



REVIEW ARTICLE

Foods from the wild: A review on the diversity and use pattern of wild edible plants of Arunachal Himalaya for sustainable management

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Abstract

Wild edible plants are extensively used worldwide to supplement food, nutrition and medicine. To find out the present diversity status and utility patterns of wild edible plants (WEPs) in the biodiversity-rich Indian Eastern Himalayan state of Arunachal Pradesh, for the purpose of plant identification and conservation of potential species, a systematic review of publications was made. A total of 662 species belonging to 340 genera and 124 families used mostly in the form of vegetables, fruits, medicines, spices and condiments have been reported. These comprise 24 species of Pteridophytes, 6 species of Gymnosperms and 632 species of Angiosperms. When the Angiosperms are put under APG IV classification, Eudicots dominate with 72.65%. Asteraceae represented as the dominant taxa with 36 species followed by Urticaceae, Rosaceae, Moraceae and Lamiaceae with more than 20 species in each. Based on the RFC values as well as other inputs, 50 highly used and preferred wild edible species having market potentiality are identified that can be included in various management practices.

Keywords

Wild edible plants, Arunachal Pradesh, use pattern, RFC values, potential species, management, conservation

Introduction

Wild edible plants (WEPs) are non-cultivated plants, collected from natural habitats which are used primarily to substantiate diet, nutrition, medicine and other needs by the aboriginal communities across the globe (1). Around 20000 wild plants are believed to be edible globally and nearly 20 plant taxa have been sustaining the daily caloric needs of more than 85% of the global population (2) especially the poor, vulnerable and agrarian sections of the rural area in underdeveloped and developing countries. Moreover, consumption and utilization of wild plants constitute an inseparable traditional and cultural component in tribal and indigenous rural communities across the globe (3). Many of these wild edible plants are also found to be nutritionally and phytochemically superior compared to some conventional plant foods (4-6) thus, grabbed global attention in their applications in health and disease management. Besides complementing nutritional needs, economic gain through the sale or exchange of these wild edible plants serves as an important source of supplementary employment and income to rural households (7). However, despite the potential for complementing the global food security and helping health care sectors towards sustainable and resilient climate change food systems (8-9), thousands of wild or non-cultivated edible

plants remain underutilized or overlooked compared to globally traded staple grains.

In India, the utilization and dependency on forest resources are comparatively very high with around 350 to 400 million rural population, especially in forest fringe areas, relying on wild plants resources as a means of subsistence and livelihood (10). The utilization of wild plants as food and medicine has also been a long integral part of the age-old tradition and culture of the tribal communities. India has rich ethnic diversity of around 553 tribal and indigenous communities (11), resulting to the production of vast traditional knowledge of the diverse floristic components leading to varied day-to-day usage of different plants resource wherein edible plants play a major role. Although about 1403 species are recently reported to be used as wild edibles (12) in the country, many more are yet to be added. It is assumed that, if extensive ethnobotanical exploration could be made in the country covering all the forested tribal communities, numerous such species can be added.

North-East India, comprising the Eastern Himalayas, is one of the major centers of species diversity with rich endemism. The region also homed vast ethnic diversity with around 300 tribal and indigenous communities living harmoniously within the forest. The livelihood of the majority of the rural mass is purely dependent on the wild forest resources. Among the north eastern states, Arunachal Pradesh situated distinctively in the transition zone of the Eastern Himalayas and Indo-Burma biodiversity hotspot with a geographical area of 83,743 km² is the largest (Fig. 1). The state is endowed with vast tracts of forest ranging from tropical to alpine and rich floral diversity with around 5000 reported species of flowering plants, including 243 endemic taxa (13). Furthermore, with 25 major and 125 minor tribes (14), the state forms one of the major abodes of varied ethnic tribal groups. Apart from practicing subsistence agriculture as the major livelihood activity, the tribal communities through trial and error have inculcated a diverse traditional knowledge on the utilization of forest resources. Wild resource such as wild edible plant still constitutes an integral and major part of the tribal food basket and many of them are also being used in the traditional health care system. Furthermore, the harvesting and selling of the wild edible fruits, vegetables in local and regional markets constitute an important source of a supplementary household to the rural communities. Although a considerable amount of literature is available detailing wild edible plants, comprehensive data on the diversity, utilization pattern and socio-economic aspects of these plants still remain insufficient. There is a need of documenting the diversity of wild edibles used in different forms by the various ethnic groups of the state for easy reference and future research and developmental activities. Keeping these void in context, efforts have been made in the present study to generate comprehensive data on the diversity, utilization pattern and socio-economic contribution of wild edible plants with an aim to identify high potential species for cultivation and conservation.

