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Research Paper

Characterization of Different Mango (*Mangifera indica*) Varieties of South Punjab

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Abstract

Mango, *Mangifera indica* Linn., popularly referred to as the King of Fruits and is one of the most popular fruits that are grown in tropical and subtropical regions of the globe. An essential part of the enhancement and creation of mango varieties is to give a proper description of the varieties. The aim of the study was to identify some morphological and biochemical characteristics of mangoes that would be useful in identifying different varieties and future breeding initiatives. The study dealt with five varieties of mangoes i.e., Anwar Ratol, Azeem Chaunsa, Alishan, Dussehri and Haiden. The results of this paper affirm that significant differences exist between the varieties determined by their physical and biochemical characteristics. Anwar Ratol was the most outstanding of the five. South Punjab is the place of high genetic variation, and this variety can be employed to create crossbreeds. It has to be explored further in order to exploit this genetic potential. The description of each variety is crucial for the success of breeding program and its successful beginning.

Introduction

Mango is scientifically known as *Mangifera indica* commonly known as the King of Fruits. It is a commercially valuable fruit produced in most of the tropical and subtropical climates globally. This is attributed to its special taste, bright color, pleasant smell, juicy touch, and good health benefits (Ntsoane et al., 2019). The mangoes contain a lot of iron, calcium, phosphorus, and essential vitamins such as A and C (Lebaka et al., 2021). The world produces 58.3 million tons of mangoes in 2021 and it will increase by 1.9 to approximately 65 million

tons in 2026 (Antwi-Boasiako et al., 2024). The UN Food and Agricultural Organization (FAO, 2023) states that Mangoes have been cultivated in more than ninety countries, although India is the country with the highest manufacturer. Asia is world's greatest continent, contributing to around 70 percent of global mango production (FAO, 2021). With an average yield of 10,340 kg per acres, the province of Punjab cultivated the greatest quantity of mangoes throughout the 2019–2020 period (PBS, 2022).

Pakistan's mango sector is concerned that this country isn't producing good-quality mangoes sufficiently quickly to sustain its position of superiority in the international marketplace. The absence of genetic diversity in mango trees is also a significant issue along with pests and diseases. Plant material can be improved by chromosome doubling, hybridization, random seedling selection, genetic mutation, and other processes that occur within species or varieties (Rajwana et al., 2011). It is important to understand that every available germplasm has some sort of use (Knight, 1993).

Evaluation plays an important part in breeding & enhancing crop yields. The breeding activities, which involve the utilization of plant substances with unique characteristics, require precise data to develop new plant varieties (Vasugi et al., 2012). The abnormal production of mangoes, inadequate harvesting, inaccuracy of the fruit maturation, and poor quality are some issues that plague a lot of mango varieties in the world. Due to that fact, a great attention is paid to locating, utilizing, and preserving the valuable plant materials for genetic presenting the promising and threatened varieties of the mangoes (Khan et al., 2015). A lot of time is required to locate, learn, experiment with, and protect these scarce genetic resources to enhance the quality and productivity of the already available mango plant materials (Rajwana et al., 2011). A number of procedures and processes have been authored on how to identify and characterize mango plant varieties in terms of their physical, biochemical, agricultural, and genetic characteristics (Krishna & Singh, 2007; Rajwana et al., 2011; Khan et al., 2015).

The effort aimed to identify and define mango genotypes in South Punjab, along with increasing the varietal diversity by selecting satisfactory fruit traits in order to satisfy evolving customer demands. Another objective was to pick critical morphological and biochemical markers for mangoes that may be used as future reference points for identifying varieties and moving breeding efforts forward.

Materials and Methods

The search was conducted out at the Horticulture Research Centre in Bahawalpur. The research involved fruits of a total of five kinds. These types include Anwar Ratol, Azeem Chaunsa, Alishan, Dusehri, and Haden. The Mango Research Centre, Shujabad's experimental mango garden, supplied fresh fruit samples (5 kg) of each variety of mango that were well distributed and of high grade. To begin the organic ripening process, the fruit specimens were kept at room temperature.

Physical attributes: Within a week, once the hue of the fruit had grown completely, the breadth and length parameters were acquired using a vernier caliper. The fruit's pulp, flesh, and seed are subsequently extracted from the fruit. The combined weight of the flesh, the pulp, and the pebble belongs to the factors that are then determined utilizing a weight balance.

