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Diversity of medicinal wild fruits in the Lower Subansiri district of Arunachal Pradesh in Northeast India

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ABSTRACT

A study of wild edible fruits and the threats to them was conducted in Lower Subansiri, Arunachal Pradesh, India. The objective was to identify and document wild edible fruit plants, the associated ethnobotanical knowledge of the local people and the threats that exist to these plants. Ethnobotanical data on wild edible fruits were collected using a guided methodology, questionnaire and field observations. The information was verified by cross-checking it among the informants. Descriptive statistics and pairwise ranking of threat factors were employed to gather the ethnobotanical data. We documented 33 lesser-known edible wild fruit species, distributed in 23 genera and 14 families. The common families that encompass more wild edible fruit species were Rosaceae (ten species), followed by Actinidiaceae (four species), Fagaceae (three species), Anacardiaceae and Moraceae which contributed two species each. Within the dominant families, the species richness shows a significant positive correlation ($r(5) = 0.94$, $p < 0.01$) with the number of genera. The study reveals wild fruits as palliatives for certain ailments and as a food supplement. Some of these fruits are under the "IUCN Red List of Threatened Species", as "Endangered" and "Least Concern" categories, which the informants claimed, is due to the increased anthropogenic pressure.

Key words: Household Consumption, Medicinal Importance, Relative Frequency of Citation, Use Value, Wild Fruits

INTRODUCTION

Fruits are one of the good sources of vitamins, minerals, and fibers. Since the time immemorial many fruits were grown wild in the Lower Subansiri district of Arunachal Pradesh. These fruits have been an important part of the dietary supplement of the local people. Some of the wild fruit plants have even become an important part of the culture in some indigenous people's tradition and are known to be effective against certain diseases thus getting popular and commercialised into various products (Prakash *et al.,* 2012). The diversity of wild fruits is due to the diverse climatic conditions largely influenced by the nature of terrains depending upon its altitude and location of the place. Several of such wild fruits such as *Actinidia deliciosa*, *Pyrus communis*, *Prunus cerasoides*, *P. salicina* and *Docynia indica* etc. are used in making alcoholic beverages for household consumption. Many of them are associated with social believes such as *Mahonia nepalensis*, *Prunus persica* and *Quercus* sp., constitute important trees of sacred grooves in Ziro and the consumption of these fruits was forbidden with the belief that deity resides in them. During the days of "Myoko" festival, these grooves are visited by the clans to apply rice powder paste to their stem as an offering and seek to protect them from ill-health. *Ficus semicordata* fruits are forbidden to be consumed by women as they are believed to have contraceptive property. Besides, fruits like *Docynia indica* are also used in making candies and against loose motion. Though consumed by the locals, many of the wild fruits were not fully exploited in the local markets. With time, a dramatic shift in the human food supply occurred with the advent of the agricultural revolution (Grivetti, 1980). Moreover, urbanisation leads to significant changes in the dietary habits of the people, which is reflected in the increased intake of fewer domesticated staple plants, and decreasing the wild varieties from the diet that once sustained health and nutrition (Grivetti, 1981). Dietary habits limited to a few domesticated species also poses two significant problems; i) Malnutrition and deficiency disease ii) A decline in knowledge about wild fruit plants and how to use them (Grivetti & Ogle, 2000). Limited reports have been recorded about wild edible fruits of medicinal importance used by the Apatanis of Arunachal Pradesh. Therefore, the present study aims at documenting and preserving the indigenous wild fruit plants used for food supplement and medicine by the Apatanis of Lower Subansiri district of Arunachal Pradesh.

MATERIALS AND METHODS

Study site

The field investigation was conducted extensively in the jungles, grasslands, sacred groves and the hilly areas of Lower Subansiri district, Arunachal Pradesh from June 2017 – May 2019, and encompassed different

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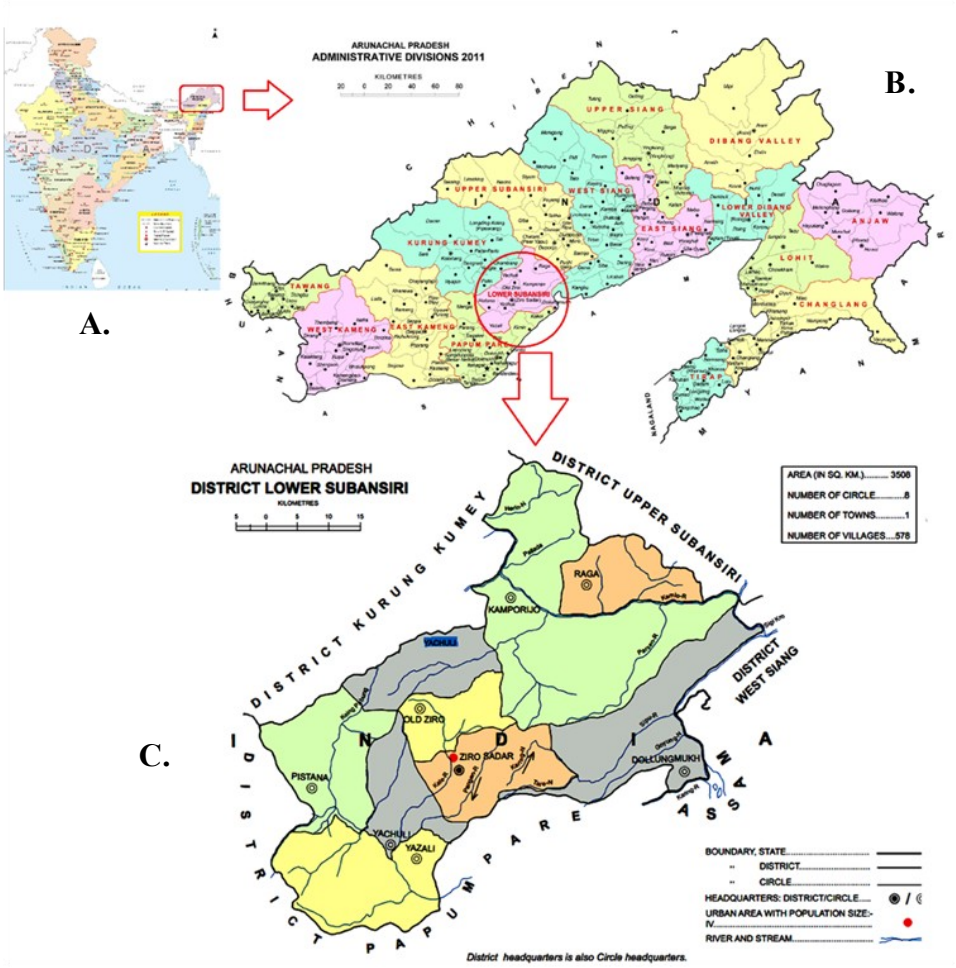

