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Nutritional potential of five unexplored wild edible plants consumed by the tribal people of Arunachal Pradesh state in India

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Abstract

Background and Objective: The objective of the present study is to evaluate the nutritional potential of five wild edible plants e.g. *Allium hookeri* Thw. Enum (bulb), *Cardamine macrophylla* Willd. (Whole plant), *Sarcochlamys pulcherrima* (Roxb.) Gaud (leaves), *Eryngium foetidum* Linn. (Leaves) and *Bambusa balcooa* Roxb. (Young shoot) collected from Arunachal Pradesh in India. These plants are consumed by the different tribal people of Arunachal Pradesh to meet their adequate level of nutrition.

Materials and Methods: The proximate parameters like ash, moisture, protein, fat, fibre, carbohydrate, energy content and minerals *viz*. sodium, calcium, potassium, iron, magnesium, manganese, copper, zinc, were evaluated in the selected wild edible plants using standard food analysis techniques. By determining their proximate and mineral's composition.

Results: The present study revealed that for different plant species, the crude fat content ranged between 1.36±0.04 - 2.60±0.13 %. The crude protein content was determined high among the whole plant of *C. macrophylla* (27.84±0.02%), leaves of *S. pulcherrima* (15.60±0.02%) and young shoot *B. balcooa* (13.24±0.02 %) while the available carbohydrate content was highest in the leaves of *E. foetidum* (76.23±0.30 %). The energy content ranged from 309.16±0.99 – 354.64 ±0.28 kcal/100g in the various wild edible plants. Among the various macronutrients estimated in the samples of plants under study, potassium was present in the highest quantity (23.98±0.13-67.14±0.29 mg/g) followed by calcium (11.96±0.27-27.35±0.27 mg/g) and sodium (0.22±0.008-2.69±0.09 mg/g).

Conclusions: The outcome of investigation indicates that nutritional values and mineral contents of these plants under investigation were richer than that of the commercial vegetables and could be used for the nutritional purpose. The present study also provides an account of ethnobotanical importance of the wild plants under investigation. These undomesticated palatable plants form an important constituent of traditional subsistence's in Arunachal Pradesh.

Keywords: wild edible plants, Arunachal Pradesh, ethnobotanical importance, nutritional composition, mineral contents

Introduction

Wild edible plants have played a vital role in supplementing the diet among the people in developing countries. Due to the speedy growth of population, scarcity of fertile land for cultivation and high prices of available staples, the poor people frequently collect wild edible plants and other plants from natural habitats to meet their adequate level of nutrition. Different biochemical methods have been developed to cultivate some desired plant species in large scale in the garden and fields to meet the caloric necessities of human being. It has also been reported in ongoing studies that cultivated plants with high chemical inputs such as fertilizers, plant growth regulator, herbicides, etc., has lost their natural taste, appearance and nutritive values [1]. Recently, a lot of interest has been focused to evaluate various wild edible plants because they serve as an indispensable constituent of human diet replenishing the body with minerals, vitamins and certain hormone precursors, in addition to protein and energy. In most of these communications, it was notified that the nutraceutical value of unconventional plants foods could be comparable to or even sometimes superior to the common vegetables [2].

These plants also contribute some beneficial products like medicine, fibre, fodder, dyes, etc. In this context, the analysis of wild edible plants is important to identify the potential sources which could be exploited as alternative food.

Arunachal Pradesh is a small state in north-eastern India. A large part in the region is botanically under-explored or even undiscovered. The forests of Arunachal Pradesh provide a large number of plants whose fruits, seeds, tubers, shoots, etc. make an important contribution to the diet of the ethnic people. The present study explores the nutritionary status of five wild plants viz. *Allium hookeri* (tuber), *Cardamine macrophylla* (whole plant), *Sarcochlamys pulcherrima* (leaves), *Eryngium foetidum* (leaves) and *Bambusa balcooa* (young shoot) reportedly consumed by the tribal people of Arunachal Pradesh. The main target of our research was to find out the nutritional prospective of these undomesticated edible plants. The traditional use and ethnobotanical importance of these plants have also been mentioned.

Allium hookeri Thw. Enum belongs to the family Liliaceae, locally known as 'Talap' in Arunachal Pradesh is a wild herb widely growing in Tawang, lower Subansiri, west Kameng, upper Dibang valley, east Kameng of Arunachal Pradesh. The leaves and roots of this plant are eaten as vegetable, and the tribal people preferred to use the different parts through the plant in preparation of palatable recipes. The plant is also used for the treatment of heart diseases [3-5].

