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Nutritional composition, vitamins, minerals and toxic heavy metals analysis of *Trianthema portulacastrum* L., a wild edible plant from Peshawar, Khyber Pakhtunkhwa, Pakistan

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This study aimed at analyzing the nutritional potential of a wild edible plant, *Trianthema portulacastrum* L. widely used in Peshawar, Khyber Pakhtunkhwa, Pakistan. The nutritional composition, vitamins, minerals and heavy elements were analyzed following the standard methods of Association of Official Analytical Chemists (AOAC). The nutritional assessment included determination of moisture, ash, lipid, fiber, protein, carbohydrate and energy. Among the nutrient values, fiber was found to be the highest (430.0 mg/g), followed by ash (348.0 mg/g), total protein (91.9 mg/g), moisture (80.0 mg/g), carbohydrate (30.2 mg/g) and total lipid (20.0 mg/g). The vitamins analyzed were found to have greater value for riboflavin (2.02 mg/g), than retinol (0.81 mg/g). Among the macro minerals, potassium was present in high concentration (51.6 mg/g) than sodium (44.0 mg/g). The trace elements were assessed using atomic absorption spectrophotometer (AAS) and their decreasing order was Fe>Zn>Mn>Ni>Cu. Two toxic metals, Pb and Cd were present in very minute quantities of 0.08 and 0.0006 mg/g, respectively. The results suggest that *T. portulacastrum* L. is a good source of fiber, proteins, riboflavin, potassium, sodium and iron.

Key words: Peshawar, Association of Official Analytical Chemists (AOAC), *Trianthema portulacastrum* L., nutritional composition, vitamins, minerals.

INTRODUCTION

Nutrition is the most important fundamental needs of humans, for development, productivity and mental health. In developing world, the high rate of population growth, cause shortage of fertile land, leading to hunger and malnutrition problems (Pelletier et al., 1995). Plants have been handled by human societies for food purposes, since time immemorial. It is true that today, human plant food is more than 85 to 90% based on mainly twelve crops, but it is also fact that in many parts of the world, wild plants have major contribution in daily intake of food (Prescott-Allen and Prescott-Allen, 1990; Scherrer et al., 2005; Bussmann et al., 2006; Bussmann and Sharon, 2006; Kunwar et al., 2006; Cavender, 2006; Pieroni et al., 2007). Green leafy vegetables are well known for their

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Table 1. Description of the selected sample plant analyzed.

Vernacular names		**Scientific Classification**	
English	Horse purslane	Kingdom	*Plantae*
Urdu	Narma	Subkingdom	Tracheobionta
Pujabi	It sit	Super division	Spermatophyta
Hindi	Santhi, Patharchata	Division	*Magnoliophyta*
Sanskrit	Chiratika	Class	*Magnoliopsida*
Marathi	Pundharighentuli	Subclass	*Caryophyllidae*
Telugu	Ambatimaadu	Order	*Caryophyllales*
Arabic	Zaleya pentandra	Family	*Aizoaceae*
Indonesian	Subang-subang	Genus	*Trianthema*
Thai	Phak bia hin	Species	*Trianthema portulacastrum* L.

nutritional importance as rich sources of proteins, vitamins like ascorbic acid, carotene, folic acid, riboflavin, and minerals like calcium, iron and phosphorus (Kris-Etherton et al., 1988; NRC, 1996; Osler et al., 2001; Sheela et al., 2004). Green wild edible plants are commonly found in countries with varied climates. Many research studies have shown several wild species fit for human consumption due to good proximate and nutritional values. Even in some modern cultures today, people consume wild plants as a normal food source, for obtaining good amounts of several nutrients and it is widely accepted that leafy green vegetables are significant nutritional sources of minerals (Grau et al., 1989; Kuhnlein, 1990; Khan et al., 2013a).

Around the world, many workers have reported the nutritional compositional evaluation and functional properties of various types of edible wild plants used in the developing countries (Lockeett et al., 2000; Akindahunsi and Salawu, 2005; Edeoga, 2006; Hassan and Umar, 2006; Ekop, 2007; Adnan et al., 2010; Mohan and Kalidass, 2010; Hussain et al., 2010; Gafar and Itodo, 2011; Vishwakarma et al., 2011; Valvi and Rathod, 2011; Naryan et al., 2011; Seal, 2011). Since Pakistan came into being, numerous wild vegetables are used as food in both urban and rural areas. The researchers have investigated several wild plants of Pakistan, for nutritional composition (Khattak et al., 2006; Imran et al., 2007; Qureshi and Bhatti, 2009; Hussain et al., 2009; Marwat et al., 2010; Jan et al., 2011; Khan et al., 2011, 2013b). The database of the nutrient and chemical compositions of these plant foods is still incomplete as many plants are still not investigated properly and thus much work is still needed to be done. In Peshawar Pakistan, many of the local wild vegetable materials are used as food without any nutritional studies.