Figure 1. Map showing the location of Lower Subansiri, Arunachal Pradesh. (A): Map of India (showing the location of Arunachal Pradesh); (B): Map of Arunachal Pradesh (one of the states of India); (C): Map of the study site, Lower Subansiri (one of the districts of Arunachal Pradesh.

seasonal wild fruit plants. The study site, Lower Subansiri district of Arunachal Pradesh, has a population of 83,030, in 652 villages, with a population density of 42 individuals per sq. km. (Census, 2011). The district covers an area of 3508 km^2 within the geographical coordinates of 26°55' and 28°21' N and92°40' and 94°21' E, at an altitude of 1500 to 2750 m above sea level, bordered by West Siang and part of Upper Subansiri in the east, Kurung-Kumey and Upper Subansiri districts in the north, Papum Pare district of Arunachal Pradesh and Assam in the south and portions of Kurung-Kumey and Papumpare districts in the west (Figure 1). The district is dominated by the Apatani, one of the 26 major tribes and 100 subtribes of the state. They belong to the Tibeto-Mongoloid stock and trace their descent from one legendary ancestor, the Abotani. The Apatani believed in the indigenous religion called 'Donyi-Polo' and are patriarchal in the social system. Earlier, they make facial tattoos to distinguish themselves from other communities settled nearby. However, the practice of tattooing has been discouraged in the recent past and now is on the verge of extinction. Apatani acquired indigenous knowledge of forest resources that they depend on for food, medicine, and shelter during normal and hard times. A humid sub-tropical to the temperate type of climate and an average Maximum and minimum of 29°C and 5°C with 927.9mm average rainfall (Census, 2011) have shaped the two major vegetation types in and around the study area namely i) sub-tropical forests and ii) temperate forests.

Plant specimen collection and identification

For ethical reasons, ethnobotanical data were collected with the prior approval and permission of the local administrator (Village Head) and the informants regarding the publication of the research. Good specimens (with flowers and/or fruits) of all the wild edible fruit plants were collected and subjected to chemical sterilisation and processed for herbarium voucher specimen preparation following Jain & Rao (1977) and Das (2018). The specimens were identified using available literature (Hooker 1972 – 1897; Kanjilal *et al.* 1934 – 1940; Chowdhery *et al.* 2009) and e-floras. For updated nomenclature www.theplantlist.org and www.worldfloraonline.org were consulted and APG-IV (APG, 2016) system of classification was followed for family delimitation. The information was also captured in photographs of the sites, individual plants, and their edible fruits. Voucher specimens were deposited in the Herbarium of the Rajiv Gandhi University after the study is over.

Table 1. Distribution of wild fruits species of medicinal importance according to their genus and families.

Family	No. of Genus	No. of Species	%age of contribution	Family	No. of Genus	No. of Species	%age of contribution
Rosaceae	6	10	31.25	Berberidaceae	1	1	3.12
Actinidiaceae	2	4	12.5	Ebenaceae	1	1	3.12
Fagaceae	2	3	9.37	Melastomataceae	1	1	3.12
Musaceae	1	3	9.37	Myricaceae	1	1	3.12
Cucurbitaceae	2	2	6.25	Oxalidaceae	1	1	3.12
Anacardiaceae	2	2	6.25	Liliaceae	1	1	3.12
Moraceae	1	2	6.25	Compataceae	1	1	3.12

Data collection

Along with the specimen collection, the field activities carried out also included taking notes on the wild fruit plants and associated indigenous therapeutic knowledge. The objective of the study was clearly explained to the participants. The indigenous therapeutic knowledge of the wild fruits was recorded following interview of informants using a questionnaire containing prior informed consent (PIC) signed by them. The informants of age group from 30 to 70 years were interviewed to record on the local household consumption of wild fruits as food and medicinal.

Validation and Reliability of the data

The report was validated by crosschecking and taking consensus among the informants which comprises of different age groups. The quantitative indices such as frequency of citation (FC), the relative frequency of citation (RFC) and the use-value (UV) were also applied.

