Journal of Horticultural Science and Technology 4(3): 81-88 (2021)
ISSN: 2617-3220 (Print), 2664-9489 (Online)
https://doi.org/10.46653/jhst2143081

Original Research

Ethno-Horticultural and Physico-Chemical Characterization of Indigenous Fruit Species for Nutritional and Socio-Economic Uplift of Local Communities from District Poonch, Azad Jammu and Kashmir

Mehdi Maqbool* , Noosheen Zahid, Syed Zulfiqar Ali Shah and Abdul Hamid

Department of Horticulture, Faculty of Agriculture, University of Poonch Rawalakot, Azad Jammu and Kashmir, Pakistan

ABSTRACT

The world is suffering due to the double burden of malnutrition i.e., under-nourished and over-nourished which is increasing day by day. Lack of dietary diversity and changing climatic scenarios are paving the way for this severe problem. There could be many solutions to address this chronic problem. However, using locally grown indigenous fruit species could be the cheapest and sustainable solution to tackle these issues locally as well as globally. To understand the existing barriers which are hindering to unlock the full potential of these fruit species, the present study was designed. To explore the ethno-horticultural and physico-chemical potential of some selected indigenous fruits such as persimmon, date plum, apple, pear, autumn olive, black raspberry, yellow raspberry, quince, barberry, apricot, fig, wood land strawberry, wild pomegranate, black mulberry, and plum were collected from different villages of District Poonch and analysed for various parameters. Ethno-horticultural information was gathered and documented during a survey conducted in this area while physico-chemical characterization was done through analytical studies. Samples were analysed for physico-chemical parameters such as, fruit weight, total soluble solids, titratable acidity, vitamin C, pH, total antioxidants, total flavonoids, and total phenols. The physico-chemical results showed that there is a huge potential of these fruit crops to be used locally and at national level. Further, small scale industry should be established to develop value added products.

Keywords: *Fruit quality, hidden hunger, indigenous fruits, micronutrients, sustainable nutrition.*

Article History: *Received 13 May 2021; Revised 03 July 2021; Accepted 01 August 2021; Published 30 September 2021.*

INTRODUCTION

The knowledge about ethno-horticultural and physico-chemical composition of indigenous plant species is considered an important source of commercialization for those plants (Silva et al., 2017). The physico-nutritional elements are the main source of nutrients and contribute widely to human nutrition (Maqbool et al., 2019; Hardisson et al., 2001), which help to prevent incidence of various diseases and maintain human health (Hooshmand and Arjimani, 2009). In this regard fruits and vegetables have an important role as they are the main source of antioxidants and other functional and nutritional elements. They contain various organic acids, carbohydrates fibres, aromatic compounds, tannins, and enzymes. Each of these compounds is considered essential for taste and nutritional value of fruits (Ertekin et al., 2006). Apart from these elementary food contents, fruits are rich source of phenolics, relatively high anthocyanins and antioxidants (Cevallos-Casals and Cisneros-Zevallos, 2004).

It has been reported by many researchers that fruits from different cultivars and wild relatives vary in their physico-chemical properties and sensory characteristics (Ajenifujah-Solebo and Aina, 2011; Lozano et al., 2009; Gil et al., 2002). This variation is always linked with variety, environmental conditions, and growing practises (Vursavus et al., 2006). Further, many scientists also reported that there were different values of phenolic contents, total flavonoids, total anthocyanins, and antioxidants among different cultivars of different fruits (Kristl et al., 2011; Cevallos-Cassals et al., 2006; Rupasinghe et al., 2006; Gil et al., 2002).

Indigenous fruit species are generally not known as cash crops due to their unexplored and unutilized market potential. They play an important role in most of the rural communities as their farming practices as well as lifestyle strategies are dependent on these indigenous fruit species (Mitra et al., 2008). The reason for not recognising them as cash crops is that they are mostly planted alongside major crops as subsistence crops (FAO, 2009).

* Corresponding author
Email: mehdimaqbool@upr.edu.pk (M. Maqbool)

In most of the cases, these indigenous fruit species are locally grown and are well adapted to the environmental and climatic conditions which is a huge advantage for farmers who can grow them on a relatively low cost (Jaenicke and Lengkeek, 2008; WHO, 2002). Therefore, they are designed to suit local conditions and for this reason research into these species and the farming systems in which they are produced has the potential to support both food security and nutritional wellbeing of growers.

The area of Azad Jammu and Kashmir is highly diverse in terms of natural flora and fauna. This genetic diversity is because of its geographic location, as it is located between the centre of China and Caucasus Mountains (Nisar et al., 2015). This mountainous area possesses varied climatic conditions ranging from subtropical to temperate. Many temperate fruits are grown in this area *e.g.,* pear, plum, apple, walnut etc. and a huge genetic diversity is found in these crops that might be because of natural seed-based proliferations, hybridization, or mutation (Ahmed et al., 2009). The mountainous region of Azad Jammu and Kashmir holds many indigenous fruit plantations. Along with number of different fruit species which consists of wild natives, a huge plantation of traditional varieties also exists (Ahmed et al., 2009). Although fruits are considered an excellent source of vitamins and dietary fibres, however, producers prefer high yielding, disease, and insect-pest resistant varieties. Whereas consumer demands for good taste, size, shape, and quality of fruit (Lace and Lacis, 2015).

