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A Multidimensional Approach to Apricot Quality Assessment

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Highlights:

- Significant variability in the physicomechanical and color properties of apricot cultivars was observed
- Larger apricot cultivars tend to exhibit lower mechanical resistance
- PCA revealed physical dimensions and mechanical properties as key contributors to variance in the dataset
- Tailored post-harvest practices based on size, mechanical strength, and color can enhance apricot durability and marketability

Keywords:

- Apricot cultivars
- Physicomechanical properties
- Colorimetric analysis
- Principal Component Analysis (PCA)
- Post-harvest handling
- Fruit quality

ABSTRACT:

In this study, physical, mechanical and color characteristics of five different apricot cultivars (Hacıhaliloğlu, White Apricot, Kabaaşı, Ordubat and Şalak) grown in Iğdır province of Türkiye were examined and the effects of the relationships between these characteristics on fruit quality and marketability were determined. While fruit width, height, thickness and weight values were examined as physical properties, penetration resistance against forces applied in horizontal and vertical directions were evaluated under the heading of mechanical properties. In addition, multiple component analysis and correlation analysis were applied to detail the relationships between these parameters. As a result of, it was determined that there were statistically significant differences in terms of physical, mechanical and color measurement values for all apricot cultivars. It was concluded that Şalak variety was larger than the other cultivars but more sensitive to mechanical forces. In general, the increase in the size of the apricots increased the deformation under load. As an expected result, the variety difference in apricots also affected the color characteristics. Considering consumer preferences, L* value, which is an indicator of brightness in fruits, has emerged as an important parameter in color measurements. PCA analyses were performed to determine the main components of variance in the data set and it was determined that apricot physical properties had a much more dominant role on this variance (78.39%). The effect of mechanical properties on the variance was calculated as 20.85%. The investigated apricot cultivars showed statistically significant differences in terms of physical, mechanical and colour properties. It was found that the Şalak variety was larger and heavier, but its mechanical resistance was lower.

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INTRODUCTION

Apricot (*Prunus armeniaca* L.), one of the widely cultivated stone fruits worldwide, is a highly valuable fruit due to its economic and nutritional properties. Anatolia became the second homeland for apricots. During the Roman and Persian wars in the 1st century BC, they were spread to Italy, and then to Greece. Later on, they spread to Spain and England in the 13th century and to France and America in the 17th century (Sochor et al., 2010). Türkiye plays an important role in world apricot production (Kan & Karat, 2019). Apricots can be consumed fresh and dried throughout the country. In the Igdir region of Türkiye, which has a microclimate, various types of apricots such as Şalak, Ordubat and Tabreze which show different physical properties, are grown (Altıkat & Temiz, 2019).

Determining the physicomechanical properties of agricultural products is a very important issue for the successful execution of maintenance, harvesting and post-harvest operations. The shape, dimensional properties, sphericity values and geometry of the fruits are important considerations for the design of harvesting machines and the smooth execution of post-harvest product processing stages (Cenkowski et al., 1991). Similarly, mechanical behaviors such as hardness, tensile strength, and coefficient of creep help to determine the resistance of fruits to damage during transportation and storage. In this way, possible problems in the shelf life and marketability of products are prevented (Beygi et al., 2009).

Due to this importance, a large number of studies have been conducted worldwide to determine the physical and mechanical properties of agricultural products and this field is still up to date. For example, Tan et al., (2023) examined the changes in the physical and mechanical properties of apricots during the ripening period. As a result of their research, they concluded that the most suitable harvest period in terms of physical and mechanical properties is 10 weeks after flowering.

Previous studies have emphasized the variability of these traits among different apricot cultivars and under different environmental conditions. For example, Muradoğlu et al., (2011) reported significant differences in fruit weight, size and resistance to mechanical damage among apricots from different regions and attributed these differences to genetic and environmental factors. These results emphasize the need for localized studies to better understand the specific characteristics of apricot cultivars in different growing regions.

Hassan-Beygi (2009) studied the physical and mechanical properties of Ordubat apricot variety in detail. As a result of their research, they determined the sphericity, coefficient of friction, hardness and the resistance of the fruits to break from the tree at different moisture levels. In some recent studies, it has been determined that there is a close correlation between the data obtained by tissue analysis of the fruits and the values obtained by hardness measurements. Gabioud Rebeaud et al., (2019) obtained similar results in their study and argued that a decision can be made about the resistance of fruits based only on their textural properties without hardness measurement.

Furthermore, Yildiz et al. (2019) used a seed analyzer to evaluate the mechanical properties of different apricots and showed significant differences in hardness and elasticity, which are crucial for post-harvest processing. Similarly, Aktas et al., (2007) compared the mechanical properties of almond cultivars with different shell types and suggested that similar evaluations from apricot kernel analysis may be useful.

