

Evaluation of Nutritional Potential of Five Unexplored Wild Edible Food Plants from Eastern Himalayan Biodiversity Hotspot Region (India)

Pallabi Kalita, Hui Tag, H. N. Sarma, A. K. Das.

Abstract—Wild edible food plants contain a number of organic phytochemical that have been linked to the promotion of good health. These plants used by the local people of Arunachal Pradesh (Northeast India) are found to have high nutritional potential to maintain general balance diet. A study was conducted to evaluate the nutritional potential of five commonly found, unexplored wild food plants namely, *Piper pedicellatum* C. DC (leaves), *Gonostegia hirta* (Blume ex Hassk.) Miq. (leaves), *Mussaenda roxburghii* Hook.f (leaves), *Solanum spirale* Roxb. (leaves and fruits) and *Cyathea spinulosa* Wall. ex Hook. (pith portion and tender rachis) from East Siang District of Arunachal Pradesh Northeast (India) for ascertaining their suitability for utilization as supplementary food. Results of study revealed that *P. pedicellatum*, *C. spinulosa*, and *S. spirale* (leaves) are the most promising species which have high nutritional content out of the five wild food plants investigated which is required for the normal growth and development of human.

Keywords—Wild edible plants, Gross energy, *Gonostegia hirta*, *Cyathea spinulosa*,

I. INTRODUCTION

WILD edible food plants have almost all of the minerals and organic nutrients established as essential for human nutrition. Vegetables hold an important position in well-balanced diets. Green leafy vegetables are believed to occupy a modest place as a source of trace elements due to their high water content [1]. Child malnutrition is a wide spread public health problem having international consequences because good nutrition is an essential determinant for their well-being [2]. Lack of nutritious food, poverty, poor hygiene and lack of health care always aggravates the problem. In order to overcome this problem, people of the most developing countries in the world take wild edible plants as their alternate source of food. Wild edible plants have made a significant

contribution to the development of rural people. India has a tribal population of 42 million, of which 60% live in forest areas and depend on forest for various edible products. Wild edible plants show that they have a very high nutritional potential, and their nutritional value is even much greater than that of some cultivated green vegetables [3]-[4]. Out of 3895 of economically significant plant species reported from North East India, nearly 7.34% are used as wild vegetables, fruits and ethno-medicine [5]. Wild edible plant species provide minerals, fibers, vitamins, pigments and other secondary metabolites such as alkaloids, polyphenolic compounds, gums and resins, essential fatty acids and thereby enhance taste and color in diet. In addition, they have anti-bacterial, hepatoprotective and anti-carcinogenic properties, and therefore have medicinal value [6].

The Himalayan region including Arunachal Pradesh is considered as one of the major centers of potential plant or one of the hotspot regions of the world having a rich heritage of biodiversity and traditional knowledge. This area has an abundance of wild edible food plants that grows throughout the year. Some of them are consumed by the local tribal communities but many remain unutilized and hence are of no use. Wild edible plants namely, *Piper pedicellatum* (*Piperaceae*), *Gonostegia hirta* (*Urticaceae*), *Mussaenda roxburghii* (*Rubiaceae*), *Solanum spirale* (*Solanaceae*), and *Cyathea spinulosa* (*Cyatheaceae*) are widely distributed in the eastern Himalayan region of India without any agronomic care. Leaves of *Piper pedicellatum*, *Gonostegia hirta*, and *Mussaenda roxburghii*, young pith and rachis of *Cyathea spinulosa* are frequently consumed as vegetables by the *Nyishi* and *Adi* Tribes of Arunachal Pradesh while the leaves and fruits of *Solanum spirale* are consumed both as vegetable as well as medicinal agent to cure stomach ache and mild fever by the *Adi* community of Arunachal Pradesh [7]. However, no records are available up to date on nutritional chemistry and future potential uses of these selected plants, while the nutritive values of these wild food plants are endemic to North-East India. Agriculture is the main occupation of this region, and therefore, the use of these wild food plants as supplementary nutrient sources of food will not only partly replace the rather expensive commercially used vegetables found in the market but also increase the socio-economic community health, food security for future scientific conservation practices and sustainable commercial utilization.

