

Chemical composition of some underutilized green leafy vegetables of Sonitpur district of Assam, India

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Abstract

The objective of this study was to analyze the nutritional, antinutritional and mineral compositions of eight locally available underutilized green leafy vegetables of Sonitpur district of Assam, India. Moisture and ash of the green leafy vegetables were in the range of 71.74-98.20 g / 100 g and 8.23-26.01 g / 100 g respectively. Fiber was higher in *Basella rubra* (8.61 g / 100 g) and lower in *Moringa oleifera* and *Amaranthus viridis* (0.25 g / 100 g). Protein content largely varied from 2.29-18.56 g / 100 g, whereas carbohydrate ranged from 5.45-11.16 g / 100 g respectively. Ascorbic acid was higher in *Diplazium esculentum* (23.59 mg / 100 g) and lower in *Brassica nigra* (8.50 mg / 100 g), β -carotenoid ranged between 4.65-18.90 mg / 100 g in all the green leafy vegetables. Antioxidant and phenolic contents of the green leafy vegetables were almost similar. *Brassica nigra* had the highest iron content (241.20 mg / 100 g) and *Moringa oleifera* recorded the lowest iron content (29.40 mg / 100 g). Calcium, potassium was almost in same range in leafy vegetables whereas sodium varied from 29.00-116.66 mg / 100 g respectively. Highest zinc content was recorded in *Brassica juncea* and *Chenopodium album* (7.50 mg / 100 g) and lowest zinc content was found in *Moringa oleifera* (1.50 mg / 100 g). Green leafy vegetables are the powerhouse of health promoting phytochemicals and can be used by the people of all ages and are useful to alleviate and combat many deficiency diseases.

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Introduction

Among all vegetables green leafy vegetables have occupied a unique place because of their colour, flavor and health benefits. They are rich source of β -carotene, ascorbic acid, iron, zinc, folate and dietary fiber (Negi and Roy, 2000). India, being bestowed with a variety of natural surroundings and varying climates and seasons has a number of edible green leafy vegetables some of which are locally grown and underutilized. In most of the underdeveloped countries, the majority of people are vegetarian and nonvegetarian items are beyond reach of poor people. Therefore, expansion of present agricultural practices into marginal lands can be expected to solve this chronic world food shortage. The process of photosynthesis is the only non depletable protein source which can supply some essential amino acids as well as provide adequate nitrogen in the diet for the synthesis of non essential amino acids (Kinsella, 1970). However, only a very small percentage of edible green leafy vegetables are being utilized for human consumption. Further, about 90 % of world plant food comes from only 20 crops and in many countries only 6 crops are actually exported and imported (Stamen, 1970). Wild plants have played a

significant role in human lives from time immemorial. They have been used as food, medicine, fiber and for other purposes like fodder for domestic animals. In search of wild edible food plants, many of which are potentially valuable for human beings, have been identified to maintain a balance between population growth and agricultural productivity, particularly in the developing countries. It has been emphasized that analyzing such plants for various nutrients would enable identification of unconventional food resources (Deans and Ritche, 1987). Apart from these, there are various types of underutilized plant parts which are available seasonally and practically no information is available on the nutritional value of such edible plants. Some researchers have also reported nutritional composition of various types of wild edible plants which are being used in the developing countries (Gopalan *et al.*, 1971; Lockeet *et al.*, 2000). The nutrient content of few of the green leafy vegetables revealed that some of the greens contained comparatively higher amounts of crude protein (Aletor *et al.*, 2002). The main objective of the present study was to determine the nutritional, antinutritional and mineral contents of eight locally available underutilized green leafy vegetables of Sonitpur district of Assam.

