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Bioculturally important plant diversity of Arunachal Pradesh: Learning from *Adi* and *Monpa* communities about 'Future crops of India'

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Arunachal Pradesh, the largest state of Northeast India, falls under Eastern Himalayan region, which is declared as one of the biodiversity Hot Spots in the world. The *Adi* and *Monpa* are two of the 26 major tribes of Arunachal Pradesh. These tribes have been selecting and using number of ethnobotanicals which are important for food, nutrition and ethnomedicine. These ethnobotanical species have great potential to develop them as 'future crops of India'. Looking to this importance of ethnobotanicals, a study was conducted during 2005-2008 among *Adi* and *Monpa* tribes. Respondents of study were sampled from randomly chosen villages of East Sinag and West Kameng districts. Data pertaining to study were collected using conventional and participatory methods. Results reveal that there are 14 ethnobotanicals used as food, nutritional and ethnomedicinal items by *Adi* tribes, while, one species was recorded from *Monpa* community being used for the similar purposes. These total 15 species play pivotal role in livelihood and support systems to its respective tribes. Large scale use, wider adaptability, semi-domestication status, high local market demand and conservation in varying micro-ecosystems are factors to consider the reported 15 species as the 'future crops of India'. Some of these species are compatible to cope-up with even climate change also. Few of reported ethnobotanicals are used to cure diseases like high blood pressure, diabetes, malaria, stomach disorders, etc. These 15 species are invaluable depositories of hidden but significant gene pool which could be used in plant breeding programme and develop new plant varieties to cope up with the challenges of food, and nutritional insecurity, and changing climate also.

Keywords: Plant biodiversity, Future crops, Ethnobotanicals, Conservation, Traditional knowledge, Wild plants

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Arunachal Pradesh is one of the Biodiversity Hotspot areas in the world and harbours a very rich and diverse flora[1]. It may be regarded as emporia of many wild relatives of cultural and economic plants[2]. Out of the 26 major tribes which are composite of 110 sub-tribes, *Adi* and *Monpa* are major tribes of Arunachal Pradesh[3]. These tribes inhabit mainly in East Siang and West Siang, and West Kameng districts of State. *Jhum* cultivation along with some horticultural crops (pineapple and orange) are basic cultivation systems and major practice for survival of *Adi* tribe, while *Monpa* performs settled agriculture in combination with *jhum* cultivation in small area and horticultural crops such as apple, kiwi fruits, plum peach and temperate vegetables. For both the tribes, mixed farming and mixed cropping (and plant need based and often multipurpose crops/plants) are basic mainstay to derive their food and nutrition from a large number of wild plant species (ethnobotanicals) from their natural habitats, *jhum* land and home garden (modified micro-ecosystems). The culturally important pant species, ethnobotanicals, make food habit of local tribes different from rest part of India. These ethnobotanicals are inextricably linked with livelihoods support systems of *Adi* and *Monpa* tribes. These ethnobotanicals play a major role in meeting the daily nutritional requirement of these tribes. A wide variety of plant leaves, flowers buds, fruits, roots and tubers are collected from wild, *jhum* land and home garden and consumed in various forms[2,4].

There are large numbers of ethnobotanicals which have immense potential for contribution to food security of not only Northeast region of India, but the country as a whole as they are well adapted to biotic and abiotic stress of local ecosystems[4]. There is ample scope to domesticate these plant species and make them as a 'future crop of India' in order to meet out the current challenges of food and nutritional security.

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As compared to commercial and cultivated crops, which are well domesticated and cultivated with external inputs, these ethnobotanicals have been conserved in community forest, *jhum* land and home gardens in natural and or with slight modifications in micro-ecosystems. These diverse ethnobotanicals have better potential to cope with the climate change, since they provide steady supply even during the extreme weather. Though, to make them more compatible and increase their yield potential for the biomass, there will be the need of developing package of practices for subsistence and commercial cultivations for these ethnobotanicals. These ethnobotanicals are rich in vitamins, minerals and dietary fiber, and are cheap source of nutrition to combat malnutrition[4]. Furthermore, they have long been a traditional part of supply systems, especially in home gardens. Some of the ethnobotanicals have been domesticated and conserved, particularly by the women in the home/kitchen garden for food and nutritional security as well as to use for curing several diseases and disorders, and fetch good price in the local market. Looking to the importance of these ethnobotanicals as the potential 'future crops of India', a study was carried out with an objective to explore the potential ethnobotanicals and analyze them for exploitation and recommend them as the 'future crop of India'; and strategies for their conservation.