In order to contribute to the growing body of knowledge and to narrow the growing gap of this subject, the present study was designed on wild edible plant, *Trianthema portulacastrum* L. commonly used as food by the people in Peshawar, Khyber Pakhtunkhwa, Pakistan, to analyze for proximate and nutrient analysis, vitamins, minerals, trace and toxic trace metals, using standard AOAC methods.

MATERIALS AND METHODS

Collection of samples

The plant materials were collected from the provincial capital city, Peshawar, as wild grown plants in agriculture fields. Ten samples were collected, at three times from different fields, during July to November 2011, and each sample was studied in triplicate, thus making a total of 90 samples analyzed. Standard methodology was used for collection of plant samples (Humphry, 1993). Specific samples were obtained with the aid of interpreters and field guides. Genus and species was identified by plant taxonomist, by comparison with herbarium reference materials. The voucher specimen was preserved in Department of Plant Sciences, KUST, Kohat, for future references. The samples were shed dried, pulverized and stored in an airtight container. Details of each plant species, in respect of their scientific, family and local names, part used and status are elaborated in Table 1 (Shah et al., 2006; ENVIS, 2012).

Nutritional composition

The content of moisture was measured by keeping the sample in oven (HB-502M Hanbaek Co, Korea) at 100 to 110°C for overnight and then cooling in desiccator to constant weight. The loss in weight was regarded as a measure of moisture. For determination of ash, the sample was heated in furnace (F6010, Branstead Thermolyne Co., Dubuque, IA, USA), at 550°C, until white or grayish white ash was obtained. Weight of the ash was noted directly. Crude fiber was determined by treating the sample with 1.25% H_2SO_4, 1.25% NaOH and then 1% HNO_3, filtered and washed with hot water after each step. The residue obtained was dried in oven at 130°C and ashed at 550°C in furnace. The loss in weight on ignition was expressed as content of crude fiber (AOAC, 2000). Total lipid was extracted from the sample with petroleum ether (60 to 80°C) in a Soxhelt apparatus for about 6 to 8 h. The

Table 2. Nutritional composition of the sample plant *Trianthema portulacastrum* L. analyzed.

Nutritional parameter	Quantity (mg/g±SD)
Moisture	$80.0^{e} \pm 2.2$
Ash	$348.0^{g} \pm 6.2$
Total lipid	$20.0^{c} \pm 0.6$
Saponifiable lipid	$11.2^{b} \pm 0.8$
Non saponifiable lipid	$8.8^{a} \pm 0.2$
Total protein	$91.9^{f} \pm 3.2$
Fiber	$430.0^{h} \pm 8.2$
Carbohydrate	$30.2^{d} \pm 1.2$
Energy (kcal/ 100 g)	76.01

[a-h] Values are mean ± standard deviations of three (n = 3) measurements. Different superscript letters within same columns are significantly different ($p < 0.05$).

Table 3. Vitamins constituents of the sample plant *Trianthema portulacastrum* L. analyzed.

Vitamin	Quantity (mg/g ± SD)
Vitamin A	$0.81^{a} \pm 0.2$
Vitamin B_2	$2.02^{b} \pm 0.3$

[a-b]Values are mean ± standard deviations of three (n = 3) measurements. Different superscript letters within columns are significantly different ($p < 0.05$).

Table 4. Minerals and toxic heavy metals of the sample plant *Trianthema portulacastrum* L. analyzed.

Mineral	Quantity (mg/g ± SD)
Macro-mineral	
Sodium	$44.00^{f} \pm 1.4$
Potassium	$51.60^{g} \pm 5.2$
Micro-mineral	
Zinc	$0.20^{d} \pm 0.02$
Copper	$0.02^{c} \pm 0.1$
Iron	$6.44^{e} \pm 0.4$
Manganese	$0.04^{c} \pm 0.01$
Nickel	$0.03^{c} \pm 0.006$
Toxic heavy metal	
Lead	$0.08^{b} \pm 0.01$
Cadmium	$0.0006^{a} \pm 0.0001$

[a-g] Values are mean ± standard deviations of three (n = 3) measurements. Different superscript letters within columns are significantly different ($p < 0.05$).

residual solvent was evaporated in a pre-weighed beaker and increase in weight of beaker gave total lipid (AOAC, 2000). Total lipid content was fractionated into saponfiable and non-saponfiable lipids by the saponification of total lipid followed by extraction of non-saponifiable fraction with petroleum ether, 40 to 60°C (AOCS, 1993).

