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EVALUATION OF NUTRITIONAL AND ANTI-NUTRITIONAL ACTIVITY OF INDIGENOUS AND UNDERUTILIZED GREEN LEAFY VEGETABLES OF NORTH INDIA

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In India, various types of underutilized foods are available seasonally but are not utilized to the extent they should be in spite of their high nutritive value. Looking into the high prevalence of over and under nutrition, these underutilized foods can be explored to overcome the nutritional disorders. In view of this, nine underutilized green leafy vegetables were identified and their proximate and anti-nutritional composition was analyzed. Moisture, ash, protein, fat, fibre and energy content of selected underutilized green leafy vegetables ranged between 75.2% to 92.6%, 6.01 g to 39.82 g, 8.19 g to 42.29 g, 1.54 g to 35.93 g, 8.42 g to 44.45 g, and 707 kJ to 1691 kJ/100 g respectively. The iron content ranged between 13.90 to 169.63 mg/100g. The highest iron content was observed in Celosia argentea (169.63 mg/100 g). Calcium in green leafy vegetables varied largely and most of the green leafy vegetables were rich in calcium. All selected underutilized vegetables were rich source of β-carotene, Anti-nutritional factors; oxalate and phytate content in green leafy vegetables ranged between 101.82 to 825 mg/100 g and 20.02 to 720.69 mg/100 g respectively.

Keywords: Underutilized, Oxalate, Phytate, Proximate composition, Beta carotene

INTRODUCTION

Malnutrition can be tremendously reduced with an increase use of foods rich in energy, proteins, iron and vitamins, most especially those from the rural environment. In order to have a healthy population that can promote development, the relation between food, nutrition and health should be reinforced (Yisa *et al.*, 2010). From the very beginning of time plants have been used as an important source of food and medicine (Hwiyang *et al.*, 2010). The number of workers tried to determine the nutritive value and mineral composition of medicinal plants, which were also being used as dietary supplements (Mahanta *et al.*, 2012). The wild edible medicinal leafy vegetables occupy an important place among food crops as these provide adequate amount of crude fiber, fats, carbohydrates, proteins, water and mineral elements like Ca, Na, Fe, P, Mg, Zn, etc., in addition to vitamins and certain hormone precursors. Studies have shown that vegetarians are less susceptible to disease and live longer, healthier and having stronger immunity (Akindahunsi and Salawu, 2005). Some indigenous leafy vegetables grow in the wild and are readily available in the field as they do not require any formal cultivation. Many of them are resilient, adaptive, and tolerate adverse climatic conditions more than the exotic species. Although, they can be raised comparatively at lower management cost and on poor marginal soil, they have remained underutilized, due to lack of awareness of their nutritional values in favour of the exotic ones (Guarino, 1997; Chweya and Eyzaguilre, 1999; Raghuvanshi and Singh, 2001; and Nnamani *et al.*, 2009). In

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many countries of the developing world, traditional and indigenous foods, which are often more nutritious than modern foods traded on the global market, are being neglected and forgotten. In most developing nations where food shortages and famine are mostly experienced, green leaves are the means of livelihood. Traditional vegetables are all those categories of plants whose leaves, fruits or roots are acceptable for use as vegetables. These crops could also help in poverty alleviation by providing income generating opportunities to farmers by linking the development of these crops to market opportunities (Joshi *et al.*, 2002). Phytochemicals, as sources of natural antioxidants, may be found in underutilized tropical vegetables (Ademoyegun *et al.*, 2013). These vegetables however contain anti-nutritional factors that can affect the availability of the nutrients. Anti-nutritional factor is known to interfere with metabolic processes such that growth and bioavailability of nutrients are negatively influenced (Abara, 2003). A study reported that oxalates causes irritation and swelling in the month and throat (Ladeji *et al.*, 2004).

Nutritive value of commonly consumed leafy vegetables has been studied extensively, but there is very less information available on nutritive value of unconventional leafy vegetables (Neeta Pattan and Usha Devi, 2014). Hence an attempt was made to identify and analyze the various underutilized green leafy vegetables for their nutrient and anti nutrient contents from around the Allahabad district of Uttar Pradesh.

METHODOLOGY

Study Area: Allahabad district of Uttar Pradesh was selected for the present research work which is located in the southern part of the Uttar Pradesh , India and stands at the confluence of the Ganges, and Yamuna rivers.

