturious ModelBP-120 Made in Germany, it was measured with an accuracy of 0.1 mg.

Moisture of the samples: in the ovenMemmert Model 600-UE Made in Germany at a temperature of 105 degrees Celsius according to the standard methodAOAC Was determined]10[.

Fruit respiration rate: to measure the respiration rate from a sensor sensitive toCO_2(Testo Micro5 device, Germany) equipped with a memory card was used. In a plastic container (10 x 20 x 20 cm) and completely sealed with air CO_2 Produced was

[4]- Chemometrics

measured by a certain weight of fruit in one hour. Breathing rate using the outside part of the slope of the curveCO_2 Produced against time$ml\ CO_2/\ kg.hr$Calculated]11[.

Some physical and geometrical properties of the samples using the device for measuring physical properties of the modelWinArea-UT-10 Manufactured by Alborz Andisheh Technologies Company, equipped with Samsung analog CCTV cameras600 TVL ModelSCB-2000 were measured.

The linear dimensions of the fruit include length(L)، an offer(IN), thickness(T) Area(A), Environment(P) and image level in axes(P_{A1}, P_{A2}, P_{A3}) was measured differently. Assuming that the apricot fruit is oval, its volume was obtained according to the following formula]12[.

$$V = \frac{4\pi}{3}\left(\frac{L}{2}\right)\left(\frac{W}{2}\right)\left(\frac{T}{2}\right) \quad (1)$$

Next, using the following relationships, other physical properties of the fruit were calculated by the machine.

Form factor[5]: In relation to the real circumference, it is called a circular circumference with an area equal to the area of the real object and is calculated from the following equation]13[.

$$Shape\ \ Factor = \frac{P_{real}}{2(\pi A)^{0.5}} \quad (2)$$

here:P_{real} The circumference of the circle is the same area as the main objectA_{real} is the area of the main object.

Roundness[6]:

It was measured using the relationship between the subroundness of apricot fruit.

$$C = \sqrt{\frac{A}{A_p}} \quad (3)$$

here:A The real area of the object and A_P The area of a circle whose diameter is equal to the diameter of the circumference of the object or the largest length of the object]13[.

Compression factor[7]:

The compression factor of fruits was calculated using the following equation]13[.

$$Compact\ \ Factor = \frac{(Perimeter)^2}{Area} \quad (4)$$

herePerimeter body environment andArea is the area of the object.

average radius[8] : It is the average of all the distances between the center of the object and the points on the edges of the object and is obtained from the following relations:

$$R_i = \sqrt{(x_i)^2 + (y_j)^2} \quad (5)$$

$$\overline{R} = \frac{\sum_{i=1}^{num_p} R_i}{num_p} \quad (6)$$

Ri The distance between the center of the object and the pixel(i, j) M. W $\overline{R}$ The average radius of the object and$on\ one_p$ Number of pixels It is present in the environment of the body.

Next, the ratio of length to width(L/W), length to thickness(L/T) and length to fruit weight(L/M) was also determined and reported.

This research was carried out in the form of a completely random design. The weight, humidity and fruit respiration tests of apricot genotypes were measured in three replicates and all geometric tests were measured in 20 replicates. Experimental data with one-way analysis of variance by softwareSPSS 20 copies were analyzed. To compare the averages, Duncan's multiple range test was used with a maximum acceptable error of 1%. Correlation of different traits by calculating Pearson coefficient of explanation[9] Checked out]14[. Principal component analysis(PCA) To group physical data of apricot genotypes using softwareMinitab Edition 18(Minitab Inc., Pennsylvania, USA) done]15[.

5-Shape Factor

6- Circularity

7- Compact Factor

8- Average Radial

9- Pearson correlation coefficient

3-Results and discussion

Figure 1 shows some apricot genotypes. Variance analysis of geometric and physical properties of apricot genotypes including geometric dimensions, average radius, perimeter, surface, volume, image surface, shape factor, compression factor, roundness along with weight, respiration rate and fruit moisture are shown in Table 1. According to this table, there is a significant difference between different apricot genotypes in terms of these geometric and physical properties. These characteristics have been measured at the specific moisture content of the genotype at the time of harvest. According to Table 2, the moisture content of the genotypes is 75.19% in the genotypeS113 up to 87.67% in the genotypeS111 Changes. These results are consistent with previous studies that reported the moisture content of some Turkish and Pakistani apricot cultivars[2 and 3]. Most of the fresh fruit consists of water, which has an important effect on the shelf life of the fruit. Determining the moisture content and water activity of the fresh fruit is very important to evaluate and predict its stability during storage and to choose the appropriate processing method. Especially, the knowledge of the moisture content of apricots plays a major role in the study and analysis of the fruit drying process using hot air and improving the fruit drying conditions.

