Potential of wild edible fruits for nutrition in indigenous communities of Northwest Himalaya, India

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Research

Abstract

Background: In the rural areas of Himachal Pradesh, poor and tribal people depend on a variety of wild plants, animals, and fungi for their own consumption and for income generation. Despite their role in bridging periods of food shortages and providing dietary variety, most of wild edible plants are not accessed for nutritional potential. This is particularly true for the district of Kinnaur (a predominantly tribal area) of Himachal Pradesh. Hence, the present study was carried out to study the nutrient content of ten wild edible fruit species growing in the district of Kinnaur. The species included *Berberis aristata*, *Elaeagnus umbellata*, *Hippophae salicifolia*, *Malus baccata*, *Prunus cornuta*, *Prunus persica*, *Pyrus pashia*, *Ramaria botrytis*, *Rosa webbiana* and *Viburnum cotinifolium*.

Methods: The samples collected from the identified plants were cleaned, dried, powdered and stored in airtight containers for laboratory analysis. Fresh fruit pulp was used for measurement of pH, titratable acidity, total soluble solids (TSS) and ascorbic acid. Fresh weight of fruit pulp was recorded by using a digital balance and the samples were later oven dried (60°C) for moisture content determination (AOAC, 2006). All the dried samples were pulverized in pestle and mortar into fine powder separately and stored in airtight containers, free from contamination till other parameters were determined. All the parameters were evaluated in triplicates, results were analyzed by using descriptive statistics and reported as mean ± standard error.

Results: The moisture content of the fruits varied from 58.76% to 89.75% while pH values ranged from 2.91 to 3.86. The crude protein of species varied between 0.38% - 4.58%. *Prunus cornuta* contained high amount of total soluble solids, TSS (18.53° Brix). The acidity in the fruits ranged between 0.47-2.73%. The total carbohydrate content varied between 19.52% and 78.40%. The highest sugars (7.60%) were observed in the fruits of *Viburnum cotinifolium*.

Total phenols ranged in between 0.26-1.47%. The maximum ascorbic acid content and antioxidant activity was recorded in fruits of *Hippophae salicifolia*. These wild edible plants had also significant amounts of minerals.

Conclusion: The study shows that these wild edible plant species are good sources of nutrition for rural population. Keeping in view the nutritional values and commercial potential, these important species need to be conserved in their natural habitats and should be included in traditional agricultural systems. Domestication of these species will not only improve the economic condition of the local people but also aid in the conservation of biodiversity.

Key words: Wild edible plants, nutritive values, domestication, conservation.

Background

Poor rural and tribal people depend on a variety of wild plants, animals, and fungi for their own consumption and for income generation. Some of these wild edibles have high nutritional value to supplement dietetic requirements of rural masses and huge profitable potential to generate income (Maikhuri 1991). Many wild edible plants are a good source of nutrition as being rich in proteins, minerals and vitamins (Nahar *et al.* 1990). At times, the nutritional value of wild plants is higher than common commercial vegetables and fruits (Nordeide *et al.* 1996, Sundriyal & Sundriyal 2001, Orech *et al.* 2007). The chemical constituents present in wild edible plants mainly consist of proteins, vitamins, minerals, carbohydrates along with variety of other compounds, out of which vitamins and minerals are particularly important, as these are not present in sufficient quantity in cereals and pulses, which form important component of human diet (Parmar & Kaushal 1982). Minerals are of prime importance in determining the fruit nutritional value. Potassium, calcium, and magnesium are the major ones. In the tissue of many fruits, calcium is one of the minerals believed to be an important factor governing fruit storage quality (Lechaudel *et al.* 2005). It is reported to delay ripening and senescence (Fergusan 1984) and to reduce storage disorder (Bangeruh 1979). The importance of minerals such as potassium, calcium and sodium to human health is well known (San *et al.* 2009).

During the recent past, wild edibles have featured prominently in the discussions and framework of rural development and biodiversity conservation (Maikhuri *et al.* 1994). However, despite their role in bridging periods of food shortages and providing dietary variety, most of wild edible plants are not accessed for nutritional potential. Evaluation of nutritional values of wild edible plant species will provide a knowledge base that may be of some benefit to the developing wild fruit based small-scale industry. During last four decades, growing interest is witnessed to assess wild edible plants for their nutritional values (Franke 1982, Bokhary & Parvez 1987, Maikhuri 1991, Dhayni & Khali 1993, Mazza 1995, Arora & Pandey 1996, Agrahar-Murugkar & Subbulakshmi 2005, Calisir *et al.* 2005, Latermea *et al.* 2006, Effiong *et al.* 2009, Tapan 2011).

Assessment of the nutritional composition of wild edible plants is very scanty in the Himalayan region (Parmar & Kaushal 1982, Rawat *et al.* 1994, Sundriyal & Sundriyal 2001, Sood *et al.* 2010); besides, there is not a single study on nutritional values of wild edible plants of the Kinnaur District, Himachal Pradesh. Therefore, the nutritional analysis of some of the most important wild edible plants will be of great importance to know the nutritional value of the wild edible plants. Thus, nutritional evaluation of the mostly used wild edible plants of Kinnaur District, Himachal Pradesh was undertaken. This will be useful in identifying potential of wild edible plants, which may bring in more economic benefits to local communities.

Materials and Methods

Study area

Kinnaur is a tribal district of Himachal Pradesh and lies between 77° 45' 00" to 79° 00' 35'' East Longitudes and 31°55'50'' to 32°05'15'' North Latitudes The entire district is spread over the Himalayan mountainous terrain, covering an area of 6,679 km^2 with altitudes ranging from 1500 to more than 6770 meters above mean sea level (Figure 1). Most of region enjoys a temperate climate, with long winters from October to May and short summers from June to September. The average annual rainfall in the district is 816 mm. The region is divided into three administrative blocks viz. Pooh, Nichar and Kalpa. The inhabitants of the area are known as 'Kinnauras' (Balokhra 1998).

