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ANTIOXIDANT ACTIVITY, SUGAR QUANTIFICATION, AND PHYTOCHEMICAL AND PHYSICAL PROFILING OF APRICOT VARIETIES OF CHITRAL AND GILGIT - PAKISTAN

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Abstract

Apricot is highly appreciated fruit worldwide. Pakistan is a 6th major producer of apricot in the world. In Pakistan, the apricot is found in Gilgit, Sakardu, Swat, Chitral and Balochistan Province. In our study, twenty six different varietiess of apricot were taken to explore their nutritional diversification. Physical properties were determined following the descriptor of apricot. Major sugars (Fructose and Glucose) were quantified through HPLC. Total phenolics, flavonoids, ascorbic acid, antioxidant activity, anthocyanin and carotenoids were analyzed using a micro plate reader (Bio Tek, USA). Bradford and Deming method was used to estimate total proteins and antioxidant enzymes (SOD, POD, CAT), respectively. The data related to physical traits showed variation in weight, size, shape and color. High-performance liquid chromatography (HPLC) analysis depicted that the range of fructose and glucose was 1.71 to 40.79 and 1.59 to 44.53 mg/100g, respectively. In phytochemical panel, antioxidant activity (45.69-90.45%), total phenolic contents (2094.4-6411.5 mg GAE/100g), ascorbic acid (69.22-91.20 mg/100g), anthocyanins (0.06-2.01 mg/100g) and total flavonoids (13.65-46.33 mg CAE/g) showed varying concentrations among examined apricot varieties. Further investigations of antioxidant enzymes (SOD, POD and CAT) and soluble protein contents revealed plenty of variations in their final values. Our results regarding different biochemical analysis revealed that the variation in these biochemical characteristics is totally dependent of variety type and geographical region. It was concluded that the varieties under analysis from Northern Pakistan are highly nutritive and beneficial for human health.

Key words: Diversification, Flavonoids, Fructose, Glucose, HPLC, Nutritive, Pomology.

Introduction

Apricot (*Prunus armeniaca* L.), the temperate gold of Pakistan; is the 3rd widely cultivated stone fruit of the world (Aubert & Chanforan, 2007). It is originated from China and Central Asia (Yuan *et al*., 2007). Apricots are generally grown for their valuable fruit consumed fresh, dried and in processed form. Various biological complexes such as antioxidants (ascorbic acid, phenolics, flavonoids and tannins), antioxidative enzymes (SOD, POD, CAT), carotenoids and tocopherols (Erdogan-Orhan & Kartal, 2011). Thus, apricot fruit possess this antioxidant ability along with other natural compounds such as, vitamins, minerals, starch, fats, and dietary fibers (Akin *et al*., 2008; Milosevic *et al*., 2012; Ali *et al*., 2014).

Pakistan is the 6th main apricot producing country after Turkey, Uzbekistan, Italy, Algeria and Iran with an annual production of 178957 tonnes (Anon., 2017). In Pakistan, most important zones of apricot production are Khyber Pakhtunkhwa (Swat and Chitral), Gilgit Baltistan, Sakardu and Balochistan (Killah Abdullah, Killah Saifullah and Loralai) (Jasra & Rafi, 2002). However, there is contradiction, but there may exist (Hussain, 1994) or 180 (Thompson, 1993) reported cultivars of apricots, i.e. Karfochuli, Sharakarfa, Halmon and Shah kanda are among most important cultivars in Chitral and Northern regions of Pakistan. These cultivars have unique characteristics, containing specific color; aroma and taste. The number of apricot trees in Northern Pakistan are 1.8 million and about 62% area among the total fruit crops area is covered by apricot trees (Anon., 2008).

The fruit of apricot is climacteric, and it ripens even after harvest. Due to climacteric nature ethylene production is more in apricot fruit and it starts ripening fast. Therefore, its flesh becomes soft and complete senescence of fruit occurs. The activity of enzymes increases due to ethyle production and respiration resulting in soft fruit texture (Egea *et al*., 2007). Breakdown of tissues causes release of antioxidants like carotenoids, phenolics, ascorbic acid and enzymes assembled within fruit cells. The quantity of phenolics reduces with the increase in enzymatic activity because they are operated as a substrate by enzyme system and respiration process (De Rigal *et al*., 2000).

The existence of natural compounds such as sugar contents, phenolics, organic acids, flavonoids and ascorbic acid play important role in determining the nutritive value and fruit quality (Caliskan *et al*., 2012). Although abundant work on apricot have been done, previously by many scientists in the world (Akin *et al*., 2008; Martinic *et al*., 2011; Haciseferogullari *et al*., 2007), but the antioxidant properties are not explored in a broader sense in apricot fruits from Pakistan. Therefore, present study was designed to organize an extensive

research work to examine the complete composition of phytochemicals fluctuating within cultivars through different biochemical and physical analyses to characterize and identify the varieties which are highly nutritive and marketable.

Materials and Methods:

Plant materials: Eighteen varieties from Chitral and eight from Gilgit were included in study (Table 1). Fruits were harvested at horticultural maturity (Fig. 1). About twenty fruits of each variety were chosen, sorted and preserved for uniformity in color, defects and size. Fruits were grinded due to perishable nature, extract were prepared and stored at -80°C before analysis.

Chemicals and reagents: Analytical grade chemicals purchased from Merck, Fluka Riedel-de-Haen and Sigma were used for these investigates.

Physical properties: Following physical parameters fruit and pit weight with electrical weighing balance, length and width of fruit and seed and flesh thickness was measured using digital vernier calliper. Fruit skin color and fruit and seed shapes were identified using the descriptors for apricot (*prunus arminiaca* L.) characterization (Guerriero & Watkins, 1984) as standard.