Identification of Underutilized Species: A total of 100

Table 1: Species Identified as Underutilized Plants

S. No.	Local Name	Botanical Name	Common Name	Family	Part of Plant Used	Medicinal Uses as Reported by Respondents
1	*Lahsua*	*Digera arvensis*	Kanjero	Amaranthaceae	Leaves	Famine food, dyspepsia, Urinary discharge
2	*Hazardana*	*Phyllanthus niruri*	Chanca piedre	Euphorbiaceae	Leaves	Snake bite, major component of liver tonics like Liv-52
3	*Poi*	*Basella alba*	Indian spinach	Basellaceae	Leaves	Cooked roots used in treatment of diarrhea, leaves used in dysentery, diuretic
4	*Surwari*	*Celosia argentea*	Quail grass	Amaranthaceae	Leaves	Blood purifier, Dysentery
5	*Chirchita*	*Achyranthes aspera*	Prickly Chaff flower	Amaranthaceae	Leaves	Asthma, bleeding, boils, cold, cough, colic, dog bite, headache, snake bite and skin diseases
6	*Pakar*	*Ficus infectoria*	White-Fruited Wavy Leaf Fig Tree	Moraceae	Leaves	Colic, Dysentery.
7	*Karm*	*Ipomoea aquatica*	Water spinach	Convolvulaceae	Leaves	Biliousness and jaundice and purify the blood
8	*Katthi Methi*	*Oxalis Corniculate*	Indian sorrel	Oxalidaceae	Leaves	Appetizer, Cough, Eye complaints, Jaundice, Rickets, Scurvy, Piles
9	*Kohar*	*Bauhinia purpurea*	Butterfly tree	Caesalpinaceae	Leaves	Swelling, Pain

households from three villages of Trans Yamuna areas of Allahabad were selected randomly and one respondent of each family was interviewed to elicit information on the underutilized plants related to extent of availability, their local uses and their medicinal importance. Among various underutilized plants identified, eleven plants species were prioritized, as underutilized green leafy vegetables for detailed study on the basis their natural habitats and scant information available on nutrient content. Species identified as underutilized plants are given in Table 1. The identified underutilized green leafy vegetables were subjected to various chemical analysis. Healthy fresh leaves of plants were removed from plant stalk, rinsed in clean water and dried to constant weighed at 60ºC using laboratory oven. The dried plant samples were ground to fine powder with an electric grinder, packed in glass jars and stored at 4ºC until analysis. Analysis of the all the eleven leafy vegetables was done in triplicate (N = 3).

Proximate Analysis: The moisture content of underutilized green leafy vegetables (leaves) was determined by gravimetrical method at 105 °C, Ref. 930.04. Ash content was determined by dry ashing in Muffle furnace at 525 °C for 3-5 hours, Ref. 930.05.The crude protein was estimated by the Kjeldahl's nitrogen method, Ref. 955.04. The value of nitrogen obtained was multiplied by the general factor (6.25) to give the percent crude protein. Crude fat was quantified by the method describe by AOAC method, Ref. 920.39 using the Soxhlet apparatus and n-hexane as a solvent. Crude fibre was estimated by acid-base digestion with 1.25 % H_2SO_4 (w/v) and 1.25% NaOH (w/v) solution Ref. 962.09 (AOAC, 2005). Available carbohydrate (excluding fibre) was calculated by difference, whereas metabolizable energy was calculated using energy conversion factors (Atwater and Bryant, 1900).

Mineral Analysis: 5 g of sample was ashed and extracted with dilute HCl. Suitable aliquots were used for the estimation of iron and calcium. Iron was estimated by the colorimetric method, Ref. 937.03 (AOAC, 2005) which is based on ferric iron giving a blood red colour with potassium thiocynate. The red colour was measured within 20 minute at 560 nm. Calcium was estimated by titrimetirc method Ref. 935.13 (AOAC, 2005). It was precipitated as calcium oxalate and was titrated with standard potassium permanganate to definite pink colour persisting for at least 1 min.

Vitamin Estimation: Ascorbic acid was estimated using the 2, 6-dichlorophenol indo-phenol, which was stoichiometrically reduced, by ascorbic acid into a colourless compound. The titration was conducted in the presence of metaphosphoric acid. β-carotene content of the sample was estimated using the method prescribed in the handbook of analysis (Rangana, 2001).