The Frequency of citation (FC) = The number of informants reporting the use of a particular species.

The Relative frequency of citation (RFC) was determined by using the following formula (Vijayakumar *et al*., 2015).

$$RFC = \frac{FC}{N}$$

Where FC is the number of informants reporting the use of a particular species and N is the total number of informants.

Use-value index. The use-value was calculated using the following formula (Vijayakumar *et al*., 2015).

$$UV = \frac{\sum Ui}{N}$$

Where Ui is the number of uses for a given species informed by each respondent and N represents the total number of respondents.

RESULTS AND DISCUSSION

Family contribution and habit of ethnomedicinal flora

Wild edible fruits are collected from the forest by the Apatani to supplement the family nutritional requirements. Their immediate dependence on nature had developed their knowledge which ultimately is reflected in their traditional culture, religion, local belief, folklore, taboos language and dialects. Altogether 33 edible wild fruit plants of medicinal importance belonging to 23 genera and 14 families are reported (Table 1). Rosaceae (10 species) is the dominant wild fruit family of the study area followed by Actinidiaceae (4 species), Fagaceae and Musaceae (3 species each). The remaining families contribute ≤2 species of wild fruits in the study area. Within the dominating families, there was a significant positive correlation ($r(5) = 0.94$, $p < 0.01$) between the number of genera and number of wild fruit species used as medicine by the Apatani (Figure 2). The dominance of these families in the area could be because of their relative abundance and easy availability to the local people enriching their knowledge about these plants. However, ethnomedicinal report on lesser-known wild fruits from this area has not been reported so far. Hence, this is the first report exclusively on lesser-known wild medicinal fruits from this region.

Most of the identified wild fruits in the study area reported to utilise as a food supplement in various ways. They are also reported to treat Gastrointestinal, parasitic and hepatobiliary problems, followed by others (fever, tonic, cold, tumours) and external injuries and bleeding (Tables 2). The wild fruits of the district are dominated by trees (52%) followed by shrubs (30%), climbers (15%) and herbs (3%) (Figure 3).

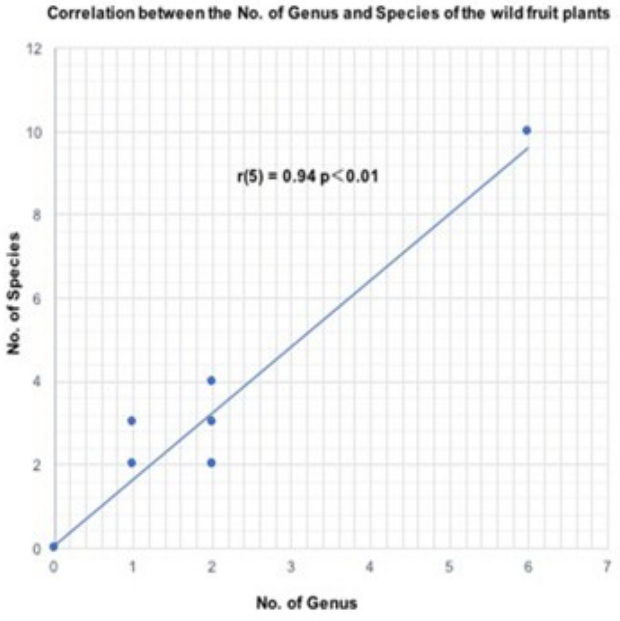

Figure 2. The relationship between genera and species richness of wild fruits used by the Apatani of Lower Subansiri district of Arunachal Pradesh.

Table 2. Major ailments cured by the Apatani tribes of East Siang using the wild fruit species.

Disease Categories	Symptoms	Number of plants used
Gastro-intestinal, parasitic and hepatobiliary	Liver and bile diseases, jaundice, dysentery, loss of appetite, improve digestion, stomach ache, constipation, diarrhea, laxative	31
Other (fever, tonic, cold, tumors)	Tonic (immune booster), cancer, tumors, fevers, colds, drought tolerant	21
External injuries and bleeding	Swellings, wounds, rheumatism, inflammations, Joints pain, pain, cuts and wounds, body inflammation, bone fracture, back pain, bleeding	10
Urogenital and venereal	Urinary problems, menorrhagia, miscarriage, childbirth, abortion, profuse menstruation, irregular menstruation, kidney stones	8
Dermatological	Skin problems, itching, and allergy, skin whitener, antimicrobial, antibacterial	5
Diabetes	Diabetes	4
Pulmonary disease	Respiratory problem, spasmodic, cough	3
Oral, dental, Hair and ENT	A toothache, flue and cough, headache, dry lips	3
Musculoskeletal and nervous system	Stiffness of limbs (cramps), astringent	2
Blood and lymphatic system	Hypertension	1
Antidote	Bee sting	1
Food supplementation	Use ofvarious forms (wine/beverages, fresh food, juice and dry pickles)	33

Plant part(s) used

In the present study, the most commonly used part of wild fruits for medicine was fruits (100%), followed by barks and stems (15.15% each), leaves (12.12%), roots (0.06%) and rhizomes (0.03%) (Figure 4).