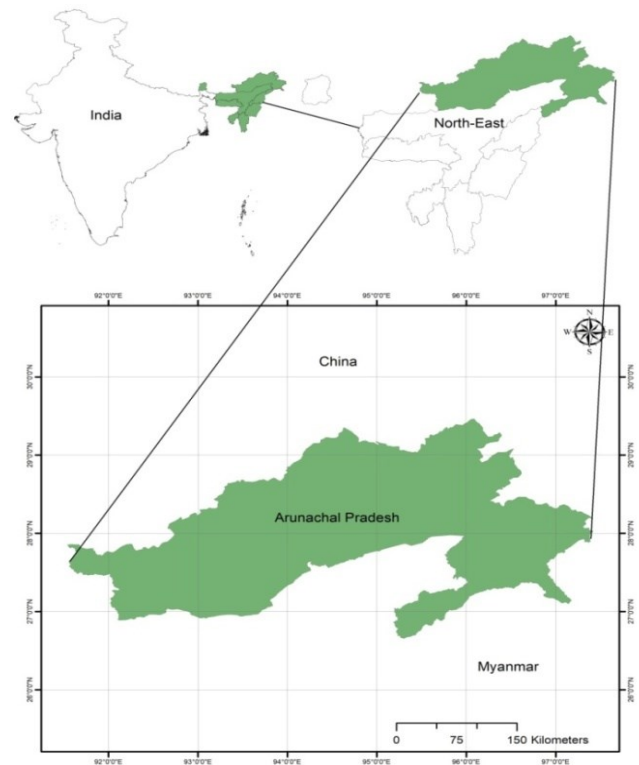


Fig. 1. Map showing geographic location of the state Arunachal Pradesh.

Materials and Methods

Data collection and analysis

An exhaustive systematic literature review was undertaken to assess the diversity, utilization pattern, marketing and conservation status of wild edible plant resources of Arunachal Pradesh. The information pertaining to wild edible plants was gathered through scrutinizing the online and offline published literatures from the period of 1990 to 2020, emphasizing the primary field-based studies. Online databases such as Google scholar, Web of Science and Research gate, comprising information on wild edible plants of Arunachal Pradesh were searched by using specific keywords including Wild edible plants, Wild fruits, Wild vegetables, Ethnobotany, Ethnomedicine, Non-Timber Forest Products (NTFP), Floral diversity, Traditional knowledge, Agro-diversity, Spices and condiments, Indigenous food items and Bio-cultural knowledge. We considered primarily the research articles published in various regional, national and international journals and excluded the publications like abstracts and proceeding volumes of conferences and seminars. A total of 74 articles were consulted and a comprehensive inventory of wild edible plants was prepared in Microsoft Excel for detailed analysis. The administrative district-wise taxonomic diversity, utilization pattern, parts used, occurrence and conservation status, of various wild edible resources by the different tribal communities were worked out separately in tabulated form and discussed.

Selection of potential wild edible plant species

The Relative Frequency of Citation (RFC) and marketing status of individual wild edible plants were considered to select highly potential wild edible plants. The RFCs of each

recorded species were worked out following the standard methods of Tardio and Pardode-Santayana (15) whereby $RFCs = FCs/N$, such that FCs is the number of literature sources mentioning species s and N is the total number of literature sources consulted ($N=73$ in the present case).

Besides the RFC values calculated through the reports of the published literature, the data available in the author's laboratory in the form of unpublished Ph. D. thesis, Dissertation work and Project reports were used to verify the potentiality status of the species. Many ethnobotanical studies through village and regular market survey were carried out in the authors' laboratory which helped in supplementing the information. These works were completed following the standard ethnobotanical methodologies used.

Verification of nomenclature of the species

The botanical nomenclature was verified and updated by consulting the Plant List, Version 1.1 (16) followed by delimitation of seed plant families using Angiosperm Phylogeny Website (Version 14) (17).

Results & Discussion

In the present review work, a comprehensive analysis of 74 research articles (18, 91) with primary field studies conducted in different parts of Arunachal Pradesh, was carried out for listing the wild edible plants under Pteridophytes, Gymnosperm and Angiosperms to generate comprehensive data on their diversity, utilization pattern and socio-economic contribution. The results achieved through the analyses of the data are presented here.

Diversity of wild edible plants and life form characteristics

A total of 662 species, 1 subspecies and 6 varieties of wild edible plants belonging to 340 genera and 124 families are compiled (Supplementary file 1). Plants classified as Angiosperms with 632 species (95.47%) are the highly utilized followed by 24 species of Pteridophytes (3.62%) and 6 species of Gymnosperms (0.91%). In species categorized as Angiosperms, the number of dicots are found to be extremely higher (78.24%) compared to monocots in food. When the Angiosperms are put under APG IV classification, it has been found that almost all the major clades are being represented by the species. Within the early and basal Angiosperms, Laurales and Piperales with 13 species each are the major order under the clade Magnoliids followed by Austrobaileyales (2 species) and Chloranthales (1 species). Among the monocot clades, the majority are represented under Commelinids (68 species) where the order Zingiberales is highly dominant (19 species). Additionally, more than 70% of species fall under Eudicots, where the clade Rosids represented the highest with 257 species followed by Asterids (166 species). In the Rosids, the order Malpighiales, Sapindales, Myrtales and Cucurbitales represent more than 20 species while in Asterids the order Lamiales (46 species), Asterales (37 species) and Ericales (34 species) dominate the clade. Other Eudicots like Ranunculales (17 species), Proteales (1 species), Caryophyllales (31 species), Dilleniales (3 species) and Saxifragales (2 species) are also found. The species repre-

sented in different orders under APG IV are given in Fig. 2.