However, the major drawback in commercial utilization of these indigenous fruit species grown in this area is the lack of nutritional importance. Many wild fruit species exists in this area are not yet characterized in terms of their ethno-botanical, biochemical, nutritional, and functional ingredients. Furthermore, no efforts have been made to exploit these indigenous fruit species for different uses. Therefore, the characterization of these indigenous fruit species is necessary for their nutritional uses. Thus, in this regard the present work has been designed to characterize ethno-horticultural and physico-chemical properties of different fruit species grown in District Poonch of Azad Jammu and Kashmir.

MATERIALS AND METHODS

Plant material

Fully mature fruits of selected indigenous fruit species were harvested from private orchards located at District Poonch, Azad Jammu and Kashmir (Fig. 1). Healthy fruits having uniform size, shape and free from all external impurities were transported to the Laboratory of Department of Horticulture, University of Poonch Rawalakot for further analysis.

Ethno-horticultural survey

An initial survey of selected area was conducted to identify indigenous fruits and then some important ethno-horticultural characteristics such as (English name, local name, botanical name, family name, and traditional uses) of selected indigenous fruit species (persimmon, date plum, apple, pear, autumn olive,

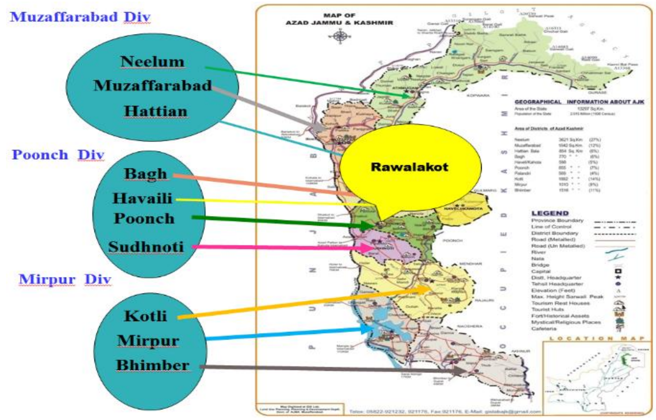

Figure 1: Map of Azad Jammu and Kashmir and description of study site - District Poonch.

black raspberry, yellow raspberry, quince, barberry, apricot, fig, wood land strawberry, wild pomegranate, black mulberry, and plum) were documented during this study.

Physico-chemical characteristics

Fruit weight

Digital balance (Model: Shimadzu A x 200, Japan) was used to determine fruit weight.

Total soluble solids

TSS was quantified by using hand refractometer (Kyoto Company, Japan). Briefly, two drops of juice from each fruit were placed on the glass of refractometer. Results were then articulated in °Brix. Before analysis, refractometer was calibrated against sucrose (Ali et al., 2014).

Titratable acidity

TA in selected fruits was measured by AOAC (2012) method No. 9720.21. Fruit pulp (5 g) was taken from each sample, mixed with deionized water (20 ml), and filtered to obtain the extract. For titration 5ml aliquot was taken and titrated against standard 0.1 N sodium hydroxide using few drops of phenolphthalein indicator till the change of colour to light pink as an end point. Readings were recorded as percent TA using the following formula.

TA (%) = 0.1 x equivalent weight of dominant acid x Normality of NaOH x titre value / Weight of sample

Vitamin C

Assessment of vitamin C in each sample of selected fruits was determined by method as reported in AOAC (2012) (Method No. 967.22). 2,6-dichlorophenol indophenol dye was used to measure vitamin C. Extracted sample (5 ml) was taken in 100 ml of conical flask and 5 ml of meta-phosphoric acid solution (4 %) was also added in this flask and this mixture was titrated with dye until light pink colour appeared as an end point.

$$\text{Vitamin C (mg/100 g)} = F \times T \times 100 / S \times D$$

Where, F = Standardization factor = ml of ascorbic acid / ml of pigment used
T = ml of pigment used for sample
S = ml of diluted sample taken for titration
D = ml of sample taken for dilution

pH

Digital pH meter (Model: WTW 82362 Inolab, Germany) was used to determine pH of fruit juice.

Total antioxidants (Activity of mg $FeSO_4$ g^{-1} FW)

Total antioxidants activity in selected fruits was measured by using Ferric Reducing Antioxidant Power (FRAP) assay. Reaction mixture contained 40 µl of fruit juice and 3 ml of FRAP reagent followed by incubation for 4 min at 37 °C. Absorbance was recorded at 593 nm, and the results were expressed as ferric reducing activity equivalent to1 mg $FeSO_4$ g^{-1} of fresh fruit weight. FRAP reagent consisted of 25 ml of 0.03 mM acetate buffer (pH 3.6), 2.5 ml of 20 mM $FeCl_3$ and 2.5 ml of 10 mM 2,4,6-Tripyridyl-s-triazine (TPTZ) solution dissolved in 40 mM HCl.

Total flavonoids

Total flavonoids were measured by using the spectrophotometric method. Fruit samples (0.5 mg) were ground by using mortar and pestle followed by mixing with 2.0 % methanolic $AlCl_3.6H_2O$ (1.5 ml) in sealed tubes and kept in the dark for 15 min. A UV-vis spectrophotometer (UV 4000 Spectrophotometer, Germany) was used for measuring absorbance at 430 nm. Results were expressed as mmol of quercetin 100 g^{-1} fresh fruit weight.