Kramarić et al. (2021) conducted a comparative analysis on mechanical properties and durability of apricot fruits and showed the influence of post-harvest conditions on fruit firmness. Their research found evidence that proper storage conditions significantly increased the shelf life of apricots and maintained their mechanical integrity. Lee et al., (2024) investigated the relationship between sensory attributes and instrumental seed properties in food products and presented adaptive methods for studying apricot kernel properties.

Finally, Güler & Aksoy (2018) focused on the effect of harvest time and storage conditions on the physical and mechanical properties of apricot fruits. They highlighted how harvest times affect the firmness and texture of apricot and provided important information to optimize post-harvest operations to maintain fruit quality.

In this study, physical and mechanical properties as well as color characteristics of Hacıhaliloğlu, White Apricot, Kabaaşı, Ordubat and Şalak apricot cultivars grown in Igdir province were investigated and detailed analyses were carried out.

MATERIALS AND METHODS

In this study, 5 apricot cultivars grown in Iğdır University Agricultural Research and Application Center were used. Apricots collected from the branches at tree maturity were brought to the laboratory and analysed (Figure 1).

Hacıhaliloğlu | White Apricot | Kabaaşı | Ordubat | Şalak

Figure 1. Apricot cultivars used in the study

In order to measure the axial dimensions (length, width and thickness) of apricot fruits and to determine fruit weights; 50 samples were randomly taken for each apricot variety and measurements were made. A digital caliper (Mitutoyo) with a precision of 0.01 mm was used for size measurements and a digital scale (Radwag) with a precision of 0.001 g was used for fruit weight measurements.

A dynamometer (MITECH-HDV-5K) was employed to measure the fracture strength of the samples. The procedure involved applying pressure at a forward speed of 60 mm per minute using a dynamometer mounted on a stand. This pressure was exerted on samples positioned horizontally, and the puncture resistance was recorded in Newtons (Kgf). These recorded values were then used in the analysis. The dynamometer utilized in the study is depicted in Figure 2, with its technical specifications provided in Table 1.

Color measurement in the study was performed using the international L*a*b*system (Figure 3). The "L*" value represents brightness and ranges from 0 to 100, where zero (0) indicates blackness and one hundred (100) indicates whiteness. The "a*" value indicates the red-green spectrum, and the "b*" value represents the blue-yellow spectrum, with both "a*" and "b*" values ranging between -90 and +90. A color measurement device (PCE-CSM 4) was used to determine the "L*", "a*", and "b*" values (Figure 4). The C* (chroma = $(a^2 + b^2)1/2$) values, which range from 0 (dull) to 60 (vivid), were generally higher in the flesh than in the skin for the same variety. The hue angle (H° = 1/tan (b/a)) is expressed in degrees: 0° (red), 90° (yellow), 180° (green) and 270° (blue).

Dynamometer stand Dynamometer

Figure 2. Dynamometer and its stand used in the research

Table 1. Technical specifications of the dynamometer and its stand

Dynamometer stand	
Capacity	500 N
Resolution	0.1 N (0.01 kgf)
Lower and upper limit	Automatic
Measurement units	N, kgf, lbf
Batery	NiCd
Dynamometer	
Loading capacity	5000 N (500 kg)
Tension-compression process	Motorized
Tension-compression speed range	0-240 mm/min

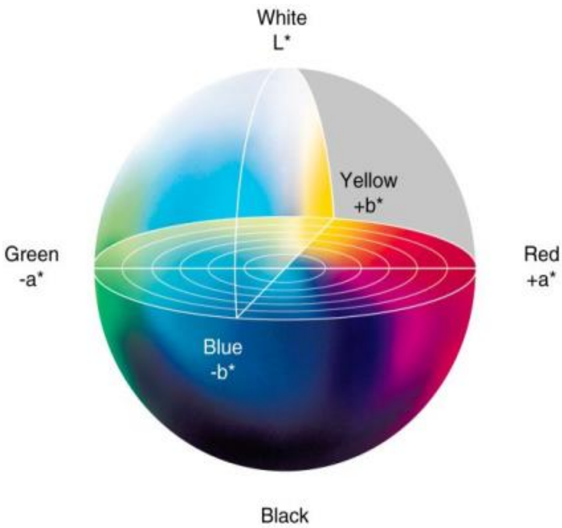

Figure 3. CIE L*a*b* color space

Figure 4. Color measurement device used in the experiments

Statistical Analyses

Statistical analyses of the results of the study were carried out in SPSS program. ANOVA analysis of variance was used to determine whether there was a significant difference between the averages obtained and Duncan Multiple Comparison Tests were used to determine the differences between the factors.