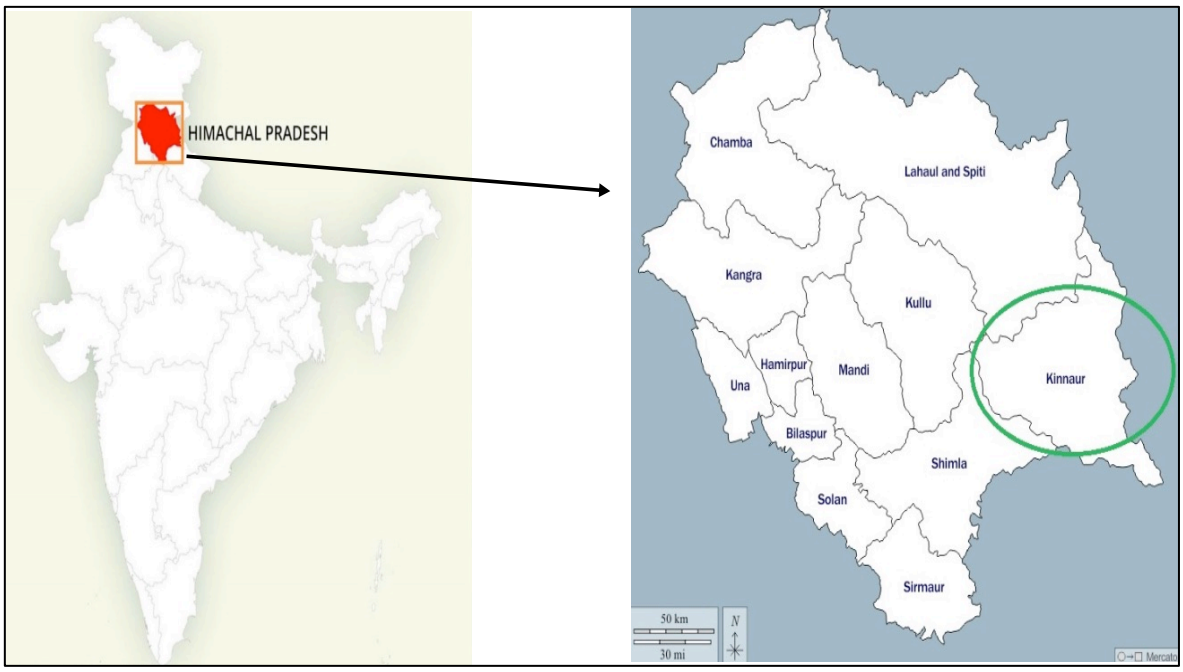

Figure 1. Map showing the location of Himachal Pradesh and district Kinnaur)

Methodology

Nine wild edible plant species (*viz. Berberis aristata* DC., *Elaeagnus umbellata* Thunb., *Hippophae salicifolia* D. Don, *Malus baccata* Loisel, *Prunus cornuta* Wall., *Prunus persica* (L.) Batsch, *Pyrus pashia* Buch.-Ham ex. D. Don, *Rosa webbiana* Wall. Ex. Royle and *Viburnum cotinifolium* D. Don) and one species of mushroom (*Ramaria botrytis* Fr. ex Bonord) were selected for the present study. These species were chosen because of their relevance or utility, the potential they have in the market, and the ease with which fruit samples may be obtained for nutritional analysis. Each of the species was given a collector number starting from WEP-1101 in the field itself (Malik et al., 2015). Healthy ripe fruit samples of wild edible plant species were collected in the month of August and September from three different sites of the district. The half kg (500 grams) of each sample species were collected from each site and a composite sample of each species was made by pooling the collected samples. The samples were brought to laboratory, cleaned to remove any attached impurities and stored in refrigerator. Fresh fruit pulp was used for measurement of pH, titratable acidity, total soluble solids (TSS) and ascorbic acid. Fresh weight of fruit pulp was recorded by using a digital balance and the samples were later oven dried (60^0C) for moisture content determination (AOAC, 2006). All the dried samples were pulverized in pestle and mortar into fine powder separately and stored in airtight containers, free from contamination till other parameters were determined. All the parameters were evaluated in triplicates, results were analyzed by using descriptive statistics and reported as mean ± standard error.

Various recommended methods for analyses of nutrients in plant materials were used as given by Allen (1989), Anderson & Ingram (1993), AOAC (1990) and Rangana (1986). The quantitative analysis of the fruit samples was carried out for proximate analysis as well as ultimate analysis. The proximate analysis provides useful information, particularly from a nutritional and biochemical point of view, and constitutes primary organic groups of the plant samples, e.g., carbohydrates, proteins, sugars, fibers, ash, acidity, etc. The ultimate analysis refers to the determination of a particular element (e.g., N, P, K, Ca, Mg, Na, etc.) or compounds present in the material (Allen 1989, Rangana 1986).

Fresh fruit weight and moisture content was determined as per method by Goel & Trivedi (1992). Crude protein was estimated by using Kjeldahl method (Rangana 1986) using the factor 6.25 for converting nitrogen content into crude protein. Crude fibers were determined by acid and alkaline digestion methods (Sadasivam & Manickam 1996). The ash content was determined by combusting the plant material in silica crucibles in a muffle furnace at 550°C till the constant weight achieved (7-8 hours). Total Soluble Solids (TSS) were measured through Hand Refractrometer (Model-Erma). Total carbohydrates were estimated by Anthrone method (Thimmaiah 1999). The total sugars, reducing and non-reducing sugars in the plant samples were assessed by determining the volume of unknown sugar solution required to completely reduce a measured volume of Fehling's solution to red, insoluble

cuprous oxide (Rangana 1986). Total phenols were estimated by using Folin-Ciocalteau reagent and 20% Na_2CO_3 solution and absorbance recorded in spectrophotometer and standard curve was prepared by using different concentrations of catechol (Rangana 1986). The pH of fresh fruit sample was recorded by digital pH meter (Hanna, model no. H1-2215), while the acidity was determined by titration of a known weight of sample with NaOH using phenolphthalein indicator. The value was calculated with reference to percent anhydrous citric acid. Ascorbic acid (Vitamin C) was determined through reduction method using a dye (2, 6-dichlorophenol indophenol), which turns blue in alkaline solution and red in acid solution and is reduced to a colorless form by ascorbic acid. The antioxidant activity was assessed based on the radical scavenging effect of the stable DPPH free radical (Hasan *et al.* 2006) measuring the absorbance at 517 nm.

Determination of Minerals

Minerals such as N, P, K, Ca, Mg, Fe, Mn, Zn and Cu were analyzed. Nitrogen was determined through the Kel plus nitrogen analyzer by digesting a known weight of plant sample and treating it with alkali. Wet digestion of sample was carried out in tri-acid Nitric acid : Sulphuric acid : Perchloric acid in the ratio of 9:4:1 for the estimation of P, K, Ca, Mg, Fe, Cu, Mn and Zn. 0.5 g of pulverized sample was digested on electric hot plate with 10-15 ml of tri-acid mixture till clear solution is obtained. After digestion content were transferred to volumetric flask along with washing with distilled water. Final volume of digest was made 50 ml for estimation of P, Cu, Fe, Mn and Zn whereas for estimation of Ca, Mg and K; 5 ml of above volume was further diluted to 100 ml. Total P in samples was determined by vandomolybdate phosphoric yellow color method (Gupta 1993). Total K, Ca, Zn, Mg, Cu, Fe and Mn were determined by using spectrophotometer, the plant samples, which were digested in a tri-acid solution of $HClO_4$, HNO_3, and H_2SO_4, were passed through atomic absorption spectrophotometer using different lamps, and calibrated for different micronutrients (Allen 1989).