Biochemical attributes for fruit quality

Total soluble solids and titratable acidity: A digital refrigerator was used to determine the total soluble solids in a mango juice sample. A conical flask filled with 10 cc of pulp solution was used to estimate titratable acidity. The conical flask was vigorously shaken after adding two to three drops of phenolphthalein indicator. Following that, 0.1 N NaOH solutions were added to a burette and rapidly filtered until a consistent pink hue was obtained. The quantity of NaOH solution required for the titration was measured and recorded. The following formula was used to calculate the percent titratable acidity**:**

$$\%\text{Titratable acidity} = (T \times N \times VI \times E / V2 \times W \times 1000) \times 100$$

Here V1 is the amount of solution generated, E is the equivalent of the weight of the acid, T is the titer of the acid, N is the average value of NaOH, V2 is the quantity of the extract, and W is the total weight of the sample.

Ascorbic acid content: The amount of ascorbic acid in the pulp was determined using the method described by Sogi et al. (2012). Each sample was first filtered using Whatman filter paper to separate the juice. The filtering liquid was subsequently transferred to a 100 mL round-bottomed flask, and 0.4% oxalic acid was then included to raise the total volume to 10 mL. A 100 mL amount of the specimen was added into a beaker, and 5 mL of this was stirred together with a freshly prepared solution of 2,6-dichlorophenol indophenol dye until a vibrant pink color appeared, which remained approximately ten to fifteen seconds. To prepare the dye, 200 mL of ascorbic acid and 52 mL of 2,6-dichlorophenol indophenol were combined in the volumetric flask, and the distilled water was stirred in till the flask reached its calibration value**.**

Total phenolic and total protein contents: The Folin-Ciocalteu reagent (0.75 mL) and the plant extract (100 mL) were added after 5 minutes of incubation at 22 o C. The mixture was then incubated at 22 o C in 90min, 0.75 mL of sodium carbonate solution was added. The sample absorbance was recorded at 725 nm of the spectrophotometer (Sogi et al., 2012). The overall protein concentration was assessed, according to what was defined by Hanif et al. (2020), by using ordinary bovine serum albumin as the reference protein sample. The antioxidative activity of the enzymes was determined in terms of the protein content.

Carotenoid and anthocyanin content: Haider and other researchers investigated the quantity of carotenoids & anthocyanins in 2023 utilizing the method they developed. Investigators start by combining a single gram of the compound with an amalgam of 15% hydrochloric acid and 85% methanol. Investigators subsequently blended the ingredients in the container of water heated to 25 degrees Celsius for six hours in total. After trembling, they initiated the extraction method. The specimen was subsequently placed in an icy centrifugation set at four degrees Celsius and spun for 20 minutes at 4000 x g. To gauge the percentage of anthocyanin found within the extract itself, investigators examined the total amount of light absorbed at 3 specified wavelengths: 650, 620, and 530 nm. They employed a UV-Vis spectrophotometer (model 2326 K) manufactured by Hermle Labortechnik GmbH in Wehingen, Germany. The total quantity of anthocyanin was then determined in milligrams per kilogram based on the new weight using a unique approach. The overall concentration of anthocyanin was then determined in milligrams per kilogram of the new weight using a specific method.

$$\text{Anthocyanins} = (A530\ \text{nm} - A620\ \text{nm}) - 0.1\ (A650\ \text{nm} - A620\ \text{nm})$$

The pigments used in photosynthesis were checked using a spectrophotometer. A little acid-cleaned sand was mixed with 5 ml of acetone to mix fresh pulp samples (0.1 grams) (BDH Chemicals, England). After that, the mixture was filtered with Whatman No. 1 filter paper and then spun in a centrifuge at 9,000 revolutions per minute for three minutes at room temperature. The solution that spilled out had been examined for its absorption of light at a trio of colors: 470, 645, and 662 nm. The number of pigments was figured out in micrograms per gram of fresh weight (FW) using these equations.

$$Cx + c = (1000A470 - 1.90Ca - 63.14Cb) / 214$$

A470 is the absorbency recorded at 470 nm, that is a length of light utilized to determine carotenoid. Ca represents chlorophyll a, while Cb signifies the b-chlorophyll. Cx + c shows the total amount of carotenoids, which includes xanthophylls and carotenes.

Antioxidative enzyme's activity: For the quantification of Peroxidase activity. The reaction mixture (2 mL) comprised 1 mL of water, 200 µl enzyme extract, and 200 µl H_2O_2 (27.5 mM). Following seven minutes of exposure to fluorescent light for both the reaction mixture and the blank, the absorbance was measured at 470 nm using a spectrophotometer (Shahbaz et al., 2023).

The procedure indicated by Lo'Ay et al. (2021) was used to assess the CAT activity: 1000 µL of newly manufactured H_2O_2 (5.9 Mm) was mixed with 1000 µL of fruit extract, and absorbance was measured at 240 nm.