Total phenols

Total phenols were measured spectrophotometrically by using Folin Ciocalteau (FC) reagent. Fruit juice (0.1 ml) was mixed with 7.0 % sodium carbonate (1.5 ml) and FC (0.5 ml). Purified water was added to make volume of mixture up to 10 ml. Reaction mixture was incubated for 2 hours at 40°C. Absorbance was recorded at 750 nm by using a UV–vis spectrophotometer (UV 4000 Spectrophotometer, Germany). Results were expressed as mg gallic acid 100 g^{-1} fresh fruit weight.

RESULTS AND DISCUSSION

Ethno-horticultural characteristics of selected indigenous fruits species

It was observed during a survey, that these indigenous fruits species are being used traditionally for therapeutics of minor ailments which shows the importance of these crops in local communities (Table 1). It was also observed that these indigenous fruits species are not only nutritious but also possess great potential. However, still there are considerable barriers which are causing the main hindrance in unlocking the full potential of these species. One of the most important barriers is that these fruits have improper supply chain system and are mostly traded locally in nearby markets. Secondly, a limited research has been conducted to explore the actual potential of these fruit species. Consequently, a limited information and knowledge was available regarding these species which has caused a lack of awareness among communities about the real significance and potential of these indigenous crops.

In terms of physico-chemical characteristics all the selected indigenous fruit species showed appreciable levels of fruit weight, total soluble solids, titratable acidity, vitamin C and pH. Further, fruits were also found to be a good source of total antioxidants, total flavonoids, and total phenols as well (Table 2).

All the indigenous fruits showed appreciated levels of fruit weight. Fruit weight of persimmon was recorded (160.4 g), for date plum (12.14 g), apple (green) (112.5 g), apple (red) (115.4 g). In case of different pear fruits, fruit weight ranged from 39.64 g to 146.9 g. Desi pear fruits showed the lowest fruit weight (39.64g) while the highest fruit weight was observed in white pear (146.9g). Similarly other pears such as small pear (95.5 g), European pear (125.0 g), black pear (127.8 g) and local pear (44.8 g) showed different fruit weight. Autumn olive is a small fruit and hence its weight was measured for ten fruits which was about 1.55 g/10 fruits. Between two raspberries, black raspberry fruits had more weight (6.63 g) as compared with yellow raspberry (6.13 g). Quince fruit showed about 150.8 g, while barberry had 9.80 g/10 fruits and apricot fruits had 54.23 g fruit weight. Among figs, cluster fig had the highest fruit weight (24.26 g), while common fig had (20.76 g) and the lowest fruit weight was recorded in wild fig (6.24 g). Fruits of wood land strawberry showed (8.23 g) fruit weight, while wild pomegranate had (44.64 g) and black mulberry fruits had (7.78 g) fruit weight. Between two plums, plum (aloocha) showed 56.17 g fruit weight while desi plum showed 22.73 g fruit weight. The difference in fruit weight of these local fruits even within the same family was observed which could be due to marked differences in size of fruits.

In case of total soluble solids, all the indigenous fruits showed appreciated levels of total soluble solids. Total soluble solids in persimmon were recorded as (15.30 °Brix), in date plum (15.32 °Brix), apple (green) had (12.32 °Brix) while apple (red) had (13.26 °Brix). Among pears, European pear (9.86 °Brix) had the maximum total soluble solids followed by black pear (8.02 °Brix), white pear (8.73 °Brix), small pear (7.83 °Brix), local pear (6.14 °Brix) while desi pear (5.24 °Brix) showed the minimum amount of total soluble solids. In case of autumn olive total soluble solids were recorded very high (19.14 °Brix). In raspberries, yellow raspberry (11.67 °Brix) showed more total soluble solids as compared with black raspberry (10.67 °Brix). In quince total soluble solids were recorded as 14.0 °Brix, in barberry (12.45 °Brix), and in apricot (16.13 °Brix). Among figs, cluster fig (15.46 °Brix) had the highest amount of total soluble solids followed by common fig (14.20°Brix) while the least amount of total soluble solids was recorded in wild fig (13.24 °Brix). Total soluble solids in wood land strawberry (14.12 °Brix) were recorded very high, while in wild pomegranate it was (8.67 °Brix) and in black mulberry total soluble solids were

Table 1: Ethno-botanical information and traditional uses of selected indigenous fruit species from District Poonch.

