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## Traditional Knowledge of Plants Used for the Treatment of Diabetes in Telangana, India: A Comprehensive Review

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### ABSTRACT

Tribal and local forest dwellers possess traditional knowledge of their surrounding plants with wide application for the treatment of various ailments. Plant-based herbal medicines have received great attention after post covid-19 scenario due to its economic, efficient, and minimal side effects. Diabetes mellitus is a well-known metabolic disorder of endocrine insulin hormone which makes it as a chronic disease. The present review focuses on the traditional knowledge of the medicinal plants used by the tribal and local people for the treatment and management of Diabetes in Telangana. The study is a combination of literature based data as well as field interaction with people which revealed that 100 species belonging to 45 families are being used directly or in combination with other plants for the treatment of Diabetes. Fabaceae was the dominant family followed by Apocynaceae and Cucurbitaceae while tree is the major habit followed by herbs and climbers. Leaves are mostly used in the drug preparations followed by bark and root/rhizome. It has been found that formulations of only 40 species are known while other 60 species are not disclosed. Among the known formulations, powder is mostly used for treatment followed by paste and decoctions. Overall the present comprehensive reviews have shown the potential of traditional medicinal plants and its related traditional knowledge for curing diabetes which provides a path for future bioprospecting. In addition to this, these species should be conserved and cultivated under *in-situ* and *ex-situ* programmes which are necessary for sustainable supply for raw material to the benefit of the society as well as to improve livelihood of tribal/local people.

**Keywords:** Traditional Knowledge, Formulations, Documentation, Conservation.

### INTRODUCTION

In recent years, especially in post COVID-19 scenario, attention toward use of herbal medicine has been increased widely in the world. In India, medicinal plants are well-known from the times of Rig-Veda for the treatment of different ailments [1]. Approximately 2,500 medicinal plants were officially recognized by WHO and over 8,000 species were listed in the traditional medicinal systems of India such as Ayurveda, Siddha, and Unani [1-3]. The tribals and/or local people, living close to nature, have traditional as well as indigenous knowledge of plants [4]. They used different formulations such as paste, decoctions, powder, smoke, juice, and pills etc. to cure different chronic diseases [5-6]. Recently nature-based drugs have shown good results in the treatment of chronic diseases due to the richness of beneficial phytoconstituents [7-8]. According to an estimation of WHO, over 80% of the population in the developing countries depend on plant-based medicine [3,9] whereas about 30 to 50% of the drugs in the market are plant-derived [10]. Among the chronic diseases, Diabetes mellitus is a major chronic metabolic disorder including type 1 and type 2 [11]. Type 1 is caused by a decrease/reduction in insulin production due to the destruction of insulin-making pancreatic beta cells by the immune system [12] whereas Type 2 diabetes mellitus is caused by insulin resistance in target cells [9] which is more prevalent than type 1 [13]. India reported over 72 million cases in 2017 which made India as the diabetic capital of the world [11,14]. Modern treatment to cure diabetes are available but there are associated side effects such as liver diseases, lactic acidosis, nausea, and severe diarrhoea [14,15]. On the other hand, herbal medicines are efficient, economical and come with minimal to no side effects [14]. Telangana is rich in biodiversity and many tribes/forest fringe villagers depend on forest for their primary health need [15]. Koyas, Gonds, Yerukalas, Naikpods, Lambada, Chenchus, Kollam, Konda reddy etc. are major tribal communities residing in Telangana which have traditional knowledge about particular diseases [15-17]. However, there is a need to relook, record and revise the formulation data of the knowledge time to time for the benefit of the society [5]. Therefore, the current comprehensive review is an attempt to document the details of plants used in the treatment of diabetes by the tribals/local people of Telangana based on literature data and author field verification including their formulations and phytochemicals.

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## MATERIAL AND METHODS

An extensive search of electronic media was conducted to obtain relevant scientific articles such as Google Scholar, Science Direct, PubMed, Taylor and Francis, Springer, NISCAIR, Research Gate, etc. Search terms such as ethnomedicine, ethnobotany, medicinal plants, Telangana, diabetes, traditional knowledge, indigenous knowledge, different districts, phytochemicals of species, etc. were used to get the details. The websites POWO (Plants of the World Online) and IPNI (The International Plant Names Index) were used to crosscheck the current and updated scientific names of the species. Indian Biodiversity Portal was used to confirm the habit specifications of each plant. Flora by R D Reddy (Telangana Forest Department) webpage was used to verify the vernacular names of the documented species. The indigenous traditional knowledge claims were also authenticated by visiting some of the tribal villages/forest areas of Telangana in three different seasons during June-2020 to June-2022. The current review also listed the phytoconstituents responsible for anti-diabetic activity.