Correlation analyses were performed to determine the interaction between the physical and mechanical properties of different apricot cultivars used in the research and to determine whether this interaction, if any, is positive or negative (Rao, 2010). Pearson correlation coefficients were used in the correlation analysis (Ratner, 2009). When interpreting these coefficients, +1 indicates a perfect positive linear relationship, -1 indicates a perfect negative linear relationship and 0 indicates a linear relationship (Cohen et al., 2014). Before starting the correlation analysis, the data were standardized. For this purpose, the variables were adjusted so that the mean was zero and the standard deviation was one (Kvam & Vidakoc, 2007).

In order to determine which characteristics are more determinant among the characteristics of the apricot cultivars used in the research, multiple component analysis (PCA) method was used and the results were presented graphically.

RESULTS AND DISCUSSION

Color Changes

The color parameters (L*, a*, b*, C, H°) of different apricot cultivars were examined and the results were evaluated using analysis of variance and Duncan multiple comparison test (Table 2).

Analysis of color parameters among apricot cultivars revealed statistically significant differences ($P<0.01$) among several traits, including L* value (brightness), a* value (red-green axis), b* value (yellow-blue axis), C value (chroma or color saturation) and H value (hue angle).

Table 2. Statistical analysis results of color across apricot cultivars

Cultivars	L*	a*	b*	C	H°
Hacıhaliloğlu	59.6 ^{ab}	5.10 ^{b}	36.92 ^{b}	37.94 ^{b}	81.45 ^{b}
White Apricot	62.5 ^{a}	-1.74 ^{c}	25.16 ^{d}	25.23 ^{e}	93.88 ^{a}
Kabaaşı	54.82 ^{c}	9.20 ^{a}	27.77 ^{d}	30.53 ^{d}	70.35 ^{c}
Ordubat	59.01 ^{b}	12.68 ^{a}	43.68 ^{a}	45.36 ^{a}	72.48 ^{c}
Şalak	60.44 ^{ab}	9.98 ^{a}	32.57 ^{c}	34.53 ^{c}	73.10 ^{c}
Standard deviation	*0.449*	*0.599*	*0.513*	*0.402*	*1.273*
F	*7.943*	*16.795*	*41.40*	*71.70*	*11.618*
P	*0.000**	*0.000**	*0.000**	*0.000**	*0.000**

*: statistically very significant. √: no statistical difference between groups with the same letter

The White Apricot variety exhibited the highest brightness with an L* value of 62.5, whereas the Kabaaşı variety displayed lower brightness with an L* value of 54.82. These findings highlight noticeable variations in brightness levels among the apricot cultivars.

Significant differences were also found in the values among the cultivars ($P<0.01$). Ordubat showed the highest red with a value of 12.68, while White Apricot showed a negative value of 1.74, indicating a shift towards green colors. Similarly, the analysis of b* values showed significant differences between the different species.

When the Cvalues of apricots were analyzed, it was determined that Ordubat variety had the highest degree with 45.36. As a result of the research, significant differences were also determined in h value. The highest h value was obtained in White Apricot with 93.88.

Differences in the color of apricots can affect consumers' market habits. For example, apricots with a bright color may be preferred more by consumers. Considering that the brightness indicator of fruits is L* value, high L* value can be considered as an important parameter in terms of marketability. There are some studies indicating that L* value varies according to the region of cultivation, maintenance activities and climatic conditions. For example, Abera et al. (2023) reported that variety and agrotechnical characteristics of avocado fruits affect L* value.

Similarly, an investigation of Fragaria chiloensis revealed high genetic variety in color attributes, notably shine, demonstrating a strong effect of genetic components on fruit color (Mora et al., 2019). Furthermore, significant differences in measurements were seen across apricot kinds, with the Ordubat variety exhibiting a stronger red hue (12.68) and the White Apricot having a negative value (-1.74), indicating a move toward green tones. Previous research on basil color qualities found large variability in measurements, highlighting the influence of genetic variety on the red-green color spectrum (Yaldız and Çamlıca, 2024).

When examining the b* value, which indicates the yellow-blue axis, the Ordubat variety has a stronger yellow hue (43.68), but the White Apricot has a* lower b* value (25.16). This finding is consistent with prior study on several fruit types, including blackberries, where fluctuations in b values were used to assess fruit ripeness and quality (Tas, 2023). The range of yellow tints observed in different fruit kinds highlights the importance of the b value as a predictor of fruit quality and consumer attractiveness.

