Analysis of Nutritional Components of Some Wild Edible Plants

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Summary: Analysis of nutritional components of *Amaranthus viridis*, *Chenopodium murale*, *Nasturtium officinale* and *Scandix pecten-veneris* was the objective of this study. Plants leaves were analysed for their proximate, minerals and fatty acid composition. Values for moisture, ash, crude protein, lipids, fibre, carbohydrates and computed energy are given. The essential bulk metal ions in the four vegetables were observed to be dominant, where K (2206-3600 mg/ 100g) was the highest and Na (109-381 mg/ 100g) was lowest. The decreasing order of essential trace metal ions concentrations was Fe > Cu > Zn > Mn > Cr > Ni. Gas chromatographic analysis revealed that palmitic acid (15.84-25.31 %) was the principal saturated; oleic acid (1.96-8.04 %) the highest monounsaturated, while α-linolenic acid (15.23-36.64 %) was found to be the predominant polyunsaturated fatty acid. The results of the study demonstrated that these wild plants could contribute useful amounts of macro and essential micronutrients, if integrated fully into human diets.

Introduction

Nutrition is the most important basic need, being a major determinant of health, labour productivity, and mental development. In most of the developing countries of the world, hunger and malnutrition are increasing due to population explosion, shortage of fertile land, and high food prices. Protein deficiency, for instance, is widespread and has been cited as the most common form of malnutrition in developing countries [1]. With a high protein content, along with energy values and the important vitamin and mineral content, green leafy vegetables have been recognized for their nutritional importance. They are rich sources of carotene, ascorbic acid, riboflavin, folic acid and minerals like calcium, iron and phosphorous. In nature, there are many under utilized greens of promising nutritive value, which can nourish the ever-increasing human population. Leafy vegetables, indeed, hold an important place in well-balanced diets. The idea of a well-balanced diet itself has changed in the recent years and lesser amounts of red meat and more vegetables and fruits are advised [2-5].

Edible wild greens are found in countries with rather varied climates. Many of them are resilient, adaptive and tolerant to adverse climatic conditions. Many contemporary authors consider several wild species of vegetables fit for human consumption [6]. Moreover, some modern cultures consume wild plants as a normal food source, obtaining fairly good amounts of several nutrients, and it is widely accepted that leafy green vegetables are significant nutritional sources of minerals [7].

The main constraint for the nutritional exploitation of these plants is the presence of certain anti nutritional and toxic substances such as nitrates, oxalates and saponins [8]. Nevertheless, these principles are also found in commercial leafy green vegetables. Furthermore, other nutrients, such as carotenoids and vitamin C are found in larger quantities in these plants [9].

Thus, while every measure is being taken to boost food production by conventional agriculture, a lot of interest is currently being focused on the possibilities of exploiting the vast numbers of less familiar plant resources existing in the wild [10]. Most reports on lesser known wild and unconventional crops indicate that they could be good sources of nutrients, and many have the potential of broadening the present narrow food base of the human species [11].

Looking into the prevalence of high levels of micro and macronutrients malnutrition among the vulnerable section of population, utilization of

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edible wild foods can be explored to overcome the nutritional disorders. Human populations of the north west region of Pakistan infact depend upon a number of plant foods to satisfy a substantial part of their nutritional requirements. However, the database of the nutrient and chemical compositions of these plant foods is incomplete. In order to contribute to the growing body of knowledge and to narrow knowledge gap on this subject, an attempt has been made to analyse some under utilized wild vegetables from north west region of Pakistan for their nutrient contents. Information about the names, families and areas of collection of these plants is given in Table-1.