Estimation of sugars by high performance liquid chromatography: HPLC was used for sugars analysis following Haider *et al*., (2014). Identified sugars were computed based on standards i.e., glucose (2%), fructose (2%) and sucrose (2%). Every sample was passed out from investigated peak areas of the sample against the corresponding standard graph. Results were presented in (g/100g).

Antioxidant activity (%) determination: Antioxidant activity of different apricot fruit was assessed by DPPH radical scavenging method as described by Haider *et al*., (2018). 50 µL from the above methanol extract was added to the 0.004 % DPPH solution. Reading was observed at 517 nm after 30 minutes incubation at room temperature. Blank was made containing the same amount of DPPH and methanol. Radical scavenging activity was measured as percent (%) inhibition of free radicals by DPPH by following way:

$$\text{Inhibition \%} = (A_{\text{blank}} - A_{\text{sample}} / A_{\text{blank}}) \times 100$$

wehere A_{blank} and A_{sample} is the absorbance value of control sample (without fruit extract) and fruit sample, respectively.

Estimation of total phenolic contents: Folin-Ciocalteu reagent method following (Ali *et al*., (2011) was used to estimate TPC in apricot fruit. Fruit extract of 1 mL along with 0.5 mL FC reagent was mixed and kept for 5 minutes in a test tube and then Na_2CO_3 solution (7.5%) was added into it and final volume was made. About 200 µL from the above solution was taken in 96 well plate and were read at 765 nm absorbance. A standard curve using different concentrations of gallic acid was drawn and results were given to gallic acid equivalent.

Table 1. List of Apricot varieties along with site of collection and GPS coordinates.

S. No.	Variety Name	Collection site	Latitude (N)	Longitude (E)
		Chitral		
1.	Muzhaki	Kosht (Mulkho)	36° 24′ 47″	072° 15′ 45″
2.	Afghani		36° 25′ 98″	072° 25′ 78″
3.	Mehteri		36° 25′ 98″	072° 25′ 78″
4.	Qazafi	Green Lasht (Charun)	36°14′ 15″	072° 08′ 16″
5.	Mirza Bibi		36° 14′ 15″	072° 08′ 16″
6.	Mashetar		36° 14′ 21″	072° 08′ 48″
7.	Lotovier Selection		36° 13′ 81″	072° 07′ 65″
8.	Gilgit Selection		36° 13′ 83″	072° 07′ 62″
9.	Green Lasht-08		36° 13′ 83″	072° 07′ 62″
10.	Kuragh-01	Kuragh (Charun)	36° 21′ 69″	072° 16′ 41″
11.	Eikot		36° 21′70″	072° 16′ 41″
12.	Begali		36° 21′ 79″	072° 16′ 51″
13.	Lootdoor-01	Lotdoor (Booni)	36° 26′ 40″	072° 26′ 87″
14.	Mirza Bagi		36° 26′ 40″	072° 26′ 87″
15.	Qazaki	Reshun (Booni)	36° 15′ 95″	072° 15′ 78″
16.	Meken		36° 15′ 79″	072° 16′ 10″
17.	Sheghnian		36° 15′ 59″	072° 16′ 13″
18.	Mulkho-01	Mulkho (Warijun)	36° 30′ 16″	072° 22′ 22″
		Gilgit		
19.	Pissan-01	Pissan (Nagar)	36° 04′ 26″	074° 25′ 55″
20.	Habi Ju-02	Sayan (Nagar)	36° 02′ 12″	074° 26′ 56″
21.	Hunza-01	Hunza (Nagar)	36° 06′ 18″	074° 28′ 53″
22.	Hunza-02		36° 06′ 32″	074° 28′ 53″
23.	Hunza-03		36° 06′ 32″	074° 28′ 53″
24.	Hunza-04		36° 06′ 32″	074° 28′ 53″
25.	Hunza-05		36° 08′ 87″	074° 28′ 73″
26.	Sufaid Khobani	Nomal (Gilgit)	36° 07′ 34″	074° 28′ 19″

Fig. 1. Fruit pics of different varieties of apricot from Gilgit and Chitral.

Determination of vitamin-C contents: 2,6-Dichlorophenol Indophenol (DCIP) was used for quantification of ascorbic acid (Ali *et al*., 2014). For the estimation of Vitamin C 900 µL sample extract, 1 mL DCIP and 100 µL of Meta phosphoric acid were mixed and solution absorbance was read at 520 nm. Results obtained were presented as mg/100 of fruit weight (FW).

Quantification of total flavonoids: Total flavonoids were quantified according to the method of Sharma *et al*., (2014). About 1 mL fruit extract was mixed with 5 mL distilled water and 5 % $NaNO_2$ solution (35 µL) and incubated for 6minutes. After that 35 µL $AlCl_3$ (10%) was added and 5 minutes later 2 mL, 1 molar NaOH was added. Sample was diluted by adding 2 mL distilled water and 200 µL solutions was taken in 96 well plate to read absorbance at 510 nm.

Determination of total anthocyanins: Total anthocyanins were assessed by the difference in pH of reaction solutions following (Lee *et al*., 2005). 2 different buffer solutions i.e., Buffer 1 (prepared by mixing 0.2 N HCL and 1.49 g KCL/100 ml water with 67:25 ratio and pH was adjusted to 1.00) and Buffer 2 (1.64 g CH3COONa /100 mL water having 4.5 pH) were prepared and anthocyanin extraction was done by grinding 1 g of apricot fruit in 5 ml distilled water. 500 µL of sample was transferred in 25 mL flask and then 12.5 mL buffer (pH 1.0) was added. 500 µL of sample was also mixed in 12.5 mL buffer (pH 4.5). Absorbance of both solutions was taken at 510 nm and 700 nm. Calculation of absorbance was done as:

$$Ab = pH: 1.0\ (A510nm - A700nm) - pH: 4.5\ (A510nm - A700nm).$$

The equation used for results calculation is;

$$\text{Total anthocyanins (mg/100 g)} = Ab/eL \times MW \times D \times V/G \times 100$$

The results were presented as mg of cyanidin 3-glucoside equivalents/100 g of fruit weight.

where; Ab represents absorbance, *e* is molar absorbance of cyanidin 3-glucoside i.e., 26900, *L* describes the length of cell path (1 cm), MW is the molar weight of anthocyanins (449.2), D, V and G are a dilution factor, final volume (mL) and weight of sample (mg), respectively.