Results

Tables 1, 2, and 3 below summarize the results of analyses performed on selected wild edible plant species (*Berberis aristata*, *Elaeagnus umbellata*, *Hippophae salicifolia Malus baccata*, *Prunus cornuta*, *Prunus persica*, *Pyrus pashia*, *Rosa webbiana*, and *Viburnum cotinifolium*) and on one mushroom (*Ramaria botrytis*). The parameters assessed were fruit weight, moisture content, crude protein, crude fiber, ash content, TSS, total carbohydrates, total sugars, reducing sugars, non-reducing sugars, total phenols, pH value, titratable acidity, ascorbic acid, macro and micro mineral elements. Fresh weight of 100 fruits was recorded in grams. The maximum fresh fruit weight of 792.60 gm/100 fruits was recorded in the *Pyrus pashia* followed by *Prunus persica* (788.40g/100 fruits). The lowest fruit weight of 9.76g/100 fruits was recorded in the *Hippophae salicifolia.* Fruit weight of other species such as *Elaeagnus umbellata, Viburnum cotinifolium, Berberis aristata, Prunus cornuta, Rosa webbiana* and *Malus baccata* was 20.08, 23.44, 26.23, 56.70, 81.32 and 91.30 grams/100 fruits, respectively. The highest moisture content of 89.75% was recorded in the fruits of *H. salicifolia* followed by *P. cornuta* (86%), *Ramaria botrytis* (86%), *E. umbellata* (79.17%), *V. cotinifolium* (78.79%) and *B. aristata* (77.57%). The fruits of other species *viz., P. persica* (71.03%), *R. webbiana* (70.85%), *M. baccata* (62.80%) and *P. pashia* (58.76%) contained relatively lesser moisture content. The highest protein content was recorded in *E. umbellata* (14.458%) which was higher as compared to other wild edible plant species. *P. cornuta* (8.46%) also had appreciable amount of proteins, which was closely followed by *V. cotinifolium* (7.34%), *P. persica* (7.08) and *H. salicifolia* (7.010%). The lowest crude protein amount was found in *R. botrytis* (0.38%) and *P. pashia* (1.62%). The crude fiber content was estimated highest in the fruits of *B. aristata* (11.32%) followed by *E. umbellata* (10.90%) and *P. pashia* (9.03%). The estimated fiber content in the fruits of *R. webbiana, H. salicifolia, V. cotinifolium, P. persica, M. baccata, P. cornuta* and *R. botrytis* was 3.93, 4.26, 4.70, 4.73, 4.76, 5.87 and 6.01%, respectively. The ash content in different wild edible plant species studied varied from 1.33% to 6.76%. Maximum ash content was recorded in *P. cornuta* (6.76%) followed by *V. cotinifolium* (6.33%), *P. persica* (5.53%) and *B .aristata* (4.37%). Whereas fruits of *H. salicifolia* contained minimum ash content (1.33%) (Table 1). The different species viz. *R. botrytis, R. webbiana, P. pashia, E. umbellata* and *M. baccata* contained 2.09, 2.16, 2.80, 3.20 and 3.20 % ash, respectively. TSS determined for various wild edible species varied from 6.13 °Brix (*R. webbiana*) to 23.77 °Brix (*M. baccata*). Other wild edible plant species such as *P. pashia* (21.80 °Brix), *R. botrytis* (20.06 °Brix) and *P. cornuta* (18.53 °Brix) also contained high amount of TSS as clear from Table 1. The total carbohydrate contents of different wild edible plant species investigated was recorded between 19.52 - 78.40%. Highest carbohydrate was found in the fruits of *P. cornuta* (78.40%) and lowest in the fruits of *B. aristata. E. umbellata* (70.82%) fruits contained also good amount of carbohydrates, it was followed by *P. pashia* (69.20%), *P. persica* (65.13%), *R. webbiana* (65.08%) and *V. cotinifolium* (63.33%). Other species such as *H. salicifolia, M. baccata* and *R. botrytis* had a low amount of carbohydrates (Table 1).

Table 1. Physico-chemical analysis of important wild edible plants of the Kinnaur District, Himachal Pradesh

Species	Fresh Fruit Weight (gm/ 100 Fruits)	Moisture Content (%)	Crude Protein (%)	Crude Fiber (%)	Ash Content (%)	TSS ^{O}Brix	Total Carbohydrates (%)	Total Sugars (%)
Berberis aristata DC.	26.23 ± 0.33^{f}	77.57 ± 0.82^{d}	3.48 ± 0.06^{e}	11.32±0.17^{a}	4.37±0.12^{c}	10.96±0.04^{e}	19.52±0.32^{f}	7.59±0.07^{a}
Elaeagnus umbellata Thunb	20.08 ± 0.35^{g}	79.17±0.40^{c}	14.46±0.05^{a}	10.90±0.06^{b}	3.20±0.10^{d}	12.67±0.33^{d}	70.82±0.43^{b}	1.65±0.04^{d}
Hippophae salicifolia D. Don	9.76 ± 0.22^{h}	89.75±0.67^{a}	7.01± 0.03^{d}	4.26±0.17^{f}	1.33±0.01^{g}	10.80±0.15^{e}	31.67±0.88^{d}	5.71±0.12^{b}
Malus baccata Loisel	91.30 ± 6.76^{c}	62.80±0.57^{f}	3.31± 0.04^{e}	4.76±0.09^{e}	3.20±0.12^{d}	23.77±0.72^{a}	25.51±0.38^{e}	5.96±0.08^{b}
Prunus cornuta Wall.	56.70 ± 0.54^{e}	86.00±0.57^{b}	8.46±0.04^{b}	5.87±0.01^{d}	6.76±0.15^{a}	18.53±0.44^{c}	78.40±0.62^{a}	6.04±0.29^{b}
Prunus persica (L.) Batsch	788.40 ± 2.92^{b}	71.03±0.56^{e}	7.08±0.04^{cd}	4.73±0.09^{e}	5.53±0.03^{b}	13.93±0.07^{d}	65.13±0.73^{c}	5.77±0.14^{b}
Pyrus pashia Buch.-Ham ex. D. Don	792.60 ± 3.87^{a}	58.76±0.33^{g}	1.62±0.02^{f}	9.03±0.06^{c}	2.80±0.11^{e}	21.80±0.42^{b}	69.20±0.98^{b}	4.14±0.08^{c}
Ramaria botrytis Fr. ex Bonord	--	86.80±0.51^{b}	0.38±0.01^{g}	6.01±0.12^{d}	2.09±0.12^{f}	20.06±0.07^{b}	23.00±0.58^{e}	4.47±0.24^{c}
Rosa webbiana Wall.	81.32 ± 0.82^{d}	70.85±0.82^{e}	3.44±0.05^{e}	3.93±0.07^{g}	2.16±0.07^{f}	6.13±0.03^{f}	65.08±0.52^{c}	4.80±0.31^{c}
Viburnum cotinifolium D. Don	23.44 ± 1.41^{g}	78.790.51±^{c}	7.34±0.03^{c}	4.7±0.06^{e}	6.33±0.13^{a}	12.70±0.35^{d}	63.33±0.88^{c}	7.60±0.31^{a}