Results and Discussion

Proximate Composition

Proximate composition of wild greens has been reported in Table-2. The moisture contents of plants ranged from 82.31 % in *Scandix pecten-veneris* to 90.54 % in *Nasturtium officinale*. With the exception of *Scandix pecten-veneris* the moisture contents of evaluated species, were in the same order as reported for most green leafy vegetables [12]. Ash values turned out to be high in *Scandix pecten-veneris* (3.10 %) and low in *Amaranthus viridis* (1.85 %). Ash content determined in *Amaranthus viridis* was slightly lower than reported by Ezeala [13]. Protein content of the samples ranged between 2.11 to 3.82 %. It was highest in *Scandix pecten-veneris*, followed by *Chenopodium murale* (2.98 %). The high crude protein content of these plants may encourage their use as high protein sources in some food formulations. It is remarkable that the total amounts of lipids in the edible wild plants studied are higher than the more common vegetables. *Scandix pecten-veneris* with 0.63 % showed the highest value followed by *Chenopodium murale*, (0.54 %), *Nasturtium officinale* (0.47 %) and *Amaranthus viridis* (0.42 %). Crude fibre content varied from 0.86 to 3.82 %, being lowest in *Chenopodium murale* and highest in *Scandix pecten-veneris*. The World Heath Organization (WHO) has recommended an intake of 223 g of fibre for every 100 kcal of diet [14]. Though it does not contribute to the nutritive value of foods, the presence of fibre in the diet is necessary for digestion and for efficient elimination of wastes [15]. Therefore the high level of fibre in plants is a desirable characteristic since fibres play an important role in the diet of humans and animal nutrition, however, the too high level of fibre in diet can cause intestinal irritation, lower digestibility, difficult absorption of mineral elements found in the plant and overall decreased nutrient utilization. Of all the plants studied, *Scandix pecten-veneris* (7.32 %) was highest in terms of total carbohydrates while others have total carbohydrate content ranging from 3.38 % in *Nasturtium officinale* to 4.74 % in *Amaranthus viridis*. The leaves had a high fuel value due to being protein and lipid rich. The energy content ranged between 28.34–50.23 kcal/ 100g.

Table-1. Description of Plants

S. No	Botanical Name	Family	English Name	Area of Collection
1	*Amaranthus viridis L.*	Amaranthaceae	Amaranth	Peshawar
2	*Chenopodium murale L.*	Chenopodiaceae	Nettle leaf goosefoot	Bannu
3	*Nasturtium officinale L.*	Brassicaceae (Cruciferae)	Watercress	Peshawar
4	*Scandix pecten-veneris L.*	Umbilliferae	Shepherd's needle, Clock needle	Manschra

Table-2. Proximate composition (%) of plants

Proximate composition	*Amaranthus viridis L.*	*Chenopodium murale L.*	*Nasturtium officinale L.*	*Scandix pecten-veneris L.*
Moisture	88.90	89.50	90.54	81.31
Ash	1.85	2.70	1.77	3.10
Crude protein	2.11	2.98	2.76	3.82
Total lipid	0.47	0.54	0.42	0.63
Crude fibre	1.93	0.86	1.13	3.82
Total carbohydrate	4.74	3.41	3.38	7.32
Energy (kcal/ 100g)	31.63	30.51	28.34	50.23

Carbohydrate and Lipid Composition

The various fractions of carbohydrates and lipids are presented in Table-3. Except for *Nasturtium officinale* (1.10 %), the difference in the total soluble sugar contents among the plant species was insignificant. *Amaranthus viridis, Chenopodium murale* and *Scandix pectin-veneris* showed, 0.75, 0.79 and 0.76 %, sugar contents respectively. The reducing sugars values ranged from 0.63 to 1.00 % being lowest in *Amaranthus viridis* and highest in *Nasturtium officinale*, while the amount of non-reducing sugars in the selected plants varied between 0.09 % in *Nasturtium officinale* to 0.12 % in each *Amaranthus viridis* and *Scandix pecten-veneris*. A range of values was observed for pectin content, being too low in *Nasturtium officinale* (0.02 %) while high in *Chenopodium murale* (0.33 %). Values for the available carbohydrate contents of these plants are substantially lower than present in the common edible plants [16].

Among the lipid fractions, significant amounts of saponifiable lipids were observed, ranging from 0.31 g/ 100g in *Nasturtium officinale* to 0.43 % in *Scandix pecten-veneris*. The non-saponifiable contents varied between 0.11g/ 100g in *Nasturtium officinale* to 0.20/ 100g in *Scandix pecten-veneris*.