The variation in hue among various fruit types underscores the significance of the b value as a measure of fruit quality and appeal to consumers. Furthermore, the Ordubat variety displayed greater color intensity, with a c value of 45.36, in contrast to the lower C value of 25.23 for the White Apricot. These findings mirror those observed in a study on color characteristics in red table grapes, wherein chroma values were utilized to distinguish between cultivars and evaluate fruit quality (Muzolf-Panek and Waśkiewicz, 2022).

In conclusion, the Hue value analysis uncovered notable disparities, with the White Apricot displaying a hue angle of 93.88, setting it apart from the other types, and the Kabaaşı variety exhibiting a hue angle of 70.35. These deviations in hue angle align with observations in similar research, such as in walnut cultivars, where substantial variation in hue angle has been documented due to genetic distinctions (Demir, 2018).

The varying angles of hue seen in different cultivars of apricots indicate that these fruits exist at various points in the color spectrum, potentially impacting how they are categorized and sold.

Physical Characteristics

The size and weight parameters of different apricot cultivars were analyzed and the results were evaluated using analysis of variance and Duncan multiple comparison test (Table 3). When Table 3 was examined, it was determined that there were statistically significant differences in the width measurements of all apricot cultivars. While Şalak was the apricot variety with the widest dimensions among the cultivars, it was followed by Kabaaşı and Ordubat cultivars. The narrowest apricot variety was Hacıhalil with 31.02 mm. Similar trends were observed in length and thickness measurements. Şalak variety was the longest and thickest variety, followed by Ordubat and Kabaaşı cultivars. As in the width value, Hacıhaliloğlu variety had the lowest measurements in length and weight values. As an expected result of the research, it was determined that the physical measurements of apricots were reflected in their weights. According to the weight values, Şalak variety was determined as the heaviest variety, while Hacıhaliloğlu was the lightest apricot variety among the cultivars.

When all measurements and weights were taken into consideration, it was determined that Şalak variety was significantly larger and heavier than the other cultivars, while Hacıhaliloğlu variety was the smallest and lightest variety. Similar results were obtained in many studies on the subject (Pandova et al., 2023; Dogan et al., 2023; Sîrbu et al., 2021).

Table 3. Statistical analysis results of measurements across apricot cultivars

Cultivars	Width (mm)	Length (mm)	Thickness (mm)	Weight (g)
Hacıhaliloğlu	31.02 [c]	33.19 [d]	30.92 [c]	19.76 [a]
White Apricot	35.00 [b]	37.64 [c]	33.36 [b]	25.77 [b]
Kabaaşı	35.57 [b]	37.98 [bc]	34.28 [b]	26.72 [b]
Ordubat	35.53 [b]	40.23 [b]	32.86 [b]	26.43 [b]
Şalak	46.22 [a]	53.92 a	42.05 [a]	58.22 [a]
Standard deviation	*0.300*	*0.371*	*0.273*	*0.898*
F	*71.07*	*90.20*	*49.59*	*57.80*
P	*0.000**	*0.000**	*0.000**	*0.000**

*: statistically very significant. √: no statistical difference between groups with the same letter

The size and therefore the weight of the fruits are among the reasons why they are preferred by consumers. For this reason, producers may tend to produce larger and heavier cultivars. However, this decision can be shaped entirely according to market demand. For example, table and dried consumption preferences may affect the apricot variety to be grown. In this research, the fact that Şalak is the best variety in terms of size and weight does not mean that it is suitable for all kinds of use. Şalak apricot variety is not suitable for drying. However, it is preferred in the market with its size and flavor for table consumption.

Mechanical Properties

Penetration resistance values of different apricot cultivars in vertical and horizontal position are presented in Table 4. When the table is examined, there were statistically significant differences ($P<0.001$) between the penetration resistance values applied in horizontal and vertical direction among all cultivars.

It was determined that vertical penetration resistance was higher than horizontal resistance in all cultivars. According to the vertical penetration resistance values, White Apricot was deformed with a value of 15.54 Kgf, followed by Kabaaşı with 8.42 Kgf and Hacıhaliloğlu with 6.7 Kgf. In terms of the force applied in the vertical direction, it was concluded that the most sensitive apricot to deformation was Şalak variety with a value of 0.79 Kgf. In terms of horizontally applied forces, deformation values varied between 9.14 Kgf and 4.37 Kgf. White Apricot variety was the most resistant variety in horizontal directional forces as in vertical directional forces.