Values are given Mean ± Standard Error; Values with different superscript are statistically significant.

The highest content of 7.60% total sugars was recorded in the fruits of *V. cotinifolium*, which was closely followed by *B. aristata* (7.59%). Total sugars of *P. cornuta* (6.04 %) were slightly higher than *M. baccata* (5.96%), *P. persica* (5.77%) and *H. salicifolia* (5.71%), whereas sugar content of *P. pashia* (4.14%) and *R. botrytis* (4.47%) was almost similar. The reducing sugar values ranged from 1.22% (*E. umbellata*) to 7.41% (*V. cotinifolium*). Reducing sugar content of species such as *M. baccata, H. salicifolia*, *P. cornuta, P. persica* was similar with value of 5.09, 5.85, 5.31 and 5.28%, respectively. *R. webbiana* contained 4.29% reducing sugar, which was slightly higher than *P. pashia* (3.99%) and *R. botrytis* (3.63%). *B. aristata* had 7.18% reducing sugar, which was a little lower to *V. cotinifolium* (7.41%). The lowest value for reducing sugar was recorded for *M. baccata* (0.11%). In case of non-reducing sugar content, *R. botrytis* was recorded with the highest value of 0.83% followed by *P. cornuta* and *H. salicifolia* with value of 0.73 and 0.67%, respectively. *B. aristata, E. umbellata, P. persica* and *R. webbiana* had 0.40. 0.43, 0.49 and 0.51% non-reducing sugar.

Variations in the phenol content of different wild edible species investigated during the present study are given in Table 2. Total phenols were found in the range of 0.26 – 1.47%. Phenolic content was found in lesser amounts in *R. webbiana* and *R. botrytis* (0.26% each). *M. baccata* fruits showed the highest phenolic content (1.46 %). The phenol content found in *E. umbellata* (1.28%) was slightly higher than that of found in *H. salicifolia* (1.106%). Phenolic content in *B. aristata* (0.27%) and *R. botrytis* (0.26 %) was almost similar. Whereas phenolic contents of *P. persica, P. pashia, V. cotinifolium* and *P. cornuta* were 0.91, 0.90, 0.64 and 0.60%, respectively. The pH values of ranged from 2.91 to 3.86, while acidity in the fruits of different wild edible plant species ranged between 0.47- 2.73%. The lowest pH value was recorded in fruits of *H. salicifolia* (2.91), whereas the lowest acidity was found in *E. umbellata* (0.47%). Variation in pH values of different wild edible fruit species was not significant and pH of all the wild edible plant species studied was acidic (Table 2).

The maximum ascorbic acid content was recorded in fruits of *H. salicifolia* (172.55 mg/100g), which was much higher than other wild edible plant species studied. Fruits of *R. webbiana* also had relatively higher ascorbic acid content (28.56 mg/100g) as compared to other wild edible species, while *P. pashia* (15.47mg/100g) and *P. persica* (13.55 mg/100g) also contained appreciable amount of ascorbic acid content. The antioxidant activity of wild edible species varied from 68 to 72 % as shown in figure 2. The highest antioxidant content was found in *H. salicifolia* which was recorded 89 %. While least, about 68 % was obtained in the *B. aristata* and *M. baccata* respectively. The antioxidant content of the selected species did not diverge much (Table 2).

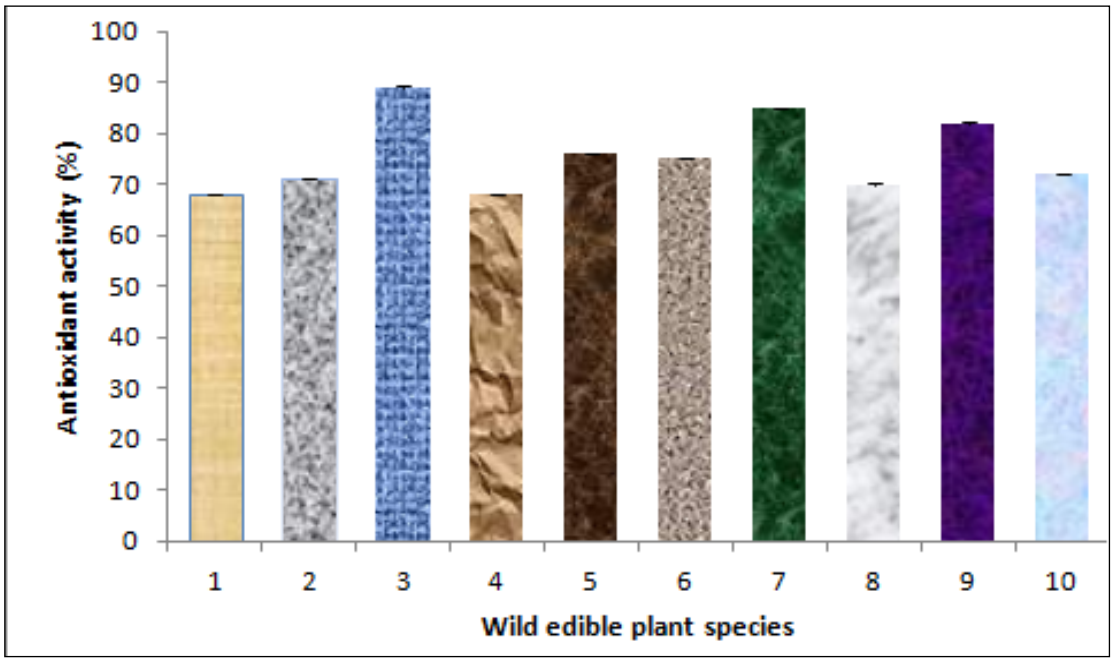

Figure 2. Antioxidant activity of selected wild edible fruits*

Legend: *1= *Berberis aristata* DC., **2=** *Elaeagnus umbellata* Thunb., **3=** *Hippophae salicifolia* D. Don., **4=** *Malus baccata* Loisel, **5=** *Prunus cornuta* Wall., **6=** *Prunus persica* (L.) Batsch, **7=** *Pyrus pashia* Buch.-Ham ex. D. Don, **8=** *Ramaria botrytis* Fr. ex Bonord, **9=** *Rosa webbiana* Wall., **10=** *Viburnum cotinifolium* D. Don

Table 2. Nutritive values of important wild edible plants of the Kinnaur District, Himachal Pradesh.

