Phenotypic and biochemical diversity among peach cultivars grown under environmental conditions of Pothohar (salt range) Pakistan

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Background. Peaches are the prominent species among the fruits due to having diverse germplasm around the globe with largest number of commercial genotypes. Pakistan is also rich in various cultivars of peaches that are rarely studied for its genetic diversity. An attempt was, therefore, made to study the phenotypic variation in peach tree and fruit characteristic of 7 desirable cultivars (namely A669, Texas y-455, Florida King, Arctic Fantacy, Spring Creast, Micholea and Swanee). **Methods.** All cultivars were grown at the Experimental Peach Block at Barani Agriculture Research Institute (BARI), Chakwal, Punjab-Pakistan. Tree traits such as growth habit, leaf characteristics, flower characteristics, morphological and biochemical fruit traits were evaluated by using IBPGR peach descriptors. **Results.** Extensive variation was found among the cultivars for various traits, including tree growth (weeping, compact or open whereas), leaf length (9.0 ± 0.8 to 12.0 ± 0.4 cm), leaf width (2.6 ± 0.1 to 3.3 ± 0.2 cm), fruit weight (45.6 ±3.3 to 107 ± 8.8 g) and stone weight (4.3 ± 0.2 to 7.5 ± 0.4 g). Besides, a significant variation among the various cultivars has also been observed regarding, titratable acidity (0.64 ± 0.02 to 1.19 ± 0.04%), °Brix (7.17 ± 0.62 to 11.27 ± 0.21), ripening index (6.02 ± 0.72 to 17.2 ± 0.44), Vitamin C (75.3 ± 15 to 116.1 ± 10.5 mg 100 g^{-1}), total sugar (13.52 ± 0.50 to 20.84 ± 1.23%), reducing sugar (5.68 ± 0.11 to 7.25 ± 0.51%), non-reducing sugar (4.12 ± 0.45 to 10.77 ± 0.8%), total phenolics (176.20 ± 7.18 to 317.72 ± 4.66 mg GAE 100 g^{-1}), radical scavenging activity (44.25 ± 0.28 to 78.17 ± 1.43%) and reducing power (0.12 ± 0.1 to

0.22 ± 0.03). Similarly, a significant correlation was noticed between many tested traits.

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Abstract

Background. Peaches are the prominent species among the fruits due to having diverse germplasm around the globe with largest number of commercial genotypes. Pakistan is also rich in various cultivars of peaches that are rarely studied for its genetic diversity. An attempt was, therefore, made to study the phenotypic variation in peach tree and fruit characteristic of 7 desirable cultivars (namely A669, Texas y-455, Florida King, Arctic Fantacy, Spring Creast, Micholea and Swanee).

Methods. All cultivars were grown at the Experimental Peach Block at Barani Agriculture Research Institute (BARI), Chakwal, Punjab-Pakistan. Tree traits such as growth habit, leaf characteristics, flower characteristics, morphological and biochemical fruit traits were evaluated by using IBPGR peach descriptors.

Results. Extensive variation was found among the cultivars for various traits, including tree growth (weeping, compact or open whereas), leaf length (9.0 ± 0.8 to 12.0 ± 0.4 cm), leaf width (2.6 ± 0.1 to 3.3 ± 0.2 cm), fruit weight (45.6 ±3.3 to 107 ± 8.8 g) and stone weight (4.3 ± 0.2 to 7.5 ± 0.4 g). Besides, a significant variation among the various cultivars has also been observed regarding, titratable acidity (0.64 ± 0.02 to 1.19 ± 0.04%), °Brix (7.17 ± 0.62 to 11.27 ± 0.21), ripening index (6.02 ± 0.72 to 17.2 ± 0.44), Vitamin C (75.3 ± 15 to 116.1 ± 10.5 mg 100 g^{-1}), total sugar (13.52 ± 0.50 to 20.84 ± 1.23%), reducing sugar (5.68 ± 0.11 to 7.25 ± 0.51%), non-reducing sugar (4.12 ± 0.45 to 10.77 ± 0.8%), total phenolics (176.20 ± 7.18 to 317.72 ± 4.66 mg GAE 100 g^{-1}), radical scavenging activity (44.25 ± 0.28 to 78.17 ± 1.43%) and reducing power (0.12 ± 0.1 to 0.22 ± 0.03). Similarly, a significant correlation was noticed between many tested traits.

Key words: *genetic diversity, morphological descriptors, sugars, phenolics, radical scavenging activity*

Introduction

The cultivation of peach (*Prunus persica* L.) has been practiced since ancient times. The annual production of peach is about 21.08 million tons from an area of 14.9 million hectares under its cultivation. Peach is currently placed as one of the main horticultural produces and is the third largest species of fruit tree in terms of production (FAOSTAT, 2012), after apples and pears. China is the largest peach producer followed by Italy, Spain, and United States. Most of the commercial production of peaches comes from the regions that lie between the latitudes 30°N and 45°S (Scorza and Okie, 1991). However, peaches are native to China, yet more than 3000 cultivars are currently cultivated worldwide, which can be characterized into different groups on the basis of morphology (Cheng, 2007). It is also a prominent species among the fruits due to having diverse germplasm around the globe with largest number of commercial genotypes.

Besides its commercial importance, peaches are one of the richest sources of nutrients and is known as a popular summer fruit (Wolfe *et al.*, 2008). Several epidemiological studies revealed the importance of fruits and vegetables in the provision of health benefits against chronic and degenerative diseases (such as stresses, atherosclerosis, heart and brain disorders, cardiovascular disease, diabetes and different types of cancer) (Del Rio *et al.*, 2013; Mahajan and Chopda, 2009; Gao *et al.*, 2013; Orazem *et al.*, 2011). Additionally, peaches have purgative properties that can prevent constipation and can be used to treat duodenum ulcers. Such medicinal value of the peaches might be due to the presence of higher amounts of antioxidants (Phenolic acids, flavonoids, and anthocyanin compounds) with great antioxidant potential.