## RESULTS

The present review covered the literature [1-96] and field based traditional knowledge of medicinal plants of Telangana which have been used in the treatment of diabetes. Most of the medicinal plants were also verified by interacting with tribal/local people and medicinal practitioners of the Telangana (Fig.1). Table-1 presented the list of plants with their family name, telugu name, habit, IUCN status and part used. About 100 species belonging to 45 families were found in the literature related to Telangana. Most plants belong to family Fabaceae (10) followed by Apocynaceae (7) and Cucurbitaceae (7). These plants are generally used by the herbalists, traditional healers, tribal and local people for the management of diabetes. The plants materials of certain species were identified in nearby forest areas and authenticated by taxonomist (Fig.2). A large percentage of plants used in the management of Diabetes are trees (34%) followed by herbs (31%), climbers (20%), shrubs (13%), twiners (1%) and grass (1%). Leaves were the most commonly used plant part for formulation followed by whole plant, fruit, bark/stem bark and roots (Fig.3) while majority of the cases more than 1 plant parts are used for formulations. Most formulations were in the form of powder, decoction, paste or extracted juice from crushed or macerated whole plant or plant part(s), which were administered depending on the extent of disease severity (Fig.4). Besides the literature, the information gathered from herbal healers/forest areas during interaction indicates that they have good working knowledge of medicinal plants to cure a well concerned

chronic diabetic disease (Table-3). IUCN status has also been searched for all the 100 species and found that most of the species are under not evaluated (NE) category and least concern (Table-1). This suggests that these plants should be evaluated for their status to avoid any biodiversity loss. It has also been found in literature that formulations of only 40 species are known while remaining 60 are not disclosed, though they are reported to have anti-diabetic potential.

## DISCUSSION

It has been found that certain areas of the state are dominated by certain tribes such as Lambadi and Koya tribes are largely seen in Erstwhile Warangal and Khammam districts while Chenchu, Erukala, and Lambadis are dominant in Nallamalais of Mahabubnagar and Gond, Naikpods, and Lambadis are common in Nirmal Dist. These tribal people, owing to their remote location and dependency on forests, have great traditional knowledge of medicinal plants. The collection of medicinal plants is also a source of livelihood for them. It has been observed that they are generally unwilling to disclose their knowledge due to three main reasons viz. the fear of over exploitation of plant species, improper use of the medicine, and fear of losing their status in the local community. Thus, a proper communication, prior consent and purpose should be clearly intimated before interaction (Fig.1). Among 100 traditionally used species, some are extensively studied for their effectiveness in diabetes treatment while many species with potential anti-diabetic activity are still remaining unexplored. Out of these 100 species, 52 species of medicinal plants are available in the list of Ayurvedic Pharmacopeia of India (API) which suggests its potential in the treatment of various diseases (Table-1). Among the species, *Gymnema sylvestre* and *Senna auriculata* were reported with a high frequency for its role in the treatment of Diabetes mellitus in Telangana. The knowledge of plant part and its formulation is known only to particular tribal and local medicinal practitioners. These medical practitioners are most often old and elderly people of the communities. Certain type of diet may be recommended when using some herbal medicines to avoid any side effects and allergenic reactions. The anti-diabetic potential of these medicinal plants is due to presence of different class of phytoconstituents viz. alkaloids, flavonoids, polyphenols, triterpenoids, tannins, carotenoids, and steroids. Often synergistic effects of all these phytoconstituents provide the desired outcome. Major reported phytoconstituents available in the listed medicinal plants were also reported in the table-2. However, there is a dire need of detail *in-vitro* and *in-vivo* studies of these medicinal plants and their formulation to authenticate and supports these traditional claims.

