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ETHNOBOTANICAL ASSESSMENT AND NUTRITIVE POTENTIAL OF WILD FOOD PLANTS

A. A. Shad*, H. U. Shah and J. Bakht

Department of Agricultural Chemistry, University of Agriculture Peshawar KPK Pakistan
*Institute of Biotechnology and Genetic Engineering, University of Agriculture Peshawar KPK Pakistan
*Corresponding author: anwaralishad@yahoo.com

ABSTRACT

Wild flora is an integral component of rural livelihoods and their exploitation has advocated for achieving the optimal dietary requirements. In this context, the current study presents systemic practice on traditional usage of wild dietary and medicinal plants in the recent scenarios of Khyber Pakhtunkhwa province of Pakistan. Ethnobotanical survey recorded 17 plants belonging to 14 families that are separately used as food and medicine by the indigenous population. The present study investigates their proximate composition, mineral profile, vitamin C, β-carotene, and anti-nutritional factors. Analysis of the data revealed that the selected species contained significant amount of protein, crude fat, crude fiber and NFE. The crude protein and crude fat contents were ranged from 3.08 to 13.78% and 0.89 to 4.13%, respectively. Vitamin C content was highest in *Oxalis stricta* (52.48±5.57 mg 100^{-1}g) and least amount was found in *Zanthoxylum alatum* (1.65±0.87 mg 100^{-1}g) on fresh weight basis. β-Carotene was found maximum in *Nasturtium officinale* (209.60 mg 100^{-1}g) followed by *Sisymbrium officinale* and *Rumex hastatus* while minimum concentration was determined in *Zanthoxylum alatum*. Analysis of the mineral profile showed that potassium was present in highest quantity followed by calcium, phosphorus, sodium and iron. Similarly, anti-nutritional factors were noted in different ranges i.e. total oxalates (14.34-362.66), phytic acid (5.97-33.09), tannins (7.27-108.49) mg 100^{-1} g on fresh weight. It can be concluded from the present study that the investigated plant species are poor source of anti-nutritional factors and key source of nutracuticles which advocates the subject plants as wild edible species for human consumptions.

Key words: Wild food, nutraceuticals, biodiversity, proximate, minerals.

INTRODUCTION

The increasing population coupled with poverty, natural and man made crisis in rural parts of Khyber Pakhtunkhwa of Pakistan poses challenges to the earnings for their livelihoods and access to food. Limited livelihoods opportunities followed by both natural and man made disasters are the major constraints beyond the food insecurity (Zeller *et al.,* 2001; Sher and Hussain, 2009). It is generally observed that most men in these areas are engaged in un-skilled labor, while women are self-employed in petty trade of agriculture especially in the collection and trade of wild food and medicinal plants. Food availability and household food security in mountain areas are closely related to agriculture (Harlan, 1992; Ogoye and Hansen, 2003). Moreover, the traditional ways of farming and livestock rearing have further reduced the income opportunity of the local and as a result about 60 percent of the population had very low purchasing power (Hole, 2005). Food is still the single most important commodity in the area accounting for 80 percent of all expenditures (Asfaw, 1997). In terms of current caloric intake, roughly 40 percent of households in the area could be classified as food insecure. When current status is combined with a measure of vulnerability (proportion of total household budget devoted to food), 30 percent of households are classified as food-insecure, and an additional 70 percent are vulnerable (Sher *et al.,* 2004).