Nitrogen content in the sample was estimated by using micro Kjeldahl method and crude protein was calculated by multiplying the evaluated nitrogen by 6.25. The value of total carbohydrate was given by: 100- (percentage of ash + percentage of total lipid + percentage of protein + percentage of crude fibre) (AOAC, 2000). The calorific value was calculated by multiplying the values of total carbohydrate, lipid and protein by the factors 4, 9 and 4 respectively, taking the sum of the products and expressing the result in kilocalories (Guil-Guerrero et al., 1998).

Vitamins analysis

Vitamin A was estimated by extraction with ethanol and then mixing with petroleum ether. The amount in extract was determined by UV-Visible Spectrophotometer (Hitachi U-2000, Japan) at 450 nm using Fikselova (2008). For riboflavin (vitamin B_2), the ethanol extract was added to potassium permanganate and H_2O_2 and allowed to stand over hot water. Then 40% sodium sulphate was added and the absorbance was measured at 510 nm by spectrophotometer (James, 1995).

Minerals and toxic heavy metals analysis

Two macro minerals, sodium and potassium were estimated by using flame photometer (Model 410 Corning, Germany). Standard solution of each was used for calibration of the instrument before analysis (AOAC, 2000). The micro minerals including Zn, Cu, Ni, Mn, and Fe along with toxic heavy metals Pb and Cd were determined by wet digestion of the sample followed by analysis using atomic absorption spectrophotometer (A-Analyst 700 Perkin Elmer/ USA) equipped with standard burner, air acetylene flame and hollow cathode lamps as radiation source (Indrayan et al., 2005).

Statistical analysis

Data were reported as mean ± standard deviation of triplicate measurements. Significant differences ($p < 0.05$) within means were analyzed by analysis of variance (ANOVA) and Tukey's honestly significant difference (HSD) test in the SPSS Statistics Software Version 20 (IBM, New York, USA).

RESULTS AND DISCUSSION

The proximate and nutritional contents are mentioned in Table 2, vitamins constituents in Table 3, while minerals and toxic heavy metals are given in Table 4. The results are discussed in comparison with published literature and biological applications under the following four headings.

Nutritional composition

Moisture is considered as a good source of water and it is necessary that 20% of the total water consumption must come from food moisture (FNB, 2005). The average

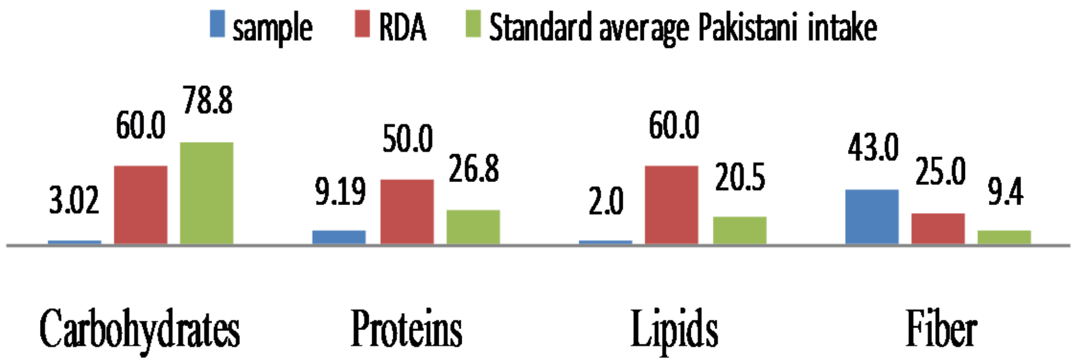

Figure 1. Nutritional composition in comparison with RDA and average nutrient intakes in Pakistan.

moisture content of *T*. *portulacastrum* L. studied was 8.0% (Table 2), very low compared to other wild edible plants such as *Amanthus viridus*, *Chenopodium murale*, *Nastrium officinale* and *Scandex pectin-veneris* with 88.90, 89.50, 90.54 and 81.31% respectively (Imran et al., 2007). However, it was very close to some common leafy vegetables such as *Xanthosem sagittifolum* (13.17%) and *Adensonia digitata* (9.5%) (Ladan et al., 1996). Ash content is the index of mineral contents in plants such as calcium, sodium, potassium, nickel and zinc. The ash content of the sample studied was 34.8% (Table 2), which showed that the leaves were rich in minerals. The value obtained was higher compared to 1.8% reported in sweet potato leaves, and 5% in *Tribulus terristris* leaves, 1.85% in *A*. *viridus* leaves, 2.70% in *C*. *murale* leaves, 1.77 and 3.10%, in *N*. *officinale* and *S*. *pectenveneris* leaves respectively (Imran et al., 2007). The crude protein content of the sample was found to be 9.19% (Table 2). This value was higher compared to 2.11% in *A*. *viridus*, 2.98% in *C*. *murale* leaves, 2.76% in *N*. *officinale*, 6.30% in water spinach and 6.40% in *Momordica foecide* leaves (Imran et al., 2007). But lower than 11.29% in balsam apple leaves, 24.85% in sweet potato leaves, *Piper guineeses* and *Talinum triangulare* with values of 29.78 and 31.00%, respectively (Akindahunsi and Salawu, 2005).