Statistical Analysis

The differences in all physical and biochemical measurements were checked using one-way ANOVA, and then the LSD test was used to compare them, with a significance level set at $P \leq 0.05$.

Results

Fruit size (length and width): The data shown in Fig. 1a about fruit length shows that Dusehri is much longer than the other four varieties: Anwar Retual, Azeem Chonsa, Alishan, and Haden. Anwar Retual and Alishan are similar in length compared to the other varieties. The statistical research revealed that the Haden, Dusehri, and Anwar types had similar fruit widths. (Fig. 1b). Gross weight of fruits, the pulp, skinning weight, and stones (g). The average fruit weight ranged from 315 to 131g. Dusehri has the largest weight of fruit when compared to Anwar Retual, Azeem Chonsa, Alishan, and Haden. Alishan had the lowest fruit weight, according to the records (Fig. 2a). The weight of the pulp varied greatly among the several varieties under study. Azeem Chounsa had the least quantity of pulp, at 72.16 grams, while Dusehri had the highest 171g (Fig. 2b). Taking into consideration Fig. 2c, no significant differences were found among the varieties. While in case of stone weight Dusehri and Anwar Retual were found to have highest stone weight (39.29 and 36.13 respectively) and least was found in Alishan i.e., 19.06 g.

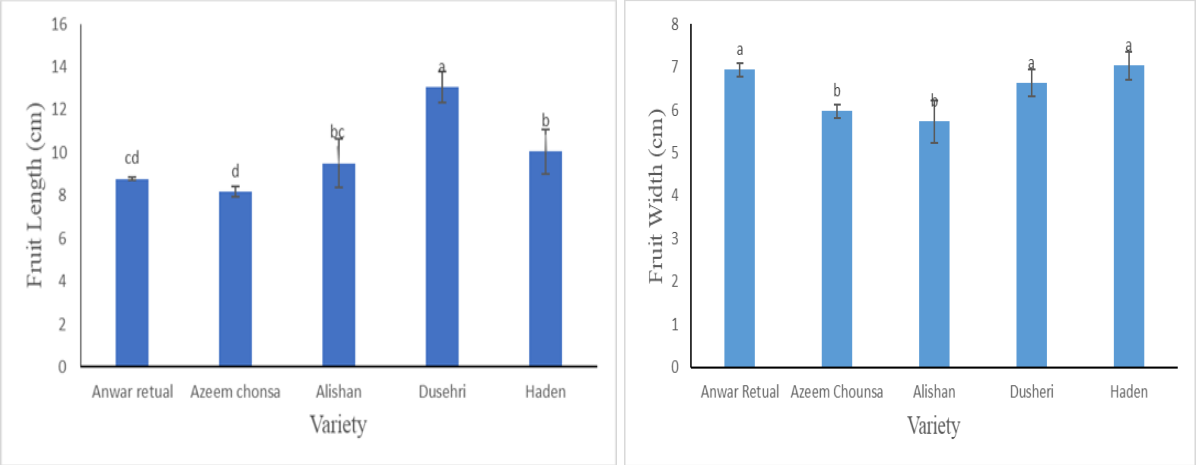


Figure 1: Fruit Size (Length figure 1a and Width 1b) of 5 Mango Cultivars. Data obtained from the average of three repetitions, with vertical bars representing the standard deviation of the mean. Mean values that have different superscript letters indicate a significant difference ($P < 0.05$).