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Table 1. Description of some underutilized green leafy vegetables of Sonitpur district of Assam, India

Botanical name	Family	English name	Local vernacular Assamese name	Cultivation	Uses
<i>Basella rubra</i>	Basellaceae	Malabar night shade	Ronga puroi	Found in settled and cultivated areas in hedges	Habitual headaches and laxative (Rathee et al., 2010; Kirtikar and Basu, 1975)
<i>Basella alba</i>	Basellaceae	Vine spinach, red vine spinach, climbing spinach, creeping spinach, buffalo spinach, malabar spinach and ceylon spinach	Xeujia puroi	It thrives in moist, fertile and well drained soils	Antimicrobial and anti-inflammatory effects. (Oyewole and Kalejaiye, 2012; Kachchhava, 2006)
<i>Diplazium esculentum</i>	Athyriaceae	Edible fern	Dhekia	Open marshy areas, stream banks and canals from sea level to 2,300 m	Antibacterial properties (Semwa et al., 2011)
<i>Moringa oleifera</i>	Moringaceae	Moringa drumstick tree	Sojina	Semi arid, tropical and subtropical areas	Antitumor, antipyretic, anti epileptic, anti-inflammatory, antiulcer, antispasmodic, diuretic, antihypertensive, cholesterol lowering, antioxidant, anti diabetic, hepatoprotective, antibacterial and antifungal activities (Anwar et al., 2007)
<i>Brassica juncea</i>	Brassicaceae	Mustard greens, Indian mustard, Chinese mustard	Lai	It is mostly found in Boreal Wet to Tropical thorn through Tropical Wet Forest Life Zones.	Hepato protective effects, Antidiabetic properties (Walia et al., 2011; Thakur et al., 2014)
<i>Chenopodium album</i>	Chenopodiaceae	White goosefoot	Zilmil	It thrives on all soil types.	Antibacterial effects (Singh et al., 2011)
<i>Amaranthus viridis</i>	Amaranthaceae	Slender amaranth	Khotura	It grows or are distributed in cultivated lands and it flowers and fruits throughout the year	Antiinflammatory effects (Macharla et al., 2011)
<i>Brassica nigra</i>	Brassicaceae	Black mustard	Sorio	Distributed in dry areas	Antioxidant and anti-inflammatory (Badrul et al., 2011)

Materials and Methods

Materials

Eight green leafy vegetables were selected for the study, were collected from Sonitpur district of Assam. All these samples were identified by a Taxonomist and are presented in Table 1. After collecting the samples to the laboratory, the edible portions were separated and washed under running tap water followed by distilled water. The leaves were dried using hot air oven at 45°C for 24 h and ground into fine powder and kept in air tight containers for further chemical analysis.

Nutritional analysis

The dried powdered samples in triplicate were used for the analysis. The recommended methods of the Association of Official Analytical Chemists (AOAC) were used for the determination of moisture, ash, lipid, crude fiber, crude nitrogen, carbohydrate (AOAC, 1990). Ash was determined in silica crucibles by incineration in a muffle furnace (KK Scientific Supplier, Model No: MF03, Korea.) at 550°C for 5 h. Lipid was extracted by continuous soxhlet method with petroleum ether (b.p.60°C). Crude fiber was estimated in Pellican fibre plus FES-08, Chennai India) by acid-base digestion with 1.25% H₂SO₄ and 1.25% NaOH solution (Maynard, 1970). Nitrogen was estimated by Kjeldahl method in (Kel

plus 20 L Pellican Equipment, India) with steam distillation and titrated with standard 0.01 M HCl solution. Crude protein was estimated by multiplying the crude nitrogen content by a factor of 6.25 (% Protein= % Nitrogen × 6.25). Carbohydrate content of the samples was estimated by anthrone method (Hedge and Hofreiter, 1962). Energy contents were calculated as described by Oshea and Maguire (1962).

Antioxidant activity

Total phenolic components were estimated by Bray and Thorpe (1954) method. Antioxidant activity was estimated by DPPH radical scavenging activity (Yen and Chen, 1995). Ascorbic acid content was estimated by titrimetric method (Harris and Ray, 1935) and β- carotenoid was determined spectrophotometrically (Vishwakarma and Dubey, 2011).

Minerals analysis

All the green leafy vegetable samples were analyzed using atomic absorption spectrophotometer (Model: Thermo Scientific, ICE 3000 Series, Newington, USA) for determination of Na, K, Ca, Mg, Cu, Mn, Zn and Fe. The method was by direct sample digests using air and acetylene flame. The calculations of the minerals were based on the comparison of absorption of samples against known concentration of standards and results were converted

to mg /100g.