However, before advocating the sustainable utilization of these wild food plants, there is an urgent need to explore their

P. K. is with the Higher Plant Diversity & Validation Unit, Centre with Potential for Excellence in Biodiversity (CPEB-II), Faculty of Life Sciences, Rajiv Gandhi University, Rono Hills, Doimukh (Itanagar), Arunachal Pradesh, India (phone+91-360-2279008; fax: +91-360-2277317; e-mail: pallabi2008rgu@gmail.com).

H.T. & A.K.D. are a main guides and PIs with Higher Plant Diversity & Validation Unit, Centre with Potential for Excellence in Biodiversity (CPEB-II), Department of Botany, Faculty of Life Sciences, Rajiv Gandhi University, Rono Hills, Doimukh (Itanagar), Arunachal Pradesh, India (phone+91-360-2279008; fax: +91-360-2277317; e-mail: huitag2008rgu@gmail.com/arup1959@gmail.com).

S.N.S. is mentor with the Centre with Potential for Excellence in Biodiversity (CPEB-II), Department of Zoology, Faculty of Life Sciences, Rajiv Gandhi University, Rono Hills, Doimukh (Itanagar), Arunachal Pradesh, India.

nutritional composition. The present study was undertaken to investigate the nutritional components of the five commonly available wild edible food plants from Northeast India, namely *Piper pedicellatum*, *Gonostegia hirta*, *Mussaenda roxburghii*, *Solanum spirale* (leaves and fruits), and *Cyathea spinulosa*, for ascertaining their suitability for use as supplementary food plants.

II. MATERIALS AND METHODS

A. Sample Preparation

Sample of fresh, tender and green leaves, stem, fruits and flowers of *Pedicellatum* (leaves), *Gonostegia hirta* (young twig/leaves), *Mussaenda roxburghii* (young leaves), *Solanum spirale* (leaves and fruits) and *Cyathea spinulosa* (tender rachis and pith portion) were collected from forests of various locations of the North Eastern states of India and taxonomically identified. The samples were washed under running water and blotted dry. The moisture content of the samples was determined at 60°C [8]. The dried matter obtained was ground to fine powder and stored at -5°C in airtight containers prior to further analysis.

B. Proximate Analysis

Moisture, ash, ether extract (EE), crude fiber (CF) and nitrogen-free extract (NFE) were determined by the methods of the Association of Official Analytical Chemistry [3]. The crude protein content was determined by Kjeldahl procedure, AOAC method 920; factor Nx6.25 was used to convert nitrogen into crude protein. The crude lipid was analyzed gravimetrically using Soxhlet apparatus (petroleum ether extraction, boiling point 60-80°C). Ash content was determined by incinerating the dried sample in a muffle furnace crude fiber system (Fibro Plus, Model Kalvat FES2). Crude fiber content was determined by the Fibertech system with repeated treatment of dilute H₂SO₄, followed by dilute NaOH and washing by water. The carbohydrate (NFE) content of feed was determined as the weight difference using moisture, crude protein, lipid, and ash content data. Cellulose and lignin were determined by the methods of Acid Detergent Solution (ADS). Gross energy was determined by using an adiabatic bomb calorimeter (IKAC-7000) using benzoic acid as a standard.

Determination of α -tocopherol and carotene contents of plant materials first included extraction of total lipid material from dried plant powder [9] followed by extraction and estimation of α -tocopherol and carotene levels by procedure of Baker and Frank [10]. For the extraction of ascorbic acid (Vitamin-C), 5.0g plant materials were ground using a pestle and mortar in 50ml of 4% (w/v) oxalic acid solution and filtered through a Whatman filter paper (No.100). The ascorbic acid content was then determined volumetrically using 2,6 - dichlorophenol indophenols dye [11].

C. Mineral Analysis

The mineral contents of the plants namely, Na, K and Ca, were estimated by flame photometry. The total phosphorus content was determined as described by Umoren et al. [12].

D. Statistical Analysis

Data are presented as means \pm SD. One-way analyses of variance (ANOVA) were carried out to compare the different values.