As mentioned earlier, peach fruits have the largest number of commercial cultivars, which reflect on its diversity (i-Forcada *et al.*, 2014). Different studies have reported a significant variability among the various cultivars of the peaches that might be due to the geographical zones, climatic conditions and crop genetics. The role of climate and geography of the area is very important concerning the physicochemical properties of the peach fruits (Chalak *et al.*, 2006). On the other hand, Cantín *et al.*, (2009) reported that the total soluble solid concentration is dependent on heritability rather than environmental conditions of the region, year of production and maturity, etc. But in most of the cases, the locally adapted germplasms having high quality and production are produced through different breeding programs (Monet and Bassi, 2008; Badenes and Byrne, 2012; Cantín *et al.*, 2010; i Forcada *et al.*, 2012).

In Pakistan, peaches stands 2nd in terms of production after apricots among the stone fruits. The occupied cultivated area by peaches is about 15,500 hectares that yield some 56,000 tons (FAOSTAT, 2012). Evaluation and characterization of peach genotype is one of the persisting activity in different climatic zones as reported by many countries, like Turkey, Romania, India, Iran, Australia, Taiwan, Pakistan and America (Hancock *et al.*, 2008). In Pakistan, peaches are mainly grown in Khyber Pukhtunkha and Baluchistan, while some early maturing varieties are also cultivated in pothohar (Salt range) region of Punjab, Pakistan. Though, the production of the peaches in the pothohar region is low, yet the determination of the diversity among the existing genotypes would be an asset for future breeding programs.

A study was therefore, designed with the objective to investigate the morphological and biochemical diversity amid the peach varieties grown under the environmental conditions of Pothohar (Salt range) region of Pakistan. The results of the study will provide with the broader picture of the potential genotypes of the area that can be helpful to breeders to produce future commercial cultivars through well designed breeding program.

Materials and Methods

Collection of the experimental materials

Experimental Peach Block at Barani Agriculture Research Institute (BARI), Chakwal was selected for the study due to the availability of the commercial cultivars grown under the Pothohar (Salt range) region of the Punjab-Pakistan. The recorded minimum winter temperatures ranged from -3.5ºC to -6.6ºC and mean annual rainfall was 260-320 mm. A total of seven commercial peach cultivars (A669, Texas y-455, Florida King, Arctic Fantacy, Spring Creast, Micholea and Swanee) with desirable traits were evaluated during the year 2015-16.

Tree vegetative and morphological characterization

To evaluate the vegetative and morphological traits of these cultivars, 5 trees between eight to nine years old were randomly selected per cultivar. All the plants in the experimental orchard were treated under same environmental, agronomic and management conditions. The cultural practices (soil management, pruning, irrigation, fertilizer, pest and disease control) were carried out according to the local system. Various traits (including tree growth habit, leaf length, leaf width, leaf blade ratio, leaf color, leaf margin, flower size, flower color, flower type, density of flower buds and intensity of anthocyanin coloration on flowering shoot) in each peach cultivar was measured directly on the spot (field) using peach descriptors developed by the International Board for Plant Genetic Resources (IBPGR) and European Cooperative Program for Plant Genetic Resources (ECPGR).

Physical and biochemical characterization of peach fruit

To study the biophysical traits, ten freshly harvest fruits from each plant of cultivars were assessed at the Pomology Laboratory, Institute of Horticultural Sciences, University of Agriculture Faisalabad, Pakistan. The studied traits, included fruit weight, fruit shape, fruit size, fruit over color, fruit ground color, flesh color, fiber of fruit, fruit skin pubescence, stone adherence, stone shape, stone surface, stone to fruit ratio and fruit symmetry. Fruit samples were harvested by a single person to maintain a steady maturity standard at the stage when green ground color switches into yellow or white. Basic quality traits such as titratable acidity, soluble solid contents and ripening index were then evaluated.

For biochemical assays, fruit samples were peeled and cut longitudinally into four pieces, the mesocarp was removed and cut down into small pieces. The samples were then frozen into liquid nitrogen and kept at -20°C until use. For each examination, 5 g of the sample was used

from the selected fruit and assayed.

Titratable acidity, total soluble solids and ripening index

Titratable acidity of fruit juice was determined by the method of Hortwitz (1960) and the data was expressed as percentage (%). The total soluble solid was measured at room temperature with a digital refractometer (Atago PR-101, Tokyo, Japan) and the data was expressed as °Brix, while ripening index was calculated based on SSC/TA ratio.

Ascorbic acid

For the determination of vitamin C contents samples were kept in metaphosphoric solution (5% HPO_3) at -20°C until use to preserve it against the oxidation. Vitamin C contents of juice were determined by the method as described by Ruck (1963) and the results were expressed as mg 100 g^{-1} of juice.

Total Phenolics

The total phenolic compounds in the extracts were examined by the Folin-Ciocalteu method (Folin and Ciocalteu, 1927) and the results were expressed as gallic acid equivalents (GAE) mg per 100 g of dry matter.

Antioxidant activity

Antioxidant assays was carried out using 1, 1-diphenyl- 2-picryl hydrazyl (DPPH) spectrophotometric method as described by Noor et al. (2014). The radical scavenging activity was measured as percent (%) inhibition of free radicals by DPPH.

