Wild Edible Fruits of Arunachal Pradesh, India: Ethno-Medicinal Uses, Socio Economic Importance and Role in Rural Economy and Livelihood Security

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Abstract

Background Forests inhibit a large number of trees, shrubs, herbs, climbers, wealth of non-timber forest products and a good number of wild edible fruits plants. These wild edible fruits are an indispensable constituent of human and rich in vitamin, minerals, fibre, antioxidants and compounds of nutritional importance such as alkaloids, essential oils and phenolic etc. Many of them are also very good source of ethno-medicines. But, the knowledge of valuable heritage of these fruits is orally handed over from one generation to other generation years after year. Nevertheless, the folk and ethno-medicinal values of these fruits are still playing a great role in treatment of diseases but now the traditional knowledge are disappearing and losing their intrinsic values. The present study was undertaken to document wild edible fruits of Arunachal Pradesh, India, and to study the socio-economic importance of these fruits among the people of the district.

Methods Extensive field surveys, plant collection, herbarium preparations and personal interviews with the traditional healers as well as local people from rural villages were conducted for this study. Altogether 50 wild edible fruits belonging to 31 families having medicinal and socio economic significance were reported in this study.

Results Among the different families, Moraceae and Rutaceae were the dominant with 5 species, followed by Phyllanthaceae, Anacardiaceae and Rosaceae, Arecaceae, Fabaceae, Lauraceae, Primulaceae and Fagaceae. In terms of parts used, the highest used was leaves (35.58 %), followed by fruits and bark (21.51%), root (10.73 %), seed (7.53 %), latex (2.15%) and shoot (1.07%). Therapeutically, the reported wild edible fruits are used against 14 classes of diseases *viz.* gastrointestinal, dermatological, cardiovascular, respiratory, urogenital, ENT, Anti-venom/ insect bite, snakebite, mental and nervous disorders, minor ailments, bone disease, food poison, jaundice, cancers and allergy. They have a number of uses in the rural economy like constructional timbers, firewood, charcoal, fodder, fish poisoning, dyes, oils etc.

Conclusions Although, these fruits play an important role in the social and cultural life of the tribal people of Arunachal Pradesh, India, but this valuable species has been vanishing at a very faster rate without proper documentation. Therefore, the claimed therapeutic values of these species are to be critically studied and conserve these valuable species before their extinction.

Background

Forests are the integral part of global sustainable development and provides renewable raw material, maintain biological diversity, mitigate climate change, protect land and water resources, improve air quality and help to alleviate poverty. From ancient times, forests have played a very important role in improving the food security and livelihood of the tribal society as well social, economic and religious activities. Rural people depends on these forests to fulfil their sustainable livelihood as well as source of income for economic prosperity. These forests inhibit a large number of trees, shrubs, herbs, climbers, as well as non-timber forest products including medicinal and aromatic plants and a good number of wild fruit plants. These wild fruits are an indispensable constituent of rural people since very ancient time.

These wild fruits are rich in vitamin, minerals, fibre, antioxidants and compounds of nutritional importance such as alkaloids, essential oils and phenolic etc. Some of these fruits reported to have comparable or even higher in nutritive values than the so called commercial fruits [1-2]. These wild fruits play a significant role in the rural life as a source of food and fodder as well have important role in socio-economic life of traditional indigenous people through their uses in ethno-medicine, shelter, fibres, dyes, and religious and traditional rituals [3]. Due to the presence of sufficiently high amount of minerals and vitamins, inclusion of these fruits in daily diet can reduce the risk of a number of diseases like diabetes, cancer and coronary heart disease [4]. In addition, incorporation of these fruits in agricultural system can also protect biological diversity as well provide adequate food security and boost the rural economy. For this purpose, proper identification, documentation as well enumeration of the valuable species is very much necessary [5].

North-east India is one of the agro biodiversity hot-spots in the India gene centre, and full of ethnic and traditional diversity. Arunachal Pradesh, geographically the largest state of North-east India is commonly known as Orchid state of India or paradise of botanist which translates to "land of the dawn-lit mountains". The state is having more than 26 major tribes and over 100 sub-tribes, with differences in their tradition and customs. The tradition, socio-culture life and custom of each tribe mostly depend on bio-diversity, forest and wildlife of the state. The state falls within the 12 mega diversity "Hot Spots" in the world having 20% species of country's fauna, 4500 species of flowering plants, 400 species of pteridophytes, 23 species of conifers, 35 species of bamboos, 20 species of canes, 52 Rhododendron species & more than 500 species of orchids. Most of the people of the state depend mainly on forests to earn their livelihood. The tribal people of the state depend on forests for food, fibre, fodder, in addition to ethno-medicines in traditional healthcare system. In addition to other edible and non-edible plants in the forests, a number of wild fruits are also there which the tribal people have been using since ancient times against a number of diseases in traditional healthcare system. But, the knowledge of this valuable heritage of these fruits has been transmitted from generation to generation orally without proper documentation [6]. In many villages, these fruits also serve as source of staple food as well serve as complementary food and offers as an source of sustainable income and livelihood security [7]. But of now, with ever increasing population pressure and shrinkage of land as well as use of forests areas for development and constructional projects, these wild fruits are in verge of extinction. Although, these fruits have been using in folk medicines of traditional healthcare system but the traditional knowledge about the ethno-medicinal uses of these fruits have been losing their intrinsic value because of lack of proper documentation [8]. Therefore it is the high time for the scientific communities to safeguard these valuable natural resources of the forests by domestication measures as well as conservation efforts [9].