In terms of species number, Asteraceae (Aster family) with 36 species represented the dominant taxa followed by Urticaceae (35 species), Rosaceae (34 species), Moraceae (29 species), Lamiaceae (23 species). Pteridophytes are represented by 17 genera belonging to 12 families viz. Thelypteridaceae (5 species), Cyatheaceae (3 species), Selaginellaceae, Ophioglossaceae, Dennstaedtiaceae, Pteridaceae, Athyriaceae, Nephrolepidaceae with 2 species each, and Marattiaceae, Gleicheniaceae, Dryopteridaceae, Polypodiaceae with 1 species each. Gymnosperms were found to be less utilized with only 3 genera belonging to 3 families viz. Taxaceae (1 species), Pinaceae (3 species) and Gnetales (2 species). Genera wise, *Ficus* (20 species) are represented by the highest number of species followed by *Rubus* (18 species), *Dioscorea* (17 species), *Piper* (11 species), *Solanum* (10 species), *Calamus* (10 species), etc. whereas, 212 genera such as *Actinidia*, *Arenga*, *Boea*, *Clausena*, *Docynia*, *Gonostegia*, *Lycianthes*, *Oreocnide*, *Pollia*, *Silene*, *Streblus*, *Turpinia* etc. are represented only by the single species. Graphical representations of the 10 highest families and genera are given in Fig. 3 & 4.

In terms of the analysis of life forms of wild edibles being utilized by the communities of the state, results revealed herbs as the highest in number with 219 species (33.08%) followed by 166 species (25.08%) of trees, shrubs (156 species), climbers (68 species), fern and fern allies (21 species), rattan and palms (18 species), bamboo and grasses (15 species) and epiphyte (1 species) as seen in Fig. 5.

Used pattern, part (s) used and mode of consumption

The species recorded in different use categories can be grouped into 6 major edible categories namely vegetable

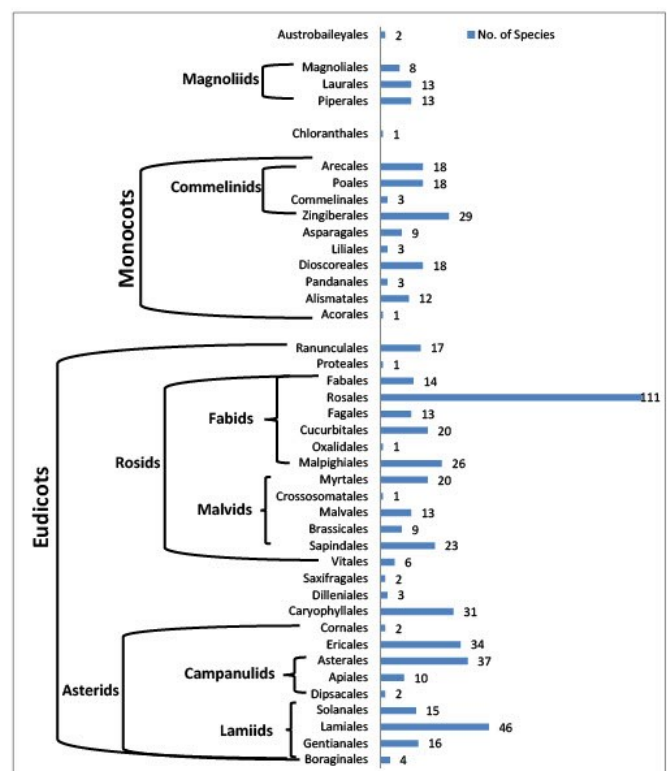


Fig. 2. The number of wild edible species of Arunachal Pradesh in different Orders and Clades as per APG IV classification.

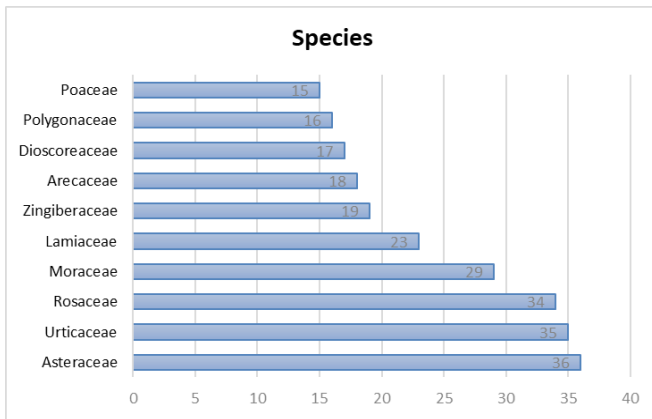


Fig. 3. The ten most dominant families of the wild edible plants of Arunachal Pradesh.