The reducing potential of the extract was measured by direct electron donation in the reduction of Fe_3+ $(CN)_6$ to Fe_2+ $(CN)_6$ as described by Yadav *et al*., (2014).

Total sugars, reducing and non-reducing sugars

Sugars were determined by method of Lane and Eynon (1923) as described by Hortzwitz (1960).

Statistical Analysis

The data was analyzed by Statistix Version 8.1 software using analysis of variance (ANOVA). The means that were found significant were further separated by LSD test at $p<0.05$ (Steel and Dickey, 1997).

Results and Discussion

Morphological characteristics of peach tree and fruit

In general, a huge variation was observed among the different cultivars concerning the morphological and phenological traits. It has been noticed that the growth habit of Texas Y 455 and Florida King was weeping, whereas Arctic Fantacy and Spring Creast had open growth habit and the remaining varieties showed compact growth habit (Fig. 1). Similarly, a significant variation was recorded in leaf length and width, but the leaf margins, leaf blade color and leaf blade ration have not shown any difference. Leaf color of all the varieties was dark green with serrate margin (Fig. 2). Moreover, the average length and the width of the leaves were ranged from 9.0 cm to 12.0 and 2.6 to 3.3 cm, respectively (Fig. 3).

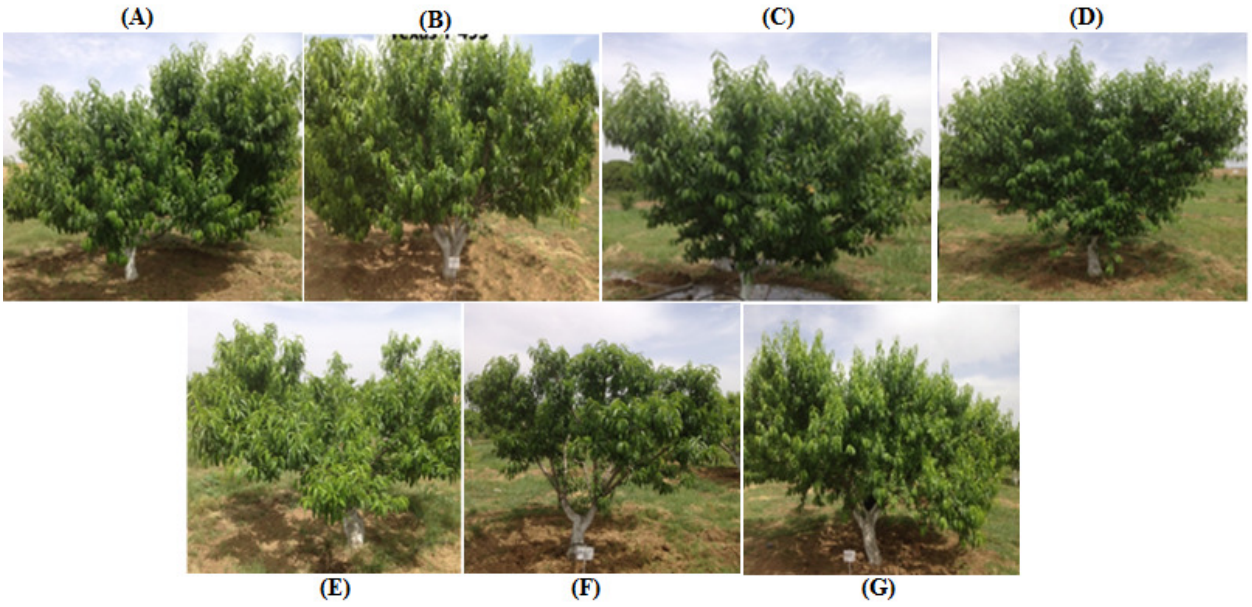


Figure 1: Variations in the tree morphology of the examined peach cultivars

In the figure, a = A669, b = Texas Y455, c = Florida King, d = Arctic Fantacy, e = Swanee, f = Spring Creast, g = Micholea. The tree growth habit of A699, Micholea and Swanee cultivars were found compact, while the the cultivars Texas Y455 and Florida King was weeping and the cultivars Arctic Fantacy and Spring Creast were found open.

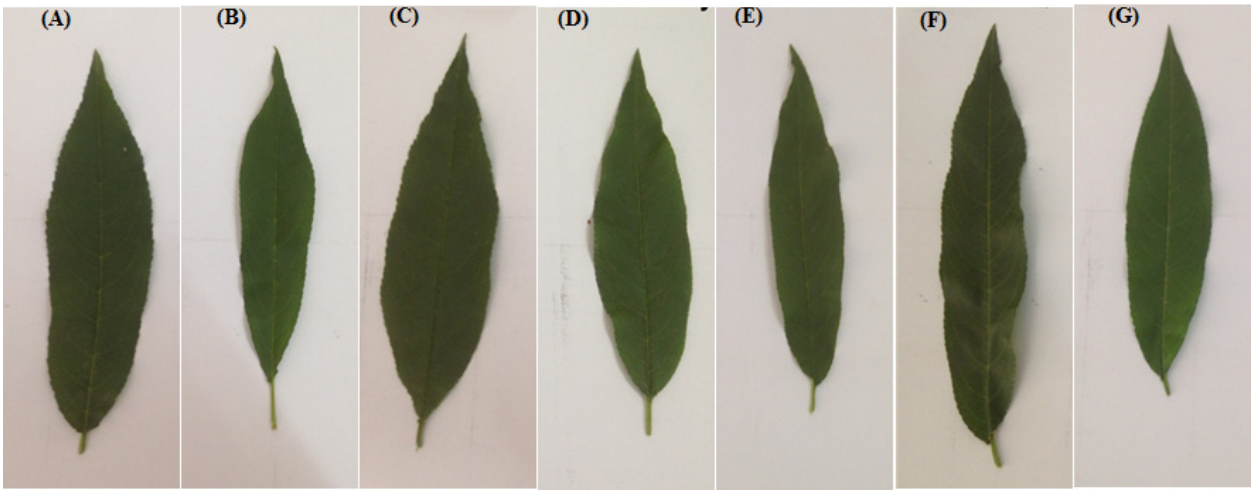


Figure 2: Variations in the leaf morphology of the examined peach cultivars

In the figure, a = A669, b = Texas Y455, c = Florida King, d = Arctic Fantacy, e = Swanee, f = Spring Creast, g = Micholea. The leaves of all the tested cultivars were serrate with dark green leaf blade.

