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Diversity of wild edible plants, nutrition and phytochemical evaluation of certain plants with ethnobotanical importance from Tinsukia district, Assam, India

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Abstract

The present study was conducted in 2021-2023 and recorded a total of 96 species, out of which 56 % were used as vegetables, 30 % *as* edible fruits and 7 % as masticatory*,* spice and condiments. This study also aims to evaluate the nutritionally important minerals concentration and phytochemical constituents of 5 plant taxa, i.e., *Sarcochlamys pulcherrima* (Roxb.*)* Gaud., *Zanthoxylum oxyphyllum* Edgew., *Smilax perfoliata* Lour., *Portulaca oleracea* L. and *Phlogacanthas thyrsiformis* (Hardw.) Mabb. which are widely used in folk healing practices and folk medicine by the various ethnic communities of Tinsukia district. The concentration of 5 macro minerals Na, K, Ca, Mg and P is in the range of 12.5 -18.4, 90.4 -246.9, 140 -214.3, 84.9 - 112.2, 23.7 - 41.2 mg/100 g respectively. The ratio of K/Na (5.9:1 to13.4:1), Ca/P (4.1:1 to 9.1:1) and K/(Ca+Mg) (0.11:1 to 0.32:1) are found to be adequate ratios ranging from respectively. Microminerals like Fe, Zn, Cu, Mn and Ni are found in the range between 5.90 -16.17, 0.41-0.91, 0.13 -0.32, 0.07 -0.27 and 0.07 - 0.17 mg/100 g respectively. Some of the important phytochemicals are also found to be present in the analyzed plants. The study shows that consumption of these species may be beneficial for maintaining good mineral nutrition among the common people at a minimum cost.

Keywords

mineral profile; phytochemicals; Tinsukia; traditional knowledge; wild edible plants

Introduction

Minerals play a vital role in human nutrition, even though they comprise only 4-6 % of the human body (1). There are about 30 elements that are necessary to different life forms, which are called essential minerals and are categorized into 2 groups, namely macro minerals and micro minerals. Calcium (Ca), Magnesium (Mg), Phosphorus (P), Potassium (K), Sodium (Na), Chlorine (Cl) and Sulfur (S) are called macro minerals or bulk elements, whereas Iron (Fe), Zinc (Zn), Manganese (Mn), Copper (Cu), Cobalt (Co), Iodine (I), Selenium (Se), Molybdenum (Mo) and Chromium (Cr) are micro minerals or trace elements. Bulk elements are required relatively in greater quantities (>100 mg/day) by our body and constitute almost 1 % of body weight; on the other hand, micro or trace elements, which are required in minute amounts, constitute <0.01 % of body weight (1). Both bulk and trace minerals are vital for normal growth and development and their deficiency can lead to organ malnutrition and nutrient-deficient disorders. Minerals play significant roles in many physiological processes, viz., cell division, cell metabolism, energy metabolism and immune responses (2, 3). For example, iron is an essential mineral and a vital component of proteins involved in oxygen transport and metabolism. Zinc is an important constituent of over 300 metalloenzymes, such as carboxypeptidase A, carbonic anhydrase, alkaline phosphatase, alcohol dehydrogenase, etc., which are involved in several metabolic processes. Sodium and potassium are essential for nerve impulses as they constitute the Na^+/K^+ pump. The sodium and potassium ratio in the diet is also important for controlling blood pressure as well as maintaining good cardiac health. The medicinal properties of a plant depend upon the different phytochemicals present in it. Phytochemicals generally do not provide nutrition, but they act as protective compounds that are found in foods of plant origin. There are several phytochemicals that have significant medicinal values; phenols, tannins, flavonoids, alkaloids, saponins, terpenoids, etc., are the most common groups of phytochemicals that have numerous medicinal values. Flavonoids are polyphenolic compounds that have strong natural antioxidants and are effective in preventing oxidative stress-related diseases. Nowadays, nutritionists, therefore, recommend taking fruits and vegetables regularly in their diet as they are rich sources of natural antioxidants.

Mineral malnutrition is a widespread health problem, particularly in developing countries. It is responsible for some chronic degenerative diseases. For example, Anemia caused by a deficiency in iron is one of the health issues worldwide, affecting nearly 30 % of the world's population (4). It is quite common among women in developing countries. Calcium deficiency is also quite common leading to the disorder osteoporosis. Hitherto, many wild vegetables are found to have excellent sources of minerals as well as other micronutrients. These vegetables are rich in vital minerals and contain several organic phytochemicals that enhance health quality, keep a well-balanced diet and act as protective against diseases such as diabetes, cancer, metabolic syndrome and cardiovascular diseases and also improve risk factors related to these diseases in our body (5, 6). Globally various ethnic communities using several wild plants as vegetables, spices, folk healing practices and traditional medicine. Apart from this, they use many wild plant species to prepare traditional beverages. Due to increasing populations and rapid urbanization in many developing countries, cultivated land is declining greatly. Hence, wild vegetables play an important part as an alternative to cultivated vegetables for improving human dietary deficiencies. As stated by FAO (Food and Agricultural Organization), at least one billion people are believed to use wild food in their diet because of its important medicinal value. In several states, numerous types of edible wild plants are exploited from the forest vegetation as sources of food by different ethnic communities. In Ghana alone, about a total of 300 plant species were consumed as wild vegetables and fruits (7). Nutritionally, Unconventional Food Plants (UFPs) are equivalent to or even superior to cultivated ones and have the medicinal significance of which some of the species still remain (8). Therefore, analysis of their chemical constituents, nutritional value and medicinal properties is necessary for their vital roles in disease inhibition and treatment.