Table 4. Penetration resistance results

Cultivars	Vertical force (Kgf)	Horizontal force (Kgf)
Hacıhaliloğlu	6.70 [c]	4.37 [c]
White Apricot	15.54 [a]	9.14 [a]
Kabaaşı	8.42 [b]	6.78 [b]
Ordubat	0.90 [d]	0.66 [d]
Şalak	0.79 [d]	0.60 [d]
Standard deviation	*0.188*	*0.105*
F	*211.5*	*255.3*
P	*0.000**	*0.000**

*: statistically very significant. √: no statistical difference between groups with the same letter

White Apricot was followed by Kabaaşı with 6.78 Kgf and Hacıhaliloğlu with 4.37 Kgf. As an expected result, Şalak variety was able to withstand a maximum horizontal load of 0.6 Kgf without deformation. These results obtained in the study contain important information in terms of transportation and storage of apricots. Especially during transportation, apricots will be more resistant to deformations if they are transported in a packaging that can be positioned vertically. Similar results were obtained in other studies on the subject (Hacıseferoğulları et al., 2007; Kaya & Yıldız 2018; Crisosto et al., 2004).

Correlation Matrix of Physical and Mechanical Properties

Correlation analyses were applied to evaluate the interaction between the physical and mechanical properties of the apricot cultivars used in the study and the results obtained are presented in the correlation matrix (Figure 5).

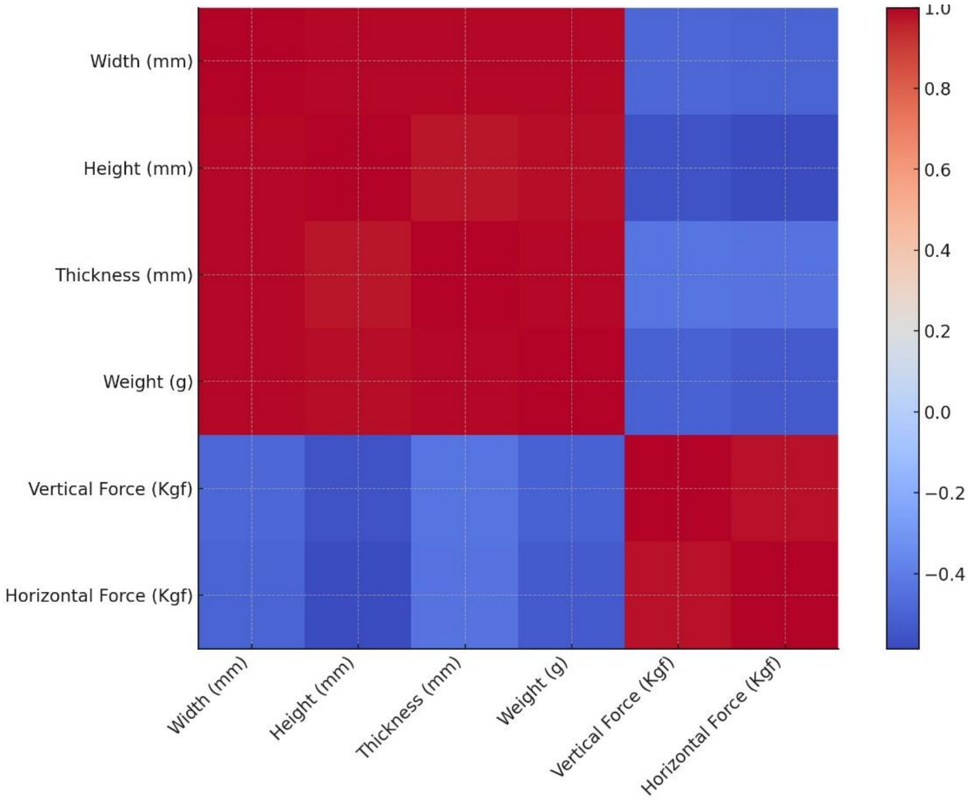

Figure 5. Corelation matrix of physical and mechanical properties

Figure 5 shows that there is a high positive correlation between the height, width and thickness values of apricot cultivars (>0.97). Similarly, a high positive correlation was determined between the weights of apricot cultivars in relation to the dimensions (>0.96). Based on these results, it can be said that the weights of apricots increase with the increase in size. This development is considered as a uniform growth pattern. In previous studies, this growth trend is observed especially in stone fruits. For example, Zhang et al., (2015) obtained similar results in peach fruit.

Another result obtained from the correlation matrix is that there is an inverse relationship between applied vertical and horizontal forces and dimensions and weight. In this context, the correlation coefficients varied between - 0.530 and - 0.648. Based on these results, it can be said that larger and heavier apricots have a softer texture and therefore have lower penetration resistance. Similar results were also found in other studies. For example, Jone & Smith (2018) examined the relationship between size and hardness in fruits. As a result of the research, it was concluded that large fruits are much more sensitive to mechanical loads.

