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REVIEW ARTICLE

Sustainable prospective of some selected species from Moraceae and Araceae family of Northeast India: A Review

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Abstract

The north-eastern region of India is a rich hub of floristic diversity. The intricate relationship between forest resources and indigenous people is a key to sustainability and rural livelihood. The objective is to review on some plants that has possible function for sustainable source of food. The regional people have been utilizing various species of the two commonly available angiosperm plant families viz. Araceae (*Alocasia macrorrhizos, Colocasia esculenta*) and Moraceae (*Ficus carica, F. semicordata, F. auriculata*) as a source of food, herbal medicine, and fodder plants. A variety of natural compounds found among various members of these two families are alkaloids viz., Alocasin B, α-monopalmitin in *A. macrorrhizos*; flavonoids viz., orientin, isovitexin, in *C. esculenta*; betulinic acid, lupeol in *F. auriculata*; quercetin, leucine, tryptophan in *F. carica*; terpenoids like α-thuzene, α-pinene in *F. semicordata*; besides the presence of phenols, tannins, saponins, fats, carbohydrates, amino acids and proteins, minerals like Ca, Mg, K, Mn, Cu. The rich tradition of indigenous herbal healthcare practices for curing various ailments are widespread among the rural communities. The review entails the indigenous practices with pharmacological efficacy, phytochemistry and sustainable prospects of Moraceae and Araceae which are widely used in food, nutraceutical and medicinal aspects. These lesser-known plant species may attribute to ecological restoration, bioremediation of toxic compounds, discovery of novel therapeutics, sources of carbon sink in near future as well.

Keywords

Indigenous, Araceae, Moraceae, Pharmacological, Sustainable prospects.

Introduction

Sustainability is a crucial step towards the survival of every organism in harmony with nature. According to Food and Agriculture Organization (FAO), sustainable food and agriculture must support four important criteria for food sustainability i.e., availability, access, utilization and stability. Due to the increase in meat consumption, the animal food industry has become one of the causative agents for maximum global carbon production globally, food scarcity and nutrition lacking diseases are at front to solve. Therefore, finding solution of food varieties that are nutritious and medicinal property rich in the wild and edible practises from traditional communities are quite urgent to battle the climate change. India recently held the rank of 120th in SDG (sustainable development report index & dashboard), 2021

toward the progress for SDG goals (1). We need to organize production system and cost speculation for local community's upliftment and economic growth (2). The Northeast (NE) region of India, the cradle of early angiosperms lies in the Himalaya and Indo-Burma biodiversity hotspot with occupancy of about 50% of total Indian biodiversity (3). NE region of India is rich in its unique biogeography and it treasures diversified plant resources that are highly valued and having high potentiality as far as medicinal value is concerned. The NE ethnic groups with more than 200 known tribes indulge with traditional knowledge systems for their food, fodder, fibre and herbal drugs giving a new dimension to ethnobotanical research. The age-old tradition of inherited medicinal practices can be a key for novel drug discovery for researchers with potential phytochemical markers.

The two angiosperm plant families Moraceae and Araceae are predominant dwellers in Northeast India with widespread distribution throughout. The dicot family Moraceae or 'Fig family' with worldwide distribution is represented by about 40 genera and over 1000 species. Whereas, the monocot family Araceae or 'Arum family' with 115 genera and over 2000 species are distributed mostly in the tropical and temperate world (4, 5). Distribution around the world of these species is given in (Table 1). The genus

Table 1. Life form and distribution pattern of studied taxa

Family	Plant species	Habit and habitat	Native range and Distribution	Reference
Araceae	*A. macrorrhizos* (L.) G. Don	Evergreen herb of marshlands	Native to India and Malesia; distributed around tropical Africa, Asia, North, South-Central America, West Indies, Indo Pacific Islands	(9–13)
	C. esculenta (L.) Schott	A perennial herb of swamplands	Native to Asia; widespread in India and Sri Lanka, distributed around the world, introduced or cultivated in Africa, Oceania, Europe, North and South America, Southeast Asia	(17, 18, 24, 29, 33)
Moraceae	*F. carica* L.	Gigantic deciduous tree, terrestrial	Native to the Mediterranean and the middle east; Distributed globally, cultivated in Asia including India	(46, 47, 54, 59, 71)
	F. semicordata Buch Ham. ex Sm.	Small medium-sized tree, terrestrial	Distributed in Bhutan, China, India, Malaysia, Myanmar, Nepal, Pakistan, Thailand, Vietnam	(72, 73)
	F. auriculata Lour.	Moderately tall deciduous tree, terrestrial	Native to Asia; distributed widely in the Himalayas from Nepal to NE India, Burma, Southern China, Indo- China and Malaya, South America, Brazil	(74–76)

Ficus L. is amongst the most significant genera in angiosperms represented by about 750 species and commonly regarded as 'keystone species' for its potential role in ecosystem maintenance providing habitat and food for a wide variety of animals (6) and its importance in rituals like ceremonies and festivals are seen in communities (7). The genus *Colocasia*, an edible aroid represented by 16 species of Southeast Asian origin, is represented predominately by *Colocasia esculenta, C. affinis*, *C. fallax*, *C. gigantea* and *C. lihengiae* from Northeast India. The genus *Alocasia* (L.) G. Don with about 2500 species worldwide is a major inhabitant of tropical and sub-tropical regions. *Alocasia macrorrhizos*, *A. fornicata* and *A. longiloba* are predominant in Northeastern marshlands (8). The ethnobotanical practices with these three genera are quite fascinating among Northeastern people in their livelihood as food in close association with nature (Table 2).

Table 2. Ethnobotanical validation of the species in terms of use among rural communities of NE India

Plant species	Tribe/ Region	Plant Parts	Indigenous medicinal practices/ commonly available food sources	Reference
A. macrorrhizos	Arunachal Pradesh	Leaves, corm	Rhizome as a food source used to treat liver disorders and abscesses	(77)
	Zeliang tribe (Nagaland)	Rhizome, leaves	Used as a food plant	(78)
	Manipur	Petioles	Cure of dizziness and headache	(79)
	Jamatia tribe (Tripura)	Root-stock	Used as vegetables	(80)
	Assam	Leaf, Rhizome	To treat knee joint pain and headache	(80, 81, 83)
C. esculenta	Assam	Whole plant	Leaves used for blood coagulation in injuries, roots against pharyngitis	
	Tai-Kha-myangs	Leaves	To treat jaundice	(82)
	Ethnic groups (Assam)	Tuber, petioles	Tuber juice used against blisters and skin sores; petiole juice for remedy of cuts and wounds	(84)
	Assam	Rhizome, petiole	Rhizome as food sources, petiole to cure haemostatic	(77)
	Mizo ethnic group	Stem	Used against insect and snake bite	(86)
	Mizoram	Stalk, rhizome	Stalk sap used to cure bee-sting, wound and cuts; rhizome used against diabetes	(86)
	Tribes of Assam	Corms, runner	Used to remedy tonsillitis and piles	(87)
	Nath people (Assam)	Leaves, roots	Leaves used for blood coagulation, roots for pharyngitis	(88)
	Bodo tribe (Assam)	Petiole	Used for minor cuts	(89)

	Mishing tribe	Tender leaves	Eaten as vegetables, used against malaria and blood coagulation	(89, 90)
F. carica	Zeliang tribe (Nagaland)	Fruit	Eaten as raw	(78)
F. semicordata	Manipur	Bark	To cure dysentery and liver disorders	(91)
	Zeliangrong ethnic group	Fruit	Used to cure diabetes	(92, 93)
	Mizoram	Bark and leaves	To cure liver ailments	(93)
	Mizo ethnic group	Stem bark	Used to heal boils	(85)
F. auriculata	Manipur	Fruit and bark	To cure dysentery, lung diseases and diabetes	(94, 95)
	Arunachal Pradesh	Whole plant	Fruits used as pig feed	(95)

This review paper emphasized these two commonly available plant families i.e., Moraceae and Araceae (3 genera and 5 species) of the NE region of India that holds potential properties to be introduced for extensive production as a sustainable food.

