



Minerals and Arsenic Composition of Twenty Five Indigenous Leafy Vegetables of Jorhat District of Assam State, India

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Indigenous leafy vegetables often considered as the 'weed of agriculture' but now they serve as a source of functional nutrients. Twenty five indigenous plant materials were collected from various places of Jorhat district, Assam, on the basis of their popularity of use by the people for evaluation of minerals and arsenic composition. The macro minerals-nitrogen content ranged from 2.71-7.10 %, phosphorous content ranged from 38.0-603.0 mg/100 g, potassium content ranged from 0.64-9.58 %, sodium content ranged from 52.0-233.0 %, calcium content ranged from 200.7-2104.96 %. The micro minerals-iron content ranged from 31.0-401.0 mg/100 g, copper content ranged from 0.003-0.020 %, zinc content ranged from 0.013-7.55 mg/100 g, manganese content ranged from 12.0-132.0 mg/100 g. The arsenic content of different leafy vegetables is ranged from 0.0-1.7 mg/100 g.

Keywords: Indigenous leafy vegetables, Wild, Macro minerals, Micro minerals, Arsenic, Edible plants.

INTRODUCTION

Traditional vegetables must be associated with traditional production systems, local knowledge and usually have a long history of local usage. Traditional leafy vegetables are those plants whose leaves are socially accepted, used and consumed for various purposes such as food, nutritional and medicinal values and additives. Wild leafy vegetables are generally ignored by the people in the developed nations which are subsistence agriculture in developing countries especially in the food insecure regions. Indigenous people in remote areas had deep knowledge about the use of these wild species as food especially during the period of drought, famine and civil unrest. The knowledge of these wild species could be considered as the most important determinant for an individual or a family to maintain their nutritional well-being to overcome malnourishment. Moreover, these wild vegetables have an important socio-economic impact by their use in medicines, foods, fibers and cultural ceremonies [1]. In recent decades, emphasis has been given on wild plant species for their possible nutritional and medicinal values to broaden the diversity of human diet [2,3]. This is because people are more concern about the benefits of modern agricultural technology and marketing of cultivate plant types with high productivity which results in massive loss of biodiversity.

Moreover, reduction of genetic diversity of plants species in human diets results the high dietary selectivity practice

which cause difficulty in getting full complement of essential nutrients through daily diet, lead to malnutrition and under-nutrition [4]. Furthermore, most of the foods consumed by people have been "upgraded" through refined and modified processes such as cooking, crushing, leaching and husking that causes reduction or removal of certain essential nutrients from the food [5].

On the other hand, modern research on wild leafy vegetables in different regions find out that most of these wild greens have great nutritional values and antioxidant properties, which are comparable to those commercially cultivated vegetables [3,6,7]. Glew *et al.* [6] reported that three usually consumed edible wild plants by the indigenous people in Niger (West Africa's Sahara region) have great influence on the nutritional status of local people due to their proportions of essential amino acids favourably adhering to the World Health Organization (WHO) standard. Besides, Maisuthisakul *et al.* [7] found that the indigenous chewing plants in Thailand contained great amount of phenolics and flavonoids responsible for antiradical activities. In other words, wild leafy vegetables often considered as the 'weed of agriculture' are now not only famine foods or wild foods in developing country, but also serve as a source of functional nutrients.

Leafy vegetables play a major role in the Assamese diet, probably due to the influence of traditional herbal medicine, easy accessibility and low cost. Further, green leaves are

considered as a main source of vitamins, minerals and fibre for local consumers. The use of wild plants as leafy vegetables is very common in Assam. Some of these species are also very popular but some species are sought-after more than others. In Assam they appear as uncultivated and semi cultivated crops or weedy and wild plants, with ecological, social and cultural values, playing a significant role in the daily food and nutritional requirement of local people mainly in the rural. However, there is no significant basis or reports in the modern literature regarding its macro-micro minerals and arsenic composition. That is why the present study was aimed to evaluate the macro-micro minerals and arsenic composition of the indigenous leafy vegetables of Jorhat district of Assam.