Species	Collector number assigned*	Reducing Sugars (%)	Non-Reducing Sugars (%)	Total Phenol (%)	pH Value	Titratable Acidity (%)	Ascorbic Acid (mg/100gm)
Berberis aristata DC.	WEP-1109	7.18±0.04^{a}	0.40±0.01^{d}	0.27±0.01^{d}	3.13±0.03^{e}	2.73±0.12^{a}	5.40±0.06^{ef}
Elaeagnus umbellata Thunb	WEP-1103	1.22±0.03^{e}	0.43±0.03^{d}	1.28±0.06^{a}	3.50±0.01^{c}	0.47±0.02^{f}	4.73±0.07^{f}
Hippophae salicifolia D. Don	WEP-1108	5.09±0.29^{b}	0.67±0.02^{b}	1.11±0.05^{a}	2.91±0.03^{f}	0.78±0.01^{d}	172.55±5.19^{a}
Malus baccata Loisel	WEP-1110	5.85±0.06^{b}	0.11±0.01^{e}	1.47±0.05^{a}	3.10±0.01^{e}	1.06±0.02^{c}	6.27±0.03^{e}
Prunus cornuta Wall.	WEP-1105	5.31±0.27^{b}	0.73±0.08^{b}	0.60±0.04^{c}	3.67±0.03^{b}	0.69±0.01^{de}	3.34±0.01^{g}
Prunus persica (L.) Batsch	WEP-1107	5.28±0.06^{b}	0.49±0.15^{c}	0.91±0.01^{b}	3.63±0.03^{b}	0.62±0.01^{e}	13.55±0.03^{d}
Pyrus pashia Buch.-Ham ex. D. Don	WEP-1101	3.99±0.06^{d}	0.15±0.01^{e}	0.90±0.03^{b}	3.86±0.03^{a}	0.70±0.03^{d}	15.47±1.19^{c}
Ramaria botrytis Fr. ex Bonord	WEP-1106	3.63±0.29^{d}	0.83±0.26^{a}	0.26±0.01^{d}	3.30±0.01^{d}	1.84±0.03^{b}	7.59±0.02^{e}
Rosa webbiana Wall.	WEP-1102	4.29±0.09^{c}	0.51±0.09^{c}	0.26±0.02^{d}	3.37±0.33^{d}	1.06±0.02^{c}	28.56±2.06^{b}
Viburnum cotinifolium D.Don	WEP-1104	7.41±0.30^{a}	0.19±0.03^{e}	0.64±0.02^{c}	3.57±0.03^{c}	0.16±0.12^{g}	5.29±0.01^{f}

Values are Mean ± Standard Error; Values with different superscript are statistically significant.
*WEP- Wild Edible Plant

In case of mineral elements, the highest value of 2.31 % nitrogen was recorded in the fruits of *E. umbellata*, which was higher than the 1.350, 1.190, 1.130, and 1.120% nitrogen estimated in the fruits *P. cornuta, V. cotinifolium, P. persica* and *H. salicifolia*, respectively (Table 3). The minimum quantity of nitrogen was found in *R. botrytis* (0.061%). The highest phosphorous content was found in the fruits of *H. salicifolia* (0.547%) followed by *P. cornuta* (0.431%), *R. webbiana* (0.390%), *R. botrytis* (0.375%) and *V. cotinifolium* (0.367%). Phosphorous content in other species: *B. aristata* (0.321%), *E. umbellata* (0.326%), *M. baccata* (0.330%) and *P. persica* (0.323%) was similar. However, highest potassium was recorded in the fruits of *P. persica* (2.867%). *P. cornuta* contained 2.376% potassium, which was slightly higher than the 2.330, 2.133, 2.101% potassium in *E. umbellata, B. aristata* and *R. botrytis*, respectively. *P. pashia* fruits had a minimum content of phosphorus (0.263%) and potassium (1.067%) among all species investigated. The fruits of *V. cotinifolium, M. baccata, R. webbiana* and *H. salicifolia* had 1.333, 1.523, 1.590 and 1.890 % potassium content, respectively (Table 3).

The concentration of calcium was maximum in the fruits of *E. umbellata* (0.637%) followed by *V. cotinifolium* (0.633%), *M. baccata* (0.610%) and *P. cornuta* (0.603%). The minimum concentration of calcium was recorded in *H. salicifolia* (0.068%). Concentration of calcium in species such as *B. aristata* (0.500%), *R. webbiana* (0.511%), *P. persica* (0.523%) and *P. pashia* was much higher as compared to minimum concentration of 0.068% in *H. salicifolia.* Whereas concentration of magnesium was maximum in *B. aristata* (0.116). Wild edible plant species such as *P. persica, P. cornuta, R. botrytis, E. umbellata* and *H. salicifolia* had 0.083, 0.067, 0.066, 0.063 and 0.062% concentration of magnesium, respectively, while magnesium was found minimum in *V. cotinifolium* (0.033%). The highest concentration of iron was found in *P. cornuta* (1.220%) followed closely by *E. umbellata* (1.217%) and *P. persica* (1.210%). Minimum iron concentration of 0.077% recorded in the fruits of *B. aristata* was lower as compared to *R. botrytis* (0.503%), *M. baccata* (0.533%), *V. cotinifolium* (0.540%), *P. pashia* (0.623%) and *R. webbiana* (0.662%). Concentrations of micro minerals such as manganese, zinc and copper were calculated in Parts Per Million (ppm). The highest concentration of Manganese was recorded in *B. aristata* (37.67 ppm) whereas zinc was found highest in *P. persica* (53.67ppm) and copper in *V. cotinifolium* (27.33ppm). Manganese values obtained for other wild edible plant species *viz. E. umbellata, M. baccata, P. cornuta, P. persica, Pyrus pashia, V. cotinifolium, H. salicifolia* and *Rosa webbiana* in order to ppm were 14.33, 8.33, 7.33,14.67, 7.67, 8.67, 28.65 and 7.75, respectively. While concentrations of zinc recorded in these species in order to ppm were 42.67, 33.67, 32.00, 53.67, 35.33, 32.10, 40.65 and 31.26, respectively (Table 3). Minimum concentrations of manganese (6.76ppm) and zinc (28.01 ppm) were recorded in *R. botrytis*, while copper concentration was lowest in *B. aristata* (1.88 ppm) which was lower than 2.95 ppm copper concentration in *H. salicifolia* and 4.08 ppm in *R. webbiana. E. umbellata* had 22.00 ppm, copper, which was higher than other species namely *P. pashia* (14.33 ppm), *M. baccata* (12.33 ppm), *R. botrytis* (10.68 ppm), *P. persica* (10.67 ppm) and *P. cornuta* (8.67 ppm).