Materials and Methods

A literature review on the species belonging to the family Araceae and Moraceae viz., *Alocasia macrorrhizos* (Fig. 1),

Fig. 1. *Alocasia macrorrhizos* (L.) G. Don

Fig. 2. *Colocasia esculenta* (L.) Schott

Fig. 3. *Ficus auriculata* Lour.

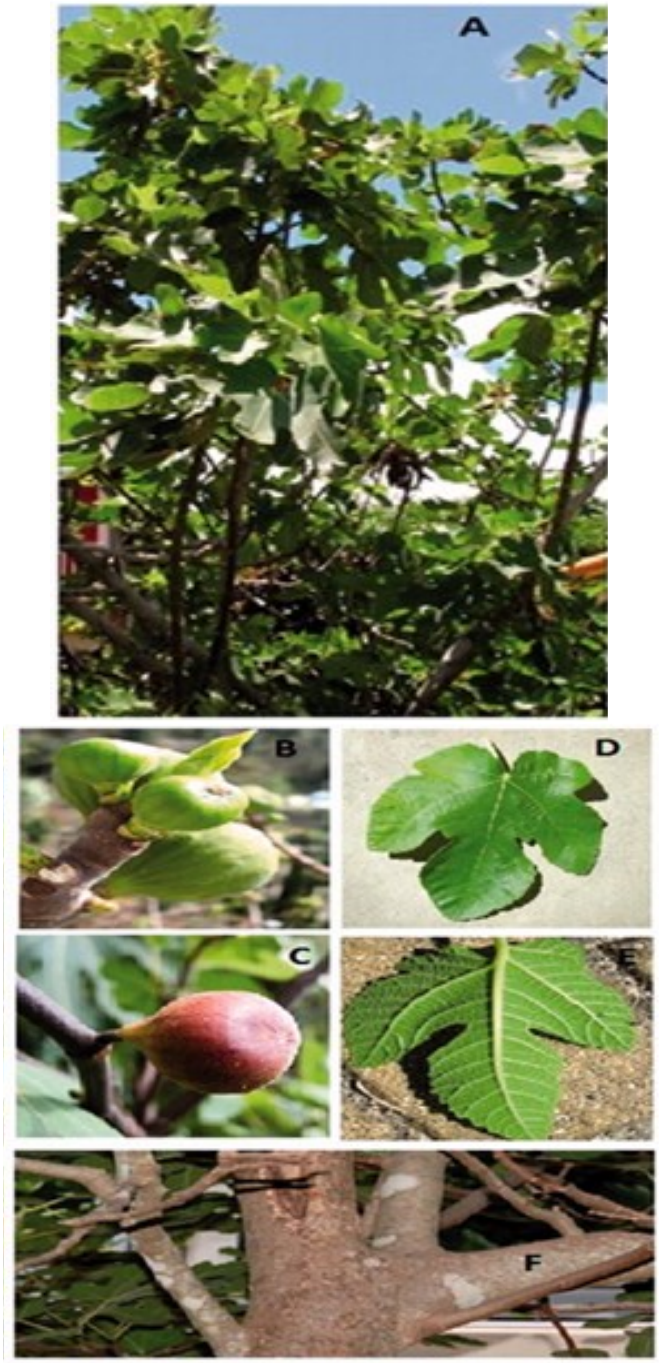

Fig. 4. A-F. *Ficus carica* L. A. Habit, B. Unripe fruit, C. Ripe fruit, D. Dorsal side of leaf, E. Ventral side of leaf, F: Stem Bark.
(Source: Pharm.Bio.52:11,1487-1503)

Fig. 5. *Ficus semicordata* Buch-Ham. ex.Sm.
(Source: IJMFM&AP Vol.2 No.1,2016
http://www.ijmfap.in/pdf_vol2_1/vol_8.pdf)

Colocasia esculenta (Fig. 2), *Ficus auriculata* (Fig. 3), *Ficus carica* (Fig. 4A-F), *Ficus semicordata* (Fig. 5) was searched with keywords like pharmacological efficacy, phytochemistry and sustainable prospects by using scientific databases including PubMed, SciFinder, Research Gate, Science Direct, Google Scholar etc. The searched information was compiled to arrange the manuscripts with distinct sections.

Results

Based on the wide ethnobotanical use of *A. macrorrhizos*, *C. esculenta*, *F. auriculata*, *F. carica* and *F. semicordata* among the communities of NE India the plant species are definitely significant for phytochemical analysis and efficacy studies on various model organisms to decipher the potential role against various ailments including prolonged and lifestyle diseases. The various plant parts or whole plant extracts of the species have elegantly shown the curative properties adding new dimensions to ethnobotanical research (Table 2).

Phytochemistry and pharmacological properties of A. macrorrhizos

A. macrorrhizos leaves extract in different solvents (chloroform, petroleum ether, ethanol, ethyl acetate, aqueous) have reported the presence of alkaloids, phenols, tannins, flavonoids, saponins, fats, carbohydrates, amino acids, proteins and minerals whereas terpenoids and steroids were absent. Further, ethanolic extract contains comparatively much more phenolic and flavonoid content than any other extract (9). Alkaloids such as β-sitosterol, hyrtiosin B, α-monopalmitin, alocasin B, 2-(5-hydroxy-1*H*-indole-3-yl)-2-oxo-acetic acid, 5-hydroxy-1*H*-indole-3-carboxylic acid methyl ester,1-O-β-D-glucopyranosyl-(2S,3R,4E,8Z)-2-[(2(R)-hydroctadecanoyl) amido]-4,8-octadecadiene-1,3-diol, 3-epi-betulinic acid, β-sitosterol-3-O- β-D-glucoside, 3-epi-ursolic acid were isolated from the rhizomes. The anticancer activity of *A. macrorrhizos* was investigated and the results demonstrated the inhibition of hepatic cancer growth in different cell lines. Anticancer activity is because they act as tumour suppressor lipids and also tubulin polymerization inhibitor (10).

Studies have revealed the antioxidant potency of *A. macrorrhizos*. The crude methanolic extract of *A. macrorrhizos* has shown the highest antioxidant activity with IC_{50} value 47.11µg/ml amongst all the other extracts which were subjected to (2,2-diphenyl-1-picryl-hydrazl-hydrate radical scavenging assay or DPPH Assay. *A. macrorrhizos* showed promising effect against a few gram-positive and gram-negative bacteria and some selected fungi. The methanolic and Carbon tetrachloride (CCl_4) extracts well demonstrated antimicrobial activities against gram positive and gram-negative bacteria. However, the petroleum ether extract, aqueous extract as well as methanolic extract depicted the presence of chemical compounds which are responsible for antifungal activities (11). It was also reported that methanolic extract possesses a significant anthelminthic potential where the study revealed that *A. macrorrhizos* took an average of 45 and 51 min for paralyzing and killing the worms viz., *Ascaris lumbricoides*, *Ascaridia galli, Pheretima posthuma* respectively (11). In another study, the methanolic extract of rhizome of *A. macrorrhizos* administered in diabetic mice lowered the blood sugar level (12, 13). The leaves extract of this plant showed to be promising antidiarrheal activity by elevating the reabsorbance of minerals in the intestine hence showing antimobility activity (14).