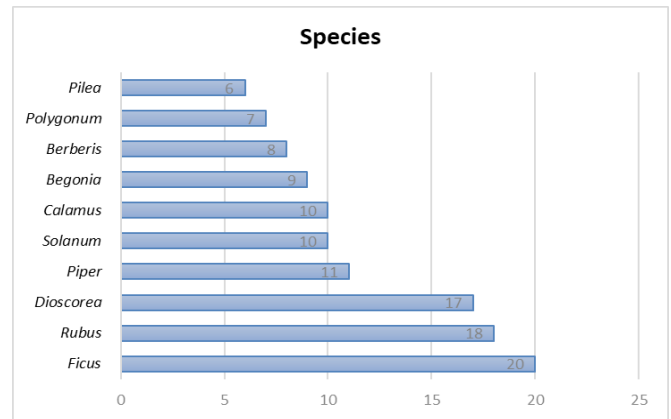


Fig. 4. The ten most utilized genera of the wild edible plants of Arunachal Pradesh

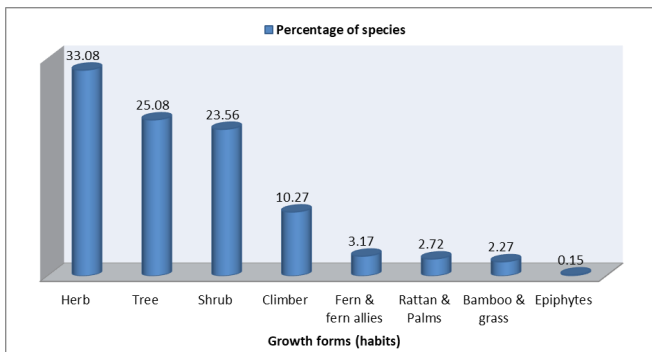


Fig. 5. Growth forms (habits) of the reported wild edible plant species of Arunachal Pradesh

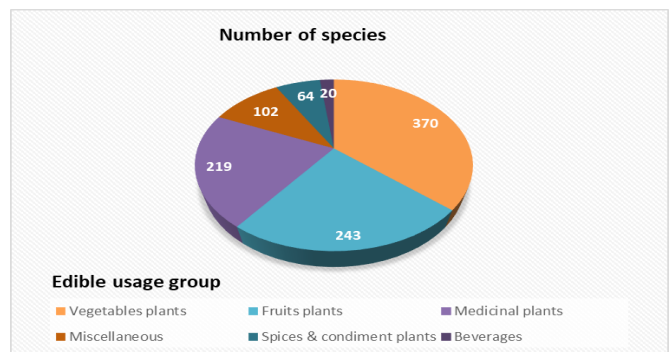


Fig. 6. Major edible usage group of wild plants of Arunachal Pradesh

plants, fruit plants, spices and condiments plants, medicinal plants, beverages and miscellaneous. The number of species used in each group is indicated in Fig. 6. The analysis indicated that the highest number of species used are vegetables where leafy vegetables constitute the major share. Although the number of species used in the beverages categories is low, this can still have significant implications since the local communities prefer to use traditional wines and local tea either on a regular basis or in specific cultural and ritual performances. The miscellaneous category included the occasional use of the species like in salt preparation, local bread, snacks etc.

The analysis of the reported uses of the 662 species also revealed that 443 species are used purely for food without any other multiple usages, while the remaining 219 species are used as medicine, fodder, construction and handicrafts, besides being used as source of nourishment.

Although both the above-ground and underground plant parts are found useful, the utilization of above-ground parts is found to be much higher (94.58%) than the underground parts (5.42%). The above-ground parts include the inflorescences (flower, flower buds), fruits (nuts, strobilus, fruit pulp, legume or pod, young fruits), leaves (leaf buds, young leaves, frond), stem (pseudostem, pith), barks, young shoots (sprout, young twig), whole plants, culm, bulbils etc. and the underground edible parts include tuber, rhizome, root, bulb and corm. Among the above-ground plant parts, fruits (32.28% spp.) and leaves (28.68% spp.) are mostly preferred parts while petiole, bark, culm and bulbil are found to be the least used parts (< 2.0 % spp. in each) (Fig. 7). Tubers and rhizomes are

found to be the most preferred underground plant parts with 36.84% each (Fig. 8).

Additionally, the utility of multiple plant parts was also obtained in several wild plants such as *Colocasia esculenta*, *Solanum americanum*, *Stellaria media*, *Bauhinia variegata*, *Oxalis debilis* var. *corymbosa*, *Fagopyrum esculentum*, *Alpinia malaccensis*, *Mussaenda roxburghii*, *Alpinia nigra*, *Musa velutina*, *Panax bipinnatifidus*, *Amomum subulatum*, *Berberis asiatica*, *Castanopsis indica*, *Gnetum gnemon* etc.