Minerals Composition

Minerals composition of the plants, reported on dry weight basis, is given in Table-4. Mineral elements were found to vary widely depending on the species. Potassium, magnesium, and calcium were present in higher amounts. All the plants studied can contribute to diet in terms of sodium, potassium, calcium and magnesium. *Scandix pecten-veneris* offers the highest amounts of sodium (381 mg/ 100g) while *Amaranthus viridis* the lowest amount of it. Potassium content was found to be high in nearly all of the species analysed, especially in *Chenopodium murale* (3600 mg/ 100g). *Scandix pecten-veneris*, on the contrary, contained 1842 mg potassium in 100g of the plant material on dry weight basis. *Amaranthus viridis* and *Nasturtium officinale* showed identical potassium contents, 3460 mg/ 100g each.

Calcium, a mineral that is essential to bone structure and function, was found high in all of the species analysed, especially in *Scandix pecten-veneris*, (3200 mg/ 100g) followed by *Amaranthus viridis* (1680 mg/ 100g). *Nasturtium officinale*, to the contrary contained 818mg/ 100g calcium. Magnesium content varied largely among the greens ranging from 300mg/ 100 g in *Nasturtium officinale* to 1842mg/ 100 g in *Amaranthus viridis*. These values correspond to those reported by Duke

Table-3. Carbohydrate and lipid composition (%) of plants on fresh weight basis

Carbohydrate and lipid composition	*Amaranthus viridis* L.	*Chenopodium murale* L.	*Nasturtium officinale* L.	*Scandix pecten- veneris* L.
Total sugar	0.75	0.79	1.10	0.76
Reducing sugar	0.63	0.76	1.00	0.64
Non-reducing sugar	0.12	0.09	0.10	0.12
Pectin	0.13	0.33	0.02	0.11
† Total lipid	0.47	0.55	0.42	0.63
Saponifiable lipid	0.32	0.39	0.31	0.43
Non-saponifiable lipid	0.15	0.16	0.11	0.20

† Same as presented in Table 2.

Table-4. Minerals composition (mg/ 100g) of plants on dry weight basis

Minerals	*Amaranthus viridis* L.	*Chenopodium murale* L.	*Nasturtium officinale* L.	*Scandix pecten-veneris* L.
Na	109.00	147.00	121.00	381.00
K	3460.00	3600.00	3460.00	2206.00
Mg	1842.00	1348.00	300.00	370.00
Ca	1680.00	1552.00	818.00	3200.00
Fe	181.00	7.300	138.00	200.00
Cu	300.00	21.00	36.00	54.00
Zn	10.00	6.00	2.08	16.00
Mn	8.00	7.60	7.00	9.00
Cr	2.00	2.200	1.00	0.40
Ni	1.20	0.60	1.00	2.40

and Edward [17]. The bioavailability of calcium and magnesium in *Chenopodium murale* and *Amaranthus viridis* may be lower than expected as high amount of oxalic acid has been reported in these species which reduces the absorption of these nutrients [18]. The absorption of calcium from *Nasturtium officinale* has been calculated between 54 % and 67 % [19]. High levels of citric and malic acids would help absorption of calcium as well as other minerals [20]. The absorption of minerals other than calcium would also benefit from lower concentrations or absence of phytates, oxalates, and fibre [21].

The iron content in the wild leafy vegetables, oscillated from 7.30 to 200 mg/ 100g, the highest value being observed in *Scandix pecten-veneris*, followed by *Amaranthus viridis* (181 mg/ 100g). *Chenopodium murale* (7.30 mg/ 100g) was comparatively low in iron. This high level of iron might be of nutritional importance especially in those parts of the world where anaemia and iron deficiency is relatively rampant. By including these iron rich greens, especially *Scandix pecten-veneris*, *Amaranthus viridis* and *Nasturtium officinale* in daily diet, one can easily meet a reasonable amount of the daily requirement of iron from one serving. Work on the iron content of *Nasturtium officinale* has been published [22]. The values reported by these authors are slightly higher than the present work. Copper is an essential redox-active transition metal that is involved in many physiological processes in plants because it can exist in multiple oxidation states *in vivo* [23]. Its adequate supply for growing plants should be ensured through artificial or organic fertilizers [24]. Copper content was significantly different among the plants species studied here. Its value was lowest in *Cenopodium murale* (21.0 mg/ 100g) while highest in *Amaranths viridis* (300 mg/ 100g). *Nasturtium officinale* and *Scandix pecten-veneris* showed 36.0 and 54 mg/ 100g contents, respectively. Baker and Senef [25] reported 10mg/ 100g dry weight average content of Cu in plant tissues.