Phytochemistry and pharmacological properties of C. esculenta

Phytochemical analysis on the leaves and petiole extracts of *C. esculenta* revealed habitation of the anthocyanin namely pelargonidin-3-glucoside, cyanidin-3-glucoside and cyanidin-3-rhamnoside that possess antioxidant activities (15, 16). The leaf extract of *C. esculenta* has shown the presence of flavonoids and triterpenoids, starch, vitamins (A, B, C), fibres, minerals (calcium, phosphorous etc.), calcium oxalate (17-19). The corms of *C. esculenta* contain important nutritive components like protein, niacin, riboflavin, thiamine, carbohydrates, minerals, lipids, calcium oxalate, unsaturated fatty acids, oxalic acid and anthocyanin. The flavonoids reported in *Colocasia* leaf extracts are orientin-7-O-glucoside, orientin, iso-vitexin-3'-O-glucoside, isoorientin, vitexin X"-O-glucoside, iso-vitexin, luteolin-7-O-glucoside, vicenin-2. The propagative part of *Colocasia* is rich in stored starch, amino acids, nitrogen content, lipids, phosphate monoester derivatives, sterols, aliphatic compounds, enzymes (20–22).

The aqueous extract of *C. esculenta* has demonstrated strong antimicrobial against *Salmonella mutans* amongst different species of microbe selected for the study (18). *C. esculenta* ethanolic extract have showed a strong potency in reducing blood glucose level in alloxan induced diabetic rats (18). Also, the juice of leaf of *C. esculenta* has reported antioxidant activity by preventing reduction in tissue glutathione level in rat liver tissue (18). The leaf juice of *C. esculenta* have shown hepatoprotective activity against paracetamol and CCl_4 in rats. The study reported that *Colocasia* extract surprising decreases the toxic marker enzyme alanine transaminease (ALT), Aspartate transaminase (AST), Alkaline phosphate (ALP) and protects the hepatocyte integrity (18). It has been also shown that compounds present in the roots of *C. esculenta* have inhibitory potential against tumour metastasis (18). In another study, it was found that cystatin present in *C. esculenta* has a dele-

terious effect on growth of fungi (26). Further, the leaf extract of *C. esculenta* showed a promising anti-inflammatory effect in carrageenan induced paw oedema in Wistar rats (18). The aqueous and ethanolic extract of *C. esculenta* have shown significant antihelminthic activity against earthworm (25). A compound present in tuber of *C. esculenta* reported antimelanogenic activity (27). Another investigation on the crude extract of *C. esculenta* has revealed the presence of immunostimulatory proteins in it. The crude extract exaggerated *in vitro* proliferation of spleen and bone marrow cells in mice in a dose-dependent manner (37).

Phytochemistry and pharmacological properties of F. carica

Phytochemical investigation on *F. carica* reported the presence of phytosterols, flavonoids, anthocyanin, phenols, amino acids, fatty acids, organic acids, hydrocarbons, aliphatic alcohols and other volatile compounds. The phytochemicals are mostly found in latex, leaves, fruits and roots. *F. carica* contains different essential minerals for human nutrition like copper, manganese, magnesium, potassium and calcium (38–43).

Ethanolic extract of *F. carica* when administered at dose of 100, 200, 300 mg/kg body weight could lower the body temperature and the effect is persistent upto 5 hrs than paracetamol (44). Further, leaf extracts prepared in different solvents (Chloroform, petroleum ether and ethanol) demonstrated antiflammatory activiy in rats against carageenan induced oedema (44). In another study conducted, it was found that the ripe fruit of *F. carica* showed remarkable antispasmodic activity in by producing instant relaxations in jejunum of rabbit. The same study described the inhibitory role of fruit extract against human platelet aggregation (48). Leaves of *F. carica* also possess antihelminthic activity and is supported by a research on its potential against *Pheretima posthuma* infections (44). Leaves of *F. carica* have showed protective activity against liver damage in rats. A concentration of 500 mg/kg body weight was administered orally which lowered the serum concentrations of liver enzymes along with other biochemical indicators (54). Fig paste of *F. carica* when fed to rats improved the lopamide induced constipation (49). In a similar study it was reported that the consumption of fig paste led to improvement in conditions in patients suffering from constipation (27). Also, the chloroform leaf extract of *F. carica* showed signcificant reduction in cholesterol levels (51). The leaf extract also regulates the secretion of cholesterol and triglyceride from the liver (52). In a study, a strong inhibitory effect against different cancer cell lines was demonstrated by latex of *F. carica* in a study (56). In another study, latex, fruit and leaf extracts of *F. carica* have lowered the feasibility of HeLa cell lines at a lower concentration (45). Extract of *F. carica* possess the capability of decreasing the hazardous effect of mu tagens present in the environment. Leaves and latex of *F. carica* have also strong inhibitory potential against growth of different species of bacteria and fungi (46, 47). The hexane and hexane ethyl acetate extract of *F. carica* have shown promising activity against viral infections (47). Furthermore, the total flavonoid from the leaves of *F. carica* have showed potent scavenging effects against the hydroxyl and superoxide ions in a concentration dependent manner (58). Ethanolic leaf extract of *F. carica* have significantly ameriolated both cellular and antibody mediated response in mice (44).

Phytochemistry and pharmacological properties of F. semicordata

Phytochemical analysis on *F. semicordata* indicated the presence of flavonoids, steroids, terpenoids, tannins, saponins, carbohydrates, glycosides (60, 61). Tannins, catechin, quercetin, mono and sesquiterpenoids, fatty acid derivatives, shikimic acids were found to be present in the dried leaves of *F. semicordata* (62). The fruits of *F. semicordata* emit a floral scent which contains compounds like terpenes (Monoterpenoids: Sabinene, Limonene-1,8-Cineole, beta-Myrcene, γ-Terpinene, Terpinolene, beta-Pinene, (E)- beta -ocimene, alpha-Thujene, (Z)- beta-Ocimene, alpha-Pinene; Sesquiterpene:α-Cubebene, β- Cubebene, α -Selinene, β-Selinene, α -Ylangene, α- Copaene, α-Gurjunene, α-Humulene, β-Caryophyllene, β-Elemene, Panasinsene, γ-Muurolene, Germaacrene A, Germacrenene D, Alloaromadendrene, (E, E) α-Farnesene, o-Cadinene; Shikimic compounds (4-Methylanisole,1,4-Methoxybenzene, Indole) (63).

The leaves of *F. semicordata* have shown antibacterial efficacy in high concentration against gram-negative bacteria as compared to the gram-positive bacteria. The leaves and fruits of *F. semicordata* possess antioxidant properties (64).