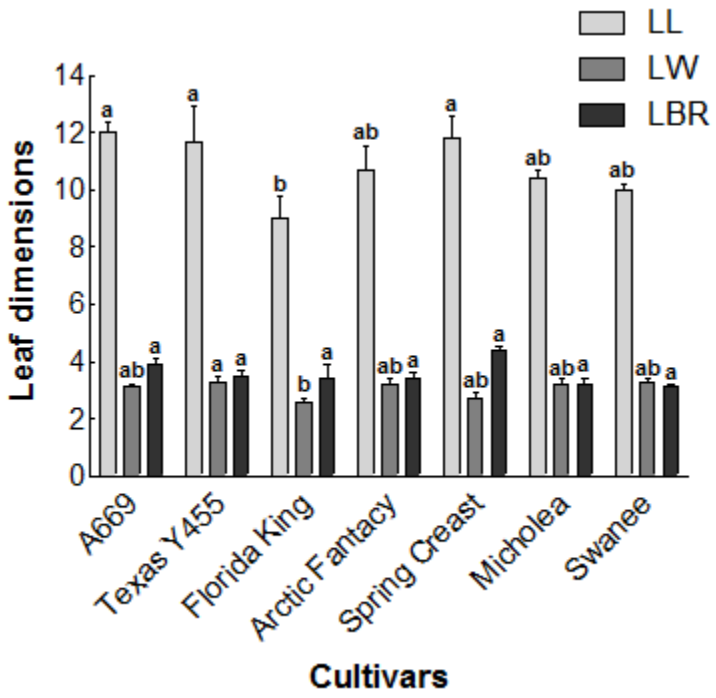


Figure 3: Leaf dimensions of the explored cultivars of peach

LD = leaf dimensions; LL = leaf length; LW = leaf width; LBR = leaf blade ration. Means that were denoted by different letters were significantly different from each other at $p \leq 0.05$.

However, the morphological description regarding the characteristics of the flower suggested variations in the intensity of anthocyanin coloration of the flowering shoot (strong, medium and weak), density of the flower bud (extreme dense, very dense and medium dense), type of flower (rosaceous and companulate), corolla color, stigma position and flower size (Table 1). Early blooming was observed in Florida King and A669, while in other varieties date of full bloom was recorded during the 1st week of March. Early blooming is a desirable characteristic in the Mediterranean areas, which results in higher yields, but in the temperate region spring frost can affect the production (Cantín *et al.*, 2010; Jung and Müller, 2009). Blooming period is certainly considered as an important trait in peach and other fruits of *Prunus* species (Cantín *et al.*, 2010). The harvesting period ranged from early-May to late-June for the various cultivars with Florida King and Swanee were harvested earlier and arctic Fantacy were harvested late. Also, the fruit development period varied among the tested cultivars of the peaches and was ranged from 85 to 115 days. The cultivar, Florida King developed through shortest period of time and was harvested earlier compared to the other cultivars (data not shown). It is quite obvious that most of the times, fruit developmental stage and harvest time is highly dependent on the cultivar (Cheng, 2007; Mounzer *et al.*, 2008), yet spring temperature might influence such periods (Lopez and DeJong, 2007). In the Mediterranean areas, both early and late-maturing peach cultivars are considered valuable regarding the market. Such variations in the harvesting time allow the peach industry to be fed with the continuous supply of fresh peaches that can satisfy the higher expectations of the consumer for a quality product (Martínez-Calvo *et al.*, 2006).

The data in Table 2 revealed significant variations, considering fruit size, skin colour and fruit shape. On the basis of fruit size, the examined cultivars were divided into two fruit groups, i.e. the large (A669, Texas Y455 and Florida King) and medium (Arctic Fantacy, Spring Creast, Micholea and Swanee). Considering the fruit shape, most of the varieties were having elliptic shape except for Florida King and Arctic Fantacy, which had ovate and round shaped fruits, respectively (Fig. 4). Certainly, the phenotypic characteristics (fruit skin color, fruit size and fruit

Table 1: Differences in the morphological characteristics of tested peach flowers from the Pothohar (Salt range) region of Pakistan

Varieties	Flower Characteristics							
	AC	**IAC**	**DFB**	**FT**	**CC**	**SP**	**A: P**	**FS**
A669	P	M	Md	Rosaceous	Pink	BA	P	Intr
Texas Y455	P	S	Ed	Rosaceous	Pink	AA	P	Intr
Florida King	P	W	Vd	Rosaceous	Pink	AA	P	Lr
Arctic Fantacy	P	W	Vd	Campanulate	Pink	AA	P	Intr
Spring Creast	P	M	Md	Rosaceous	Light Pink	AA	P	Lr
Micholea	P	M	Vd	Rosaceous	Pink	BA	P	Sm
Swanee	P	W	Vs	Campanulate	Light Pink	BA	P	Lr

The bold abbreviation AC = presence of anthocyanin coloration on flowering shoot; IAC = intensity of anthocyanin coloration; DFB = density of flower bud; FT = flower type; CC = corolla color; SP = stigma position compared to anther; A:P = anther:pollen; FS = flower size and the regular abbreviation P = presents, M = medium, S = strong, W = weak, Md = medially dense, Ed = extremely dense, Vd = very, Vs = very spurse, BA = below anther, AA = above anther, Intr = intermediate, Lr = large, Sm = small.