Fig1. Images of apricot genotypes.

In Table 2, the average geometric dimensions of different apricot genotypes are compared. According to this table, the length of the genotypes is from 40.49 mm (genotypeB121) to 53.02 mm (genotypeR126), their width from 36.75 mm (genotypeS113) to 40.46 mm (genotypeS134) and the thickness of the fruits from 33.57 mm (genotypeS113) to 42.27 mm (genotypeR126) Obtained. The geometric dimensions of the investigated genotypes are within the range of dimensions of Iranian apricot cultivars that have been reported in previous studies[3 and 16]. But they are bigger than some figures of northern areas of Pakistan]6[. The dimensions of Turkish apricot varieties, hybrid apricots of Iran and the Caucasus region, and some European varieties were also within the range of the dimensions of the examined genotypes.]8[. Determining the geometric dimensions of the fruit is used to calculate the size of the compartment and the components of the separating and sorting devices. Another important physical property is the mean geometric radius of the fruit, which is used to design fruit grading processes. The geometric mean radius of the investigated genotypes is 19.83 mm in the genotypeS113 up to 24.98 mm in genotypeS217 Changes. The geometric diameter of apricot genotypes is consistent with the results obtained for commercial apricot cultivars]16[. Based on the results in Table 2, the genotypesS113 AndR126 Optimizing the smallest and largest image surfaces perpendicular to the length(P_{A1}), an offer(P_{A2}) and thickness(P_{A3}) because of the small dimensions of the genotype fruitS113 and large dimensions in the genotypeR126 Is. Due to the small dimensions of the genotypeS113Apricot fruit of this genotype is the smallest environment (mm 21/132), level ($mm^2$70/1207) and volume ($mm^3$04/27056). While for genotypesR126 AndS134 The maximum amount of environment (mm 164-167), level ($mm^2$1950-1800) and volume ($mm^3$50000-52500) was obtained. Smaller size of apricot genotypeS113 It shows that compared to other genotypes, more fruits of this genotype

can be placed in a certain volume of packaging. Measuring and determining these physical properties is very important for fruit processing and storage, especially the surface area is used to determine the drying speed and thus estimate the drying time. In terms of roundness, a significant difference was observed between different genotypes. GenotypeS111 with 0.87 and genotypesB121AndS211 They had the lowest and highest roundness values with 0.96.

Table 2 shows that the shape factor of apricot genotypes is significantly different from each other. The highest amount of shape factor in the genotypeS111 (1/09) was observed, but other genotypes do not have significant differences in terms of this feature. Shape factor is a material science engineering term that shows the relationship between the compression or bending of a material when a load is applied to it and the shape of that object. The shape factor basically shows how the shape of an object affects the amount of deformation of the object when pressure is applied to it. Shape factor is used to compare the compressibility of two different shapes of the same material. Regarding the compression factor, similar results were obtained with the shape factor. Thus, the genotypeS111 With a compression factor of 14.81, it had the highest amount of compression factor compared to other genotypes and showed a significant difference with other genotypes in terms of this characteristic. The compression factor of other genotypes had no statistically significant difference.

In terms of respiration rate, there is a significant difference between apricot genotypes. The highest breathing rate in genotypesB121 (ml CO2/Kg.hr 64/1) andB114 (ml CO2/Kg.hr 1/72) and the lowest breathing rate in genotypesS211 (ml CO2/Kg.hr 1/01) andB142 (ml CO2/Kg.hr 1/03) was obtained. Based on the respiratory behavior, apricot is an ascending fruit like other stone fruits. This means that metabolic activities and fruit ripening process continue after harvesting. Therefore, apricots are sensitive and perishable fruits. In general, the lower the respiration rate of the fruit, the more fresh it can be kept. Therefore, based on the respiratory behavior of the fruit, genotypes are expected B114 AndB121 be less maintainable and more perishable.

In terms of fruit weight, no significant difference was observed between the tested genotypes (Table 2). The lowest amount of fruit weight is 27.31 grams (genotypeS113) and the highest amount of fruit weight 51.96 grams (genotypeS217) Is. Fruit weight is one of the most important qualitative characteristics of fresh apricots]17[. Previous studies also showed that different varieties of apricot are very variable in terms of fruit size and weight[17 and 18]. Tested and abandoned[10] (2005) showed that the genotypes of the Iran-Caucasus geographic region have a lower weight than the European genotypes.]19[.