Keeping in view all these information, the present research work was carried out to innumerate the ethno-medicinal uses of wild fruits of Arunachal Pradesh as well as of these fruits in the socio-economic life of rural people.

Methods

Study Area

The present research work was carried out during 2017-2019 to document the ethno-medicinal uses of wild fruits of East Siang, Upper Siang, West Siang, and Lower Dibang valley districts of Arunachal Pradesh in the traditional healthcare system of rural people as well as the uses of these species in the socio-economic life of rural people. The study consisting of collection, identification and proper enumeration of the species. Field visits were done to collect the information about the available wild fruits. The methods for the field work was followed as suggested by [10-12]. Questionnaires were prepared and personal interviews were taken with the traditional healers of rural villages to collect the information about the ethno-medicinal uses of the fruits among the rural people by following standard guidelines. The uses of these fruits among the rural people like local name, parts used, name of the diseases, methods of preparation, dosage etc. were collected. Literature survey was done as well as various floras and monographs were consulted to identify the collected specimen. After identification of the species, they were processed, dried and herbarium specimen were prepared according to the conventional herbarium techniques [13]. The voucher specimens were deposited at department of Horticulture, Aromatic and Medicinal Plants, Mizoram University, India.

Regarding the use of these fruits in the socio-economic life of rural people, questionnaire was prepared and people of different age groups were interviewed including rural practitioner, old men and women, young youths. To know the uses of these fruits in socio-economic life of the rural people like constructional timber, firewood, charcoal, fodder, etc. aged men and women were interviewed. Similarly, to know the uses of these fruits for making dyes, rural people involved in handicraft industry were interviewed. Similarly, market surveys were done at rural markets and sellers were asked about market price, demand, season of availability etc.

Results And Discussion

Ethno-medicinal evaluation

Fig. 2 represents the data on family wise representation of the wild fruits of Arunachal Pradesh having ethno-medicinal uses. From the results of the present investigation, it is clear that, a total of 50 wild fruits having ethno-medicinal uses. These fruits are represented by 31 families of which Moraceae and Rutaceae family having the highest of 5 species, followed by Phyllanthaceae with 4 species, Anacardiaceae and Rosaceae 3 species, Arecaceae, Fabaceae, Fagaceae, Lauraceae and Primulaceae each by 2 species and rest all are 1 species each.

Table 1 represents the details about the uses of wild edible fruits of Arunachal Pradesh in the traditional healthcare system of rural people. The details information about the uses of wild fruits in the traditional healthcare system was collected from the traditional healthcare practitioner in the villages.

Table 1:
Ethno-medicinal uses of wild edible fruits of four districts of Arunachal Pradesh

Fruit used	Vernacular name	Family	Diseases	Part used	Formulation
<i>Artocarpus heterophyllus</i> . Lam	Belang	Moraceae	Skin disease, ringworm infestation, Cracking of feet	Roots, latex, leaves	i) Latex from the stem are collected and apply in skin diseases. ii) Paste made from leaves are applied externally against ringworm and cracking of feet
<i>Ardisia crenata</i> Sims.	So-Bumlo	Myrsinaceae	Skin disease	Leaf	i) Leaves are crushed, extracted the juice and used against skin disease like acne.
<i>Averrhoa carambola</i> L.	Tador	Oxalidaceae	Chicken pox, ringworms, fever, throat inflammation	Leaves, seed, fruits	i) Leaves are crushed and are externally apply against chicken pox, ringworm infestation. ii) The juice of ripe fruits are taken to give relieve from fever and throat inflammation.
<i>Antidesma buniis</i> (L.) Spreng.	Kompong-Perong	Phyllanthaceae	Indigestion, cough, stomachache, insomnia	Bark, leaves, fruits	i) Bark and leaves extract are taken orally for treatment of cough, indigestion and stomachache. ii) Fruit juice is used against insomnia.

<i>Bischofia javanica</i> Blume	Sitiil	Phyllanthaceae	Cholera, skin diseases	Leaves, bark	<p>i) Decoction of bark is taken internally for the treatment of cholera.</p> <p>ii) The leaves are ground and applied externally on the affected part of skin to cure Eczema.</p>
<i>Bauhinia variegata</i> L.	Ogok	Fabaceae	Stomach-ache, diarrhoea, dysentery	Leaves, Flower	<p>i) The juice of flower is drunken against diarrhoea, and dysentery.</p> <p>ii) The leaves are boiled or chewed raw against stomach-ache.</p>
<i>Baccaurea ramiflora</i> Lour.	Bureng	Phyllanthaceae	Constipation	Bark, fruit	i) Fresh bark is chewed or fruit juice is taken orally against constipation.
<i>Castanopsis hystrix</i> Hook. f. & Thomson ex A. DC.	Sirang-Raaye	Fagaceae	Chest pain	Bark	i) Bark paste is applied on the chest to control chest pain.
<i>Calamus tenuis</i> Roxb	Esong	Arecaceae	Stomach disorder	Shoot	i) Young shoots are consumed raw for stomach disorder.
<i>Castanopsis indica</i> Roxb	Koyu -Korang Raaye	Fagaceae	Stomach disorder, skin disease, indigestion, headache	Leaves, bark	i) Decoction of leaves is applied against stomach disorder and skin diseases like wart, acne.