Antinutritional analysis

Oxalic acid was estimated by titration method (Mahadevan, 1979). Tannins were estimated spectrophotometrically (Model No Cecil CE 7400 series 7000, Aquarious double unit) by Folin-Denis method (Schanderi, 1970). Phytic acid was estimated by Wheeler and Ferrel (1971) method.

Statistical analysis

All the experiments were conducted in triplicates and were evaluated by one-way ANOVA. Values of $P \leq 0.05$ were considered as statistically significant. Statistical evaluations were carried out using SPSS 16.0 software package for windows.

Results and Discussion

Nutritional content

The edible portions, moisture, ash, lipid, crude protein, crude fibre, carbohydrates are reported in Table 2. The edible portions of the green leafy vegetables ranged within 28-87 g / 100 g of fresh vegetables. Moisture content of the vegetables ranged from 71.74-98.20 % wet basis, highest being in *Moringa oleifera* (98.20 g / 100 g) and lowest in *Diplazium esculentum* (71.74 g / 100 g). The moisture content obtained in leafy vegetables was close to the values reported by Gupta and Prakash (2011), where they studied to formulate micronutrient rich products with dried greens of *Amaranthus peniculatus* and *Peucedanum graveolens*. Badau et al. (2013) reported that the higher moisture content provides greater activity of water soluble enzyme and co-enzyme, which is needed for metabolic activity of leaves.

The values of ash content on dry weight basis ranged between 8.23-26.01 g /100g, highest in *Brassica juncea* (26.01 g / 100 g) and lowest in *Basella alba* (8.23 g / 100 g), which are in line with Aletor et al. (2002), where they studied the chemical composition and functional properties of the leaf protein concentrates of commonly available leafy vegetables namely *Vernonia amygdalina* (Bitter leaf), *Amaranthus hybridus* (Green tete) and *Telfaria occidentalis* (Fluted pumpkins). Lipid content ranged between 0.19-4.19 g / 100 g, which is very low as compared to the leaves of *Anona senegalensis* (24.0%) reported by Yisa et al. (2010). *Talinum triangulare* (5.90%), *Amaranthus hybridis* (4.80%) and *Basella alba* (8.71%) reported by Mziray et al. (2001) respectively.

Basella rubra showed the highest crude fibre value (8.61 g / 100 g) and lowest was found to be

in *Moringa oleifera* and *Amaranthus viridis* (0.25 g / 100 g). The results were compared with the works of Aletor et al. (2002). Fibre consumption helps in softening stool and lowering of plasma cholesterol in the body. It also plays a physiological role in maintaining the internal distension for a normal peristaltic movement of intestinal tract. However, it is also reported that vegetables which has high fiber content may cause intestinal irritation and decrease the nutritional bioavailability (Pillai et al., 2013).

Chenopodium album and *Diplazium esculentum* revealed more or less same protein contents. *Amaranthus viridis* was found to have low protein content of 2.29 g / 100 g and are line with Aletor et al. (2002) and Tag et al. (2014), where they studied nutritional potential and traditional uses of high altitude wild edible plants in *Eastern Himalayas*. Carbohydrate contents of all green leafy vegetables ranged between 11.16 g / 100g to 5.45 g / 100 g. *Basella alba* had the highest 11.16 g /100 g and lowest in *Diplazium esculentum* 5.45 g / 100 g. The similar values were reported for the carbohydrate contents of wild edible herbs used in Eastern Chattisgarh (Vishwakarma and Dubey, 2011). The high carbohydrate content in food means high energy content, which helps in digestion and assimilation of other foods. They are also responsible for carrying out daily activities in day to day life (Gordon and Kessel, 2002; Yisa et al., 2010). The calorific value of green leafy vegetable ranged between 195.00 Kcal to 541.33 Kcal, and highest being in *Amaranthus viridis* and lowest in *Diplazium esculentum*. Similar values were found in *Vitex doniane* (194.03 Kcal), *Limosella aquatic* (152.00 Kcal) and *Corchorus olitorius* (184.00 Kcal) (Gladys Oguche, 2012).