Estimation of total carotenoid contents: Total carotenoid contents were quantified by following method of Rodriguez-Amaya, (1999). Methanol and petroleum ether (100 ml) with ratio of 1 and 9 was taken and then 5 g of fruit was homogenized in it and shifted to a funnel in which filtration of Petroleum ether layer was done using sodium sulphate. Total carotenoids were read at wave length of 450 nm. A standard curve of known concentration of β -carotene was drawn and results were demonstrated as mg/100 g β -carotene equivalents FW.

Activity of enzymes i.e. catalase, peroxidase and superoxide dismutase: Specific activity of enzymes was determined as methods described by Naqvi *et al*., (2011) and Haider *et al*., (2014). Activity of CAT (240 nm) and POD (470 nm) was observed. Whereas, the activity of SOD was observed at 560 nm.

Total soluble protein: The assessment of total soluble protein contents was carried out following Bradford method (Bradford, 1976). Fruit extract (50µL) was mixed with Bradford reagent (2 mL). Absorbance of sample and blank (Bradford reagent only) was observed at 595 nm. A standard curve was prepared using different concentrations of bovine serum albumin (BSA) and results were presented as mg/100 of FW.

Statistical analyses

The experimental data was analyzed statistically using complete randomized design (CRD). LSD test was applied with 5 % level of significance to compare means.

Results

Physical properties: Analysis of variance revealed that all qualitative and quantitative characters such as fruit length, width and weight, fruit shape and color, seed length and width, seed shape, pit weight and flesh thickness were significantly different from each other as shown in (Table 2). The variety Mirza bibi had maximum fruit length (49.51 mm) and seed length (33.07 mm), while maximum fruit width (41.26 mm) and fruit weight (39.80 g) was recorded in Muzhaki. Maximum flesh thickness (12.39 mm), pit weight (3.36 g) and seed width (19.033 mm) was recorded in Pissan-01, Qazaki and Qazafi respectively, suggesting these are the prime varieties.

Estimation of sugars by high performance liquid chromatography: Analysis of variance of major sugars (glucose and fructose); the significant differences (p<0.05) were observed among all the selected apricot varieties. The data illustrated that the contents of fructose and glucose were in the range of 1.71 to 40.79 and 1.59 to 44.53 mg/100g respectively. The highest contents of fructose and glucose was recorded in Qazafi (40.79 and 44.53 mg/100g) and lowest in Gilgit selection (1.71 and 1.59 mg/100 g) respectively (Table 3).

Phytochemicals

Antioxidant activity: Antioxidant activity as determined by DPPH assay revealed significant differences at p<0.05 significance level among all the tested varieties as shown in table 3. Generally, the antioxidant activity of all examined varieties ranged 45.69% to 90.45%. Highest activity was found in Mehteri (90.45%) and lowest was recorded in Green Lasht-08 (45.69%).

Total phenolic contents: Determination of TPC in all varieties revealed significantly different (at p<0.05 level of significance) results. The total phenolic contents assessed were found in a range between 2096.4 to 6411.5 mg GAE/ 100 g (Table 3). Pissan-01 possessed highest phenolics (6411.5 mg GAE/ 100 g) while lowest phenolic were detected in Lotovier selection (2096.4 mg GAE/ 100 g).

Vitamin C: The results obtained for Vitamin C contents of tested varieties were significant (p<0.05) and exist in the range of 69.22 to 91.20 mg/100g on dry weight basis (Table 3). Hunza-05 showed highest (69.22 mg/100g) and Qazaki showed lowest (69.22 mg/100g) ascorbic acid contents among all the inspected varieties.

Total flavonoid contents: The results of total flavonoid contents were presented as mg catechin equivalent/100g on the basis of dry weight (Table 3). Sheghnian excelled the rest of the varieties and showed highest value of flavonoids (46.33 mg CE/100g) while Lotovier selection (13.65 mg CE/100g) registered minimum amount.

The anthocyanin contents: The anthocyanin in tested apricot cultivars were in the range of 0.1467 to 2.0967 mg/100g (Table 3). The results were variable at p<0.05 among all the varieties from Gilgit and Chitral. The anthocyanin contents were higher in Begali (2.0967 mg/100g) and tiniest in Hunza-01 (0.1467 mg/ 100g).

Total carotenoids: Total carotenoids contents were evaluated based on mg/100 g of β- carotene equivalents. Total carotenoid contents assed existed in the assortment of 4.69 to 100.89 mg/100 g among the varieties (Table 3). Highest quantity of carotenoid contents was found in Gilgit selection (100.89 mg/100 g FW) followed by Hunza-02 (98.02 mg/100 g FW), Muzhaki (89.58 mg/100 g FW) and lowest in (4.75 mg/100 g FW).