Zinc, a trace mineral that is especially important for the normal functioning of the immune system, was relatively abundant in *Scandix pecten-veneris* (16.00 mg/ 100g). Though leafy vegetables are not considered as good sources of zinc, consumption of 300 g per day (on fresh weight basis) of *Scandix pecten-veneris* leaves provide sufficient zinc to meet the recommended daily allowance of 8 mg/ 100g while *Amaranthus viridis*, which contains 10.00 mg/ 100g, provide about half of this value. No significant differences were observed in the manganese content of different species. Values for manganese among the plants ranged from 7.0 mg/ 100g in *Nasturtium officinale* to 9.0 mg/ 100g in *Scandix pecten-veneris*.

Chromium, the metal that plays a role in the maintenance of normoglycemia by activating the β-cells of the pancreas, was observed in the plants with contents ranging from 0.40 mg/ 100g in *Scandix pecten-veneris* to 2.20 mg/ 100g in *Chenopodium murale* [26]. Comparatively low but detectable levels of nickel content were observed in the plants. Its amount varied between 0.60mg/ 100g in *Chenopodium murale* to 2.40 mg/ 100g in *Scandix pecten-veneris*. Values for *Amaranthus viridis* (1.20 mg/ 100g) and *Nasturtium officinale* (1.0 mg/ 100g) were different insignificantly. The concentrations of chromium and nickel, 1.0mg/ 100g each, were identical in *Nasturtium officinale*. Nickel is naturally more abundant in plants than in animal flesh. In trace amounts, it may be beneficial to activate some enzyme systems. Nickel toxicity in humans, at higher levels, is not a very common occurrence because the absorption of nickel is very low [27].

Fatty Acid Composition

The total lipidic content, referred to fresh plant weight and the percentage of fatty acids for the wild greens are given in Table-5. The major fatty acids have 16 or 18 carbon atoms with a variable degree of unsaturation. In general, the predominant fatty acids present in all of the species were palmitic (16: 0), stearic (18: 0), oleic (18: 1ω9), linoleic (18: 2ω6) and linolenic acids (18: 3ω3). Palmitic acid (16: 0) was the major saturated fatty acid, contributing 15.84 to 25.31 % of the total fatty acids in *Scandix pecten-veneris* and *Amaranthus viridis*, respectively. These results are higher than observed by Han-Ping and Harold [28]. The stearic acid (18: 0) content was highest in *Nasturtium officinale* (13.77 %) and lowest in *Chenopodium murale* (2.21 %). Smaller amounts of 14:0, 20:0, 22:0, were also detected. Lauric acid was detected only in *Amaranthus viridis* (0.91 %) and *Chenopodium murale* (1.80 %). The percentage of total saturated fatty acids (TSF) was found to be

Table-5. Fatty acid composition (%) of plants

Fatty acids	*Amaranthus viridis* L.	*Chenopodium murale* L.	*Nasturtium officinale* L.	*Scandix pecten-veneris* L.
C10: 0	0.00	0.00	0.00	0.00
C12: 0	0.91	1.80	0.00	0.00
C14: 0	1.26	0.31	0.57	0.59
C16: 0	25.31	15.84	16.28	24.15
C18: 0	3.83	2.21	13.77	5.37
C20: 0	0.89	0.82	0.00	1.72
C22: 0	2.16	1.18	0.00	0.00
Total saturated fatty acids	34.36	22.16	30.62	31.83
C16: 1ω9	1.78	1.34	1.62	1.61
C18: 1ω9	8.04	5.47	1.96	7.07
C20: 1ω9	0.00	1.34	0.00	2.06
C22: 1ω13	0.00	0.00	0.45	1.28
Total monounsaturated fatty acids	9.82	8.15	4.03	12.02
C18: 2ω6	11.31	17.00	12.37	16.06
C18: 3ω3	29.00	34.99	36.64	15.23
Total polyunsaturated fatty acids	40.31	51.99	49.01	31.29