It is thought that wild fruits contain more easily extractable phytochemicals, crude drugs and many other mixtures which may be proven as valuable in phytotherapy (Elisa *et al*., 2015). Besides fruits, leaves and roots are also favoured parts in many cases possibly because they also contain higher concentrations of bioactive compounds than other plan parts (Savikin *et al*., 2013). In many cases, the same plant parts are used to treat different diseases, for example, the fruits of *Diospyros kaki, Melastoma malabathricum* are used for the treatment of high blood pressure, cancer and constipation, in dry lips, wound healing and toothache etc. (presented in Table 3).

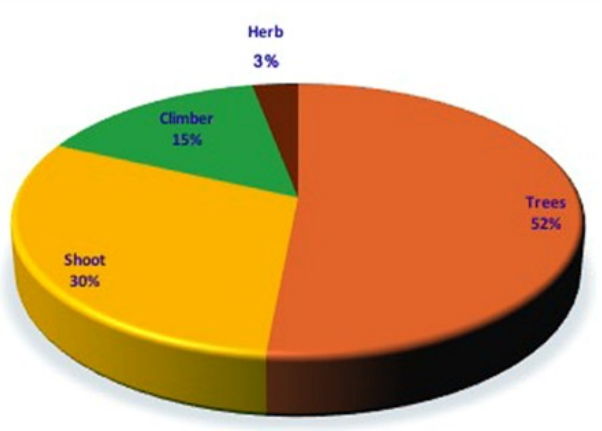

Figure 3. Growth forms of the recorded wild medicinal fruit plants.

Method of preparation and administration

Fruit juice of all the 33 species was used in medicine, food supplementation, and beverage preparation. The various plant parts such as leaf, stem and bark were mostly used in decoctions (14 species) and roots and rhizome in decoction or infusion (3 species) during herbal preparations. Decoctions are often found to be one of the major forms of preparation in ethnobotanical practice as they are easy to prepare by mixing with water, tea or soup (El *et al*., 2015). The most frequent use of decoction might also be because heating can cause acceleration of biological reactions resulting in the increased availability of many active compounds (Chen *et al*., 2008). The quantity and dosage of medicinal drugs are not fixed and differs with age, the state of health of the patient and the severity of the disease.

Relative frequency of citation and use value

The local importance of every species concerning the informants who cited uses of these plant species is shown by RFC (Vitalini *et al*., 2012). In the present study, RFC ranges from 1 to 0.25 (Table 3). *Actinidia deliciosa*, *Averrhoa carambola, Docynia indica*, *Ficus auriculata, Mahonia nepalensis, Melastoma malabathricum*, *Musa paradasiaca, M. sapientum, Myrica esculenta*, *Prunus salicina*, *Prunus ferganensis, Pyrus communis* and *Pyrus pashia* were the most cited ethnomedicinal wild fruit species. Thus, the unique abilities for curing different diseases have been known and well-established among the indigenous people. The relative frequency of citation could form an important research baseline in the selection of the promising plant and subsequent evaluation of plant-derived medicinal compounds, and drug

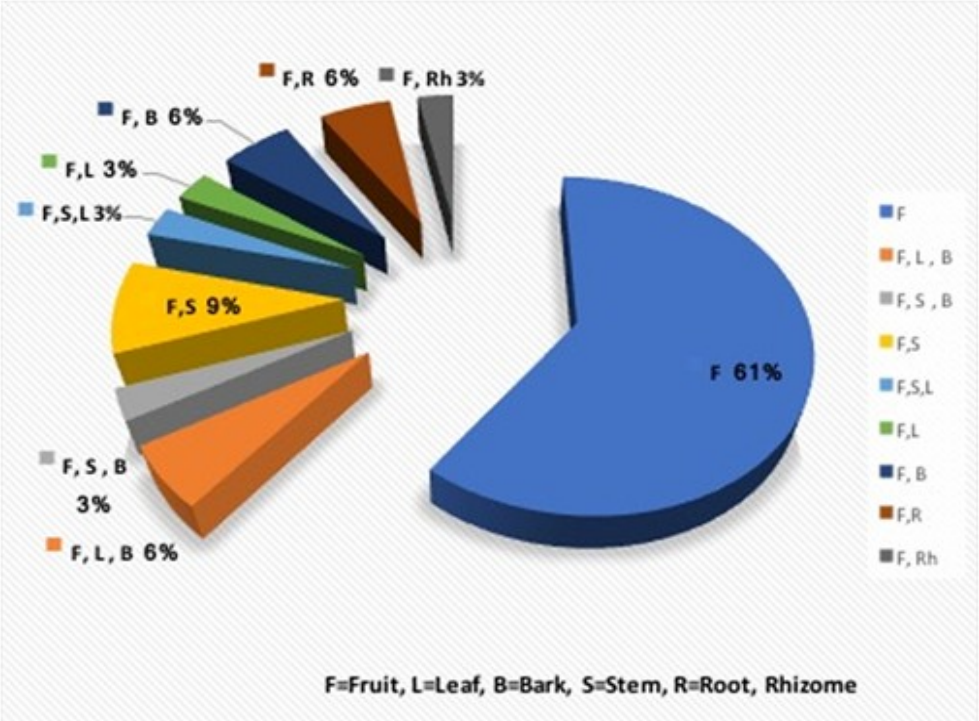

Figure 4. Plant parts used as medicine.