The Northeastern states of India share an international border with neighbouring countries viz., Myanmar, Bangladesh, Nepal and Bhutan and home to many indigenous communities with more than 150 ethnic groups, speaking a variety of languages and dialects (9). States viz., Arunachal Pradesh, Meghalaya, Mizoram and Nagaland are largely inhabited by diverse indigenous communities and States viz., Assam, Manipur, Tripura and Sikkim are inhabited by people of numerous religious-like, Hindus, Christians and Muslims and a mixture of local tribes and communities. The dominant indigenous community in Assam includes Adivasi, Bodo, Garo, Mishing, Moran, Motok, Nepali, Rabha, Singpho, Sonowal, Sonowal Kachari, Tai Ahom, Tai-Phake etc., Tinsukia district is one among the 34 districts in the state of Assam, India. The district shares a long boundary on the north, east and south sides with 3 districts of Arunachal Pradesh which are Changlang, Siang, Lohit and Lower Dibang Valley. Though the districts share a boundary with Arunachal Pradesh, the export and import trade plays a vital role in the area. A huge number of local tribal vendors from both states frequently come to trade different varieties of wild plants in the market of the Tinsukia district. The peoples of these regions are very rich and unique in traditional knowledge; they have used a variety of wild plants in their daily lives from the immemorial period. However, there is limited information on the mineral composition as well as the other nutrient components of wild vegetables. Therefore, the present study attempted to evaluate the ethnobotanical knowledge and the mineral composition and screening of phytochemicals of a few selected wild medicinal plants of the Tinsukia District of Assam.

Materials and Methods

Study Area

The study was carried out in Tinsukia district of Assam, India, located at 27^0 29' 20.58" N latitude and 95^0 21' 35.71" E longitude. It shares boundaries with three districts of Arunachal Pradesh (viz. Lower Dibang Valley, Namsai and Changlang) in the northern, eastern and southern parts. In the north-western and south-western parts, it shares with Dhemaji and Dibrugarh district of Assam respectively. Tinsukia has an enormous number of forest reserves. The district has a total forest area of about 917.31 sq. km, which includes one Biosphere Reserve, 2 National Parks, 2 Wildlife Sanctuaries and 35 Reserve Forests. Different communities such as Moran, Motok, Bengali, Adivasi, Sonowal Kachari, Tai Ahom, Marwari, Nepali, Singpho, Bihari, etc. are the inhabitants of the district. A limited number of minor tribes, like Tai Phake, Khamyang, Nocte, etc., are also scattered in the district (Fig. 1).