Assessment of specific activity of antioxidant enzymes: The specific activity of antioxidant enzymes i.e. superoxidase dismutase (SOD), peroxidase (POD) and catalase (CAT) was statistically difference at $p\leq0.05$ among all the varieties (Table 4). The results obtained for the specific activity of CAT were in the range of 4.04 to 48.36 IU/mg of protein. Specific activity of POD was variable among all the tested varieties of apricot fruits. The highest POD enzyme activity was recorded in Sufaid khobani (1.93 IU/mg of protein) and lowest in Mirza bagi (0.24 IU/mg of protein). The results obtained for Superoxide dismutase (SOD) were in the range of 4.02 to 36.43 mg/g of fruit weight.

Soluble protein contents: The results regarding protein were variable among all the apricot varieties of Northern areas. Mulkho-01 showed maximum protein contents (23.42 mg protein /100 g FW) among all the tested cultivars. Total protein contents were in the range of 1.56 to 23.42 mg/100g. The results of soluble protein contents were expressed as mg/100 g of fruit weight (Table 4).

Table 2. Physical characteristics of different twenty six apricot cultivars.

Variety name	Fruit color	Fruit shape	Seed shape	Fruit weight (g)	Pit weight (g)	Fruit length (mm)	Fruit width (mm)	Flesh thickness (mm)	Seed length (mm)	Seed width (mm)
Muzhaki	greenish white	round flat	Ovate	39.80 ± 0.73a	2.48 ± 0.14b	38.45 ± 3.04 bcde	41.26 ± 2.64 a	10.21 ± 0.93 cde	23.79 ± 0.07 hij	17.77 ± 0.50 cde
Afghani	green	oblong	oblong	25.25 ± 1.65g	1.92 ± 0.07efg	36.50 ± 1.40 def	32.32 ± 0.69 jkl	10.31 ± 0.54 cd	23.92 ± 0.15 hij	17.49 ± 0.63 def
Mehteri	greenish white	ovate	round	20.56 ± 0.58jk	2.18 ± 0.08cd	34.96 ± 1.03 defg	31.77 ± 0.26 klm	9.30 ± 0.62 efgh	24.28 ± 0.66 ghij	16.41 ± 0.67 gh
Qazafi	orange	oblong	oblong	20.13 ± 0.71 kl	2.29 ± 0.06bc	44.10 ± 2.07ab	39.58 ± 2.63 abc	8.49 ± 0.39 hi	27.58 ± 1.70 cd	19.03 ± 1.03 a
Mirza Bibi	orange	oblong	Ovate	23.69 ± 0.54hi	1.86 ± 0.08 gh	49.51 ± 0.29 a	36.88 ± 0.17 defgh	9.13 ± 0.98fghi	33.07 ± 2.83 a	18.17± 0.49 abcd
Mashetar	red	obovate	round flat	12.33 ± 0.10m	1.63 ± 0.07ij	29.50 ± 1.94 gh	29.36 ± 2.38 m	5.84 ± 0.77 n	18.67 ± 0.51 n	14.73 ± 0.44 j
Lotovier Selection	yellow	triangular	oblong	26.31 ± 0.55fg	2.10 ± 0.07cde	40.91 ± 0.89bcd	31.63 ± 0.68klm	8.63 ± 0.06 ghi	29.97 ± 0.51 b	17.11 ± 0.36 efg
Gilgit Selection	yellow	ovate	oblong	22.27 ± 0.71 hi	2.07 ± 0.20def	39.02 ± 1.20 bcde	31.86 ± 0.75 klm	8.21 ± 0.32 ij	27.58 ± 0.51 cd	15.33 ± 0.24 ij
Green Lasht-08	lite yellow	ovate	oblong	32.0 ± 0.82cd	2.18 ± 0.08cd	23.58 ± 3.48h	37.84 ± 1.12 bcdef	10.75 ± 0.44 bc	26.86 0.33 de	17.28 ± 0.22defg
Kuragh-01	greenish white	round flat	oblong	18.96 ± 0.42 l	1.88 ± 0.08fg	30.09 ± 0.11fgh	29.94 ± 0.60lm	8.49 ± 0.56 hi	21.09 ± 0.13 lm	14.86 ± 0.32 ij
Eikot	orange	round flat	oblong	23.60 ± 0.49 h	2.07 ± 0.06def	24.11± 1.72 h	24.92 ± 0.67 n	6.25 ± 0.34mn	18.68 ± 1.25 n	14.51 ± 0.70 j
Begali	yellow	ovate	round	27.05 ± 0.81f	2.25 ± 0.08cd	40.22 ± 1.66 bcde	38.74 ± 0.89 abcde	11.02 ± 0.90 bc	26.21 ± 1.24 defg	18.05±0.40abcde
Lootdoor-01	lite yellow	round flat	oblong	33.02 ± 0.47 c	2.23 ± 0.10 cd	39.64 ± 0.67 bcde	39.35 ± 0.65 abcd	11.66 ± 0.38 ab	22.96 ± 0.57 jkl	17.10 ± 0.01 efg
Mirza Bagi	yellow	round	round	23.69 ± 0.74h	1.75 ± 0.16ghi	39.66 ± 0.04 bcde	31.59 ± 0.27 klm	9.75 ± 0.09 def	29.61 ± 0.86 b	15.81 ±0.03 hi
Qazaki	green	triangular	round	38.28 0.85 a	3.36 ± 0.22a	38.29 ± 0.33 bcde	40.16 ± 0.04 ab	10.16 ± 0.60 cde	26.41 ± 1.89 def	17.96 ±0.38 bcde
Meken	yellow	round	round	12.93 ± 0.14m	1.75± 0.11 ghi	28.95 ± 0.93gh	31.17 ± 1.19 klm	6.87 ± 0.27 klm	20.25 ± 0.78 mn	16.49 ± 0.52 fgh
Sheghnian	red	oblong	round	29.17 ± 0.54 e	1.50 ± 0.07 j	34.96 ± 1.16 defg	33.62 ± 0.24ijk	8.95 ± 0.34 fghi	21.61 ± 0.07 klm	15.10 ± 0.05 ij
Mulkho-01	green	oblong	round	21.85 ± 0.86 ij	1.02 ± 0.04k	43.66 ± 2.56 abc	35.45 ± 3.17 fghi	9.51 ± 0.07 defg	29.51 ± 0.97 bc	17.48 0.090 def
Pissan-01	orange	round	round	31.67 ± 0.74cd	2.29 0.06 bc	37.25 ± 2.48 cde	37.37 ± 2.23 cdefg	12.39 ± 0.37 a	24.61 ± 1.03 fghij	17.75 0.70 cde
Habi Ju-02	green	round flat	round	20.50 ± 0.86jk	2.08 ± 0.11de	38.54 ± 0.86 bcde	34.77 ± 0.63 ghij	7.32 ± 0.42 jk	23.18 ± 0.61 ijk	17.59 0.76 de
Hunza-01	green	triangular	round	23.01 ± 0.80 hi	1.92 ± 0.02efg	37.58 ± 0.89 bcde	36.33 ± 0.04 efgh	7.25 ± 0.05 jkl	24.92 ± 0.36efghi	17.73 ± 0.30 cde
Hunza-02	yellow	round	round	34.58 ± 0.59 b	1.68 ± 0.08hij	38.10 ± 1.24 bcde	37.47 ± 1.02 cdef	8.86 ± 0.15 fghi	24.10 ± 0.32 hij	19.01 ± 0.39 a
Hunza-03	yellow	Flat	round	31.44 ± 0.84d	2.13 ± 0.05 cd	33.93 ± 0.33 efg	31.42 ± 0.62 klm	6.27 ± 0.21 lmn	25.17 ± 0.13 efgh	15.85± 0.12 hi
Hunza-04	white	ovate	round	29.83 ± 0.89e	1.73 ± 0.08ghi	36.92 ± 0.47 de	34.77 ± 0.63 ghij	7.32 ± 0.42 jk	23.18 ± 0.61 ijk	17.73 ± 0.74 cde
Hunza-05	yellow	Flat	round	35.66 ± 0.92 b	1.57 ± 0.07 ij	33.76 ± 0.41 efg	36.33 ± 0.04 efgh	8.71 ± 0.09 ghi	25.39 ± 0.06 efgh	18.87 ± 0.44 ab
Sufaid Khobaani	white	oblong	oblong	27.61 ± 0.97f	2.16 ± 0.05 cd	36.19 ± 1.27 def	34.61± 0.85 hij	9.45 ± 0.55 defgh	26.81 0.93 de	18.66 ± 0.33 abc