Methodology

The study was conducted during the years 2005-2008 in *Adi* dominated randomly selected villages namely Balek, Rasam, Bilat, Yagbo, Runne, Boing, Yagrung, Renging, Napit, Mirbuk, Mirku, Sille and Gune from Paighat circle, and Mebo village from Mebo circle of East Siang district, Arunachal Pradesh. Similarly, two villages namely Dirang and Leechh were selected randomly from West Kameng district of state. Total 240 wise men and women (15 from each village) were selected from 16 villages that had at least 20 yrs of experience in using and conserving the ethnobotanicals used as food plants. The following criteria were adopted to select a particular species to name that as a 'future crop of India': large scale consumption; frequency of use; role in ensuring food and nutritional security; economic viability; market value; conservation mode; cultural values for *Adi* and *Monpa* tribes; and compatibility to multiply and transfer genetic resources from one micro-ecosystem to another. The data pertaining to study were collected using field observations and interview with structured questionnaire containing open ended questions. Focused group discussions (FGD) were held in each village with the help of local *Gaon Burha* (village customary chief) in order to know history, use pattern and conservation status of each plant. Standard methodologies of field and herbarium technique were followed[5]. The ethnobotanicals were identified at Botanical Survey of India, Itanagar, Arunachal Pradesh and with the help of standard Indian flora. Some of nutritional parameters of few selected species were analyzed using proximate analysis method. Preference ranking and screening of each species as 'future crops of India' was done using PRA technique of preference matrix ranking in the focus group discussions (FGD). Information about food and medicinal values of each plant species reported in this article were observed to be part of community knowledge systems, hence the prior informed consent (PIC) was obtained from community leader of each village (*Gaon Burha*- customary chief) [6].

Results and discussion

The study revealed that *Adi* tribes consume 14 edibles, whereas *Monpa* consume 1 edible as ethnobotanicals. These are used at large scale and with higher percentage and good local market demand (Table 1). The identified 15 species have great food and medicinal values. *Ritar/Adi dhaniya* (Fig.1) is well famous for its use value (0.82% ash, 6.92% protein, and 1.14% fat) and flavouring edible and chutney. It can be cultivated year round and has high market demand. *Akshap* (Fig.2) is known for its high level of fiber content and vitamins, while *Bangko* (Fig.3) is the integral part of both food and medicine. The leaf and roots are bitter in taste and used by *Adi* tribe in curing diabetes and malaria. *Dilap* (Fig.4), is highly preferred as spice and vegetable both; its bulbs are used in curing snakebites. *Gende* (Fig.5), *Paput* (Fig.6) and *Oyik* (Fig.7) are popular for their tenderness and preferred to be given to lactating mothers and small children. Especially *Oyik*, a slippery leafy vegetable is blended with rice and dishes prepared from local fishes and are given to children and elders for quick energy source. *Onger*, an armed shrub (Fig.9), is used year round and given in the boiled form either alone or mixed with some other leafy vegetables and chicken, pork or fish to the special guests. It is considered to be nutritious (ash 0.72%, fibre 8.27%, protein 5.80% and fat 2.51%) and ethnomedicinal against many stomach disorders

Table 1— Ethnobotanicals explored from *Adi* and *Monpa* communities as the potential 'future crops of India'