Anti-Nutritional Factors: Phytate content was determined by extracting it with Trichloroacetic acid and precipitated as ferric salt (Sadasivam and Manickam, 2008). The amount of iron present in the test was determined from the standard curve at 480 nm. The total oxalates in the form of oxalic acid in vegetables were determined as per method (Gupta, 2007). The following reaction was used for estimating the amount of oxalate in the sample. The sample was titrated with standard $KMnO_4$ solution until faint pink colour end point was developed.

Statistical Analysis: All analysis was done using duplicate independent samples with three analytical replications. Data were expressed as mean ± standard error.

RESULTS AND DISCUSSION

Proximate Composition: The detailed chemical analysis of all the eleven green leafy vegetables with respect to their various nutrient contents have been presented in Table 1. The proximate composition on fresh weight basis of the different underutilized species has been reported in Table 2. *Basella alba* had the highest moisture content of 92.6 percent and least was found in *Achyranthes aspera* (73.23%). The high level of moisture in all the samples investigated suggested that the leafy vegetables can not be stored for long without spoilage, since a higher water activity could enhance microbial action bringing about food spoilage. *Ipomoea aquatica* had the highest ash content of 39.82 g/100 g followed by *Ficus infectoria* with a value of 28.48 g/100 g. In contrast, the ash value of *Ipomoea aquatica Forsk* leaves as 10.83 g/100 g dry weight (Umar *et al.*, 2007). The high ash content of plants is an indication that the leaves contain nutritionally important mineral elements when compared to the values obtained for cereals and tubers. The Protein contents of selected underutilized leafy vegetables ranged between 8.19 to 42.29 g/100 g. *Basella alba* contained the highest protein content (42.29 gm/100 g), followed by *Achyranthes aspera* (8.19 gm/100 g). Values of protein recorded in this study are slightly higher than those reported in similar underutilized green leafy vegetables of Southern Karnataka which ranged between 0.7 to 3.6 g/100 g (Sheela *et al.*, 2004). Fibre content varied from 8.42 to 44.45 g/100 g being highest in *Phyllanthus niruri* (44.45

Table 2: Proximate Composition of the Underutilized Green Leafy Vegetables at Fresh wt Basis (per 100 g of Edible Portion)

S. No.	Local Name	Botanical Name	Moisture (g)	Ash (g)	Protein (g)	Fat (g)	Crude Fibre (g)	Carbohydrate (g)	Energy (KJ)
1	*Lahsua*	*Digera arvensis*	79.9	3.53	4.36	0.31	6.29	1.07	161
			±0.10	±0.12	±0.42	±.03	±0.08	±0.31	±3.85
2	*Hazardana*	*Phyllanthus niruri*	78	3.79	5.7	1.86	9.78	1.29	161
			±1.17	±0.43	±0.10	±0.36	±0.74	±0.10	±3.20
3	*Poi*	*Basella alba*	92.6	1.6	3.13	0.91	1.02	0.65	95
			±0.14	±0.05	±0.21	±0.05	±0.04	±0.19	±0.86
4	*Surwari*	*Celosia argentea*	84.4	3.06	1.45	1.25	0.68	9.06	220
			±0.13	±0.05	±0.23	±0.03	±0.04	±0.15	±0.45
5	*Chirchita*	*Achyranthes aspera*	75.2	1.49	2.03	0.86	0.86	21.5	418
			±2.6	±0.07	±0.23	±0.02	±0.12	±2.35	±9.89
6	*Pakar*	*Ficus infectoria*	82.6	4.95	5	2.1	4.7	2.21	199
			±0.09	±0.29		±0.19	±0.39	±0.52	±1.92
7	*Karm*	*Ipomoea aquatica*	84.2	6.3	2.4	0.4	3.21	3.57	111
			±0.44	±0.33	±0.23	±0.04	±0.17	±0.68	±2.39
8	*Kahtthi Metthi*	*Oxalis Corniculate*	80	3.53	3.5	2.6	1.95	8.3	294
			±0.56	±0.12	±0.42	±0.42	±0.06	±0.22	±4.88
9	*Kohar*	*Bauhinia purpurea*	78.8	2.9	3.2	1.15	4.26	9.58	253
			±1.27	±0.09	±0.24	±0.14	±0.16	±1.15	±6.16

Note: Analysis of the all the eleven leafy vegetables was done in triplicate (N = 3), considering them as the three replications±SD.