Antioxidant activity

Antioxidant activity, ascorbic acid, β -carotenoid, and phenolic contents are presented in Table 3. All the green leafy vegetables showed appreciable free radical scavenging activity. Antioxidant activity was almost same for all the samples but *Brassica juncea* (95.55%) showed the highest free radical scavenging activity and *Amaranthus viridis* showed the lowest (92.95%). Similar results were reported by Gupta and Prakash (2009) in Indian green leafy vegetables for their antioxidant activity.

There was not much difference found in the ascorbic acid content of the green leafy vegetables. *Diplazium esculentum* was found to be rich source of ascorbic acid, having 23.59 mg / 100 g and lowest in *Brassica nigra* 8.50 mg / 100 g. The results of ascorbic acid content found in the present study are comparatively higher than the values reported

Table 2. Nutritional content of hot air oven dried green leafy vegetables

Green leafy vegetables	Edible portions (g/100g)	Ash (g/100g)	Moisture (g/100g)	Lipid (g/100g)	Crude protein (g/100g)	Carbohydrate (g/100g)	Crude fibre (g/100g)	Calorific value (kcal)
<i>Basella rubra</i>	28	20.76±0.01 ^g	88.44±0.004 ^b	0.61±0.010 ^d	10.31±0.017 ^g	7.84±0.028 ^d	8.61±0.014 ^f	375.00±3.60 ^g
<i>Basella alba</i>	40	8.23±0.01 ^a	88.46±0.029 ^b	0.66±0.010 ^d	4.72±0.034 ^d	11.16±0.023 ^g	2.34±0.017 ^d	402.66±2.51 ^g
<i>Diplazium esculentum</i>	54	14.42±0.01 ^c	71.74±0.417 ^a	0.34±0.020 ^f	18.32±0.028 ^h	5.45±0.026 ^a	4.45±0.013 ^a	195.00±2.00 ^g
<i>Moringa oleifera</i>	70	8.93±0.01 ^b	98.20±0.046 ^d	3.01±0.010 ^e	4.72±0.036 ^d	8.58±0.055 ^f	0.25±0.011 ^a	293.66±6.40 ^g
<i>Brassica juncea</i>	79	26.01±0.01 ^h	92.22±1.003 ^c	2.99±0.020 ^f	3.86±0.023 ^b	7.39±0.030 ^f	1.35±0.017 ^b	267.66±1.15 ^b
<i>Chenopodium album</i>	54	20.44±0.01 ^f	88.55±0.009 ^b	0.19±0.011 ^a	18.56±0.017 ^g	8.65±0.020 ^f	1.70±0.005 ^c	425.33±2.51 ^g
<i>Amaranthus viridis</i>	80	20.20±0.01 ^g	88.01±0.421 ^b	0.27±0.011 ^b	2.29±0.017 ^a	7.96±0.021 ^g	0.25±0.016 ^a	541.33±1.52 ^h
<i>Brassica nigra</i>	87	18.41±0.05 ^d	89.95±0.476 ^b	4.19±0.005 ^h	4.03±0.023 ^c	5.56±0.034 ^b	1.34±0.017 ^b	413.66±1.15 ^f

(Results were expressed as mean of three replications ± standard deviation and values followed by different letters are significantly ($P \leq 0.05$) different from each other)

Table 3. Ascorbic acid, β -carotenoid, antioxidant and phenolic content of hot air oven dried green leafy vegetables

Green leafy vegetables	Ascorbic acid (mg/100g)	β -carotenoid (mg/100g)	Antioxidant activity by DPPH (% Inhibition)	Phenolic content (mg/g)
<i>Basella rubra</i>	12.68±0.02 ^c	12.68±0.03 ^f	95.01±0.01 ^b	2.28±0.02 ^a
<i>Basella alba</i>	12.38±0.01 ^c	12.38±0.05 ^f	95.03±1.04 ^b	2.64±1.04 ^a
<i>Diplazium esculentum</i>	23.59±0.05 ^f	4.65±0.03 ^a	94.94±0.81 ^b	2.39±0.81 ^b
<i>Moringa oleifera</i>	19.30±0.07 ^e	18.90±0.03 ^g	94.90±0.86 ^b	2.36±0.86 ^b
<i>Brassica juncea</i>	11.40±0.01 ^b	8.45±0.03 ^c	95.55±1.38 ^b	2.36±1.38 ^b
<i>Chenopodium album</i>	14.70±0.03 ^d	9.54±0.03 ^d	94.92±0.89 ^b	2.49±0.89 ^d
<i>Amaranthus viridis</i>	13.40±0.05 ^d	6.54±0.03 ^b	92.95±1.65 ^a	2.53±1.65 ^d
<i>Brassica nigra</i>	8.50±0.12 ^a	10.60±0.03 ^e	95.52±0.45 ^b	2.28±0.04 ^a