To comprehend the detailed consumption pattern of individual wild plant species, we categorized the mode of consumption of different plant parts primarily into *Raw-Fresh*, *Cooked* and *Processed* forms. Fruits that are consumed directly ripe or unripe and the leaves, stems and flowers that are chewed directly or made into salad or chutney (a type of ground mixture) are placed under the *Raw-Fresh* use category; plant parts that are consumed either by boiling, frying, roasting or made into soup or sauce are placed under *Cooked* category; products like edible oils, spice and condiments, local beverages (tea and local wine), salt, flour, pickles are placed under *Processed* category. Multiple modes of consumption of wild edible parts observed are placed under the category *Raw-Cooked*, *Raw-Processed*, *Cooked-Processed* or *Raw-Cooked-Processed*.

The analysis revealed that almost 85% of the recorded edible plant species are preferred to be consumed by the communities in a single form either in *Raw-Fresh* (40%), *Cooked* (39%) or *Processed* (6 %) form, while the remaining 15 % are consumed in multiple forms represent-

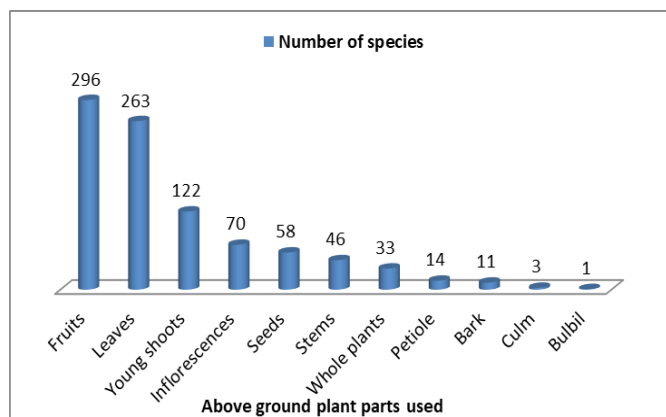


Fig. 7. Number of species in different above ground plant parts of the wild edible plants

ing either as *Raw-Cooked* (9%), *Raw-processed* (3%) or *Cooked-Processed* form (Fig. 9). Furthermore 1% of species are also found to be consumed in all the forms.

Highly utilized and preferred species

Among the 662 enlisted wild edible plants, more than 50% are found to be reported in more than one publication. For the identification of highly utilized and preferred species, the Relative Frequency of Citation (RFC) value of individual species was considered here. RFC values are used as a measure of consensus between the information provided by different literature sources and describe the local importance of each recorded species (92). The present analysis recorded the RFC value ranging from 0.01 to 0.71. About 85 species exhibited an RFC value of more than 0.10 while 579 species have less than 0.10 RFC.

The obtained RFC values of the mentioned species signified higher utilization and preference by the tribal communities of Arunachal Pradesh. The maximum value of RFC was recorded in *Clerodendrum glandulosum* (0.71) followed by *Houttuynia cordata* (0.60), *Solanum americanum* (0.49), *Centella asiatica* (0.44), *Diplazium esculentum* (0.42), *Litsea cubeba* (0.42), *Acmella paniculata* (0.37), *Solanum torvum* (0.37) and *Dillenia indica* (0.34) signifying their higher utilization and preference by the tribal communities of the state (Supplementary file 1). Whereas, the lower RFC value of 0.01 were recorded in *Acer acuminatum*, *Antidesma acidum*, *Boehmeria glomerulifera*, *Debregeasia orientalis*, *Eremocaulon capitatum*, *Litsea lancifolia*.

Although some species like *Actinidia callosa*, *Alpinia malaccensis*, *Ardisia solanacea*, *Calamus erectus*, *Piper ped-*

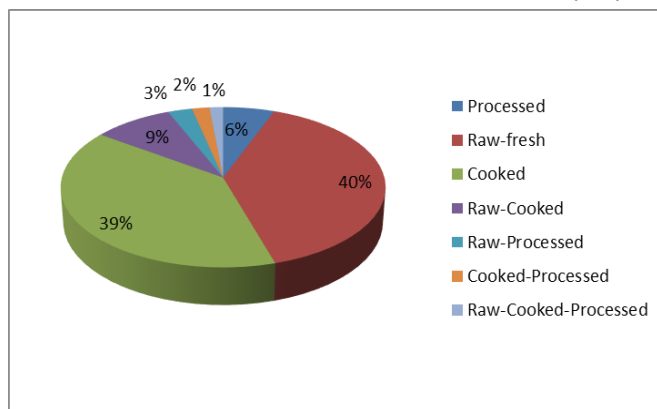


Fig. 9. Different forms of uses of the wild edible plants of Arunachal Pradesh

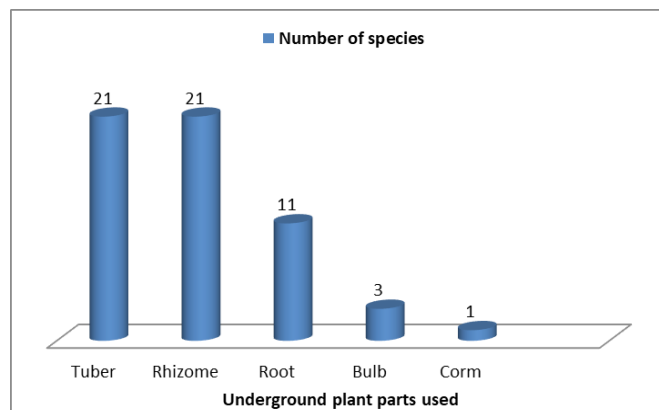


Fig. 8. Number of species in different underground plant parts of the wild edible plants