III. RESULTS AND DISCUSSION

A. Proximate Composition

The proximate composition of the five wild food plants namely; *C. spinulosa*, *P. pedicellatum*, *G. hirta*, *M. roxburghii*, and *S. spirale* (both leaves and fruits) on a fresh weight basis, are presented in Table I. Moisture and nitrogen extract (NFE) content were nearly identical in all the plants. Among these five plants, *P. pedicellatum* (16.8%), *S. spirale* (leaves) (15.9%), *G. hirta* (14.3%) possessed the highest amount of crude protein, followed by *M. roxburghii* (12.9%); *S. spirale* (fruits) (11.9%), and *C. spinulosa* (1.5%) had comparatively less crude protein. The ash content in these plants ranged from 0.65% to 22.8%, the highest amount being displayed by *S. spirale* (fruit) and the lowest by *C. spinulosa*, while *C. spinulosa* possessed the highest amount of crude fiber (34.6%), followed by *P. pedicellatum* (17.8%), *G. hirta* (17.6%), *S. spirale* (leaves) (17.09%) which had second highest amount of crude fiber and less in *S. spirale* (fruit) (16.6%) and *M. roxburghii* (10.3%). The cellulose and lignin content of the five plant samples were very identical. *P. pedicellatum* and *C. spinulosa* possessed the highest amount of cellulose (89.8%), (78.7%) and lignin (80.2%), (72.7%), which is followed by *S. spirale* (fruit and leaves) and *G. hirta* and *M. roxburghii* had less amount of cellulose and lignin in comparison to the other four plants. Total carbohydrates (including starch) content of *C. spinulosa* (64.85%) was significantly higher ($p < 0.001$) than the five other plants under study, whereas *S. spirale* (fruit) possessed the highest amount of crude lipid (10.9%), followed by *M. roxburghii* (5.73%), *P. pedicellatum* (4.81%), and *S. spirale* (leaves) (2.79%) and less in *G. hirta* (0.98%) and *C. spinulosa* (0.18%).

Carbohydrates are the important components of storage and structural materials in the plants and animals. They exist as free sugars and polysaccharides. Therefore, it is reasonable to assume that because of high protein and low carbohydrate content, *P. pedicellatum*, *C. spinulosa* and *S. spirale* (leaves) may be used as supplementary food for the future generation.

B. Energy Values and Vitamin Content

As shown in Table II, the gross energy of *G. hirta* and *C. spinulosa* possessed the highest value (389.2 kcal/100g and 372.84 kcal/100g), followed by *M. roxburghii* and *P. pedicellatum* (both 358 kcal/100g); *S. spirale* (both fruits and leaves (347 kcal/100g and 338 kcal/100g)) had less gross energy value in comparison to the above plants.

TABLE I
PROXIMATE COMPOSITION OF FIVE WILD EDIBLE PLANTS FROM EAST SIANG DISTRICT (ARUNACHAL PRADESH), ON DRY MATTER BASIS (%)^{*}

Component	<i>C. spinulosa</i>	<i>P. pedicellatum</i>	<i>G. hirta</i>	<i>M. roxburghii</i>	<i>S. spirale</i> (leaf)	<i>S. spirale</i> (fruit)
Moisture (g%)	62.73±0.99	81.69±0.38	87.13±0.08	79.35±0.07	81.35±0.14	70.5±0.26
NFE (Nitrogen extract) (g%)	0.25± 0.05	2.69 ± 0.10	2.29 ± 0.04	2.07± 0.12	2.55± 0.03	1.9± 0.02
Crude protein (g%)	1.5 ± 0.3	16.8± 0.63	14.3 ± 0.26	12.9 ± 0.8	15.9± 0.2	11.9± 0.1
Ash (g%)	0.65±0.04	14.1±0.07	14.3±0.08	10.9 ± 0.6	12.3 ± 0.3	22.8 ± 0.4
Crude fiber (g%)	34.6 ± 0.32	17.8 ± 0.14	17.6 ± 0.03	10.3 ± 0.02	17.09±0.03	15.6±0.07
Cellulose (g%)	78.7 ± 0.2	89.8 ± 0.4	35.9 ± 0.5	21.9± 0.3	56.6 ± 1.3	50.3 ± 1.4
Lignin (g%)	72.7 ± 0.3	80.2 ± 0.6	35.3 ± 0.5	34.5 ± 1.2	56.3 ± 1.01	48.8 ± 0.8
Total carbohydrate (g%)	64.85±96.57	45.61±0.05	48.35±0.19	50.48±9.50	43.79±10.2	52.05±4.9
Crude lipid (g%)	0.18 ±0.006	4.81 ± 0.09	0.98± 0.6	5.73 ± 0.01	2.79 ±0.006	10.9 ± 0.1