Figure 4: Variations in the fruit and seed characteristics of the examined peach cultivars

In the figure, a = A669, b = Texas Y455, c = Florida King, d = Arctic Fantacy, e = Swanee, f = Spring Creast, g = Micholea.

Table 2: Fruit phenotypic characteristics of the cultivated peach cultivars at Pothohar (Salt range) region of Pakistan

Cultivars	FS	FSh	FOC	RAOC	FGC	FF	FSK	FC	ACF
A669	Lr	E	PR	M	GY	P	P	Y	US
Texas Y455	Lr	M	PR	S	GY	P	P	Y	US
Florida King	Lr	O	OR	Lr	OY	P	P	OY	US
Arctic Fantacy	M	R	DR	Lr	GW	P	A	GW	WF
Spring Creast	M	M	LR	M	GY	P	P	GY	US
Micholea	M	M	DR	Lr	GY	P	P	GW	US
Swanee	M	M	DR	Lr	GY	P	P	GW	A

The bold abbreviation FS = fruit size; FSh = fruit shape; FOC = fruit over color; RAOC= relative area of over color; FGC = fruit ground color; FF = fruit fiber; FSP = fruit shin pubescence; FC = flesh color, ACF = anthocyanin coloration of the flesh and the regular abbreviation Lr = large, M = medium, S = small, E = elliptic, O = Ovate, R = Round, PR = pink red, OR = orange red, DR = dark red, LR = light red, GY = greenish yellow, Y = yellow, OY = orange yellow, GW = greenish white, US = under the skin, WF = whole flesh, P = present, A = absent.

shape etc.) can attract the potential consumers, which boost the market value of the fruits. Additionally, fruit size and shape can also affect the postharvest handling (Cantín *et al.*, 2010). The fruit color, the peel over color and the fruit ground color of the tested cultivars of the peaches were substantially different with Florida King had completely distinct color form all other cultivars (Fig. 4). The area of over color was large in Florida King, Arctic Fantacy, Micholea and Swanee, medium in A669 and Spring Creast and small in Texas Y455. It has been assumed that intensive colored fruits certainly attracts greater number of consumers (Iglesias and Echeverría, 2009). No variation was found in fruit skin pubescence except for Arctic Fantacy, which had no skin pubescence (Table 2).

The color of the fruit flesh exhibited that A669 and Texas Y455 had yellow, whereas Arctic Fantacy, Micholea and Swanee had greenish white color. It was also observed that the flesh color of Arctic Fantacy, Micholea and Swanee was quite homogeneous. On the contrary,

Florida King and Spring Creast had markedly different color compared to the other tested cultivars of the peaches. The observed color for Florida King and Spring Creast were ranged from orange yellow to greenish yellow (Table 2, Fig. 4). The anthocyanin coloration of the cultivars, Arctic Fantacy and Swanee were remarkably different from the rest of the tested cultivars. It was previously reported by Cantín *et al*., (2009) that white-fleshed fruits found to have higher blush percentage as compared to yellow-fleshed fruits. Likewise, high variation has been observed among the tested species regarding the mucron tip, shape of pistil end, stone shape, stone surface and stone size (Table 3). The cultivar Arctic Fantacy was found to be without mucron tip at pistil end, while the other cultivars have well developed mucron tip (Fig. 4).

Table 3: Phenotypic characteristics of fruit stone of the cultivated peach cultivars at Pothohar (Salt range) region of Pakistan

Cultivars	FSA	MTPE	SPE	StSh	StS	StSe/F
A669	CSt	P	Pd	O	Gr	M
Texas Y455	CSt	P	Pd	E	Gr	L
Florida King	CSt	P	Pd	E	Pt and Gr	L
Arctic Fantacy	FSt	A	Dd	O	Pt	M
Spring Creast	CSt	P	Pd	E	Pt and Gr	L
Micholea	FSt	P	Fl	E	Pt and Gr	M
Swanee	FSt	P	Pd	E	Gr	L

The bold abbreviation FSA = flesh to stone adherence; MTPE = murcon tip at pistil end; SPE = shape of pistil end; StSh = stone shape; StS = stone surface; StSe/F = stone size compared to fruit and the regular abbreviation CSt = cling stone, FSt = free stone, P = present, A = absent, Lr = large, M = medium, E = elliptic, O = Ovate, Pd = pointed, Dd = depressed, Fl = flat, Gr = groves, Pt = pits.

Fruit weight is one of the main quantitative inherited traits that might have a role in determining the fruit quality, yield and consumer acceptance. In the presents study, the fruit weight of the tested cultivars was differed by 2.5 folds and was found between 45.6 to 107 g

(Fig. 5A). These results confirmed the previous findings, where high variability was found in fruit weight among different peach (Iglesias and Echeverría, 2009) and apricot accessions (Ruiz and Egea, 2008). Also, the fruit weight of the Texas Y 455 and A669 were heavier than all other cultivars under investigation. The highest fruit weight might be attributed to the maturity of the fruit and harvest date (Lopez and DeJong, 2007). On the contrary, minimum fruit weight was observed in Swanee and Micholea. Previously, it has been observed that flat peaches cultivars had minimum fruit weight, but our results oppose it as there was no flat peach observed in our study (Table 2). Among the studied cultivars of peach significant variability was also noticed in the stone weight (Fig. 5B). Maximum stone weight was observed in Texas Y 455 and minimum stone weight was observed in Micholea. Our results are in agreement with those of Jana (2015), who discovered a significant variation in fruit stone weight of different Indian peach cultivars (i.e. ranged from 1.5 to 7.8 g. We suggested that stone weight can be varied from cultivar to cultivar.

