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Research Article

Ethnomedicinal Plants Used by the Pnar Tribes of Meghalaya for the Treatment of Diabetes Mellitus

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ABSTRACT

Diabetes mellitus is the world's major public health issue and has been dubbed the "Silent Epidemic" of the twenty-first century. This is the first ethnobotanical exploration to document the folk medicinal usage of plants with therapeutic antidiabetic properties by the Pnar tribes of East Jaintia Hills, Meghalaya. Forty-one practitioners and knowledgeable people were interviewed using a semi-structured questionnaire. Field inventories were then conducted to collect plant material for botanical identification. In this study, 51 plant species belonging to 34 families and 45 genera have been identified. This study indicates that herbs were the most prevalent living form used (N = 23) for the treatment. *Rhus semialata* is one of the most frequently cited medicinal plants, with a Relative Frequency of Citation (RFC) of 0.73. Moreover, the details about the phytochemicals and the pharmacological activities of identified plant species have been reviewed and disclosed. Agricultural expansion, deforestation, urbanization, and unscientific exploitation of the forests were cited most when respondents were asked about the threat to medicinal plants. Of the 51 plant species, 12 are included on the IUCN Red List. Therefore, this documentation of indigenous plants would create awareness about the importance of medicinal plants and their conservation and protection.

Keywords: Diabetes, Ethnomedicine, East Jaintia Hills, Indigenous knowledge, Medicinal plants, Meghalaya

Introduction

Diabetes mellitus is a metabolic disorder and a major growing health problem that gradually affects different body organs. It is defined as a rise in blood glucose levels after any sort of meal [1]. Insulin insufficiency or dysfunction is the cause of diabetes. This disease develops slowly, with symptoms appearing several years after the commencement of the disease. Severe and irreparable problems might occur during this period [2]. Diabetes is preventable, but if it is not well controlled, it increases the chance of developing other illnesses, notably cardiovascular problems. It occurs because the majority of diabetic patients also have other additional disorders, such as hyperlipidemia, hypertension, obesity, and reduced physical activity, which contribute to the etiology of cardiovascular diseases. It is estimated that 537.3 million adults (20-79 years) of the world's population are living with diabetes, and 6.7 million died in 2021. Moreover, diabetes is predicted to affect 643 million people by 2030 and 783 million by 2045 [3, 4].

Diabetes is linked to many long-term consequences, including damage to blood vessels, sores and infections, vision problems, a decreased ability to manage blood pressure and cholesterol, nerve damage and discomfort pain, requiring early diagnosis, treatment, and lifestyle adjustment[5]. Treatment of diabetes without side effects is still challenging for the medical community. Currently, there are several drugs available to treat hyperglycaemia in type 2 diabetes, including biguanides and sulfonylureas; however, these drugs have side effects [6]. Therefore, an increasing

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number of people are opting herbal medicines as an alternative therapy for diabetes owing to their fewer or no adverse effects [7, 8].

Natural products, particularly those of plant origin, have always been a great source of medications. Many of the now available drugs were produced from them, either directly or indirectly [9]. Such herbs have shown antidiabetic efficacy when assessed using various types of experimental tools [10]. Wide arrays of plants contain flavonoids, alkaloids, carotenoids, glycosides, and terpenoids, which have antidiabetic properties [11]. The anti-hyperglycemic effects of these plant constituents are often attributable to their ability to increase pancreatic tissue efficiency, achieved by enhancing insulin production or reducing intestinal glucose absorption [12]. Therefore, despite the availability of antidiabetic medications on the market, plant-based therapies are important components of modern pharmaceuticals, especially in rural areas, due to their accessibility, affordability, and lack of side effects.

The therapeutic impact of medicinal plants in Meghalaya's North, East, South, West and Central regions indicated that this state is a huge area to utilize herbs for treating common ailments, including fever, headache, infected wounds, stomach problems, etc [13,14,15]. However, there are very few published records on the ethnomedicinal use of the Pnar tribe. Therefore, the primary goal of this study is to highlight the number of medicinal plants recommended for the management of diabetes in the East Jaintia Hills, Meghalaya.

Material and Methods

Study area

Meghalaya, one of the Seven Sister States of North-eastern India, is surrounded by three unique tribal tribes- the Khasis, the Jaintias, and the Garos, each of which inhabits their respective hill district of the state. The study area, i.e., East Jaintia Hills district (Figure 1), is categorized as a remote area with few healthcare resources, leading residents to rely on traditional medicine. Traditional healers who use medicinal plant-based combinations for a variety of maladies show that traditional medicines are still a crucial component of their modern health treatment [16]. It is felt that prospection and exploration of medicinal plants, which play such a significant part in the health care of Pnar tribe, are needed to intensify a greater effort.

East Jaintia Hills, the eleventh district of Meghalaya, has a moderate climate with a humid subtropical monsoon-type environment. It is located between 25°21′29.74″ N latitude and 92°22′05.0″ E longitude and covers an area of 2040 sq. kilometres at an elevation around 1262 m above mean sea level. The rainy season starts from mid-May to September, with November to January being the

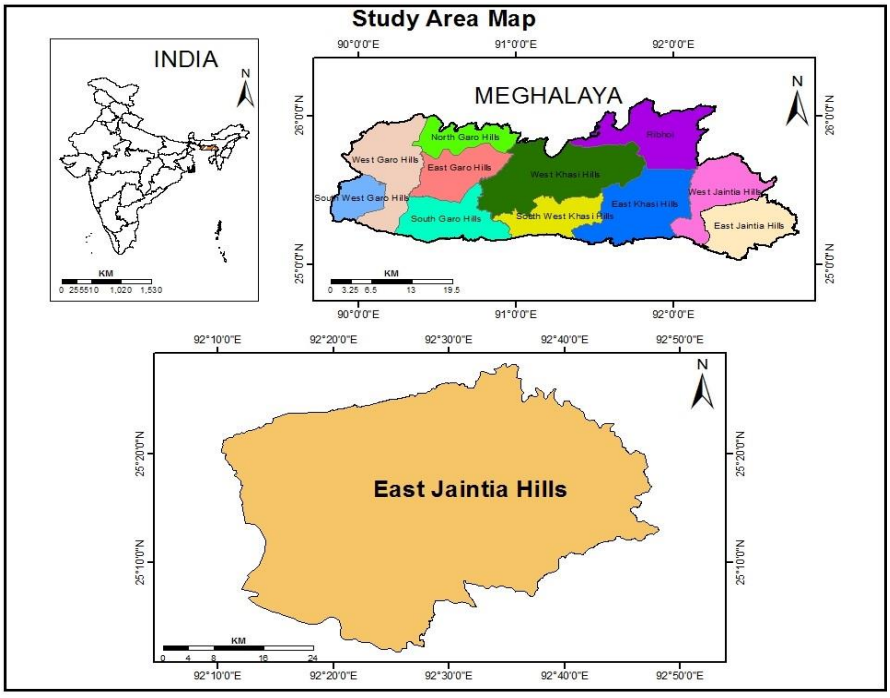

Figure 1. Location map of the study area

coldest months with an average temperature of 8.2˚C (46.8˚F), and the warmest month is August, with an average temperature of 29.5˚C (86.1˚F). The average annual temperature is about 18˚C (64.4˚F). The district is 97 kilometres from the state capital, and the National Highway 44 connecting Shillong and the eastern region of Assam passes through the district. The majority of the inhabitants in this area are Pnar tribes, and they all communicate in Pnar dialect.

Ethnobotanical data collection and investigation method

Field investigations were conducted in the East Jaintia Hills district between 2019 and 2021. Information about ethnomedicinal plants was obtained using questionnaires and semi-structured interviews with traditional healers and local people who can formulate remedies for their families or neighbours. The interactions mostly focused on their prior experience, the type of dosage form they used, duration of use, portions used, and the source of their knowledge. Medicinal plants indicated by the informant were photographed and noted with local names. Informants were urged to exhibit or gather the plants they use to treat diabetes wherever feasible. Field collected plant samples were dried and compressed in newspapers. Newspapers were replaced every day until they remained dry after compression. The dried specimens were mounted on herbarium-sheets accordingly [17], and identified with the aid of existing key books viz—Flora of Assam [18], Forest Flora of Meghalaya [19] and various e-floras. The Botanical Survey of India, Shillong, was later consulted to confirm species. The authenticity of the scientific and author names of the medicinal plants was further confirmed by accessing www.plantsoftheworldonline.org and www.theplantlist.org (in August 2020).

Data analysis

The collected data were pooled and analyzed in Microsoft Excel 2019. The tables, pie-chart, and graphs represent the result of the overall ethnomedicinal study in East Jaintia Hills, Meghalaya. In the current study, the following indices were calculated.

The Relative Frequency of Citation (RFC) value for medicinal plant species is calculated based on the referencing percentage of respondents for each species. The Frequency of Citation (FC) is the number of respondents who cited a specific species. The following formula proposed by Tardio and Pardo-de Santayana, 2008 [20] was determined to calculate RFC:

$$\mathrm{RFC} = \frac{\mathrm{FC}}{\mathrm{N}}, (0 < \mathrm{RFC} < 1)$$

RFC refers to the Relative Frequency of Citation, FC refers to the Frequency of Citation for each species, and N is the total number of respondents who participated in the survey. RFC varies from 0 (when no one refers to a plant as being useful) to 1 (when all informants consider a certain species beneficial).