					<p>ii) The powdered leaves are mixed with water and given to cure indigestion</p> <p>iii) Paste prepared from the leaves are applied against headache.</p>
<i>Citrus grandis</i> (L.)	Rebab	Rutaceae	Swelling, constipation	Fruit, Leaf	<p>i) Hot leaf decoction are made and applied externally in swelling area.</p> <p>ii) Fruit juice is used against constipation.</p>
<i>Citrus medica</i> L	Sipa-Yegra	Rutaceae	Constipation, backpain	Root, Leaves	<p>i) Roots decoction paste are applied externally for back pain.</p> <p>ii) Fruit juice is used against constipation.</p>
<i>Citrus limon</i> Burm.f	Singkom	Rutaceae	Dysentery, cuts, indigestion	Fruit, leaves and stem	<p>i) Bark of fruits and leaves are chewed raw and apply externally on cuts and wound</p> <p>ii) Fruit is used against indigestion and dysentery</p>
<i>Canarium strictum</i> Roxb	Hilum/Tikok	Burseraceae	Insect bite, Fever, cough, chicken fox	Bark, Leaf	<p>i) The extracted juice of bark is used against insect bite.</p>

					ii) The bark and resin are burnt around household for the prevention of chicken pox.
<i>Dillenia indica</i> L.	Sompa	Dilleniaceae	Dysentery, Diarrhoea, Fever	Fruits, Leaf	<p>i) The fruits are tonic; taken orally in dysentery, diarrhoea.</p> <p>ii) The fruit juice is used as a cooling beverage in fever.</p> <p>iii) Leaves are directly consume for treatment of dysentery.</p>
<i>Epipremnum pinnatum</i> (L.) Engl.	Talo	Araceae	Fracture, Chest pain	Leaves	i) Decoction leaves paste is applied externally to cure fracture and chest pain.
<i>Elaeagnus latifolia</i> L.	Raapgam	Elaeagnaceae	Anaemia	Roots, leaf	i) Fruits Juice are used against anaemia
<i>Emblica officinalis</i> G.	Amloki	Phyllanthaceae	Scurvy	Fruits	i) Fruits are used against opening of previously healed wounds
<i>Elaeocarpus floribundus</i> Blume.	Jolpai	Leguminosaceae	Inflamed gums	Leaves, bark	i) Infusion of bark and leaves are used as a mouthwash against inflamed gums.
<i>Entada pursaetha</i> DC.	Pyopa	Elaeocarpaceae	Fever, Cold	Bark, leaves	i) Bark powder are used against fever.

					ii) The leaf juice is taken orally to cure common cold.
<i>Ficus auriculata</i> Lour.	Tapang	Moraceae	Diarrhoea, dysentery, cuts, wounds, vomiting, cholera	Stem, fruits	i) The fruits are roasted and are used to cure diarrhoea and dysentery. ii) The stem latex is widely used in cuts and wounds.
<i>Ficus semicordata</i> Buch.-Ham	Takuk	Moraceae	Boils, constipation, headache, indigestion	Latex, fruits, leaf, root	i) Latex is directly applied to boils. ii) Fruits juice is drink for headache. iii) Leave and root juice are used against constipation and indigestion.
<i>Ficus hirta</i> Reinw.ex Blume	Siipop	Moraceae	General weakness	Root	i) The extracted root juice is drink for the treatment of body weakness.
<i>Garcinia cowa</i> Roxb	Tabi-Tarak	Clusiaceae	Dysentery, fever, constipation	Fruits	i) Fruits are cut into slices, sundried and are used in dysentery and fever.
<i>Gynocardia odorata</i> Roxb.	Sibeng-Tulpai	Achariaceae	Sprains, skin diseases, jaundice	Seeds, young shoot	i) Seed are crushed and oil is extracted which is applied externally in the treatment of acne and sprains.

					ii) Young shoots are grinded and drink the juice to combat jaundice.
<i>Melastoma malabathricum</i> L.	Kesi-Yayi	Melastomataceae	Dysentery, diarrhoea, cuts, wound	Leaves	i) Decoction of leaves is orally taken in treatment of dysentery and diarrhoea. ii) Leaves are chewed raw and apply to cuts and wound.
<i>Myrica esculenta</i> Buch.-Ham	Ketir	Myricaceae	Diarrhoea	Bark, flower	i) Decoction of bark and flower are drink to treat diarrhoea
<i>Morus alba</i> L.	Eeyum-Tayin	Moraceae	Fever	Leaves	i) Decoction of leaves used against fever.
<i>Maesa japonica</i> (Thunb.) Moritzi & Zoll.	Ko-Kebung	Primulaceae	Itching	Leaves	i) Leaf paste is applied externally to cure itch.
<i>Mangifera sylvatica</i> Roxb	Monaam-Tagung	Anacardiaceae	Diarrhoea	Seed	i) Kernel are make powder and mixed with water and drink to treat Diarrhoea
<i>Litsea cubeba</i> (Lour.) Pers.	Raayil	Lauraceae	Cough, Indigestion	Seed	i) Seeds are eaten raw to promote digestion and to treat cough.
<i>Livistona jenkinsiana</i> Griff.	Taek	Arecaceae	Stomach ailment	Seed, fruits	i) Seeds and Fruits are used to cure some stomach ailments.
<i>Leea indica</i> (Burm.f.) Merr.	Talu	Leeaceae	Dysentery, fever,	Leaves, roots	i) The juice leaves were