English name	Local name	Botanical name	Family name	Traditional uses
Persimmon	Japani phal	*Diospyros kaki* L.	Ebenaceae	Used for the treatment of jaundice.
Date plum	Kala amlok	*Diospyros lotus* L.	Ebenaceae	Used for the treatment of diarrhea.
Apple (Green)	Saib	*Malus domestica* L.	Rosaceae	It is used fresh as well as in dry form.
Apple (Red)	Saib	*Malus domestica* L.	Rosaceae	Fruit is used to increase appetite and cure stomach disorders.
Small pear	Nashpati	*Pyrus pashia* L.	Rosaceae	Nashpati leaves are used to treat inflammation of prostrate and urinary bladder.
White pear	Farashishi	*Pyrus pyrifolia* L.	Rosaceae	Fruit is used to regulate cholesterol and hypertension.
European pear	Naakh	*Pyrus communis* L.	Rosaceae	Fruit is used for its high dietary fiber (regulation bowel movement) and is suitable for diabetic patients.
Black pear	Koturnal	*Pyrus pashia* L.	Rosaceae	Koturnal fruits are used to regulate cholesterol and hypertension.
Desi pear	Botangi	*Pyrus pashia* L.	Rosaceae	Fruits are used for curing cough, nausea and common cold.
Local pear	Kashmiri Botangi	*Pyrus pashia* L.	Rosaceae	Fruits are used for curing cough, nausea and common cold.
Autumn olive	Ghiani, Japanese silver berry	*Elaeagnus umbellate* L.	Elaeagnaceae	Traditionally, flowers are used to cure cardiac disorders. Seeds are considered good for cough. Oil extracted from seeds is used to treat lungs.
Black raspberry	Paghnar	*Rubus occidentalis* L.	Rosaceae	People eat black raspberry to treat stomach pain and bleeding gums.
Yellow raspberry	Paghnar	*Rubus idaeus* L.	Rosaceae	People eat black raspberry to treat stomach pain and bleeding gums.
Quince	Bhaidana	*Cydonia oblonga* Miller	Rosaceae	Quince fruit is considered good as an anti-diabetic agent. Seeds are used in curing cough, bronchitis, constipation, migraine, nausea and common cold.
Barberry	Sumbul, Daruhaldi	*Berberis vulgaris* Royle.	Berberidaceae	Leaves are used in treatment of jaundice. Roots are used in the treatment of eye problems.
Apricot	Hari	*Prunus armeniaca* L.	Rosaceae	Fruits are used as antidiarrheal purpose. Fruits of wild apricot are processed into jam, chutney, and dried products.
Common fig	Anjeer	*Ficus carica* L.	Moraceae	Fruit is edible and eaten fresh or dried. Fig fruits are also used for preparing jam and jellies. Fig is also well known in curing skin infections because of its high laxative properties.
Cluster fig	Bar	*Ficus racemosa* L.	Moraceae	Fruit powder is used to heal skin problem. It is used to treat muscular pain, pimples, boils, cuts, etc.
Wild fig	Phagwara	*Ficus palmata* Forssk	Moraceae	Fruit is edible in fresh form. Fruits are well known for curing skin infections.
Wood land strawberry	Amulbuddi	*Fragaria vesca*	Rosaceae	These wood land strawberry fruits are free from cholesterol. These fruits are usually eaten raw.
Wild pomegranate	Darona, Anar	*Punica granatum* L.	Lythraceae	Some of the most popular pomegranate health benefits are digestion, piles, antioxidant, cancer, cardiovascular, bone health, dental problem, and anemia etc.
Black mulberry	Toot	*Morus nigra* L.	Moraceae	Fruits are edible catkins, eaten fresh or made into pies, tarts, puddings etc. The wood is used for making hockey sticks. It is principally grown for feeding silkworms.
Plum	Aloocha	*Prunus domestica* L.	Rosaceae	Plum fruits are eaten fresh and used as spice in dry form. They are considered good for maintaining eye health and preventing heart from various problems.
Desi plum	Aloobhukhara	*Prunus armeniaca* L.	Rosaceae	Fruits are eaten fresh or used to make chutneys in dried form.

found as 12.26 °Brix. Between two plums, a higher value of total soluble solids was recorded in plum (aloocha) (13.23 °Brix) as compared with desi plum (12.45 °Brix). Similar results were obtained by Erturk et al. (2009), where they found that plum with red colour (14.78 %) had higher amount of total soluble solids when compared with dark purple colour plum fruit (11.98 %). The difference in total soluble solids of these local fruits even within the same family was observed which could be due to marked differences in water contents of fruits (Vilhena et al., 2020).

Appreciated amount of total titratable acidity was found in all the indigenous fruits. Total titratable acidity in persimmon fruits was recorded as 0.07 %, in date plum (0.49 %), in apple (green) (0.84 %) and in apple (red) (0.87 %). Among pears, small pear (0.59 %) and European pear (0.59 %) had higher and similar amount of total titratable acidity which was followed by white pear (0.53 %), black pear (0.49 %) and local pear (0.32 %), while the lowest amount of total titratable acidity was recorded in desi pear (0.31 %). In case of autumn olive total titratable acidity was found as 0.56 %. In raspberries, yellow raspberry (2.40 %) had more total titratable acidity value as compared with black raspberry (2.06 %). In quince total titratable acidity was recorded as (0.43 %), in barberry (0.67 %) and in apricot (0.21 %). Among figs, cluster fig (0.33 %) had the highest amount of total titratable acidity which was followed by common fig (0.26 %), while the lowest amount of total titratable acidity was found in wild fig (0.23 %). In wood land strawberry it was 0.34 %, in wild pomegranate (0.89 %), and in black mulberry it was (0.45 %). In case of plums, desi plum (0.43 %) had more total titratable acidity as compared with plum (aloocha) (0.25 %). However, lower values of titratable acidity were observed in fruits of present study as higher values were reported earlier by Erturk et el. (2009) in red skinned plum (4.99 %) and in dark purple skinned plum (3.89 %), which indicates that the fruits used in present study were less acidic.