discoveries (Mukherjee, 2006). Species with high RFC values should be evaluated and authenticated for pharmacological and biological activities and work for the development of marketable products (Mukherjee *et al*., 2012). The use-value (UV) measures the level of application of a particular plant species. In the present study *Pyrus communis, Musa paradasiaca, Mahonia nepalensis, Melastoma malabathricum*, *Musa sapientum, Prunus salicina*, *Docynia indica*, *Actinidia deliciosa*, *Averrhoa carambola, Ficus auriculata, Myrica esculenta*, *Prunus ferganensis*, *Pyrus pashia, Terminalia chebula* and *Cerasus cerasoides,* were ascribed UV values of 2.25, 2.2, 2, 2, 2, 2, 1.95, 1.8, 1.5, 1.5, 1.5, 1.25, 1.25, 1.25 and 1.12 respectively. UV determines the extent to which a species can be used; thus, species with a high UV are more exploited in the study area to cure a particular ailment or to use as a food supplement than those with a low UV. It is found that plants having more use reports (UR) always have high UVs while those having fewer URs, reported by informants have lower UV. It is also observed that plants which are frequently used are more likely to be biologically active (Trotter & Logan, 1986). Plants with lower UV and RFC values are not necessarily unimportant, but their low values may indicate that the young people of the area are not aware of the uses of these plants and, therefore the understanding of their use is at risk of not being pass down to future generations, thus this knowledge may eventually disappear (Camou-Guerrero, *et al*., 2008). As the values for the UV and RFC are dynamic and change with location and with the knowledge of the people, so the values of UV and RFC may vary from area to area and even within the same area. Ethnomedicinally famous herb, *Paris polyphylla*, which is also enlisted as "vulnerable" under the IUCN Red List of Threatened Species is in our collection and is known to a few informants as the fruits are sometimes consumed. The RFC and UV of *P. polyphylla* is very low, however, the informants know about the plant as potential as the rhizome of the plant is exploited in huge amount and sold to Southeast Asian countries like China and Myanmar etc. despite the ban imposed by the local administration out of fear of its possible extinction (Pertin, 2016). This is the first quantitative ethnobotanical investigation exclusively on medicinal wild fruits carried out in this area; therefore, we compared our results with the few available similar studies on wild fruits carried out in other parts of the country (Chua-Barcelo, 2014). In a study carried out by Muhammad *et al*. (2015), in Swat valley of North Pakistan, the ethnomedicinal, edible wild fruit species used in the region was dominated by species (26%) of the Rosaceae family, mostly of tree growth (55%) similar to our result. However, the subsequent dominating families were different as Moraceae (12%) and Rhamnaceae (10%). This revealed that there were differences in most of the cited species and their quantitative values. The differences, however, may be due to variations in the climatic condition of these different geographical locations resulting in vegetational diversity.

Threats to wild plants and conservation status

Wild fruits have been facing threats in their natural habitat in the region from various human activities and the level of impact varies with the type of activity. To understand the factors more threatening to wild fruits, a pairwise ranking of the six most cited factors (undercultivation, human settlement, forest firing, infrastructure development projects, agricultural land expansion, & Firewood collection) were conducted through interviews with ten selected informants. Fifteen possible pairs were

Table 3. Wild fruit plants of the Medicinal importance of East Siang district, Arunachal Pradesh, India.