Wild plants contain potential bio-molecules both in organic and inorganic combinations (Penny *et al.,* 2002). They are vital, inexpensive and lucrative source of vitamins, antioxidants, fiber, minerals and other nutrients for many economical deprived natives. These plants have high nutraceutical value and are used for wide range of ailments and have the potential to protect human body from cancer, diabetes, inflammatory and cardiovascular diseases. Literature survey revealed that considerable work has been done on the organic constituents, however, little attention has been paid to the attributes of inorganic elements which plays a very important role in the formation of the active chemical constituents and thus responsible for nutritional as well as therapeutic properties (Rajurkar and Damame, 1998; Ray 2004). A direct correlation between elemental content of wild plants and their nutraceutical ability is not yet understood in term of modern scientific perspectives. Besides, the exploitation of such plants is limited due to the presence of some toxic and anti-nutritional factors viz. oxalates, tannins, alkaloids and saponins, however, significant variation was observed in terms of anti-nutritional factors among the wild food plants (Mathenge, 1997; Gupta *et* *al.,* 2005). However, several researchers reported that many traditional and conventional plants had the same range of these anti-nutritional factors. Nevertheless, these bio-molecules analysis would raise the awareness about the exploitation of these wild plants as food and medicine.

The present study documented 17 wild plants used as food and medicinal plants collected from different mountainous packets of Khyber PakhtunKhwa Province of Pakistan. They substitute the common, expensive and sometime scarcely available conventional plant based foods. The low-income dwellers rely on such plants both for cash and subsistence and can be exploited because of their high nutritional and therapeutic value.

MATERIALS AND METHODS

Location and description of the study area: The study area is situated in the North West and South-West of Pakistan (Coordinates: 34.00 °N and 71.32 °E). The area is spread over 101741 Km² (Britannica Online Encyclopedia, 2011). It is a wide arable land with irrigation facilities (around 10-12% is cultivated). The estimated population in 2010 is approximately 21 million (Population Census Organization Pakistan, 2011; Khalil, 2007). It borders Afghanistan to the north-west, makes it of strategic importance to Pakistan. An interesting feature in the topography is the junction where the slopes of the Hindu Kush Mountains on the Iranian plateau and Eurasian land plate, while peripheral eastern regions are located near the Indian subcontinent, give way to the Indus-watered hills approaching South Asia.

Data collection: A combination of quantitative and qualitative research methods was undertaken in various parts of the study area. The concepts of validity and reliability were applied for the integration of qualitative and quantitative techniques. Participatory techniques were used to collect information and the main techniques and tools used for data collection were household surveys, key informant interviews and focus group discussions (Alexiades and Sheldon, 1996; Andrea *et al.,* 2000a; 2007b).

Sample collection: The major aspects of survey were information about the respondent/informant, date and place of gathering information, local name of the wild dietary flora and parts used. In this way, informants identified more than 100 trees, herbs and shrubs that are used for various purposes. However, we exclude all those plants that either could not be identified or their use is restricted to medicine only from our study list. Seventeen wild plants were selected from subject area including Bajuar, Buner, Dir, D.I. Khan and Swat districts of the Khyber PakhtunKhwa Province which were recommended by more than 50% of the informants. Furthermore, seven species; *Berberis lyceum, Nasturtium officinale, Oxalis stricta, Plantago major, Rumex hastatus*, *Sisymbrium officinale* and *Zanthoxylum alatum* were collected from their natural habitat at their mature stage They were analyzed for their proximate composition, mineral contents, vitamin C, β-carotene and anti-nutritional factors to evaluate their nutritive value in human diet.

Proximate composition: Moisture, ash, crude fat and crude protein were determined using the standard laboratory protocol (AOAC, 2000). Similarly, Vitamin C was determined by the dye reduction method. For this purpose the ascorbic acid content of the sample was titrated with 2, 6 dichlrophenol indophenol (AOAC, 2000; Arya *et al.,* 2000) and β-Carotene was isolated by column chromatography and estimated Spectrophotometrically using the modified method of Noelle and Grivetti, (2002).

Nitrogen free extract represents the digestible carbohydrate and can be found by the difference. This value was obtained by subtracting the sum of the percentages of moisture, crude fiber, crude protein, crude fat and Ash from 100 (Iqtidar and Saleemullah, 2004).