Phytochemistry and pharmacological properties of F. auriculata

The hexane, chloroform and methanol soluble extracts of bark of *F. auriculata* were tested for the presence of different secondary metabolites. Carbohydrates, alkaloids, saponins, resins, phenols, proteins, amino acids were present in all three extracts. The presence of phytosterols and flavonoids was indicated in methanol and chloroform extracts but was absent in hexane extracts. The presence of glycosides was only found in the methanolic extract. Fats and fixed oils were not present in any of the three extracts being screened (65). Phytochemical investigation on the methanolic and chloroform leaf extract of *F. auriculata* indicated the presence of alkaloids, phenols, tannins, flavonoids, terpenoids, carbohydrates. Glycosides were found to be present only in methanolic extract whereas saponins were absent in both the extracts (50). Myricetin, betulinic acid, beta -sitosterol-3-O- beta- D-glucopyranoside, lupeol, quercetin-3-O- beta- D-glucopyranoside, stigmasterol, scopoletin, bergapten (66).

The leaf extracts of *F. auriculata* exhibited antibacterial activity against *Escherichia coli* and *Salmonella typhimurim*. The antioxidant analysis of leaves of *F. auriculata* had revealed strong DPPH scavenging potential. However, the anti-cancerous activity was not found to be effective at a low concentration of 100 µg/ml (50).

Discussion

Sustainability not only advocate the safeguard for the environment but also emphasizes eco-friendly food production, distribution and consumption keeping harmful impact away from the environment. Choosing green clean organic plant-based food is a crucial step for food sustainability. Modern techniques of sustainable agriculture focus on more increase in the product without hazardous impact on the ecosystem. Sustainable farming of these plant species belonging to the two families i.e., Araceae and Moraceae will support low carbon food production and could encourage biodiversity restoration. Arum plants being easily propagated and Fig plants for their modest contribution in providing food and shelter for numerous flora and fauna, have a role to restore the outer ecosystem. The plant species belong to the family Araceae are widespread in the vicinity of swamplands whereas the species belong to Moraceae are dominant in terrestrial habitat. A variety of nutritive compounds reported among the members of these extensively studied genera viz., *Alocasia*, *Colocasia* and *Ficus*. Only few species are mentioned in this study among these genera to reduce the haphazard content of multiple species.

Family Moraceae and Araceae are quite abundant in their distribution as discussed (Table 1). Apart from mentioned members, other species of NE region like *Abelmoscus manihot, Abrus precatorius, Desmodium, Peperomia pellucida, Polygonum hydropiper* etc (81, 87) also are full of potential compound for medicinal purposes as well as good nutritive food. As the mentioned species also holds the same purposes, hence, are good alternatives for sustainable way of living. Some of their particular beneficial roles discussed are like bioprospecting of effective phytochemical makers from Moraceae and Araceae has provided an added advantage. Some of those maker phytoconstituents viz. Hyrtiosin B, hyrtiosulawesin, Alocasin, Alomacrorrhizos A, Campesterol, fucosterol, beta-sitosterol, 1-O-β-D-glucopyranosyl-(2S,3R,4E,8Z)-2-[(2(R)-hydroctadecanoyl) amido]-4,8-octadecadiene-1,3-diol having role in anti-inflammatory, anti-oxidant, antiproliferative activity, hepatoprotective activity (11) may be a potent candidate in more effective new drug development.

Antioxidant properties of orientin 7-O- glucoside kaempferol , vicenin-2, Iso- vitexin-3'-O-glucoside, Iso- orientin, vitexin X"-O-glucoside , orientin, quercetin, myricetin, quercetin-3-o-beta-D-glucopyranoside, scopoletin, bergapten (67); antifungal properties of cystatin, Cyanoglucoside (66, 68, 69) bacterial growth inhibition of compound like coumarin Betulinic acid, lupeol, stigmasterol, beta-sitosterol-3-O-beta-D- glucopyranoside; hepatoprotective activity due to quercetin and catechin (42); Anti-diabetic activity shown by quercetin and Gallic acid respectively (70) are the boon to phytochemical profiling.

The high content of alkaloids viz., Alocasin B, α-monopalmitin in *A. macrorrhizos*; flavonoids viz., orientin, isovitexin, in *C. esculenta*; Betulinic acid, lupeol in *F. auriculata*; quercetin, leucine, tryptophan in *F. carica*; terpenoids like α-thuzene, α-pinene in *F. semicordata*; besides the presence of phenols, tannins, saponins, fats, carbohydrates, amino acids and proteins, minerals like Ca, Mg, K, Mn and Cu. Significant pharmacological activities established are antioxidant, antimicrobial, antidiabetic, hepatoprotective, immunostimulant, anticancer. From the present literature review, the traditional use of plants belonging to these three genera checks out for having effective therapeutic roles (Table 2) as per their various pharmacological activities discussed (Table 3). They are widely distributed, easily propagated and cultivated popularly as an edible food source for their nutritional value. Therefore, these plants can be acknowledged for commercial large-scale cultivation for sustainable agricultural practices and low-cost production of processed food.

Reviewing in *Ficus* spp. indigenous knowledge found popular use of its species in liver diseases and from previous studies it has been found that many other commonly occurring species in this geographic region known to have similar properties (96). There is scope of further extensive research in antifertility study for the *Ficus* sp. viz., *F. auriculata*, *F. carica* and *F. semicordata* (97, 98). Sustainable food production has emerged as a challenge for the resilience of the environment. Therefore, the addition of these plants in sustainable farming practices could balance out the harmful impacts of the environment suffered from massive poultry and dairy food production. Procurement of these wild plant species is very essential for future use as wholesome food which will be a step to remove the world hunger problems around the globe. On the other hand, the production of such native wild forest resources will bring the knowledge and practices of ethnic people to the world for the socio-economic development of the communities.

Conclusion

Switching to alternate food items that are nutritious and easily grown for the betterment of the health of people is always a positive emphasis. All these plants contain important bioactive compounds that impart characteristic biological properties to them. Various research works are being conducted to report pharmacological activities like antidiabetic, antihypertensive, antimicrobial, anthelminthic, anticancer, antiproliferative, anti-inflammatory, hepatoprotective, immunomodulatory properties of various species of *Alocasia, Colocasia,* and *Ficus*. However, there are some few species for which scientific evaluation and deeper understanding of compounds mechanism of action is still to be done. Since food system is the locus of all environmental impacts. This review focused on the plants have a reliable lead towards sustainability in the sense of distribution, nutrition, traditional values as well as cost-effectiveness.

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Authors contributions

Both JMD and BS shaped and wrote the manuscript and NN and MKB conceive and analysed the data.

Compliance with ethical standards

Conflict of interest: The authors declare that no conflict of interest exists.