			headache, sprain		<p>taken orally to treat dysentery and mild fever</p> <p>ii) The paste of leaves and roots are externally applied to treat headache, sprain etc.</p> <p>ii) The decoction of leaf is consumed by women during pregnancy to control body pain.</p>
<i>Phoebe cooperiana</i> P. C. Kanj. & Das	Tapil	Lauraceae	Itching	Bark	i) Bark paste is applied externally to cure itch.
<i>Passiflora edulis</i> Sims.	Marsang-Riiyong	Passifloraceae	Dysentery, constipation	Leaves, fruits	<p>i) Leaves are boiled and extract are drunken against dysentery.</p> <p>ii) Fruits are eaten raw to get relief from constipation.</p>
<i>Pandanus odoratissimus</i> L.	Taku	Pandanaceae	Skin diseases	Leaf	i) Paste of the leaves are externally applied on the skin diseases like wart, ringworm.
<i>Rhus chinensis</i> Mill.	Tagmo	Anacardiaceae	Cough, fever, dysentery	Fruit, leaf	<p>i) Fruits are mixed with common salt and soaked in water which eaten and drink to cure indigestion.</p> <p>ii) Decoction of leaves are</p>

					used against dysentery.
<i>Rubus calycinoides</i> Hayata ex KoidZ.	Pasi-Payi	Rosaceae	Wound	Leaf	i) Crushed leaves are applied externally for wound.
<i>Rubus ellipticus</i> Smith.	Tayin	Rosaceae	Gastric, fever, wound, dysentery	Fruit, roots, young shoot	i) A paste of the roots are applied externally to treat wounds. ii) Juice of the root is taken to treat gastric, fever and dysentery.
<i>Rubus niveus</i> Thunb.	Inmin-Tayin	Rosaceae	Dysentery	Fruits, roots	i) The juice of fruits and the roots are taken for the treatment of dysentery.
<i>Saurauia roxburghii</i> Wall.	Taan	Actinidiaceae	Fever, boils	Leaves, Bark	i) Decoction of bark is orally given for fever. ii) Infusion of leaves is used to treat boils.
<i>Syzygium cumini</i> Lam.	Jongkeng	Myrtaceae	Dysentery, diarrhoea,	Bark	i) Decoction of bark is used to treat dysentery.
<i>Spondias pinnata</i> Kurz	Belum/Dorgeng	Anacardiaceae	Cough, joints pain, diarrhoea, sour throat	Leaves, fruits, bark	i) Paste of the bark is used externally in joints pain. ii) Decoction of bark is given in severe cough. iii) Unripe fruits are consumed for sour throat. iv) Juice of leaves are

					used for common cough remedy, diarrhoea etc.
<i>Sterculia lanceifolia</i> Roxb	Aanggom-Bayom	Malvaceae	Fever	Pod	i) The pod decoction is given to cure fever.
<i>Trichosanthes dunniana</i> Levl.	Pak-Sung gal	Cucurbitaceae	Wound, Diarrhoea	Fruits	i) Fruit juice is extracted and drink to cure diarrhoea.
<i>Terminalia citrina</i> Roxb.ex	Hilika	Combretaceae	Fever, stomach aches, kidney problem	Seed, bark, fruits	i) Decoction of bark is taken orally for kidney problem. ii) Fruit is directly consumed for stomach-ache.
<i>Tamarindus indica</i> L.	Imli	Fabaceae Fabaceae	Cough, cold, asthma, Fever	Fruits, leaf, Bark	i) Decoction of bark is used for asthma. ii) The decoction of leaves is used against cough, fever. iii) Leaves are make paste and applied externally for joint pains.
<i>Zanthoxylum rhetsa</i> (Roxb) DC.	Onger	Rutaceae	Wart, jaundice, stomach pain, snake bite, asthma, toothache	Bark, leaves, seeds, fruits	i) Bark pounded and mixed with oil, used externally as remedy for stomach pains. ii) Leaves are boiled for the treatment of jaundice and warts.

					<p>iii) Bark are chewed and applied to snakes bites.</p> <p>iv) The paste of seed are used to treat asthma, toothache.</p>
<i>Zanthoxylum armatum</i> DC.	Ombey	Rutaceae	Cuts, wounds, stomach pain	Leaves, bark	<p>i) A paste of the leaves is applied externally to cuts and wound.</p> <p>ii) An infusion of the leaves is drunk to relieve stomach pains.</p>
<i>Ziziphus mauritiana</i> Lam.	Bogori	Rhamnaceae	Fever, old wounds, indigestion	Bark, root, fruits	<p>i) The roots are dried and make powder which is very effective in case of fever and old wounds.</p> <p>ii) Fruits are mixed with salt and chilli peppers fruits are consumed as a digestant.</p> <p>ii) Decoction of roots is also good for treatment for fever.</p>

The data regarding the uses of different parts of the wild fruits plants in the traditional healthcare system have been represented in Fig. 3. The Fig. reveals that among the different plant parts, the highest part used was leaf with 33 uses (35.48%), followed by fruits and bark 20(21.51%), root 10(10.75%), seed 7 (7.53%), latex 2(2.15%) and shoot with 1 use (1.08%).

