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Evaluation of Nutritional Potential of Five Unexplored Wild Edible Plants Consumed by the Tribal People of Arunachal Pradesh State in India

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Abstract The nutritional potential of five wild edible plants e.g. fruits of *Melodinus khasianus*, leaves of *Solanum nigrum*, *Phytolacca acinosa*, *Piper pedicellatum* and *Pouzolzia hirta* collected from Arunachal Pradesh in India, were assessed by determining their proximate and mineral's composition. These undomesticated eatable plants form an important constituent of traditional subsistences in Arunachal Pradesh. The present study divulged that for different plant species, the crude fat content ranged between 0.60±0.05 - 6.39±0.03 %. The crude protein content was determined high among the leaves of *P. acinosa* (21.90±0.02%), *P. pedicellatum* (21.22±0.03%) and *S. nigrum* (21.18±0.01 %) while the carbohydrate content was highest in the fruits of *M. khasianus* (80.88±0.13 %). The energy content ranged from 325.83±2.40 – 409.90 ±0.66 kcal/100g in the various wild edible plants. Among the various macronutrients estimated in the plants under study, potassium was present in the highest quantity (13.74±0.24- 75.72±0.45 mg/g) followed by calcium (12.07±0.32-25.73±0.07 mg/g) and sodium (0.21±0.01-0.42±0.002 mg/g). The micronutrients, such as iron, zinc, copper, manganese and magnesium were analyzed. The result 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 gives an account of ethnobotanies significance of the wild plants under investigation.

Keywords: *nutritional value of wild plants, proximate composition, mineral contents, Arunachal Pradesh, India*

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1. Introduction

In developing countries various types of wild edible plants are consumed as sources of food. Due to the sharp increase in population, scarcity of fertile land for cultivation and high prices of available staples, some 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 to 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 tribal people. The present study explores the nutritionary status of five wild plants viz. fruits of *Melodinus khasianus*, leaves of *Solanum nigrum*, *Phytolacca acinosa*, *Piper pedicellatum* and *Pouzolzia hirta* reportedly consumed by the tribal people of Arunachal Pradesh. The main target of the research was to find out the nutritional potential of these undomesticated edible plants. The traditional use and ethnobotanical importance of these plants have also been mentioned.

Melodinus is a genus of ca. 53 species in the family Apocynaceae, mainly distributed in tropical and

subtropical Asia and from Oceania to the Pacific coast. Among them, ca. 11 species occur in South China, Southwest China and Taiwan. Some species, such as *M. suaveolens* and *M. henyri* have been used in Chinese's folk medicine for the treatment of meningitis in children, rheumatic heart diseases, diuresis, bone fracture [3].

The plant, *Melodinus khasianus* Hook.f. is known as 'Zoge' in Arunachal Pradesh. The fresh leaves are crushed and made into paste. One tablespoon of paste is mixed in a tea cup with warm water and taken and used by the tribal people of Arunachal Pradesh for the treatment of dysentery, cholera and diarrhea [4].

Phytolacca acinosa Roxb. known as 'Papok" in Arunachal Pradesh, belonging to the family Phytolaccaceae is found on various parts of North-east India. The tender leaves and twigs are cooked like the vegetable. The young shoots have an excellent flavor and are reported to be used as an asparagus substitute [5]. The root of this plant is used in the medication of urinary disorders, nephritis, oedema, abdominal distension, and also it is used to treat boils, carbuncles and sores. Recently, the plant has been studied for the isolation of potential anti-AIDS drug [6]. *Solanum nigrum* Linn. known as 'How-ore' in Arunachal Pradesh, belonging to the family Solanaceae. The leaves and fruits are reported to be considered as anti-oxidant, anti-inflammatory, diuretic and anti-pyretic. The different parts of the plant have been extensively used as food and for the treatment of several acute and chronic diseases. The plant found to contain active substances, such as total alkaloid, steroidal saponins and glycoprotein, exhibiting anti-tumor activity. In Indian traditional medicine, the plant is also used as a hepatoprotective agent [7].

Piper pedicellatum C.DC belongs to the family Piperaceae. It is called as 'Raro' by the Nyshi tribe of Arunachal Pradesh and the leaves and stem from the plant are eaten like a vegetable. The decoctions of leaves on the plant are used by the tribal people for the treatment of scabies, abscesses and allergy [8,9].