Cardamine macrophylla Willd., belongs to the family Brassicaceae, traditionally known as 'Pimtale' among the Nyshi tribe of Arunachal Pradesh. The leaves from this plant are consumed as a vegetable [6].

Sarcochlamys pulcherrima (Roxb.) Gaud, belongs to the

family Urticaceae, is a popular wild edible ethno-medicinally important plant, growing in the several parts of North-East India. The leaves of the plant are reported to be used for the treatment of worm infection, dysentery and diarrhea. The young shoots and leaves are consumed as vegetable and also cooked with meat by the different ethnic people of North-East India. The anti-bacterial and anti-fungal activities of the leaves on the plant have been reported [7].

Eryngium foetidum Linn, belongs to the family Apiaceae. It is called as 'Ori' by the 'Nyshi' tribe of Arunachal Pradesh. It used in folk medicine for the management of several anti-inflammatory disorders. The leaves and roots are boiled, and the decoctions are taken for the treatment of pneumonia, flu, diabetes, constipation, malaria fever and reportedly used to alleviate stomach pains [8].

Bambusa balcooa Roxb. belonging to the family Poaceae, is widely distributed in the several parts of North –East India. The young shoots are cooked as vegetable.

The purpose of the present study was to determine the nutritional quality and mineral contents of five wild edible plants e.g. *Allium hookeri* (bulb), *Cardamine macrophylla* (whole plant), *Sarcochlamys pulcherrima* (leaves), *Eryngium foetidum* (leaves) and *Bambusa balcooa* (young shoot) which are traditionally used as food and medicine by the different tribal people of Arunachal Pradesh in India.

Materials and methods

Plant materials

The five plant materials, e.g. *A. hookeri* (tuber), *C. macrophylla* (whole plant), *S. pulcherrima* (leaves), *E. foetidum* (leaves) and *B. balcooa* (young shoot) were collected from different places of Arunachal Pradesh in June 2014 and authenticated in our office. The voucher specimens were preserved in the Plant Chemistry department of our office under registry no BSITS 76, BSITS 77, BSITS 78, BSITS 79 and BSITS 80, respectively. The plant parts were shed-dried, pulverized and stored in an airtight container and proximate composition, and mineral contents were carried out in the laboratory.

Estimation of ash

Five gm of each sample were weighed in a silica crucible and heated in the muffle furnace for about 5-6 h at 500 °C. It was cooled in a desiccator and weighed. It was heated again in the furnace for half an hour, cooled and weighed. This was repeated consequently, until the weight became constant (ash became white or grayish white). The increase in weight of the crucible gave the ash content in the plant materials [9].

Estimation of moisture

Two gm of each sample was taken in a flat-bottom dish and kept overnight in an air oven at 100–110°C and weighed. The loss in weight was regarded as a measure of moisture content of the plants [9].

Estimation of crude fat

Two gm moisture free of each sample was extracted with petroleum ether (40-60°C) in a Soxhlet apparatus for about 6-8 h. After boiling with petrol, the residual petrol was filtered using Whatman no. 40 filter paper and the filtrates were evaporated in a pre-weighed beaker. Increase in weight of the beaker gave the amount of crude fat content in the plants [9].

Estimation of crude fibre

Two gm of moisture and fat-free material of each sample were treated with 200 mL of 1.25 % H_2SO4. After filtration and washing, the residue was treated with 1.25 % NaOH. It was then filtered, and residue was washed in boiling water followed by 1 % HNO_3 and again with hot water. The washed residue was dried in an oven at 130 °C to constant weight and cooled in a desiccator. The residue was scraped into a pre-weighed porcelain crucible, weighed, heated in muffle furnace at 550 °C for two hours, cooled in a desiccator and reweighed. Crude fibre content was expressed as percentage loss in weight on ignition [9].

Estimation of crude protein

The crude protein was determined using micro Kjeldahl method. Two gm. of each sample compound were decomposed by digestion with concentrated sulphuric acid in the presence of a catalyst, until the mixture was clear. The digest was taken in a round-bottom flask, and the solution was diluted with distilled water. An excess of sodium hydroxide solution (40%) was added to the diluted reaction mixture, the liberated ammonia was distilled in steam and absorbed in 25 ml N/20 sulphuric acid. Titration of the residual mineral acid with standard sodium hydroxide gives the equivalent of ammonia obtained from the weight in the sample taken. From this, the percentage of nitrogen in the compound was calculated. Based on early determinations, the average nitrogen (N) content of proteins was found to be about 16 percent, which led to use of the calculation N x 6.25 (1/0.16 = 6.25) to convert nitrogen content into protein content [9].