(Results were expressed as mean of three replications ± standard deviation and values followed by different letters are significantly ($P \leq 0.05$) different from each other)

by Dansi *et al.* (2008), in their studies on *Vernonia amygdalina* (13.41 mg / 100 g) and *Cleome gynandra* (14.00 mg / 100 g) but can be comparable with the works of (Cladwell, 1972) on the leafy vegetables of Malaysia. Ascorbic acid is an important vitamin which plays a crucial role in maintaining a healthy life style and preventing many diseases. It is also required for the synthesis of collagen (Olayinka, 2012). *Moringa oleifera* had the highest β -carotenoid content (Table 3) of 18.90 mg / 100 g and lowest in *Diplazium esculentum* 4.65 mg / 100 g. The results are similar with the works of Negi and Roy (2000) on fenugreek (15.0-26.5 mg / 100 g). Kaur *et al.* (2007) reported similar results when they studied physicochemical properties of mustard, mint and spinach (17.18-23.33 mg / 100 g) respectively.

Green leafy vegetables are good source of phenolic content. *Basella alba* had the highest phenolic content of 2.64 mg/g and *Brassica nigra* and *Basella rubra* (2.28 mg /g) recorded the lowest the results can be corroborated with the findings of

Kamel *et al.* (2013), where they studied the influence of drying process on the functional properties of some plants namely coriander, dill, parsley and celery. Total phenolic contents of the all leafy vegetables were almost similar, and are comparable with the works of Saxena *et al.* (2007) and Ng *et al.* (2012), where they worked on nutritional profile and antioxidative properties of selected tropical wild vegetables. Phenolic compounds are nonnutritive secondary metabolites which are beneficial to humans to prevent various diseases. Silva *et al.* (2007) and Delgado *et al.* (2009) reported that phenolic compounds are able to protect human cells against oxidative damage and also possesses anti carcinogenic properties.

Minerals content

The mineral contents of the green leafy vegetables were statistically significant ($P \leq 0.05$), and found to be the rich sources of minerals (Table 4). Iron content was found highest in the order *Brassica nigra* (241.20 mg / 100 g), *Brassica juncea* (118.50 mg / 100 g),

Table 4. Mineral content of hot air oven dried green leafy vegetables

Green leafy vegetables	Iron (mg/100g)	Zinc (mg/100g)	Copper (mg/100g)	Manganese (mg/100g)	Sodium (mg/100g)	Potassium (mg/100g)	Calcium (mg/100g)	Magnesium (mg/100g)
<i>Basella rubra</i>	57.37±0.02 ^c	3.13±0.30 ^b	2.80±0.025 ^d	132.27±1.05 ^g	116.66±1.5 ^e	71.36±0.66 ^b	65.30±0.45 ^a	16.13±0.15 ^d
<i>Basella alba</i>	90.80±0.06 ^a	3.50±0.26 ^b	2.60±0.045 ^c	74.20±1.73 ^d	52.33±0.64 ^f	73.30±1.00 ^c	62.00±0.08 ^c	16.20±0.20 ^f
<i>Diplazium esculentum</i>	38.20±0.07 ^b	4.30±0.26 ^c	1.70±0.20 ^a	21.11±0.87 ^a	29.00±1.38 ^a	74.46±1.36 ^d	52.66±0.49 ^b	15.30±0.20 ^a
<i>Moringa oleifera</i>	29.40±0.07 ^a	1.50±0.25 ^a	2.40±0.25 ^b	43.27±0.88 ^b	43.33±1.15 ^b	75.33±1.15 ^e	67.93±0.16 ^e	16.03±0.15 ^c
<i>Brassica juncea</i>	118.50±0.07 ^f	7.50±0.30 ^f	2.60±0.15 ^c	45.97±1.28 ^c	51.20±0.85 ^c	73.47±1.05 ^c	36.60±0.24 ^a	16.33±0.20 ^f
<i>Chenopodium album</i>	85.46±0.06 ^d	7.50±0.25 ^f	3.80±0.26 ^e	94.44±1.21 ^e	78.30±2.45 ^f	70.70±0.36 ^a	64.10±0.16 ^d	16.23±0.20 ^f
<i>Amaranthus viridis</i>	118.13±0.05 ^f	6.10±0.26 ^e	2.40±0.20 ^b	224.46±1.50 ^h	94.66±1.42 ^f	73.08±1.00 ^c	66.70±0.49 ^f	16.70±0.20 ^h
<i>Brassica nigra</i>	241.20±0.03 ^g	5.50±0.26 ^d	1.90±0.15 ^a	102.73±0.58 ^f	62.06±1.67 ^d	73.83±0.76 ^c	67.13±0.22 ^f	15.96±0.15 ^b