The Family Importance Value (FIV) Index was determined by estimating the proportion of informants who mentioned a certain family [21]

$$\mathrm{FIV} = \frac{\mathrm{FC(Family)}}{\mathrm{N}} \times 100$$

Where FC is the number of informants who mentioned a certain family, and N is the total number of respondents.

Results and Discussion

Socio-economic characteristics of the interviewed households

The findings indicated that all interviewees who participated were married and were Christians**.** Among the 41 individuals, 23 (56%) males and 18 (44%) females, aged 29 to 83 years, were interviewed. The majority of the interviewers had primary education (32%), and 17% had attended up to higher education. As indicated in Table 1, the majority of the informants do not practice ethnomedicine full-time, or as a vocation; only 12% rely on ethnomedicine as their primary source of income. Most men were engaged in agriculture and business as their primary occupations, while most women were housewives. According to the mode of knowledge and practice experience acquisition, 46% of people obtain their knowledge from heredity and 54% through personal experience. Every interviewer had at least 10 to 20 years of expertise in their field, and 41% had more than 32 years of experience. These basic findings indicate that indigenous knowledge is well established among the elderly but appears to be declining in the younger generation as knowledgeable people keep their information secret.

Table 1. Demographic profile of informants (N=41)

Demographic	Variables	Frequency (%)
Gender	Male	56
	Female	44
Age group (years)	29-39 years	15
	40-46 years	17
	49-62 years	46
	63-72 years	12
	73-78 years	10
Educational qualifications	Illiterate	12
	Primary	32
	Middle	24
	Matriculate	15
	> Matriculate	17
Occupation	Herbal healer	12
	Farmer	24
	Government Servant	15
	others	27
	None	22
Mode of acquisition of knowledge	Inheritance	46
	Experience	54
Duration of working experience	10-20 years	49
	21-31 years	10
	>32 years	41

Documentation and enumeration of medicinal plants

The present study provides information on 51 medicinal plants, divided into 45 genera under 34 families, used by Pnar tribe for antidiabetic therapy. It is summarized in Table 2 and Figure 6. The most prevalent living forms among the identified plants were herbs (23 species), and trees (17 species). However, other growth forms were also identified and represented in (Figure 2a). The majority of plants' life spans were recorded as perennial (82.35%) and annual (17.65%) (Figure 2b). Most of the respondents obtained medicinal plants from forests or jungles (37.25%), gardens or farms (33.33%), and the rest (29.41%) were either imported or purchased from a nearby town or neighbouring regions (Figure 3). Herbs, which are the most commonly used, are generally easy to find, handle, and prepare, according to the participants. The substantial percentage of woody plants in our study is likely due to ability of trees to endure abundant rainfall, thus resulting in their richness and availability throughout the year.

Frequency of plant part(s) utilization

Diabetes patients require treatment all year long. Leaves, roots, and stems are widely available and can be harvested at any time of the year, whereas fruits, flowers, and seeds are seasonal. In our study, the most frequently used plant parts are the aboveground plant components, i.e., leaves (22 species), because they are the major photosynthetic organs and serve as a reservoir for anti-lethal exudates as well as being rich in bioactive secondary metabolites and therapeutic benefits for human health [22]. However, the following parts are used for diabetes treatment as depicted in Figure 4 fruits (14 species), complete plants (7 species), flowers (4 species), seeds (3 species), pods (2 species), bark (3 species), and subterranean portions of roots and rhizomes (5 species).

Mode of preparation and administration

The findings of our study validated that infusion and decoction (Figure 5) are the most favoured methods of administration, which is consistent with the findings of Nadaf *et al.* [23] and Napagoda *et al.* [24]. For most ethnomedicine in the research area, there is no standardized measure for the dosage. The dosage to be consumed is specified by traditional healers and experienced individuals, or it may also be taken depending on the severity of the condition. (Table 2).

Family importance value (FIV) of medicinal plants

The families with the most antidiabetic species, based on the number of FIV index was Ru-

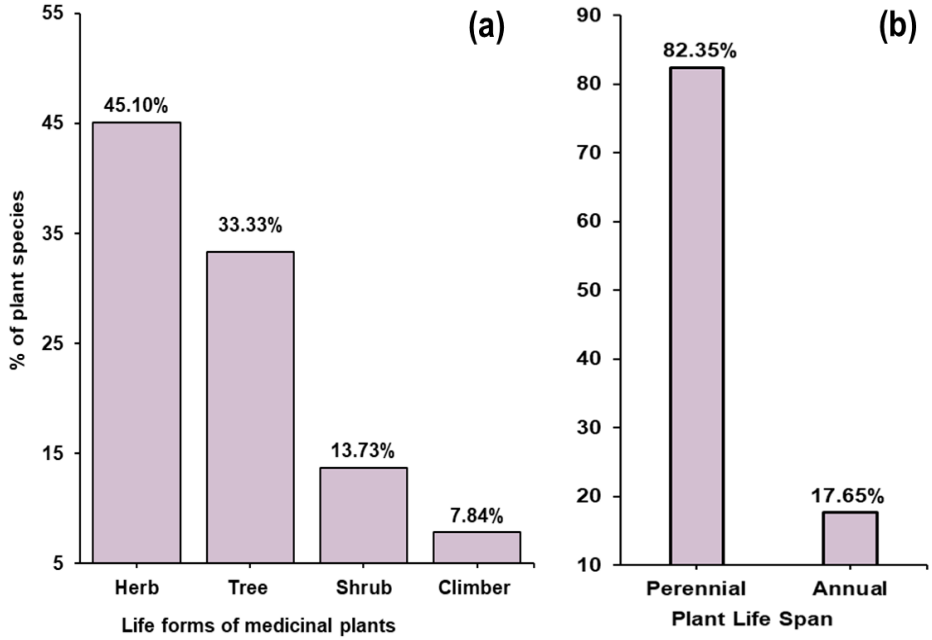

Figure 2. Growth habits of the recorded medicinal plant species (a) and plant life span of the study area (b).

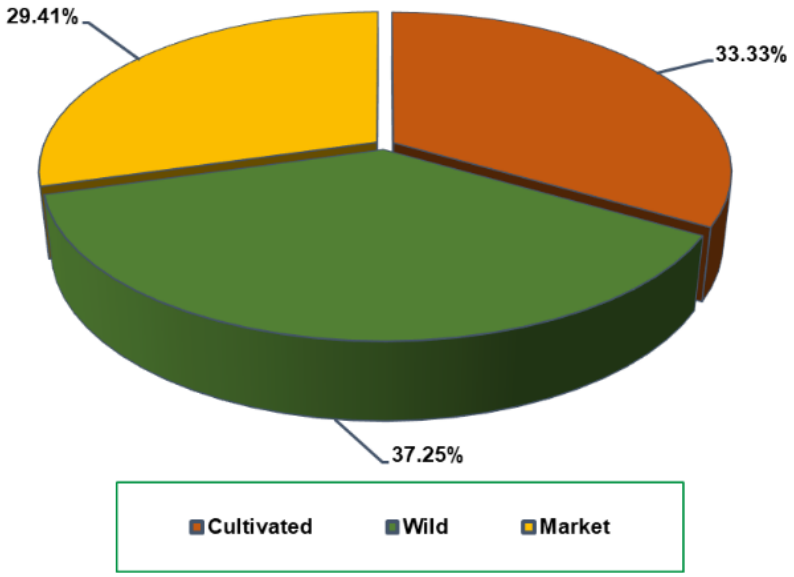

Figure 3. Source of medicinal plants used in the treatment of diabetes ailments

taceae (4 species with FIV 9.76) followed by Cucurbitaceae (3 species with FIV 7.32), Acanthaceae, Amaryllidaceae, Apiaceae, Apocynaceae, Euphorbiaceae Fabaceae, Malvaceae, Melastomaceae, Myrtaceae, Poaceae, Solanaceae and Zingiberaceae, (2 species with FIV 4.88 for each). The other remaining families were represented by one species each with an FIV Index of 2.44 (Figure 6 and Table 2). Similarly, Momin *et al.* [25] reported that the Rutaceae family has the largest number of plant species from a study conducted in the Garo hills region of Meghalaya.

Relative frequency of citation and frequency of citation

The frequency of mentioned antidiabetic effects in the interview for each plant ranged from 0.07 to 0.73, as shown in Table 2. *Rhus semialata* Murray was the most cited medicinal plant with an RFC of 0.73, followed by *Emblica officinalis* Gaertn. (0.63), *Solanum muricatum* Aiton (0.54), *Passiflora edulis* Sins (0.49), and *Ziziphus jujuba* Lank (0.46). The ethnomedicinal plant species with high RFC values indicate that the majority of the people in the research area choose to use plants

that are easily accessible, abundant locally, and have widespread knowledge among the local communities. Also, plants with a high frequency of citation are known to have a range of phytochemical substances.