Estimation of available carbohydrate

Percentage of available carbohydrate was given by: 100-(percentage of ash + percentage of fat + percentage of protein + percentage of crude fibre) [9].

Estimation of energy content

The three components of foods which provide energy are protein, carbohydrate and fat. One gram carbohydrate and protein each yield four kcal energy whereas one gram fat yields nine kcal energy. Therefore, the energy contents of each plant sample were determined by multiplying the values obtained for protein, fat and available carbohydrate by 4.00, 9.00 and 4.00, respectively and adding up the values [9-10].

Estimation of minerals in plant material

Plant material was taken in a precleaned and constantly weighed silica crucible and heated in a muffle furnace at 400°C till there was no evolution of smoke. The crucible was cooled at room temperature in a desiccator and carbon-free ash was moistened with concentrated sulphuric acid and heated on a heating mantle till fumes of sulphuric acid ceased to evolve. The crucible with sulphated ash was then heated in a muffle furnace at 600°C till the weight of the content was constant (~2–3 h). One gram of sulphated ash obtained above was dissolved in 100 mL of 5 % HCl to obtain the solution ready for determination of mineral elements through atomic absorption spectroscopy (AAS) (AA 800, Perkin-Elmer Germany). Standard solution of each element was prepared and calibration curves were drawn for each element using AAS [11].

Statistical analysis

All assays were carried out in triplicate and values were

obtained by calculating the average of three experiments and data are presented as Mean ± SEM (Standard Error Mean).

Results and discussion

The edible parts of fresh plant materials *e.g A. hookeri C. macrophylla S. pulcherrima E. foetidum* and *B. balcooa* collected from different places of Arunachal Pradesh have a relatively high moisture content when compared to ash, crude protein, crude fat, dietary fibre and available carbohydrate content (Table 1).

Table 1: Proximate composition of the wild edible leaves collected from Arunachal Pradesh

Name of the Plant	Parts used	Ash %	Moisture %	Crude fat %	Crude fibre %	Protein % 6.25x % of N	Carbohydrate %	Energy content kcal/100g
A. hookeri	Tuber	22.62±0.25	89.75±0.12	1.83±0.02	2.38±0.02	11.33±0.02	61.83±0.28	309.16±0.99
C. macrophylla	Whole plant	19.14±0.08	91.17±0.11	2.42±0.02	0.55±0.03	27.84±0.02	50.03±0.05	333.30±0.33
S. pulcherrima	Leaves	12.99±0.08	82.43±0.11	1.84±0.02	0.64±0.02	15.60±0.01	68.91±0.13	354.64±0.28
E. foetidum	Leaves	14.04±0.11	89.02±0.13	2.60±0.13	0.58±0.02	06.54±0.06	76.23±0.30	354.55±0.42
B. balcooa	Young shoot	21.44±0.06	71.22±0.09	1.36±0.04	0.96±0.03	13.24±0.02	62.98±0.09	317.20±0.07

Each value in the table was obtained by calculating the average of three experiments (n=3) and data are presented as Mean ± SEM

The edible parts of all plants contain minerals like sodium, potassium, calcium, manganese, magnesium, iron, zinc and copper in varying concentration with potassium having highest concentration (Table 2).

Table 2: Minerals content of the wild edible leaves collected from Meghalaya state

Name of the Plant	Parts used	Minerals present mg /g (Mean ± SEM)							
		NA	K	CA	MN	CU	FE	MG	ZN
A. hookeri	Tuber	0.60±0.01	36.14± 0.31	11.96± 0.27	0.10± 0.001	0.071±0.001	1.97±0.001	0.75±0.001	1.37±0.001
C. macrophylla	Whole plant	2.69±0.09	47.77± 0.35	21.51± 0.21	0.22± 0.001	0.195±0.001	2.30±0.001	0.91±0.001	0.59±0.001
S. pulcherrima	Leaves	0.25±0.007	28.47± 0.19	22.93± 0.35	0.05± 0.001	0.006±0.0001	0.38±0.001	0.94±0.001	0.42±0.001
E. foetidum	Leaves	0.36±0.007	23.98± 0.13	27.35± 0.27	0.11±0.002	0.182±0.001	1.06±0.001	1.09±0.001	1.10±0.001
B. balcooa	Young shoot	0.22±0.008	40.15± 0.27	13.10± 0.20	0.22±0.001	0.019±0.0001	0.21±0.001	0.52±0.006	0.97±0.001

Each value in the table was obtained by calculating the average of three experiments (n=3) and data are presented as Mean ± SEM