NFE = 100 - % (Moisture + crude fat + crude protein + crude fiber + Ash)

Energy calculation: The caloric value of the sample was calculated from the energy yielding components i.e. Fats, Protein, Carbohydrate. The crude fat was multiplied by 9.1 and the sum of protein and carbohydrates (NFE) was multiplied by 4.3. The sum of resulting figures (fat, protein and carbohydrate) will be kilo calories (K cal) per 100 g sample (Merrill and Watt, 1973).

Mineral profile analysis: Dried plant material, in triplicate, were subjected to wet digestion procedure for the determination of mineral contents in accordance with AOAC (2000). Phosphorous determination was accomplished using molibdate-vanadate method (Cavell, 1955; Jackson, 1962). The absorbance of the complex mixture was measured by a Spectrophotometer (Model: OPTIMA SP-3000 Plus) at 740 nm. Sodium and potassium were determined by flame photometry technique (Jenway, Model PFP7). Similarly, Atomic Absorption Spectrophotometer (Perkin Elmer, model A Analyst 700) were used for the determination of Calcium, Magnesium, Iron, Zinc, Cadmium, Lead, Cupper, Chromium, Manganese, Selenium and Nickel (AOAC, 2000).

Anti-nutritional factors: Total oxalate contents were determined by extracting with hydrochloric acid and soluble oxalate with water followed by precipitation with calcium oxalate from deproteinized extract and subsequent titration with potassium permanganate (Gupta *et al.,* 2005). Total phenol contents in the methanolic extracts were assessed using a modified version of the

Folin–Ciocalteu assay. Gallic acid was used as a standard Li *et al.,* 2008). Tannins level in the methanolic extracts was assessed using the vanillin-HCl method reported by Waterman and Mole (1994). Similarly, pytic acid was determined using the method of Vaintraub and Lapteva (1988).

Anti-oxidant Activity: Anti-oxidant activity was determined by using the 2, 2-diphenyl-1-pycril hydrazyl (DPPH) radical scavenging assay as described by Choi (2002). DPPH (1 mL, 0.3 mM) solution in ethanol was added to 2.5 mL (100 mg mL^{-1}) of methanol extract and mixture was allowed to react for 30 min. at room temperature and absorbance was recorded using UV visible spectrophotometer at 518 nm. HPLC grade Rutin hydrate (95%, 1 mM) was used as standard, while absolute ethanol was used as negative control. The experiment was repeated in triplicate, using fresh plant sample each time and the average absorbance values were converted to percentage anti-oxidant activity.

Statistical analysis: The data was collected in triplicate and standard error (SE) was calculated according to Steel *et al*. (1997).

RESULTS AND DISCUSSION

Dwellers of the subject area are facing various contributing factors of malnutrition such as rapid population growth, poverty, natural and manmade disasters. The livelihood of rural inhabitants in particular is disturbed to a great extent due to Afghan war and unabated natural chaos. Wild plants have been recognized as the cheapest and most abundant source of food and medicine in the subject area since long. The present study was designed to document the edible and remedial ethnobotanical awareness of the local inhabitants of the surveyed areas. Furthermore the selected species were investigated for their nutraceutical potential as well. Seventeen wild plants were collected from various region of the subject area based on their possible nutritive and pharmacological potential, during the present ethnobotanical survey. It was found that wild plants were an integral component of the livelihood of these areas for diverse rationale, round the year. Wild plants provided food in the form of fruits, leaves, roots, seeds, and other plant parts, either raw or cooked and herbal medicines in the form of extracts, decoction, infusion, syrups and milky latex. The general purposes of their uses include dietary diversification, increase food supply, flavoring agent or spices, increase nutraceuticals potential of diet and for various human ailments. Results presented in Table 1 revealed that wild edible species are separately consumed in the study areas with slight cooking differences. Similarly, Hamayun *et al.* (2006) explored the ethnobotanical knowledge of district Swat of KPK, Pakistan by traditional harvesting techniques of wild fruits and edible portion. Similarly, Ahmad and Javed (2007) recorded the economic importance of indigenous uses of 81 selected plants belonging to 44 families, out of which 35 were used by local community and sold in local markets. Gilani *et al.* (2006) also recorded 21 important herbs belonging to 19 families used medicinally by the local inhabitants in Abbottabad, district KPK Pakistan. Some of these wild plants are traded to national herbal markets and as a result they play a vital role in improving the socioeconomic conditions of the study area. Reuslts of our study revealed that *Berberis lycium, Debregeasia* saeneb and *Oxalis stricta* had medicinal importance, while *Amaranthus spinosis, Astragalus anisacanthus, Caralluma edulis, Nasturtium officinale, Plantago major, Rumex hastatus* and *Sisymbrium officinale* are important both as food supplement for animals and local inhabitants and other commercial uses such as herbal medicine, essentials, fiber and vitamins resources. Findings of the current survey concluded that these wild plants are either used separately or in amalgamation with others such as wheat/maze flour, spices, meats, potatoes etc.