34.36 % in *Amaranthus viridis*, 22.16 % in *Chenopodium murale*, 30.62 % in *Nasturtium officinale* and 31.83 % in *Scandix pecten-veneris*

The fatty acids of the lipidic fraction of these plants are, in general, mainly unsaturated (Fig. 1). The distribution of total monounsaturates (MUFA) was 9.82 % in *Amaranthus viridis*, 8.15% in *Chenopodium murale*, 4.03 % in *Nasturtium officinale* and 12.02 % in *Scandix pecten-veneris*. The predominant monounsaturated fatty acids were palmitoleic and oleic acids. The oleic acid varied between 1.96 to 8.04 % in *Nasturtium officinale* and *Amaranthus viridis*, respectively. In general these figures for *Amaranthus viridis* agree with those reported in the literature [29]. Erucic acid (22: 1ω13) content ranged from absence in *Amaranthus viridis* and *Chenopodium murale* to 1.28 % in *Scandix pecten-veneris*. These values are in the same order as reported earlier [9]. Obtained data for the leaves of these plants, however, could not be compared with those in the literature, which are for seeds [30]. The presence of high amount of erucic acid, present in many plants, possesses the main problem for edible purposes. Various regulations restrict the erucic acid content up to 10 % at the most. High erucic acid content is recommended for polymer industry where as low erucic acid is recommended for the edible purposes [31]. Our results demonstrate that the level of this acid does not make the consumption of these plants risky for human health.

Polyunsaturated fatty acids (PUFAs), having medicinal importance constituted the major fraction of total fatty acids. Total PUFAs were

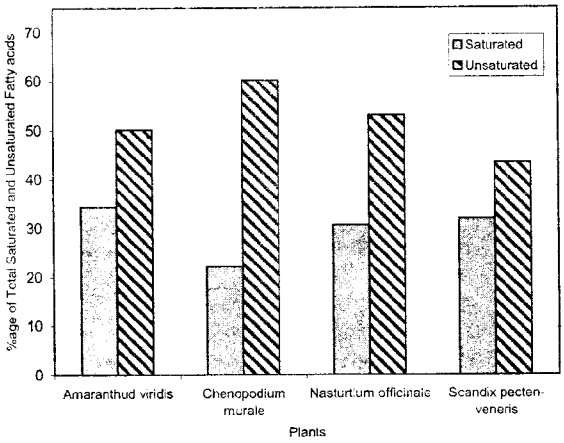

Fig. 1. Comparison of saturated and unsaturated fatty acid contents of plants.

found to be 40.31 % in *Amaranthus viridis*, 51.99 % in *Chenopodium murale*, 49.01 % in *Nasturtium officinale* and 31.29 % in *Scandix pecten-veneris*. The amounts of linoleic acid; (18: 2ω6), and α-linolenic acid; (18: 3ω3), in the plants are noteworthy because both are essential fatty acids in humans and therefore must be obtained through the diet. *Chenopodium murale* had the highest content of LA (17.00 %), and *Amaranthus viridis* had the lowest (11.31 %). With regard to ALA, *Nasturtium officinale* had the highest amount (36.64 %), and *Scandix pecten-veneris* had the lowest (15.23 %). The linoleic and α-linolenic acids contents of *Amaranthus viridis* analysed in the present study (29.00 %) generally fall below the range of values that has been reported elsewhere [32]. With the exception of *Scandix pecten-veneris*, the plants