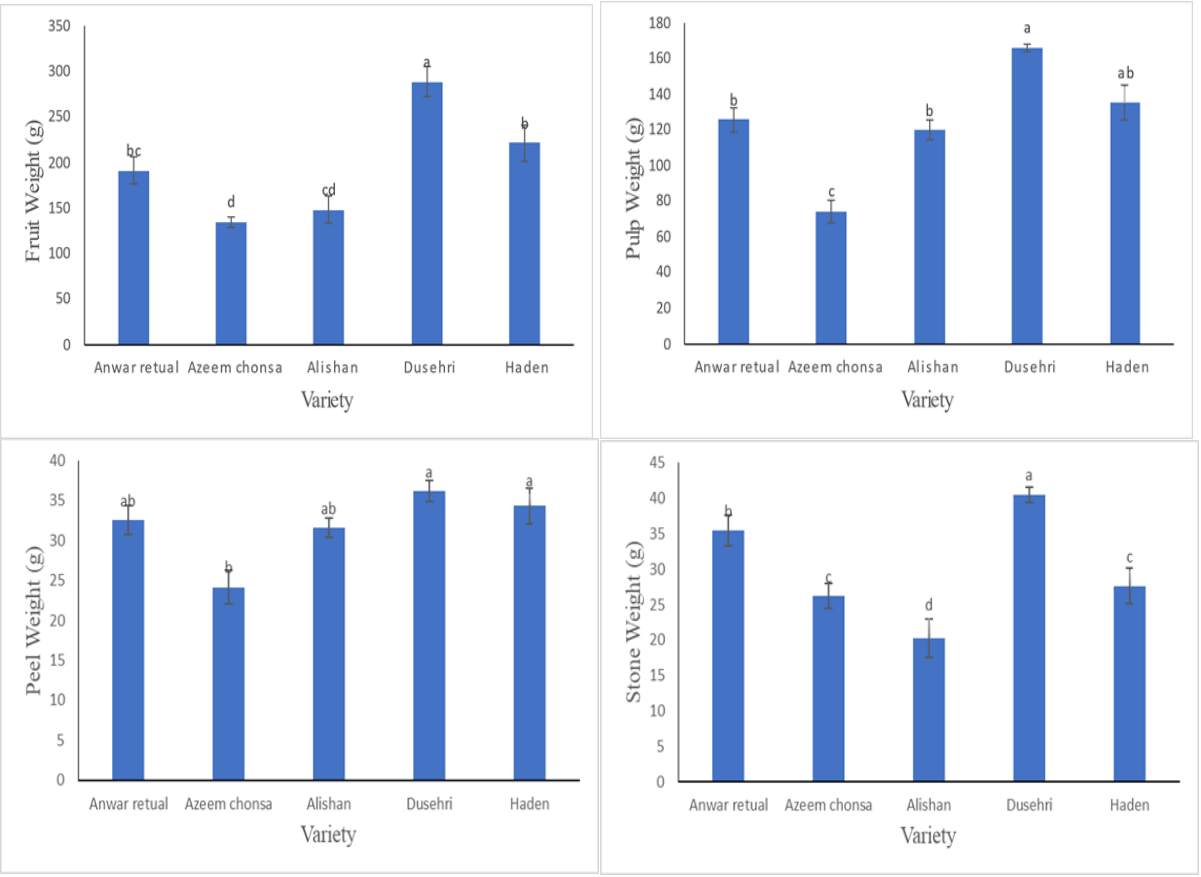


Figure 2: They estimated the weighing of the flesh (2a), pulp (2b), peel (2c) and bone (2d) of 5 varieties of mango. The vertical lines represent the standard deviation, SD, of a statistic since it is calculated as the mean of all three groups of data points in a line. There is very high variability in the mean value of consonants ($P < 0.05$).

TSS (Brix) and TA (%): The TSS levels varied between 14.83 and 16.36. Anwar Retual and Azeem Chonsa had higher soluble solids content than the other types, although they were not significantly different from Alishan and Haden. Alishan has maximum TSS value than Dusehri

and Haden but minimum value as compare to Anwar Retual and Azeem Chonsa (Figure 3a). Taking into consideration figure 3b, Alishan has more titratable acidity (1.63%) as compare to Anwar Retual, Azeem Chonsa, Dusehri and Haden. Anwar Retual has minimum TA as compare to Alishan but maximum from Azeem Chonsa, Dusehri and Haden. Azeem Chonsa and Haden have similar TA.