The therapeutic classification of wild fruits of Arunachal Pradesh, north-east India are presented in Table 2. The data presented in the Table reveals that most of the wild fruits having ethno-medicinal uses in the traditional healthcare system of tribal people of Arunachal Pradesh, India. Among the different species studied in the present investigation, the maximum number of species were used in gastrointestinal disorders (31 spp.), followed by allergy (18 spp.), dermatological problem (7 spp.) respiratory ailments (7 spp.), minor ailments (5 spp.), cardiovascular disorders, mental and nervous disorders (4 spp. each), jaundice (3 spp.) ENT, anti-venom/ insect bite/sting/snake bite, bone disease, food poison (2 spp. each), and urogenital problems and cancers (1 sp. each)

Table 2:
Therapeutic Categorization of Wild edible fruits

Classes of disease	Fruits used
Dermatological problem	<i>Artocarpus heterophyllus, Ardisia crenata, Averrhoa carambola, Bischofia javanica, Castanopsis indica, Gynocardia odorata, Pandanus odoratissimus</i>
Gastrointestinal disorders	<i>Averrhoa carambola, Antidesma bunius, Bischofia javanica, Bauhinia variegata, Baccaurea ramiflora, Calamus tenuis, Castanopsis indica, Citrus grandis, Citrus medica, Citrus limon, Dillenia indica, Ficus auriculata, Ficus semicordata, Garcinia cowa, Melastoma malabathricum, Myrica esculenta, Mangifera sylvatica, Litsea cubeba, Livistona jenkinsiana, Leea indica, Passiflora edulis, Rhus chinensis, Rubus ellipticus, Rubus niveus, Syzygium cumini, Spondias pinnata, Trichosanthes dunniana, Terminalia citrina, Zanthoxylum rhetsa, Zanthoxylum armatum, Ziziphus mauritiana</i>
Cardiovascular disorders	<i>Castanopsis hystrix, Epipremnum pinnatum, Elaeagnus latifolia, Zanthoxylum rhetsa</i>
Respiratory problems	<i>Averrhoa carambola, Bischofia javanica, Canarium strictum, Litsea cubeba, Rhus chinensis, Tamarindus indica, Zanthoxylum rhetsa,</i>
Urogenital problem	<i>Terminalia citrina</i>
ENT diseases	<i>Ficus glomerata, Averrhoa carambola</i>
Antivenom/ Insect bite/Sting/ Snake bite.	<i>Canarium strictum, Zanthoxylum rhetsa</i>
Mental and Nervous disorders	<i>Bischofia javanica, Entada pursaetha, Ficus hirta, Tamarindus indica</i>
Minor ailments	<i>Antidesma bunius, Bischofia javanica, Bauhinia variegata, Baccaurea ramiflora, Castanopsis indica</i>
Bone diseases	<i>Epipremnum pinnatum, Leea indica</i>
Allergy	<i>Averrhoa carambola, Antidesma bunius, Bischofia javanica, Castanopsis indica, Canarium strictum, Dillenia indica, Entada pursaetha, Ficus auriculata, Ficus semicordata, Garcinia cowa, Morus alba, Maesa japonica, Leea indica, Phoebe coperiana, Rhus chinensis, Suarauia roxburghii, Tamarindus indica, Ziziphus mauritiana</i>
Cancer	<i>Melastoma malabathricum</i>
Food Poison	<i>Citrus medica, Garcinia cowa</i>
Jaundice	<i>Gynocardia odorata</i>

Socio Economic Characterisation

Plants for timber, fodder and other miscellaneous purposes

Table 3 reveals the data regarding the socio-economic uses of wild fruits of Arunachal Pradesh, north-east India for constructional timber, firewood, charcoal and fodder. In Arunachal Pradesh, north-east India most of the houses in the villages are made of with woods and each household depends on trees available in the forests or home gardens to construct their houses. Some of the wild fruits trees produce very good timbers for construction of houses. in the villages. Among the different species of fruits, *Phoebe cooperiana* produce best quality timber. In addition, timbers of *Castanopsis hystrix*, *Syzygium cumini*, *Spondias pinnata* and *Terminalia citrina* timbers were extensively use by the tribal people of the state. In addition, timbers made from *Saurauia roxburghii*, *Castanopsis indica* and *Canarium strictum* were moderately used by the rural people for constructional works.

In addition to use as constructional timbers as well as making furniture, in the rural villages which are far from the city, people still cook their daily foods as well as pig feed in the firewood. Since each and every family have a good number of pigs so they need a sufficient quantity of firewood every day to prepare pig feed. In the villages, they consume significant quantity of firewood (4,000 – 6,000 kg/family/year). During the day time, the men and women goes to nearby forests and their home gardens to collect the firewood. In addition to the other forest trees, wild fruits are also very good source of firewood. Fruits like *Castanopsis hystrix*, *Castanopsis indica* and *Saurauia roxburghii* produced best quality firewood. In addition, *Bischofia javanica* and *Syzygium cumini* also produce very good quality firewoods extensively used by the rural people of Arunachal Pradesh.

In Arunachal Pradesh, north-east India, the livelihood of rural rural people still depends on domestic animals. Each and every households have different types of domestic animals including cow and goat. All these animals need fodder every day. Average fodder need per family varies from 5,000-8,000 kg per year and these fodders come from agricultural fields, agroforestry trees and agricultural by-products. The leaves of wild fruits serves the purpose of fodder need needs of each family. *Artocarpus heterophyllus*, *Ficus auriculata* and *Ficus semicordata* were very good fodder for these domestic animals.

In the rural areas of Arunachal Pradesh, people still use charcoals for different purposes like for cooking and other needs. Some families even earn their livelihood by selling the charcoals prepared from different trees. Some of the wild fruits produce very good source of charcoals. Fruit trees like *Tamarindus indica*, *Syzygium cuminii*, *Castanopsis hystrix*, *Castanopsis indica* produce best quality charcoals used by the rural people for various purposes.

Table 3:

Wild edible fruits tree species used as for Constructional timbers (CT), Firewood (FW), Charcoal (C) and Fodder (F) in Arunachal Pradesh.