Ammomum aromaticum Roxb has the lowest FC value with 0.07, indicating that the species is less commonly used for antidiabetic treatment, but it is abundant in the wild and is mostly used for making local rice brew, which is locally known as 'Sadhier or Kiad'. Indigenous people believe these drinks have restorative and medicinal properties, which can cure diarrhoea and urinary tract disorders. It is considered a health tonic, and a minimal amount is advised daily. However, because this drink contains alcohol, excessive consumption can

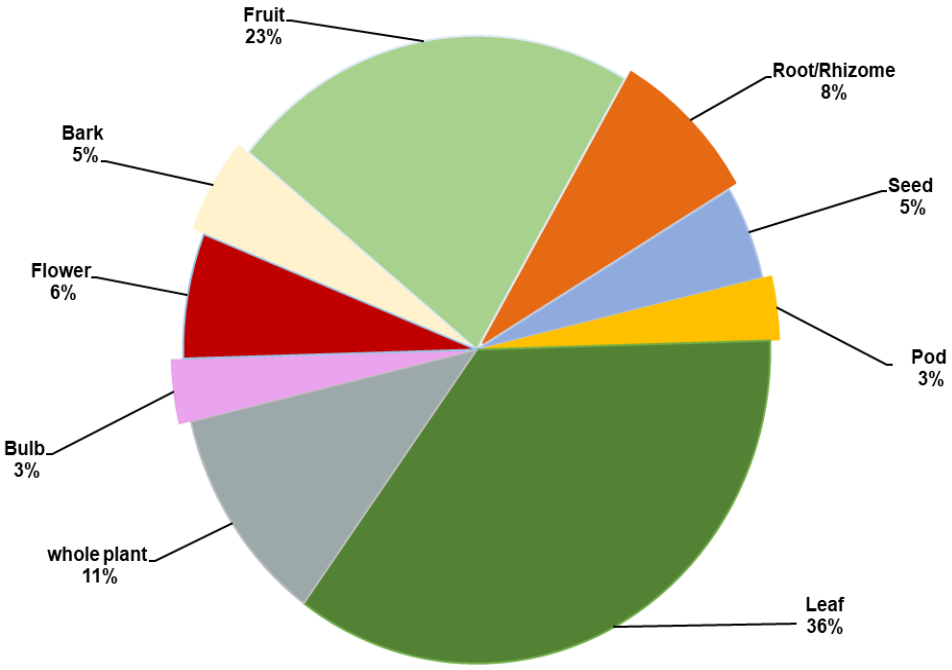

Figure 4. Depicting the usage of different parts of plants for the treatment of diabetes

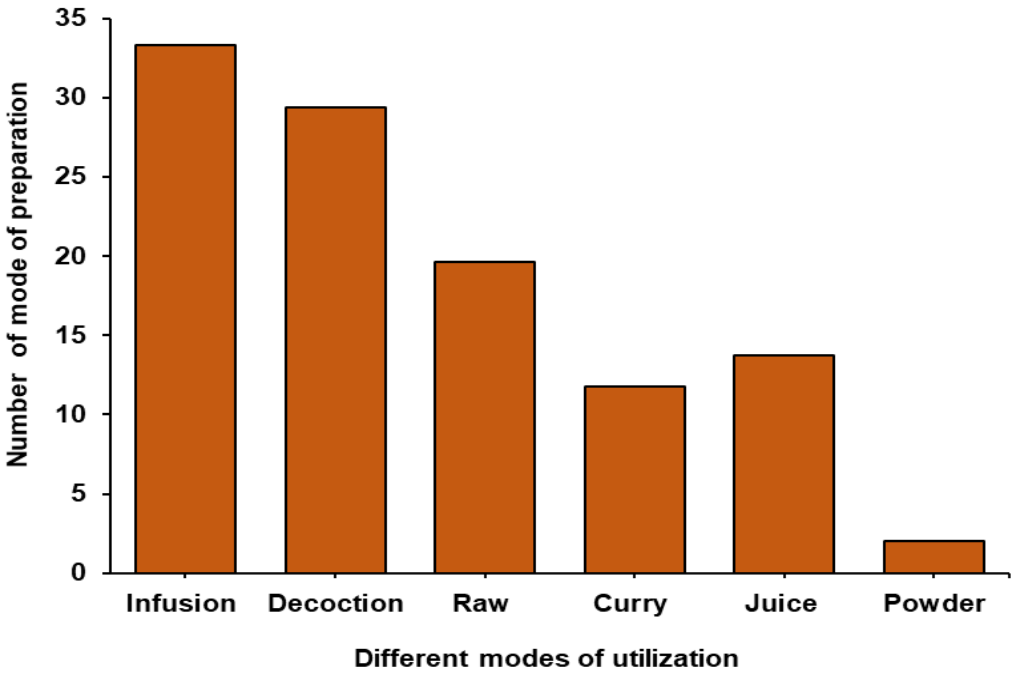

Figure 5. Distribution of formulation usage taken for the treatment of diabetes by the Pnar tribes

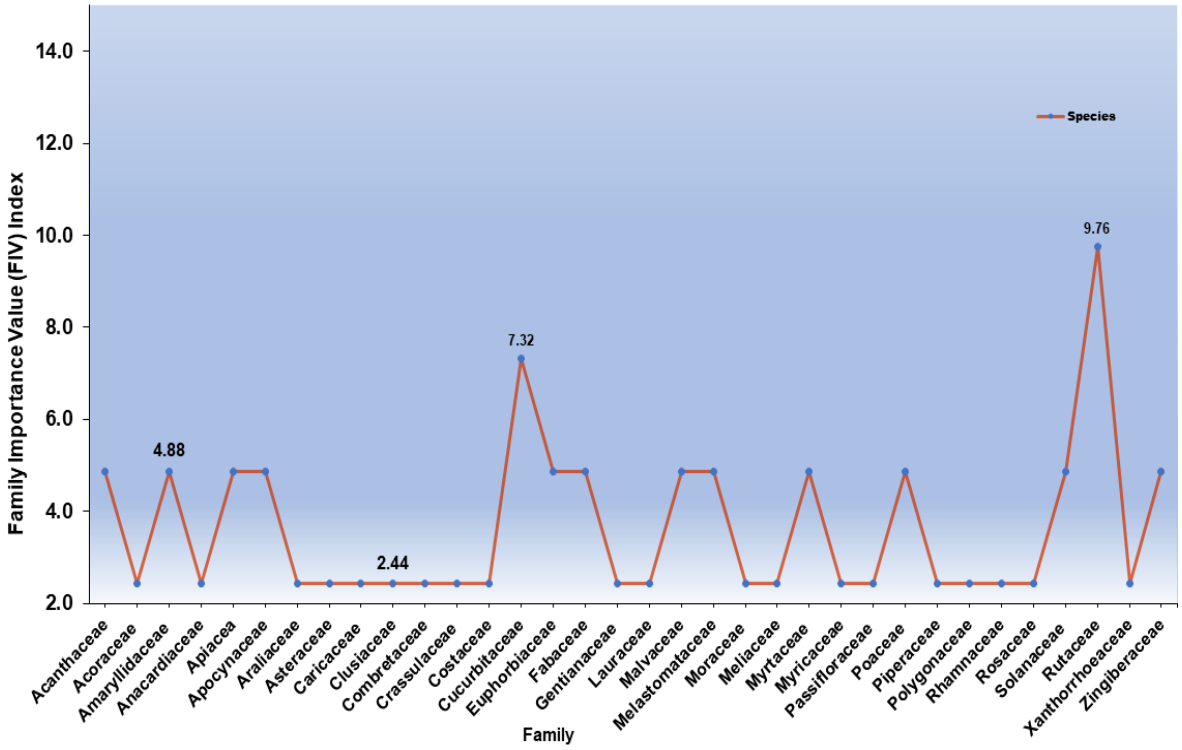

Figure 6. Family wise species arrangement with FIV Index

lead to intoxication and be harmful to one's health.

Phytochemicals of the reported ethnomedicinal plants

Our literature survey has indicated that the common phytochemicals and pharmacological activities in the reported plants are alkaloids, flavonoids, glycosides, terpenoids, tannins, and saponins (Table 2). These phytochemicals have been reported to have good antidiabetic properties. Flavonoids reduce diabetes aetiology and consequences by regulating glucose metabolism, hepatic enzyme activity, and lipid profile [26]. Tannins enhance the pathologic oxidative state of a diabetic condition by increasing glucose uptake and inhibiting adipogenesis [27]. Saponin helps lower blood glucose levels by blocking the enzymes that convert disaccharides to monosaccharides [28]. Glycosides help stimulate insulin secretion and inhibit α-amylase and α-glucosidase [29]. Triterpenes have the ability to block glucose metabolism enzymes, prevent diabetic complications, and regulate plasma glucose and insulin levels [30]. Therefore, these plant species commonly used by Pnar tribes for the treatment of diabetes should be further studied *in vivo* and scientifically validated. The outcome of scientific validation of this therapy may result in the discovery of promising phytochemicals against diabetes. Further, this finding will give ideas to synthetic organic Chemists to design and create novel compounds with enhance antidiabetic activity.