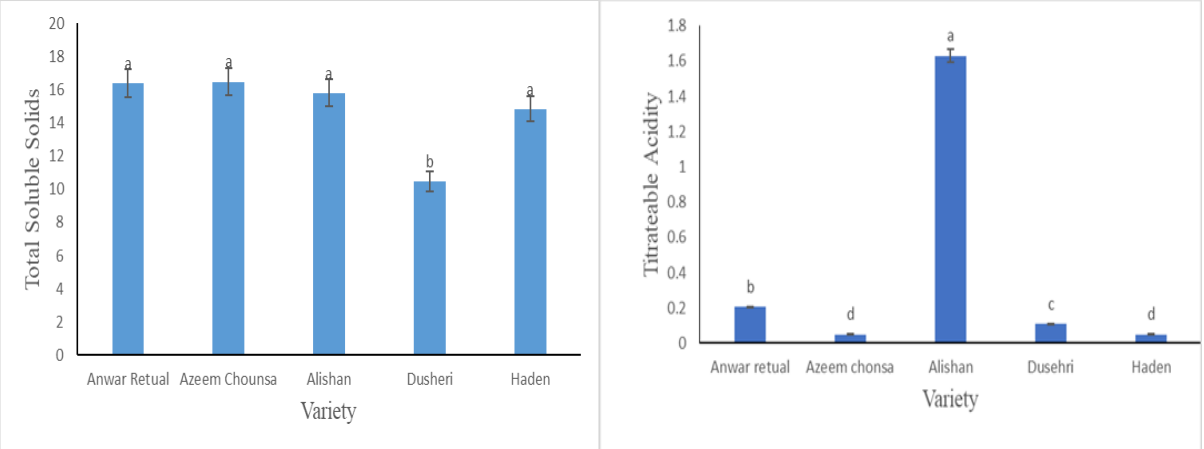


Figure 3. The entire solids that are (3a) and pH titratable (3b) for 5 mango types were measured. The outcomes indicate the mean value of the three separate studies, with the horizontal lines representing how significantly the mean values differ. Significant variations in findings are indicated by letters above the mean values ($P < 0.05$).

Ascorbic Acid (mg/100g): The highest content of ascorbic acid was detected in Alishan (87 mg/100g) compared to Anwar Retual, Azeem Chounsa, Dusehri and Haden. Statistical description showed that there were great differences across all the varieties (Fig. 4).

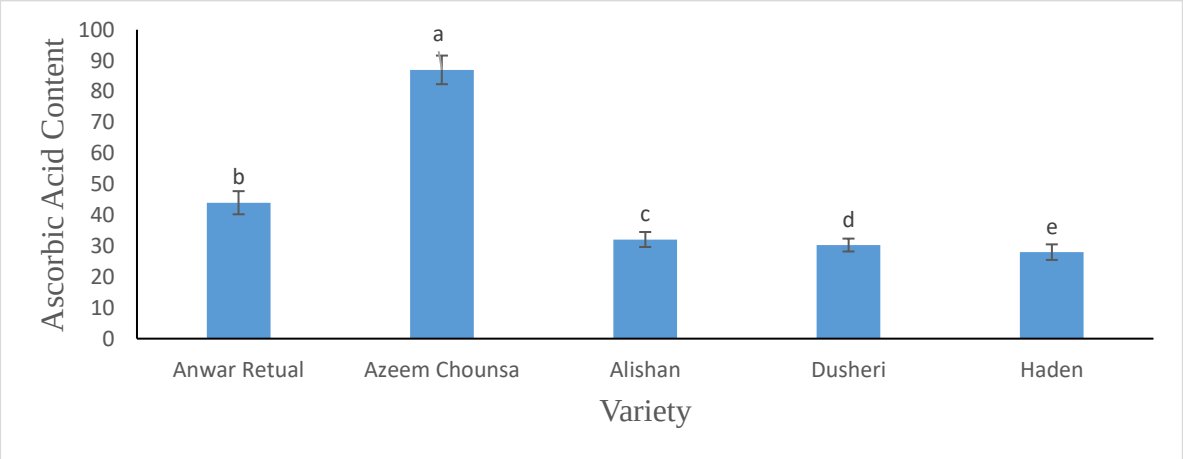


Figure 4. Ascorbic acid of 5 Mango Cultivars. The information acquired due to an average of three repetitions with vertical bars that indicate the standard deviation of the mean. Mean values and which are represented with different superscript letters signify a big variation ($P < 0.05$).

Total Protein Content (g) and Total Phenolic Content (mg GAE/g DW): Considering the statistical analysis of Fig. 5a, it is possible to note that there were no significant differences between the varieties in case of total protein content between 2.32g 2.25g. As compared to other 4 varieties used in this study, Haiden has maximum value (44 mg GAE/g DW) of the

total phenolic content. Haden contains more phenolic content as compared to Anwar Retual, Alishan and Dusehri and less compared to Azeem Chonsa as revealed in Fig 5b.