Among the reported wild edible plants of the same family, sample leaves contain higher crude protein value. According to the WHO recommended dietary allowance (RDA) of protein, for children, adult male and adult female is 28, 63 and 50 g respectively (Akindahunsi and Salawu, 2005), while in Pakistan the average protein intake is 43.4g/day (Figure 1) (NNSP, 2011). As the plant protein is also considered as biological value, so for 100 g of *T*. *portulacastrum* L. provide 9.19 g of proteins indicate that the sample plant is a good source of daily proteins. Lipid in food is considered as a chief source of storage form of energy, essential fatty acids and fat soluble vitamins and precursors of vitamins. The sample plant contained 2.0% crude lipid (Table 2). It is lower than 11% in water spinach leaves, 12% in *Senna obtusfolia*, 11% in *Amaranthus caudatus* leaves, 28.2% in *Centilla asiatica* leaves, 29% in *Bahunian purpurea* leaves and 60% in *Amaranthus hybridus* but higher than 0.47% in *Amaranthus viridus*, 0.54% in *C*. *murale* and 0.63% in *S*. *pectenveneris* leaves (Imran et al., 2007). The crude fiber content of sample leaves was 43% which is higher compared to 7.20% in sweet potato leaves, 13% in *Tribubus terristris* leaves, 29.0% in balsam apple leaves, 1.93% in *A*. *viridus*, 3.82% in *S*. *pectenveneris* leaves (Akindahunsi and Salawu, 2005).

Dietary fiber helps to reduce serum cholesterol level, risk of coronary heart diseases, colon and breast cancer and hypertension. The high level of fiber in diet can cause intestinal irritation, lower digestibility, difficult absorption of minerals found in plant and overall decrease nutrient utilization (Imran et al., 2007). The carbohydrate content of sample leaves was 3.02%, considerably low when compared to other wild edible plants such as *A*. *caudatus* leaves (61.03%), 55.67% in *T*. *terristris*, 54.2% in water spinach leaves, 75% in sweet potato leaves, 82.8% in *Corchorus triden* leaves. But closely similar when compared to *A*. *viridus*, *C*. *murale*, *Nastritium officinale* and *S. pectenveneris* leaves that is 4.74, 3.41, 3.38 and 7.32% respectively (Imran et al., 2007). Carbohydrates are principal and indispensible source of energy. The RDA for carbohydrates is 130 g (FAO, 1998), while in Pakistan 349 g of carbohydrate intake is reported (Figure 1) (Ministry of Health and Nutrition, 1994). Due to carbohydrates content sample, plant can be a good food source. The 100 g of *T. portulacastrum* L. provide 76.01 kcal of energy. This reveals that the sample plant can contribute meaningfully to the daily energy requirement of a person.

The caloric value of the sample plant was high compared to *A*. *viridus* (31.63 kCal), *S*. *pectenveneris*

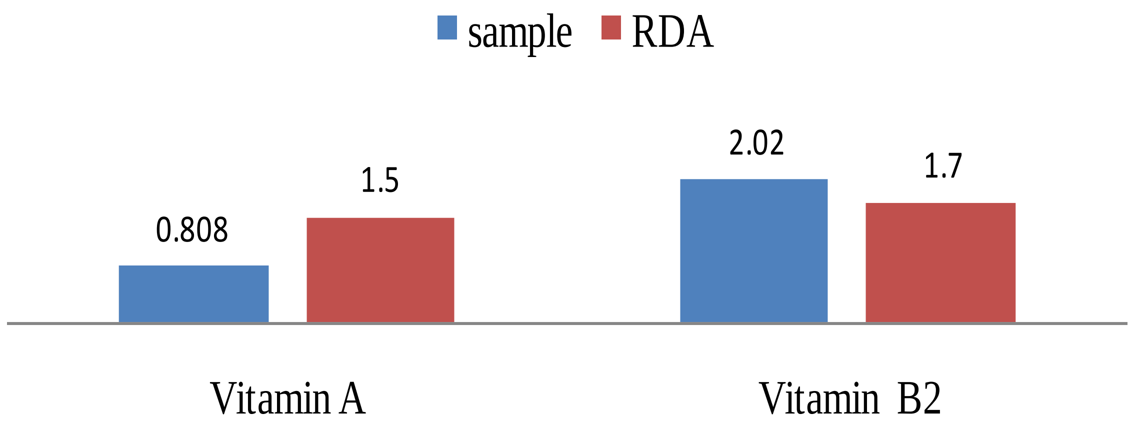

Figure 2. Vitamins content in comparison with RDA.