Conservation status and threat to medicinal plant resources

According to the IUCN Red List Categories and Criteria (Assessed on August 9th, 2022), 10 plant species were of Least Concern, 1 species was Data Deficient (2.1%), and 1 species was near threatened (NT) (2.1%), while the rest of the species have not yet been assessed, and the population trend status for each species is mentioned in (Table 3). Based on findings from the field survey, medicinal plant species are increasingly at risk from habitat degradation. The main causes listed were deforestation, fire, agricultural expansion, construction, overgrazing, urbanization, and unscientific exploitation of forests. The results of Lamare and Singh [87, 88] also indicated that extraction of limestone and the open dumping of overburden from adjacent mines have a negative impact on soil, water, and air quality, as well as on forest health and water availability, which eventually affects the flora and fauna of the study area.

Table 2. Details of ethnomedicinal plants used to treat diabetes in the East Jaintia Hills district

Family	Botanical Name	Vernacular name	Habit	Part used	Route of Administration	FC	RFC	Class of compounds
Acanthaceae	*Phlogacanthus puninervius* T. Anderson	Dein kajut (so)	Sh	L; Fl	An infusion of leaves is taken orally once a day. Curry prepared from aerial portion is eaten with rice.	9	0.22	Tannins, alkalodis, saponins, proteins, carbohydrates, and phenols [31].
	Phlogacanthus thyrsiformis (Roxb. ex Hardw.) Mabb.	Dein kajut (stem)	Sh	L; Fl	Infusion of leaves is taken orally once a day.	5	0.12	Tannins, alkaloids, saponins, proteins, carbohydrates, and phenols [31].
Acoraceae	*Acorus calamus* L.	Khahmat	H	Rt	Decoction of roots is administered orally, 2-3 cups a day.	11	0.27	Carbohydrates, alkaloids, glycosides, coumarin, saponin, deoxy sugar, flavonoid, quinones, and phenols [32].
Amaryllidaceae	*Allium cepa* L.	Piat	H	Bb	Juice of raw bulb is taken with meals.	13	0.32	Flavonoids, S-methyl cysteine sulfoxide, S-propyl cysteine sulfoxide, cycloalliin,thiosulfinates and sulfides [33].
	Allium sativum L.	Rasun	H	Bb	Raw bulbs are consumed with rice twice a day.	17	0.41	Carbohydrates, vitamins, amino acids, and lipids components [32].
Anacardiaceae	*Rhus semialata* Murray	Soh bluh	T	Fr	Fruit infusion is taken twice a day.	30	0.73	Flavonoids, triterpenoids, phenolics, tannins, coumarins, Urushiols, steroids, fatty acids, lignans, and aromatic alkanes [34].
Apiaceae	*Apium graveolens* L.	**S**elery	H	W	Decoction of the whole plant is taken orally once a day.	9	0.22	Caffeic acid. gallic acid,ferulic acid, quercetin, luteolin, chlorogenic acid, syringic acid, **p-** coumaric acid, and vanillic acid [35].
	Centella asiatica (L.) Urb.	Takhieh	H	W	A decoction of the entire plant is given once a day. Most of the time is consumed as salad.	10	0.24	Alkaloids , flavonoids, phytosteroids, and phenolic compounds [36].
Apocynaceae	*Alstonia scholaris* (L.) R. Br.	Dein thlen	T	B; Rt	Infusion of bark and roots is administered orally every morning on an empty stomach.	8	0.20	Alkaloids, flavonoids, glycosides, saponins, tannins and triterpenoids [37].
	Catharanthus roseus (L.) G. Don	Syntu jri	H	L; Fl	Three pieces of fresh leaves or flowers are consumed regularly.	11	0.27	Phenolic compounds and alkaloids such as vincristine, vinblastine, alstonine,

Family	Botanical Name	Vernacular name	Habit	Part used	Route of Administration	FC	RFC	Class of compounds
								serpentine, reserpine, and ajamalicine [38].
Araliaceae.	*Hydrocotyle javanica* Thunb	Takhieh heh sla	H	W	Fresh juice is taken once a day.	7	0.17	Coumarins, flavonoids, saponins, terpenoids, phenols, glycosides, cardiac glycosides, tannins, steroids and phytosterols [39].
Asteraceae	*Vernonia amygdalina* Delile	Dein shini	Sh	L	Infusion of leaves is taken once a day.	13	0.32	Reducing sugar, glycosides, flavonoids, saponins, terpenoids, alkaloids and tannins [40].
Caricaceae	*Carica papaya* L.	Soh kymphor	T	Fl; L	Fried flowers are taken every day to reduce the blood glucose level. Decoction of tender leaves is taken once a day.	15	0.37	Saponins, glycosides, terpenoids, alkaloids, polyphenol, flavonoids and tannins [41].
Clusiaceae	*Garcinia pedunculata* Roxb.	Dieng soh darnei	T	Ft	The fruit is boiled until it becomes concentrated, then 1 cup of the filtered decoction is taken twice a day.	14	0.34	Phenolics which included gallic, benzoic, tannic, vanillic, pyrogallol, and trans-cinnamic acids, as well as flavonoids like naringin, catechin, quercetin, and rutin [42].
Combretaceae	*Terminalia chebula* Retz.	Soh kthang	T	Fr	Dried / fresh fruits are consumed every day.	6	0.15	Alkaloids, cardiac glycosides, carbohydrates, flavonoids, steroid, saponins, tannins, and phenolics [43].
Costaceae	*Chamaecostus cuspidatus* (Nees & Mart.) C. D. Specht & D.W. Stev.	Dawai shini	H	L	One fresh leaf is consumed every day to prevent diabetes.	11	0.27	Catechin, caffeoyl putrescine, proline, caffeic acid, gracillin, zerumbone, and linoleic acid [44].
Crassulaceae	*Bryophyllum pinnatum* (Lam.) Oken	Syntu ing	H	L	Raw leaves are consumed 2-3 times a day.	8	0.20	Glycosaponins, tannins, steroidal, polyphenols, glycosides, flavonoids, and tannins [45].
Cucurbitaceae	*Momordica balsamina* L.	Kerela (khian)	C	Fr	The fruits are fried in a small amount of mustard oil with a piece of *Allium cepa* and taken twice a day.	9	0.22	Flavonoids, phenols, tannins, saponins, lectins, and amino acids [46, 47].
	Momordica charantia L.	Kerela (dkhar)	C	Fr	Juice prepared from fresh fruits is taken once a day.	11	0.27	Momordicosides, amino acids, amines, momordin, sterols,

Family	Botanical Name	Vernacular name	Habit	Part used	Route of Administration	FC	RFC	Class of compounds
								carbohydrates, flavonoids, glycosides saponins, polypeptide p- insulin, and charatin [48, 49].
	Sechium edule (Jacq.) Sw.	Biskot	C	Fr; L	It is cooked as vegetables and eaten every day with meals.	10	0.24	Phenolics, flavonoids tannins [50].
Euphorbiaceae	*Emblica officinalis* Gaertn.	Soh saplo	T	Fr	Three fresh fruits are taken regularly to prevent diabetes.	26	0.63	Beta amyirin, beta-sitosterol, estradiol, ellagic acid, leucodelphinidin, sesamine, kaempferol, quercetin, dapagliflozin, and zeatin [51].
	Phyllanthus amarus Schumach. & Thonn.	Sla bhumi amla	H	L	Infusion of dried or fresh leaves is administered orally twice a day.	4	0.10	Anthraquinones, flavonoids, tannins, cardiac glycosides, alkaloids, and saponin [52].
Fabaceae	*Tamarindus indica* L.	Soh spain tylli	T	Fr	Infusion of fruit is taken once a day.	16	0.39	Alkaloids, anthraquinones, glycosides, proteins, and saponins [53].
	Trigonella foenum- graecum L.	Fenugreek	H	S	An infusion of seeds powder was kept overnight and drank the next morning.	11	0.27	Flavonoids, alkaloids, carbohydrate, steroid, glycoside and glycosides [54, 55].
Gentianaceae	*Swertia charita* (Roxb.) Buch. -Ham. ex C.B.Clarke	Shirta	H	W	Infusion of the whole plant is administered orally twice a day	9	0.22	Flavonoids, saponins, tannins, alkaloids, emodins, proteins, coumarins, glycosidea, terpenoids, steroids and carbohydrates [56]
Lauraceae	*Cinnamomum tamala* (Buch. -Ham.) T.Nees & C.H.Eberm.	Sla tyrpad	T	L	Infusion of leaves was kept for an hour and is taken in 2-3 cups daily.	10	0.24	Flavones, alkaloids, steroids, glycosides, and terpenoids [57].
Malvaceae	*Abelmoschus esculentus* (L.) Moench.	Bindi	H	P	After cutting both ends of two pods, split them in half in the middle. Place them in a glass of water overnight and consume the decoction before breakfast the next day.	7	0.17	Polysaccharides flavonol glycosides, and tannin [58, 59].
	Hibiscus sabdariffa L.	Jajew	Sh	L; Fr	Decoction of dried fruit is consumed daily after meals. Leaves	6	0.15	Anthraguinone, alkaloids, cardiac glycoside, phlobatannins, flavonoids, phenols,