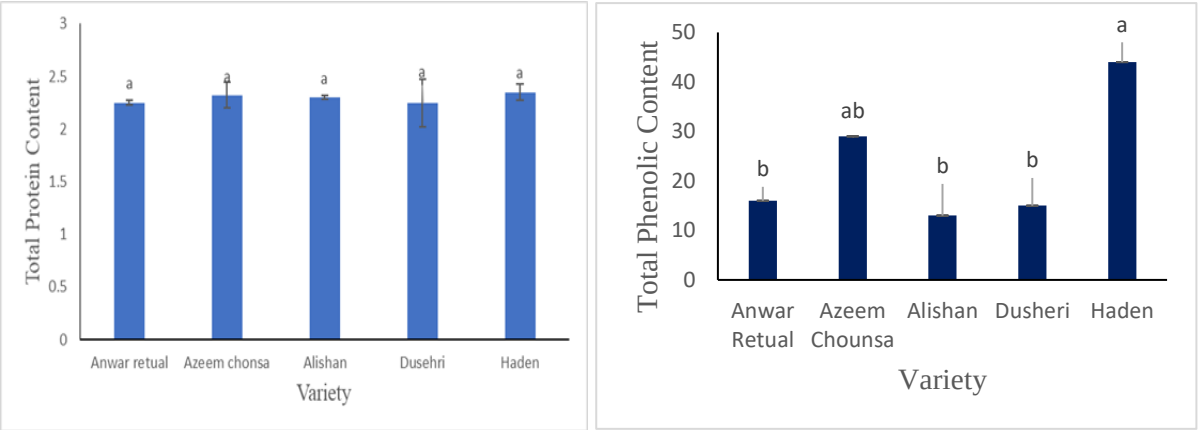
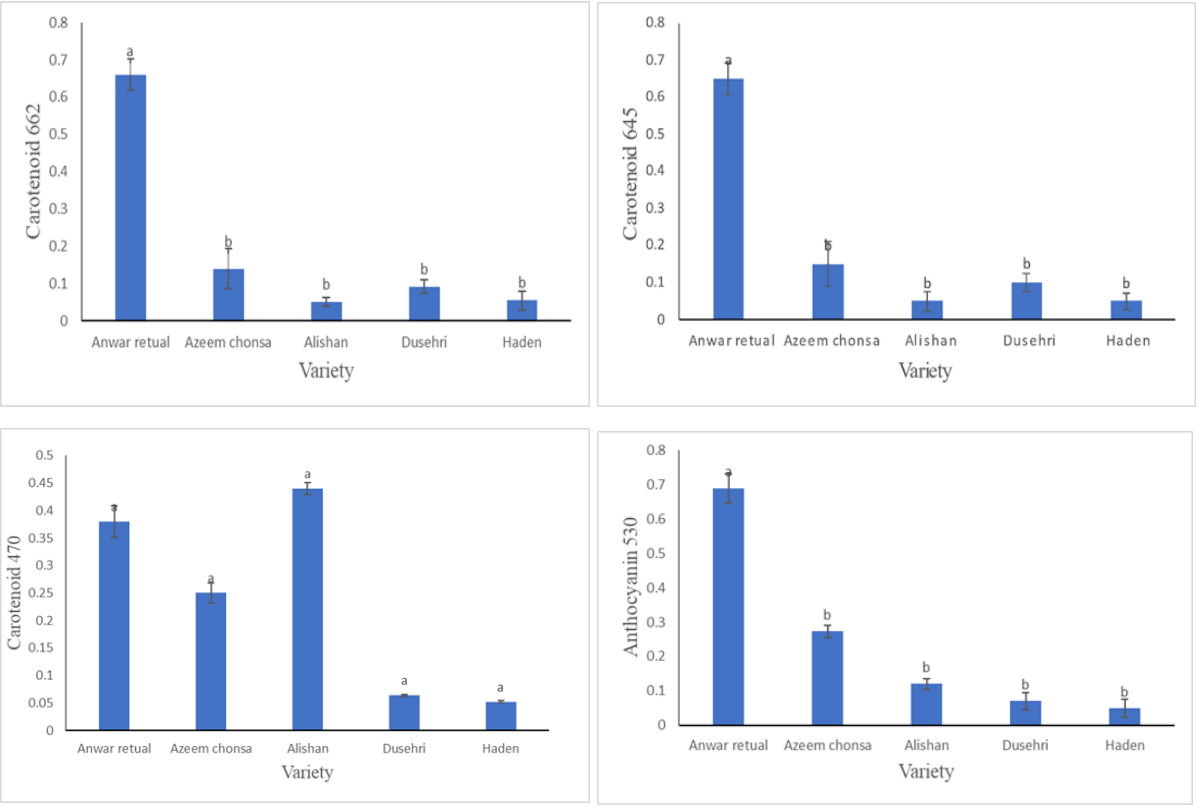


Figure 5. Total Protein content (5a) and Total Phenolic Content (5b) of 5 Mango Cultivars. Data obtained from the average of three repetitions, with vertical bars representing the standard deviation of the mean. Mean values that have different superscript letters indicate a significant difference ($P < 0.05$).

Carotenoid content (mg/ 100 g FW) and Anthocyanin content: The content of Carotenoid and Anthocyanin was measured using 3 Wavelengths i.e., 662, 645, 470 and 530, 620 and 650 respectively. In order to estimate carotenoid content, Anwar Retual has a maximum value when it is subjected to wavelength of 662 and 645 as compared to other four varieties. Alishan was observed to give maximum value when 470 Wavelength was applied. To determine the anthocyanin contents under the influence of different wavelengths of 530, 620 and 650 Anwar Retual recorded high anthocyanin activity.