icellatum, *Pouzolzia hirta*, *Solanum kurzii*, *Docynia indica*, *Gynura bicolor*, *Lasia spinosa*, *Ammomum aromaticum*, *Rhynchotechum ellipticum*, *Phoebe goalparensis* and *Elatostema lineolatum* showed lower (< 0.10) RFC value, they are still recognized as highly preferred species in the state (18, 37, 40, 44, 88) having higher utility rate and marketing. Lower RFC scores of these plant species may be attributed to the restricted traditional knowledge of their uses and limited distribution. Based on the RFC values calculated and as well as our understanding of the local utilization pattern of the species through various ethnobotanical surveys and market survey for project and dissertation works undertaken in the authors' department, we have identified 50 highly used and preferred wild edible species having market potentiality. The list of these species with their parts used, habit and RFC value is provided in Table 1.

Wild edible plants as Ethno-medicine

Amongst the 662 wild edible species, 313 species are also found to be used for various other purposes like medicine, construction and handicrafts, hunting tools, fodder, cultural rituals etc. indicating the various usage of the wild edible plants besides providing nutritional requirements. Among the wild edible species with ethnomedicinal implications, around 250 species are found to be used for the treatment of wide array of ailments implying the rich traditional knowledge system of tribes occupying Arunachal Pradesh. In general, these plant species are used in the treatment of more than 50 different ailments ranging from simple diseases like common colds fever, headache, stomach ache, diarrhea, gastritis to more complicated health issues like malaria, cancer, asthma, liver disorder, rheumatism. Commonly mentioned wild edible plants used of their medicinal property include *Antidesma bunius*, *Artemisia indica*, *Centella asiatica*, *Dioscorea belophylla*, *Fagopyrum esculentum*, *Ficus hirta*, *Houttuynia cordata*, *Illicium griffithii*, *Paederia foetida*, *Panax bipinnatifidus*, *Paris polyphylla*, *Plantago major*, *Solanum americanum*, *Tacca integrifolia*, *Zanthoxylum armatum* etc. It can be observed that the species used as medicines are mostly categorized as vegetables, fruits and spices and condiments. It has also been established that the majority of the ethnomedicinal plants used by the indigenous communities are from the food plants (93). Many of the species reported here as wild edible plants like *Centella*

Table 1. High priority wild edible plant species used in the state of Arunachal Pradesh, India