Pouzolzia hirta Hassk. belongs to the family Urticaceae, It is commonly known as 'Huaig' among the 'Nyshi' tribes of Arunachal Pradesh. The leaves on the plant are eaten like a vegetable. The 'Adi' tribes of this state use the plant to increase the lactation in a woman [10]. The fresh rhizome of this plant is eaten to get relief from stress.

2. Materials and Methods

2.1. Plant Materials

The five plant materials, e.g. fruits of *M. khasianus*, leaves of *S. nigrum*, *P. acinosa*, *P. pedicellatum* and *P. hirta* were collected from different places of Arunachal Pradesh in June 2014 and authenticated in Botanical Survey of India, Howrah, India. The voucher specimens of the plants were preserved at the Plant Chemistry department under registry no BSITS 70, BSITS 72, BSITS 73, BSITS 74 and BSITS 75, 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.

2.2. Estimation of Ash

Five gram 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). Weight of ash gave the ash content [10].

2.3. Estimation of Moisture

Two gram 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 [10].

2.4. Estimation of Crude Fat

Two gram 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 petroleum-ether, the residual petroleum-ether was filtered using Whatman no. 40 filter paper and the filtrate were evaporated in a pre-weighed beaker. Increase in weight of a beaker gave crude fat. [10].

2.5. Estimation of Crude Fibre

Two gram of moisture and fat-free material of each sample were treated with 200 mL of 1.25 % H_2SO_4. 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. [10].

2.6. Estimation of Crude Protein

The crude protein was determined using micro Kjeldahl method. Two gram 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 25ml 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 sample 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 [10].

2.7. Estimation of Carbohydrate

Percentage of carbohydrate was given by: 100- (percentage of ash + percentage of fat + percentage of protein + percentage of crude fibre) [10].

2.8. 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 [10,11].

2.9. 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 [12]. 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.

3. Results and Discussion

The edible parts of fresh plant materials *e.g* the fruits of *M. khasianus*, leaves of *S. nigrum*, *P. acinosa*, *P. pedicellatum* and *P. hirta* 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).

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).

The proximate analyses of the nutritive contents of five plants are depicted in Table 1. The results obtained from systematic chemical analysis of all five wild edible plants established that energy content in the fruits of *M. khasianus* was maximum (409.90±0.66 kcal/100g) followed by the leaves of *P. pedicellatum* (342.56±0.29 kcal/100g) and leaves of *S. nigrum* (334.95±0.53 kcal/100g). The leave of *P. acinosa* was found to be of less nutritive value (325.83±0.38 kcal/100g) as compared to other plants under investigation. The crude protein contents ranged from 21.90±0.03 % (leaves of *P. acinosa*) to 7.20±0.03% in the fruits of *M. khasianus*. The crude protein content in *P. acinosa* found to be very much comparable with those of almond (20.80 %), cashewnut (21.20 %) [13].

The crude protein contents in the leaves of *P. pedicellatum* (21.22±0.03 %), *S. nigrum* (21.18 ±0.02 %), and *P. hirta* (19.19±0.02 %) were more than what is stated for lesser-known wild leafy vegetables such as *Momordica balsamina* (11.29±0.07%), *Carpesium cernuum* (17.22±0.03%), *Eurya acuminata* (14.72±0.04 %) and *Ardisia humilis* (12.71±0.33%) [14,15,16]. These indicate that low cost plant samples are very good sources of protein.

The fruits of *M. khasianus*, leaves of *P. pedicellatum* and *P. hirta* with high content of carbohydrates (80.88±0.13 %, 63.06±0.06 % and 60.47±0.17 % respectively) compared well to that reported for almond (10.50 %), apple (13.7 %) [13], wood apple (18.1 %), potato (20.9 %) and ripe mango (14.9%) (Table 3) [13,17] and these could be supplemented in feed formulations. The ash content was found lowest in *M. khasianus* (3.9±0.12 %) and highest in *P. lacinosa* (18.65±0.60 %). The fat content in the fruits of *M. khasianus* (6.39±0.03 %), in the leaves of *S. nigrum* (2.01±0.02 %) and also in *P. acinosa* (1.32 ±0.03 %) was particularly high and well compared to that reported for some common vegetables like spinach (0.7 %), lettuce (0.20 %) (Table 3) [13]. The leaves of *S. nigrum* contained the highest amount of crude fibre (1.77±0.03 %) and the lowest amount is detected in the leaves of *P. hirta* (1.01±0.04 %) 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) [17].