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References

1. Sachs JD, Kroll K, Lafortune G, Fuller G, Woelm F. The decade of action for the Sustainable Development Goals. Sustainable Development Reports 2021. UK. Cambridge. Cambridge University Press. 2021. p. 9-10. https://doi.org/10.1017/9781009106559.
2. Blay-Palmer A, Roberta S, Custof J. A Food politics of the possible? Growing sustainable food systems through networks of knowledge, Agriculture and Human Values. 2016;33(1):27-43. https://doi.org/10.1007/s10460-015-9592-0
3. Mao AA, Hynniewta TM, Sanjappa M. Plant wealth of Northeast India with reference to ethnobotany. Indian J Tradit Knowl. 2009;8(1):96–103. Available from: http://nopr.niscair.res.in/handle/123456789/2979
4. Tamokou JDD, Mbaveng AT, Kuete V. Antimicrobial activities of African medicinal spices and vegetables. Medicinal spices and vegetables from Africa. Academic Press, 2017:207-37. https://doi.org/10.1016B978-0-12-809286-6.00008-X
5. Mahbubur RAHM and Barman AK. A Preliminary Taxonomic Account of the Family Caesalpiniaceae of Rajshahi. Discovery. 2017;53(256):243–54. Available from: www.discoveryjournals.com
6. Chaudhary LB, Sudhakar JV, Kumar A, Bajpai O, Tiwari R, Murthy GVS. Synopsis of the genus *Ficus* L. (Moraceae) in India. Taiwania. 2012; 57(2):193–216. https://doi.org/10.6165/tai.2012.57(2).193
7. Gogoi P, Nath N. Diversity and inventorization of angiospermic flora in Dibrugarh District, Assam, Northeast India, Plant Science Today. 2021;8(3):621-28. https://doi.org/10.14719/pst.2021.8.3.1118.
8. Nabis B. Karyomorphological studies in three species of *Alocasia* (Schott.) G.Don.- An ethno-medicinally and economically important genus. Int J Life-Sciences Sci Res. 2018;4(6):2116–21. https://doi.org/10.21276/ijlssr.2018.4.6.8.
9. Singh SK, Patel JR, Dangi A. Physicochemical, qualitative and quantitative determination of secondary metabolites and antioxidant potential of *A. macrorrhizos* leaf extracts. Pharma Innov. J. 2019;8(1): 399–404. Available from: https://www.thepharmajournal.com/archives/?year=2019&vol=8&issue=1&ArticleId=2937
10. Elsbaey M, Ahmed KFM, Elsebai MF, Zaghloul A, Amer MMA, Lahloub M-F. Cytotoxic constituents of *Alocasia macrorrhiza*. Zeitschrift fur Naturforsch. - Sect. C J. Biosci. 2017;72(1-2):21–25. https://doi.org/10.1515/znc-2015-0157
11. Banik S, Ibrahim Md. Amin MN, Moghal Md. MR, Majumder MS, Alam Md.K et al. Determination of biological properties of *A. macrorrhizos*. A medicinal plant. World Journal of Pharmaceutical Research. 2014;3(9):193-210. Available from: https://wjpr.s3.ap-south-1.amazonaws.com/article_issue/1414994325.pdf
12. Rahman MM, Hossain MA, Siddique SA, Biplab KP. Antihyperglycemic, antioxidant and cytotoxic activities of *A. macrorrhizos* (L.) rhizome extract. Turkish J Biol. 2012;36(5):574–79. https://doi.org/10.3906/biy-112-11
13. Fang S, Lin C, Zhang Q, Wang L, Lin P, Zhang J et al. Anticancer potential of aqueous extract of *Alocasia macrorrhiza* against hepatic cancer *in vitro* and *in vivo*. J Ethnopharmacol. 2012;141 (3): 947–56. https://doi.org/10.1016/j.jep.2012.03.037.
14. Islam M K, Mahmud I, Saha S, Sarar AB, Mondal H, Hossain ASM MA et al. preliminary pharmacological evalution of *Alocasia indica* Schott tuber. Journal of Integreteed Medicine. 2013.11(5):343-51. https://doi.org/10.3736/jintegrmed2013045
15. Cambie RC and Ferguson LR. Potential functional foods in the traditional Maori diet. Mutat. Res. - Fundam Mol Mech Mutagen. 2003;523–24:109–17. https://doi.org/10.1016/s0027-5107(02)00344-5
16. Kowalczyk E, Kopff A, Fijalkowski P, Kpff M, Niedworok J, Blaszczyk J et al. Effect of anthocyanins on selected biochemical parameters in rats exposed to cadmium. Acta Biochim Pol. 2003;50(2):543–48. https://doi.org/10.18388/abp.2003_3707
17. Prajapati R, Kalariya M, Umbarkar. C. esculenta: A potent indigenous plant. Int J Nutr Pharmacol Neurol Dis. 2011;1(2):90-96. https://doi.org/10.4103/2231-0738.84188
18. Pawar HA, Choudhary PD, Kamat SR. An overview of traditionally used herb, *C. esculenta*, as a Phytomedicine. Med Aromat. Plants 2018;7(4):1–7. https://doi.org/10.4172/2167-0412.1000317
19. Abaza AM, Ahmed YM, Abbas MG, Soliman HA, Ashour HK. Chemical Constituents of *C. esculenta* leaves extract in Relation to its Self Defense against the Cotton leafworm, *Spodoptera littoralis* (Boisd.) 2015;13(1): 1–7. Available from: https://cat.journals.ekb.eg/article_18373_0bbe958f040abdb485e95f73dce5c8a3.pdf
20. Saklani S, Chandra S. Phytochemical screening of Garhwal Himalaya wild edible fruit *Ficus palmata*. Int J Pharm Tech Res. 2012;4 (3): 1185–91. Available from: https://www.researchgate.net/publication/285789934
21. Lindawati NY. Determination of total flavonoid levels on leaf stalks ethanol extract of taro (*C. esculenta* (L.) Schott). J Farm. (Journal Pharmacy) 2018;1:58–66. https://doi.org/10.37013/jf.v1il.65
22. Arlin BD, Fadjar KH, Nunuk H. An identification of nutrition, phytochemicals and antioxidants Taro (*Colocasia* sp.). In: Proceedings of 1st Asian Conference on Humanities, Industry and Technology for Society. 2019 30-31 July; Surabaya, Indonesia. EAI. https://doi.org/10.4108/eai.30-7-2019.2287620
23. Ufelle SA, Onyekwelu KC, Ghasi S, Ezeh CO, Ezeh RC, Esom EA. Effects of *C. esculenta* leaf extract in anemic and normal wistar rats. J Med Sci. 2018;38(3):102–06. https://doi.org/10.4103/jmedsci.jmedsci_80_17
24. Vasant OK, Vijay BG, Virbhadrappa SR, Dilip NT, Ramahari MV, Laxamanrao BS. Antihypertensive and diuretic effects of the aqueous extract of *C. esculenta* Linn. leaves in experimental paradigms. Iran J Pharm Res. 2012;11(2): 621–34. Available from: https://pubmed.ncbi.nlm.nih.gov/24250487/
25. Kubde MS, Khadabadi SS, Farooqui IA, Deore SL. *In-vitro* anthelmintic activity of *C. esculenta.* Sch Res Libr. 2010;2(2): 82–85. Available from: https://www.scholarsresearchlibrary.com/abstract/invitro-anthelmintic-activity-of-colocasia-esculenta-9491.html
26. Yang AH, Yeh KW. Molecular cloning, recombinant gene expression and antifungal activity of cystatin from Taro (*C. esculenta* cv. Kaosiung no. 1). Planta 2015;221(4):493–501. https://doi.org/10.1007/s00425-004-14628
27. Kim KH, Moon EJ, Kim SY, Lee KR. Anti-melanogenic fatty acid derivatives from the tuber-barks of *Colocasia antiquorum* var. *esculenta*. Bull Korean Chem Soc. 2010;31(7):2051–53. https://doi.org/10.5012/bkcs.2010.31.7.2051
28. Kalariya M, Parmar S, Sheth N. Neuropharmacological activity of hydroalcoholic extract of leaves of *C. esculenta*. Pharm Biol. 2010;48(11): 1207–12. https://doi.org/10.3109/13880201003586887