Sl. nos	High priority species	Edible parts	Habits	RFC values
1.	<i>Acmella paniculata</i> (Wall. ex DC.) R.K. Jansen	Leaves, tender shoots, inflorescence	Herb	0.37
2.	<i>Allium hookeri</i> Thwaites	Whole plant, leaves, bulb, flowers	Herb	0.29
3.	<i>Alpinia nigra</i> (Gaertn.) Burt	Pseudostem, fruits, flowers, rhizomes	Herb	0.08
4.	<i>Amaranthus spinosus</i> L.	Leaves, tender shoots	Herb	0.18
5.	<i>Amaranthus viridis</i> Linn.	Leaves, tender shoots, flowers	Herb	0.18
6.	<i>Amomum dealbatum</i> Roxb.	Seed, young sprouts, piths	Herb	0.07
7.	<i>Angiopteris evecta</i> (Forst.) Hoffm.	Rhizome, young fronds	Shrub	0.16
8.	<i>Cardamine hirsuta</i> L.	Flower, whole plant, tender shoots	Herb	0.16
9.	<i>Castanopsis hystrix</i> A. DC.	Fruits	Tree	0.08
10.	<i>Castanopsis indica</i> (Roxb. ex Lindl.) A.DC.	Fruits, leaves	Tree	0.22
11.	<i>Centella asiatica</i> L.	Leaves, flowers, tender shoots	Herb	0.44
12.	<i>Choerospondias axillaris</i> (Roxb.) B. L. Burt & A. W. Hill	Fruits	Tree	0.14
13.	<i>Clerodendrum glandulosum</i> Lindl.	Flowers, leaves, tender shoots	Shrub	0.71
14.	<i>Colocasia esculenta</i> (L.) Schott	Young shoots, petiole, leaves, rhizomes	Herb	0.22
15.	<i>Crassocephalum crepidioides</i> (Benth.) S.Moore	Leaves, young shoots, flowers	Herb	0.33
16.	<i>Dendrocalamus hamiltonii</i> Nees & Arn. Ex Munro	Young shoots	Herb	0.26
17.	<i>Dillenia indica</i> L.	Young flowers, fruits	Tree	0.34
18.	<i>Dioscorea alata</i> L.	Tubers	Climber	0.19
19.	<i>Dioscorea bulbifera</i> L.	Tubers, bulbils	Climber	0.19
20.	<i>Diplazium esculentum</i> (Retz.) Sw.	Young fronds	Herb	0.42
21.	<i>Elatostema platyphyllum</i> Wedd.	Leaves, tender shoots, flowers	Herb	0.11
22.	<i>Elatostema sessile</i> J.R.Forst. & G.Forst.	Leaves, tender shoots	Herb	0.11
23.	<i>Elsholtzia blanda</i> Benth.	Seeds	Shrub	0.03
24.	<i>Eryngium foetidum</i> L.	Leaves	Herb	0.25
25.	<i>Fagopyrum esculentum</i> Moench	Leaves, fruits, tender shoots	Herb	0.25
26.	<i>Garcinia cowa</i> Roxb.	Fruits	Tree	0.05
27.	<i>Garcinia pedunculata</i> Roxb.ex Buch.-Ham.	Fruits	Tree	0.15
28.	<i>Gynura cusimbua</i> (D.Don) S.Moore	Tender stem, leaves, flower	Herb	0.10
29.	<i>Homalomena aromatica</i> Schott	Rhizome	Herb	0.04
30.	<i>Houttuynia cordata</i> Thunb.	Tender shoots, leaves, roots	Herb	0.60
31.	<i>Illicium griffithii</i> Hook. f. & Thomson	Seed, flower, fruits	Tree	0.11
32.	<i>Litsea cubeba</i> (Lour.) Pers.	Fruits, seeds	Tree	0.42
33.	<i>Musa acuminata</i> Colla	Fruits, inflorescence	Herb	0.07
34.	<i>Musa velutina</i>	Fruits, inflorescence, stems	Herb	0.12
35.	<i>Myrica esculenta</i> Buch.-Ham. ex D. Don	Fruits	Tree	0.16
36.	<i>Oenanthe javanica</i> (Blume) DC.	Whole plant	Herb	0.16
37.	<i>Perilla frutescens</i> (L.) Britton	Seeds	Herb	0.18
38.	<i>Phoebe cooperiana</i> P.C.Kanjilal & Das	Fruits	Tree	0.14
39.	<i>Phyllostachys bambusoides</i> Siebold & Zucc.	Young shoots	Herb	0.05
40.	<i>Piper pedicellatum</i> C. DC.	Leaves, young shoots	Herb	0.21
41.	<i>Plantago major</i> L.	Leaves	Herb	0.19
42.	<i>Pouzolzia hirta</i> Blume ex Hassk.	Leaves, tender shoots	Herb	0.15
43.	<i>Solanum americanum</i> Mill.	Leaves, young fruits, flowers, tender shoots	Herb	0.49
44.	<i>Solanum torvum</i> Sw.	Fruits, tender leaves	Shrub	0.37
45.	<i>Spilanthes acmella</i> (L.) L.	Tender leaves, young shoots, inflorescence	Herb	0.14
46.	<i>Spondias pinnata</i> (L. f.) Kurz	Fruits, young leaves	Tree	0.16
47.	<i>Terminalia chebula</i> Retz.	Fruits	Tree	0.23
48.	<i>Zanthoxylum acanthopodium</i> DC.	Fruits, leaves	Shrub	0.14
49.	<i>Zanthoxylum armatum</i> DC.	Leaves, fruits, seeds	Tree	0.32
50.	<i>Zanthoxylum rhetsa</i> DC.	Tender leaves, fruits, seeds	Tree	0.26

asiatica, *Illicium griffithii*, *Panax bipinnatifidus* are well recognized and globally significant for their medicinal properties.