The present study also analyzed seven species for their proximate composition, mineral profile, vitamin C, β-carotene, and anti-nutritional factors to evaluate their nutritional adequacy. These dietary wild species were selected on the basis of their possible nutraceutical and dietary potential. The species included *Berberis lycium*, *Nasturtium officinale*, *Oxalis stricta, Plantago major*, *Rumex hastatus*, *Sisymbrium officinale* and *Zanthoxylum alatum*. Analysis of the data (Table 2) revealed that the moisture content of the *Oxalis stricta* was maximum (84.78±3.62%) followed by *Nasturtium officinale* (80.08±4.97%). Minimum level of moisture was found in seed and fruit part of *Zanthoxylum alatum* (39.78%). Maximum amount of ash (3.07±0.13%) was observed in *Nasturtium officinale* followed by *Berberis lycium* (2.78±1.02%), whereas minimum amount was found in *Rumex hastatus* (1.48±0.15%). Mean value of crude protein presented in Table 2 revealed that the studied plants had protein content in the range of 3.08-13.78%. Similar values of proximate composition have also been reported by Aletor and Adeogun (1995) of tropical plants of Nigeria while Gopalan *et al.* (1996) and Hussain (2000) reported associated values for the conventional food and vegetables of different plant species. Analysis of the data also indicated that the studied plants were moderate sources of fat (0.89-4.13%). Maximum amount of ether-extracted fat was found in fruit and seed part of *Zanthoxylum alatum*. Aletor *et al.* (2002) reported 2.2% to 7.3% crude protein in fresh leafy vegetables, similar to the present results. Likewise, maximum crude fiber content was estimated in *Rumex hastatus* (28.43%) followed by *Sisymbrium officinale* (14.72%). Minimum amount of fiber was found in *Plantago major* (4.28%). The Nitrogen Free Extract (NFE) was found to be the major chemical constituent of proximate composition in the selected wild plants used as food and medicines. Mean value of the data (Table 2) showed that highest amount of NFE was found in *Zanthoxylum alatum* (35.57%) followed by *Plantago major* (8.02%) whereas lowest concentration of NFE was observed in *Oxalis stricta* (1.22±0.45%). Similarly, Table 2 also suggested that the investigated plants were reasonable sources of vitamin C and β-carotene which ranged between 1.65-52.48 and 5.24-209.60 mg 100^{-1}g, respectively. Highest amount of vitamin C was found in *Oxalis stricta* (52.48 mg 100^{-1}g), whereas maximum level of β-carotene was noted in *Nasturtium officinale*. These results are confirmed with those reported by Faboya, (1990), Akpanyung *et al.* (1995), Sundriyal and Sundriyal (2000), Alverez, (2002), Sellappan and Akoh, (2002), Gupta *et al.* (2005) and Li *et al.* (2008). Their reported average values were 0.50 to 5.77% ash, 2.7 to 35.88 % fiber, 0.25 to 33.88% crude protein and 15 to 40% NFE in various wild plants used as food and medicine. Contrary, some researchers reported extremely varied quantity of chemical composition of indigenous wild spices used as food and medicine (Shingade *et al.,* 1995). The possible reason could be due to species differences, different age/stage of the species and different agro-climatic conditions.