29. Pereira PR, Mattos EBA, Correa ACNTF, Vericimo MA, Paschoalin VMF. Anticancer and immunomodulatory benefits of Taro (*C. esculenta*) corms, an underexploited tuber crop. Int J Mol Sci. 2021;22(1):1–33. https://doi.org/10.3390%2Fijms22010265

30. Nur-Hadirah K, Arifullah M, Nazahatul AA, Klaiklay S, Chumkaew P, Norhazlini MZ et al. Total phenolic content and antioxidant activity of an edible Aroid, *C. esculenta* (L.) Schott. IOP Conf Ser Earth Environ Sci. 2021;756: 012044. https://doi.org/10.1016/j.foodchem.2016.10.084

31. Dhanraj N, Kadam MS, Patil KN, Mane VS. Phytochemical screening and Antibacterial Activity of Western Region wild leaf *C. esculenta*. Int Res J Biol Sci. 2013;2(10): 1-6. Available from: http://www.isca.in/ /IJBS/Archive/v2/i10/4.ISCA-IRJBS-2013-142.pdf

32. CO E. Iroaganachi M, Eleazu KC. Ameliorative potentials of Cocoyam (*C. esculenta* L.) and unripe plantain (*Musa paradisiaca* L.) in renal and liver growth in streptozotocin induced diabetic rats. J Diabetes Metab. 2013;2(2):140-47. https://doi.org/10.1155/2013/160964

33. Li HM, Hwang SH, Kang BG, Hong JS, Lim SS. Inhibitory effects of *C. esculenta* (L.) Schott constituents on aldose reductase. Molecules 2014;19(9): 13212–24. https://doi.org/10.3390/molecules190913212

34. Boban PT, Nambisan B, Sudhakaran PR. Hypolipidaemic effect of chemically different mucilages in rats: A comparative study. Br J Nutr. 2006;96(6):1021–29. https://doi.org/10.1017/bjn20061944

35. Sakano Y, Mutsuga M, Tanaka R, Suganuma H, Inakuma T, Toyoda M et al. Inhibition of human lanosterol synthase by the constituents of *C. esculenta* (Taro). Biol Pharm Bull. 2005;28(2):299–304. https://doi.org/10.1248/bpb.28.299

36. Brown AC, Reitzenstein JE, Liu J, Jadus MR. The anti-cancer effects of poi (*C. esculenta*) on colonic adenocarcinoma cells *in vitro*. Phyther Res. 2005;19(9):767–71. https://doi.org/10.1002/ptr.1712

37. Pereira PR, Winter HC, Vericimo MA, Meagher JL, Stuckey JA, Goldstein IJ et al. Structural analysis and binding properties of isoforms of tarin, the GNA-related lectin from *C. esculenta*. Biochim Biophys Acta - Proteins Proteomics 2015;1854(1):20–30. https://doi.org/10.1016/j.bbapap.2014.10.013

38. Oliveira AP, Valentao P, Pereira JA, Silva BM, Tavares F, Andeade PB. *F. carica* L.: Metabolic and biological screening. Food Chem Toxicol. 2009;47(11):2841–46. https://doi.org/10.1016/j.fct.2009.09.004

39. Oliveira AP, Silva LR, Andrade PB, Valentao P, Silva BM, Goncales RF. Further insight into the latex metabolite profile of *F. carica*. J Agric Food Chem. 2010;58(20):10855–63. https://doi.org/10.1021/jf1031185

40. Russo F, Caporaso N, Paduano A, Sacchi R. Phenolic compounds in fresh and dried figs from Cilento (Italy), by considering Breba Crop and Full Crop, in Comparison to Turkish and Greek Dried Figs. J Food Sci. 2014;79(7):C1278-84. https://doi.org/10.1111/1750-3841.12505

41. Vaya J and Mahmood S, Vaya - 2006 - Flavonoid content in leaf extracts of the Fig (*F. carica* L.), Carob (*Ceratonia siliqua* L.) and Pistachio (*Pistacia lentiscus* L.).pdf. 2006;28(3-4):169–75. https://doi.org/10.1002/biof.5520280303

42. Solomon A, Golubowicz S, Yablowicz Z, Grossman S, Bergman M, Gottlieb HE et al. Antioxidant activities and anthocyanin content of fresh fruits of common Fig (*F. carica* L.). J Agric Food Chem. 2006;54(20):7717–23. https://doi.org/10.1021/jf060497h

43. Saeed MA, Sabir AW. Irritant potential of triterpenoids from *F. carica* leaves. Fitoterapia 2002;73(5):417–20. https://doi.org/10.1016/s0367-326x(02)00127-2

44. Patil VV, Bhangale Sc, Patil VR. Studies on immunomodulatory activity of *F. carica*. Int J Pharm Pharm Sci. 2010;2(4):97–99. Available from: https://eijppr.com/storage/models/article/XWaqgGbQO58KKfy7mHINGDiyn9jrhWqrsaHNDh1WYM-R90DtVkU5pymgL05Uo/ficus-carica-linn-a-review-on-its-pharmacognost

45. Khodarahmi GA, Ghasemi N, Hassanzadeh F, Safaie M. Cytotoxic effects of different extracts and latex of *F. carica* L. on HeLa cell line. Iran J Pharm Res. 2011;10(2):273–77. Available from: https://pubmed.ncbi.nlm.nih.gov/24250354/

46. Jeong M.R, Kim H-Y, Cha J-D. Antimicrobial activity of methanol extract from *F. carica* leaves against oral bacteria. J Bacteriol Virol. 2009;39(2): 97–102. http://dx.doi.org/10.4167/jbv.2009.39.2.97

47. Aref HL, Salah KBH, Chaumout JP, Feikh A, Aouni M, Said K. *In vitro* antimicrobial activity of four *F. carica* latex fractions against resistant human pathogens (antimicrobial activity of *F. carica* latex). Pak J Pharm Sci. 2010;23(1):53–58. Available from: http://www.pakmedinet.com/PJPS.

48. Gilani AH, Mehmood MH, Janbaz KH, Khan A-U, Saeed SA. Ethnopharmacological studies on antispasmodic and antiplatelet activities of *F. carica*. J Ethnopharmacol. 2008;119(1):1–5. https://doi.org/10.1016/j.jep.2008.05.040

49. Lee HY, Kim J-H, Jeung H-W, Lee C-U, Kim D-s, Li b et al. Effects of *F. carica* paste on loperamide-induced constipation in rats. Food Chem Toxicol. 2012;50(3-4):895–902. https://doi.org/10.1016/j.fct.2011.12.001

50. Kumari A, Verma R, Sharma M, Chauhan P, Kumar A. Evaluation of Phytochemical, antioxidant, antibacterial and anti-cancerous activity of *F. auriculata* Lour. and *Osyris wightiana* Wall. ex Wight. Pharmacol. Life Sci Bull Env Pharmacol Life Sci. 2018;7(8):645-70. Available from: https://www.researchgate.net/publication329436057_Evaluation_of_Phytochemical_antioxidant_antibacterial_and_anti-cancer-ous_activity_of_Ficus_auriculata_Lour_and_Osyris_wightiana_Wall_ex_Wight

51. Canal JR, Torres MD, Romero A, Perez C. A chloroform extract obtained from a decoction of *F. carica* leaves improves the cholesterolaemic status of rats with streptozotocin-induced diabetes. Acta Physiol Hung. 2000;87(1):71–76. https://doi.org/10.1556/aphysiol.87.2000.1.8