**Table 1:** List of species used for treatment of diabetes in Telangana with their family, Telugu names, habit, IUCN status and part used

Family	Botanical Name	Telugu Name	Habit	IUCN	Part Used
Acanthaceae	<i>Andrographis paniculata</i> (Burm.f.) Nees	Nelavemu	H	LC	L <sup>[4,18]</sup>
	<i>Barleria longifolia</i> L. (Schumach.) Hein	Enugu palleru	H	LC	Ap <sup>[19,20]</sup>
Adiantaceae	<i>Adiantum incisum</i> Forssk.	Myrakshipa	H	NE	W <sup>[2]</sup>
Amaranthaceae	<i>Aerva lanata</i> (L.) Juss. ex Schult.	Pindi kura	H	NE	W <sup>[21]</sup>
	<i>Alternanthera sessilis</i> (L.) R.Br. ex DC.	Ponnagantikura	H	LC	Ap <sup>[19,22]</sup>
	<i>Celosia argentea</i> L.	Gunugu	H	LC	Sd <sup>[23,24]</sup>
Anacardiaceae	<i>Lannea</i>	Gumpena	T	LC	L,B <sup>[25]</sup>

	<i>coromandelica</i> (Houtt.) Merr.				
Apocynaceae	<i>Caralluma umbellata</i> Haw.	Kundheti Kommu	H	NE	St <sup>[26]</sup>
	<i>Catharanthus pusillus</i> (Murray) G.Don	Kanupoolaku	H	NE	W <sup>[27]</sup>
	<i>Catharanthus roseus</i> (L.) G.Don	Billa ganneru	H	NE	W <sup>[18]</sup>
	<i>Hemidesmus indicus</i> (L.) R.Br. ex Schult.	Barri Sugandhi	Tw	NE	R <sup>[28]</sup>
	<i>Hemidesmus indicus</i> var. <i>pubescens</i> (Wight & Arn.) Hook.f.	Sugandhipala	C	NE	W <sup>[29]</sup>
	<i>Ichnocarpus frutescens</i> (L.) W.T.Aiton	Nalla Teega	C	NE	R <sup>[30]</sup>
	<i>Tylophora indica</i> (Burm.f.) Merr.	Kakapalla	C	NE	L <sup>[31]</sup>
Aristolochiaceae	<i>Aristolochia indica</i> L.	Nallaeswari	C	LR	R <sup>4</sup>
Asclepiadaceae	<i>Gymnema sylvestre</i> (Retz.) R.Br. ex Sm.	Podapathri	C	NE	L <sup>[6,32]</sup>
	<i>Pergularia daemia</i> (Forssk.) Chiov.	Juttipalateega	C	LC	R <sup>[33]</sup>
Asparagaceae	<i>Asparagus racemosus</i> Willd.	Shatavari	C	NDA	T*
Asphodelaceae	<i>Aloe vera</i> (L.) Burm.f.	Kalabanda	H	NE	L <sup>[34]</sup>
Asteraceae	<i>Chrysanthemum indicum</i> L.	Chamanthi	H	NE	F <sup>[23,36]</sup>
	<i>Sphaeranthus indicus</i> L.	Bodasaram	H	LC	L <sup>[35]</sup>
Bignoniaceae	<i>Oroxylum indicum</i> (L.) Benth. ex Kurz.	Mokka vepa	T	NE	B,R <sup>[37]</sup>
Boraginaceae	<i>Coldenia procumbens</i> L.	Hamsapadu	H	LC	W <sup>[19,38]</sup>
Caesalpiniaceae	<i>Senna auriculata</i> L. Roxb.	Tangedu	S	LC	St <sup>6</sup> ,Sd <sup>[32]</sup> ,G,L <sup>[39]</sup> ,FI,R <sup>[40]</sup>
	<i>Senna alata</i> L.	Sima avisi	S	LC	L <sup>[41]</sup>
	<i>Senna fistula</i> L.	Rela	T	LC	Fr,St <sup>[2]</sup>
	<i>Senna occidentalis</i> L.	Kasinda	S	LC	Fr <sup>[11]</sup>
Capparaceae	<i>Capparis zeylanica</i> Wight & Arn.	Adonda	S	NE	Fr <sup>[16]</sup> ,
	<i>Maerua oblongifolia</i> (Forssk.) A.Rich.	Bhuchakra gadda	S	NE	T <sup>[28]</sup>
Combretaceae	<i>Terminalia arjuna</i> (Roxb. ex DC.) Wight & Arn.	Tellamaddi	T	NE	St.b <sup>[42]</sup>
	<i>Terminalia catappa</i> L.	Badam	T	LC	B <sup>2</sup>
	<i>Terminalia chebula</i> Retz.	Karakkaya	T	LC	Fr <sup>[9]</sup>
Commelinaceae	<i>Commelina benghalensis</i> L.	Venna veduru	H	LC	W <sup>2</sup>
Convolvulaceae	<i>Jacquemontia pentanthos</i> (Jacq.) G.Don	Katla puvvu	C	NE	U <sup>[23]</sup>
Cornaceae	<i>Alangium salviifolium</i> (L.f.) Wangerin	Ooduga chettu	T	LC	Fl.b <sup>[43]</sup>
Cucurbitaceae	<i>Coccinia grandis</i> (L.) Voigt	Dondakaya	C	NE	W, L <sup>[18]</sup>
	<i>Corallocarpus epigaeus</i> (Rottler) Hook.f.	Naga Donda	C	NE	T <sup>[30]</sup>
	<i>Cucurbita pepo</i> L.	Budida-gummadi	C	LC	Sd <sup>[23,44]</sup>
	<i>Luffa acutangula</i> var. <i>amara</i> (Roxb.) C.B.Clarke	Beera	C	NE	Fr <sup>[27]</sup>
	<i>Momordica charantia</i> L.	Kakara	C	NE	L,Fr,Sd <sup>[18]</sup>
	<i>Momordica dioica</i> Roxb. ex Willd.	Bodakakara	C	NE	Fr <sup>[2,28]</sup>
	<i>Solena amplexicaulis</i> (Lam.) Gandhi	Adavi Donda	C	NE	W <sup>[45]</sup>
Cyperaceae	<i>Cyperus rotundus</i> L.	Chiru Pungeram	H	LC	T <sup>[16]</sup>
Dioscoreaceae	<i>Dioscorea alata</i> L.	Dukka Pendalam	C	NE	T <sup>[46]</sup>
Euphorbiaceae	<i>Acalypha indica</i> L.	Muripinda	H	NE	L <sup>[9]</sup>
	<i>Croton bonplandianus</i> Baill.	Gali vana chettu	H	NE	Fr,St,L <sup>[21]</sup>