Anti-nutritional factors are widely distributed in wild plants used as food and medicine (Oboh and Akindahunsi, 2004) which are responsible for several health complications. Several anti-nutritional factors including oxalate, tannins, phytic acid, lignins, saponins, alkaloids, cyanogens and enzyme inhibitors (Makkar and Singh, 1993; Gupta *et al.,* 2005; Shingade *et al.,* 1995) whose presence greatly impair the digestion of various nutrients, therefore, reducing the nutritional value of such plants and limiting their utilization as food (Gidamis *et al.,* 2003; Prathibha *et al.,* 1995). Results presented in Table 3 revealed that the investigated plants had lower

Table 1: List of wild plants investigated with their related information.

Botanical name	Local name	Family	Parts used	Growth Habit	Methods of use
Amaranthus spinosis L.	chlwae	Amaranthaceae	Aerial parts	Herb	Used as vegetable and fodder
Astragalus anisacanthus Boiss	Mamol	Leguminosae	Young shoots	Herb	Used as vegetable
Bauhinia variegata L.	Kulyar	Caesalpinaceae	Bark and Flower heads	Tree	Anthelminthic, astringent and used as vegetable
Berberis lycium Royle	Tor kwaray	Berberidaceae	Leaves, stem, root	Shrub	Stomachic, expectorant and the leaves paste with tomatoes is used with various dishes and the fruits are edible
Caltha alba Jacb.	Makhanpath	Ranunculaceae	Aerial parts	Herb	Antispasmodic and used as pot-herb
Capsella bursa-pastoris L.	Barmbaisa	Brassicaceae	Leaves, stem and flowering tops	Herb	Stimulant, diuretic and rarely used as vegetable
Caralluma edulis (Edgew.) Benth. and Hook.	Pamnkai	Asclepiadaceae	Aerial parts	Herb	Carminative and used as vegetable
Debregeasia saeneb (Forssk) Hepper and Wood	Ajlai	Urticaceae	Aerial parts and fruits	Shrub	Fruits are edible and also used as flavoring agent and antifungal and curing skin problems,
Oxalis stricta L.	Tarookay	Oxalidaceae	Aerial parts	Herb	Used as flavoring agent, eaten as salad and mixed and cooked with conventional and wild vegetables
Nasturtium officinale L.	Tara Mira	*Brassicaceae*	Aerial parts	Herb	Used as wild vegetable
Oxallis corniculata L.	Gardai tarukay	Oxalidaceae	Flower and Leaves	Herb	Anti-scorbutic and Flavoring agent
Plantago major L.	isphagol	Plantaginaceae	Whole plant	Herb	Leaves are edible,
Rumex hastatus D. Don	Tarookay	Polygonaceae	Aerial parts and roots	Herb	Raw, Cooked and Extracts
Sisymbrium officinale L.	Sharshum	Cruciferae	Aerial parts	Herb	Leaves are eaten as salad and it is also used as vegetable
Zanthoxylum alatum DC.	Dambara	Rutaceae	Bark, Stem, Fruits and seeds	Shrub	used as condiment, flavoring agent
Zizyphus oxyphyla Edgew.	Elanai	Rhamnaceae	Roots, fruits	Shrub	Roots are used in curing jaundice. Fruits are edible and used in gas trouble.
Zizypus numularia (Burm. f.) Wight and Arn.	Kurkanda	Rhamnaceae	Roots, fruits, branches and leaves	Shrub	Fruits are Edible and laxative with sour taste while leaves are used in scabies and boils.

level of total oxalates, soluble oxalates and phytic acid whereas moderate level of Tannins and total phenols, which was found to be in the range of total oxalates (14.34-362.66), soluble oxalates (6.87-211.23), phytic acid (5.97-33.09) and tannins (7.27-108.49) mg 100^{-1}g. Similar pattern of anti-nutritional contents of some of the unconventional food plants were reported (Shingade *et al.,* 1995). Total phenols varied from 23.35 to 316.66 mg/100 g in the analysed plants. Likewise, maximum value of percent antioxidant activity was observed in *Sisymbrium officinale* (45.66%), whereas minimum in *Zanthoxylum alatum* (9.67%). It can be concluded that the wild edible species are a good source of various nutrients (Table 3).