52. Asadi F, Poukabir M, Maclaren R. Alterations to lipid parameters in response to fig tree (*F. carica*) leaf extract in chicken liver slices. Turkish J Vet Anim Sci. 2006;30(3):315–18. Available from: https://www.researchgate.net/publication/288392707_Alterations_to_lipid_parameters_in_response_to_fig_tree_*Ficus_carica*_leaf_extract_in_chicken_liver_slices

53. Patil BR and Ageely HM. Antihepatotoxic activity Of *C. esculenta* leaf juice. Int J Adv Biotechnol Res. 2011;2(2): 296–304. Available from: https://www.researchgate.net/publication/267385770_Antihepatotoxic_activity_of_*Colocasia_esculenta*_leaf_juice

54. Mujeeb M, Khan AS, Aeri V, Ali B. Hepatoprotective activity of the ethanolic extract of *F. Carica* Linn. leaves in carbon tetrachloride-induced hepatotoxicity in rats. Iran J Pharm Res. 2011 Spring;10(2):301-06. Available from: ncbi.nlm.nih.gov/pmc/articles/PMC3828912/

55. Deka K, Nath N. Traditional hepatoprotective herbal medicine of Bongaigaon District, Assam (N.E. India), 2015;2(5):265-76. Available from**:** imedpub.com/articles/traditional-hepatoprotective-herbal-medicine-of-bongaigaon-district-assam-neindia.pdf

56. Rubnov S, Kasman Y, Rabinowitz R, Schlesinger M, Mechoulam R. Suppressors of cancer cell proliferation from Fig (*F. carica*) resin: Isolation and structure elucidation. J Nat Prod. 2001;64(7): 993–96. https://doi.org/10.1021/np000592z

57. Shahinuzzaman M, Zahira Y, Anur FH, Akhtar P, Kadir NHA, Hasan AKM et al. *In vitro* antioxidant activity of *F. carica* L. latex from 18

different cultivars. Scientific Reports, 10(1):10852. https://doi.org/10.1038/s41598-020-67765-1

58. Yang XM, Yu W, Ou Z-p, Ma H-L, Liu W-M, Ji X-J Antioxidant and immunity activity of water extract and crude polysaccharide from *F. carica* L. fruit. Plant Foods Hum Nutr. 2009;64(2):167–73. https://doi.org/10.1007/s11130-009-0120-5

59. Badgujar SS, Vainav VP., Atmaram HB., Raghunath TM. Traditional uses, phytochemistry and pharmacology of *F. Carica:* A review. Pharm BIOL. 2014;52(11): 1487-503. https://doi.org/10.3109/13880209.2014.892515

60. Patil M. Quantification of phytochemical constituents and *in vitro* antioxidant activity in the leaves of *Citrus medica*. Int J Curr Pharm Res. 2017;9(5): 119–23. http://dx.doi.org/10.22159/ijcpr.2017v9i5.22153

61. Gupta Shashi, Rabinarayan A, Harisha CR, Vinay S. Detailed pharmacognostical and phytochemical screening of stem and stem bark of *F. semicordata* Buch-Ham. ex Sm. An extra pharmacopoeial drug of ayurveda. Pharmacognosy Journal. 2019;11(6): 1303-11. http://dx.doi.org/10.5530/pj.2019.11.202

62. Al-Snafi AE. Phenolics and flavonoids contents of medicinal plants, as natural ingredients for many therapeutic purposes-A review. IOSR J Pharm. 2020;10(7):42–81. Available from: http://iosrphr.org/papers/vol10-issue7/Ser-2/B1007024281.pdf

63. Knudsen JT, Erksson R, Gershenzon J, Stahl B. Diversity and distribution of floral scent. Bot Rev. 2006;72(1):1–120. Available from: https://www.jstor.org/stable/435451

64. Baral R. Current perspectives on medicinal and aromatic plants phytochemical screening, free radical scavenging and *in vitro* anti- bacterial activity studies of various extracts of selected medicinal plants of Nepal. 2021;4(1): 22–35. https://doi.org/10.38093/cupmap.896273

65. Gaire BP, Lamichhane R, Sunar CB, Shilapkar A, Neupane S, Panta S. Phytochemical screening and analysis of antibacterial and antioxidant activity of *F. auriculata* (Lour.) stem bark. Pharmacogn J. 2011;3(21): 49–55. https://doi.org/10.5530/PJ.2011.21.8

66. Al Fishawy AM, Zayed RA, Afifi SM. Phytochemical and pharmacological studies of *F. auriculata* Lour. (Family: Moraceae) cultivated in Egypt. Planta Med. 2011;4:189-95. http://dx.doi.org/10.1055/s-0031-1282654

67. Liu F, Yang Z, Zheng Xi, Luo S, Zhang K, Li G. Nematicidal coumarin from *F. carica* L. J Asia Pac Entomol. 2011;14(1):79–81. https://doi.org/10.101/j.aspn.2010.10.006

68. Sudhakar P, Thenmoghi V, Srivignesh S, Dhanalakshmi M. *C. esculenta* (L.) Schott: Pharmacognostic and pharmacological review. J Pharmacogn Phytochem. 2020;9(4):1382–86. https://doi.org/10.227/phyte.2020.v9.j4s.11937

69. Ahmad J. Evaluation of antioxidant and antimicrobial activity of *F. carica* leaves: An *in vitro* approach. J Plant Pathol Microbiol. 2012;04(1):1–4. https://doi.org/10.4172/2157-7471-100157

70. Gupta S, Ranade A, Gayakwad S, Acharya R, Pawar S. Hepatoprotective activity of *F. semicordata* Buch.-Ham. ex Sm. leaves aqueous extract on d-galactosamine induced toxicity in hepg2 cell line. Indian J Nat Prod Resour. 2020;11(4):239–43. Available from: http://nopr.niscair.res.in/handle/123456789/56149

71. Mawa S, Husain K, Jantan I. *F. carica* L. (Moraceae): Phytochemistry, traditional uses and biological activities. Evidence-based complement Altern Med. 2013. https://doi.org/10.1155/2013/974256

72. Kaur V, Kumar T, Upadhyaya K. An overview of the phytomedicinal approaches of *F. semicordata.* World J Pharm Pharm Sci. 2016;5: 606–16. Available from https://www.wjpps.com/Wjpps_controller/abstract_id/4849

73. Gupta S, Acharya R. Ethnomedicinal claims of *F. semicordata* Buch.-Ham. ex Sm.: A review. Int J Green Pharm. 2018;12(1): S206 –S213. https://doi.org/10.22377/ijgp.v12101.1621

74. Tamta G, Mehra N, Tandon S. Traditional uses, phytochemical and pharmacological properties of *F. auriculata*: A review. Journal of Drug Delivery and Therapeutics. 2021;11(3):163–69. http://dx.doi.org/10.22270/jddt.v11i3.4853

75. Zhang Z, Wang X.M, Liao S, Tian H. Taxonomic treatment of the *F. auriculata* complex (Moraceae) and typification of some related names. Phytotaxa. 2019;399(3):203–08. http://dx.doi.org/10.11646/phytotaxa.399.3.4