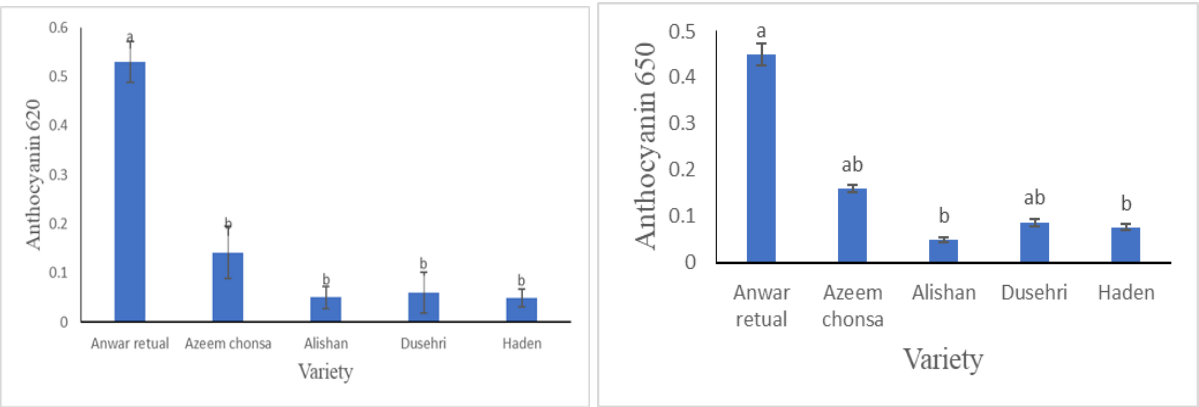


Figure 6. Carotenoid and Anthocyanin content of 5 cultivars Mango. Results of the mean of three data, the standard deviation of mean being represented by the vertical bars. The difference in the mean values when they are represented by different superscript letters implies that they are significantly different ($P < 0.05$).

Activity of Antioxidative Enzyme (U/mg protein): POX activity was quantified and the similar values were obtained between Duesehri and Haden (1.92) and the minimum value was recorded as 1.78 in Anwar Retual with no significant difference among them. A value of 0.21 to 0.10 was measured in the case of CAT activity in which Alishan had the highest CAT activity. Both POX and CAT are depicted in Fig. 7.

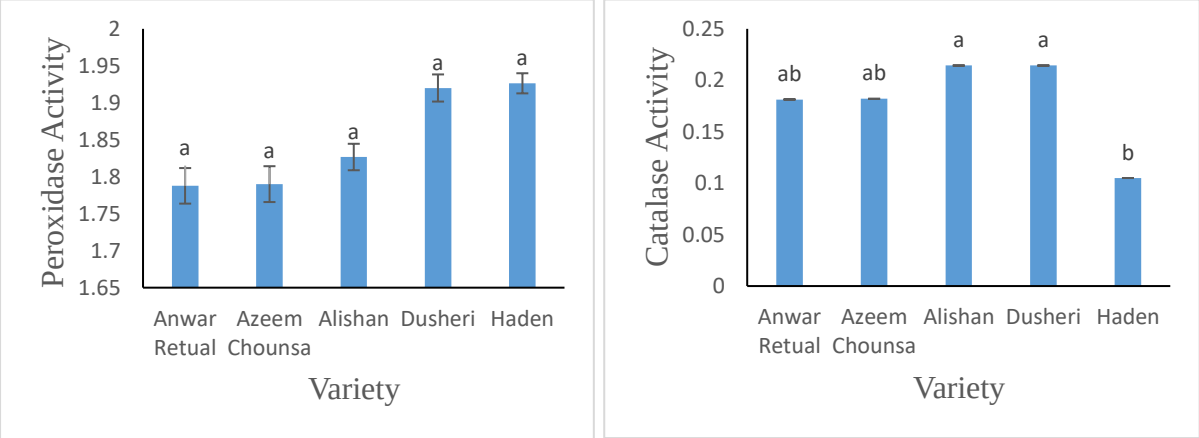


Figure 7. activity of 5 Mango Cultivars Peroxidase and Catalase. The results were taken to be the mean of three repetitions with the vertical bars showing the standard deviation of the mean. The difference between the mean values that have various superscript letters signifies a significant difference ($P < 0.05$).