Family	Botanical Name	Vernacular name	Habit	Part used	Route of Administration	FC	RFC	Class of compounds
					are also prepared with curry.			saponins, steroids, terpens, and tannins [60].
Melastomataceae	*Melastoma malabathricum* L.	Slidong	Sh	L	A decoction of fresh leaves is taken every day to reduce the blood glucose level.	10	0.24	Flavonoids, tannins, steroids, saponins, alkaloids, carbohydrates, proteins and amino acids [61].
	Osbeckia nepalensis Hook.	Sla slidong (lieh)	Sh	L	Decoction of leaves is administered orally once a day. Also cooked as vegetables.	11	0.27	Saponin, flavonoids and antioxidant [62].
Meliaceae	*Azadirachta indica* A. Juss.	Sla neem	T	L; Rt; B	Infusion of leaves, roots, or bark is taken orally once a day during the day.	5	0.12	Azachdirichtin, acetyl oxyturanoe acid, gliserid oil, and meliacinolin [63].
Moraceae	*Morus alba* L.	Soh mariat	T	Ft; Rt	Infusion of roots is taken twice a day. One glass of fruit juice is consumed each day.	15	0.37	Antidiabetic, anterosclerosis, alkaloids, flavonoids, stilbenoids and anti-obesity [64].
Myricaceae	*Myrica esculenta* Buch. - Ham.ex D. Don	Soh siliya	T	Fr	Fruit juice is taken orally twice a day.	12	0.29	Alkaloids, diarylheptanoids, ionones, steroids, saponins, triterpenoids, glycosides, carbohydrates, proteins, flavonoids and flavonols [65].
	Myrica nagi Thunb.	Soh saphe	T	Fr; B	Decoction of bark is taken. Fresh fruits are consumed 6-10 pieces every day.	9	0.22	Flavonoids, phenols, resin, tannins, glycosides, carbohydrates, proteins, and lipids [66].
Myrtaceae	*Psidium guajava* L.	Soh priam	T	L	Decoction of leaves is taken in one cup on alternate days.	8	0.20	Alkaloids, anthraquinone, coumarin, fixed oil, saponin gycosides, steroidal glycosides, quinones, carbohydrates, total proteins, flavonoids, tannin, and terpenoids [67].
Passifloraceae	*Passiflora edulis* Sins	Soh brab	C	L	Decoction of leaves is taken once a day.	20	0.49	Alkaloids, saponins, flavonoids and mainly polyphenols [68].
Piperaceae	*Piper betel* L.	Pathi	H	L	Juice made from 3 or 5 fresh leaves is taken once a day. Betel leaves are also chewed with *Areca catechu* and	15	0.37	Flavonoids, alkaloids, phenol, saponins, sterols, quinines, and tannins [69].

Family	Botanical Name	Vernacular name	Habit	Part used	Route of Administration	FC	RFC	Class of compounds
					mineral slaked lime.			
Poaceae	*Cymbopogon citratus* (DC.) Stapf	Lemon grass	H	W	Decoction of the leaves or roots is taken twice a day.	11	0.27	Flavonoids, phenolics, alkaloids, alkaloids, and saponins, [70].
	Cymbopogon nardus (L.) Rendle	Lemon grass	H	W	Infusion of the leaves or roots is taken twice a day.	9	0.22	Carbohydrates, saponins, steroids, saponins, glycosides, flavonoids, phenolics, protein and amino acids [71].
Polygonaceae	*Fagopyrum acutatum* Mansf. ex K.Hammer	Iarain	H	W	Cooked as vegetables and consumed twice a day to prevent diabetes.	11	0.27	Tannins, phenolics, flavonoids, steroids, volatile oils [72]
Rhamnaceae	*Ziziphus jujuba* Lank	Soh broi	T	L; Fr	Infusion of leaves and fruits is taken in 1 cup twice a day after meals.	19	0.46	Triterpenes, phenolic acids, flavonoids and quercetin glycosides [73, 74].
Rosaceae	*Potentilla fulgens* Wall	Pathang	H	Rt	Roots are chewed every day along with betel nut (*Areca catechu* L.), betel leaves *(Piper betel* L.) and small amount of mineral slaked lime.	7	0.17	Tannins, flavonoids, triterpenoids, polyphenol [75].
Rutaceae	*Aegle marmelos* (L.) Correa	Soh bel	T	S	Infusion of dried and ground seeds is taken regularly.	4	0.10	Alkaloids(marmelosin [76], glycosides, saponins, tannins, coumarins, anthraquinones, flavonoids, and carbohydrates,12-hydroxyoctadec-cis-9-enoic acid [77, 78].
	Citrus maxima Merr.	Sohbah	T	S	Infusion of seed powder was kept for 2-3 hours and is taken orally.	10	0.24	Antidiabetic, amino acids, carotenoids, polyphenols, terpenoids, vitamins, and sterols [79].
	Glycosmis pentaphylla (Retz)D.C	Sohsning	Sh	Fr; L	Fruits are eaten raw. Decoction of leaves is taken twice a day.	6	0.15	Amides, alkaloids, glycosides, flavonoids, steroids, terpenoids, phenolic compounds, and fatty derivatives [80].
	Murraya koenigii (L.) Spreng.	Sla curry	T	L	Decoction of leaves is taken orally at 2-3 cups daily after food.	7	0.17	Saponins, flavonoid, tannins, alkaloids, glycosides [81].
Solanaceae	*Solanaum incanum* L.	Synthang khian	H	Fr	2-6 pieces of fresh fruit are eaten daily with meals.	10	0.24	Alkaloids, flavonoids, saponins and phenolic acids [82].

Family	Botanical Name	Vernacular name	Habit	Part used	Route of Administration	FC	RFC	Class of compounds
	Solanum muricatum Aiton	Soh shini	H	Fr	2-4 pieces of fruit are consumed each day.	22	0.54	Antidiabetic, flavonoids, and phenol as antioxidant [83].
Xanthorrhoeaceae	*Aloe vera* (L.) Burm.f.	Syntu Aloe vera	H	L	30 ml of juice prepared from fresh leaf pulp is taken once a day.	8	0.20	Glycosides, proteins, carbohydrates, anthraquinones, amino acids, sterols, glucomannans and lipids [84].
Zingiberaceae	*Ammomum aromaticum* (Roxb)	Sla thiat	H	L	Decoction of leaves is taken once a day.	3	0.07	Volatile oils(cineole, neral, geranial, α-terpineol) [85].
	Curcuma longa L.	Shyrmit	H	Rh	Half a tablespoon of rhizome powder is mixed with 100ml of milk and is taken every morning.	15	0.37	Triterpenoids/steroids, phenols, alkaloids, terpenoids, flavonoids, and tannins [86].

Abbreviations: FC=Frequency of citation; RFC= Relative Frequency of Citation; T= Tree; Sh=Shrub; H=Herb; C=Climber; L=Leaf; Fr= Fruit; W=Whole plant, Fl=Flower; S=Seed, Rt=Root; Rh=Rhizome; Bb=Bulb; P=Pod and B=Bark

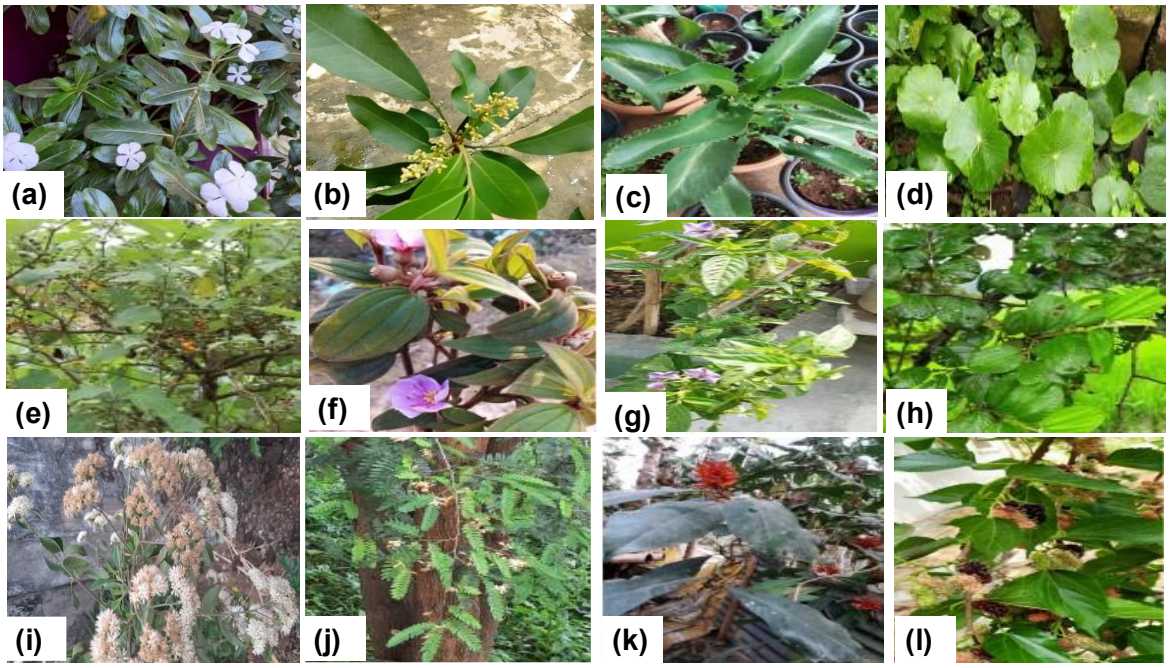

Figure 7. Selected images of medicinal plants in the study area. (a) *Catharanthus roseus* (L.) G. Don, (b) *Glycosmis pentaphylla* (Retz) D.C, (c) *Bryophyllum pinnatum* (Lam.) Oken, (d) *Hydrocotyle javanica* Thunb, (e) *Solanaum incanum* L., (f) *Melastoma malabathricum* L., (g) *Solanum muricatum* Aiton, (h) *Ziziphus jujuba* Lank (i) *Vernonia amygdalina Delile,* (j) *Tamarindus indica* L, (k) *Phlogacanthus puninervius T. Anderson, (l) Morus alba* L.