Plant species	Family	Local name	CT	FW	C	F
<i>Artocarpus heterophyllus</i> Lam.	Moraceae	Belang	+	++	+	++++
<i>Antidesma bunius</i> (L) spreng.	Phyllanthaceae	Kompong – Perong	-	++	-	+
<i>Bischofia javanica</i> Blume.	Phyllanthaceae	Sitiil	+	+++	+	-
<i>Bauhinia variegata</i> L.	Fabaceae	Ogok	-	++	-	-
<i>Baccaurea ramiflora</i> Lour.	Phyllanthaceae	Bureng	-	+	-	+
<i>Castanopsis hystrix</i> Hook. f. & Thompson ex A.DC.	Fagaceae	Sirang-Raaye	++	++++	++++	-
<i>Castanopsis indica</i> Roxb	Fagaceae	Koyu-Korang	++	++++	++++	-
<i>Canarium strictum</i> Roxb	Burseraceae	Hilum/Tiikok	++	+	+	-
<i>Dillenia indica</i> L.	Dilleniaceae	Sompa	+	++	+	-
<i>Elaeocarpus floribundus</i> Blume.	Elaeocarpaceae	Jolpai	-	++	+	-
<i>Ficus auriculata</i> Lour.	Moraceae	Tapang	-	+	+	++++
<i>Ficus semicordata</i> Buch-Ham.	Moraceae	Takuk	-	+	+	++++
<i>Gynocardia odorata</i> Roxb	Achariaceae	Sibeng-Tulpil	-	+	+	-
<i>Phoebe cooperiana</i> PC Kanjilal and Das.	Lauraceae	Tapil	++++	++	++	-
<i>Saurauia roxburghii</i> Wall.	Actinidiaceae	Taan	+++	++++	+++	-
<i>Syzygium cumini</i> Lam.	Myrtaceae	Jongkeng	+++	+++	++++	-
<i>Spondias pinnata</i> (L.f) Kurz	Anacardiaceae	Belum/Dorgeng	+++	++	++	-
<i>Sterculia lanceifolia</i> Roxb	Malvaceae	Aanggom-Bayom	+	++	+	-
<i>Terminalia citrina</i> Roxb.ex	Combretaceae	Hilika	+++	++	++	-
<i>Tamarindus indica</i> L.	Fabaceae	Imli	-	++	++	-
<i>Ziziphus mauritiana</i> Lam.	Rhamnaceae	Bogori	-	++	++	-
*+=Fairly used; ++= Moderately used; +++= Extensively used; ++++= Best quality and - = Not used.						

Plants for fish-poisoning

Arunachal Pradesh is a state which is criss-crossed by numerous rivers, riverine and streams. Most of the villagers in the rural areas generate their income by selling the fishes collected from the rivers. A good number of wild fruits have been used by the rural people to catch fishes (Table 4). The freshly crushed or powered plant component is put into the running streams and the toxic chemicals present in the plant kills the fishes present in the rivers. The quantity of plant material applied vary from species to species. Fruit species like *Gynocardia odorata*, *Myrica esculenta* and *Zanthoxylum rhetsa* were extensively used as fish poison. These species are mainly used to catch the small sized fishes in the rivers as well as small streams and ponds. It is reported that the chemicals present in the fruits affect the respiratory system of fishes [14], however, there is no report available on the effect of such poisoning on flesh quality of fish.

Table 4:
Wild fruits used for Fish poisoning in Arunachal Pradesh.

Plant species	Family	Local name	Part used
<i>Gynocardia odorata</i> Roxb	Achariaceae	Sibeng-Tulpai	Fruit
<i>Myrica esculenta</i> Buch-Ham.	Myricaceae	Ketir	Bark
<i>Zanthoxylum rhetsa</i> (Roxb) DC.	Rutaceae	Onger	Bark, leaves

Wild fruits for making dyes

The handicraft industry of Arunachal Pradesh, north-east India is very rich. The rural people mostly prepared these handicrafts by using the locally available materials. Some wild fruits of Arunachal Pradesh are also used for making dyes used in the local handicraft industries to colour the traditional dresses of men and women (Table 5). Colour of such dyes has no bad effects on health and is long lasting. Wild fruits like *Baccurea ramiflora*, *Bischofia javanica*, *Garcinia cowa*, *Myrica esculenta* and *Ziziphus mauritiana* produce very good quality dyes used by the rural people to make dyes in handicraft industry.

Table 5:
Wild plant species used as dyes in Arunachal Pradesh

Plant species	Family	Local name	Part used
<i>Baccurea ramiflora</i> Lour.	Phyllantaceae	Bureng	Bark, Leaves
<i>Bischofia javanica</i> Blume.	Phyllanthaceae	Sitiil	Bark
<i>Garcinia cowa</i> Roxb	Clusiaceae	Tabi-Tarak	Bark
<i>Myrica esculenta</i> Buch-Ham.	Myricaceae Ketir	Ketir	Bark
<i>Ziziphus mauritiana</i> Lam.	Rhamnaceae	Bogori	Bark

Wild fruits and their value added products

The wild fruits bear extensively large number of fruits in the trees and most of the household have 2-3 trees of wild fruits. Because of this reason, during the peak season of fruiting, the wild fruits available in glut in the villages. Additionally, due to less market demand as raw fruits, most of them spoiled during their fruiting season. To get rid of this problem, a number of value added products can be prepared from these fruits and thus can save these fruits from spoilage and additionally the farmer can earn extra income. Table 6 represents the various value added products prepared from the wild fruits of Arunachal Pradesh.