gm), followed by *Digera arvensis* (31.41 gm). A study also affirmed that leafy vegetables are particularly rich in fibre (Tanya *et al.*, 1997). High levels of dietary fibre in leafy vegetables are advantageous for their active role in the regulation of intestinal transit, increasing dietary bulk and increasing faeces consistency due to their ability to absorb water (Jenkin *et al.*, 1986). Fat levels for the raw samples varied with species with the highest value of 35.93 g/100 g observed in *Achyranthes aspera* and lowest in *Digera arvensis,* i.e., 1.54 g/100 g. Due to the generally low level of crude fat in vegetable leaves, their consumption in large amounts is a good dietary habit and may be recommended to individuals suffering from overweight or obesity. These low values of crude fat in leafy samples corroborate the findings of other authors (Goel and Kumar, 1989; and Sheela *et al.*, 2004). The energy content ranged between 707 to 1691 KJ/100 g. The calorific values of most vegetables are low (30-50 Kcal/100 g) (Devlin, 1982).

Minerals and Vitamin Content: Table 3 shows the minerals and vitamin content of selected underutilized plants in fresh weight basis. Among the underutilized species identified, iron content ranged between 13.90 to 169.63 mg /100 g. The highest iron content was observed in *Celosia argentea* (169.63 mg/100 g). In general, Amaranth leaves (27.3 mg/100 g), Colocasia leaves (10 mg/100 g), Mustard leaves (16.3 mg/100 g), Bathua leaves (4.2 mg/100 g) are commonly consumed iron rich leafy vegetables. Iron content in most of the selected underutilized leafy vegetable in the present study is comparable to the commonly consumed iron rich vegetables, therefore these identified underutilized vegetables like *Lahsua* (22.38 mg/100 g), *Surwari* (26.48 mg/100 g), *Pathri* (15.54 mg/100 g), *Chirchita* (15.94 mg/100 g), and *Kohar* (8.68 mg/100 g) can be popularized as iron rich food sources. Some of the selected underutilized leafy vegetables were very good source of iron and one serving of these in daily diet can easily fulfill 1/3 of daily iron requirement. Further Table 3 shows that amongst the underutilized greens the calcium content ranged between 128.19-2175.30 mg/100 g. Calcium content of was found maximum in *Digera arvensis* (2017.90 mg /100 g). The highest vitamin C content was found in *ficus infectoria* (402.76 mg/100 g), followed by *Celosia argentea* (388.21 mg/100 g) and *Oxalis corniculate* (340.51 mg/100 g). Considering the daily recommended intake of ascorbic acid, i.e., 40 mg/per day (FAO/WHO, 2002), consumption of underutilized greens and flowers in fresh form can provide a day's requirement of Vitamin C. The vitamin C content in *Digera arvensis* (68.7 mg/100 g) was found to be little higher than the values found in the present study (40 mg/100 g) (Sankhala *et al.*, 2005). Similarly the vitamin C content of 13.3±0.27 as observed in *Phyllanthus niruri* was found to be lower in comparison to values (35.18 mg/100 g) (Akubugwo *et al.*, 2007). The highest beta-carotene content was found in *Basella alba* (25216 μg/100 g) followed by *Ficus infectoria* (18216.34 μg/100 g) and lowest was found in *Digera arvensis* (4075 μg/100 g). Hence, these underutilized plants could be exploited as a good source of vitamin A. Its role in vision and growth regulation has made the public health officials to look for urgent and rapid methods of combating the problem. These leafy vegetables therefore can serve as a potential source of provitamin A to the population.

Anti-Nutritional Factors of the Underutilized Plants: Table 4 depicts the contents of oxalate and phytate in selected underutilized plants. *Celosia argentea* and *Digera arvensis* had the highest phytate content of 720.69 and 519.90 mg/100 g respectively. *Phyllanthus niruri* and *Ipomoea aquatica* were within the same range while *Ficus infectoria* had the least value (20.02 mg/100 g). The results are in agreement with a study (Day and Underwood, 1986) but relatively higher as compared to some wild, underutilized crop seeds (Fetuga and Balogun, 1988). The presence of phytic acid in biological system may chelate divalent metals like calcium, magnesium or blocks the absorption of essential minerals in the intestinal tract (Dan, 2005) thus decreasing their bio-availability (Oniobon *et al.*, 2007). Phytate chelates with mineral elements thereby having significant effects on the utilization of the minerals and also react with basic residue of protein (Fergusion *et al.*, 1993). The oxalate content in green leafy vegetables ranged between 101.82 to 825 mg/100 g being highest in *Digera arvensis* leaves (825 mg/100 g). Oxalate content in the selected green leafy vegetables were comparatively lower than the oxalate content of commonly consumed green leafy vegetables like *Spinach* (658 mg/100 g) and *Amaranth gangeticus* (772 mg/100 g) (Gopalan *et al.*, 2004). This suggests that these underutilized vegetables analyzed in the present study can