The conservation of medicinal plants has been found to be extremely poor. The main impediments to the preservation and conservation of medicinal plants were a lack of awareness and knowledge of the importance of medicinal plants among the indigenous community residing in or close to the research region. This was because most individuals who possessed knowledge of medicinal plants passed away without adequately passing it on to the next generation.

Table 3. IUCN Red Listed medicinal plants recorded in the study area

Botanical Name	IUCN Status	Assessed Date	Status (2022)
Acorus calamus L.	LC	27th February 2013	Increasing
Aegle marmelos (L.) Correa	NT	13th November 2019	NA
Alstonia scholaris (L.) R. Br.	LC	9th August 2020	NA
Apium graveolens L.	LC	2nd May 2012	Increasing
Azadirachta indica A. Juss.	LC	15th January 2018	Stable
Carica papaya L.	DD	29th July 2016	Decreasing
Centella asiatica (L.) Urb.	LC	17th April 2018	Stable
Cinnamomum tamala (Buch. -Ham.) T.Nees & Eberm.	LC	10th June 2019	Decreasing
Citrus maxima Merr.	LC	12th June 2018	Stable
Emblica officinalis Gaertn.	LC	28th August 2019	Decreasing
Terminalia chebula Retz.	LC	25th September 2020	NA
Ziziphus jujuba Lank	LC	1st March 2007	NA

Conclusion

The present research concludes that the people of East Jaintia Hills, Meghalaya, who have an extensive knowledge of medicinal plants and rely on them for the treatment of diabetes, were found to employ 51 plant species. Relevant information on medicinal plants is more common among the elderly. The younger generation is apathetic about their use because of their proclivity towards allopathy treatment. To the best of our knowledge, the present study is most probably the first initiative to document the ethnomedicinal plants of the East Jaintia Hills district, Meghalaya, which enabled us to contribute in a small way to the preservation of the indigenous medical systems. Our findings indicate that the richness of plant species is diminishing because of human intrusion, including randomly harvesting young plants, unscientific heavy industries, and overexploitation, etc. This has triggered the destruction of habitats of medicinal plants, leading to a reduction in the biodiversity of medicinal plants. As a result, natives should be encouraged to use medicinal plants sustainably by adopting appropriate conservation measures. It is also essential to educate the next generation about the therapeutic uses of medicinal plants as they serve as the basis for the discovery of new drugs; otherwise, this knowledge will fade with time.

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References

1. Modak M, Dixit P, Londhe J, et al. (2007) Indian herbs and herbal drugs used for the treatment of diabetes. Journal of Clinical Biochemistry and Nutrition 40 (3): 163-173. doi: 10.3164/jcbn.40.163.
2. Powers, A.C. (2011) Diabetes Mellitus. In Longo, D.N., Kasper, D.L., Jameson, J.L., Fauci, A.S., Hauser, S.L. and Loscalzo, J., Eds., Harrison's Principles of Internal Medicine, 18th Edition, Volume 2, McGraw-Hill Companies, Inc., New York, 2968-3009 - References - Scientific Research Publishing.https://www.scirp.org/(S(351jmbntvnsjt1aadkozje))/reference/referencespapers.aspx?referenceid=541067. Accessed: June 2022.
3. Al Mouslem AK (2022) Antidiabetic and hypolipidemic potentials of extract of Picris babylonica in Streptozotocin-Induced Diabetic Model in Rats. Biomedical and Pharmacology Journal 15 (1): 261-267. doi: 10.13005/bpj/2362.
4. Magliano D, Boyko E, Balkau B, et al. (2021) International Diabetes Federation, IDF Diabetes Atlas. 10 ed, ed. I.D. Federation. Brussels, Belgium.
5. Srithi K, Trisonthi C, Wangpakapattanawong P, et al. (2012) Medicinal plants used in Hmong women's healthcare in northern Thailand. Journal of Ethnopharmacology 139 (1): 119-135. doi: 10.1016/j.jep.2011.10.028.
6. Kameswara Rao B, Giri R, Kesavulu MM, et al. (2001) Effect of oral administration of bark extracts of Pterocarpus santalinus L. on blood glucose level in experimental animals. Journal of Ethnopharmacology 74 (1): 69–74. doi: 10.1016/S0378-8741(00)00344-5.
7. Noor A, Gunasekaran S, Amirtham S, et al. (2008) Antidiabetic activity of Aloe vera and histology of organs in streptozotocin-induced diabetic rats. Current Science 94(8): 1070-1076.
8. Rao MU, Sreenivasulu M, Chengaiah B, et al. (2010) Herbal medicines for diabetes mellitus: A Review. International Journal of PharmTech Research 2(3): 1883-1892.
9. Sharifi-Rad M, Nazaruk J, Polito L, et al. (2018) Matricaria genus as a source of antimicrobial agents: From farm