The mineral composition of edible parts of the plants are shown in Table 2. High concentrations of sodium (Na) was present ranging from 0.21±0.01 mg/g (*M. khasianus*) to 0.42±0.002 mg/g (*P. pedicellatum*). The sodium levels of some cultivated vegetables and fruits vary between 30-1249 mg/kg (Table 4) [17].

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
M. khasianus	Fruits	3.9±0.115	84.63±0.12	6.39±0.03	1.61±0.03	7.20±0.03	80.88±0.13	409.90±0.66
S. nigrum	Leaves	17.00±0.08	76.31±0.12	2.01±0.02	1.77±0.03	21.18±0.02	58.02±0.12	334.95±0.53
P. acinosa	Leaves	18.65±0.60	72.37±0.32	1.32±0.03	1.54±0.02	21.90±0.03	56.57±0.63	325.83±0.38
P. pedicellatum	Leaves	13.12±0.07	89.44±0.11	0.60±0.05	1.99±0.02	21.22±0.03	63.06±0.06	342.56±0.29
P. hirta	Leaves	17.99±0.08	77.35±0.04	1.31±0.02	1.01±0.02	19.19±0.02	60.47±0.17	330.51±0.47

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

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
M. khasianus	Fruits	0.21±0.01	13.74± 0.24	12.07± 0.32	0.07± 0.001	0.017±0.001	0.22±0.001	0.35±0.001	0.43±0.001
S. nigrum	Leaves	0.41±0.005	54.96± 0.45	26.33± 0.25	0.17± 0.002	0.029±0.001	1.32±0.001	1.17±0.002	1.53±0.001
P. acinosa	Leaves	0.29±0.004	75.72± 0.45	26.73± 0.39	0.36± 0.001	0.029±0.001	0.52±0.001	1.17±0.001	1.51±0.001
P. pedicellatum	Leaves	0.42±0.002	37.79± 0.03	24.93± 0.43	0.11±0.002	0.033±0.002	0.41±0.001	0.99±0.002	0.55±0.001
P. hirta	Leaves	0.27±0.007	34.02± 0.49	25.73± 0.07	0.32±0.001	0.022±0.002	0.69±0.001	1.06±0.001	1.31±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.

Table 3. Proximate composition of some common vegetables and fruits

Name of the Plant	Ash (%)	Moisture (%)	Crude fat (%)	Protein (%) (6.25x % of N)	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

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 potassium (K) content was highest in the leaves of *P. acinosa* (75.72±0.45 mg/g) and least in the fruits of *M. khasianus*. (13.74±0.24 mg/g). Na and K take part in ionic balance of the human body and maintain 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 human 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 [18].

The ratio of K/Na were significant in the leaves of *P. acinosa* (261.10), *S. nigrum* (134.04) and *P. hirta* (126.00) 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)[13] 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 *P. acinosa* (26.73± 0.39 mg/g) followed by *S. nigrum* (26.33± 0.25 mg/g) and *P. hirta* (25.73± 0.07 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 [12].

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 [19] A sufficient amount of Cu was present in the leaves of *P. pedicellatum* (0.033±0.002 mg/g), *P. acinosa* (0.029±0.0001 mg/g) and in *S. nigrum* (0.029±0.0001 mg/g).

An appreciable quantity of Zinc (Zn) was found to be present ranging from 0.43±0.001 mg/g (*M. khasianus*) to 1.53±0.001 mg/g (*S. nigrum*). 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 [19].

The Manganese (Mn) concentrations of the plants studied varied between 0.07±0.0001 to 0.36±0.0001 mg/g. The highest Mn value was found on the leaves of *P. acinosa* (0.36±0.001 mg/g) and appreciable amounts of this element were observed in all other plants, and the 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 [20].

High concentrations of Iron (Fe) were present on the leaves of *P. hirta* (0.69±0.001 mg/g) and *P. acinosa* (0.52±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 [20].

The Magnesium (Mg) concentrations of the plants studied ranged from 0.35±0.001 to 1.17±0.001 mg/g. The highest amount of Mg was found on the leaves of *P. acinosa* and in *S. nigrum*. A very good quantity of Mg was also present on the leaves of *P. hirta* (1.06±0.0008 mg/g) and *P. pedicellatum* (0.99±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 [20].

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

4. 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.

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