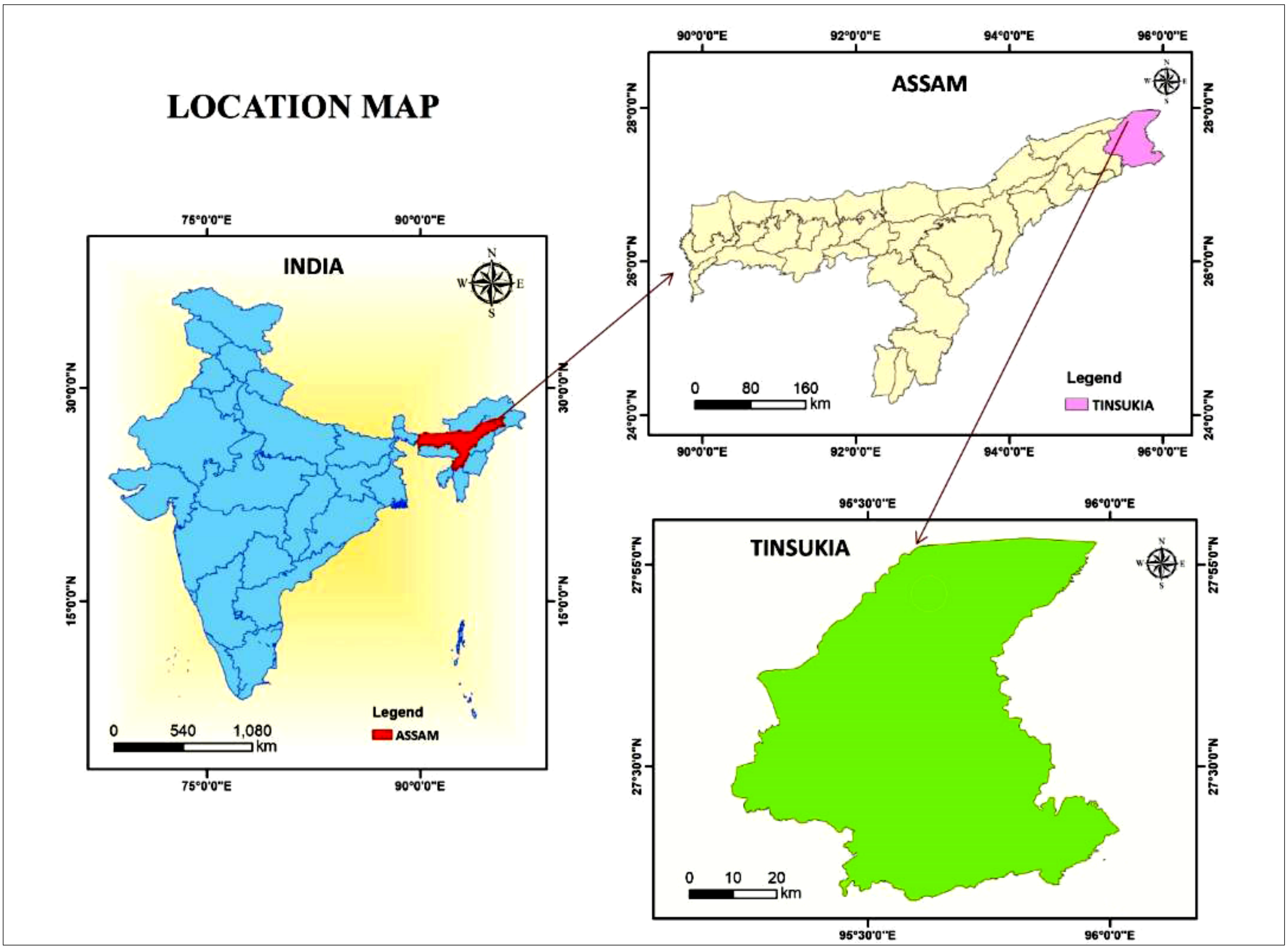

Fig. 1. Map of the study area.

Method

An extensive field survey was carried out from 2021 to 2023 with the help of local people of the area who have knowledge of wild plants from different villages and regional markets of the district.

Villagers were interviewed using a standardized questionnaire format, which involved personal and group discussions. During the time of collection, detailed information about the uses of wild edible plant species was recorded. The collected specimens were identified by consulting relevant literature (10-13). Herbarium specimens were prepared following standard methods of plant taxonomy and stored in the Raw Drug and Herbarium (NEIAFMRH) of North Eastern Institute of Ayurveda and Folk Medicine Research (NEIAFMR), located in the Pasighat, Arunachal Pradesh. To analyze the mineral profile of a few ethnomedicinal plants. Few plants viz. *Sarcochlamys pulcherrima* (Roxb.) Gaud., *Zanthoxylum oxyphyllum* Edgew., *Smilax perfoliata* Lour., *Portulaca oleracea* L. and *Phlogacanthus thyrsiformis* (Hardw.) Mabb. were selected based on their repeated uses in preparing different traditional medicines and traditional food preparation.

Raw sample preparation

The freshly collected vegetable plants were cleaned with water and allowed to dry. The moisture was then blotted with tissue paper. The non-edible parts were removed and discarded while the edible parts were chopped into small pieces. It was then dried in a shady, well-ventilated room at an ambient temperature for 7-10 days. Thus, the prepared samples were considered as raw samples.

Analysis of minerals

To analyze the minerals content (viz. Ca, P, Mg, Na, K, Fe, Zn, Cu, Mn and Ni), each dried sample was weighed. Ashes of each dried sample were obtained by incinerating in a muffle furnace at 550 ^{0} C (14). A triple acid mixture (HCl-HNO_3-H_2SO_4) in the ratio of (1:2:4) was used to digest the calcined ash for each sample to dryness. 2 N HNO_3 was used to dissolve the residue, while Whatman-42 filter paper was used to filter the insoluble portion. The filtrate was collected (50 mL) and preserved for metals analysis. Atomic Absorption Spectrophotometer (Perkin Elmer Analyst 200) was used to measure the concentration of Ca, Mg, Fe, Zn, Cu, Mn and Ni while flame photometry was employed to analyse Na and K. By colorimetric method, P was analyzed using molybdovanadate reagent (15).

Analysis of Phytochemicals

The presences of phytochemical constituents (phenols, tannins, flavonoids, alkaloids, saponins and terpenoids) were analyzed using standard methods (14, 16, 17).

Statistical analysis

All the data of mineral analysis are expressed as mean ± SDs (n=3). The comparisons between the mean values are tested at a level of $P \leq 0.05$.