to pharmacy and food applications. Microbiological Research 215: 76–88. doi: 10.1016/j.micres.2018.06.010.
10. Salehi B, Martorell M, Arbiser J, Sureda A, et al. (2019) Antidiabetic potential of medicinal plants and their active components. Biomolecules 9 (10): 551. doi: 10.3390/biom9100551.
11. Afrisham R, Aberomand M, Ghaffari MA, et al. (2015) Inhibitory Effect of Heracleum persicum and Ziziphus jujuba on Activity of Alpha-Amylase. Journal of Botany 1–8. doi: 10.1155/2015/824683.
12. Kooti W, Farokhipour M, Asadzadeh Z, et al. (2016) The role of medicinal plants in the treatment of diabetes: a systematic review. Electronic physician 8 (1): 1832–1842. doi: 10.19082/1832.
13. Langshiang AS, Debnath A, Bhattacharjee A, et al. (2020) Traditional healing practices of Pnar and War communities in West Jaintia Hills district of Meghalaya, Northeast India. Indian Journal of Traditional Knowledge (19(4): 776-787.
14. Kayang H, Kharbuli B, Myrboh B, et al. (2005) Medicinal plants of Khasi hills of Meghalaya, India. Acta Horticulturae (675) 1: 75–80. doi: 10.17660/ActaHortic.2005.675.9.
15. Marak NM, Lalnundanga (2018) Enumeration of ethnomedicinal plants in Rongram Block of West Garo Hills District, Meghalaya. Science Vision 18 (1): 16–21. doi: 10.33493/scivis.18.01.03.
16. Bamon F, Lalnundanga (2022) Indigenous use of medicinal plants by the Pnar community in East Jaintia Hills District, Meghalaya. Journal of Complementary Medicine Research 13 (4): 53. doi: 10.5455/jcmr.2022.13.04.11.
17. Jain, Rao (1977) Handbook of field and herbarium methods.
18. Kanjilal UN, Kanjilal PC, Dey RM, et al. 1934) Flora of Assam, IV. Government of Assam, Assam, India.
19. Haridasan K, Raghavendra Roa R (1985) Forest flora of Meghalaya. Dehra Dun, India, Bishen Singh Mahendra Pal Singh.
20. Tardío J, Pardo-de-Santayana M (2008) Cultural Im portance Indices: A Comparative Analysis Based on the Useful Wild Plants of Southern Cantabria (Northern Spain)1. Economic Botany 62 (1): 24–39. doi: 10.1007/s12231-007-9004-5.
21. Vitalini S, Iriti M, Puricelli C, et al. (2013) Traditional knowledge on medicinal and food plants used in Val San Giacomo (Sondrio, Italy)—An alpine ethnobotanical study. Journal of Ethnopharmacology 145 (2): 517–529. doi: 10.1016/j.jep.2012.11.024.
22. Ahmad M, Sultana S, Fazi-i-Hadi S, et al. (2014) An Ethnobotanical study of Medicinal Plants in high mountainous region of Chail valley (District Swat- Pakistan). Journal of Ethnobiology and Ethnomedicine 10(36): 1-18. doi: org/10.1186/1746-4269-10-36
23. Nadaf M, Joharchi M, Amiri MS (2019) Ethnomedicinal uses of plants for the treatment of nervous disorders at the herbal markets of Bojnord, North Khorasan province, Iran. Avicenna Journal of Phytomedicine 9 (2): 153–163.
24. Napagoda MT, Sundarapperuma T, Fonseka D, et al. (2018) An Ethnobotanical Study of the Medicinal Plants Used as Anti-Inflammatory Remedies in Gampaha District, Western Province, Sri Lanka. Scientifica 1-8. doi: 10.1155/2018/9395052.
25. Momin KCh, Suresh CP, Momin BC, Singh YS, et al. (2016) An ethno-botanical study of wild plants in Garo Hills region of Meghalaya and their usage. International Journal of Minor Fruits, Medicinal and Aromatic Plants 2(1): 47-53.
26. AL-Ishaq, Abotaleb M, Kubatka P, et al. (2019) Flavonoids and their antidiabetic effects: cellular mechanisms and effects to improve blood sugar levels. Biomolecules 9 (9): 430. doi: 10.3390/biom9090430.
27. Kumari M, Jain S (2012) Tannins: An antinutrient with positive effect to manage diabetes. Research Journal of Recent Sciences 1 (12): 1–4.
28. Barky ARE, Hussein SA, Alm-Eldeen A-E, et al. (2017) Saponins and their potential role in diabetes mellitus. Diabetes Management 7 (1): 148.
29. Adki KM, Kulkarni YA (2021) Glycosides from Natural Sources in the Treatment of Diabetes Mellitus. In: Chen H, Zhang M eds Structure and Health Effects of Natural Products on Diabetes Mellitus. Singapore, Springer Singapore. 81-102. 10.1007/978-981-15-8791-7_5.
30. Nazaruk J, Borzym-Kluczyk M (2015) The role of triterpenes in the management of diabetes mellitus and its complications. Phytochemistry Reviews 14 (4): 675-690. doi: 10.1007/s11101-014-9369-x.
31. Kripasana K, Xavier J (2020) Phytochemical analysis and antioxidant activity of leaf extracts of some selected plants of the family Acanthaceae. Plant Science Today 7 (2): 264-274. doi: 10.14719/pst.2020.7.2.717.
32. Chakraborty R, Sen S, Ali Ahmed F, et al. (2020) Evaluation of in vitro antidiabetic and anti-oxidant potential of Acorus calamus rhizome. Indo Global Journal of Pharmaceutical Sciences 10 (3): 35–40. doi: 10.35652/IGJPS.2020.10304.
33. Galavi A, Hosseinzadeh H, Razavi BM (2020) The effects of Allium cepa L. (onion) and its active constituents on metabolic syndrome: A review. Iranian Journal of Basic Medical Sciences 24(1): 3-6. doi: 10.22038/ijbms.2020. 46956.10843.
34. Li M, Wang A, Zhang Y, Han T, et al. (2022) A comprehensive review on ethnobotanical, phytochemical and pharmacological aspects of Rhus chinensis Mill. Journal of Ethnopharmacology 293:115288. doi: 10.1016/j.jep.2022.115288.
35. Pérez Gutiérrez RM, Muñiz-Ramirez A, Garcia-Campoy AH, et al. (2021) Evaluation of the antidiabetic potential of extracts of Urtica dioica, Apium graveolens, and Zingiber officinale in Mice, Zebrafish, and Pancreatic β-Cell. Plants 10 (7): 1438. doi: 10.3390/plants10071438.
36. Rahman, S, M A H Mostofa J, Parvin A, et al. (2011) Antidiabetic activity of Centella asiatica (L.) urbana in alloxan induced type 1 diabetic model rats. Journal of Bio-Science 9(19): 23-27. doi: org/10.3329/jbs. v19i0.12996.
37. Boggula N, Chettupalli AK, Reddy NS, et al. (2017) Anti diabetic effect of Alstonia scholaris linn bark in alloxan induced diabetic rats. Journal of Global Trends in Pharmaceutical Sciences 8(1): 3590-3598.
38. Goboza M, Meyer M, Aboua YG, et.al (2020) In vitro antidiabetic and antioxidant effects of different extracts of Catharanthus roseus and its indole alkaloid, Vindoline. Molecules 25(23): 5546. doi.org/10.3390/molecules25235546.
39. Krithika N, Arumugasamy K (2016) phytochemical screening and in vitro antioxidant activities of ethnomedicinal plant Hydrocotyle javanica Thunb. (Apiaceae).

Journal of Environmental Nanotechnology 5 (4): 27–33. doi: 10.13074/jent.2016.12.164214.
40. Asante D-B, Effah-Yeboah E, Barnes P, et al. (2016) Antidiabetic Effect of Young and old ethanolic leaf extracts of Vernonia amygdalina: A comparative study. Journal of Diabetes Research 1–13. doi: 10.1155/2016/8252741.
41. Ogundele AV, Otun KO, Ajiboye A, et al. (2016) Antidiabetic efficacy and phytochemical screening of methanolic leaf extract of pawpaw (Carica papaya) Grown in North Central Nigeria. Journal of the Turkish Chemical Society, Section A: Chemistry 4 (1): 99-144. doi: 10.18596/jotcsa.52813.
42. Ali Md Y, Paul S, Tanvir EM, Hossen Md, et al. (2017) Antihyperglycemic, Antidiabetic, and Antioxidant Effects of Garcinia pedunculata in Rats. Evidence-Based Complementary and Alternative Medicine 1–15. doi: 10.1155/2017/2979760.
43. Gupta A, Kumar R, Pandey AK (2020) Antioxidant and antidiabetic activities of Terminalia bellirica fruit in alloxan induced diabetic rats. South African Journal of Botany 130: 308–315. doi: 10.1016/j.sajb.2019.12.010.
44. Shukla V, Bajpai V, Singh P Rai p, et al. (2022) Identification and quantification of phytochemicals of Chamaecostus cuspidatus (Nees & Mart.) C.D.Specht & D.W.Stev and Cheilocostus speciosus (J. Koenig) C.D.Specht by LC-MS techniques and their in - vitro antiadipogenic screening. Natural Product Research 1–5. doi: 10.1080/14786419.2022.2050225.
45. Latif A, Ashiq K, Qayyum M (2019) Phytochemical and pharmacological profile of the medicinal herb: Bryophyllum pinnatum. Journal of Animal & Plant Sciences, 29(6): 1528-1534.
46. Sani AA, Idris SB, Yakubu S (2019) Antidiabetic activity of methanolic extract of Momordica balsamina in Rabbits. Scientific Research Journal 7(6): 1-6. doi: 10.31364/SCIRJ/v7. i6.2019.P0619657
47. Hassan LG, Umar KJ (2006) Nutritional value of balsam apple (Momordica balsamina L.) leaves. Pakistan Journal of Nutrition 5(6): 522-529.
48. Bharti SK, Krishnan S, Kumar A, Kumar A (2018) Antidiabetic phytoconstituents and their mode of action on metabolic pathways. Therapeutic Advances in Endocrinology and Metabolism 9 (3): 81–100. doi: 10.1177/2042018818755019.
49. Tran N, Pham B, Le L (2020) Bioactive Compounds in Antidiabetic Plants: From herbal medicine to modern drug discovery. Biology 9 (9): 252. doi: 10.3390/biology9090252.
50. Lukiati B, Nugrahaningsih N, Arifah SN (2019) The Role of Sechium edule Fruits Ethanolic Extract in Insulin Production and Malondialdehyde Level in Stz-Induced Diabetic Rat. Journal of Tropical Biodiversity and Biotechnology 4 (1): 11-17. doi: 10.22146/jtbb.33948.
51. Sharma P, Joshi T, Joshi T, Chandra S, et al. (2020) In silico screening of potential antidiabetic phytochemicals from Phyllanthus emblica against therapeutic targets of type 2 diabetes. Journal of Ethnopharmacology 248: 112268. doi: org/10.1016/j.jep.2019.112268.
52. Adedapo A, Ofuegbe S, Oguntibeju O (2014) The Antidiabetic activities of the aqueous leaf extract of Phyllanthus amarus in some laboratory animals. Intech Open. doi: 10.5772/57030
53. Krishna RN, Anitha R, Ezhilarasan D (2020) Aqueous extract of Tamarindus indica fruit pulp exhibits antihyperglycaemic activity. Avicenna Journal of Phytomedicine 10(5): 440–447.
54. Mowla A, Alauddin M, Rahman MA, et al. (2009) Antihyperglycemic effect of Trigonella foenum-graecum (fenugreek) seed extract in alloxan-induced diabetic rats and its use in diabetes mellitus: a brief qualitative phytochemical and acute toxicity test on the extract. African journal of Traditional, Complementary, and Alternative Medicines 6 (3): 255–261. doi: 10.4314/ajtcam. v6i3.57165.
55. Kavita, M D, Sharma OP (2022) Antidiabetic activty of methi seeds (Trigonella foenum graceum). World Journal of Pharmaceutical and Medical Research 8(6): 89-93.
56. Yadav M, Chatterji S, Gupta SK, et al. (2014) Preliminary phytochemical screening of six medicinal plants used in traditional medicine. *International Journal* of *Pharmaceutical Sciences* 6 (5): 539-542.
57. Sharma P, Kumar R, Rani R (2021) Phytochemical Profiling and Antioxidant Activity of Cinnamomum tamala Methanolic Leaf Extract. International Journal of Zoological Investigations 7(2): 376-386. doi: org/10.33745/ijzi. 2021.v07i02.008.
58. Elkhalifa AEO, Al-Shammari E, Adnan M, et al. (2021) Development and Characterization of Novel Biopolymer Derived from Abelmoschus esculentus L. Extract and Its Antidiabetic Potential. Molecules 26 (12): 3609. doi: 10.3390/molecules26123609.
59. Maria EEC, Luciana MP de S, Elba dos SF et al. (2015) Nutritional, antinutritional and phytochemical status of okra leaves (Abelmoschus esculentus) subjected to different processes. African Journal of Biotechnology 14 (8): 683–687. doi: 10.5897/AJB2014.14356.
60. Ndarubu TA, Chiamaka OS, Alfa S, Aishatu M, et al. (2019) Phytochemicals, hypoglycemic and hypolipidemic effects of methanol leaf extract of Hibiscus sabdariffa in alloxan induced diabetic rats. GSC Biological and Pharmaceutical Sciences 8(3): 70–78. doi: org/10.30574/gscbps.2019.8.3.01170.
61. Kumar V, Ahmed D, Gupta PS, et al. (2013) Antidiabetic, anti-oxidant and anti-hyperlipidemic activities of Melastoma malabathricum Linn. leaves in streptozotocin induced diabetic rats. BMC Complementary and Alternative Medicine 13 (1): 222. doi: 10.1186/1472-6882-13-222.
62. Devi MN, Singh KB, Singh SR (2012) Antihyperglycemic effect of Aqueous and Ethanol extract of Aerial part of Osbeckia nepalensis Hook in Alloxan induced Diabetic rats. International Journal of PharmTech Research 4(1): 233-244.
63. Novitasari PR, Gemantari BM, Mufidah S, Sari PA (2021) Potential Effects of Neem Plants (Azadirachta indica A. Juss.) as an Antidiabetic Agent. Journal of Food and Pharmaceutical Sciences 9(2): 422-430.
64. Chan EW, Phui-Yan LY, Siu-Kuin WO (2016) Phytochemistry, pharmacology, and clinical trials of Morus alba. Chinese Journal of Natural Medicines. 14(1):17-30.
65. Sood P, Shri R (2018) A review on ethnomedicinal, phytochemical and pharmacological aspects of Myrica esculenta. Indian journal of Pharmaceutical Sciences 80(1): 2-13. doi: 10.4172/pharmaceutical-sciences.1000325.
66. Saklani S, Chandra S, Mishra AP (2012) Nutritional evaluation, antimicrobial activity and phytochemical screening of wild edible fruit of Myrica nagi pulp. International Journal of Pharmacy and Pharmaceutical Sciences 4 (3): 407-411.