Sl. No.	Scientific name/ Habit/ Brochure no.	Family	Parts used	Local name	Location	Uses	FC	RFC	UV
1.	*Actinidia arguta* (Siebold & Zucc.) Planch. ex Miq./Cl/RGUHAVS001	Actinidiaceae	Fruit	Harkhu (Ap)	Ziro	Fruit is used as a food supplement. Fruit is used against menstrual disorder and liver complaints.	40	0.67	0.85
2.	*Actinidia callosa* L. /Cl/ RGUHAVS 002	Actinidiaceae	Fruit	Antitari (Ap)	Ziro	Fruit is used as a food supplement. Fruit is used against inflammation, abdominal pain, and fever.	40	0.67	0.9
3.	*Actinidia deliciosa* C.F. Liang & A.R. Ferguson/ Cl/ RGUHAVS003	Actinidiaceae	Fruit	Harkhu (Ap)	Ziro	Fruit is used as a food supplement and for wine preparation. Fruit is used in urinary stone, rheumatoid arthritis, and cancer.	60	1	1.8
4.	*Averrhoa carambola* L. Syn. *Averrhoaacutangula*Stokes, /Tr/ RGUHAVS004	Oxalidaceae	Fruit	Kordoi	Ziro	Fruit eaten raw also use as anti-jaundice, and as a hepatoprotective agent.	60	1	1.5
5.	*Cerasus cerasoides* (Buch. -Ham. ex D.Don) S.Y. Sokolov/Tr/ RGUHAVS005	Rosaceae	Fruit and bark	Sembo (Ap)	Ziro	Fruit is used as a food supplement. Fruit is used as an astringent; appetizer, the juice of the bark is applied externally to treat backaches.	52	from 0.87	1.12
6.	*Coccinia grandis* (L) Voight/Cl/RGUHAVS006	Cucurbitaceae	Fruit	Jojuru (Ap)	Ziro	Fruit is used as a vegetable and as a food supplement. Fruit is also used for diabetes and hepatopancreatic.	50	0.83	1.09
7.	*Diospyros kaki* L /Tr/ RGUHAVS008	Ebenaceae	Fruit	Moreh miiji (Ap)	Ziro	Fruit is used as a food supplement and used against high blood pressure, cancer and constipation.	52	0.87	0.98
8.	*Docynia indica* (Wall.) Decne. *(Syn = Cydoniaindic* (Wall.) Spach, *Docyniadelavayi*Rehder, *Pyrusindica*Wall., /Tr/ RGUHAVS009	Rosaceae	Fruit	Pecha (Ap)	Ziro	Fresh fruits are used as food supplement, also used for making pickle. The fruit juice is useful for stomach disorder and Diarrhea.	60	1	1.95
9.	*Ficus auriculata* Lour. /Tr/ RGUHAVS010	Moraceae	Fruit, leaf, bark	Takuk (N)	Joram	Fruit is edible as a food supplement, leaf as fodder, used as a laxative, to relieve bee sting and during diarrhea.	60	1	1.5
10.	*Ficus subulata* Blume. /Sh/ RGUHAVS011	Moraceae	Fruit	Siireh maloh (Ap)	Ziro	Fruit is used as a food supplement. Helps in breaks and sprain of body parts and in childbirth.	50	0.83	1.2
11.	*Fragaria nubicola* Lindl. / Hr/RGUHAVS012	Rosaceae	Fruit	Aki tayin (Ap)	Ziro	Edible fruit, treatment of cough, fever, and profuse menstruation	56	0.95	1.5
12.	*Lithocarpus pachyphillus* (Kurz) Rehder/Tr/ RGUHAVS013	Fagaceae	Fruit	Sankhe (Ap)	Ziro	Edible fruit, cure indigestion	15	0.25	0.3
13.	*Mahonia nepalensis* DC. ex Dippel / Sh/ RGUHAVS033	Berberidaceae	Fruit, bark, stem	Thaming (Ap)	Ziro	Edible fruit; bark useful for curing wounds, stem against itching, dysentery	57	0.95	2
14.	*Melastoma malabathricum* L. /Sh/ RGUHAVS015	Melastomataceae	Fruit	Dai dasa (N)	Joram	Edible fruit; fruit used in dying. Fruit used in dry lips, wound healing and toothache.	58	0.97	2
15.	*Musa paradasiaca* L. /Sh/ RGUHAVS016	Musaceae	Fruit, Stem	Kol	Ziro	Fruits and stems are taken as food. Unripe fruit are used to stop diarrhea, dysentery and diabetes.	60	1	2.2

Table 3 continued.

16.	*Musa sapientum* L. /Sh/ RGUHAVS017	Musaceae	Fruit, Stem, Leaf	Kol	Ziro	Fruits and stems are taken as food. Unripe fruit are used to stop diarrhea, dysentery, and diabetes, stem juice and leaves are applied over swollen feet and skin disorders.	60	1	1.15
17.	*Musa velutina* H. Wendl. &Drude */Sh/* RGUHAVS018	Musaceae	Fruit, stem	Kol	Ziro	Fruit is taken as a food. Juice of the stem and fruit are used in stomach ache and diarrhea.	40	0.67	0.95
18.	*Myrica esculenta* Buch-Ham. ex D. Don /Tr/ RGUHAVS018	Myricaceae	Fruit, Leaf, Bark	Baching (Ap)	Ziro	Fresh fruit is edible as a food supplement and used in making pickle. Fruit and bark are used in indigestion, skin disease, Jaundice. Leaf for headache.	59	0.98	1.5
19	*Paris polyphylla* Smith / Hr/RGUHAVS019	Liliaceae	Fruit, rhizome	Kala Katchu or Jungli Katchu	Talle valley	Fruit is eaten raw. Initially, never used as in the herbal treatment of ailments. Exploited and sold to neighboring countries, illegally, despite the ban by the govt. for its uses in brain tumor, snake bite and as aphrodisiacs, Analgesic, antipyretic, antispasmodic, antitussive, narcotics.	5	0.08	0.08
20.	*Prunus ferganensis* (Kost. & Rjab.) Y.Y. Yao/ Tr/RGUHAVS020	Rosaceae	Fruit	Takung (Ap)	Ziro	Fruit is used as a food supplement, stored in dark rice barn for future consumption; increases digestion (Appetizer). It is the wild version of peach and is tolerant to drought.	60	1	1.25
21.	*Prunus salicina* Lindl. /Tr/ RGUHAVS021	Rosaceae	Fruit	Palam (Ap)	Ziro	Fruit is used as a food supplement, for wine preparation, pickle. Acts as a laxative (cure constipation) and improves the immune system.	60	1	2
22.	*Pyrus communis* Lin. /Tr/ RGUHAVS022	Rosaceae	Fruit	Naspati (Ap)	Ziro	Fruit is used as a food supplement, for wine preparation, acts as an appetizer, immune booster, antibacterial, spasmodic, skin whitening agent.	60	1	2.25
23.	*Pyrus pashia* Buch. - Ham.ex D. Don /Tr/ RGUHAVS023	Rosaceae	Fruit	Piita-ahi (Ap)	Ziro	Fruit is used as a food supplement, against gastrointestinal, constipation and digestive problems.	58	0.97	1.25
24.	*Quercus* sp. /Tr/ RGUHAVS024	Fagaceae	Fruit, Stem	Kra ahi (Ap)	Ziro	Fruit is used as a food supplement. Trees for religious value for making altar (called agyanaye) in Apatani community.	25	0.42	0.5
25.	*Quercus spicata* Sm. (syn. *Lithocarpus elegans* (Blume) Hatus. ex Soepadmo.) /Tr/ RGUHAVS025	Fagaceae	Fruit	Tibeh (Ap)	Ziro	Fruit is used as a food supplement. Fruit is used to cure menstrual abnormality. Fruiting of the plant marks the presence of rodents.	28	0.47	0.55
26.	*Rhus semialata* Murray / Tr/RGUHAVS026	Anacardiaceae	Fruit	Taam ahi (N)	Yazali	Fruit is used as a food supplement, dried and taken with tea. Also used for diarrhea, Dysentery.	42	0.7	0.83
27.	*Rubus ellipticus* Sm. /Sh/ RGUHAVS027	Rosaceae	Fruit	Mipya jilyung (Ap)	Ziro	Fruit is used as a food supplement, used as laxative during constipation.	26	0.43	0.55
28.	*Rubus fairholmianus* Gardn. /Sh/RGUHAVS028	Rosaceae	Fruit, root	Mipya yoyu (Ap)	Ziro	Fruit is used as a food supplement, root is used for anti-inflammatory agent.	26	0.43	0.6