Results and Discussion

Ethnobotanical records

The majority of fringe villages of the ethnic community, viz., Moran, Motok, Adivasi, Tai Ahom, Sonowal Kachari, Nepali and Singpho, of the district, are dependent on forest resources for their day-to-day life requirements such as food, fodder, fuel, shelter, medicines and sociocultural aspects. The present study recorded a total of 96 species belonging to 71 genera under 48 families. Out of 96 species, 58 were used as vegetables, 31 as edible fruits, 7 species as spices and condiments and 8 species were used as Masticatory (Fig. 2, 3). In the present study, 5 species were selected to evaluate the nutrition and phytochemical constituents based on their uses in multipurpose uses by ethnic communities of the Tinsukia district. The systematic documentation with their ethnobotanical information was recorded and listed in Supplementary Table 1. Among the 51 families recorded, the 5 families Araceae with 7 genera, Amaranthaceae with genera, Arecaceae with 4 genera, Clusiaceae with 4 genera and Solanaceae with 4 represent the dominant family in the study area (Fig. 4). It also recorded that most of the fruit parts of the species were used as edible parts in the area (Fig. 5-7).

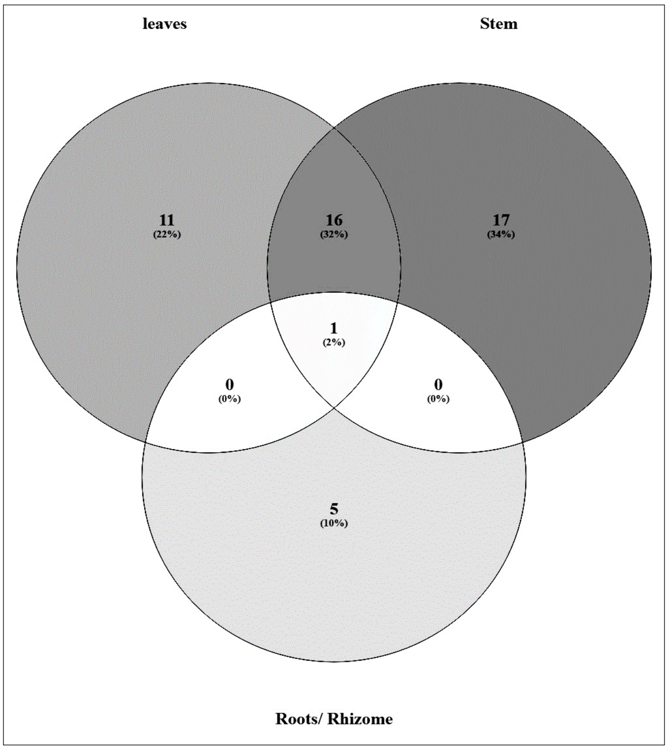

Fig. 2. Ven diagram showing the use of different vegetative parts of plants.

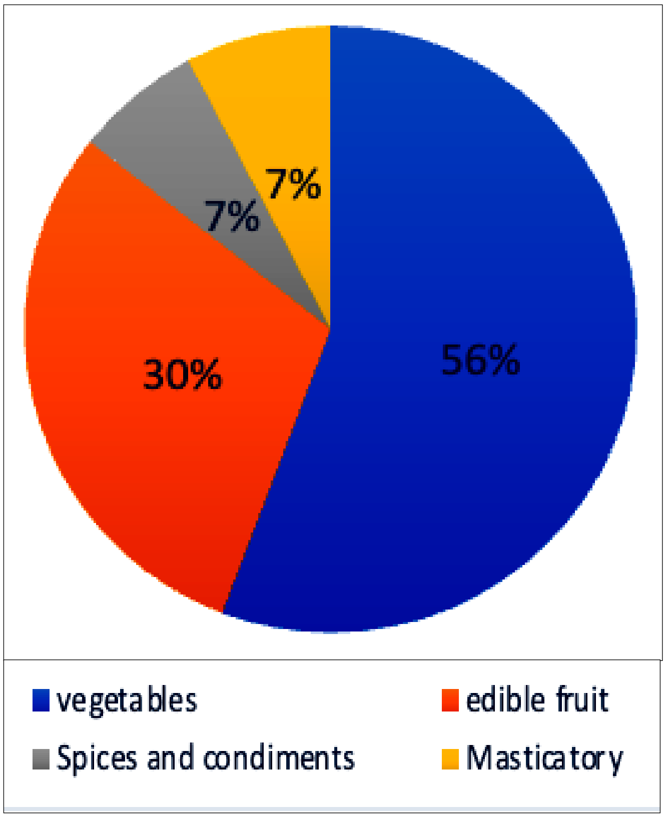

Fig. 4. Pie diagram of the types of plants used.