67. Manikandan R, Anand AV, Kumar S, et al. (2016) Phytochemical and In vitro Antidiabetic Activity of Psidium Guajava Leaves. Pharmacognosy Journal 8 (4): 392–394. doi: 10.5530/pj.2016.4.13.
68. Chandrasekhar D, Jose SM, Jomy A, Joseph A, Pradeep A et al. (2019) Antiglycation property of Passiflora edulis f. Flavicarpa deg. foliage in type 2 diabetic patients. Clinical Epidemiology and Global Health 7 (3): 409–412. doi: 10.1016/j.cegh.2018.07.002.
69. Kavitha S, Perumal P (2018) Antidiabetic and antioxidant activities of ethanolic extract of Piper betle l. leaves in catfish, Clarias gariepinus. Asian Journal of Pharmaceutical and Clinical Research 11 (3): 194-198. doi: 10.22159/ajpcr. 2018.v11i3.22393.
70. Garba HA, Mohammed A, Ibrahim MA, Shuaibu MN (2022) Effect of lemongrass (Cymbopogon citratus Stapf) tea in a type 2 diabetes rat model. Clinical Phytoscience 6(1): 1-10 doi.org/10.1186/s40816-020-00167-y
71. Muttalib SA, Edros R, Nor AM, Kutty RV (2018) A Review: The extraction of active compound from Cymbopogon sp. and its potential for medicinal applications. International Journal of Engineering Technology and Sciences 5(1): 82-98. doi.org/10.15282/ijets.5.1.2018.1008.
72. Zhang L-L, He Y, Sheng F, Hu Y-F, Song Y, et al. (2021) Towards a better understanding of Fagopyrum dibotrys: a systematic review. Chinese Medicine 16 (1): 89. doi: 10.1186/s13020-021-00498-z.
73. Stoilova I, Trifonova D, Marchev A (2017) Phytochemical Constituents and In Vitro Antidiabetic Properties of Ziziphus jujuba (Rhamnaceae) Fruits. International Journal of Pharmacognosy and Phytochemical Research 9(2):150–158. doi:10.25258/phyto. v9i2.8056
74. Elaloui M, Laamouri A, Ennajah A, Cerny M, Mathieu C et al. (2016) Phytoconstituents of leaf extracts of Ziziphus jujuba Mill. plants harvested in Tunisia. Industrial Crops and Products 83: 133–139. doi: 10.1016/j.indcrop.2015.11.029.
75. Pradeep Kumar (2021) A Review on Potentilla fulgens (Wall. Ex Hook) and its pharmacological efficacy. World Journal of Advanced Research and Reviews 10 (3): 141–145. doi: 10.30574/wjarr.2021.10.3.0270.
76. Prajapat RP, Gupta V, Soni B, Choudhary D, Ram V et al. (2012) Extraction and Isolation of Marmelosin from Aegle Marmelos, Synthesis and Evaluation of Their Derivative as Antidiabetic Agent. Der Pharmacia Lettre 4 (4): 1085-1092.
77. Abdallah IZA, Salem IS, Abd El-Salam NAS (2017) Evaluation of Antidiabetic and Antioxidant Activity of Aegle Marmelos L. Correa Fruit Extract in the Diabetic Rats. The Egyptian Journal of Hospital Medicine 67 (2): 731–741. doi: 10.12816/0037829.
78. Pathirana CK, Madhujith T, Eeswara J (2020) Bael (Aegle marmelos L. Corrêa), a Medicinal Tree with Immense Economic Potentials. Advances in Agriculture 1-13. doi: 10.1155/2020/8814018.
79. Sapkota B, Devkota HP, Poudel P (2022) Citrus maxima (Brum.) Merr. (Rutaceae): Bioactive Chemical Constituents and Pharmacological Activities. Evidence-Based Complementary and Alternative Medicine 1-16. doi: 10.1155/2022/8741669.
80. Khandokar L, Bari MdS, Seidel V, Haque MdA (2021) Ethnomedicinal uses, phytochemistry, pharmacological activities and toxicological profile of Glycosmis pentaphylla (Retz.) DC.A review. Journal of Ethnopharmacology 278 114313. doi: 10.1016/j.jep.2021.114313.
81. James SA, Omwirhiren REM, Joshua IA, Dutse I (2016) Antidiabetic Properties and Phytochemical Studies of Ethanolic Leaf Extracts of Murraya Koenigii and Telfairia Occidentalis on Alloxan-Induced Diabetic Albino Rats. Advances in Life Science and Technology 49: 57-66.
82. Mwonjoria JK, Ngeranwa JJ, Kariuki HN, Githinji CG, Sagini MN, et al. (2014) Ethno medicinal, phytochemical and pharmacological aspects of solanum incanum (lin.). International Journal of Pharmacology and Toxicology 2 (2): 17–20. doi: 10.14419/ijpt. v2i2.1454.
83. Chaerunnisa NN, Suarsi I, Dachlan DM, Virani D, Arundhana AI (2018) The Effect of Pepino (Solanum Muricatum Aiton) Extract on Blood Glucose Level in Type 2 Diabetic Rats. International Journal of Science and Healthcare Research 4(3): 283-285.
84. Malik JA, Iqbal S, Biswas J, Biswas J, Riaz U, Datta S (2021) Antidiabetic Property of Aloe vera (Aloe barbadensis) and Bitter Melon (Momordica charantia). In: Aftab T, Hakeem KR eds Medicinal and Aromatic Plants. Cham, Springer International Publishing. pp 257–269.
85. Widowati W, Wargasetia TL, Afifah E, Mozef T, Kusuma HSW, Nufus H et al. (2018) Antioxidant and antidiabetic potential of Curcuma longa and its compounds. Asian Journal of Agriculture and biology 6(2): 149-161
86. Lamare RE, Singh OP (2017) Changes in Soil Quality in Limestone Mining Area of Meghalaya, India. Nature Environment and Pollution Technology 16 (2): 6.
87. Lamare RE, Singh OP (2016) Limestone Mining and its Environmental Implications in Meghalaya, India. 14.
88. Plants of the World Online Kew Science https://powo.science.kew.org/. Accessed date: 07 August 2021.
89. The Plant List (2013) Version 3.1. http://www.theplantlist.org/. Accessed date: 09 August 2021.

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