	<i>Euphorbia antiquorum</i> L.	Bontajemudu	S	LC	L <sup>[9]</sup>
	# <i>Euphorbia hirta</i> L.	Reddyvari nanabala	H	NE	L <sup>[19,47]</sup>
Fabaceae	<i>Albizia odoratissima</i> (L.f.) Benth.	Ganara	T	LC	St.b <sup>[48]</sup>
	# <i>Bauhinia variegata</i> L.	Devakanchanam	T	LC	Fr <sup>[49]</sup>
	# <i>Clitoria ternatea</i> L.	Shanku pushpi	C	NE	Fr,R <sup>[19,28]</sup>
	# <i>Pongamia pinnata</i> (L.) Pierre	Kanugachettu	T	NE	Fr <sup>[19]</sup>
	# <i>Pterocarpus marsupium</i> Roxb.	Peddegi	T	NT	Fr,L <sup>[30]</sup> W. oil <sup>[48]</sup>
	# <i>Pterocarpus santalinus</i> L.f.	Rakta Chandanam	T	EN	B <sup>[34,50]</sup>
	<i>Sesbania grandiflora</i> (Linn.) Poiret	Sukunasamu	T	NE	Y.fr <sup>[41]</sup>
	# <i>Tamarindus indica</i> L.	Chinta chettu	T	LC	W <sup>[49]</sup>
	<i>Tephrosia purpurea</i> (L.) Pers.	Vempali	S	LC	W <sup>2 (2)</sup>
# <i>Trigonella foenum-graecum</i> L.	Menthulu	H	NE	Sd <sup>4</sup>	
Gentianaceae	<i>Enicostema axillare</i> (Poir. ex Lam.) A.Raynal	Resca	H	LC	W <sup>[30,45]</sup>
Lamiaceae	<i>Leucas aspera</i> (Willd.) Link	Timmichettu	H	NE	W <sup>[19,51]</sup>
	# <i>Ocimum sanctum</i> L.	Tulasi	S	NE	L <sup>[19,52]</sup>
	# <i>Vitex negundo</i> L.	Tellavavili	S	LC	L <sup>[33]</sup>
Lauraceae	<i>Litsea glutinosa</i> (Lour.) C.B.Rob.	Naramamidi	T	LC	B <sup>[35]</sup>
Loganiaceae	# <i>Strychnos nux-vomica</i> L.	Vishamusti	T	NE	St <sup>4</sup>
Malvaceae	<i>Helicteres isora</i> L.	Nuli Thada	S	NE	R <sup>[26]</sup>
	<i>Grewia flavescens</i> Juss.	Banka jana	T	LC	L <sup>[19,54]</sup>
	<i>Thespesia lampas</i> (Cav.) Dalzell	Adavi benda	S	NE	R <sup>[53]</sup> ,Sd <sup>[33]</sup>
Meliaceae	# <i>Azadirachta indica</i> A.Juss.	Vepaku	T	LC	L*
	<i>Soymida febrifuga</i> (Roxb.) A.Juss.	Somida	T	NE	B <sup>[55]</sup>
Menispermaceae	<i>Cocculus hirsutus</i> (L.) W.Theob.	Dusaratiga	C	NE	L <sup>[19]</sup>
	# <i>Tinospora cordifolia</i> (Willd.) Hook.f. & Thomson	Tippateega	C	NE	W <sup>4</sup> ,L <sup>[53]</sup>
Mimosaceae	<i>Acacia leucophloea</i> (Roxb.) Willd.	Tellatamma	T	LC	St.b <sup>[33]</sup>