All the values are means of three replications +SD

Values with same letters are not statistically different at alpha 0.05

Table 3. Glucose, fructose, antioxidant activity, total phenolic contents, ascorbic acid, total flavonoids total anthocyanin and total carotenoids of different twenty six apricot cultivars.

Variety Name	Glucose (mg/100g)	Fructose (mg/100g)	AoA (%)	TPC (mg GAE/100g)[a]	AA (mg/100g)[a]	TFC (mg CE/g)[a]	TA (mg/100g)[a]	TC (mg/100g ß-carotene)[a]
Muzhaki	6.75 ± 1.05 l	12.26 ± 1.04 h	55.58 ± 0.55 l	5187.3 ± 44.54 bc	79.76 ±0.43 ef	15.91 ± 2.03 kl	0.073 ± 0.04 ef	89.58 ± 1.42 bc
Afghani	3.42 ± 0.02 m	8.33 ± 0.02 jk	59.56 ± 0.70 k	2096.4 ± 29.69 p	89.01 ± 0.17 b	44.90 ± 1.59 a	0.203 ± 0.16 cdef	24.37 ± 0.59 i
Mehteri	13.27 ± 0.05 i	4.66 ± 0.03 l	64.50 ± 0.96 i	6351 ± 59.38 a	74.27 ± 0.15 mno	34.58 ± 1.99 b	0.197 ± 0.05 cdef	49.76 ± 1.53 ef
Qazafi	44.53 ± 0.05 a	40.79 ± 0.03 a	75.32 ± 0.78 d	5084.2 ± 197.69 c	78.58 ± 0.98 fgh	33.98 ± 1.71 b	0.120 ± 0.04 ef	40.17 ± 0.77 gh
Mirza bibi	20.67 ± 0.01 g	31.02 ± 0.04 d	69.21 ± 0.62 g	5272.1 ± 115.31 b	81.29 ± 0.11 d	20.56 ± 1.67 hij	0.393 ± 0.18 c	67.40 ± 1.07 d
Mashetar	3.95 ± 0.02 m	7.60 ± 0.02 k	63.44 ± 0.46 j	3096.4 ± 14.53 ijk	69.22 ±1.24 q	28.84 ± 1.84 c	0.060 ± 0.05 f	11.82 ± 0.54 jk
Lotovier selection	10.44 ± 0.02 jk	5.24 ± 0.02 l	70.44 ± 1.14 f	3241.8 ± 44.54 hi	78.35 ± 1 ghi	13.65 ± 2.43 l	0.190 ± 0.07 def	36.46 ± 0.69 h
Gilgit selection	1.59 ± 0.02 n	1.71 ± 0.01 n	58.91 ± 0.81 k	2932.7 ± 29.69 kl	76.24 ± 0.16 kl	18.86 ± 1.79 ijk	0.220 ± 0.11 cdef	100.89 ± 0.09 a
Green Lasht-08	14.45 ± 0.02 i	15.69 ± 0.02 g	45.29 ± 0.82 o	2860 ± 112.08 lm	72.72 ± 0.61 p	24.68 ± 1.97 def	0.137 ± 0.06 ef	88.47 ± 1.02 bc
Kuragh-01	22.63 ± 0.04 ef	12.09 ± 0.01 hi	55.20 ± 0.35 lm	2744.8 ± 52.14 mn	77.61 ±0.32 hij	20.14 ± 1.81 hij	0.373 ± 0.11 cd	24.67 ± 0.79 i
Eikot	27.93 ± 0.03 d	30.26 ± 0.02 d	76.35 ± 0.48 d	5060 ± 107.05 cd	74.44 ± 0.02 mn	27.84 ± 1.62 cd	0.090 ± 0.04 ef	17.59 ± 1.22 ij
Begali	21.24 ± 0.02 fg	30.22 ± 0.03 d	62.55 ± 0.35 j	3387.3 ± 74.22 h	77.73 ± 0.06 hi	16.97 ± 1.94 jkl	2.097 ± 0.09 a	20.19 ± 0.66 ij
Lootdoor-01	24.24 ± 0.07 e	30.20 ± 0.09 d	51.70 ± 0.32 n	2496.4 ± 14.84 o	76.20 ± 0.08 kl	14.74 ± 1.64 l	0.107 ± 0.08 ef	35.02 ± 1.14 h
Mirza bagi	22.50 ± 0.04 ef	18.63± 0.05 ef	66.58 ± 0.92 h	2969.1 ± 29.69 jkl	75.17 ± 0.14 lm	18.96 ± 1.46 ijk	0.090 ± 0.05 ef	25.29 ± 1.69 i