Status of Management and Conservation

Nevertheless, despite the higher dependency on these wild resources, there is still a lack of sustainable management and conservation practices in the state for the majority of the species. Among the enlisted species only around 5% of the species like *Allium hookeri*, *Calamus tenuis*, *C. flagellum*, *C. rotang*, *Cheilocostus speciosus*, *Chimonobambusa callosa*, *Clerodendrum glandulosum*, *Curcuma aromatica*, *C. caesia*, *Dendrocalamus hamiltonii*, *Dioscorea alata*, *Diospyros kaki*, *Elaeagnus conferta*, *Houttuynia cordata*, *Litsea cubeba* etc. are found under sustainable management practices through their introduction and cultivation in different agroforestry system. However, the majority of the highly utilized species including *Clerodendrum glandulosum*, *Piper pedicellatum*, *Zanthoxylum acanthopodium*, *Z. armatum*, *Z. rhetsa*, *Dioscorea oppositifolia*, *D. esculenta*, *D. hamiltonii*, *Smilax perfoliata* etc. (Fig. 11) are directly harvested from the wild and owing to their higher marketability, sustainable harvesting practices are hardly being followed. It is opined by different studies that over-exploitation through unscientific harvesting and illegal trading, leads the sustainability of wild edible plant resources at stake. Although it is difficult to assess the threatened status of all the reported species following IUCN due to a lack of species-wise assessment work, some of the taxa are found under threatened categories. Presently out of the total enlisted species, 21.29% of the species are found to be included in the Least Concern categories and almost 76% of species used as wild edible are yet to find their way into the IUCN Assessment Process. Very few species are found Critically Endangered (*Gentiana kurroo*, *Saurauia punduana*), Endangered (*Taxus wallichiana*, *Illicium griffithii*, *Arenga micrantha*), Vulnerable (*Piper pedicellatum*, *Pinus merkusii*, *Siphocampylus affinis*) and Near Threatened (*Ficus hirsuta*, *Dioscorea hamiltonii*) (Fig. 10). However, the species like *Rhynchosyris ellipticum*, *Phoebe cooperiana*, *Homalomena aromatica*, *Livistona jenkinsiana*, *Garcinia pedunculata* etc. are found rarely distributed in the state.

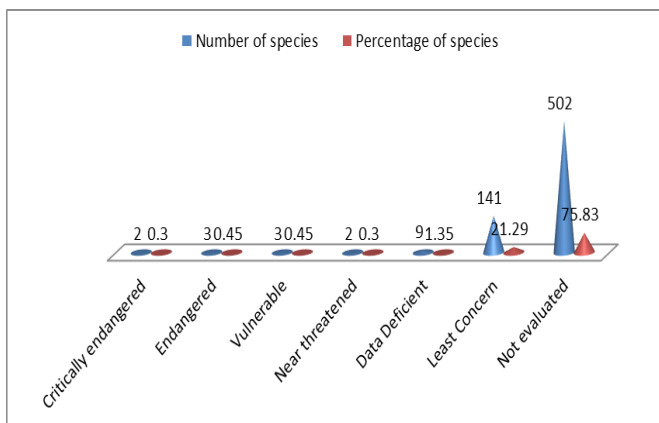


Fig. 10. Status of various threats categories of the wild edible plants of Arunachal Pradesh

Sustainable management and conservation of wild resources have been a key concern not only for the conservation of biodiversity but also for sustaining the livelihood of the rural and tribal communities that depends immensely on these resources. However, the current rate of development activities, other anthropogenic disturbances coupled with a lack of sustainable management and conservation methods may put additional pressure on the wild edible resources of the state. Thus, there is a need to develop and promote sustainable harvesting methods and conservation practices involving the local communities. Encouraging the local communities to cultivate the high valued wild resources in the farmland and other agroforestry systems could in long run may not only provide additional income to the farmers but will also help in reducing the pressure on its natural wild edible plants .

Conclusion

The state of Arunachal Pradesh represents one of the highest representations of Wild edible plants in the country where almost 10 % of the flora of the state is used as wild edibles. Many of these species today are preferred locally and marketed extensively having the potentiality of good revenue generation to the locals. As these species are being successfully used for the health and nutrition management by the ethnic groups since time immemorial without the support of the modern industrial products, they may become a good source for fulfilment of the huge nutritional demands of the growing population of the nation as well as of the globe through their proper experimentation and sustainable management. The extensive collections and marketing of many of these species on one hand, and continued habitat destruction for various developmental activities on the other, possesses great threats to the species. As the state comprises a huge land cover under degraded and marginal forests, the widely used species can be managed in these land through proper planning and strategy involving the local communities. Keeping the view of the importance of wild species to meet the nutritional and medicinal requirements, there is a need for an integrated approach for protection, management and value additions through R & D interventions .

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Authors contributions

PRG designed the objectives, plan of work and framed the manuscript. SN, RB, TY, PA and DG compiled and analyzed the data. SK, TD and PA analyzed the compiled data and



Fig. 11. Wild edible plants in the local markets of Arunachal Pradesh- A. *Houttuynia cordata* B. *Eryngium foetidum* C. *Amomum subulatum* D. *Phoebe cooperiana* E. *Dioscorea hispida* F. *Zanthoxylum rhetsa* G. *Piper nigrum* H. *Alpinia nigra* I. *Clerodendrum glandulosum* J. *Litsea cubeba* K. *Phyllostachys bambusoides* L. *Oenanthe javanica* M. *Solanum americanum* N. *Musa* sp. O. *Pilea bracteosa* P. *Pouzolzia hirta* Q. *Zanthoxylum armatum* R. *Piper pedicellatum*.

wrote the manuscript. PRG, SK, PA and RM verified the taxonomic identity and nomenclature of the species. PRG and BS helped in data interpretation and manuscript correction. All authors read and approved the final manuscript manuscript.

Compliance with ethical standards

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

Ethical issues : None.

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