Table 3 continued.

29.	*Rubus niveus* Thumb. /Sh/ RGUHAVS029	Rosaceae	Fruit, root	Yikhe jilyung (Ap)	Ziro	Fruit is used as a food supplement, root in wound healing and anti-inflammatory agent.	26	0.43	0.6
30.	*Saurauia griffithii* Dyer / Tr/RGUHAVS030	Actinidiaceae	Fruit, leaf	Hinchi (N)	Joram	Edible fruit as food supplement, leaf helps in constipation, branches of tree used for making altar in Nyishi community	26	0.43	0.6
31.	*Spondias axillaries* Roxb./ Tr/RGUHAVS031	Anacardiaceae	Fruit, bark	Biiling (Ap)	Ziro	Fruit is used as a food supplement. Fruit is used for antimicrobial, digestion. The Bark as purgative.	26	0.43	0.6
32.	*Terminalia chebula* Retz. / Tr/RGUHAVS033	Combretaceae	Fruit	Hellica	Ziro	Fruit used as a food supplement. Fruits are chewed for the treatment of cough, stomach and renal disorder.	40	0.67	1.25
33.	*Trichosanthes homophylla* Hayata (Syn. *Trichosanthes mushaensis* Hayata)/Cl/ RGUHAVS033	Cucurbitaceae	Fruit	Riiko	Ziro	Fruit is used in treating diabetes, anticancer.	30	0.5	0.67

[1]*New ethnobotanical record from the Apatani of Lower Subansiri, Arunachal Pradesh, India.*

Note 1: A= Adi; Ap= Apatani; As= Assamese; G= Galo; N= Nyishi; Nc= Nocte; T= Tangsa; Tg= tagin; and Tr= Tree; Sh= Shrub; Hr= Hurb; Cl= Climber; FC= Frequency of Citation; RFC= Relative frequency of citation; UV= Use value