[10]-Asma and Ozturk

Table 1 Variance analysis of some physical and geometrical characteristics of apricot

Source		**Mean Square**								
	df	**Length**	**Width**	**Thickness**	**Elongation**	**Average R**	**Perimeter**	**Area**	**Volume**	**Mass**
Model	10	214.9**	112.3**	89.4**	0.1**	34.3**	1532.1**	668027.5**	843090060.3**	6565688.4ns
Intercept	1	250950.1**	193108.7**	165082.8**	143.4**	56306.1**	2515181.8**	277838883.1**	188186494796.5**	9123267.8ns
Genotype	10	214.9**	112.3**	89.4**	0.1**	34.3**	1532.1**	668027.5**	843090060.3**	6565688.4ns
Error	99	6.5	4.3	3.9	0.1	1.1	50.6	21936.5	34185984.7	6647484.3
Total	110									

Table 1 Continued variance analysis of some physical and geometrical characteristics of apricot

Source		**Mean Square**							
	df	Shape Factor	Compact Factor	Circularity	P)a(	P)b(	P)c(	Moisture	Respiration
Model	10	0.0**	0.2**	0.0**	322655.1**	485349.6**	666990.9**	120.2**	0.6**
Intercept	1	126.9**	23146.1**	93.0**	176517254.9**	233278172.9**	277866632.8**	767580.6**	190.9**
Genotype	10	0.0**	0.2**	0.0**	322655.1**	485349.6**	666990.9**	120.2**	0.6**
Error	99	0.1	0.1	0.0	12153.8	17164.0	22228.4	0.2	0.0
Total	110								

**: Significant at 0.01 level ns: not significan

Aspect ratio(L/W, L/T, L/M) The fruits of different genotypes are shown in Table 3. Genotypes were significantly different from each other in terms of these characteristics at the 1% probability level. The minimum and maximum valueL/W Better health in genotypesB121 AndS111 It was observed with an average of 0.96 and 1.31. About the value of the ratioL/T, genotypeB121 with the lowest average of 1.05 and genotypeS217 with an average of 1.35, they accounted for the highest amount. GenotypeS111 with an average of 1.24, the highest value of the ratioL/M and showed a significant difference with other genotypes, while the genotypesB105 ، B121 ،R126 ،S134 ،B142 ،B209 AndS217 With an average of 1-14, the lowest valueL/M had the The aspect ratio in the studied genotypes was very similar to its values in commercial cultivars of the country. the amount ofL/W in genotypesS111 AndS217It is higher than the values reported for some commercial cultivars]16[. Correlation between different geometric traits, respiration rate, weight and humidity of different apricot genotypes is shown in Table 4. According to this table, the dimensions (length, width and thickness) of the fruit had a significant and positive correlation with each other and with the surface area, circumference and volume of the fruit. The geometric mean radius of the fruit also showed a very large and significant correlation with the dimensions of the fruit. The shape factor has a positive and large correlation with the compression factor(r=0.96), and negative and significant correlation with roundness(r=-0.49) It had fruit. The shape factor also has a significant correlation with the ratio of fruit dimensions(L/W , L/T ,L/M) shows. In the case of grape fruit, it was shown that the shape factor has a negative correlation with the length(L/W) And Faulknor has fruit compression]13[. On the other hand, the fruit compactness factor also showed a negative and significant relationship with the roundness of the fruit.(r=-0.49). Fruit weight had a positive and significant relationship with fruit dimensions, fruit area and volume, but no clear and significant relationship was observed between fruit weight and its respiration rate. Fruit respiration rate had no significant relationship with fruit length, but with geometric mean diameter(r=0.28)، level(r=0.26) and volume(r=0.26) The fruit showed a positive and significant relationship, so that the respiration rate was higher in the bigger fruit. But the breathing rate showed a small and significant correlation with the compression factor (r=0.19, P<0.05)). The length of the fruit had a very significant and negative correlation with the roundness of the fruit, and the longer the fruit was, the roundness decreased significantly. As can be expected, the length of the fruit had a very large and significant correlation with the three levels of the fruit image. Fruit respiration rate and fruit length did not show a clear relationship, but fruit weight and moisture had a positive and highly significant correlation with fruit length. In the fruits that had a longer length, the weight of the fruit and its moisture increased significantly. Fruit width showed a direct and highly significant relationship with thickness, geometric mean radius, circumference, area and volume of fruit. With the increase in fruit humidity, the image levels of the fruit showed a significant increase.So that there is a positive and significant correlation between humidity and image levelsP_{A1} (r=0.35, p<0.01) And P_{A2} (r=0.25, p و (۰،۰۱>P_{A3} (r=0.26, p<0.01) was observed. Similar results have been reported for apricot kernels and kernels]4[. Unlike the length of the fruit, its width showed an inverse relationship with the shape factor and a direct relationship with the roundness of the fruit. Fruit width had no significant effect on the compression factor. Fruit width had a significant and large correlation with image levels. A positive and significant relationship was observed between fruit width and fruit thickness with respiration rate. Similar to fruit length, width and thickness also showed a positive and significant relationship with fruit weight and moisture content. Regarding the thickness of the fruit, no significant relationship was observed with the factor of shape, roundness and compactness of the fruit. No significant correlation was observed between breathing with shape factor, compression factor and roundness. In the case of fruit weight, no correlation was seen with these physical properties.