EXPERIMENTAL

Twenty five indigenous plant materials viz. *Bacopa monnieri*, *Leucas longifolia*, *Enhydra fluctuans*, *Eryngium foetidum*, *Amaranthus spinosus*, *Pteridium aquilinum*, *Amaranthus viridis*, *Hydrocotyl rotundifolia*, *Alternanthera sessilis*, *Paederia foetida*, *Eclipta alba*, *Houttuynia cordata*, *Talinum triangulare*, *Polygonum chinense*, *Oxalis corniculata*, *Oldenlandia corymbosa*, *Malva sylvestris*, *Chrysopogon coronerium*, *Trigonella foenum-graecum*, *Basella rubra*, *Chenopodium album*, *Stellaria media*, *Basella alba*, *Centalla asiatica* and *Oxalllis acetosella* were collected from various places of Jorhat district on the basis of their popularity of use by the people of Jorhat district. These plants were planted in pot in the Department of Biochemistry and Agricultural Chemistry, Assam Agricultural University, Jorhat, India for investigation. Young tender edible parts of these plant species were collected and dried under sunshine and after drying milling were done in wily mill (IKON, Dehli). The dry powder was used for investigation.

Soil pH was determined by Potentiometer Method in 1:2.5 soil water ratio using Systronic μ -pH System 361 [8]. Organic carbon of the soil was determined by Walkey and Black wet digestion method [9]. Available nitrogen in the soil sample was determined by alkaline potassium permanganate (KMnO_4) method [10]. Available phosphorus in the soil was determined by Bray's method [11] using UV-visible spectrophotometer. Available potassium in the soil was determined by ammonium acetate extraction [8] using flame photometer, Systronic, Model-130. The nitrogen content was determined by micro-Kjeldahl method [12]. The phosphorous content of the indigenous leafy vegetables was determined by Fiske and Sukhrow method [13]. The mineral solution prepared as per method [14] was used for the estimation of potassium, sodium and calcium content by flame photometry method [15]. The estimation of copper, zinc, manganese and arsenic were done from mineral solution by atomic absorption spectrophotometric method.

RESULTS AND DISCUSSION

The research findings of soil analysis, macro minerals, micro minerals and arsenic content are presented in the Tables 1 and 2, respectively.

Chemical analysis of soil: The pH value was found 6.2 which are ideal for the growth of microbes. Similar results

TABLE-1
FEW CHEMICAL PARAMETERS OF SOIL

Parameters	Value
pH	6.2
Organic carbon (%)	0.834
Av-N (kg ha^{-1})	492.1
Av- P_2O_5 (kg ha^{-1})	29.8
Av- K_2O (kg ha^{-1})	185.9

were reported by Karmakar [16]. The organic carbon (OC) value was found 0.834 % which is ideal source for plant nutrients. These are in agreement with the report of Chakraborty *et al.* [17]. The available-N (kg ha^{-1}) value was found 492.1 which are in agreement with the report of Baruah *et al.* [18]. The available- P_2O_5 (kg ha^{-1}) value was found 29.8. Similar results (26.8 kg/ha) are reported by Das *et al.* [19]. The available- K_2O (kg ha^{-1}) value was found 185.9 which are almost similar with values (173.9 kg/ha) obtained by Das *et al.* [19]. This may be due to farmy yard manure added to the soil.

Macro mineral content: Human body needs many minerals that are called essential minerals. Essential minerals are macro minerals and micro minerals. A balanced diet provides all the essential minerals. Minerals needs for healthy growth and metabolism. Minerals work in conjunction with vitamins to perform many bodily functions like bone formation, heart function and digestion. Macro minerals like nitrogen, phosphorous, potassium, sodium and calcium have been determined in different indigenous leafy vegetables.

The nitrogen content of the selected indigenous leafy vegetables is ranged from 2.71-7.10 %. The indigenous leafy vegetables *Pteridium aquilinum* (7.10 %) has the highest nitrogen content and *Paederia foetida* (2.71 %) has lowest nitrogen content. The results are comparable with the results obtained by Kamga *et al.* [20] in Nightshade contained the highest level of total N (6.11 ± 0.636 %) on dry weight basis. Jain *et al.* [21] reported nitrogen content in *Oxalis corniculata* leaves 3.56 % and Jimoh *et al.* [22] reported that *Amaranthus asper* leaves contained 1.78 mg/100 g (dry weight basis) nitrogen.