The proximate analyses of the nutritive contents of five plants are shown in Table 1. The results obtained from systematic chemical analysis of all five wild edible plants established that energy content in the leaves of *S. pulcherrima* was maximum (354.64±0.28 kcal/100g) followed by the leaves of *E. foetidum* (354.55±0.42 kcal/100g) and whole plant of *C. macrophylla* (333.30±0.33 kcal/100g). The tuber of *A. hookeri* was found to be of less nutritive value (309.16±0.99 kcal/100g) as compared with other plants under investigation. The crude protein contents ranged from 6.54±0.06 % (leaves of *E. foetidum*) to 27.84±0.02% in the whole plant of *C. macrophylla*. The crude protein content in *C. macrophylla* was found to be very much comparable with those of almond (20.80 %), cashewnut (21.20 %) [12]. The crude protein contents in the leaves of *S. pulcherrima* (15.60±0.01 %) and young shoot of *B. balcooa* (13.24 ±0.02 %) were more than what is stated for lesser-known wild leafy vegetables such as *Momordica balsamina* (11.29±0.07%), *Ardisia humilis* (12.71±0.33%) [13-15]. these indicate that low cost plant samples are very good sources of protein.

The leaves of *E. foetidum,* leaves of *P. pedicellatum*, *S. pulcherrima* and young shoots of *B. balcooa*, with high content of available carbohydrates (76.23±0.30 %, 68.91±0.24 % and 62.98±0.09 % respectively) compared well to that reported for almond (10.50 %), apple (13.7 %)[12], wood apple (18.1 %), potato (20.9 %) and ripe mango (14.9%) (Table 3) [12, 16].

Table 3: Proximate composition of some common vegetables and fruits

Name of the Plant	ASH (%)	Moisture (%)	Crude fat (%)	Protein (%) (6.25x % of N)	Available Carbohydrate (%)	Crude fibre (%)	Nutritive value (kcal /100g)
Apple	1.2	84.6	0.3	0.2	10.5	3.2	58
Brinjal	1.6	88.7	0.3	1.4	1.7	6.3	24
Broad beans	2.8	82.4	0.1	4.5	1.3	8.9	48
Cabbage	1.6	91.9	0.1	1.8	1.8	2.8	27
Cauliflower	2.2	90.8	0.4	2.6	0.3	3.7	30
Lettuce	1.7	93.4	0.3	2.1	-	-	21
litchi	1.0	84.1	0.2	1.1	-	-	61
Mango ripe	1.1	81.0	0.4	0.6	14.9	2.0	74
Papaya ripe	1.3	90.8	0.1	0.6	4.6	2.6	32
Potato	1.0	74.7	0.1	1.6	20.9	1.7	97
Spinach	2.3	92.1	0.7	2.0	0.4	2.5	26
Wood apple	6.9	64.2	3.7	7.1	18.1	-	134

and these could be supplemented in feed formulations. The ash content was found lowest in the leaves of *S. pulcherrima* (12.99±0.08 %) and highest in the tuber of *A. hookeri* (22.62±0.25 %). The fat content in the leaves of *E. foetidum* (2.60±0.13 %), in the whole plant of *C. macrophylla* (2.42±0.02 %) and also in the leaves *S. pulcherrima* (1.84 ±0.02 %) was particularly high and well compared to that reported for some common vegetables like spinach (0.7 %), lettuce (0.20 %) (Table 3) [12]. The tuber of *A. hookeri* contained the highest amount of crude fibre (2.38±0.02 %) and the lowest amount is detected in the whole plant of *C. macrophylla* (0.55±0.03 %) and similar to commercial fruits and vegetables like apple (3.2 %), broad beans (8.9 %), cabbage (2.8 %), potato (1.7 %), spinach (2.5 %) (Table 3) [12]. The mineral compositions of edible parts of the plants are shown in Table 2. High concentrations of sodium (Na) were present ranging from 0.22±0.008 mg/g (*B. balcooa*) to 2.69±0.09 mg/g (*C. macrophylla*). The sodium levels of some cultivated vegetables and fruits vary between 30-1249 mg/kg (Table 4) [16].

The potassium (K) content was highest in the whole plant of *C. macrophylla* (47.77±0.35 mg/g) and least in the leaves of *E. foetidum*. (23.98±0.13 mg/g). Na and K take part in ionic balance of the human body and maintained tissue excitability. Na plays an important role in the transport of metabolites and K is important for its diuretic nature. The K/Na ratio in our body is of great concern to prevent high blood pressure and the ratio should be greater than one because K depresses and Na enhances blood pressure [17].