Table 2 Some geometrical and physical characteristics of apricot

Genotype	Length (mm)	Width (mm)	Thickness (mm)	Perimeter (mm)	Average Radial (mm)	Volume (mm^3)	Area (mm^2)
B105	41.56±1.49^{a}	37.22±1.63^{c}	34.96±1.04^{a}	133.69±5.40^{ab}	20.09±0.70^{ab}	28368.43±2777.85^{ab}	1241.29±87.59^{ab}
S111	48.66±3.06^{c}	37.14±1.15^{b}	34.89±0.89^{a}	144.13±6.54^{cd}	21.36±0.92^{c}	33067.07±3273.04^{bc}	1404.35±118.41^{c}
S113	41.82±1.55^{a}	36.75±1.31^{a}	33.57±1.16^{a}	132.21±4.16^{a}	19.83±0.59^{a}	27056.04±2482.40^{a}	1207.70±72.63^{a}
B114	50.62±3.63^{cde}	44.22±2.93$^{It\ is}$	42.20±2.64^{d}	160.39±10.46^{fg}	24.01±1.53^{if}	49908.72±9027.53^{fg}	1782.89±225.00^{if}
B121	40.49±2.81^{a}	42.09±2.13^{d}	38.40±2.22^{b}	139.55±8.27^{bc}	20.95±1.18^{bc}	34530.74±6072.85^{c}	1355.16±157.44^{bc}
R126	53.02±2.79$^{It\ is}$	44.58±1.40^{if}	42.27±0.73^{d}	164.57±5.51^{g}	24.64±0.69^{f}	52350.34±4233.95^{g}	1871.80±103.79^{fg}
S134	51.69±2.28^{of}	46.4±2.49^{f}	40.15±1.91^{bc}	166.27±8.39^{g}	24.98±1.21^{f}	50686.93±7114.82^{g}	1931.40±187.81^{g}
B142	50.03±1.89^{cd}	42.1±1.24^{d}	39.80±0.78^{bc}	155.03±4.36^{if}	23.19±0.57^{of}	43917.04±2996.17^{of}	1656.41±78.89^{of}
B209	48.51±3.24^{c}	42.79±2.38^{of}	40.94±3.10^{cd}	153.65±8.83$^{It\ is}$	22.99±1.28^{d}	44831.72±7507.64^{def}	1632.35±182.46^{d}
S211	46.00±2.90^{b}	43.4±2.37^{of}	39.42±1.90^{bc}	149.76±7.33^{of}	22.31±1.20^{d}	41496.80±6708.64^{d}	1545.45±167.80^{d}
S217	53.00±1.27$^{It\ is}$	44.2±2.82$^{It\ is}$	39.53±3.10^{bc}	164.09±6.19^{g}	24.52±1.03^{f}	48764.34±7360.97^{efg}	1853.26±158.77^{fg}

Values with different letters in column are significantly different in Duncan's multiple range test ($p < 0.05$).