Qazaki	27.51 ± 0.03 d	15.89 ± 0.04 g	63.09 ± 1.35 ij	4011.5 ± 81.76 g	80.38 ± 0.09 de	20.94 ± 2.44 ghi	0.177 ± 0.05 df	35.43 ± 0.45 h
Meken	41.56 ± 0.01 b	37.75 ± 0.01 b	81.85 ± 0.42 c	3187.3 ± 44.54 i	73.33 ± 0.37 nop	23.137 ± 1.46 efgh	0.097 ± 0.04 ef	54.69 ± 0.50 e
Sheghnian	8.84 ± 0.02 k	9.01 ± 0.01 j	53.56 ± 1.05 m	2132.7 ± 103.92 p	73.03 ± 1.62 op	46.33 ± 2.14 a	0.220 ± 0.08 cdef	34.54 ± 0.56 h
Mulkho-01	2.31 ± 0.09 mn	2.90 ± 0.01 m	90.46 ± 0.51 a	3132.7 ± 14.84 ij	76.42 ± 0.52 jk	44.37 ± 2.23 a	0.077 ± 0.07 ef	15.51 ± 0.96 j
Pissan-01	35.52 ± 0.02 c	17.35 ± 0.02 f	88.57 ± 0.31 b	4896.4 ± 29.69 de	72.54 ± 0.12 p	26.570 ± 1.77 cde	0.267 ± 0.11 cde	64.84 ± 0.85 d
Habi Ju-02	10.31 ± 0.01 jk	8.54 ± 0.05 jk	76.18 ± 0.68 d	2635 ± 146.46 no	79.50 ± 1.27 efg	24.60 ± 1.61 defg	0.240 ± 0.06 cdef	85.12 ± 0.80 c
Hunza-01	20.61 ± 0.03 g	17.34 ± 0.01 f	73.43 ± 0.45 e	4872.1 ± 155.94 e	85.443 ± 0.37 c	21.38 ± 1.53 fghi	0.147 ± 0.08 ef	42.75 ± 1.32 fgh
Hunza-02	17.86 ± 0.02 h	10.85 ± 0.01 hi	62.61 ± 0.74 j	4326.7 ± 22.68 f	76.47 ± 0.04 jk	20.24 ± 1.55 hij	0.220 ± 0.07 cdef	98.35 ± 0.83 a
Hunza-03	35.98± 0.06 c	19.30 ± 0.01 e	64.87 ± 0.12 i	3163 ± 71.16 i	77.26 ± 0.04 ijk	21.06 ± 1.55 fghi	0.173 ± 0.05 ef	52.52 ± 0.91 e
Hunza-04	24.22 ± 0.01 e	33.21 ± 0.02 c	71.80 ± 0.70 f	6411.5 ± 81.76 a	80.66 ± 0.05 de	26.57 ± 1.66 cde	0.220 ± 0.10 cdef	47.08 ± 0.98 efg
Hunza-05	17.57 ± 0.06 h	15.28 ± 0.08 g	75.57 ± 0.40 d	5187.3 ± 14.85 bc	91.20 ± 0.95 a	44.170 ± 1.64 a	1.477 ± 0.28 b	4.75 ± 0.80 k
Sufaid khobaani	11.18 ± 0.01 j	18.22 ± 0.02 f	67.40 ± 0.64 h	2957 ± 129.70 kl	87.95 ± 0.07 b	27.16 ± 1.91 cd	0.207 ± 0.09 cdef	95.37 ± 0.56 ab
Mean	18.85 ± 1.31	17.46 ± 0.83	67.13 ± 10.73	3834.36 ± 1248.14	78.26 ± 5.24	26.19 ± 9.4	0.30 ± 0.45	48.56 ± 28.96
CV (%)	5.83	4.89	1.28	2.74	0.97	8.54	40.28	10.93

AoA represents antioxidant activity; TPC represents total phenolic contents; AA represents the Ascorbic Acid; TC represents the total carotenoids; TFC represents the total flavonoid compounds and TA represents the total anthocyanins

All the values are means of three replications +SD, Values with same letters are not statistically different at alpha 0.05,

[a]Results were expressed on dry weight basis

Table 4. Soluble protein contents, CAT, SOD and POD contents of twenty six different apricot cultivars.