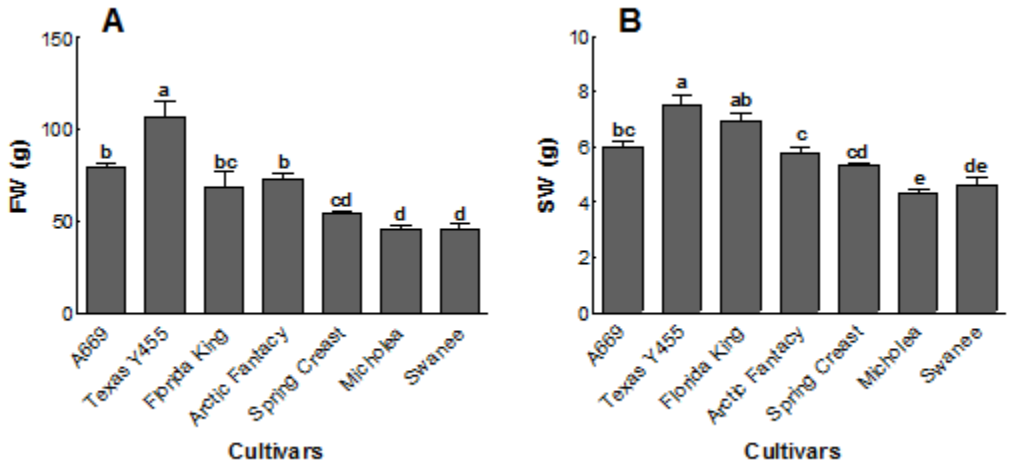


Figure 5: Differences in the leaf weight and seed weight of the studied cultivars of peach

Figure 5A represents the fruit weight (FW), where figure 5B represents the seed weight (SW) of the various tested cultivars of peach that is cultivated in the Pothohar (Salt range) region of Pakistan. Means that were denoted by different letters were significantly different from each other at $p \leq 0.05$.

Biochemical characteristics of peach fruit

Soluble solid content and titratable acidity are also important quality traits, which are closely linked to consumer acceptance and satisfaction. Soluble solid contents and titratable

acidity varied significantly among the tested cultivars, which ranged from 7.17 to 11.27 °Brix and 0.64 to 1.19%, respectively (Fig. 6A & 6B). It was noted that Micholea had the highest soluble solid contents (11.27 °Brix) with lowest titratable acidity (0.64), inversely Texas Y455 had the lowest soluble solid contents (7.17 °Brix) with highest titratable acidity (1.19%). Generally sugar contents are linked to the °Brix of the fruits juice. Moreover, fruit sweetness and sugar contents are strictly interlinked but widely controlled by the acidity and flavor of the fruit that acts as an antagonist (Crisosto *et al.*, 2006). Similarly, significant variations in the ripening index of the fruit and acidity of the fruit juice of various peach cultivars were recorded, which ranged from 6.02 to 17.2 (Fig. 6C). The highest ripening index was recorded in Micholea with low titratable acidity and high soluble solid contents, whereas Texas Y455 had the lowest ripening, titratable acidity and TSS. In past significant variations were discovered in fruit quality indices, such as SSC and titratable acidity in different fruit cultivars (Tavarini *et al.*, 2008). In this study, except Texas Y455, the values for titratable acidity were lower than 0.9%, which is considered as a threshold for the normal acidity in peaches (Hilaire, 2003). Fathi et al. (2013) has also reported interlinks between low ripening index, high titratable acidity and low soluble solid contents. It was formerly reported that titratable acidity can play a significant role in consumer acceptance of new cherries (Fathi and Ramazani, 2007). Likewise, a huge deviation has been noted among the explored peach cultivars in sugar contents (Fig. 6D). Total sugars, reducing sugars and non-reducing sugars in peach fruit ranged from 13.52 to 18.54%, 5.68 to 8.63% and 4.12 to 10.77%, respectively. Colaric *et al.*, (2005) reported that total sugar contents of peaches and nectarines are highly related to aroma and taste and consider very important quality trait in fruit breeding programs. It was reported that variations in the sugar contents might be dependent on genotypic and/or year of production, variation among trees and fruits on the same tree (Quilot *et al.*, 2004).

Vitamin C content, expressed in mg $100g^{-1}$ (Fig. 7A) was statistically significantly different for the available cultivars of peaches. The ascorbic acid contents of the fruits were laid between 75.3 to 116.1 mg $100g^{-1}$. The results thus indicated that the peach is a good source of vitamin C and highlight the fact that ascorbic acid can reflects on the overall quality of the peach fruit. The ascorbic acid contents were previously evaluated in 218 peach genotypes from different progenies that differed significantly (Cantin *et al.*, 2009).