(Results were expressed as mean of three replications ± standard deviation and values followed by different letters are significantly (P ≤ 0.05) different from each other)

Table 5. Antinutritional content of hot air oven dried green leafy vegetables

Green leafy vegetables	Oxalic acid (mg / 100g)	Tannin (mg / 100g)	Phytic acid (mg / 100g)
<i>Basella rubra</i>	5.53±0.035 ^d	10.40±0.36 ^a	363.00±2.64 ^d
<i>Basella alba</i>	2.86±0.017 ^b	12.66±1.15 ^b	183.00±2.00 ^b
<i>Diplazium esculentum</i>	1.72±0.017 ^a	10.19±0.46 ^a	103.16±1.76 ^a
<i>Moringa oleifera</i>	4.83±0.028 ^c	17.86±0.11 ^c	273.54±1.58 ^b
<i>Brassica juncea</i>	6.10±0.028 ^e	107.00±5.19 ^f	291.73±1.51 ^c
<i>Chenopodium album</i>	2.81±0.013 ^b	72.00± 1.62 ^d	380.84±1.65 ^e
<i>Amaranthus viridis</i>	9.42±0.017 ^e	71.66±1.15 ^d	924.70±1.65 ^e
<i>Brassica nigra</i>	7.49±0.080 ^f	83.00±1.65 ^e	507.36±1.00 ^f

(Results were expressed as mean of three replications ± standard deviation and values followed by different letters are significantly (P ≤ 0.05) different from each other)

Amaranthus viridis (118.13 mg / 100 g), *Basella alba* (90.80 mg / 100 g) and *Chenopodium album* (85.46 mg / 100 g) respectively. While the rest of the green leafy vegetables had iron content in the range of 29.40-57.37 mg / 100 g. Iron content analyzed in the present study were similar to the values as reported by Singh *et al.* (2001), where they studied the nutritional compositions of selected green leafy vegetables, herbs and carrots of Haryana, India.

Of the eight green leafy vegetables analyzed, *Moringa oleifera* contained the highest amount of potassium (75.33 mg / 100 g) and *Chenopodium album* had the lowest amount (70.70 mg / 100 g), the rest had the potassium contents in the range of 71.36-74.46 mg / 100 g. Nair *et al.* (2013) reported that the high amount of potassium increases the iron utilization and is also beneficial to the people taking diuretics to control hypertension.

In all the samples studied the calcium content was found to be in the range of 36.60-67.93 mg / 100 g. *Moringa oleifera* had the maximum amount and *Brassica juncea* recorded the minimum amount.

Calcium is an important mineral for human beings, which provides good strength of bones and teeth (Amagloh and Nayarko, 2012). It plays an important role in blood clotting, muscles contraction, and neurological function and also helps in enzymatic metabolic processes (Senga *et al.*, 2013).