Table 2 Continued: Some geometrical and physical characteristics of apricot

Genotype	Shape factor	Compact factor	Circularity	P_{A1} (mm^2)	P_{A2} (mm^2)	P_{A3} (mm^2)	Respiration ($mLCO_2$/Kg.hr)	Moisture Content(%)	Mass (g)
B105	1.07±0.01^{a}	14.41±0.28^{a}	0.94±0.02$^{It\ is}$	1134.52±71.20^{b}	1135.32±65.43^{a}	1239.96±88.94^{ab}	1.15±0.25^{cd}	85.57±0.11^{of}	38.75±3.63^{a}
S111	1.09±0.01^{b}	14.81±0.21^{b}	0.87±0.02^{a}	1044.82±58.11^{b}	1305.75±104.89^{bc}	1404.35±118.41^{c}	1.26±0.24^{of}	87.67±0.38^{f}	32.64±2.57^{a}
S113	1.07±0.01^{a}	14.49±0.20^{a}	0.92±0.02^{cd}	937.40±59.26^{a}	1118.09±60.08^{a}	1207.70±72.63^{a}	1.14±0.20^{bc}	75.19±1.47^{a}	27.01±2.96^{a}
B114	1.07±0.01^{a}	14.48±0.17^{a}	0.92±0.02^{cd}	1430.82±169.17^{d}	1659.17±188.39^{of}	1775.24±236.15^{if}	1.72±0.19^{g}	85.12±0.43^{d}	43.87±7.67^{a}
B121	1.07±0.01^{a}	14.41±0.25^{a}	0.96±0.02^{f}	1133.00±123.10^{b}	1267.21±152.26^{b}	1355.16±157.44^{bc}	1.64±0.02^{g}	81.37±0.71^{b}	38.53±4.80^{a}
R126	1.07±0.01^{a}	14.48±0.26^{a}	0.90±0.02^{bc}	1532.20±59.95$^{It\ is}$	1748.22±70.27$^{It\ is}$	1871.80±103.79^{fg}	1.45±0.24^{f}	85.18±1.63^{d}	46.81±2.82^{a}
S134	1.07±0.01^{a}	14.34±0.18^{a}	0.94±0.01$^{It\ is}$	1378.94±130.07^{cd}	1616.83±157.13^{d}	1931.40±187.81^{g}	1.50±0.62^{f}	84.94±0.36^{d}	50.61±5.96^{a}
B142	1.08±0.01^{a}	14.52±0.22^{a}	0.91±0.03^{bcd}	1340.40±62.03^{cd}	1582.85±69.15^{d}	1656.41±78.89^{of}	1.03±0.11^{ab}	81.85±0.38^{bc}	48.90±4.27^{a}
B209	1.07±0.01^{a}	14.51±0.19^{a}	0.93±0.02^{of}	1339.78±128.98^{cd}	1577.36±180.13^{d}	1642.21±176.41^{of}	1.30±0.19$^{It\ is}$	83.17±0.99^{c}	49.64±8.17^{a}
S211	1.08±0.01^{a}	14.56±0.21^{a}	0.96±0.02^{f}	1315.46±123.14^{cd}	1398.85±129.20^{c}	1545.45±167.80^{d}	1.01±0.19^{a}	86.95±0.83^{if}	37.79±5.31^{a}
S217	1.08±0.01^{a}	14.56±0.23^{a}	0.90±0.03^{b}	1347.12±147.66^{cd}	1609.28±166.41^{d}	1853.26±158.77^{fg}	1.29±0.30$^{It\ is}$	81.87±0.78^{bc}	51.96±5.39^{a}

Table 3 Pearson coefficients of different geometrical and physical characteristics of apricot