Variety name	Protein (mg/100 g)[a]	CAT (IU/g of protein)[a]	SOD (IU/g of protein)[a]	POD (IU/g of protein)[a]
Muzhaki	2.37 ± 0.03 ef	31.4 ± 0.45 cdef	25.62 ± 1.12 cde	0.84 ± 0.09 efghi
Afghani	7.57 ± 0.05 b	9.84 ± 0.03 n	20.76 ± 1.79 ijk	0.32 ± 0.02 n
Mehteri	2.27 ± 0.05 ef	32.65 ± 0.60 cde	25.23 ± 1.68 cdef	0.92 ± 0.05 def
Qazafi	2.50 ± 0.03 ef	30.74 ± 0.36 defg	22.14 ± 1.58 ghij	0.82 ± 0.05 fghi
Mirza bibi	2.79 ± 0.01 def	27.82 ± 0.17 ghi	16.53 ± 2.07 l	0.86 ± 0.05 efgh
Mashetar	7.39 ± 0.74 b	10.3± 1.02 n	35.67 ± 1.47 a	0.31 ± 0.07 n
Lotovier selection	2.89 ± 0.03 def	28.31 ± 1.77 gh	26.59 ± 1.35 cd	0.70 ± 0.09 ghijk
Gilgit selection	3.22 ± 0.12 de	23.72 ± 0.83 j	24.16 ± 0.80 defg	0.82 ± 0.14 efghi
Green Lasht-08	1.56 ± 0.04 f	48.36 ± 1.12 a	9.79 ± 1.23 n	1.54 ± 0.04 b
Kuragh-01	2.29 ± 0.04 ef	33.49 ± 0.64 cd	27.62 ± 1.10 c	0.82 ± 0.04 efghi
Eikot	2.40 ± 0.06 ef	33.45 ± 0.74 cd	14.02 ± 0.82 m	1.06 ± 0.06 cd
Begali	2.50 ± 0.04 ef	29.56 ± 0.48 fgh	23.81 ± 1.57 defgh	0.68 ± 0.07 hijk
Lootdoor-01	2.53 ± 0.01 ef	30.11 ± 0.09 efg	36.43 ± 1.55 a	0.62 ± 0.03 jk
Mirza bagi	3.24 ± 0.06 de	22.98 ± 0.31 j	23.50 ± 0.71 efghi	0.72 ± 0.10 ghij
Qazaki	4.91 ± 0.18 c	15.19 ± 0.58 m	35.32 ± 1.93 a	0.52 ± 0.07 klm
Meken	2.75 ± 0.11 def	27 ± 1.00 hi	22.72 ± 1.19 fghij	0.65 ± 0.12 ijk
Sheghnian	7.33 ± 0.07 b	10.46 ± 0.04 n	22.47 ± 2.04 fghi	0.36 ± 0.04 mn
Mulkho-01	23.42 ± 0.68 a	4.04 ± 0.71 o	21.18 ± 0.90 hij	0.24 ± 0.07 n
Pissan-01	7.77 ± 0.24 b	9.94 ± 0.35 n	15.33 ± 0.95 lm	0.40 ± 0.11 lmn
Habi Ju-02	3.05 ± 0.09 de	24.87 ± 0.69 ij	9.86 ± 1.03 n	1.12 ± 0.17 c
Hunza-01	4.07 ± 0.23 cd	18.46 ± 1.19 kl	15.89 ± 0.90 lm	0.65 ± 0.10 ijk
Hunza-02	3.94 ± 0.60 cd	19.56 ± 2.90 k	4.02 ± 1.67 o	0.59 ± 0.11 jkl
Hunza-03	2.23 ± 0.04 ef	33.97 ± 0.56 c	20.50 ± 0.98 jk	1.01 ± 0.23 cde
Hunza-04	3.27 ± 0.02 de	23.17 ± 0.06 j	15.98 ± 1.58 lm	0.88 ± 0.09 defg
Hunza-05	4.72 ± 0.04 c	16.26 ± 0.09 lm	30.80 ± 1.12 b	0.61 ± 0.07 jk
Sufaid khobani	1.66 ± 0.06 f	43.92 ± 1.85 b	18.06 ± 1.89 kl	1.93 ± 0.10 a
Mean	4.41 ± 3.93	24.60 ± 10.45	21.71 ± 7.92	0.77 ± 0.37
CV (%)	19.11	7.58	7.93	15.17

CAT represents the Catalase; SOD represents the superoxide dismutase; POD represents peroxidase; IU represents the International Unit
All the values are means of three replications +SD
Values with same letters are not statistically different at alpha 0.05
[a]Results were expressed on dry weight basis

Discussion

The results of physical properties of apricot varieties from Gilgit and Chitral revealed that these varieties have maximum fruit weight, fruit length and width, so they meet the market demand and suitable for fresh consumption as well as for processing industry. Our findings relating to fruit physical quantitative characters are in agreement with Haciseferogullari *et al*., (2007) and Ahmadi *et al*., (2008). Yellow and orange fruit color was observed in most of the varieties, which is in complete resemblance with the previous judgments of Martinic *et al*., (2011) and Milosevic *et al*., (2012). Physical properties of fruit such as weight, shape, color and size have significant influence on the sensual qualities of fruits and in tantalizing the purchaser. These qualities of fruits are significant for processing, packing and finding new ways for improving horticultural industry (Ahmadi *et al*., 2008; Leccese *et al*., 2011).