The sodium content of green leafy vegetables ranged between 29.00- 116.66 mg / 100 g highest was found in *Basella rubra* and lowest in *Diplazium esculentum*. The results are comparable with the works of Gopalan *et al.* (1996), where they studied the proximate nutritive contents of Indian foods. Alinnor and Oze (2011) reported that sodium is an important mineral which assists in the regulation of the body fluids and maintenance of electrolyte balance in the body. *Chenopodium album* (3.80 mg / 100 g), *Basella rubra* (2.80 mg / 100 g), *Basella alba* (2.60 mg/100g) *Brassica juncea* (2.60 mg / 100 g), *Moringa oleifera* (2.40 mg / 100 g) and *Amaranthus viridis* (2.40 mg / 100 g) evinced the highest in the order of copper content and *Diplazium esculentum* (1.7 mg / 100 g) recorded the lowest. The copper content of the

green leafy vegetables in the present study is similar to the works done by Barminas *et al.* (1998), where they studied the the mineral composition of non-conventional leafy vegetables like *Moringa oleifera*, *Adansonia digitata*, *Colocasia esculenta* and *Cassia tora*. Alinnor and Oze (2011) opined that copper is required for enzyme production in the body and helps in biological electron transport.

The magnesium level of the green leafy vegetables was found in between (15.30- 16.70 mg / 100 g). Similar values were reported by Salazar *et al.* (2006), on chemical composition and antinutritional factors of *Lycianthes synanthera* leaves (chomte). According to Alinnor and Oze (2011) magnesium plays an important role in calcium metabolism in bones and also prevents circulatory diseases. It also helps in regulating blood pressure and insulin release.

Amaranthus viridis contained the highest amount of manganese (224.46 mg / 100 g) and the rest of the green leafy vegetables varied within 21.11 mg /100 g to 132.27 mg / 100 g). *Diplazium esculentum* had the least content (21.11 mg /100g), which are comparable with the works of Odhava *et al.* (2007) on *Bidens pilosa* (21 mg / 100 g) and *Centella asiatica* (23 mg / 100 g), *Chenopodium album* (27 mg / 100 g), *Portulaca oleracea* (24 mg /100 g), respectively.

Highest zinc content was recorded in *Brassica juncea* and *Chenopodium album* (7.50 mg/100g) and lowest was found in *Moringa oleifera* (1.50 mg /100 g). Zinc content present in the study can be supported with the works done by Singh *et al.* (2001). Shankar and Prasad (1998) reported that zinc plays an important role in cellular and humoral immunity.

Antinutritional content

Oxalic acid, tannin and phytic acid are antinutritional factors, which are widely found in plant foods. Comparatively *Amaranthus viridis* (9.42 mg / 100 g), *Brassica nigra* (7.49 mg /100g) *Brassica juncea* (6.10 mg /100 g) and *Basella rubra* (5.53 mg / 100 g) revealed more oxalic acid contents and *Diplazium esculentum* (1.72 mg / 100 g) was found to have the lowest oxalic acid content (Table 5). The results are in line with the works of Gupta *et al.* (2005), where they analyzed the nutrient and antinutrient contents of underutilized green leafy vegetables. Tannin content was highest in *Brassica juncea* 107.00 mg /100 g and lowest in *Diplazium esculentum* 10.19 mg / 100 g. The results are in line with the works of Gupta *et al.* (2005). Phytic acid is a naturally occurring antinutritional factor mostly present in plant foods and it is also phosphorus storage compound present in green leafy vegetables. The advantage of phytic acid is on its effect in

digestion and absorption of minerals. *Amaranthus viridis* evinced highest phytic acid content (924.70 mg /100 g) and *Diplazium esculentum* had the lowest phytic acid content (103.00 mg / 100 g). However, Yadav and Sehgal (2003) reported 234.50 mg / 100 g phytic acid content in *Chenopodium album* but there is a wide variation in the present study and the variation may be attributed to agroclimatic condition.

Conclusion

Based on the analysis performed in this study we can conclude that the green leafy vegetables, which are mostly neglected, have a good potential in terms of food value and can serve as an easily accessible food resources. Green leafy vegetables are rich sources of proteins and minerals, but their utilization is limited. Variations in the chemical constituents may be attributed to species differences and different climatic conditions, and age of the plants. There are many green leafy vegetables available in this part of the country, whose nutritional profile are yet to be documented. More systematic study on these green leafy vegetables is required to exploit it industrially.

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