Table 6:
Locally prepared value added products in Arunachal Pradesh

Food/Beverages	Plant species	Local name	Part used	Preparation.
Pickle	<i>Artocarpus heterophyllus</i> Lam.	Belang	Fruit	Unripe fruits are slice into pieces and mixed with spices, oil and vinegar
Pickle	<i>Dillenia indica</i> L.	Sibeng-Tulpi	Fruit	Ripe or unripe fruits are slices into pieces and mixed with spices, oil and vinegar.
Pickle	<i>Elaeocarpus floribundus</i> Blume.	Jolpai	Fruit	Fruits are cut into pieces and mixed with spices, oil and vinegar.
Pickle	<i>Mangifera sylvatica</i> Roxb	Moonam-Tagung	Fruit	Unripe fruits are slice into pieces and mixed with spices, oil and vinegar
Pickle	<i>Emblica officinalis</i> G.	Amloki	Fruit	Fruits are boiled, dried and mixed with spices, oil and vinegar.
Pickle	<i>Ziziphus mauritiana</i> Lam.	Bogori	Fruit	Ripe fruits are boiled and mixed with spices, oil and vinegar.
Pickle	<i>Tamarindus indica</i> L.	Imli	Fruit	Unripe pods are mixed with spices, oil and vinegar.
Wine	<i>Bischofia javanica</i> Blume.	Sitiil	Fruit	Fruit are mixed with sugar and kept in airtight container and fermented for 1 months.

Miscellaneous uses of wild edible fruits

Table 7 depicts that most of the wild fruits have miscellaneous uses. The rural people uses different plant parts of these fruits in their day to day life for various purposes. Leaves of *Livistona jenkinsiana* are used in making of roof of the houses which is a good replacement of thatch. Similarly, leaves of *Saurauia roxburghii* are used in some local ritual purposes. Wood of *Phoebe cooperiana* and *Artocarpus heterophyllus* are being used for making homemade furnitures. *Phoebe cooperiana* are used to make wooden containers which are generally used for feeding of pigs and cows.

Table 7:
Some wild plants of miscellaneous use in Arunachal Pradesh.

Plant species	Family	Local name	Uses
<i>Livistona jenkinsiana</i> Griff.	Arecaceae	Taek	Leaves for making roof of home
<i>Saurauia roxburghii</i>	Actinidiaceae	Taan	Leaves for ritual purpose
<i>Artocarpus heterophyllus</i> Lam.	Moraceae	Belang	Wood used for making furniture
<i>Phoebe cooperiana</i> PC Kanjilal and Das.	Lauraceae	Tapil	Wood used for furniture and containers

Marketing status of wilds

In Arunachal Pradesh, north-east India, among 3-4 villages there is one local market or rural hat. The rural people sell and buy their paddy, home garden produces and other essential needs in these markets. Most of these hats are weekly. Observations are being taken five important local markets (hats) at East Siang and Upper Siang district to know the availability, market price and consumption pattern of wild edible species (Table 8). Weekly survey revealed the simultaneous availability of an individual species in the two markets, however, market prices varied at both the markets. In general, the wild fruits are collected by the rural men and women one day before the market day from the forests as well as from home gardens and bring them to market by themselves or sold through some middlemen. Most of the fruits have good demand in the rural hats which people buy either to consume them as raw or to produce value added products. The availability of these fruits vary from fruits to fruits and their market price also vary from Rs. 20/- to 40/-per Kg depending upon the type of the fruits. Interview with the shop owners revealed that the availability of the wild fruits decreased as compared to previous years.

Table 8:
Some wild edible fruits available in the weekly markets

Plant species	Local name	Time of availability	Price/kg
<i>Artocarpus heterophyllus</i> Lam.	Belang	June-Sep	Rs.20/-
<i>Averrhoa carambola</i> L.	Tador	Nov-Jan	Rs. 40/-
<i>Baccaurea ramiflora</i> Lour.	Bureng	June-Aug	Rs.30/-
<i>Canarium strictum</i> Roxb	Hilum/Tiikok	Nov-Jan	Rs.40/-
<i>Citrus grandis</i> (L.)	Rebab	June-Dec	Rs. 20/-
<i>Citrus medica</i> L	Sipa-yegra	June-Sep	Rs. 20/-
<i>Citrus limon</i> Burm.f	Singkom	July-Aug	Rs. 20/-
<i>Dillenia indica</i> L.	Sompa	July-Aug	Rs. 20/-
<i>Elaeagnus latifolia</i> L.	Raapgam	Jan-May	Rs.30/-
<i>Emblica officinalis</i> G.	Amloki	Aug-Dec	Rs. 40/-
<i>Elaeocarpus floribundus</i> Blume.	Jolpai	June-Nov	Rs. 40/-
<i>Garcinia cowa</i> Roxb	Tabi-Tarak	May-June	Rs. 40/-
<i>Myrica esculenta</i> Buch.-Ham	Ketir	May-Aug	Rs. 40/-
<i>Mangifera sylvatica</i> Roxb	Moonam-Tagung	May-June	Rs. 30/-
<i>Passiflora edulis</i> Sims.	Marsang – Riyyong	August-December	Rs. 40/-
<i>Syzygium cumini</i> Lam.	Jongkeng	April-July	Rs. 20/-
<i>Tamarindus indica</i> L.	Imli	July-December	Rs. 40/-
<i>Ziziphus mauritiana</i> Lam.	Bogori	Dec-Feb	Rs. 20/-

Discussions

Wild edibles are collected from the natural forests in the form of fruits, leaves, stems, roots, etc., and these plants still share a good proportion of tribal diets throughout the world [15-16]. Traditionally these species have been meeting the nutritional requirement of the local inhabitants [17]. In north-east India, a major portion of population depends upon a number of plants for their survival. They depend on the wild edibles as a source of ethno- medicines as well as use in their socio- economic life like construction of houses, fuel wood, as well as miscellaneous uses [18].