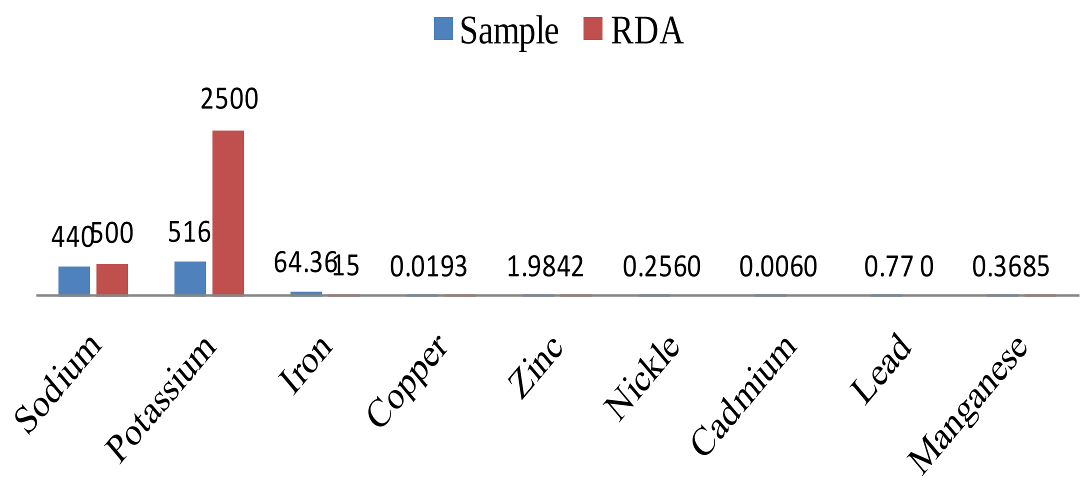

Figure 3. Sodium and potassium contents in comparison with RDA.

(50.23 kcal) (Imran et al., 2007), but lower when compared to *A*. *caudatus* 326.7 Kcal, *Discorea bulbifera* 304.7 kcal and 333.1 kcal of *Ficus bengalensis* (Imran et al., 2007).

Vitamin analysis

Vitamin A is necessary for vision process and also plays a role in skin mucosa, normal reproductive capabilities and is an important anti oxidant (FAO, 2001). The sample contained 0.081 mg/100 g of vitamin A (Table 3). The RDA for vitamin A is 1.5 mg/100 g (Figure 2). The results show that the sample is not a good source of vitamin A. The sample contained 0.202 mg/100 g of vitamin B_2. The RDA for riboflavin is 1.7 mg. The results show that it is a rich source of riboflavin compared to vitamin A. Riboflavin is present in body as co–enzyme which acts as hydrogen acceptor in amino acid metabolism (FAO, 2001).

Minerals analysis

Sodium maintains fluid volume outside the cell thus normalize the cell functions. The sodium content of the sample was 44 mg/g (Table 3), slightly low compared to reported (50 mg/g) for *Tribus terristis* leaves and very low than 450 mg/kg in *S*. *obtusfolia* but quite high in comparison to *Asparagus officinalis* (0.184 mg/kg) and *Momordica dioica* (0.151 mg/kg) (Khan et al., 2011). The RDA for sodium is 500 mg for adults (Figure 3). The plant sample leaves can be good source of food for hypertensive patients (FAO, 2001). Potassium content of the sample was 51.60 mg/g (Table 4), high compared to other green leafy vegetables as 64.2 mg/kg found in *Diospyros mespiliformis*, 1.09 mg/kg in *A*. *officinalis*, 0.825

mg/kg in *M*. *dioicas* and 4.409 mg/kg in *I. astrgaalina* (Khan et al., 2011). The RDA for potassium is 2500 mg for adults (Figure 3), and the sample contributes good percentage to RDA, meaning the good source that can contribute to the diet of hypertensive patients (FAO, 2001).