In case of vitamin C all the indigenous fruits showed good levels of vitamin C. In persimmon good amount of vitamin C content were recorded (4.62 mg/100 g). In date plum (7.62 mg/100 g), apple (green) (8.66 mg/100 g) and apple (red) (8.41 mg/100 g) appreciated amount of vitamin C content was noted. Among pears, white pear (7.33 mg/100 g) showed the highest levels of vitamin C content which were followed by black pear (7.20 mg/100 g), small pear (5.69 mg/100 g), local pear (5.67 mg/100 g) and European pear (5.34 mg/100 g), while the lowest value was recorded in desi pear (4.25 mg/100 g). In case of autumn olive vitamin C content were found as 8.43 mg/100 g. In raspberries, black raspberry (9.33 mg/100 g) had more vitamin C content as compared with yellow raspberry (8.00 mg/100 g). In quince vitamin C content were recorded as 8.40 mg/100 g, in barberry (8.71 mg/100 g) and in apricot (7.76 mg/100 g). Among figs, wild fig (8.15 mg/100 g) had the highest levels of vitamin C content which were followed by common fig (7.22 mg/100 g), while the lowest amount was recorded in cluster fig (4.76 mg/100 g). In wood land strawberry it was noted as 8.67 mg/100 g, in wild pomegranate (8.34 mg/100 g), and in black mulberry (7.56 mg/100 g). In plums, plum (aloocha) (7.78 mg/100 g) had more vitamin C content as compared with desi plum (7.12 mg/100 g). Similar results were reported by Gil et al. (2002) where they observed vitamin C content in the range of 3-10 mg/100 g in five fresh plum cultivars.

Table 2: Physico-chemical characteristics of selected indigenous fruit species from District Poonch.

Fruit name	Fruit weight (g)	Total soluble solids (°Brix)	Titratable acidity (%)	Vitamin C (mg/100 g)	pH	Total antioxidant (mg $FeSO_4$ g^{-1} FW)	Total flavonoids (mmol of quercetin 100 g^{-1} FW)	Total phenols (mg gallic acid per 100 g)
Persimmon	160.4	15.30	0.07	4.62	6.20	11.76	3.23	10.32
Date plum	12.14	15.32	0.49	7.62	4.56	12.34	4.21	10.45
Apple (Green)	112.5	12.32	0.84	8.66	3.99	12.14	3.06	12.84
Apple (Red)	115.4	13.26	0.87	8.41	3.63	15.19	2.84	11.24
Small pear	95.5	7.83	0.59	5.69	4.75	11.43	1.66	10.64
White pear	146.9	8.73	0.53	7.33	4.68	17.64	2.31	14.36
European pear	125.0	9.86	0.59	5.34	5.14	16.79	2.38	15.83
Black pear	127.8	8.02	0.49	7.20	4.63	14.20	1.98	13.56
Desi pear	39.64	5.24	0.31	4.25	5.14	6.10	1.10	4.87
Local pear	44.8	6.14	0.32	5.67	4.98	6.13	0.98	4.81
Autumn olive	1.55/10 fruits	19.14	0.56	8.43	3.64	13.31	2.18	13.23
Black raspberry	6.63	10.67	2.06	9.33	3.74	14.34	3.80	12.72
Yellow raspberry	6.13	11.67	2.40	8.00	3.77	14.10	3.67	13.56
Quince	150.8	14.0	0.43	8.40	3.43	11.26	2.23	10.42
Barberry	9.80/10 fruits	12.45	0.67	8.71	4.32	12.45	3.17	15.56
Apricot	54.23	16.13	0.21	7.76	4.56	16.78	2.98	4.86
Common fig	20.76	14.20	0.26	7.22	4.24	16.23	4.27	13.26
Cluster fig	24.26	15.46	0.33	4.76	6.10	14.78	3.21	10.36
Wild fig	6.24	13.24	0.23	8.15	5.40	15.45	3.24	11.12
Wood land strawberry	8.23	14.12	0.34	8.67	4.34	13.24	4.23	11.28
Wild pomegranate	44.64	8.67	0.89	8.34	3.78	13.23	4.12	12.19
Black mulberry	7.78	12.26	0.45	7.56	4.12	12.65	4.54	10.98
Plum (Aloocha)	56.17	13.23	0.25	7.78	3.36	17.80	2.68	5.10
Desi plum	22.73	12.45	0.43	7.12	3.52	15.70	2.11	3.34

The pH values in all the indigenous fruits showed good levels. In persimmon pH was noted as 6.20, in date plum (4.56), in apple (green) (3.99) and in apple (red) it was recorded as 3.63. In case of pears, the highest value of pH was noted in European pear (5.14) which was equal to desi pear (5.14) and followed by local pear (4.98), small pear (4.75) and white pear (4.68), while the lowest amount of pH was noted in black pear (4.63). In autumn olive pH was found as 3.64. In raspberries, yellow raspberry (3.77) had more pH than black raspberry (3.74). In quince it was 3.43, in barberry (4.32) and in apricot it was (4.56). Among figs, cluster fig (6.10) had the highest value of pH which was followed by wild fig (5.40), while the lowest value was noted in common fig (4.24). In wood land strawberry it was recorded as 4.34, in wild pomegranate (3.78) and in black mulberry (4.12). In case of plums, desi plum (3.52) had more pH value as compared with plum (aloocha) (3.36). Almost similar values of pH were reported earlier by Erturk et al. (2009), where they found that dark purple and red skinned plum fruits had 3.13 and 3.70 pH, respectively.