76. Zhang LF, Zhang Z, Wang XM, Gao HF, Tian HZ, Li HQ. Molecular phylogeny of the *F. auriculata* complex (Moraceae). Phytotaxa 2018;362(1): 39–54. http://dx.doi.org/10.11646/phytotaxa.362.1.3

77. Hazarika P, Kakati N, Kalita RK. Indigenous knowledge in relation to conservation and management of forest biodiversity of Assam. Lifesciences Leafl. 2015;63:64–93. Available from: http://lifesciencesleaflets.ning.com

78. Singh N, Gajurel P, Rethy P. Ethnomedicinal value of traditional food plants used by the Zeliang tribe of Nagaland. Indian J Tradit Knowl. 2015;14(2):298–305. Available from: http://nopr.niscair.res.in/bitstream/123456789/32087/1/IJTK%2014(2)%20298-305.pdf

79. Singh TT, Sharma HM. An ethnobotanical study of monocotyledonous medicinal plants used by the scheduled caste community of Andro in Imphal East District, Manipur (India. Life Sci Informatics Publ. 2018;4(4):55–72. Available from: http://www.rjlbpcs.com/article-pdf-downloads/2018/20/278.pdf

80. Das G, Sharma RK. Diversity of wild plants used by the Jamatia tribe of Tripura for their edible underground plant parts. Int J Pharm Biol Sci. 2019;9(2):326–30. http://dx.doi.org/10.21276/ijpbs.2019.9.2.44

81. Ghosh D, Parida P. Medicinal plants of Assam, India: A mini review. Int J Pharmacol Pharm Sci. 2015;2(6):5–10. Available from https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.735.1075&rep=rep1&type=pdf

82. Sonowal R, Barua I. Ethnomedical practices among the Tai-Khamyangs of Assam, India. Stud Ethno-Medicine. 2011;5(1):41–50. https://doi.org/10.1080/09735070.2011.11886390

83. Gogoi P, Namita N. Indigenous Knowledge of ethnomedicinal plants by Assamese community, Journal of Threatened Taxa, 2021;13(5):18297-312. https://doi.org/10.11609/jott.6772.13.5.18297-18312.

84. Tamuli P, Ghosal A. Ethnomedicinal plants used by major ethnic groups of Assam (India) for curing skin diseases. Int J Herb Med. 2017;5(4): 140–44. Available from: https://www.florajournal.com/archives/2017/vol5issue4/PartB/6-3-20-495.pdf

85. Lalmuanpuii J, Rosangkima G, Lamin H. Ethno-medicinal practices among the Mizo ethnic group in Lunglei district, Mizoram. Sci Vis. 2013;13(1):24–34. Available from https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.403.4681&rep=rep1&type=pdf

86. Sharma HK, Chhangte L, Dolui AK. Traditional medicinal plants in Mizoram, India. Fitoterapia. 2001;72(2):146–16. https://doi.org/10.1016/s0367-326x(00)00278-1

87. Das N, Saikia SP, Sarkar S, Devi S. Medicinal plants of North-Kamrup district of Assam used in primary healthcare system. Indian J Tradit Knowl. 2006;5(4):489–93. Available from http://hdl.handle.net/123456789/6928

88. Sikdar M, Dutta U. Traditional phytotherapy among the Nath people of Assam. Stud. Ethno-Medicine. 2008;2(1):39–45. http://dx.doi.org/10.1080/09735070.2008.11886313

89. Saikia B, Borthakur SK, Saikia N. Medico-ethnobotany of Bodo tribals in Gohpur of Sonitpur district, Assam. Indian J Tradit Knowl. 2010;(9):52–54. Available from http://nopr.niscair.res.in/bitstream/123456789/7154/1/IJTK%209(1)%2052-54.pdf

90. Kutum A, Sarmah RHD. An ethnobotanical study of Mishing tribe living in fringe villages of Kaziranga National Park of Assam. Int J. 2011;1(4):45–61. Available from https://www.cibtech.org/J-LIFE-SCIENCES/PUBLICATIONS/2011/Vol%201%20No.%204/38-4-JLS-ROSHAN.pdf

91. Athokpam R, Bawari M, Duttachoudhry M. A review on medicinal plants of Manipur with special reference to Hepatoprotection. Int J Adv Pharm Res. 2014;5(3):182-91. Available from: 275215291_A_REVIEW_ON_MEDICINAL_PLANTS_OF_MANIPUR_WITH_SPECIAL_REFERENCE_TO_HEPATOPROTECTION

92. Panmei R, Gajurel PR, Singh B. Ethnobotany of medicinal plants used by the Zeliangrong ethnic group of Manipur, Northeast India. J Ethnopharmacol. 2019;235:164–82. https://doi.org/10.1016/j.jep.2019.02.009

93. Rai PK, Lalramnghinglova H. Ethnomedicinal plant resources of Mizoram, India: Implication of traditional knowledge in health care system. Ethnobot Leafl. 2010;14:274–305. Available from: http://publication/274832147_Ethnomedicinal_Plant_Resources_of_Mizoram_India_Implication_of_Traditional_Knowledge_in_Health_Care_System

94. Singh S, Phurailatpam AK, Wangchu L, Ngangbam P, Chanu TM. Traditional medicinal knowledge of underutilized minor fruits as medicine in Manipur. Int J Agric Sci. 2014;4(8): 241–47. Available from: chfcau.org.in/sites/default/files/pdf/epub/Underutilized-minor-fruits-as-medicine-in-Manipur.pdf

95. Murtem G, Chaudhry P. An ethnobotanical study of medicinal plants used by the tribes in Upper Subansiri district of Arunachal Pradesh, India. Am J Ethnomedicine. 2016;3(3):35–49. Available from: imedpub.com/articles/an-ethnobotanical-study-of-medicinal-plants-used-by-the-tribes-in-upper-subansiri-district-of-arunachal-pradesh-india.pdf

96. Das A, Borthakur MK. Hepatoprotective activity of *Chenopodium album* Linn. Against paracetamol induced liver damaged in Albino rats. International journal of pharmaceutical Sciences and Research. 2019;11(11): 5605-10. https://doi.org/10.13040/IJPSR.0975-8232.11(11):5605-10

97. Naghdi M, Maghbool M, Seifalah-Zade M, Mahaldashtian M, Makoolati Z, Kouhpayeh SA et al. Effects of common fig (*F. carica*) leaf extracts on sperm parameters and testis of Mice intoxicated with formaldehyde. Evidence Based complementary and Alternative Medicine. 2016; 2539127,9. https://doi.org/10.1155/2016/2539127.

98. Sharma RK, Geyal AK, Yadav SK, Bhat RA. Antifertility activity of *Ficus religiosa* fruits extracts on Goat uterus *in vitro*. Int J Drug Dev and Res. 2013;5(4):330-35.Available from: https://www.ijddr.in/drug-development/antifertility-activity-of-ficus-religiosa-fruits-extract-on-goat-uterus-invitro.php?aid=5798

99. Asraf K, Haque MR, Amir M, Ahmed N, Ahmed W, Sultan S et al. An overview of phytochemical and biological activities; *Ficus deltoidei* Jack and other *Ficus* spp. J pharm Bioallied Sci. 2021; 13 (1):11-25. https://doi.org/10.4103/jpbs.JPBS_232_19

100. Fulda S. Betulinic acid. A natural product with anticancer activity. Mol Nutr Food Res. 2009;53(1):140-46. https://doi.org/10.1002/mnfr.200700491

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