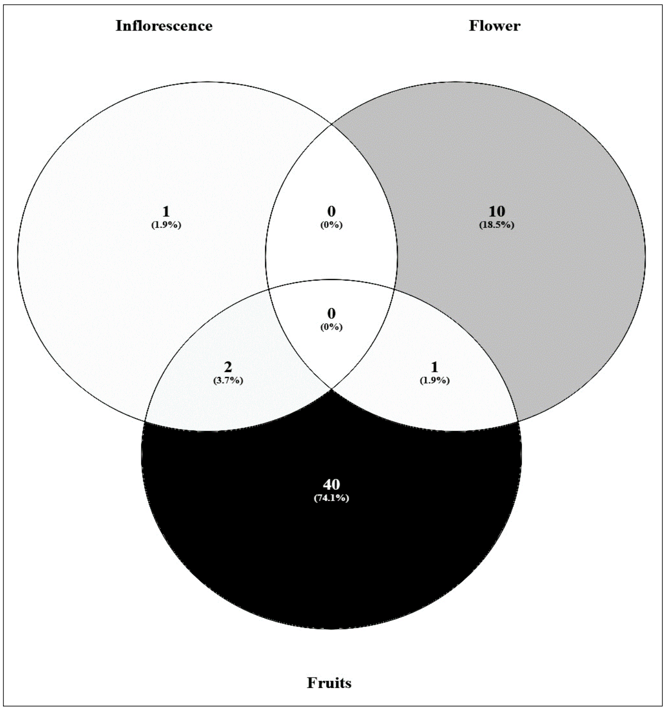

Fig. 3. Ven diagram showing the use of different reproductive parts of plants.

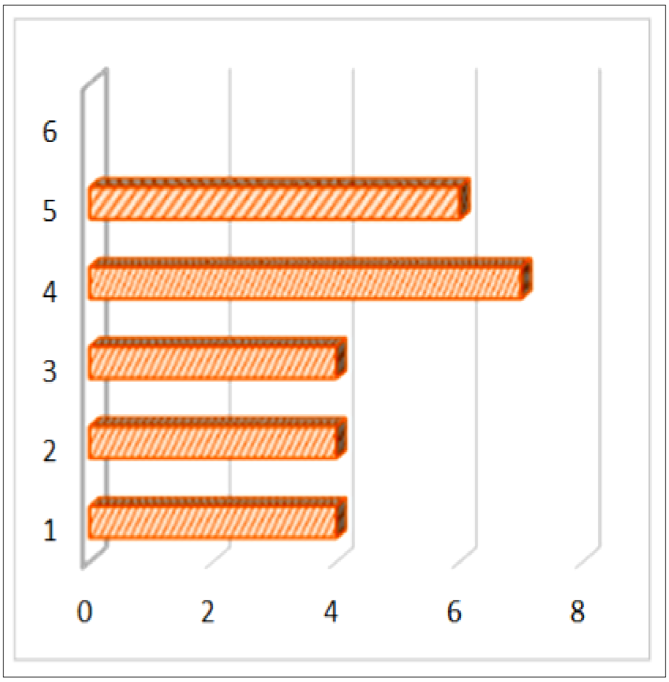

Fig. 5. Five dominant families of the study area.