All the indigenous fruits showed good amount of total antioxidants. In persimmon total antioxidants were noted as 11.76 mg $FeSO_4$ g^{-1} FW, in date plum (12.34 mg $FeSO_4$ g^{-1} FW), in apple (green) (12.14 mg $FeSO_4$ g^{-1} FW) and in apple (red) (15.19 mg $FeSO_4$ g^{-1} FW). Among pears, white pear (17.64 mg $FeSO_4$ g^{-1} FW) had the highest amount of total antioxidants which was followed by European pear (16.79 mg $FeSO_4$ g^{-1} FW), black pear (14.20 mg $FeSO_4$ g^{-1} FW), small pear (11.43 mg $FeSO_4$ g^{-1} FW) and local pear (6.13 mg $FeSO_4$ g^{-1} FW), while the lowest total antioxidants were recorded in desi pear (6.10 mg $FeSO_4$ g^{-1} FW). In autumn olive total antioxidants were observed as 13.31 mg $FeSO_4$ g^{-1} FW. In case of raspberries, black raspberry (14.34 mg $FeSO_4$ g^{-1} FW) had more total antioxidants as compared with yellow raspberry (14.10 mg $FeSO_4$ g^{-1} FW). In quince total antioxidants were noted as 11.26 mg $FeSO_4$ g^{-1} FW, in barberry (12.45 mg $FeSO_4$ g^{-1} FW) and in apricot (16.78 mg $FeSO_4$ g^{-1} FW). Among figs, common fig (16.23 mg $FeSO_4$ g^{-1} FW) had the highest level of total antioxidants which was followed by wild fig (15.45 mg $FeSO_4$ g^{-1} FW), while the lowest level was noted in cluster fig (14.78 mg $FeSO_4$ g^{-1} FW). In wood land strawberry it was recorded as 13.24 mg $FeSO_4$ g^{-1} FW, in wild pomegranate (13.23 mg $FeSO_4$ g^{-1} FW) and in black mulberry (12.65 mg $FeSO_4$ g^{-1} FW). In case of plums, plum (aloocha) (17.80 mg $FeSO_4$ g^{-1} FW) had more total antioxidants as compared with desi plum (15.70 mg $FeSO_4$ g^{-1} FW). This is a fact that antioxidants vary from species to species and with difference in climatic conditions (Scalzo et al., 2005). Fruits are considered a good source of natural antioxidants and hence many studies have been conducted to exploit their remarkable antioxidant potential (Scalzo et al., 2005). In the present study, antioxidant activity was due to presence of high vitamin C, total flavonoids, and total phenols in all the indigenous fruits. Variation in genetic makeup for antioxidant activity also exists, depending upon vitamin C, total flavonoids, and total phenols in fruits. In a previous study by Gil et al. (2002), it has been reported that a strong correlation was observed among antioxidants, total flavonoids and total phenols in various fruits including plums, peaches, and nectarines.

Total flavonoids in all the indigenous fruits were recorded in appreciable amount. In persimmon total flavonoids were noted as 3.23 mmol of quercetin 100 g^{-1} FW, in date plum (4.21 mmol of quercetin 100 g^{-1} FW), in apple (green) (3.06 mmol of quercetin 100 g^{-1} FW) and in apple (red) (2.84 mmol of quercetin 100 g^{-1} FW). Among pears, European pear (2.38 mmol of quercetin 100 g^{-1} FW) had the highest level of total flavonoids which was followed by white pear (2.31 mmol of quercetin 100 g^{-1} FW), black pear (1.98 mmol of quercetin 100 g^{-1} FW), small pear (1.66 mmol of quercetin 100 g^{-1} FW) and desi pear (1.10 mmol of quercetin 100 g^{-1} FW), while the lowest level was observed in local pear (0.98 mmol of quercetin 100 g^{-1} FW). In case of autumn olive total flavonoids were noted as 2.18 mmol of quercetin 100 g^{-1} FW. In raspberries, black raspberry (3.80 mmol of quercetin 100 g^{-1} FW) had more total flavonoids as compared with yellow raspberry (3.67 mmol of quercetin 100 g^{-1} FW). In quince it was noted as 2.23 mmol of quercetin 100 g^{-1} FW, in barberry (3.17 mmol of quercetin 100 g^{-1} FW) and in apricot (2.98 mmol of quercetin 100 g^{-1} FW). In case of figs, common fig (4.27 mmol of quercetin 100 g^{-1} FW), had the maximum value of total flavonoids which was followed by wild fig (3.24 mmol of quercetin 100 g^{-1} FW), while the minimum value was noted in cluster fig (3.21 mmol of quercetin 100 g^{-1} FW). In wood land strawberry it was recorded as 4.23 mmol of quercetin 100 g^{-1} FW, in wild pomegranate (4.12 mmol of quercetin 100 g^{-1} FW) and in black mulberry (4.54 mmol of quercetin 100 g^{-1} FW). In case of plums, plum (aloocha) (2.68 mmol of quercetin 100 g^{-1} FW) had more total flavonoids as compared with desi plum (2.11 mmol of quercetin 100 g^{-1} FW).