Micro minerals analysis

The copper content of plant sample is 20 mg/kg (Table 4), which is higher compared to 0.1 mg/kg in *D*. *mespiliformis* and 0.25 mg/kg in *F*. *bengalensis*, 12.8 mg/kg in *T. terristis* leaves and 5.0 mg/kg in *Cassia siamea* leaves (Khan et al., 2011; Gafar and Itodo, 2011). The RDA value for copper is 1 to 3 mg for adult (Figure 3). Copper contributes a role in hemoglobin formation and play a role in iron and energy metabolism (FAO, 2001). The zinc content of sample leaves was found to be 200 mg/kg, higher compared to 0.200 mg/kg in *Diospyros mespiliformis*, 1 mg/kg in *T. terristris* leaves but lower when compared to 68.5 mg/kg in *C*. *siameea* (Khan et al., 2011; Gafar and Itodo, 2011). Zinc plays a vital role in gene expression, regulation of cellular growth and participates as a cofactor of many enzymes. It also plays an important role in motility of sperm during liquation and mating. The RDA of zinc is 12 to 15 mg for adults (FAO, 2001). Iron content of sample was 6.44 mg/g, higher than other vegetables like *C. siamea* 700 mg/kg (Khan et al., 2011). The RDA value of iron is 10 to 15 mg/100 g. This sample is a good source of iron. Iron is required for hemoglobin formation and its deficiency leads to anemia (FAO, 2001). Manganese content of plant sample was 40 mg/kg higher than 9.8 to 38 mg/kg reported in some leafy vegetables and lower than 116 mg/kg in balsam apple leaves (Khan et al., 2011). The RDA for manganese is 2 to 5 mg. The result showed that *T*. *portulacastrum* L. is a good source to provide daily manganese.

Manganese is a co-factor for many enzymes which take part in glucose and amino acid metabolism (FAO, 2001). The amount of nickel present was 30 mg/kg in the sample. This quantity was quite higher when compared to other edible wild plants like *F*. *bengalensis* 1.14 mg/kg (Gafar and Itodo, 2011). Nickel is needed in very small amount to the body. The health benefits of Ni are healthy skin and optimal growth and also take part in iron metabolism. Higher quantity leads to toxicity (Gafar and Itodo, 2011).

Toxic heavy metals analysis

The lead content of sample was 80 mg/kg (Table 4), higher compared to *F*. *bengalensis* (0.25 mg/kg). Lead is toxic and non essential element for human body as it causes rise of blood pressure, kidney damage, miscarriage, subtle abortion, brain damage, decline fertility of men through sperm damage and diminishes learning abilities due to neuron damaging actions (Gafar and Itodo, 2011). Cadmium concentration of *T*. *portulacastrum* L. was 0.6 mg/kg higher compared to *F*. *bengalensis* (0.017 mg/kg) and lower than other usual edible plants. Cadmium is highly toxic for a body and it causes several health hazards, including cell death and cell proliferation (Gafar and Itodo, 2011).

Conclusions

The present study provides an evidence of the potential nutritional value of the selected wild edible plant, *T*. *portulacastrum* L. It showed to have good proximate values of proteins, lipids, carbohydrates, fiber and moisture. The macro minerals (Na and K), micro minerals (Fe, Cu, Ni and Mn), and vitamins (A and B_2) were also present in appreciable quantities. The toxic heavy metals, Pb and Cd were present in very minute quantities and therefore may not pose any threat to health. Though, *T*. *portulacastrum* L., may not provide all nutrients required by man, yet it contains sufficiently good amount of some essential nutrients like vitamin B_1, iron and fiber. These results were making *T*. *portulacastrum* L., a good source of food and therefore could be recommended for edible purposes.

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REFERENCES

Adnan M, Hussain J, Shah MT, Shinwari ZK, Ullah F, Bahader A, Khan N, Khan AL, Watanabe T (2010). Proximate and nutrient composition of medicinal plants of humid and sub-humid regions in North-west Pakistan. J. Med. Plants Res. 4(4):339-345.

Akindahunsi AA, Salawu SO (2005). Phytochemical screening and nutritional, anti nutritional composition of leafy vegetables. Afr. J. Biotechnol. 4(6):496-504.

AOAC (2000). Association of Official Analytical Chemists. Official methods of analysis of AOAC international, 17th Edn., Washington DC, USA.

AOCS (1993). American Oil Chemists Society. Official and tentative methods of analysis, 4th Edn., AOCS., Champaign, IL. USA.

Bussman RW, Sharon D (2006). Traditional medicinal plant use in Northern Peru: tracking two thousand years of healing culture. J. Ethnobiol. Ethnomed. 2:47.

Bussmann RW, Gilbreath GG, Solio J, Lutura M, Lutuluo R, Kunguru K, Wood N, Mathenge SG (2006). Plant use of the Maasai of Sekenani Valley, Maasai Mara, Kenya. J. Ethnobiol. Ethnomed. 2:22.