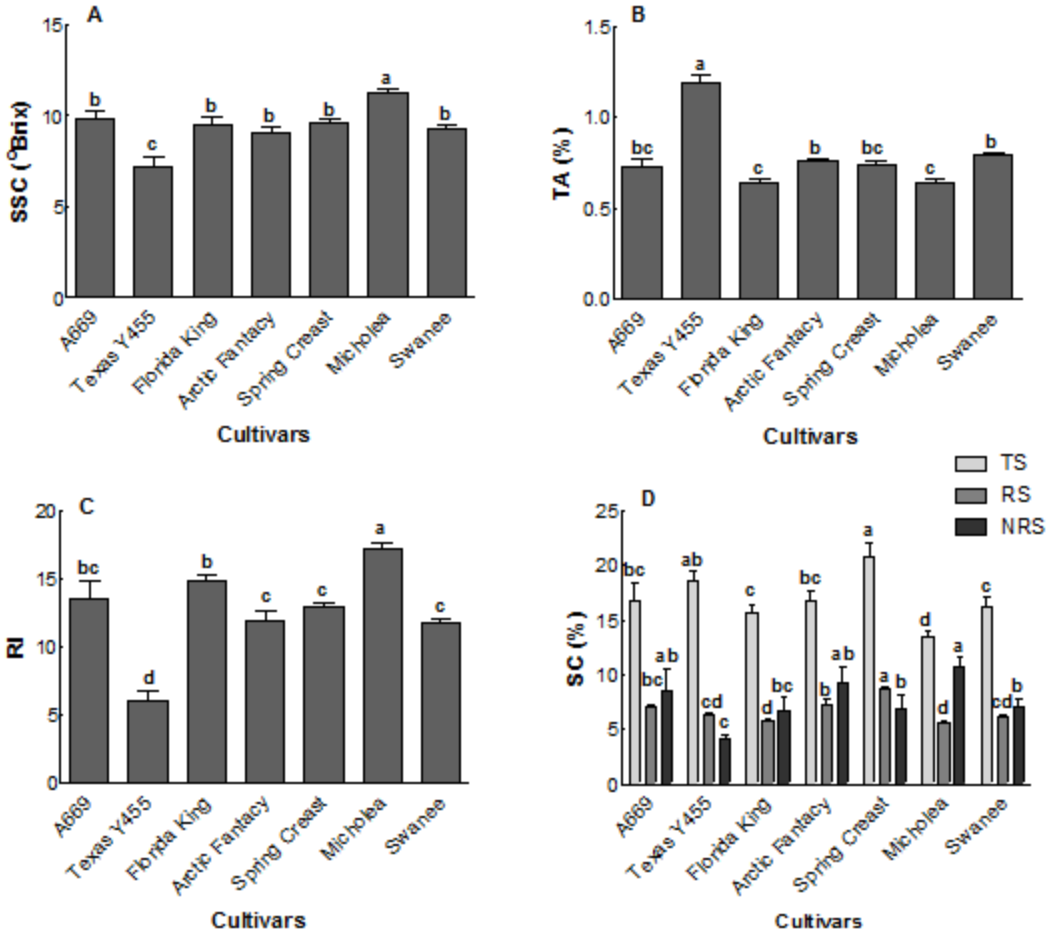


Figure 6: Disparities in Soluble solid contents, titratable acidity, ripening index and sugar contents of the analysed cultivars of peach

Figure 6A represents the soluble solid contents (SSC), figure 6B represents the titratable acidity (TA), Figure 6C represents the ripening index (RI) and Figure 6D represents the sugar contents (SC) of the various tested cultivars of peach that is cultivated in the Pothohar (Salt range) region of Pakistan. Means that were denoted by different letters were significantly different from each other at $p \leq 0.05$.

Antioxidant activity

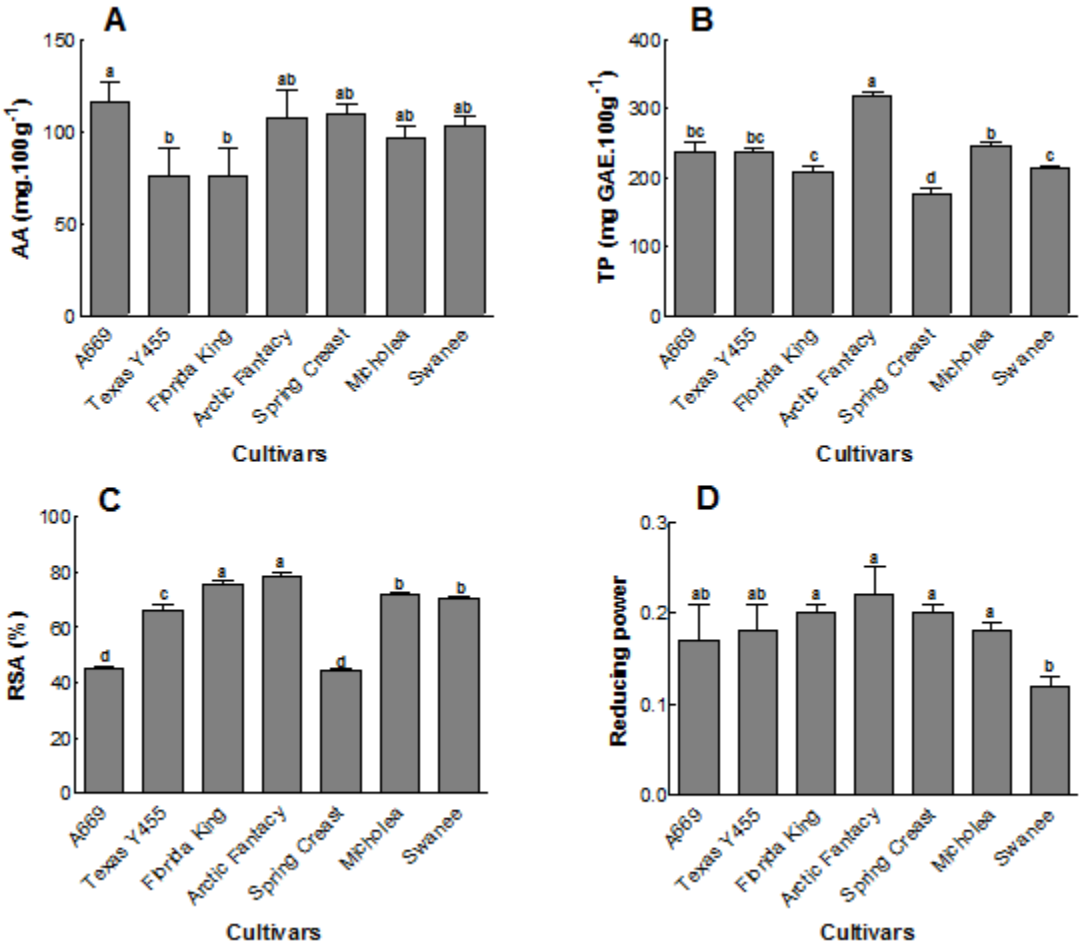
A significant variation in total phenolic contents, radical scavenging activity and reducing power was observed in our study (Fig. 7). Highest phenolic contents (317.72 mg GAE $100g^{-1}$), radical scavenging activity (78.17%) and reducing power (0.22%) was recorded in Arctic Fantacy. The lowest phenolic contents (176.20 mg GAE $100g^{-1}$) and radical scavenging activity (44.25%) was found in Spring Creast, whereas the lowest reducing power was spotted in Swanee