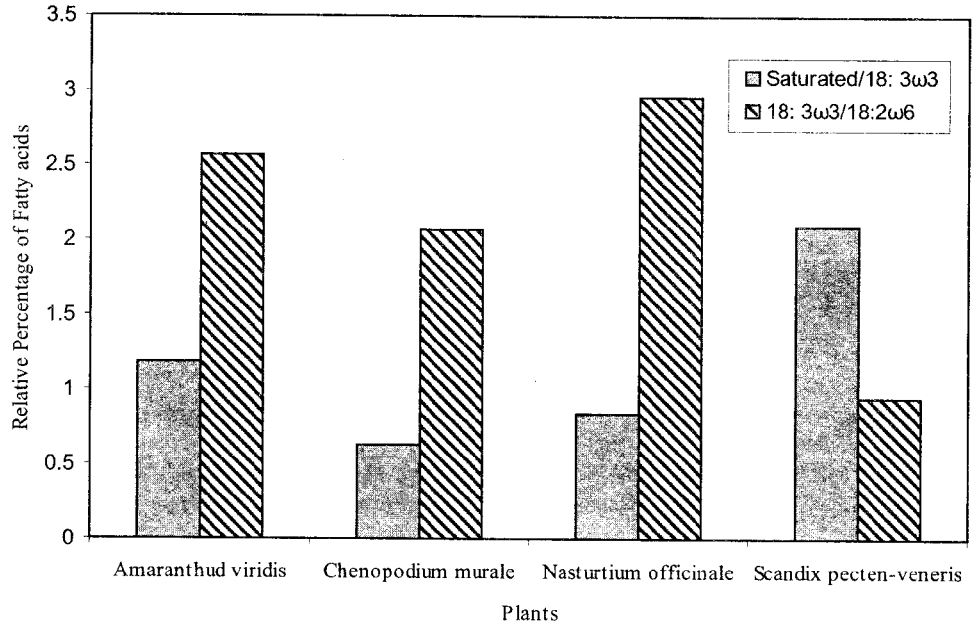

Fig. 2. Saturated/ 18: 3ω3 and 18: 3ω3/ 18: 2ω6 fatty acids ratio of plants.

species were low with regard to their saturated/ 18:3ω3 while high in 18: 3ω3/ 18: 3ω6 ratios (Fig. 2), indicating their good nutritional qualities. The optimal dietary intake of α-linolenic acid seems to be about 2 g per day or 0.6 to 1 % of total energy intake. Keeping the amount of dietary LA constant, 3.7 g ALA has been found to have biological effects similar to those of 0.3 g of long chain omega-3 PUFAs with conversion of 11 g ALA to 1 g long-chain omega-3 PUFAs. Thus a ratio of 4 (15 g LA: 3.7 g ALA) is appropriate for conversion. Thus presence of two essential fatty acids i.e. linoleic and α-linolenic acids, in the ratio of less than 4 to 1 % in the diet is a major issue [33-34]. The high content of ω3 fatty acids coupled with comparatively high 18: 3ω3/ 18:2ω6 ratios, in *Amaranthus viridis*, *Chenopodium murale* and *Nasturtium officinale*, demonstrate good nutritional qualities of these plants.

The nutrient contents studied in the present work, in most of the cases, were different than reported elsewhere. Differences in climate, soil, agronomic practices, plant cultivars, rainfall and possibly temperature are the probable major causes for differences in nutrient levels and indicate the need for locally prepared food composition tables.

Experimental

Collection and Pretreatment of Plant Samples

Four different species of wild green leafy vegetables were collected from N-WFP Pakistan. Standard botanical field collection methodology was used for the collection of plant samples [35]. Specific samples were obtained with the aid of interpreters and field guides. Multiple specimens of edible portions of each type were collected. Genus and species were confirmed by comparison with herbarium reference materials at Department of Botany, University of Peshawar, Pakistan. Before analysis, samples were inspected for non-plant materials and any visible dirt and insect parts were removed. A sample composite (leaves) of each specimen was analysed for proximate composition, available carbohydrates, fatty acids and minerals profiles.