	Length	Width	Thickness	Perimeter	Area	Volume	L/W	L/T	L/M	Average R	Shape Factor	Compact Factor	Circularity	P_{A1}	P_{A2}	P_{A3}	Respiration	Mass	Moisture
Length	1																		
Width	0.66**	1																	
Thickness	0.67**	0.88**	1																
Perimeter	0.93**	0.89**	0.83**	1															
Area	0.91**	0.90**	0.84**	0.99**	1														
Volume	0.87**	0.92**	0.92**	0.97**	0.98**	1													
L/W	0.56**	-0.24*	-0.11	0.22*	0.18	0.11	1												
L/T	0.57**	-0.11	-0.22	0.30**	0.26**	0.12	0.87	1											
L/M	-0.14	-0.41**	-0.40**	-0.30**	-0.32**	-0.33**	0.29*	0.26**	1										
Average R	0.92**	0.90**	0.84**	0.99**	0.99**	0.98**	0.19*	0.27**	-0.32**	1									
Shape Factor	0.17	-0.20*	-0.14	0.02	-0.075	-0.068	0.45**	0.40**	0.26**	-0.06	1								
Compact Factor	0.19*	-0.18	-0.12	0.05	-0.05	-0.04	0.45**	0.40**	0.24*	-0.04	0.96**	1							
Circularity	-0.50**	0.24*	0.10	-0.19	-0.14	-0.09	-0.91**	-0.78**	-0.33**	-0.15	-0.49**	-0.49**	1						
P_{A1}	0.77**	0.89**	0.94**	0.90**	0.91**	0.95**	.01	-0.03	-0.41**	0.91**	-0.14	-0.12	0.04	1					
P_{A2}	0.90**	0.85**	0.91**	0.96**	0.96**	0.98**	0.22*	0.17	-0.32**	0.96**	-0.03	-0.01	-0.19*	0.94**	1				
P_{A3}	0.91**	0.90**	0.84**	0.99**	0.99**	0.98**	0.18	0.26**	-0.32**	0.99**	-0.08	-0.05	-0.14	0.91**	0.96**	1			
Respiration	0.15	0.34**	0.30**	0.27**	0.28**	0.28**	-0.18	-0.14	-0.16	0.28**	-0.09	-0.08	0.07	0.23*	0.26**	0.27**	1		
Mass	0.56**	0.56**	0.58**	0.62**	0.62**	0.61**	0.08	0.08	-0.83**	0.63**	-0.14	-0.12	-0.01	0.62**	0.63**	0.62**	0.08	1	
Moisture	0.30**	0.20*	0.25**	0.28**	0.26**	0.26**	0.19	0.13	-0.15	0.27**	0.10	0.13	-0.06	0.35**	0.25**	0.26**	0.08	0.17	1

** Correlation is significant at the 0.01, * Correlation is significant at the 0.05 level

Table 4 Dimensional characteristics ratio of different apricot genotypes

Genotypes	L/W	L/T	L/M
B105	1.12±0.04[c]	1.19±0.02[b]	1.08±0.09[ab]
S111	1.31±0.07[It is]	1.39±0.08[f]	1.50±0.17[d]
S113	1.14±0.04[c]	1.25±0.05[cd]	1.56±0.16d
B114	1.15±0.05[c]	1.20±0.04[bc]	1.18±0.18[bc]
B121	0.96±0.03[a]	1.05±0.04[a]	1.06±0.12[ab]
R126	1.19±0.06[d]	1.25±0.06[d]	1.14±0.08[abc]
S134	1.11±0.02[c]	1.29±0.02[d]	1.03±0.11[a]
B142	1.19±0.05[d]	1.26±0.04[d]	1.03±0.08[a]
B209	1.13±0.06[c]	1.19±0.08[b]	1.00±0.14[a]
S211	1.06±0.03[b]	1.17±0.03[b]	1.24±0.21[It is]
S217	1.20±0.06[d]	1.35±0.09[It is]	1.03±0.12[a]

principal component analysis method (PCA) one of the chemometrics classification methods of pattern recognition[11] It has been used by many researchers to analyze, group and reduce the number of dimensions in the data series without losing information to classify different food products.]15[. In this method, reducing the dimensions of the data is obtained by using a smaller number of main components compared to the primary variables used. Scoring page[12] It contains variable information that is drawn for a smaller number of field variables with the names of main components. The first componentMain (PC_1) covers data changes as much as possible. The second principal component (PC_2), which is perpendicular to the first principal component, covers the remaining changes in the data as much as possible. By drawing the main components, it becomes possible to observe mutual relationships, recognize and interpret sample patterns, group, evaluate similarities and differences[20 and 21].

Scoring page[13] Dom Part (PC_2) on the first component (PC_1) the principal components (Figure 2) obtained based on special vectors for each component, showed five distinct groups of apricot genotypes such that six genotypes B142,B209 ،B114 ،S217، R126 andS134 Next to each other and in the first group, the genotypes B121 and S211 in the second group and the genotypesB105 ،S113، AndS111 They were placed in the third, fourth and fifth groups respectively. Group one in positive PC values$_1$ and group two to five in negative PC values$_1$ And they were completely different from each other. The results of the analysis of the main components of the morphological traits of 27 Iranian apricot cultivars showed that the samples were classified into three groups. The total variance of the first and second components was 91.23% and only one figure had the highest quality]22[.

Also, the grouping of 11 Romanian apricot cultivars using principal component analysis and the variables of carotenoid, fatty acids and volatile compounds with 76% description and after removing the volatile compounds with 83% description of the total variance of the two main components has been successful.]23[. Multivariate analysis and clustering of geometric features, including dimensions and shape, have also been used to group different grape cultivars.]24[.