(0.12%). Furthermore, Fig. 7 also represents the reductive capability of peach varieties that was ranged from 0.12 ± 0.1 to 0.22 ± 0.03. The highest reducing power was exhibited by Arctic Fantacy and the lowest by Swanee. Radical scavenging activity can be measured with the help of DPPH, which have a deep violet color due to a steady free radical. After accepting the hydrogen atom from the antioxidant the violet color of DPPH is reduced to a pale yellow, which indicates the presence of the antioxidants. Lee et al. (2003) reported that in the evaluation of an antioxidant potential of samples, the use of a scavenging stable DPPH radical is highly reliable. Generally, highly reduced DPPH reflects on higher radical scavenging activity that can be associated to the superior antioxidant activity of the sample (Ghafar *et al.*, 2010). Valero and Serrano (2010) has stated that the fruit nutritional composition including bioactive compounds can be affected by agricultural factors and climatic conditions. However, in our study all the cultivars were grown under same cultural practices and environmental conditions, therefore, variations in fruit quality characters and bioactive compound may be linked to the varietal differences. A higher difference in total phenolic contents and antioxidant activity was reported by Hegedús *et al*., (2011) among a wide range of apricot genotypes grown under same environmental conditions. Similarly, Cantín *et al*., (2009) has recorded a huge genotypic influence on antioxidant activity of the fruits. In this study, Arctic Fantacy variety showed highest total phenolic contents with high radial scavenging activity. The reducing power of the fruit can also be dependent on the presence of the antioxidants, higher the amounts of antioxidants the better is the reducing power of the fruit. Phenolics are one of the best antioxidants that can break the free radical chains by donating their protons. Regarding human health phenolic compounds are considered to be beneficial as an antioxidant, anticancer, anti-inflammatory and immune-stimulating agents (Gao *et al.*, 2013). Especially, polyphenols form fruit extracts can be vital in controlling the incidence of colon cancer (Eid *et al.*, 2014).

Correlation between quality traits

The correlation between pomological traits is summarized in table 4. Fruit weight was negatively correlated with the soluble solid contents, ripening index, while positively correlated with the titratable acidity. In addition, soluble solid contents was significantly correlated with titratable acidity, ripening index and non-reducing sugars. The titratable acidity showed a higher negative correlation with ripening index and non-reducing sugars. This indicated that the fruits ripening index increases with a decrease in the acidity. Moreover, a positively significant

354 correlation was also found between total sugars and reducing sugars. Similar results concerning
355 the correlation among the various quality traits was found by Abidi et al. (2011), when they
356 studied the parental lines and progenies of the nectarine.
357



358
359 **Figure 7:** Variations in ascorbic acid, total phenolic contents, radical scavenging activity and
360 reducing power of the analysed cultivars of peach
361 Figure 7A represents the Amino acid contents (AA), figure 7B represents the total phenolic contents
362 (TP), figure 7C represents radical scavenging activity (RSA) and figure 7D represents reducing power
363 (RP) of the various tested cultivars of peach that is cultivated in the Pothohar (Salt range) region of
364 Pakistan. Means that were denoted by different letters were significantly different from each other at
365 $p \leq 0.05$.

366

Table 4: Correlation coefficient (r) between quality traits of the selected peach cultivars from the Pothohar (Salt range) region of Pakistan

Fruit traits	FW	SSC	TA	RI	AA	TS	RS	NRS	RSA	TPC	RS
FW	1										
SSC	-0.774*	1									
TA	0.754*	-0.883**	1								
RI	-0.735*	0.967**	-0.950**	1							
AA	-0.415	0.434	-0.403	0.305	1						
TS	0.314	-0.554	0.453	-0.571	0.162	1					
RS	-0.035	-0.096	-0.001	-0.140	0.620	0.818*	1				
NRS	-0.592	0.855**	-0.744*	0.797*	0.558	-0.622	-0.068	1			
RSA	-0.054	-0.080	-0.017	0.014	-0.529	-0.620	-0.670	0.121	1		
TPC	0.257	-0.074	0.059	-0.082	0.1253	-0.387	-0.156	0.436	0.528	1	
RP	0.282	-0.0z31	-0.126	0.095	-0.105	0.187	0.340	0.115	0.070	0.350	1

'*' represents significance at $p \leq 0.05$; '**' represents significance at $p \leq 0.01$.

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