Principal Component Analysis (PCA)

In this study, Multiple Component Analyses (PCA) were used to determine the principal components that best describe the apricot characteristics based on the physical and mechanical properties of different apricot cultivars. From the findings of the PCA, it was evident that two principal components could explain 99.24% of the total variance in the data set. This means that the properties of apricots can be effectively summarized by two dimensions (Figure 6).

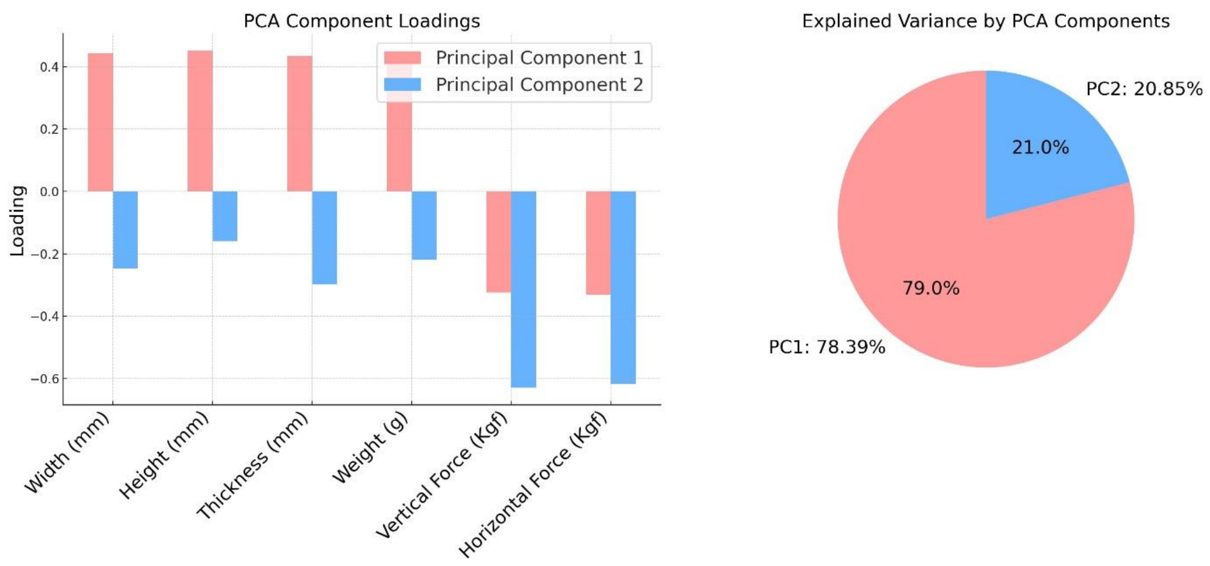

Figure 6. PCA component loadings and variances

The first principal component, PC1, has very strong positive loadings for physical properties such as width, height, thickness and weight. The share of PC1 in total components was determined as 78.39%. Based on this value, it can be said that the physical characteristics of apricots are more dominant than other variables, in other words, physical characteristics are the main source of variation in the data. The remaining 20.85% was defined as PC2. PC2 was formed by the force values applied in horizontal and vertical directions, which were evaluated among the mechanical properties. The high coefficient values of the forces constituting PC2 were evaluated as an indicator of the response of these parameters to the mechanical forces of apricots. The low percentage of PC2 can be concluded that mechanical resistance is not as important as physical properties in the whole data set used in the research.

The findings of this research are in line with previous studies using PCA on relevant datasets. For example, Zhang et al. (2015) performed PCA on the physical and mechanical properties of peaches and showed that more than 95% of the total variance was explained by the first two principal components. The first one is taken to represent physical dimensions, while the second one is related to mechanical properties, especially hardness and resistance to deformation. This study shows that the overall properties of stone fruits such as apricots are defined by physical size and mechanical strength. These results obtained in the study are consistent with the literature. For example, Kara and Karaat (2019) used PCA analysis in their study on different apricot cultivars and concluded that the variation in the data is mostly due to the physical properties of apricots.

CONCLUSION

In this study, physical, mechanical and color properties of different apricot cultivars grown in Iğdır province of Türkiye were investigated and the following results were obtained.

1. Statistically significant differences were determined between apricot cultivars in terms of physical, mechanical and color properties. When compared with other apricot cultivars, it was determined that Şalak variety was larger and heavier but less resistant to mechanical resistance.