Discussion

Wild edible plant parts such as fruits, leaves, buds, roots, bark etc., are used for food, medicine, fiber and other purposes like fodder for domestic animals. In developing countries, starch-based foods are the main staple. Thus, protein deficiency is common. To alleviate the situation, efforts are underway to explore the lesser-known wild edible plants as sources of nutrient supplements (Vishwakarma & Dubey 2011). In the present exploration a total of ten important wild edible plants were analyzed for their nutritional values. The moisture content varied from 58.76 % (*P. pashaia*) to 89.75% (*H. salicifolia*). The highest moisture content was recorded in *H. salicifolia* and is comparable to the moisture content (84.9-97.6 %) of *H. rhamnoides* reported by Dhyani *et al.* (2007) in different populations from Garhwal Himalayas, while the values of moisture content of *B. aristata, E. umbellata* and *P. pashia* were in consonance with the study of Parmar & Kaushal (1982). However, Sood *et al.* (2010) reported higher moisture content in *B. lycium* as compared to present investigation in *B. aristata*.

Proteins not only support growth but also play important role in maintenance and repair of body tissue. Total daily intake of protein is based on the growth needs and weight of an individual. Different wild edible plants showed variation in protein content. It varied from 0.381- 14.458 % being highest in *E. umbellata* and lowest in *R. botrytis.* Vishwakarma & Dubey (2011) also showed variation in protein (1.2 to 17.84 %.) values of edible plants of Chattisgarh. Similarly, Gopalan *et al.* (1971) has also reported 7% to 32% crude protein in common leafy vegetables in India.

Table 3: Mineral content values of important wild edible plants of the Kinnaur District, Himachal Pradesh.

Species	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	Fe (%)	Mn (Ppm)	Zn (Ppm)	Cu (Ppm)
Berberis aristata DC.	0.557±0.008^{d}	0.321±0.005^{d}	2.133±0.088^{c}	0.500±0.001^{e}	0.116±0.004^{a}	0.077±0.00^{h}	37.67±0.333^{a}	45.67±0.341^{b}	1.88±0.016^{h}
Elaeagnus umbellata Thunb	2.313±0.008^{a}	0.326±0.003^{d}	2.330±0.067^{b}	0.637±0.003^{a}	0.063±0.003^{d}	1.217±0.00^{a}	14.33±0.661^{c}	42.67±0.067^{c}	22.00±0.57^{b}
Hippophae salicifolia D. Don	1.120± 0.004^{c}	0.547±.016^{a}	1.890±0.033^{d}	0.068±0.008^{f}	0.062±0.001^{d}	1.086±0.011^{c}	28.65±0.802^{b}	40.65±0.097^{d}	2.95±0.019^{h}
Malus baccata Loisel	0.530±0.001^{d}	0.330±0.01^{d}	1.523±0.067^{e}	0.610±0.010^{b}	0.047±0.002^{f}	0.533±0.006^{f}	8.33±0.033^{d}	33.67±0.333^{f}	12.33±0.660^{d}
Prunus cornuta Wall.	1.350±0.006^{b}	0.431±0.016^{b}	2.376±0.033^{b}	0.603±0.007^{b}	0.067±0.003^{c}	1.220±0.012^{a}	7.33±0.332^{ef}	32.00±0.577^{f}	8.67±0.333^{f}
Prunus persica (L.) Batsch	1.130±0.006^{c}	0.323±0.009^{e}	2.867±0.088^{a}	0.523±0.007^{c}	0.083±0.004^{b}	1.210±0.005^{b}	14.67±0.334^{c}	53.67±0.328^{a}	10.67±0.669^{e}
Pyrus pashia Buch.-Ham ex. D. Don	0.260±0.004^{e}	0.263±0.01^{f}	1.067±0.008^{g}	0.567±0.007^{c}	0.037±0.001^{g}	0.623±0.014^{e}	7.67±0.299^{e}	35.33±0.617^{e}	14.33±0.333^{c}
Ramaria botrytis Fr. ex Bonord	0.061 ±0.002^{f}	0.375±0.010^{d}	2.101±0.067^{c}	0.550±0.009^{d}	0.066±0.004^{c}	0.503±0.006^{g}	6.76±0.440^{f}	28.01±0.088^{h}	10.68±0.336^{e}
Rosa webbiana Wall.	0.550±0.008^{d}	0.390±0.008^{c}	1.590±0.064^{e}	0.511±0.002^{e}	0.050±0.006^{e}	0.662±0.005^{d}	7.75±0.079^{e}	31.26±0.067^{fg}	4.08±0.337^{g}
Viburnum cotinifolium D. Don	1.190±0.005^{b}	0.367±0.006^{d}	1.333±0.067^{f}	0.633±0.003^{a}	0.033±0.002^{g}	0.540±0.015^{f}	8.67±0.330^{d}	32.10±0.577^{f}	27.33±0.669^{a}

Values are in Mean ± Standard Error; Values with different superscript are statistically significant.