The phosphorous contents of different leafy vegetables in this study is ranged from 38.0-603.0 mg/100 g. *Polygonum chinense* (603.0 mg/100 g) has the highest phosphorous content and *Oxalllis acetosella* (38.0 mg/100 g) has lowest phosphorous content. The results are comparable with the results obtained by Kamga *et al.* [20] which varies from 420 mg to 540 mg/100 g on dry weight basis in few green leafy vegetables; Zeghichi *et al.* [23] reported that *S. pecten-veneris* contain 518 mg/100 g of phosphorous and Caunii *et al.* [24] reported that the phosphorous content in four green leafy vegetables varies from 23 mg to 66 mg/100 g on dry weight basis. Phosphorus is essential component of bone. Deficiency of phosphorus-calcium balance result in osteoporosis, arthritis, pyorrhea, rickets and tooth decay.

The potassium contents of different leafy vegetables is ranged from 0.64-9.58 %. *Talinum triangulare* (9.58 %) has the highest potassium content and *Basella rubra* has the lowest (0.64 %) potassium content. Potassium is a key circulating electrolyte involved in the regulation of ATP dependent channels along with sodium. These channels are the Na^+/K^+ -ATPases

TABLE-2
MACRO MINERAL CONTENT ON DRY WEIGHT BASIS OF INDIGENOUS
LEAFY VEGETABLES OF JORHAT DISTRICT, ASSAM (g % AND mg %)

S. No.	Local name	Scientific name	g %					mg %				
			N	P (mg %)	K	Na	Ca	Fe	Cu	Zn	Mn	As
1	Brahmi	<i>Bacopa monnieri</i>	3.92	91.00	1.09	231.00	0.20	51	0.016	0.02	35.67	1.20
2	Doron	<i>Leucas longifolia</i>	4.26	119.00	3.87	132.67	1.20	151	0.003	0.046	44.00	0.27
3	Helosi sak	<i>Enhydra fluctuans</i>	5.38	92.00	6.06	233.00	0.90	31	0.020	0.055	39.67	0.30
4	Mandhanian	<i>Eryngium foetidum</i>	5.10	119.67	4.54	156.33	0.80	51	0.009	0.015	24.00	0.60
5	Hatikhotora	<i>Amaranthus spinosus</i>	5.91	129.00	5.28	132.00	1.30	31	0.019	0.019	59.00	0.00
6	Dhekia	<i>Pteridium aquilinum</i>	7.10	130.67	4.39	92.00	0.30	31	0.043	0.016	27.67	0.00
7	Khotora	<i>Amaranthus viridis</i>	5.00	100.00	3.69	126.33	1.20	401	0.010	0.009	76.33	0.80
8	Saru Manimoni	<i>Hydrocotyl rotundifolia</i>	3.94	95.00	4.02	116.33	1.50	71	0.015	0.077	55.00	0.6
9	Matikandori	<i>Alternanthera sessilis</i>	4.44	143.33	6.34	155.00	0.70	139	0.016	3.73	12.00	0.00
10	Bhedailata	<i>Paederia foetida</i>	2.71	102.67	0.70	52.00	2.10	41	0.007	0.013	25.00	1.20
11	Keheraj	<i>Eclipta alba</i>	3.80	78.00	3.58	105.00	1.00	51	0.015	6.29	72.33	0.00
12	Masundori	<i>Houttuynia cordata</i>	2.82	109.67	3.56	116.67	1.00	91	0.013	0.088	82.00	0.00
13	Pirali paleng	<i>Talinum triangularae</i>	4.79	86.00	9.58	186.00	0.40	51	0.016	0.062	84.67	0.60
14	Madhuholang	<i>Polygonum chinense</i>	5.53	603.00	3.32	92.33	1.20	41	0.020	0.016	48.33	0.30
15	SaruTengesi	<i>Oxalis corniculata</i>	3.13	142.00	3.76	136.00	0.70	61	0.005	0.015	48.00	0.00
16	Bonjaluk	<i>Oldenlandia corymbosa</i>	2.83	134.00	1.27	101.33	1.20	91	0.007	0.074	50.33	0.70
17	Laffa	<i>Malva sylvestris</i>	5.11	120.67	3.66	102.00	1.50	51	0.013	0.009	32.00	0.30
18	Baburi	<i>Chrysopagon coroneriam</i>	5.17	104.33	4.93	186.33	0.80	221	0.013	0.019	132.00	0.77
19	Methi	<i>Trigonella foenum-graecum</i>	5.75	62.67	2.50	186.00	1.10	51	0.004	0.060	70.00	0.80
20	Puroi (red)	<i>Basella rubra</i>	2.95	115.00	0.64	172.00	1.50	31	0.006	0.018	13.33	0.00
21	Jilmil	<i>Chenopodium album</i>	5.91	129.00	5.62	153.33	1.70	91	0.015	0.031	75.67	0.70
22	Morolia	<i>Stellaria media</i>	4.37	108.33	2.26	92.00	1.40	121	0.006	6.08	41.00	0.00
23	Puroi (green)	<i>Basella alba</i>	4.51	108.00	0.86	194.67	1.50	106	0.013	7.55	70.00	1.70
24	Bor Manimoni	<i>Centella asiatica</i>	2.55	95.00	1.66	82.33	1.00	101	0.005	0.025	68.67	0.00
25	Bor Tangeshi	<i>Oxallis acetosella</i>	5.11	38.00	2.24	92.67	0.80	151	0.011	0.022	69.00	0.00
SED (±)			0.06	1.32	0.10	1.65	0.41	0.84	0.003	0.02	2.28	0.06
CD at 5 %			0.10*	2.27*	0.027*	2.82*	0.70*	1.44*	0.004*	0.03*	3.90*	0.10*