The attribute loading diagram shows the correlation coefficients between the main components and the variables of geometric characteristics and weight. This diagram enables the selection of the most important variables. Variables with a larger vector and farther from the origin are more important in the studied classification]25[. This diagram shows that most variables are located in the positive part of the first component.

Breathing and humidity variables with smaller vectors were less important in the classification and have been removed, and the amount of variables decreased from 17 to 15 (Figure 3 and Table 6). These remaining variablesGreat impact on the floorClassification of apricot genotypes based on characteristics were examined and thus the variancecomponents The first and second reached 91% from 9/82 (Table 5). In the first factor of volume variables (0.314), surface (0.312), average radius (0.312) AndP_{A3} (0.312) with the largest positive coefficients had the greatest effect on the grouping of variables (Table 6). In the second factor, the variables of length (0.490), shape factor (0.435), compression factor (0.472) and length (0.228) with positive values and roundness with negative values (-0.483) are the most They have shown the effect in the grouping of variables (Table 6).

Table 5 Eigenanalysis of the Correlation matrix and their cumulative variances for main components

Component	Own value	Proportion	Cumulative
1	10.075	0.672	0.672
2	3.574	0.238	0.910
3	0.663	0.044	0.954
4	0.305	0.020	0.974
5	0.233	0.016	0.990
6	0.092	0.006	0.996
7	0.040	0.003	0.999
8	0.016	0.001	1.000
9	0.002	0.000	1.000
10	0.001	0.000	1.000

Table 6 Eigenvectors of different variables in first four components and their coefficients

[11] - Pattern Recognition Technique

[12] - Score plot

[13] - Score plot

Variable	PC1	PC2	PC3	PC4
Length	0.282	0.228	-0.106	0.061
Width	0.287	-0.171	0.255	0.060
Thickness	0.287	-0.126	0.175	-0.480
Volume	0.314	-0.012	0.045	-0.123
Perimeter	0.311	0.055	0.017	0.096
Area	0.312	0.027	-0.028	0.126
L/W	0.049	0.490	-0.381	0.059
Shape Factor	-0.028	0.435	0.633	0.352
Average Radial	0.312	0.035	-0.014	0.114
Compact Factor	-0.058	0.472	0.418	-0.338
Circularity Factor	-0.045	-0.483	0.402	0.166
P_{A1}	0.297	-0.075	0.042	-0.281
P_{A2}	0.309	0.045	-0.028	-0.238
P_{A3}	0.312	0.027	-0.027	0.130
Mass	0.276	-0.065	-0.060	0.537

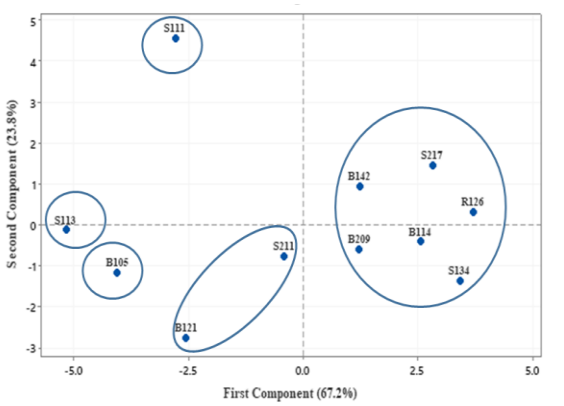

Fig 2 Score plot of Iranian apricot genotypes scattered in principle components area base on the geometrical characteristics

Loading page[14]Dom Part (PC_2) on the first component (PC_1) investigated variables using principal component analysis showed a high correlation between all investigated variables except for length, shape factor, compactness factor and roundness (Figure 3). These results were consistent with the results obtained from Pearson correlation coefficients (Table 3).

The high correlation of a variable with the first principal component indicates that this variable is in the direction of the maximum dispersion of the data set. Very high correlation of a variable with the second principal component (PC_2), indicating that this variable plays an essential role in the residual dispersion of the original data set, which is not considered by the first component.]25[. The results of decomposition into main components can determine the main difference factors between the samples.

Eigenvalues, percentage of variance and cumulative percentage of variance of ten main and independent factors are shown in table number 5. In the first factor, the shape factor, compactness and roundness factor had negative coefficients and other variables had positive eigenvalues, which explained 67.2% of the total variance. In the second factor, width, thickness, volume, roundness, P_{A1} And the negative weight and other variables were with positive values that explained 23.8% of the total variance. According to the results of Table 5, the first and second factors caused the biggest difference with a total variance of 91% between the samples.