*Each value represents mean ± SD of three determinations

TABLE II
ENERGY VALUES AND VITAMIN CONTENTS CONCENTRATION IN 6 WILD FOOD PLANTS SAMPLE^{*}

Components	<i>C. spinulosa</i>	<i>P. pedicellatum</i>	<i>G. hirta</i>	<i>M. roxburghii</i>	<i>S. spirale</i> (leaves)	<i>S. spirale</i> (fruits)
Gross energy (kcal/100g)	372.84±1.7	358±1.6	389.2±2.2	358±2.1	338±1.2	347±1.4
Vitamin A (mg/100)	24.5 ± 1.3	45.1 ± 0.05	22.1 ± 0.06	66.1 ±0.09	42.9 ± 1.6	34.6 ± 1.5
Vitamin C(mg/100g)	20.7 ± 11.3	39.5 ± 52.3	22.6 ± 18.8	21.1 ±12.1	45.6 ±55.6	53.4± 60.9
Vitamin E (mg/100)	26.1 ± 0.6	32.4 ± 1.4	43.2 ± 1.5	27.8 ±1.03	55.7 ± 0.7	23 ± 0.5

*Values are means of triplicate determinations

Vitamin content of these wild edible plants are shown in Table II. Vitamin C (Ascorbic acid) contents of *S. spirale* (fruit) had significantly higher value (53.4 mg/100g), which was followed by *S. spirale* (leave) and *P. pedicellatum*; *G. hirta*, *M. roxburghii*, and *C. spinulosa* have exhibited remarkable similarity in possessing nearly the same value (Table II). *S. spirale* (leaf) was characterized as possessing highest value of α -tocopherol content (55.7mg/100g) and the second highest was possessed by *G. hirta* (43.2 mg/100 g) and *P. pedicellatum* (32.4 mg/100 g) which was slightly more than the other three plants, whereas *M. roxburghii* had significantly the highest amount of Vitamin A (Carotenoid) content (66.1 mg/100 g). The lowest level of ascorbic acid was found in *C. spinulosa* (24.5 mg/100 g) and *G. hirta* (22.1 mg/100 g).

Vitamins are important constituents of animal diet. But human being cannot synthesize these compounds, which are necessary for their survival. Most of the vitamins must be provided by the diet or by supplements; only 3 vitamins (D, K, and B) can be manufactured in the body from non dietary sources. It has been reported that the fresh and natural food contains all the necessary vitamins in appropriate quantity [13].

Vitamin A has multiple functions and plays a highly important role in vision. The approximate daily requirement of vitamin A is 1.5mg.

Vitamin E, the nature's most effective lipid soluble antioxidant compound present in biological membranes confers stability to the membranes [14]. It also plays an important role in cardiovascular pathology in lower animals.

Recent studies suggest that vitamin C links with a mineral ion before it can be absorbed into the blood stream [15]. The useful effects of vitamin C in developing body resistance to cold and tissue-healing are well known. It has been shown that vitamin C has virucidal activity and its effectiveness in the therapy of measles and mumps is also receiving considerable attention of the scientists. The approximate daily requirement

of Vitamin C or ascorbic acid is 45 μ g. The normal human plasma ascorbic acid concentration is (0.7 to 1.2) μ g/dl. Therefore, the present study indicated that sufficient amount of vitamin A, C and E were present in these plants which can be used as a supplementary human and animal diet.