and their primary function is in the transmission of nerve impulses in the brain. The results are slightly higher than obtained by other authors. These results are comparable with the results obtained by Grace *et al.* (4.90 to 6.11 %) [25] and Kamga *et al.* (3.08 to 5.86 %) [20].

The sodium contents of different leafy vegetables is ranged from 52.0-233.0 %. The indigenous leafy vegetable *Enhydra fluctuans* (233.0 %) has the highest sodium content and *Paederia foetida* (52.0 %) has the lowest sodium content. Sodium is involved in the regulation of plasma volume, acid-base balance, nerve and muscle contraction [26]. The results are comparable with the results obtained by Gupta *et al.* [27] in *Celosia argentea* (240.6 mg %) and *Centella asiatica* had (107.8 mg %) and Zeghichi *et al.* [23] in *S. pecten-veneris* (381 mg % and 662 mg %) in Pakistan and Greece, respectively.

The calcium contents of different leafy vegetables is ranged from 200.7-2104.96 %. *Paederia foetida* (2104.96 %) has the highest calcium content and *Bacopa monnieri* (200.7 %) has lowest calcium content. Calcium is an important constituent of bones and teeth. It involved in regulation of nerve and muscle function. In blood coagulation, calcium activates the conversion of pro-thrombin to thrombin. The results are comparable with the results obtained by Grace *et al.* [25] in *Chenopodium album* and *Solanum nigrum* which was 18213.2 mg/100 g and 16890.0/100 g of calcium, respectively and Kamga *et al.* [20] reported that calcium content varies from 1150 mg to 2690 mg/100 g in three leafy vegetables.

Micro mineral and arsenic content: Micro minerals are the part of enzymes, hormones and cells in human body. Insufficient intake of micro minerals can cause symptoms of nutritional deficiency. Arsenic is one of the most important environmental pollutants and persistent bioaccumulative carcinogen. Micro-minerals like iron, copper, zinc, manganese and heavy metal like arsenic have been determined in different indigenous leafy vegetables which are vital for maintaining health.

The iron contents of different leafy vegetables is ranged from 31.0-401.0 mg/100 g. The indigenous leafy vegetables *Amaranthus viridis* (401.0 mg/100 g) has the highest iron content and *Enhydra fluctuans*, *Amaranthus spinosus*, *Pteridium aquilinum* and *Basella rubra* (31.0 mg/100 g) has lowest iron content. The results are comparable with the results obtained by Grace *et al.* [25] in *Chenopodium album* and *Solanum nigrum* contains 120.4 mg/100 g and 177.1/100 g of iron on dry weight basis, respectively; Singh *et al.* [28] found total iron content of selected green leafy vegetables ranged from 22.3 to 84.4 mg/100 g on a dry matter basis and Kamga *et al.* [20] reported that iron content varies from 3.34 mg to 38.79 mg/100 g on dry weight basis in three leafy vegetables. Iron is an important trace element in the human body, it plays crucial roles in haemopoiesis, control of infection and cell mediated immunity [29]. The deficiency of iron has been described as the most prevalent nutritional deficiency and iron deficiency anemia is estimated to affect more than one billion people worldwide [30]. The

consequences of iron deficiency include reduced work capacity, impairments in behaviour and intellectual performance and decrease resistance to infection [31].