Good amount of total phenols was recorded in all the indigenous fruits. In persimmon total phenols were noted as 10.32 mg gallic acid per 100 g, in date plum (10.45 mg gallic acid per 100 g), in apple (green) (12.84 mg gallic acid per 100 g) and in apple (red) (11.24 mg gallic acid per 100 g). In case of pears, the highest levels of total phenols were noted in European pear (15.83 mg gallic acid per 100 g) which were followed by white pear (14.36 mg gallic acid per 100 g), black pear (13.56 mg gallic acid per 100 g), small pear (10.64 mg gallic acid per 100 g), and desi pear (4.87 mg gallic acid per 100 g), while the lowest levels were recorded in local pear (4.81 mg gallic acid per 100 g). In autumn olive it was noted as 13.23 mg gallic acid per 100 g. In case of raspberries, yellow raspberry (13.56 mg gallic acid per 100 g) had more total phenols as compared with black raspberry (12.72 mg gallic acid per 100 g). In quince it was noted as 10.42 mg gallic acid per 100 g, in barberry (15.56 mg gallic acid per 100 g) and in apricot (4.86 mg gallic acid per 100 g). Among figs, common fig (13.26 mg gallic acid per 100 g) had the highest amount of total phenols which was followed by wild fig (11.12 mg gallic acid per 100 g), while the lowest amount was noted in cluster fig (10.36 mg gallic acid per 100 g). In wood land strawberry it was noted as 11.28 mg gallic acid per 100 g, in wild pomegranate (12.19 mg gallic acid per 100 g) and in black mulberry (10.98 mg gallic acid per 100 g). In case of plums, plum (aloocha) (5.10 mg gallic acid per 100 g) had more total phenols as compared with desi plum (3.34 mg gallic acid per 100 g).

A difference in total flavonoids, total phenols and total antioxidants was also recorded in all the indigenous fruits under study. Quinic acid, rutin, iso-quercitrin, chlorogenic acids etc. are predominant markers for fruit nutritional quality and these different acids are responsible for the formation of flavonoids complex (Liaudanskas et al., 2020). Total phenolic contents are the essential components in various fruits and are well known due to their health-related properties. Phenolic compounds are also responsible for contribution of colour in fruits (Nisar et al., 2015). Phenolic contents help to protect low density lipoprotein from oxidation and thus they are considered to avoid age related diseases (Fang et al., 2002). The amount of phenolic contents varies with the type of fruit. Rupasinghe et al. (2006) recorded 86 to 413 mg gallic acid per 100 g in plum. Whereas Nisar et al. (2015) recorded 2.63 to 9.93 mg gallic acid per 100 g total phenolics, while in the present study total phenolic contents in plum were recorded as 3.34 mg gallic acid per 100 g. The difference in total phenols might be due to difference in extraction methods, environmental factors, and genotypes.

CONCLUSION

It can be concluded from this study that these indigenous fruit species are popular in local communities and are mostly consumed in areas where they are produced. Very little fruits are being sent to the main urban markets of this region or Pakistan. Therefore, in this regard a comprehensive research studies are required to supply disease free planting material, to give a detailed plan for managing trees and fruits, to provide indices for maturity, to develop an optimum system for handling, processing, and packaging of these fruits after harvest. Thus, a complete value chain approach is needed to rectify these issues and to provide a long-term solution for these species, so that all the stakeholders involved in this whole chain are benefitted either through addressing the issue of malnutrition or by earning some good living.

Author contribution statement

Mehdi Maqbool: Conceptualized idea, conducted this research work, collected data and data analysis. **Noosheen Zahid:** Conceptualized idea and designed this research work and collected data. **Syed Zulfiqar Ali Shah:** Assisted in methodology, validation, and data collection. **Abdul Hamid:** Assisted in methodology, validation, editing and reviewing.

Acknowledgements

Authors are highly thankful to the local farmers for providing information and fruit samples free of cost to conduct this study.

REFERENCES

Ahmed, M., Anjum, M.A., Rabbani M.A. and Hassan, L. 2009. Characterization of indigenous *Pyrus* germplasm of Azad Jammu and Kashmir revealed by SDS-PAGE analysis. *African Journal of Biotechnology*, 8: 6442-6452. https://doi.org/10.5897/AJB09.1034

Ajenifujah-Solebo, S.O. and Aina, J.O. 2011. Physico-chemical properties and sensory evaluation of jam made from black-plum fruit (*Vitex doniana*). *African Journal of Food Agriculture and Nutrition Development*, 11: 4772-4784. https://doi.org/10.4314/ajfand.v11i3.66629

Ali, A., Zahid, N., Manickam, S., Siddiqui, Y. and Alderson, P.G. 2014. Double layer coatings: A new technique for maintaining physico-chemical characteristics and antioxidant properties of dragon fruit during storage. *Food Bioprocess and Technology*, 7: 2366-2374.

AOAC. 2012. Official Method of Analysis. The Association of Official Analytical Chemists. 14th Edition. Arlington, VA.

Cevallos-Casals, B.A. and Cisneros-Zevallos, L. 2004. Stability of anthocyanin-based aqueous extracts of Andean purple corn and red-fleshed sweet potato compared to synthetic and natural colorants. *Food Chemistry*, 86: 69-77. https://doi.org/10.1016/j.foodchem.2003.08.011

Cevallos-Casals, B.A., Byrne, D., Okie, W.R. and Cisneros-Zevallos, L. 2006. Selecting new peach and plum genotypes rich in phenolic compounds and enhanced functional properties. *Food Chemistry*, 96: 273-280. https://doi.org/10.1016/j.foodchem.2005.02.032

Ertekin, C., Gozlekci, S., Kabas, O., Sonmez, S. and Akinci, I. 2006. Some physical, pomological, and nutritional properties of two plum (*Prunus domestica* L.) cultivars. *Journal of Food Engineering*, 75: 508-514. https://doi.org/10.1016/j.jfoodeng.2005.04.034

Erturk, Y., Ercisli, S. and Tosun, M. 2009. Physico-chemical characteristics of wild plum fruits (*Prunus spinosa* L.). *International Journal of Plant Production*, 3: 89-92.