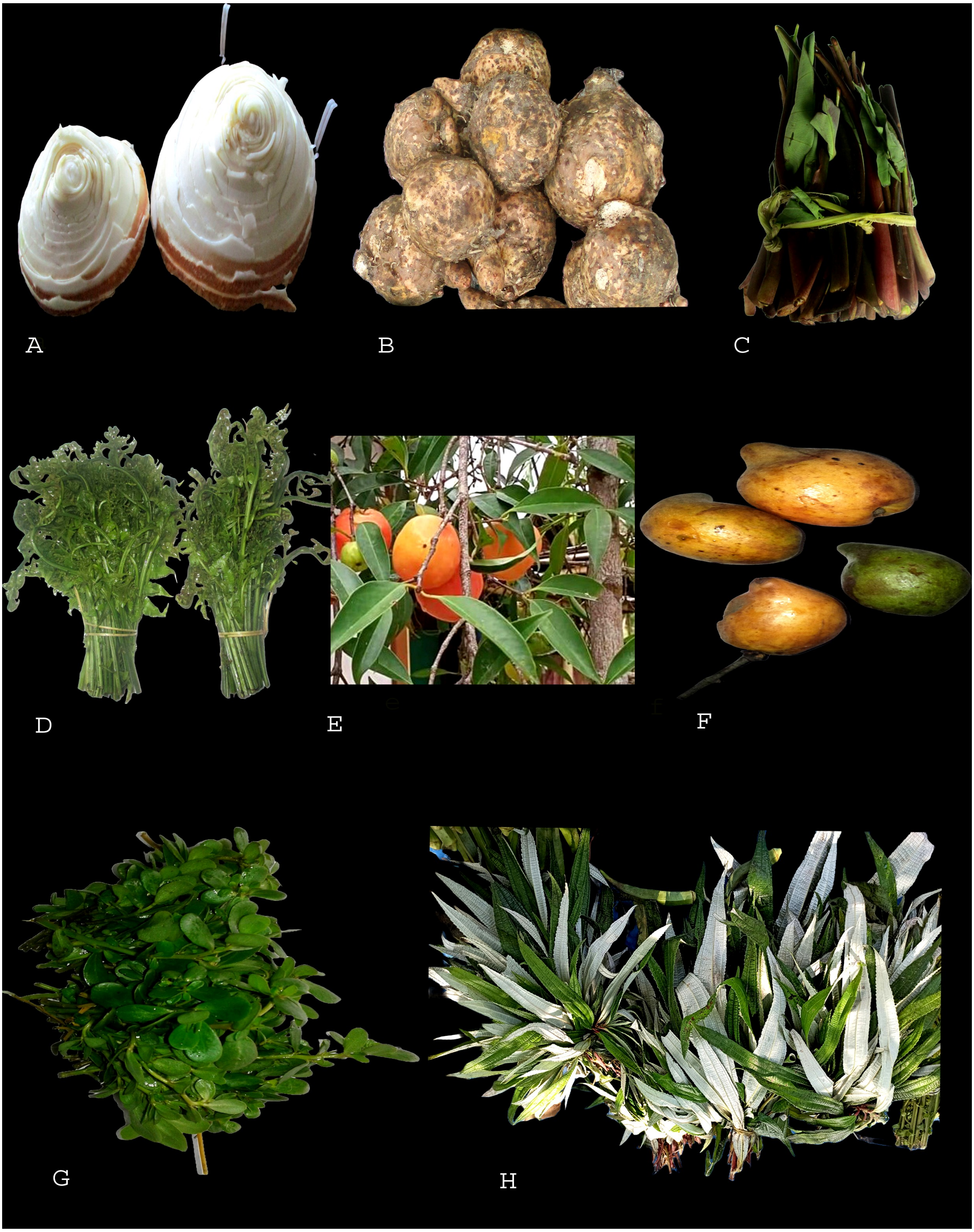

Fig. 6. A. *Bambusa balcooa*, **B**. *Amorphophallus bulbifer,* **C**. *Colocasia esculenta*, **D**. *Diplazium esculentum;* **E**. *Garcinia cowa*, **F**. *Garcinia morella,* **G**. *Portulaca oleracea,* **H**. *Sarcochlamys pulcherrima.*

Minerals and Phytochemical Analysis

Some of the nutritionally important alkali metals, alkaline earth metals and transition metals are estimated. The analysis of the macro-mineral present in edible plants is listed in Table 1. Macro-mineral content of these medicinal/edible plants was significantly different (P<0.05). The concentration of sodium in raw vegetables ranges from 12.5 mg/100 g (*P. oleracea*) to 18.4 mg/100 g (*X. oxyphyllum)*. Whereas another study reports are on the amounts of sodium in *P. oleracea* 55 mg/100 g respectively (18) and also reported (7.17 mg/100 g) (19). Sodium concentration is comparatively low in the vegetables. Consumption of a

Fig. 7. A. *Flacourtia jangomas*, **B**. *Musa balbisiana*, **C**. *Phlogacanthus thyrsiformis*, **D**. *Phlogacanthus curviflorus*, **E**. *Smilax perfoliata*, **F**. *Zanthoxylum oxyphyllum*.

Table 1. Concentration of macro-elements present in the raw wild vegetables (mg/100 g).

Plant samples	Na	K	Ca	Mg	P
Sarcochlamys pulcherrima (Roxb.) Gaud.	16.9 ± 1.4^{a}	117.4 ± 10.1^{a}	240.2 ± 3.1^{a}	85.7 ± 3.4^{a}	23.7 ± 1.6^{a}
Smilax perfoliata Lour.	14.7 ± 0.8^{c}	114.3 ± 12.3^{a}	363.1± 2.1^{c}	84.9 ± 8.5^{a}	28.9 ± 1.1^{c}
Portulaca oleracea L.	12.5 ± 2.1^{d}	138.8 ± 7.7^{c}	172.5 ± 1.1^{d}	112.2 ± 10.5^{c}	41.2 ± 1.2^{d}
Phlogacanthus thyrsiformis (Roxb. ex Hardw.) Mabb.	15.2 ± 2.7^{c}	90.4 ± 37.8^{d}	143.7 ± 1.2^{a}	102.2 ± 8.2^{d}	27.3 ± 2.1^{c}
Zanthoxylum oxyphyllum Edgew.	18.4 ± 0.6^{b}	146.9 ± 10.2^{b}	214.3 ± 2.3^{b}	106.3 ± 2.1^{b}	25.1 ± 0.7^{b}

All data are the means ± SD of triplicate experiment (**n**=3). Mean values in a column with different letters are significantly different at $P<0.05$

low-sodium diet is very necessary to maintain good health. Excess intake of sodium results in high blood pressure, potassium deficiency, liver and kidney disease, etc. and it may also cause heart disease due to improperly balanced potassium (20). The potassium content of the selected plant samples is higher than that of the sodium content which is essential in diet to regulate blood pressure. The potassium contents of raw samples of *Phlogacanthus thyrsiformis* and *Zanthoxylum oxyphyllum* ranged from 90.4 mg/100 g to 246.9 mg/100 g. Potassium accelerates several reactions, including protein synthesis, nerve transmission and contraction of muscles. Insufficient consumption of nutritional potassium may also increase the risk of several heart and blood vessel problems (21).