The copper contents of different leafy vegetables is ranged from 0.020-0.003 %. *Enhydra fluctuans*, *Polygonum chinense* (0.020 %) has the highest copper content and *Leucas longifolia* (0.003 %) has lowest copper content. Copper is required for the proper growth, development, maintenance of bone, brain, heart and many other body organs. The results are comparable with the results obtained by Grace *et al.* [25] in *Chenopodium album* and *Solanum nigrum* contains 9.1 mg/100 g and 11.2/100 g of copper on dry weight basis respectively; Singh *et al.* [28] reported that copper content of green leafy vegetables ranged from 0.8 to 1.0 mg/100 g and Zeghichi *et al.* [23] reported that *S. pecten-veneris* contain copper 54 and 1.71 mg/100 g in Pakistan and Greece, respectively.

The zinc contents of different leafy vegetables is ranged from 7.55-0.013 mg/100 g. *Basella alba* (7.55 mg/100 g) has the highest zinc content and *Paederia foetida* (0.013 mg/100 g) has lowest zinc content. Zinc has a role in the regulation of blood glucose levels via insulin function. Zinc is an essential micronutrient for human growth and immune functions [32]. The results are comparable with the results obtained by Grace *et al.* [25] in *Chenopodium album* and *Solanum nigrum* contains 23.0 mg/100 g and 26.1 mg/100 g of zinc on dry weight basis respectively; Kamga *et al.* [20] reported that zinc content varies from 0.021 mg to 0.102 mg/100 g on dry weight basis in three leafy vegetables and Afolayan and Jimoh [3] reported that zinc contents of four green leafy vegetables ranged from 4.2 to 5.5 mg/100 g.

The manganese contents of different leafy vegetables is ranged from 132.00-12.00 mg/100 g. *Chrysopogon coroneriam* (132.00 mg/100 g) has the highest manganese content and *Alternanthera sessilis* (12.00 mg/100 g) has lowest manganese content. Very low intakes of manganese are associated with poor bone formation. Manganese is a required co-factor for an enzyme prolidase required to make collagen. It is also a co-factor for an enzyme manganese superoxide dismutase (MnSOD), is a potent antioxidant. The results are comparable with the results obtained by Afolayan and Jimoh [3] in four green leafy vegetables ranged from 8.3 to 11.8 mg/100 g; Singh *et al.* [28] in green leafy vegetables ranged from 1.8 to 10.2 mg/100 g and Asaolu *et al.* [33] in some green leafy vegetables ranges between 2.54 mg/100 g and 10.06 mg/100 g.

The arsenic contents of different leafy vegetables is ranged from 1.70-0.0 mg/100 g. *Basella alba* (1.70 mg/100 g) has the highest arsenic content and *Amaranthus spinosus*, *Pteridium aquilinum*, *Alternanthera sessilis*, *Eclipta alba*, *Houttuynia cordata*, *Oxalis corniculata*, *Basella rubra*, *Stellaria media*, *Centalla asiatica*, *Oxallis acetosella* (0.0 mg/100 g) has lowest arsenic content. Arsenic affect young nervous system of the child and thereby adversely affecting the intellectual development and subsequent behaviour of the child [25]. The results are comparable with the results obtained by Grace *et al.* [25] in *Chenopodium album* and *Solanum nigrum* contains 1.8 mg/100 g and 1.9 mg/100 g of arsenic on dry weight basis, respectively and Jahanara [34] in few green leafy vegetables ranges between 0.047 to 0.324 mg/100 g.

The variation in the macrominerals, microminerals and arsenic constituents of wild leafy vegetables may be due to the stage of maturity of the plant, conditions of growth, soil fertility and environmental conditions of the plant species.

Conclusion

Indigenous leafy vegetables considered as 'weed of agriculture' and famine foods or wild foods in developing country which serve as a source of functional nutrients are rich source of macro-micronutrient and very less contamination by arsenic.

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