Cavender A (2006). Folk medicinal uses of plant foods in southern Appalchia, United States. J. Ethnopharmacol. 108: 74-84.
Edeoga HO, Omosun G, Uche LC (2006). Chemical composition of *Hyptis sauveolens* and *Ocimum gratissium* hybrids from Nigeria. Afr. J. Biotechnol. 5(10):892-895.
Ekop AS (2007). Determination of chemical composition of *Gnetum africana* (AFANG) seeds. Pak. J. Nutr. 6(1):40-43.
ENVIS (2012). Environmental Information centers on medicinal plants. Available online at: (http://envis.frlht.org/botanical_search.php). Accessed on June 20, 2012.
FAO (1998). Carbohydrates in human nutrition, Food and Agriculture Organization of the United Nations: Rome. Report of a Joint FAO/WHO Expert Consultation. FAO Food Nutri. pp. 66
FAO (2001). Human vitamin & mineral requirements. Report of a joint FAO/WHO expert consultation Bangkok, Thailand.
Fikselova M, Silhar S, Marecek J, Francakova H (2008). Extraction of carrot (*Daucus carota* L.) carotenes under different conditions. Czech J. Food Sci. 26:268-274.
FNB (2005). Food and Nutrition Board. Dietary reference intakes for water, potassium, sodium, chloride, and sulfate. The National Academies Press, 500 Fifth Street, N.W. Washington, DC 20001, USA. pp 77-185.
Gafar MK, Itodo AU (2011). Proximate and mineral composition of hairy indigo leaves. Elec. J. Env. Agricult. Food Chem. 10(3):2007-2018.
Grau J, Jung W, Muznker B (1989). Plantas Medicinales, Bayasy, Y Verduras silvestres, 1st Edn., Blume, Barcelona, Spain. p 287.
Guil-Guerrero JL, Gimenez-Gimenez A, Rodriguez-Garcia I, Torija-Isasa ME (1998). Nutritional composition of Sonchus species (S. asper L., S. oleraceus L., and S. tenerrimus L.). J. Sci. Food Agric. 76:628-632.
Hassan LG, Umar KJ (2006). Nutritional value of Balsam Apple (*Momordica balsamina* L.) leaves. Pak. J. Nutr. 5(6): 522-529.
Humphry CM, Clegg MS, Keen CL, Grivetti LE (1993). Food diversity and drought survival. The Hausa example. Int. J. Food Sci. Nutr. 44(1):1-16.
Hussain J, Khan AL, Rehman N, Hamayun M, Shah T, Nisar M, Bano T, Shinwari ZK, Lee IJ (2009). Proximate and nutrient analysis of selected vegetable species: A case study of Karak region, Pakistan. Afr. J. Biotechnol. 8(12):2725-2729.
Hussain J, Muhammad Z, Ullah R, Khan FU, Ullah I, Khan N, Ali J, Jan S (2010). Evaluation of the chemical composition of *Sonchus eruca* and *Sonchus asper*. J. Am. Sci. 6(9):231-235.
Imran M, Talpur FN, Jan MI, Khan A, Khan I (2007). Analysis of nutritional components of some wild edible plants. J. Chem. Soc. Pak. 29(5):500-505.
Indrayan AK, Sharma S, Durgapal D, Kumar N, Kumar M (2005). Determination of nutritive value and analysis of mineral elements of some medicinally valued plants from Uttaranchal. Curr. Sci. 89:1252-1255.
James CS (1995). Analytical chemistry of food. Chapman and Hall, London. pp. 64-65.
Jan G, Kahan MA, Ahmad M, Iqbal Z, Afzal A, Afzal M, Shah GM, Majid A, Fiaz M, Zafar M, Waheed A, Gul F (2011). Nutritional analysis, micronutrients and chlorophyll contents of *Cichorium intybus* L. J. Med. Plant Res. 5(12):2452-2456.
Khan KY, Khan MA, Niamat R, Munir M, Fazal H, Mazari P, Seema N, Bashir T, Kanwal A, Ahmed SN (2011). Element content analysis of plants of genus *Ficus* using atomic absorbtion spectrometer. Afr. J. Pharm. Pharmacol. 5(3):317-321.
Khan N, Ruqia B, Hussain J, Jamila N, Rahmsn NU, Hussain ST (2013a). Nutritional Assessment and Proximate Analysis of Selected Vegetables from Parachinar Kurram Agency. Am. J. Res. Comm. 1(8):184-198.
Khan N, Tahir N, Sultana A, Hussain I, Kim KS (2013b).Nutritional composition, vitamins, minerals and toxic heavy metals analysis of *Digera muricata* (L.) Mart. a wild edible plant from Peshawar, Pakistan. Afr. J. Pharm. Pharmacol. 7(25):1695-1702.
Khattak IA, Khan IA, Nazif W (2006). Weeds as human food- a conquest for cheaper mineral sources. J. Agric. Biolog. Sci. 1(2):12-15.