Table 4: Minerals content in some common vegetables and fruits

Name of the Plant	Minerals present mg/g							
	NA	K	CA	MN	CU	FE	CR	ZN
Apple	0.280	0.750	0.100	0.0014	0.0010	0.0066	0.0008	0.0060
Brinjal	0.030	2.000	0.180	0.0013	0.0012	0.0038	0.0007	0.0022
Broad beans	0.435	0.390	0.500	-	0.0017	0.014	-	-
Cabbage	-	-	0.390	0.0018	0.0002	0.008	0.0005	0.003
Cauliflower	0.530	1.380	0.330	0.001	0.0013	0.0123	0.0003	0.0040

The ratio of K/Na were significant in the young shoot of *B. balcooa* (182.50), leaves of *S. pulcherrima* (113.88) and *E. foetidum* (66.61) and very much compared with some common fruits (Amla 45, papaya ripe 11.5, tomato 11.31, *Castanea sativa* 56.67, *Punica granatum* 1400.00) [12] and so the consumption of these vegetables may control the high blood pressure.

The calcium (Ca) is the most abundant macro-minerals of the studied vegetables. Calcium content was highest in the leaves of *E. foetidum* (27.35±0.27 mg/g) followed by *S. pulcherrima* (22.93±0.35 mg/g) and the whole plant of *C. macrophylla* (21.51±0.21 mg/g). The Ca levels of some cultivated vegetables and fruits vary between 0.1-1.300 mg/g (Table 4). Calcium constitutes a large proportion to the bone, human blood and extracellular fluid. It is also very much required for the normal functioning of the cardiac muscles, blood coagulation, milk clotting and the regulation of cell permeability [11].

Copper (Cu) is an essential trace element that cannot be formed by the human body. It exists as an important component of an enzyme that helps the incorporation of iron into red blood cells, preventing anaemia [18]. A sufficient amount of Cu was present in the whole plant of *C. macrophylla* (0.195±0.002 mg/g), in the leaves of *E. foetidum* (0.182±0.0001 mg/g) and in the tuber of *A. hookeri* (0.071±0.0002 mg/g).

An appreciable quantity of Zinc (Zn) was found to be present ranging from 0.42±0.001mg/g (*S. pulcherrima*) to 1.37±0.001 mg/g (*A. hookeri*). Zn is an essential element in the nutrition of human being where it functions as an integral part of some enzymes, which play a central role in nucleic acid metabolism. In addition, Zn is a membrane stabilizer and a stimulator of the immune response. Its deficiency leads to growth failure and poor development of gonadal function [18].

The Manganese (Mn) concentrations of the plants studied varied between 0.05±0.0001 to 0.22±0.0001 mg/g. The highest Mn value was found on the whole plant of *C. macrophylla* (0.22±0.001 mg/g) and appreciable amounts of this element were observed in all other plants, and our results were in the limits. This element plays an important role in the metabolism of protein, carbohydrate, lipid and in the production of steroid sexual hormones [19].

High concentrations of Iron (Fe) were present on the whole plant of *C. macrophylla* (2.30±0.001 mg/g) and in the tuber of *A. hookeri* (1.97±0.001 mg/g) which are well compared to some common leafy vegetables. These high Fe levels in some wild edible plants studied could be clarified with different soil characteristics of the growing area. It is a component of muscle and blood and is essential to carry oxygen around the body. Regular consumption of iron rich vegetables can prevent the iron- deficiency anaemia [19].

The Magnesium (Mg) concentrations of the plants studied ranged from 0.52±0.001 to 1.09±0.001 mg/g. The highest amount of Mg was found in the leaves of *E. foetidum.* A very good quantity of Mg was also present on the leaves of *S. pulcherrima* (0.94±0.001 mg/g) and on the whole plant of *C. macrophylla* (0.91±0.001 mg/g). Magnesium is very much essential in a human body to maintain normal nerve and muscle function. So the regular consumption of this magnesium rich vegetables, control the blood-glucose levels and support a healthy immune system [19].

The mineral findings of all these plants obtained from the present study were similar and comparable to the commercial vegetables and fruits.

Conclusion

The study showed that the wild edible plants collected from Arunachal Pradesh state in India were rich in protein, available carbohydrate, total dietary fibre and minerals, and it is believed that these plants could be used for the nutritional purpose of human being due to their good nutritional qualities, and adequate protection may be obtained against diseases arising from malnutrition.

The experimental findings also revealed that these wild edible plants were the good source of nutrient for tribal population,

and in addition well comparable with various commercial vegetables. So the cultivation of these wild edible species needs to be adopted in large scale, which will produce economic benefits for poor farmers.

Conflict of interest statement
We declare that we have no conflict of interest.

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