Local name	Plant name	Family	Habit	Altitude (in m)	Parts used	Frequency of use	Scale of use (in %)	Seasonal availability	Conservation micro-ecosystems	Market value (in Rs/kg)*[1]	Preference ranking*[2]
Adi dhaniya	*Eryngium foetidum*	Apiaceae	Herb	120-160	Leaves	5-6 times in a week	95.6	Year round	HG, JL[ϕ]	60.0	II
Akshap	*Mussenda roxburghii*	Rubiaceae	Shrub	150-170	Tender leaf	3-4 times in a week	71.6	Year round	HG, JL	32.6	IV
Bangko	*Solanum spirale*	Solanaceae	Shrub	130-160	Tender leaf	Almost everyday	89.7	Year round	HG, JL	62.5	II
Bathua	*Chenopodium album*	Chenopodiaceae	Shrub	1500-1676	Tender leaf and seed	6-7 times in a week	98.6	December to March	HG	60.0[+] 150.0[#]	I
Dilap	*Alleum hookeri*	Liliaceae	Herb	160-350	Whole plant	4-5 times in a week	90.5	June to September	HG	60.5	II
Gende	*Gynura cripidioides*	Asteraceae	Herb	130-160	Tender leaf	6-7 times in a week	85.9	May to August	HG, JL	40.0	III
Marshang	*Spilanthes acmela*	Asteraceae	herb	120-170	Tender leaf	3-4 times in a week	68.7	Year round	HG, JL	30.4	V
Namdung	*Perilla ocymoides*	Lamiaceae	Herb	130-170	Seeds	3-4 times in a week	99.0	November-December	HG	65.5	II
Nemar	*Piper mullesua*	Piperaceae	Shrub	110-150	Fruits	As spice 1-2times in a wk	59.7	August to October	HG	70.5	VI
Ogen	*Solanum nigrum*	Solanaceae	Herb	120-160	Tender leaf /fruits	2-3 times in a week	69.6	June to September	HG, JL	42.4	V
Onger	*Zanthoxylum rhetsa*	Rutaceae	Shrub	150-250	Tender leaf	Almost everyday	98.5	Year round	HG, JL	60.0	I
Ongin	*Clerodendrum colebrookianum*	Verbenaceae	Shrub	140-220	Tender leaf	Almost everyday	93.6	Year round	HG, JL	65.5	I
Oyik	*Pouzolzia hirta*	Urticaceae	Herb	140-180	Tender leaf	Almost everyday	90.2	May to August	HG, JL	40.0	II
Paput	*Gnepalium affine*	Asteraceae	Herb	140-170	Tender leaf	4-5 times in a week	84.8	May to August	HG, JL	35.5	III
Takang/ Dhekia saag	*Diplezium esculentum*	Athyriaceae	Fern	100-150	Tender leaf	4-5 times in a week	92.8	June to August	HG, RB	45.5	II

*[1] The mean market value. The calculation made after pooling the individual value from all the respondents

*[2] Preference ranking to screen a particular species for its value and potential for making them 'future crop of India' was done using PRA tool matrix preference ranking. This exercise was done adopting focus group discussion method (FGD-a PRA tool) in every village of *Adi* and *Monpa* tribes with the help of all the 15 respondents of each village. In the last on the basis of mean score of each village, ranking was made for every species. Two ranks are same because of equal weightage (score) assigned by respondents for the species

+ The value of leaves

The value of seeds

[ϕ]Abbreviation: HG , JL = Home garden and jhum land, HG= Home garden, JL= Jhum land, RB= River bank

and protection from intestinal infection, especially from tapeworms. Leaves of *Onger* are also used as biopesticides in paddy crop against chewing cutting types of mouth parts bearing insects. Paste of green leaves is mixed in standing water and used for ecofriendly harvesting of the fishes. *Marshang* (Fig.10) is used as the spicy ingredient and vegetable both but is rich in ash (1.64%), fiber (5.45%), protein (4.76%) and fat (2.19%). Its leaves and flowers are also used in ecofriendly fish harvesting in stagnant water bodies. *Namdung* (Fig.11) is one of the oily plants found in the semi-domesticated form. Its seeds (Fig.8) are mixed with rice while cooking to make rice tastier. It is also used in making chutney with other leafy ethnobotanicals. Seeds sometimes are fermented and used. Seeds are rich in magnesium and elder women prescribe it to be eaten by the pregnant ladies. The seed contains about 17.0% protein, 51.0% fat, 11.3% carbohydrate, 4.4% ash[7]. The oil is rich in n-3 PUFA linolenic acid (56.8%) hence good for heart. Protein is of good quality net protein utilization (NPU) averaging >50% and true digestible protein (TDP) averaging >80%. Cooking and/or dehuling of perilla increase NPU and TDP, whereas roasting