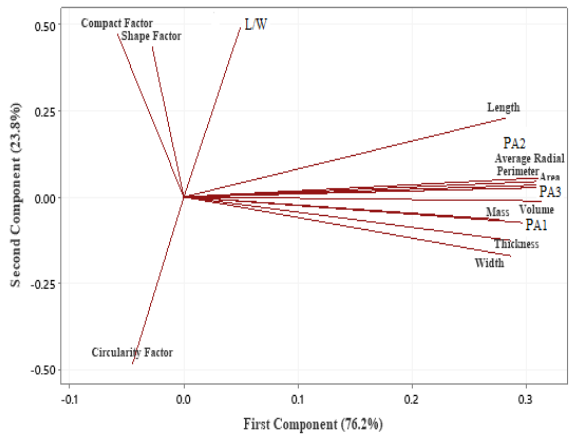

Fig 3 Loading plot of different variables in first two principal components PC1 and PC2

4- The final conclusion

In this research, some geometrical and physical properties of 11 top Iranian apricot genotypes were investigated and compared with each other. The results showed that the genotypes have significant differences with each other in terms of these characteristics. A high correlation was observed between some apricot traits, which can be used to reduce the number of traits measured in subsequent apricot germplasm studies. In the following, it was shown that it is possible to group apricot genotypes native to Iran based on the physical and geometric characteristics of the fruit. Principal component analysis was able to divide apricot genotypes into five distinct groups. Based on this, the first two components described the most variance (91%) in the investigated data. In terms of the measured characteristics of 6 genotypesB114, R126, S134, B142, B209, S217 In one group, genotypesB121 AndB211 in a group and genotypesS111, S113 AndB105 Each was placed in separate groups. The results of this research regarding the measurement of

[14] - Loading plot

geometric characteristics of apricot genotypes can be useful and important for the design and construction of tools for harvesting, transportation, grading, packaging, processing and other processes related to apricot fruit.

5- Resources

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مقاله علمی_پژوهشی

گروه‌بندی برخی ژنوتیپ‌های برتر زردآلوی بومی ایران بر اساس خواص فیزیکی و هندسی

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چکیده

در این پژوهش ۱۱ژنوتیپ برتر زردآلو از نظر برخی خواص فیزیکی و هندسی شامل سرعت تنفس، وزن، ابعاد میوه، محیط، سطح، حجم، شعاع متوسط هندسی، سطوح تصویر، فاکتور شکل، گردی، فاکتور فشردگی، نسبت طول به عرض(L/W)، نسبت طول به ضخامت(L/T) و نسبت طول به وزن (L/M)بررسی شدند. این ویژگی‌ها در مقدار رطوبت معین در زمان برداشت از ۷۵/۱۹ تا ۸۷/۶۷ درصد اندازه‌گیری شدند. در ادامه همبستگی بین صفات بررسی شد و ژنوتیپ‌ها براساس داده‌های به‌دست آمده با استفاده از تجزیه و تحلیل مؤلفه‌های اصلی (PCA) گروه‌بندی شدند. نتایج نشان داد ژنوتیپ‌های زردآلو از نظر ویژگی‌های فیزیکی و هندسی اختلاف معنی‌داری با یکدیگر ($P<0.01$) داشتند. مطالعه همبستگی بین صفات نشان داد که در میوه‌هایی که طول بزرگتری داشتند، وزن میوه و رطوبت به‌طور معنی‌داری افزایش می‌یابد. فاکتور شکل و فاکتور فشردگی نیز همبستگی مستقیم و معنی‌داری با یکدیگر و رابطه عکس و معنی‌داری با گردی میوه داشتند. این تحقیق نشان داد که امکان گروه‌بندی ژنوتیپ‌های زردآلوی بومی ایران بر اساس ویژگی‌های فیزیکی و هندسی میوه وجود دارد. بر اساس تجزیه و تحلیل مؤلفه‌های اصلی ژنوتیپ‌های زردآلو به پنج گروه متمایز تقسیم شدند و دو مؤلفه اول بیشترین واریانس (۹۱ درصد) را در داده‌های مورد بررسی توصیف کردند. نتایج این پژوهش می‌تواند در طراحی تجهیزات و ادوات برداشت، جابه‌جایی، جداسازی، بسته‌بندی و فرآوری میوه نقش مهمی داشته باشد.