The World Health Organization has recommended an intake of 233 g of crude fiber for every 100 Kcal of diet. Although it does not contribute to the nutritive value of food, presence of fiber in diet is necessary for digestion and elimination of wastes. Therefore, a good amount of fiber is always desirable since it plays an important role in human nutrition (Imran *et al.* 2007). Crude fiber content varied from 3.93 - 11.32% being lowest in *R. webbiana* and highest in *B. aristata.* Fibre values of present study were less as compared to 45.82% fiber estimated in *Salvadora persica* a wild edible plant of Rajasthan (Gehlot 2006). The fiber content of *P. cornuta* (3.67%) and *P. persica* (3.63 %) was little lower to 5.09% fiber reported by Agunbiade & Olanlokun (2006) in *Prunus amygdalus*. Crude fiber values of other wild edible species investigated were in comparable range of earlier studies in various wild edible plant species (Sundriyal & Sundriyal 2001, Dhyani *et al.* 2007; Vishwakarma & Dubey 2011). Ash content recorded in *B. aristata* (4.37 %) was higher as compared to earlier reported 2.05% (Parmar & Kaushal 1982) in this species and 0.82% in *B. lycium* (Sood *et al.* 2010). Similarly, ash content recorded in other wild edible species was in comparable range to earlier studies in various wild edible plant species (Sundriyal & Sundriyal, 2001; Zatylny *et al.* 2005).

Total soluble solid (TSS) is very important, giving information about sugar content of fruits. TSS contents in the fruits of various wild edible species ranged between 6.13 % - 23.77 %. TSS values of present study slightly varied from earlier studies carried by Sundriyal & Sundriyal (2001) on different wild edible plants Sikkim Himalayas. TSS value of *H. salicifolia* was more or less same as reported by Dhyani *et al.* (2007). TSS value of *B. aristata* was less as compared to *B. lycium* reported by Sood *et al.* (2010). While *E. umbellata* had more TSS content compared to *E. latifolia* reported from Sikkim Himalayas (Sundriyal & Sundriyal 2001). The TSS value of *P. pashia* of the present study was less as compared to Parmar & Kaushal (1982). TSS contents of *V. cotinifolium* were similar to those reported by Zatylny *et al.* (2005) in *Viburnum trilobum,* While TSS of *Prunus cornuta* (18.53°Brix) was comparable to the TSS value of *Prunus avium* (20 °Brix) reported by Karlidag *et al.* (2009). Carbohydrates are easily digested, provide the necessary calories in the diets of most people promote the utilization of dietary fats and reduce wastage of proteins (Agatemor & Mark 2006). All ten wild edible plant species analyzed are nutritious as they contain a fine amount of carbohydrate. Carbohydrate content of the investigated wild edible plant species varied from 19.52 % (*B. aristata*) to 78.40 % (*P. cornuta*). Sundriyal & Sundriyal (2001) also reported high carbohydrates in *Prunus cerasoides* (83%). While carbohydrate content present in *B. aristata* (19.52 %) was higher than *B. lycium* (12.64%) as reported by Sood *et al.* (2010). It was also higher than as reported by Goel & Trivedi (1992) in *B. asiatica* (9.2%). The amount of carbohydrate present in *H. salicifolia* (31.67 %) was similar to *H. rhamnoides* (32.53%) from Sikkim Himalaya (Sundriyal & Sundriyal 2001). Total sugars ranged from 4.10% (*E. umbellata*) to 5.71% (*H. salicifolia*). The lowest amount of total sugar present in *E. umbellata* was low as compared to 8.34g/100g total sugar recorded by Parmar & Kaushal (1982). However, the present results of total sugars for this species were in comparable range to the total sugar values present in *E. latifolia* (2.10%) as reported by Sundriyal & Sundriyal (2001). This study in comparisons to Sood *et al.* (2010) study on *B. lycium* (15.45%) was different.

Phenolic compounds also contribute to fruit quality and nutritional value in terms of modifying color, taste, aroma, and flavor, and also in providing health-beneficial effects. The phenolic content varied from 0.258% - 1.467 %, being minimum in *R. webbiana* and maximum in *M. baccata.* The phenolic content recorded in the fruits analyzed during present study was higher as compared to the phenolic contents reported by Tapan (2011) in wild edible fruits of Meghalaya. The pH value of studied wild edible plant species ranged from 2.91-3.86 and thus all wild edible species investigated were acidic. The pH not only depends on total amount of different acids but also on the ionization constants of the different acids. The pH value of *B. aristata* of present study was in conformity with pH value reported by Sood *et al.* (2010) in *B. lycium*, while acidity recorded during this study was slightly higher than reported by Parmar and Kaushal (1982). Zatylny *et al.* (2005) reported pH from 2.89 to 3.13 in *Viburnum trilobum,* which was similar to *V. cotinifolium* (3.57) in the present investigation. Titratable acidity reflects the total amount of acids present in the sample. The pH and titratable acidity of investigated wild edible species are well in the range as reported by various other workers in other wild edible plant species from Himalayas and elsewhere (Wehmeyer 1966, Parmar & Kaushal 1982; Sundriyal & Sundriyal 2001).

Ascorbic acid (Vitamin C) in all the studied species varied between 5.29 to 172.55 mg/100g, which shows that these wild edible species are good sources of vitamin C. Pharmaceutically; ascorbic acid has been useful in treatment of scurvy. It is also the most important nutrient as it acts as an anti-oxidant. Content of vitamin C in these wild edible plant species was in conformity with the findings that wild edible plant species are rich source of vitamins including ascorbic acid (Rawat *et al.* 1994; Sundriyal & Sundriyal 2001, Rakesh *et al.* 2004). *H. salicifolia* contained high ascorbic acid content (172.55 mg/100 g) as compared to other species investigated during the present study. However, the value of Vitamin C was less than 286mg/100g of Vitamin C reported by Sundriyal & Sundriyal (2001)

from Sikkim Himalayas and (191-295.6 mg/100g) by Shah *et al.* (2007) from Pakistan in *H. rhamnoides*. The Vitamin C content in Sea buckthorn ecotypes was also reported in the range of 170 mg/100g to 250 mg/100g by Sabir *et al.* (2005) and in the range of 92 mg/100g to 461 mg/100 g by Xurong *et al.* (2001). These results agree with our studies on Vitamin C. The ascorbic content of 15.47 mg/100g present in *Pyrus pashia* was much higher than 1.22 mg/100gm reported by Parmar & Kaushal (1982). While vitamin C content in *P. persica* (13.93 mg/100 g) recorded during present study comparable to 9.95 mg/ 100 gms in *P. armeniaca* (Parmar & Kaushal 1982). However, the values were less as compared to the high amount of Vitamin-C content reported in cultivated fruits such as amla (600 mg/100g), pineapple (39mg/100g) and papaya (57 mg/100g; Nazarudeen 2010). There is a great deal of interest in edible plants that contain antioxidants and health-promoting phytochemicals as potential therapeutic agents (Ishaq *et al.* 2015). Natural antioxidants from plants have attracted greater interest of researchers and consumers because of their ability to scavenge free radicals and being safer than synthetic antioxidants. Free radicals are thought to be responsible in the development of a number of disorders, including cancer, neuro degeneration and inflammation (Bhatt *et al.* 2018). Aparecida de-Assis and his co-workers (2009) reported that there is direct correlation of ascorbic acid with antioxidant capacity. Since the highest ascorbic acid among the selected fruits was determined in *H. salicifolia*, antioxidant activity was also at peak in the same as show in figure 2. Both vitamin C concentrations and total phenol contents strongly correlate with antioxidant capacity (Gardner *et al.* 2000). The results obtained in *H. salicifolia* were comparable to the antioxidant content of *H. salicifolia* growing in forests of Sikkim (Goyal *et al.* 2011).