Table 3: Minerals and Vitamin Content of Underutilized Foods at Fresh wt Basis (per 100 g of Edible Portion)

S. No.	Local Name	Botanical Name	Iron (mg)	Calcium (mg)	Vitamin C (mg)	Beta-Carotene (μg)
1	Lahsua	*Digera arvensis*	22.38±0.73	404±3.77	40	816±95.2
2	Hazardana	*Phyllanthus niruri*	3.6±0.07	202±2.17	13.3±0.27	3750±244.9
3	Poi	*Basella alba*	1.18±0.05	65.3±2.88	16.01±0.08	1866±108.8
4	Surwari	*Celosia argentea*	26.48±0.14	170.6±2.17	60.6±7.07	2166±136
5	Chirchita	*Achyranthes aspera*	15.94±0.94	309.3±2.17	16	1066±108.8
6	Pakar	*Ficus infectoria*	6.07±0.02	210±5.76	70±7.07	3166±360
7	Karm	*Ipomoea aquatica*	2.2±0.08	96.6±4.35	53.3±5.44	2833±136
8	Kahtthi Metthi	*Oxalis Corniculate*	11.38±1.10	256±15.08	68±6.53	3200±288
9	Kohar	*Bauhinia purpurea*	8.68±0.14	240±7.54	40	1833.3±136.08

Note: Analysis of the all the eleven leafy vegetables was done in triplicate (N = 3), considering them as the three replications ± SD.

Table 4: Anti-Nutritional Factors of Underutilized Foods at Fresh wt Basis (per 100 g of Edible Portion)

S. No.	Local Name	Botanical Name	Phytate (mg)	Oxalate (mg)
1	Lahsua	*Digera arvensis*	104.5±0.40	165.14±4.98
2	Hazardana	*Phyllanthus niruri*	92±2.94	29.33±1.19
3	Poi	*Basella alba*	95±7.36	41.32±0.47
4	Surwari	*Celosia argentea*	112.5±3.53	23.4±1.19
5	Chirchita	*Achyranthes aspera*	85±8.16	63.06±1.19
6	Pakar	*Ficus infectoria*	3.48±0.23	30.8±2.07
7	Karm	*Ipomoea aquatica*	88±7.17	139.3±5.98
8	Kahtthi Metthi	*Oxalis Corniculate*	77±2.04	32.2±1.19
9	Kohar	*Bauhinia purpurea*	85±4.08	129.41±1.47
10	Makoy	*Solanum nigrum*	85±4.08	49.86±2.39

Note: Analysis of the all the eleven leafy vegetables was done in triplicate (N = 3), considering them as the three replications ± SD.

be better source of iron and calcium in terms of bioavailability and can be substituted in place of some important green leafy vegetable when low oxalate diet is required. Oxalic acid is a non-nutrient factor and its higher content is not desirable as it impairs calcium absorption by forming insoluble calcium oxalate (Rao and Vijay, 2002). Besides, it may also contribute to oxaluria, thus, increasing the urolithiasis risk factor. The oxalic acid content of *Ipomoea aquatica* found in tribal areas of Bihar was comparatively higher, i.e., 373.24 mg/100 g than the values found in the present study. Oxalic acid can remove calcium in the form of calcium oxalate in the blood. However, the oxalate content in *Digera arvensis* grown in Udaipur district of Rajasthan was lower (132.5 mg/100 g) than values obtained in the present study. The correlation between oxalate and phytate in the underutilized plants was found positive and significant (r = 0.60) indicating that underutilized leafy vegetables containing higher concentrations of phytate also contain higher oxalate.

CONCLUSION

Underutilized green leafy vegetables found in Allahabad district contain appreciable amount of iron, calcium, beta-carotene and vitamin C. The iron content of these green leafy vegetables is higher than that of commonly consumed leafy vegetables like spinach and amaranth. These selected green leafy vegetables have great nutritional importance particularly in preventing micronutrient deficiencies and can become a source of poverty alleviation of poor local community of study area. Better communication methods and awareness about underutilized plants and their nutrient content can raise their acceptance and adoption levels as well as improve the nutritional quality of daily diets.

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