2. It was determined that there were statistically significant differences between apricot cultivars in terms of color characteristics. It was concluded that this difference was caused by variety characteristics. However, it can be said that brighter colored fruits are preferred by consumers in terms of marketing of fruits. For this reason, L* value, which is an indicator of brightness, draws attention as an important parameter in such studies.

3. Correlation analyses were performed to determine the relationships between the physical dimensions and mechanical properties of apricots. As a result of the analysis, it was determined that there was a strong and positive correlation between the dimensions of apricots, while there was a strong negative correlation between the dimensions and their resistance to mechanical loads. In the research, it was determined that the increase in apricot size caused a decrease in their resistance to mechanical loads.

4. PCA analyses were performed to determine the main components of variance in the data set and it was determined that Apricot physical properties had a much more dominant role on this variance (78.39%). The effect of mechanical traits on the variance was determined as 20.85%.

Conflict of Interest

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

Author's Contributions

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

REFERENCES

Abera, D., Zerihun, M., & Yenasew, A. (2023). Effect of variety and agro-ecology on physio-chemical and organoleptic quality of avocado fruit grown in Ethiopia. *Cogent Food & Agriculture*. https://dx.doi.org/10.1080/23311932.2023.2273637

Aktas, T., Polat, R., & Atay, Ü. (2007). Comparison of mechanical properties of some selected almond cultivars with hard and soft shell under compression loading.*Journal of Food Process Engineering*, 30(5), 660-672. https://dx.doi.org/10.1111/J.1745-4530.2007.00164.X

Altıkat, S., & Temiz, Ş. (2019). Physico-mechanical and some chemical properties of apricot varieties in Iğdır Province. *YYU Journal of Agricultural Science, 29*(3), 373-381. https://doi.org/10.29133/yyutbd.521570

Beygi, S. R., Ghaebi, S. M., & Arabhosseini, A. (2009). Some physico-mechanical properties of apricot fruit, pit and kernel of Ordubad variety. *Agricultural Engineering International: the CIGR Ejournal, 9*, 1-16.

Cenkowski, S., Bielewicz, J., & Britton, M. G. (1991). A single kernel creep and recovery test. *Transactions of the ASAE, 34*(6), 2484-2490.

Cohen, J., West, S. G., & Aiken, L. S. (2014). Applied multiple regression/correlation analysis for the behavioral sciences. Psychology Press.

Crisosto, C. H., Garner, D., Crisosto, G. M., & Bowerman, E. (2004). Increasing peach market life by chilling injury reduction. *Postharvest Biology and Technology*, 34(2), 193-207. https://doi.org/10.1016/j.postharvbio.2004.05.002

Demir, B. (2018). Application of data mining and adaptive neuro-fuzzy structure to predict color parameters of walnuts (Juglans regia L.). *Turkish Journal of Agriculture and Forestry*, *42*(3), 216-226. https://dx.doi.org/10.3906/TAR-1801-78

Dogan, A., Firat Ege, K., Levent, O., & Asma, B. (2023). Characterization of new late-spring-frost-tolerant apricot hybrids: physical and biochemical fruit quality attributes, volatile aroma compounds. Ciência Rural, 53(1). https://dx.doi.org/10.1590/0103-8478cr20220144

Gabioud Rebeaud, S., Jaylet, A., Cotter, P., Camps, C., & Christen, D. (2019). A Multi-Parameter Approach for Apricot Texture Analysis.*Agriculture,* 9(4), 73. https://dx.doi.org/10.3390/AGRICULTURE9040073

Güler, H., & Aksoy, U. (2018). Impact of harvest time and storage conditions on the physicomechanical properties of apricot fruits. *Scientia Horticulturae*, 239, 129-135

Hacıseferoğulları, H., Özcan, M., Demir, F., & Çalışır, S. (2007). Some nutritional and technological properties of Gilaburu (Viburnum opulus L.) fruits growing wild in Turkey. *Journal of Food Engineering*, 78(4), 1361-1366. https://doi.org/10.1016/j.jfoodeng.2006.02.042

Hassan-Beygi, S. R. (2009). Some Physico-Mechanical Properties of Apricot Fruit, Pit and Kernel of Ordubad Variety. *Journal of Food Engineering*, 93(4), 407-412.

Jones, D., & Smith, A. (2018). Size and firmness relationship in apricots. *Postharvest Biology and Technology, 138*, 45-51. https://doi.org/10.1016/j.postharvbio.2018.01.003

Kan, T., & Karaat, F. G. (2019). Farklı rakımlarda yetiştirilen bazı kayısı çeşitleri ile zerdali meyvelerinde fenolik bileşiklerin incelenmesi. *YYU Journal of Agricultural Science, 29*(1), 88-93.