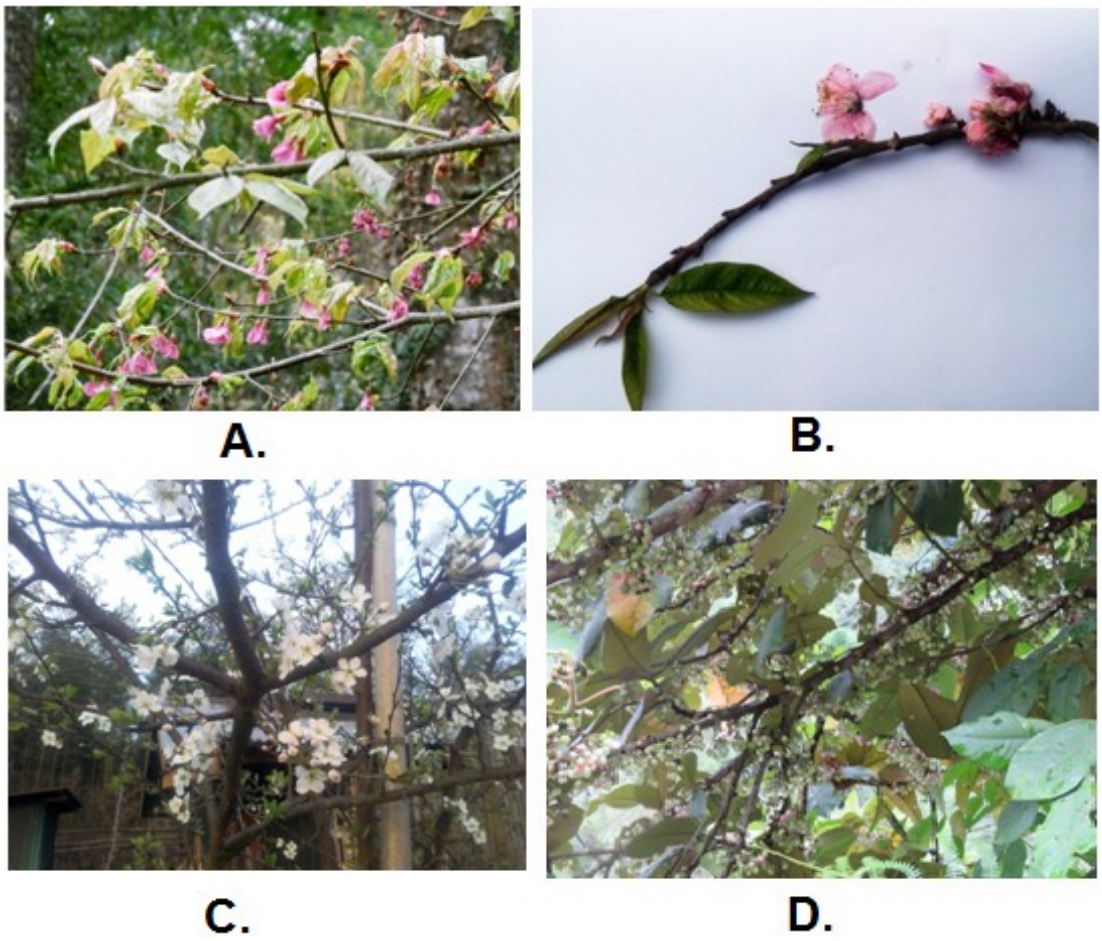

Figure 5. Wild fruit plants of Threatened Species under IUCN Red List (A, B & C) and ENVIS Centre on Floral Diversity, BSI, Kolkata, West Bengal (D).

A. *Cerasus cerasoides* (least concerned category *under IUCN Red List of Threatened species);* B. *Prunus ferganensis (least concerned category under IUCN Red List of Threatened species);* C. *Prunus salicina* (least concerned category under IUCN Red List of Threatened species); D. *Saurauia griffithii* (intermediate category under "ENVIS Centre on Floral Diversity, BSI, Kolkata, West Bengal, Ministry of Environment, Forest & Climate Change, Government of India of Threatened species).

Table 4. Results of pairwise ranking of factors considered as threats to wild edible fruit plants in the study area.

Factors	Respondent										Score	Rank
	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10		
A. Under-cultivation	2	2	3	2	0	0	4	0	0	2	15	5th
B. Human settlement	3	3	2	4	3	3	2	2	4	1	27	3rd
C. Forest fire	0	1	0	0	1	5	0	1	2	3	13	6th
D. Infrastructure development projects	4	4	4	3	2	1	5	3	3	5	34	2nd
E. Agricultural land expansion (shifting cultivation and cash crop plantation)	1	0	1	1	5	4	1	4	5	0	22	4th
F. Firewood collection	5	5	5	5	4	2	3	5	1	4	39	1st

Note: (R1 – R10): Respondent

obtained from N (N-1)/2 relations for pairwise ranking, where N was the number of factors. "Firewood collection" was rated as the principal threat to the availability of wild fruit plants in the area. "Infrastructure development projects" was cited in the second rank, where wild fruit trees were destroyed due to the construction of roads and buildings. "Human settlement" was cited in the third rank, "Agricultural land expansion (shifting cultivation and cash crop plantation)"as the fourth rank, "Under-cultivation" as the fifth rank and "Forest Fire" as the sixth rank that posed a threat to wild fruit plants of the region (Table 4).

CONCLUSION

This paper highlights 33 wild fruit species which are used in home remedies and as food supplements by local people for the Lower Subansiri district of Arunachal Pradesh. The most common plants in the study area with an ethnomedicinal value are *Pyrus communis, Musa paradasiaca, Mahonia nepalensis, Melastoma malabathricum*, *Musa sapientum, Prunus salicina*, *Docynia indica*, *Actinidia deliciosa*, *Averrhoa carambola*, *Ficus auriculata, Myrica esculenta*, *Prunus ferganensis, Pyrus pashia, Terminalia chebula* and *Cerasus cerasoides*, all of which have high UV, FC and Relative frequency of citation. The Pearson correlation coefficient between UV and RFC is 0.88, with a degree of freedom 31 and a p-value <0.0001, which reflects a much highly significant positive correlation between the use-value and relative frequency of citation. The coefficient of determination of regression (R^2) = 0.78 which means that 78% of the variability in the use value (UV) can be explained in terms of the relative frequency of citation (RFC). Apart from its diversity in the area, three species on our list have been classed under the IUCN Red List of Threatened Species e.g. *Cerasus cerasoides* (least concerned) by Rhodes *et al*. (2016), *Prunus ferganensis* (least concerned) by Pollard *et al*. (2016), *Prunus salicina* (least concerned) by Rhodes & Maxted (2016) [Figure 5]. One more species on our list have been classed threatened under "ENVIS Centre on Floral Diversity, BSI, Kolkata, West Bengal, Ministry of Environment, Forest & Climate Change, Government of India e.g. *Saurauia griffithii* (intermediate) (ENVIS, 2011) [Figure 5]. The wild fruits of the area are currently threatened by firewood collection, infrastructure development projects, human settlement, Agricultural land expansion (shifting cultivation and cash crop plantation) which are the main causes of reduction of wild fruits in the area. Therefore, conservation of wild fruits of the Lower Subansiri becomes a necessity which may be achieved with prioritizing on medicinal valued fruit plants. The wild fruits employed in the food supplementation, beverage preparation, disease treatments need pharmacological screening, bioactive ingredient determination, formulation and standardization and drug preparations to cure several numbers of ailments.

Author Contributions

Conceptualization: VSA. Investigation and Data Collection: HA & VSA. Methodology: VSA. Statistical and Formal Analysis: VSA. Resources: VSA. Supervision: VSA. Writing – review & editing: VSA.

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