Fig.1 Ritar (*Adi dhaniya*)

Fig.2 *Akshap*

Fig.3 *Bangko*

Fig.4 *Alleum hookeri*

Fig.5 *Gende*

Fig.6 *Paput*

Fig.7 *Oyik*

Fig.8 *Namdung with* seeds

Fig.9 *Onger*

Fig.10 *Marshang*

Fig.11 *Namdung* plant

Fig.12 *Bathua*&buckwheat

Fig.13 *Nemar*

Fig.14 *Ongin*- flower with fruits

Fig.15 *Ogen*

Fig.16 *Takang/Dhenkiya saag*

Fig.17 *Kaibandhu* plant with fruits

exerts a negative effect[7]. The plant yields an essential oil, which is used as food flavouring in candies and sauces[8]. It also contains perillartin, a mono-teropenoid (about 350 times sweeter than sucrose) is the constituent of slightly sweet volatile oil[7,9]. It is also part of the barter system to exchange foods with other tribes. Due to its great demand in the local market and also by the non-tribal people, the species is now fully domesticated by the *Adi* women and is being cultivated in *jhum* land.

Nemar (Fig.13) is a valuable substitute for tobacco. *Ogen* (Fig.15) was found to be frequently used as vegetable. Its fruits are used by the children and women. *Ongin* (Fig.14) is a most popular and classical vegetable plant with rich nutritional parameters (ash 1.85%, fibre 4.36% protein 4.76% and fat 1.65%). Its leaves are used most frequently and a best local ethnomedicine against diabetes, high blood pressure and malaria. It is important to reveal that green and dried leaves of the edible plant are used in barter system to exchange foods with other tribes of state. It is also sent to other regions of Arunachal Pradesh and Assam. This contributes significantly in annual income of *Adi* women who are responsible for conservation, collection and selling of all the edibles. *Takang/Dhekia saag* (Fig.16) was screened to be most hardy fibrous edible after the *Akshap*. It is a fern and used frequently during the rainy season. Its use is at a large scale across the *Adi* community and non-tribal people also use it. When Arunachal Pradesh is cut-off from rest part of India due to the flood, then the species is used as local vegetable to cope-with the changed climate and guaranteed vegetable supply. *Monpa* tribe has developed classical protocol and traditional agronomic practices to cultivate *Bathua* as a food and ethnomedicinal crop. The *Bathua* with 1-2m in height (Fig.12) is most likely intercropped with buckwheat crop. Leaves of *Bathua* are used as vegetable, while seeds are used to prepare number of dishes for a famous festival, *Lohsar* (start of New Year of *Monpa* tribe).

These listed and screened 15 species as the 'future crops of India' are backbone of food, medicinal and livelihood security of respective tribal communities of Arunachal Pradesh. It was observed that there were total 15 ethnobotanicals which are used at large scale ranging from 59.7 to 99.0% (Table 1). These ethnobotanicals also hold significant market value. These species vary from each other on account of seasonal availability, frequency of use and market values. The *Adi* and *Monpa* communities assign different rank value to each species on the basis of percentage and frequency of use which shows the degree of local importance to each species. Community level screening revealed that these species have great value to develop cultivation protocol and package of practices to make all the 15 species as the 'future crops of India'.

Conservation strategies

The identified 15 species are spread in two climates. Fourteen species viz. *Adi Dhaniya, Akshap*, *Bangko*, *Dilap*, *Gende*, *Marshang*, *Nmadung, Nemar*, *Ogen*, *Onger, Ongin*, *Oyi, Paput* and *Takang/Dhekia saag* were observed to found in subtropical ecosystems(Fig.17). While, *Bathua* species was recorded from sub-temperate ecosystem. It is imperative to mention that these 15 species are conserved basically in micro-ecosystems namely home garden, *jhum* land and river bank (Fig.18). A single species can be conserved either in one or two micro-ecosystems. This shows potential of a species for its wider adaptability. Except *Dhenkiya saag* (it is found around river bank and other aquatic bodies), every species is managed and find human intervention for the conservation in order to use them in food, nutrition and medicinal purposes. However, these reported species are at threat from various fronts such as large scale deforestation, encroachment of forest lands for diverse use; extensive logging, timber extraction; fragmentation and conversion of forest lands for *Jhum* cultivation; unregulated shifting cultivation; overexploitation of diversity from natural habitat; invasion of alien weeds e.g. *Mikania micrantha, Lantana camara* var. *aculeata*; changing ecosystem due to forest clearance and climate change (eg. *Zanthoxylum rhetsa* was earlier easily available); population growth due to influx (illegal immigrants), urbanization and migration of villagers to lower plains and shortening of *Jhum* cycle (now 5-10 yrs, earlier 15-20 yrs).