The composition of sugars plays important role in the consumer preference that provides the basis for selection of commercially best cultivars (Ledbetter *et al*., 2006). The same proportion of these sugars has been reported by Drogoudi *et al*., (2007); Akin *et al*., (2008). Caliskan *et al*., (2012) have reported the glucose and fructose contents of Turkish apricot cultivars 2.7 g /100 g and 2.8 g /100 g respectively. The variation in findings possibly due to genetic and environmental effects which may interrupt the qualitative and quantitative configuration of the sugar profile by fluctuating the enzymes action which is involved in the synthesis and modification of fruit chemical properties.

Oxidation may cause damage in cells of humans, animals and plants. These oxidative compounds also cause the decomposition of food products and as a result the nutritional profile and sensory quality of fruits is decreased. So, the antioxidant reacts against these oxidative compounds and protect cells from damage (Pokorny *et al.,* 2001). The antioxidant activity (%) was ascertained by the access ability of fruit extract to the free radicals. Ali *et al.,* (2014) quantified the antioxidant activity of some apricots from Gilgit region of Pakistan and the results were in good agreements with our findings. The highest antioxidant activity may be due to highest phenolics because antioxidant activity is affected by the concentration of phenolic contents (Durmaz & Alpaslan, 2007).

Phenolic compounds have main contribution for antioxidants because it can prevent the lipid peroxidation in fruits and vegetables. The phenolic contents of apricot varieties from Maltsya were in the range from 4233.70-8180.49 mg GAE/100g fruit weight (Akin *et al.*, 2008). Milosevic *et al*., (2012) have also reported that apricot fruit contains an appreciable amount of phenolic contents. The results of TPC from apricot varieties of Northern areas are in resemblance with previous findings of many researchers in world. However, difference within and among cultivars are also present that may be because of different cultural practices, climatic fluctuations and variable cultivars (Dragovic-Uzelac *et al*., 2007).

Ascorbic acid is one of the important phytochemical compounds in fruits and vegetables that plays vital role in the body. Fruits and vegetables are main source of vitamin C covering 91% 91% body requirement. Ali *et al*., (2011) studied six cultivars of Northern areas and proposed that ascorbic acid contents were variable from 67.39 to 90.94 mg/100 g FW. It has been well-found that the climatic conditions, agronomic practices and cultivar type make compositional differences in ascorbic acid contents of apricot fruits (Ali *et al*., 2014).

Flavonoids are part of polyphenol group and occur naturally in plants. They perform different biological functions in organisms with non-hazardous concentration. Canadanovic-Brunet *et al*., (2013) premeditated the flavonoid contents of dried apricot and they have found that flavonoid contents were in the range of 3.03 to 218.5 R/g. The flavonoid contents in apricot were 7 µg CE/mg (Sharma *et al*., 2014). These varieties of Northern areas contain higher amount of flavonoid contents and our findings resemble with previous reports of Milosevic *et al*., (2012).

The name of anthocyanins is derived from "anthos" means flower and kyanos means blue. They confer blue, red and purple colors to plant tissues and mainly subsidize the visual quality of fruits (Kong *et al*., 2003). The presence and variability of anthocyanin contents in different fruit and vegetable crops have reported from 0-515 mg/g FW by many food experts (Kalt *et al*., 2000; Moyer *et al*., 2002). However, variation exists from crops to crops as well within different varieties of same species. This variation in anthocyanin concentrations may be due to genetic distinctions.

The carotenoids of fruit protect cell membrane from oxidative damage as they have antioxidant properties. They are responsible for the unique orange and yellow peel and pulp color of most Prunus species (Sandmann, 2001). The carotenoid contents of apricot in the previous studies (Akin *et al*., 2008; Ali *et al*., 2014) have been reported in the range of 9.02 to 91.89 mg/100 g and 1.36 to 38.52 g /100 g of fresh weight. Our study illustrates that apricot grown in Northern areas of Pakistan contains exceptional amount of carotenoid contents. The carotenoids of fruit protect cell membrane from oxidative damage as they have antioxidant properties. However, variation among all the cultivars is present and it is mainly dependent of cultivars and region of cultivation (Dragovic-Uzelac *et al*., 2007).

The respiration and ethylene production in climacteric fruits increases the activity of enzymes responsible for ripening due to which fruit texture decreases. The fruit becomes very soft and rotting occurs which leads to the inappropriate fruit quality and disturbance in nutritional status of fruit (Parasana *et al*., 2007). The activity of POD damages the fruit color as it helps in browning of fruits. Anyhow, there are certain enzymes like CAT and SOD which protect fruits from damage at the time of destruction of tissues during ripening by scavenging free radicals. The results of activity of antioxidant enzymes in apricot fruits from Northern Areas are in agreement to previous scientists. Lower POD activity was recorded, and it could be because POD activity decreases when fruit is kept in heat for longer period. While, CAT could transfer H_2O_2 into oxygen and water forms, so it remains unaffected from heat (Lee *et al*., 2003).

Apricot fruit contains very minute amount of soluble protein contents i.e. only 1 to 2% (Fatima *et al*., 2018). Ambrosio *et al*., (2013) investigated the protein contents at three stages of maturity; green, yellow and deep orange and the results obtained for soluble protein contents were 0.42, 0.36 and 0.31 mg/g fruit weight respectively. Many researchers have also described it may be when the senescence of fruit tissue occurs free redical scavenging activity also decreases and as a result variability in protein contents and POD activity increase (Rastegar *et al*., 2012).

Conclusion

The assessment of the antioxidant and physical properties of apricot fruit from Chitral and Northern areas (Gilgit) of Pakistan demonstrates that the fruit of these regions have highest antioxidant activity and is rich nutritional compounds. The varieties Muzhaki, Mirza bibi, Sheghnian, Hunza-06 and Qazafi are the best ones regarding sugar contents, total phenolics, total carotenoids, total flavonoids, and ascorbic acid and protein contents. Therefore, these must be taken in consideration by the farmers for their wider cultivation.

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