Kris-Etherton PM, Krummel D, Russell ME, Dreon D, Mackey S, Borchers J, Wood PD (1988). The effect of diet on plasma lipids, lipoproteins, and coronary heart disease. J. Am. Diet. Assoc. 88:1373-1400.
Kuhnlein HV (1990). Nutrient values in indigenous wild green plants and roots used by the Nuxalk People of Bella Coola, British Columbia. J. Food Comp. Anal. 3:38-46.
Kunwar RM, Nepal BK, Kshhetri HB, Rai SK, Bussmann RW (2006). Ethnomedicine in Himalaya: a case study from Dolpa, Humla, Jumla and Mustang districts of Nepal. J. Ethnobiol. Ethnomed. 2:27.
Ladan MJ, Bilbils LS, Lawal M (1996). Nutrient composition of some green leafy vegetables consumed in Sokoto, Nigeria. J. Basic. Appl. Sci. 5:39-44.
Lockeett CL, Calvert CC, Grivetti LE (2000). Energy and micronutrient Composition of dietary and Medicinal wild plants Consumed during drought: Study of Rural Fulani, Northeastern Nigeria. Int. J. Food. Sci. Nutr. 51(3):195-208.
Marwat KB, Hashim S, Ali H (2010). Weed Management: A case study from North-West Pakistan. Pak. J. Bot. 42:341-353.
Ministry of Health and Nutrition (1994). Recommended Dietary Allowances for dietary fiber. In: Recommended Dietary Allowance for the Japanese 5th edn. Daiich Shuppan Press: Tokyo. pp 58-59.
Mohan VR, Kalidass C (2010). Nutrtional and antinutritional evaluation of some unconventional wild edible plants. Tropic. Subtropic. Agroecosyst. 12(3):495- 506.
Naryan MKR, Anilkumar N, Balakarshan V (2011). Wild edible plants used by kattunaikka, paniya and kuruma tribes of wayand district, Kerala, India. J. Med. Plant Res. 5(15):3520-3529
National Research Council (1996). Carcinogens and Anticarcinogens in the Human Diet: A Comparison of Naturally Occurring and Synthetic Substances National Research Conncil, National Academy Press, Washington, DC, USA. pp. 19-34.
NNSP (2011). National Nutrition Survey of Pakistan. Pakistan Medical Research Council (PMRC) Nutrition Wing, Cabinet Division, Government of Pakistan, Supported by UNICEF Pakistan.
Osler M, Heitmann BL, Gerdes LU, Jorgensen LM, Schroll M (2001). Dietary patterns and mortality in Danish men and women: a prospective observational study. Br. J. Nutr. 85(2):219-225.
Pelletier DL, Frongillo EA Jr, Schroeder DG, Habicht JP (1995). The effects of malnutrition on child mortality in developing countries. Bull. World Health Organ. 73(4):443-448.
Pieroni A, Houlihan L, Ansari N, Hussain B, Aslam S (2007). Medicinal perceptions of vegetables traditionally consumed by south-Asian migrants living in Bradford, Northern England. J. Ethnopharmacol. 113:100-110.
Prescott-Allen OC, Prescott-Allen R (1990). How many plants feed the world? Conserv. Biol. 4:365-374.
Qureshi R, Bhatti GR (2009). Ethanobotanical uses of herbs from northern part of Nara desert Pakistan. Pak. J. Bot. 41(4):1565-1572.
Scherrer AM, Motti R, Weckerle CS (2005). Traditional plant use in the areas of Monte Vesole and Ascea, Cilento National Park (Campania, Southern Italy). J. Ethnopharmacol. 97:129-143.
Seal T (2011). Determination of nutritive value, mineral contents and antioxidant activity of some wild edible plants from Meghalaya state, India. Asian.J. App. Sci. 4(3):238-246.
Shah SRU, Qasim M, Khan IA, Shah SAU (2006). Study of medicinal plants among weeds of wheat and maize in Peshawar region. Pak J. Weed Sci. Res. 12(3):191-197.
Sheela K, Kamal G, Nath D. Vijayalakshmi GM, Yankanchi RBP (2004). Proximate Composition of Underutilized Green Leafy Vegetables in Southern Karnataka. J. Hum. Ecol. 15(3):227-229.
Valvi SR, Rathod VS (2011) Mineral composition of some wild edible fruits from Kolhapur district. Int. J. App. Biol. Pharm. Technol. 2(1):392-396.
Vishwakarma KL, Dubey V (2011). Nutritional analysis of indigenous wild edible herbs used in eastern chattisgarh, India. Emir. J. Food Agric. 23(6):554-560.