Proximate Analysis

Moisture, ash and crude fibre were determined by AOAC methods [36]. Nitrogen content in the samples was estimated by the micro-Kjeldahl method and crude protein was calculated (N x 6.25) [37]. Total lipids in the samples were

extracted by means of the chloroform/ methanol (2:1, v/v) and measured gravimetrically [38]. Total Carbohydrate was obtained by difference [39]. The calorific value was calculated by multiplying the values of total carbohydrate, lipid and protein by the factors 4, 9, 4 respectively, taking the sum of the products and expressing the results in kilocalories [40].

Carbohydrates and Lipids Analysis

Extraction of total water-soluble sugar as well as reducing sugar and pectin determination was carried by the method of AOAC [36]. The non-reducing sugar was obtained by subtraction. Total lipid content was fractionated into saponifiable and non-saponifiable lipids by the saponification of total lipid followed by extraction of non-saponifiable fraction with petroleum ether, 40-60 °C [41].

Minerals Analysis

The samples were dried in the oven (Gallenkamp, England) overnight at 110 °C. The finely ground plant material, 0.50 g, was taken and digested using 20 mL concentrated nitric acid. After adding 10 mL of perchloric acid, the contents were heated gently on a hotplate followed by a vigorous heating till dryness (approximately1-2 mL). This digestion technique makes no attempt to dissolve any silicate-based material that may be present in the samples. After cooling, the digested samples were quantitatively transferred to a flask and diluted to 100 mL with deionised water and then filtered. Atomic absorption spectrophometer (A. Analyst 700 Perkin Elmer/ USA, equipped with standard burner, air acetylene flame and hollow cathode lamps, as radiation source) was used for the analysis of minerals [42].

Fatty Acids Analysis

The fatty acid composition of the total lipids extracted from each sample was determined by the following preparation. Extracted lipid was saponified [41] and, after the removal of non-saponifiable lipid, was esterified [31]. Prepared fatty acid methyl esters were analysed with a Perkin Elmer gas chromatograph, model 8700, fitted with SP-2340 methyl lignoserate-coated (0.20 μm film thickness), capillary column (60 m x 0.25 mm) and flame ionisation detector. Other conditions were as follows: (1) initial oven temperature, 130 °C; (2) ramp rate (increasing temperature rate) 10 °C/ min; (3) final temperature, 220°C; (4) injector temperature was 260°C (5) detector temperature was 270 °C and (6) temperature hold, 5 min before and 10 min after the run. A 1-2 μL sample volume was injected. The nitrogen with a flow rate of 3.5 mL/ minute was used as a mobile phase. Fatty acid were identified by comparing their relative and absolute retention times to those of authentic standards of fatty acid methyl esters obtained from Sigma Chemical Co. Quantification was done by a built-in data-handling program provided by the manufacturer of the gas chromatograph (Perkins Elmer). The data were transferred on an Epson LX-800 printer attached to the instrument through an RS-232-C port. FA composition was reported as a relative percentage of the total peak area.

Conclusion

The data contained in the present report provide an evidence of the potential nutritional values of the indigenous plants of the north-west region of Pakistan. The report suggests that, while it is uncommon to find a single plant food that scores high in every nutritional category, the leaves of *Amaranthus viridis, Chenopodium murale and Nasturtium officinale* appeared to be promising sources of macronutrients, essential fatty acids as well as many of the trace metals that are critical for growth, development and general health. It is tempting to dismiss *Scandix pecten-veneris* for its low content of α-linolenic acid; however, in addition to high level of protein and fibre, it could contribute significant amounts of several minerals to the diet, including iron, calcium, sodium and zinc. Thus, these foods if consumed on a daily basis can take care of the micro and macronutrients deficiency of underutilized foods, which may contribute significantly to the nutrient intake of rural population of Pakistan. Since little information is available about the nutritional potential of *Scandix pecten-veneris* so further research into amino acid patterns, bioavailability of vitamins, digestibility and possible toxic constituents is necessary to explore it fully for human or animal nutrition. The data presented here, will be informative and helpful in estimating the total intake of various nutrients in these wild species from Pakistan.

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