In the present investigation, altogether 50 wild edible fruits belonging to 31 families having medicinal values were reported. Among the different families, Moraceae and Rutaceae were the dominant with 5 species, followed by Phyllanthaceae, Anacardiaceae and Rosaceae, Arecaceae, Fabaceae, Lauraceae,

Primulaceae and Fagaceae. In terms of parts used, the highest used was leaves (35.58 %), followed by fruits and bark (21.51%), root (10.73 %), seed (7.53 %), latex (2.15%) and shoot (1.07%). Therapeutically, the reported wild edible fruits are used against 14 classes of diseases. Our present study is in close conformity with the previous studies in Arunachal Pradesh where the researchers proved that a number of plants of the state have been used as ethno-medicine by the tribal people of the state [19].

In Arunachal Pradesh, India, the tribal people use the wild fruits to sustain rural livelihood in the socio-economic life of rural people. They use these fruits for constructional timbers, firewood, charcoal, fodder, fish poisoning, dyes, etc. A number of previous studies also in the same line of our study where they reported that a number of wild edible fruits of north-east India have been used for constructional timber, firewood, charcoal, fodder and many other miscellaneous purposes [20-21]. In addition, most of the wild edible fruits have been used in the socio-economic life of rural people of north-east India like fish poisoning, dyes, oils, fermented products like pickles, and other miscellaneous uses [22].

The local inhabitants of Arunachal Pradesh, India, consume a large number of wild edible fruits as important parts of their diets. Most of the species were used for their fruits, seeds, leaves, shoots, flowers, and roots or rhizomes. Similar ratios and trends of usage for different plant parts are reported for the country of India [23, 1]. The tribal people of the state collect these wild edible fruits from primary and secondary forests and most of these fruits are sold in the local markets or huts. These wild fruits, therefore, are helpful in alleviating a subsistence economy [17]. In addition to use as a source of medicine, a number of these species are also processed into value added products, which reduce the spoilage of these fruits during the on season and can be stored for use in a lean period also helps the farmers to maximise their income [24]. Consumption of wild plants provides substantial nutritional dietary benefits to tribal populations of remote areas. Some wild edible plants are rich in nutrient content, and may even be superior to cultivated ones in this respect [25]. A varied diet of wild edible plants may also increase one's sense of food palatability, which in turn may lead to an increase in food intake [26-27]. Due to the inaccessibility of many regions, wild plants can serve as an important supplement to conventional, domesticated crops.

The population density of these wild species is progressively decreasing and their natural regeneration is often poor in natural habitats due to intense biotic and abiotic pressure. The pressure is further aggravated, as they are collected freely in large quantity from the backyard/forest for selling in the markets and used as fuel wood. Such uncontrolled exploitation of these naturally occurring wild genetic resources has led them to become rare to very rare and many may become extinct in near future. Furthermore, this may lead to narrowing the genetic diversity and variability of these wild species. With the ever increasing population, there is a great need to popularize and conserve these genetic resources in order to meet the future demand for human food, nutrition, medicine, and gene(s) sources for adapting to climate change.

Utilization of wild edible plants will be an effective tool for restoration of traditional knowledge system inherent in tribal people. This can easily be achieved in the government launches programme involving

local community on care and share basis for conservation of genetic resources of wild edible fruits. The necessary steps should also be taken for cultivation of important wild edibles in agro forestry system. Undoubtedly, the traditional wisdom of controlled exploitation will constitute the traditional heritage of the people of Arunachal Pradesh, India. There is an ample scope for studies on regeneration behaviour, population structure and status of such biological resources. The studies on phonological characteristics of different species must be given due importance. The outcome of such studies will be useful in determining appropriate conservation strategy.

Conclusion

North- east region of India is a treasure trove for wild edible fruit crops in India. Wild fruit species of in Northeast India have diverse social, economic and scientific importance. To safeguard the existing genetic diversity of these valuable species sincere *in situ* conservation efforts are urgently required. Dynamic conservation and preservation of associated indigenous knowledge among local tribal and farmer communities can be carried out through policy interventions, implementation of farmers rights and generating awareness among the local people. Proper strategies must be frame out for their conservation and utilization. Researchers, scientists' farmers, and the entrepreneurs should work together to make these valuable species as commercial crops for future. Then only food, nutritional and livelihood security among the rural people may be achieved. Bio prospecting of these valuable genotypes would further enhance the possibilities of utilizing rare genes to mitigate the challenges of climate change and biological stresses. Value addition and product development will help to conserve these species and thus conserve them along with associated traditional knowledge.

Declarations

Ethics approval and consent to participate

The authors declare that there is no conflict of interest in whatsoever.

Prior oral consent was obtained from the interviewed people.

Consent for publication

Not applicable.

Availability of data and material

The datasets used and/or analysed during the current study are available in the University.

Competing interests

The authors declare that they don't have competing interests

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Authors' contributions

BT conducted the survey, personal interview and collected the data. TKH compiled the data, did the literature survey and wrote the manuscript.

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Figures

Figure 1

Map of study area

Figure 2

Family wise representation of wild edible fruits of Arunachal Pradesh, India

Figure 3

Parts used Percentage of wild edible fruits