The mineral content varies with physiochemical properties and topographic position within an ecosystem (Kutbay & Ok 2001). Plant species take the mineral elements in different concentration and accumulate them in various tissues (Arenas & Scarpa 2007). Mineral ions are of prime importance in determining the fruit nutritional value. Vitamins and minerals present in the diet are necessary for normal growth and metabolism and influence the utilization of other nutrients. Required amounts of minerals must be in human diet to pursue good healthy life (San *et al,* 2009). The wild edible plant species are often excellent sources of minerals, particularly of calcium, phosphorus, magnesium, potassium, iron and sodium. The trace mineral content of fruits depends on the amount present in the soil in which the plant grows (Kibar & Temel 2016). The results of the present investigation showed that wild edible plants are good sources of minerals. However, mineral contents were found to vary depending on the species. Potassium, iron, calcium, and magnesium which are nutritionally important were found in reasonable amount. While manganese and copper were in lesser amount. The highest values of nitrogen, phosphorus and potassium were observed in *E. umbellata, H. salicifolia* and *P. persica,* respectively. While highest magnesium and calcium contents were recorded in *B. aristata* and *E. umbellata*, respectively. Potassium was found to be the most abundant mineral present in all species ranging from 1.067 - 2.867% being lowest in *P. pashia* and highest in *P. persica.* Calcium is essential to bone structure and function was in good amount in all fruit species studied especially in *E. umbellata* (0.637%) followed by *V. cotinifolium* (0.633%), *M. baccata* (0.610%) and *P. cornuta* (0.603%). Magnesium is an essential part of many enzyme systems and is also important in maintaining the electrical potential of nerve and muscle membranes (Agatemor and Mark, 2006). Magnesium of wild edible plants was recorded in the range of 0.033 - 0.116 %. These values correspond to earlier reports on mineral studies of wild edible plants (Sundriyal & Sunderiyal 2001, Agrahar-Murugkar & Subbulakshmi 2005).

Microelement iron was highest in *P. cornuta*, manganese and zinc in *B. aristata* fruits, while copper was present more in *V. cotinifolium*. The values of present study on mineral content are in comparable range to values reported for some other wild edible plant species from Himalayas (Sundriyal & Sunderiyal 2001, Agrahar-Murugkar & Subbulakshmi 2005). However, mineral values of the present investigations are higher than earlier studies (Parmar & Kaushal 1982, Sood *et al.* 2010). These slight variations in results of present study in for different variable as compared to earlier studies on other wild edible plant species could be due to geographical locations, species difference and variation in climatic conditions (Wehmeyer 1966, Parmar & Kaushal 1982, Sundriyal & Sundriyal 2001, Dhyani *et al.* 2007, Sood *et al.* 2010).

Comparison with cultivated fruit species

Nutritive values of some commercial cultivated fruit species are given in table 4. Moisture content recorded in *P. pashia* (58.76%) *R. webbiana* (70.85%) during the present study was less as compared to cultivated fruits such as apple, pear, plum, etc. (Table 4). Other wild edible fruits studied had high moisture contents. Wild edible fruits are a good source of crude fiber. The crude fiber content of all the wild edible fruits studied was significantly higher than that of cultivated fruits. Ascorbic acid in wild edible fruits studied during present investigation was less as compared to Amla (Table 4). However, ascorbic acid in *P. persica* (13.55mg/100g) and *P. pashia* (15.47mg/100g) is higher than apple, peach and plum. Though total sugar content of wild edible fruits was lower as compared to

temperate cultivated fruit crops, but it was in appreciable amount. Similarly wild edible plants were as rich in mineral content as cultivated fruits. The nutritive values of all studied wild edible fruits of Kinnaur District, Himachal Pradesh are in comparable range with wild species from different parts of Himalaya (Maikhuri 1991, Dhyani & Khali 1993, Sundriyal & Sundriyal 2001, Sood *et al.* 2010).

Table 4. Nutritive value of most common cultivated commercials fruits of India.

Fruit	Moisture (%)	Fiber (%)	Carbohydrate (%)	Vitamin-C (mg/100g)	Total Sugar	Ca (%)	P (%)	F (%)
Apple	85.90	1.00[b]	13.40	2.00	13.4[b]	0.01	0.02	1.70
Pear	86.90	1.00	11.50	--	--	0.01	0.70	--
Peach	90.10	---	7.60	1.00	--	0.01	0.03	1.70
Plum	89.80	---	8.90	1.00		0.02	0.02	0.50
Amla	81.8	3.4	---	600.00	13.7	--	--	1.2
Pineapple	86.50	0.30	12.00	63.00	10.8[b]	0.02	0.01	0.90
Guava	81.70	5.2	8.10[a]	212	11.2	--	0.02[a]	0.27
Mango ripe	81.00	0.70	10.60[a]	16.00	16.90	0.01[a]	0.02	1.0
Papaya	89.60		9.50	46.00	7.2[b]	0.01	---	0.40
Grapes	86.70	3.00	10.10	17.00	--	0.03	0.02	0.30
Orange	87.80	---	10.60	68.00	--	0.05	0.02	0.10
Lemon	85.00	--	11.10		--		0.01	

Source: [a]Sundriyal 1999, [b]Nazarudeen 2010

Conclusion

It is evident from the results that wild edible plant species of Kinnaur District, Himachal Pradesh are good sources of valuable nutrients and minerals for the local population. These plants can help to overcome the nutritional deficiency especially in rural areas. Although, studies on nutritional status of wild edible plants in India are gaining much needed impetus, still large number of wild edible plant species remains unexplored for biochemical research. Little known other wild edible plants and those growing in cold desert areas need to be assessed for their nutritional value. The important species need to be conserved in their natural habitats. Besides, potential species that can be commercially exploited should be included in traditional agricultural system based on their nutritional values. Some value addition in the form of pickle, chutney, jam, jelly, candy etc. should be encouraged among people to increase fruit shelf life and economic profit to local communities. Moreover, domestication of these species will not only improve the economic condition of the local people but will also help in the conservation of biodiversity.

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