Ca (Calcium) plays an essential role in the growth and healthy upkeep of bones, teeth, body muscles and blood. It is abundantly found to be present in the study plant samples ranging from 140 mg/100 g (*Sarcochlamys pulcherrima*) to 214.3 mg/100 g (*Zanthoxylum oxyphyllum*). Strong teeth and bones are outcomes of an adequate source of calcium (Ca). It also results in good healthy skin, helps in regulating cardiovascular functions and blood pressure levels, supports the breakdown of iron and is mandatory for appropriate cell division (22, 23). The plant's sample of magnesium ranges from 84.9 mg/100 g (*Smilax perfoliata*) to 112.2 mg/100 g (*Portulaca oleracea*). Nutritional deficiency of Mg (Magnesium) is associated with coronary heart disease (CHD) (22); Regular consumption of these wild vegetables can prevent coronary heart disease as all these wild vegetables are main sources of Mg (Magnesium). The amount of Phosphorus (P) in wild vegetables ranges from 23.7 mg/100 g (*Sarcochlamys pulcherrima*) to 41.2 mg/100 g (*Portulaca oleracea*). Phosphorus (P) plays a major role in the growth and development and improves the body tissue. In addition, with calcium and magnesium, Phosphorus (P) is also necessary for appropriate growth and development of bones in newborns and children (23). Several researchers have reported that Macrominerals and trace elements useful in the diet were found to have higher content in wild species than in domesticated ones. Reports are on a high content of K in *Sanguisorba minor* Scop. (24). In addition, it was also reported that comparable results for Ca^{+}, Mg^{2+}, Fe^{2+}, Cu^{2+}, Mn^{2+} and Zn^{2+} are in domesticated *S. minor* plants (25).

The content of K/Na, Ca/P and K/(Ca+Mg) present in wild vegetables/medicinal plants samples were listed in Table 2. The ratio of K/Na in our body is of major *concern* to stop high blood pressure besides for normal maintenance of proteins throughout growth (26). Nutritionists suggest a dietary K: Na ratio > 5:1 to continue optimal health (27). The rate for all wild vegetables ranged from 5.9:1 (*Phlogacanthus thyrsiformis*) to 13.4:1 (*Zanthoxylum oxyphyllum*). Wholly these vegetables are found to have suitable levels of K/Na ratios and hence, intake of these vegetables may regulate hypertension. The Ca/P ratio of fresh vegetables *Portulaca oleracea* and *Smilax perfoliata* ranges from 4.1:1 to 9.1:1. The Ca/P ratios of the studied wild vegetables are somewhat higher than the required amount of intestinal absorption of Ca and phosphorus(P). Foods containing a high value of K/ (Ca + Mg) ratio (≥ 2.2 expressed in meq) are susceptible to hypomagnesemia, a condition of electrolyte disbalance where the level of Mg is low in the blood (28). The findings show that the value of the K/ (Ca + Mg) ratio is less than the susceptible range. The resultant values range from 0.11:1 (*Smilax perfoliata*) to 0.32:1 (*Zanthoxylum oxyphyllum*).

The analysis for micro-mineral content of wild vegetables is listed in Table 3. The mineral contents of these selected plant samples were significantly different ($P<0.05$). The volume of iron in these selected plant samples ranges from 5.90 mg/100 g (*Smilax perfoliata)* to 16.17 mg/100 g (*Portulaca oleracea*), which shows equivalences to maximum values reported from leafy vegetables (4). Usual consumption of these wild vegetables can stop iron deficiency. The ratio range of zinc in these wild vegetables' ranges from 0.41 mg/100 g (*Sarcochlamys pulcherrima*) to 0.91 mg/100 g (*Zanthoxylum oxyphyllum*). The level of zinc studied in these vegetables compares favorably with the value reported for some other green leafy vegeta-

Table 2. Concentration of micro-elements present in the raw wild vegetables (mg/100 g).

Plant Samples	Fe	Zn	Cu	Ni	Mn
Sarcochlamys pulcherrima (Roxb.) Gaud.	15.41 ± 1.11[a]	0.41 ± 0.11[a]	0.21 ± 0.02[a]	0.14 ± 0.01[a]	0.27 ± 0.10[a]
Smilax perfoliata Lour.	5.90 ± 0.64[c]	0.54 ± 0.03[a]	0.13 ± 0.00[c]	0.07 ± 0.02[b]	0.15 ± 0.01[b]
Portulaca oleracea L.	16.17 ± 1.12[a]	0.81 ± 0.11[b]	0.14 ± 0.01[c]	0.17 ± 0.00[c]	0.07±0.01[b]
Phlogacanthus thyrsiformis (Roxb. ex Hardw.) Mabb.	7.2 0± 1.50[d]	0.68 ± 0.08[c]	0.21 ± 0.01[a]	0.11 ± 0.02[a]	0.22 ± 0.01[d]
Zanthoxylum oxyphyllum Edgew.	11.40 ± 1.16[b]	0.91 ± 0.11[b]	0.32± 0.01[b]	0.11 ± 0.01[a]	0.13 ± 0.01[b]

All data are the means ± SD of triplicate experiment (**n**=3). Mean values in a column with different letters are significantly different at $P<0.05$.