Discussion

This study was carried out in order to determine the native and historically grown varieties of mangoes in South Punjab. This research was used in the description of the predominant mango varieties in south Punjab, Pakistan. The level of Significance among various varieties of Pomological markers was lower. Using Factorial Analysis, all the characteristics under analysis turned out to be working to describe mango cultivars. The obtained results were very useful in characterizing the germplasms as well as in designing local Mango varietal catalogs. A comparable research had been previously conducted on local

varieties on Mango (Bora et al., 2017; Kher & Sharma, 2002), Citrus (Debbabi et al., 2013), fig (Saddoud et al., 2008), and showed that the under discussion pomological characteristics were characterized by incessant variation whereas the current work did not report the high variability which could be explained by genetic make-up of each variety that predetermined various traits, which are also significantly influenced by environmental factors.

The mean fruit length showed a significant difference with the ranges of 10.33 to 8.83; we agree with the results of Bora et al. (2017) and Kher and Sharma (2002). Conversely, the width of the fruits did not differ significantly in this study, but past studies by Bora et al. (2017) and Kher and Sharma (2002) have shown that they have significant differences, which could be because of genetic differentiation in different varieties of fruits and the way the environment affects them. The mean weight of fruits ranged between 315g and 131g that shows high quality of variability which may be explained by the fact that the types have different respiration rates. The peel weight was between 33.6g and 32.1g without much variation in the varieties. There is an observable difference in table 1b that pulp weight of various mango varieties did not significantly differ with our findings which could be attributed to the environmental factors and disparity in growing conditions as compared to previous research undertaken by Bora et al., (2017) which could be the case. The study of Bora et al., (2017) confirms that stone weight shows overwhelming differences with 39.29 to 19.09g. Such biochemical characteristics of fruits, as soluble solids, acidity etc., are vital in choosing good cultivars or varieties. Flavor, texture, aroma volatiles, and biochemical properties are significantly different in determining the quality of mangoes, the result indicated that no significant variation existed in all varieties except Duesehri that exhibited the lowest TSS content and this might be because of environmental factors or varietal characters (Bora et al., 2017; Singh, 2002). Alishan (1.63 percent) had been found to have the highest possible titratable acidity and the range of acidity was found to be 1.63 to 0.05 percent, which is a wide variation. It was also confirmed by (Bakhshi and Bajwa, 1959) whose research showed a significant difference between the various mango varieties. As compared to Anwar Retual, Azeem Chounsa, Dusehri and Haden, the maximum value of the ascorbic acid content was found in Alishan (87 mg/100g). The statistical analysis represented big differences between the varieties. The varying amounts of ascorbic acid are also supported by the fact that, Mitra et al. (2001) reflected a range of 21.66 mg/100 g to 125.40 mg/100 g of ascorbic acid levels in items. This variation in the concentration of ascorbic acid could be explained by the genetic variation of the subjects of experiments.

There were no notable differences in the total protein content but there was high level of variation in terms of total phenolic contents 15-44 (mg GAE/g DW), which may be as a result of genetic composition of every variety. The natural appearance of the fruit product in terms of carotenoids is indicated by total carotenoids and the fruits that contain more of these compounds have some advantage particularly in international trade where the use of chemicals to add the color of fruits is not allowed. The amount of carotenoids and anthocyanins was determined at three wavelengths: 662, 645, 470 and 530, 620, 650 using carotenoids and anthocyanins respectively. Anwar variety had the highest carotenoid content value at wavelengths of 662 and 645 as compared to the other four varieties. In the meantime, the maximum value was obtained at the wavelength of 470. To determine the content of anthocyanin under the influence of wavelengths of 530, 620 and 650 the Anwar Retual

exhibited highest anthocyanin activity. Differences in the levels of Carotenoids were also noticed by (Bora et al., 2017; Hoda et al., 2003). POD causes the poor flavors, loss of texture, and change of color. The Quantification of POX activity revealed that Duesehri and Haden had similar values (1.92) and least of 1.78 was found in Anwar Retual with no significant difference between them. In some way our study is somehow in congruence with Liu et al., (2013) difference, which could be because of environmental factors. When the activity of CAT occurred, a value of 0.21 to 0.10 was measured with Alishan demonstrated to have maximum CAT activity.

Conclusion

The results of this research confirm the hypothesis that there is a great difference between the genotypes as per their physical and biochemical characteristics. The germplasm of South Punjab is also varied with potentiality to hybridize with and therefore proper exploration is required to exploit the potential to full potential. Characterization is, therefore, an important initial move in the establishment of a breeding program.

Author Contributions

Methodology, A.N.; Formal analysis, M.A.B.; Writing-original draft preparation, M.A.A.; Writing—review and editing, A.L, A.S, F.R.; Supervision, M.I. All authors have read and agreed to the published version of the manuscript**.**

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Conflicts of Interest

The authors declare that there are no competing interests.

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