The present study also investigated fourteen (14) elements (Ca, Mg, Na, K, P, Zn, Cu, Mn, Fe, Se, Cr, Pb, Ni and Cd) in the studied plants. Table 4 shows the mean concentration of various elements in the studied plants based on the dry weight of the plant. The results revealed that different mineral matter of the investigated plants ranged from 0.001- 540 mg 100^{-1} g (Table 4). Heavy metal contents were in descending order of K> Ca> P >Na>Mg>Fe > Mn > Zn > Cu >Ni >Se whereas Se, Cr, Ni, Pb and Cd were not detected in some species. Similar pattern was also reported by Guil *et al.* (1996), Barminas *et al.* (1999) and Maiga *et al.* (2005). Highest amount of iron and copper was found in *Oxalis stricta* (7.283 mg 100^{-1}g) and *Zanthoxylum alatum* (6.34 mg 100^{-1}g), respectively whereas maximum amount of zinc and selenium was found in *Rumex hastatus* (0.073 mg 100^{-1}g) and *Berberis lycium* (0.049 mg 100^{-1}g), respectively as compared to other species. Manganese content varied from 0.016 mg 100^{-1}g (*Berberis lycium*) to 0.052 mg 100^{-1}g **(***Oxalis stricta*). Zn plays an important role as an antioxidant in animal (Bray and Betteger, 1990) as well as in plant membranes (Din *et al.,* 1996). This may be the possible reason that wild plants are considered good antioxidant sources (Kumari *et al.,* 2004). Latest research confirms the role of wild plants as bio-indicator and accumulator for atmospheric and soil pollution (Bonanno and Giudice, 2010; Ruiz and Velasco, 2010; Al-Yemni *et al.,* 2011). Results of the present study revealed that the studied plants were poor sources of lead, cadmium, chromium and nickel. The nickel content ranged from 0.012-0.083 mg 100^{-1}g, however, in some species the concentration was not detectable.

Table 2: Analysis of different nutritional contents of examined plants.

Subject Plants	Part analyzed	Moisture	Ash	Protein	Crude Fiber	Fat	NFE Contents	Energy Content (KCal 100^{-1} g)	β-Carotene mg 100^{-1} g	Vitamin C mg 100^{-1} g
		Percentage								
Plantago major	Aerial part	78.68±0.52	2.77±0.22	4.72±-0.13	4.28±0.64	1.63±0.43	8.02±3.14	69.62±7.13	35.02±1.02	42.57±2.82
Nasturtium officinale	Aerial part	80.08±4.97	3.07±0.13	3.61±0.08	9.43±0.61	1.12±0.05	2.70±4.18	37.32±3.58	209.60±7.77	51.85±1.98
Rumex hastatus	Aerial part	50.07±0.93	1.48±0.15	13.78±0.29	28.43±0.56	2.50±0.15	3.40±3.14	96.62±4.76	178.35±0.44	29.290±0.48
Sisymbrium officinale	Aerial part	75.48±1.42	1.84±0.13	4.76±0.12	14.72±0.72	1.51±1.12	1.64±0.75	42.44±6.85	203.79±3.46	32.05±0.96
Berberis lycium	Leaves and fruits	77.86±5.42	2.78±1.02	3.83±2.43	12.33±4.72	0.98±2.32	2.24±1.15	35.02±3.42	91.54±3.42	13.68±3.42
Oxalis stricta	Aerial part	84.78±3.62	2.48±0.89	3.08±1.76	7.55±3.12	0.89±0.38	1.22±0.45	26.589±5.36	24.95±1.22	52.48±5.57
Zanthoxylum alatum	Fruits and seeds	39.78±1.89	2.28±0.58	6.58±1.35	11.67±2.02	4.13±1.23	35.57±3.15	218.46±5.44	5.24±1.35	1.65±0.87

Table 3: Phytochemical/anti-nutritive compounds and anti-oxidant activity of examined plants.