Table 3. K/Na, Ca/P and P/ (Ca+ Mg) ratio of the wild vegetables.

Plant Samples	K/Na (wt/wt)	Ca/P (wt/wt)	K/ (Ca + Mg) (meq/meq)
Sarcochlamys pulcherrima (Roxb.) Gaud.	6.9	5.9	0.21
Smilax perfoliata Lour.	7.7	9.1	0.11
Portulaca oleracea L.	11.1	4.1	0.19
Phlogacanthus thyrsiformis (Roxb. ex Hardw.) Mabb.	5.9	5.2	0.15
Zanthoxylum oxyphyllum Edgew.	13.4	8.5	0.32

meq= (mg/atomic weight) × valency.

bles (26, 29). Zinc is one of the most important mineral nutrients and is necessary for the proper function of over 200 enzymatic reactions in the body (7). The copper level of the vegetable's ranges from 0.13 mg/100 g (*S. perfoliata)* to 0.32 g/100 g (*X. oxyphyllum)*. Values for manganese for these vegetables range from 0.07 mg/100 g (*P. Oleracea)* to 0.27 mg/100 g (*S. pulcherrima)*. Copper and manganese are essential for humans because they exhibit a wide range of biological functions, such as components of enzymatic and redox systems (30). Nickel is an important trace element that plays its role as a co-enzyme in different enzymes such as urease. The amount of Ni in these vegetables' ranges from 0.07 mg/100 g (*Smilax perfoliata*) to 0.17 (*Portulaca oleracea*).

The phytochemical screenings of the investigated vegetables are summarized in Table 4. Phenols, alkaloids, tannins and flavonoids are present in all the samples. Saponin is absent in *Smilax perfoliata* and *Phlogacanthus thyrsiformis*. Only *Smilax perfoliata* and *Portulaca oleracea* are found to have terpenoids. Phenols, tannins and flavonoids are good natural antioxidants and the presence of these phytochemicals proves that they have medicinal values. The results of the mineral content of the targeted wild vegetables in the study are comparable with the mineral content of common cultivated vegetables. The mineral content of some common vegetables in India was reported (31) is listed in Table 5; Fe concentration was found to be higher, whereas content of K was found to be lower in our targeted wild vegetables compared to the common cultivated vegetables. Concentrations of other minerals were comparable with the commonly cultivated green leafy vegetables.

Table 4. Minerals concentration of some common green vegetables (Results are expressed as mg/100g of edible portion).

Name of the vegetables	Na	K	Ca	Mg	P	Fe	Cu
Cabbage (green)	14.98	233	51.76	17.99	30.15	0.35	0.03
Lettuce	17.53	279	56.76	43.22	44.1	2.73	0.14
Spinach	42.5	625	82.9	86.97	32.59	2.95	0.17
Amaranth leaves (green)	16.08	572	330	194	73.22	4.64	0.21

Table 5. Phytochemicals identified in wild vegetables.

Samples	Phenols	Alkaloids	Saponins	Tannins	Flavonoids	Terpenoids
Sarcochlamys pulcherrima (Roxb.) Gaud.	+	+	+	+	+	-
Smilax perfoliata Lour.	+	+	-	+	+	+
Portulaca oleracea L.	+	+	+	+	+	+
Phlogacanthus thyrsiformis (Roxb. ex Hardw.) Mabb.	+	+	-	+	+	-
Zanthoxylum oxyphyllum Edgew.	+	+	+	+	+	-

+ Present; **-** Absent.

Conclusion

The ethnobotanical plants are good sources of minerals. Together with vital nutrients, wild vegetables provide a wide range of bioactive substances that have a major positive impact on both illness prevention and health promotion. Additionally, they are important in preventing various metabolic and age-related illnesses. The present study reveals that the majority of plants are rich in K, Ca, Mg, P, Fe and Zn and are rich in iron concentration. Regular consumption of such vegetables can help treat iron deficiency anaemia. Instead of having plant resources, there are certain gaps in documentation and analysis of chemical constituents of the unconventional species; therefore, detailed scientific studies are required to establish the medicinal value.

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Authors' contributions

PS carried out the chemical analysis and conceptualization. DB conducted the field survey, identified wild edible plants and wrote the original draft. AB conceptualized the work and finalised the draft manuscript. BD carried out the Field survey and edited the draft manuscript. SB supervised the phytochemical analysis. NN carried out the filed survey. AA edited the draft manuscript of phytochemical parts.

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interests to declare.

Ethical issues: None

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