Kan, T., & Karaat, F. G. (2019). Farklı rakımlarda yetiştirilen bazı kayısı çeşitleri ile zerdali meyvelerinde fenolik bileşiklerin incelenmesi. *YYU Journal of Agricultural Science, 29*(1), 88-93.

Kaya, C., & Yildiz, H. (2018). Evaluation of apricot (Prunus armeniaca L.) varieties grown in different ecological conditions in Turkey. *Scientia Horticulturae*, 235, 136-145. https://doi.org/10.1016/j.scienta.2018.02.050

Kramarić, P., et al. (2021). Comparative analysis of mechanical properties and shelf life of apricot fruits. *Journal of Food Science and Technology,* 58(2), 652-659.

Kvam, P. H., & Vidakovic, B. (2007). Statistics for engineering and the sciences. Cengage Learning.

Lee, Y. Y., Lee, S., Ham, S. H., Lee, M. G., Hahn, J., Kim, Y., & Choi, Y. J. (2024). Relationship between sensory attributes and instrumental texture properties in meat analog patty system substituted with sweet potato stem. *Journal of the Science of Food and Agriculture*, 104(4), 1657-1665. https://dx.doi.org/10.1002/jsfa.13533

Mora, F., Zúñiga, P. E., & Figueroa, C. R. (2019). Genetic Variation and Trait Correlations for Fruit Weight, Firmness and Color Parameters in Wild Accessions of Fragaria chiloensis. *Agronomy*, *9*(9), 506. https://dx.doi.org/10.3390/agronomy9090506

Muradoğlu, F., Pehluvan, M., Gündoğdu, M., & Kaya, T. (2011). Iğdır yöresinde yetiştirilen bazı kayısı (Prunus armeniaca L.) genotiplerin fiziko kimyasal özellikleri ile mineral içerikleri. *Iğdır Üniversitesi Fen Bilimleri Enstitüsü Dergisi, 1*(1), 17-22.

Muzolf-Panek, M., & Waśkiewicz, A. (2022). Relationship between Phenolic Compounds, Antioxidant Activity and Color Parameters of Red Table Grape Skins Using Linear Ordering Analysis. *Applied Sciences*, *12*(12), 6146. https://dx.doi.org/10.3390/app12126146

Pandova, S., Mihaylova, D., Popova, A., Savchovska, S., & Zhivondov, A. (2023). Dynamic biometric data, total soluble solids, ash content, firmness, and color characteristics of two peach varieties. Acta Scientiarum Technologiae, 45(2), 135-145. https://dx.doi.org/10.15547/ast.2023.02.019

Ratner, B. (2009). The correlation coefficient: Its values range between +1/−1, or do they? *Journal of Targeting, Measurement and Analysis for Marketing,* 17(2), 139-142. https://doi.org/10.1057/jt.2009.5

Sîrbu, S., Gherghel, M., Iurea, E., Corneanu, M., & Chelaru, S. (2021). Pomological characteristics of some apricot varieties grown in the northeast area of Romania. Current Trends in Natural Sciences, 10(20), 135-144. https://dx.doi.org/10.47068/ctns.2021.v10i20.019

Sochor, J., Zitka, O., Skutkova, H., Pavlik, D., Babula, P., Krska, B., ... & Kizek, R. (2010). Content of phenolic compounds and antioxidant capacity in fruits of apricot genotypes. Molecules, 15(9), 6285-6305.

Tan, B., Kuş, E., Tan, K., Gülsöy, E., & Alwazeer, D. (2023). Determination of optimum harvest time and physical and chemical quality properties of Shalakh (Aprikoz) apricot cultivar during fruit ripening. *Acta Scientiarum Polonorum Hortorum Cultus*, 22(1), 73-85. (https://dx.doi.org/10.24326/asphc.2023.4807).7

Tas, A. (2023). Determination of fruit quality characteristics of blackberry genotypes growing naturally in Düzce (Türkiye). *Omuanajas*.

Yaldiz, G., & Çamlıca, M. (2024). Genetic diversity of selected basil (Ocimum basilicum L.) genotypes based on morphological, yield, and leaf color parameters. *Journal of Plant Nutrition*, *47*(4), 461-472. https://dx.doi.org/10.1080/15427528.2024.2336262

Yildiz, K., et al. (2019). Assessment of mechanical properties of apricot fruits using a texture analyzer. *Postharvest Biology and Technology*, 149, 186-192.

Zhang, Y., Wang, X., & Liu, H. (2015). Correlation between physical dimensions and mechanical properties in peaches. *Journal of Agricultural and Food Chemistry, 63*(14), 3527-3533. https://doi.org/10.1021/jf506046h