Fang, N., Yu, S. and Prior, R.L. 2002. LC/MS/MS characterization of phenolic constituents in dried plums. *Journal of Agricultural and Food Chemistry*, 50: 3579-3585. https://doi.org/10.1021/jf0201327

Food and Agriculture Organisation of the United Nations. 2009. The state of food insecurity in the world. FAO, Rome.

Gil, M.I., Tomas-Barberan, F.A., Hess-Pierce, B. and Kader, A.A. 2002. Antioxidant capacities, phenolic compounds, carotenoids, and vitamin C contents of nectarine, peach, and plum cultivars from California. *Journal of Agricultural and Food Chemistry*, 50: 4976-4982. https://doi.org/10.1021/jf020136b

Hardisson, A., Rubio, C., Baez, A., Martin, M., Alvarez, R. and Diaz, E. 2001. Mineral composition of the banana (*Musa acuminata*) from the Island of Tenerife. *Food Chemistry*, 73: 153-161.

Hooshmand, S. and Arjimani, B.H. 2009. Viewpoint: dried plum, an emerging food that may effectively improve bone health. *Aging Research Reviews*, 8: 122-127. https://doi.org/10.1016/S0308-8146(00)00252-1

Jaenicke, H. and Lengkeek, A. 2008. Marketing the products of underutilized crops - Challenges and opportunities for pro-poor economic development. *Acta Horticulturae*, 770: 87-94. https://doi.org/10.17660/ActaHortic.2008.770.9

Kristl, J., Slekovec, M., Tojnko, S. and Unuk, T. 2011. Extractable antioxidants and non-extractable phenolics in the total antioxidant activity of selected plum cultivars (*Prunus domestica* L.): Evolution during on-tree ripening. *Food Chemistry*, 125: 29-34. https://doi.org/10.1016/j.foodchem.2010.08.027

Lace, B. and Lacis, G. 2015. Evaluation of pear (*Pyrus communis* L.) cultivars in Latvia. *Horticultural Science* (Prague), 42: 107-113. https://doi.org/10.17221/39/2014-HORTSCI

Liaudanskas, M., Rugile, O., Lanauskas, J., Kviklys, D., Zymone, K., Rendyuk, T., Živikas, V., Uselis, N. and Janulis, V. 2020. Variability in the content of phenolic compounds in plum fruit. *Plants*, 9: 1611-1626. https://doi.org/10.3390/plants9111611

Lozano, M., Vidal-Aragón, M.C., Hernández, M.T., Ayuso, M.C., Bernalte, M.J., García, J. and Velardo, B. 2009. Physicochemical and nutritional properties and volatile constituents of six Japanese plum (*Prunus salicina* Lindl.) cultivars. *European Food Research and Technology*, 228: 403-410. https://doi.org/10.1007/s00217-008-0946-3

Mahammad, M.U., Kamba, A.S., Abubakar, L. and Bagna, E.A. 2010. Nutritional composition of pear fruits (*Pyrus communis*). *African Journal of Food Science and Technology*, 1: 76-81.

Maqbool, M., Zahid, N., Hamid, A., Shah, S.Z.A., Yaqoob, A., Abbas, S.A., Rafique, S. 2019. Evaluation of physico-nutritional and functional properties of indigenous pear cultivars grown in Rawalakot, Azad Jammu and Kashmir. *Pakistan Journal of Agricultural Sciences*, 56: 607-611. https://doi.org/10.21162/PAKJAS/19.7366

Mitra, S.K., Pathak, P.K. and Chakraborty, I. 2008. Underutilized tropical and subtropical fruits of Asia. *Acta Horticulturae*, 770: 67-76. https://doi.org/10.17660/ActaHortic.2008.770.7

Nisar, H., Ahmed, M., Hussain, S. and Anjum, M.A. 2015. Biodiversity in morpho-physiological characteristics of indigenous plum germplasm from Azad Jammu and Kashmir, Pakistan. *Zemdirbyste-Agriculture*, 102: 423-430. https://doi.org/10.1016/j.scienta.2006.01.020

Rupasinghe, H.P.V., Jayasankar, S. and Lay, W. 2006. Variation in total phenolics and antioxidant capacity among European plum genotypes. *Scientia Horticulturae*, 108: 243-246. https://doi.org/10.1016/j.scienta.2006.01.020

Scalzo, J., Politi, A., Pellegrini, N., Mezzetti, B. and Battino, M. 2005. Plant genotype affects total antioxidant capacity and phenolic contents in fruit. *Nutrition*, 21: 207-213. https://doi.org/10.1016/j.nut.2004.03.025

Silva, E.P., Abreu, W.C., Gonçalves, O.A., Damiani, C. and Vilas Boas, E.V.B. 2017. Characterization of chemical and mineral composition of Marolo (*Annona crassiflora* Mart.) during physiological development. *Food Science and Technology*, 37: 13-18.

Vilhena, N.Q., Gil, R., Llorca, E., Moraga, G. and Salvador, A. 2020. Physico-chemical and microstructural changes during the drying of persimmon fruit cv. Rojo Brillante harvested in two maturity stages. *Foods*, 9: 870. https://doi.org/10.3390/foods9070870

Vursavus, K., Kelebek, H. and Selli, S. 2006. A study on some chemical and physico-mechanic properties of three sweet cherry varieties (*Prunus avium* L.) in Turkey. *Journal of Food Engineering*, 74: 568-575. https://doi.org/10.1016/j.jfoodeng.2005.03.059

World Health Organisation of the United Nations. 2002. The World Health Report, Reducing Risks, Promoting Health. Geneva.