The changes in lifestyle, food habit and exotic culture have made the new generation more prone to easy life.

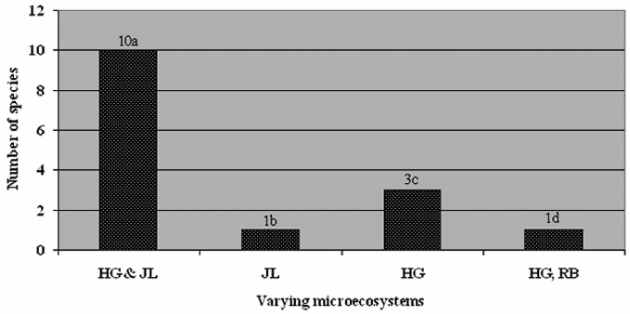

Fig. 18 Conservation of future crops in varying microecosystems

They are going after fast food and loosing interest in agriculture, traditional food gathering and horticulture including vegetable gardening. Materialistic thinking and immediate returns are the priorities for them[4,5]. This attitude has been affecting the biodiversity of these areas and their sustenance. The gap between the generations with respect to traditional knowledge (TK) is getting widened and food and medicinal uses of ethnobotanicals are not properly getting diffused among them. The TK is restricted to elder generation in the absence of proper documentation and is eroding[4,5]. The conversion of natural vegetation areas into cash crops like tea, cardamom, ginger and turmeric; and more emphasis and the policy by the government for monoculture plantations like *Khasi* mandarin, apple, kiwi fruits, pineapple and banana for higher revenue generation have resulted in forest land clearing and destruction of natural habitat, thus posing a threat to the indigenous crops.

Conclusion and policy implications

From foregoing study, it has been concluded that listed 15 species of ethnobotanicals may be recommended as the 'future crops of India'. The future endeavors should be focused on the following interventions: conduct ecogeographic surveys, inventorize, develop a national database and disseminate the database on ethnobotanicals for better understanding and manage them as 'future crops India' *in-situ*. Standardization of agrotechniques of 'future crops India' and bringing them under domestication on top priority. These 15 species are invaluable depositories of hidden but significant gene pool, which could be used in plant breeding programme and develop new plant varieties to cope up with the challenges of food, nutritional and medicinal insecurity. Hence, it is needed to characterize the above listed ethnobotanicals and their variants at morphological, phytochemical and molecular levels. Evaluation of recorded ethnobotanicals for vitamins, dietary fibre, folic acid/folate, antioxidants, flavonoids, amino acid content and product diversification and scientific validation should receive high priority. Prospecting these promising species having medicinal value for developing new herbal pharmaceuticals and other natural products should be emphasized. Government policies should be framed to encourage participatory conservation of these reported species and other important ones too, involving local communities. *Adi* and *Monpa* women are the primary conservators/producers, collectors and sellers of reported 15 species[6]. More information on the nutritional content, antioxidant properties, etc. will add to market value to the 'future crops of India', thus could provide better opportunity for income and livelihoods to women folk. Rewarding and recognizing the outstanding conservators and knowledge holders through *Biodiversity Conservation Champions Award* for promising and valuable species, release of postage stamps on it, etc. are needed for promotion of 15 listed species as 'future crops of India'. Equitable benefit sharing procedures among grassroots conservators and other agencies have to be worked out on war-foot basis. For all this, there has to be an active role from government and academia. The lack of attention by research and developmental agencies is leading to the under exploitation of these promising species as 'future crops of India'. Thus, these 15 species can play a significant role in reducing poverty and ensuring food and nutritional security in the scenario of climate change.

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