C. Mineral Ion Concentration

The mineral compositions of the five wild food plants are presented in Table III. A significant variation in metal contents was noticed among these plants, which may be attributed to differences in their genus and species level. As shown in Table III, potassium and phosphorus were the most abundant of the elements considered, followed by calcium and sodium. Among these plants, *M. roxburghii* and *S. spirale* (leaves) were shown to possess the highest amount of potassium (23.8g % and 23.3g %), which were followed by *P. pedicellatum* and *G. hirta*. The lowest level of potassium was shown by *S. spirale* (fruit) and *C. spinulosa* (0.64g % and 0.05g %). Interestingly, the sodium content was identical in all the five wild food plant samples, but calcium level was found to be very low in *C. spinulosa* (0.08g %) in comparison to the other four plants which were very much identical in their calcium content. *S. spirale* (fruits) was characterized and was found to have the highest amount of phosphorus (1.02 g %), which was followed by *S. spirale* (leaves) (0.99g %), *G. hirta* (0.89g %), and *M. roxburghii* (0.77g %); *P. pedicellatum* and *C. spinulosa* had comparatively less phosphorus content (0.22-0.41g %).

Mineral elements play an important role in regulating many vital physiological processes in the body, such as regulation of enzyme activity (cofactor or metallic-enzyme), skeletal structures (e.g., calcium and phosphorus), neuromuscular irritability and clotting of blood (calcium) [16]. Human diet should provide sufficient nutrients for maintenance, growth, and body functions [17]. Non-availability of adequate quantities of minerals in the diet may affect growth and may

cause irrecoverable deficiency diseases. On playing physiological action, potassium plays an important role for muscle contraction, calcium for the teeth and bones, and sodium for nerve and water balance.

TABLE III

MINERAL ION CONCENTRATION IN SIX WILD EDIBLE PLANTS SAMPLE*

Components	<i>C. spinulosa</i>	<i>P. pedicellatum</i>	<i>G. hirta</i>	<i>M. roxburghii</i>	<i>S. spirale</i> (Leaf)	<i>S. spirale</i> (Fruit)
Calcium (ppm)	0.08 ± 0.05	0.14 ± 0.006	0.14 ± 0.01	0.15 ± 0.003	0.14 ± 0.008	0.13 ± 0.0006
Phosphorus (g/kg)	0.22 ± 0.0001	0.41 ± 0.0003	0.89 ± 0.005	0.77 ± 0.01	0.99 ± 0.001	1.02 ± 0.002
Potassium (mg%)	0.05 ± 0.001	0.71 ± 0.003	0.41 ± 0.05	23.8 ± 0.009	23. ± 0.005	0.64 ± 0.2
Sodium (mg%)	0.06 ± 0.01	0.07 ± 0.003	0.06 ± 0.003	0.07 ± 0.002	0.07 ± 0.003	0.07 ± 0.002

*Values are means of triplicate determinations

Phosphorus performs a numerous normal physiologic functions including skeletal development, mineral metabolism, energy transfer through mitochondrial metabolism, cell membrane phospholipids content and function, cell signaling, and even platelet aggregation. Because of its importance, normal homeostasis maintains serum concentrations between 2.5 to 4.5 mg/dl [18]. For these reasons, the selected five wild edible plants are further recommended for their use as supplementary human and animal diet based on the findings of our present empirical studies.

IV. CONCLUSION

Thus the present study has demonstrated that, among the five tested wild edible food plants, *P. pedicellatum*, *C. spinulosa*, and *S. spirale* (leaves), could be important sources of proteins, vitamins and minerals, suitable for incorporation in human and animal diet. Ethno botanical studies has revealed that with the growing urbanization, shrinkage of forest area and influence of western culture and education, changes have occurred in the food habits of the local communities in Eastern Himalayan region of India. The high nutritional quality and unique taste of these wild food plants which are currently used as important component in traditional dishes of the local tribal communities are likely to be neglected in near future due to the influence of the continental and pan Indian dishes. Therefore, it is now imperative that a nutritional, anti-nutritional, and analytical medicinal database of these wild edible food plants should be set up to retain the information of these unique species. Further research can be pursued for validation of pharmacological and nutraceutical potential of the selected plants.

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