Subject Plants	Total oxalates	Soluble oxalates	Phytic acid	Tannins	Total phenols	Antioxidant activity
	mg 100^{-1} g					Percentage
Plantago major	103.00±2.64	13.33±0.88	21.23±1.18	24.34±2.33	59.67±1.20	27.51±0.54
Nasturtium officinale	362.66±2.33	170.00±1.57	13.55±0.44	59.66±1.45	70.34±4.37	37.96±1.74
Rumex hastatus	320.33±4.33	186.00±7.50	33.09±1.49	108.49±5.78	316.66±2.02	32.34±2.47
Sisymbrium officinale	254.00±4.04	101.66±3.75	10.53±0.49	83.66±2.40	173.33±3.52	45.66±1.82
Berberis lycium	14.34±2.33	7.53±0.19	5.97±3.20	7.27±1.52	23.35±3.54	15.22±1.31
Oxalis stricta	321.34±2.33	211.23±0.37	28.36±1.34	11.29±2.64	62.11±2.23	23.97±2.52
Zanthoxylum alatum	23.34±2.33	6.87±0.56	6.67±1.28	16.57±3.45	30.21±3.85	9.67±1.29

Table 4. Elemental composition (mg 100^{-1}g) in selected wild plants collected from various region of Khyber Pukhtunkhwa.

Elements	*Rumex hastatus*	*Sisymbrium officinale*	*Plantago major*	*Nasturtium officinale*	*Berberis lycium*	*Oxalis stricta*	*Zanthoxylum alatum*
Lead	0.0014±0.001	ND	0.001±0.001	ND	ND	ND	0.002±0.001
Selenium	ND	0.023±0.01	ND	0.025±0.001	0.049±0.002	ND	ND
Cadmium	0.002±0.001	0.002±0.001	ND	0.001±0.0013	ND	0.001±0.002	0.001±0.001
Chromium	0.004±0.002	0.0031± 0.001	0.002±0.001	0.003±0.001	ND	0.001±0.001	ND
Zinc	0.073±0.04	0.031± 0.002	0.062±0.013	0.045±0.004	0.042±0.002	0.071±0.015	0.032±0.012
Copper	0.02±0.01	0.12± 0.05	0.17±0.03	1.07±0.05	3.54±1.09	0.25 ±0.01	6.34±2.69
Manganese	0.034±0.011	0.042±0.012	0.023±0.005	0.046±0.04	0.016±0.01	0.052±0.018	0.043±0.017
Iron	3.876±0.518	1.147±0.015	2.1918±0.32	4.1835±1.171	0.175±0.051	7.352±0.412	0.425±0.02
Nickel	0.012±0.01	0.037±0.01	0.031±0.001	0.083±0.004	ND	0.012±0.001	ND
Sodium	25.20±3.36	12.93±1.61	30.93±8.87	19.23±5.31	7.84±2.09	1.49 ±0.01	5.84±2.09
Potassium	353.77±13.46	452.37±11.05	539.60±10.20	278.90±17.08	65.18±8.02	120.12±0.01	87.84±8.34
Calcium	175.29±10.28	235.46±11.22	306.64±14.25	153.00±8.04	110.84±7.55	105.63±9.34	96.78±6.86
Manganese	7.84±1.09	8.57±2.06	10.84±2.34	6.48±1.06	4.50±2.10	7.85±3.10	9.80±2.61
Phosphorus	15.47±.15	12.30±3.10	17.50±3.20	14.50±1.10	10.84±3.34	12.93±1.61	17.52±1.41

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