	<i>Leucaena leucocephala</i> (Lam.) de Wit	Kaniti	T	LR	L,St,Sd,G <sup>[47]</sup>
Moraceae	# <i>Ficus benghalensis</i> L.	Marri	T	NE	St.b <sup>4</sup>
	# <i>Ficus hispida</i> L.f.	bomme-medi	T	LC	Fr <sup>[16,56]</sup>
	# <i>Ficus racemosa</i> L.	Medi	T	LC	B,R <sup>[9,49]</sup>
	# <i>Ficus religiosa</i> L.	Pippalamu	T	LC	W <sup>[47]</sup>
Musaceae	# <i>Musa × paradisiaca</i> L.	Arati	S	LC	Fr <sup>[2,57]</sup>
Myrtaceae	<i>Psidium guajava</i> L.	Jama	T	LC	L <sup>[4]</sup>
	# <i>Syzygium cumini</i> (L.) Skeels	Neredu	T	LC	Sd,L <sup>[4]</sup> ,Fr <sup>[8]</sup>
Nyctaginaceae	# <i>Boerhavia diffusa</i> L.	Atika mamidi	H	NE	W <sup>[18]</sup>
	<i>Bougainvillea spectabilis</i> Willd.	Kagitapu Chettu	C	NE	L <sup>[28,58]</sup>
Olacaceae	<i>Ximenia americana</i> L.	Nakkeri	S	LC	St.b <sup>[16]</sup>
Phyllanthaceae	# <i>Emblica officinalis</i> Gaertn.	Usiri	T	LC	Fr <sup>[35,59]</sup>
	<i>Phyllanthus amarus</i> Schumach. & Thonn.	Nela usiri	H	NE	W <sup>[45]</sup> , L <sup>[9]</sup>
	<i>Phyllanthus niruri</i> L.	Nela usiri	H	NDA	L*
Poaceae	<i>Bambusa arundinacea</i> (Retz.) Willd.	Veduru	G	NE	St.b <sup>[8]</sup>
	<i>Chloris barbata</i> Sw.	Uppu gaddi	H	NE	L <sup>[47]</sup>
	# <i>Cynodon dactylon</i> (L.) Pers.	Garika	H	NE	R <sup>[49]</sup>
Rubiaceae	<i>Ceriscoides turgida</i> (Roxb.) Tirveng.	Tella velugakayalu	T	NE	B <sup>[9]</sup>
	<i>Mitragyna parvifolia</i> (Roxb.)	Rudraksha-	T	NE	R, L, Fr <sup>[58]</sup>

	Korth.	kamba			
Rutaceae	# <i>Aegle marmelos</i> L.	Maredu	T	NT	L <sup>[49]</sup>
	# <i>Bergera koenigii</i> L.	Karivepaku	T	LC	L*
Santalaceae	# <i>Santalum album</i> L.	Srigandamu	T	V	H.W,E. oil <sup>[34]</sup>
Sapotaceae	<i>Mimusops elengi</i> L.	Vakulamu	T	LC	Sd <sup>[43]</sup>
Solanaceae	<i>Capsicum annum</i> L.	Mirapa	H	NE	Fr <sup>[8]</sup>
	# <i>Solanum nigrum</i> L.	Kamanchi	H	NE	Fr <sup>[27]</sup>
	# <i>Solanum xanthocarpum</i> Schrad & Wendl	Nelamulaka	H	NE	Fr <sup>[55]</sup>
Typhaceae	<i>Typha angustata</i> Bory & Chaub.	Jammu	H	LC	R <sup>[58]</sup>
Zingiberaceae	# <i>Curcuma domestica</i> valetton.	Pasupu	H	DD	R,W <sup>[49]</sup>

DD: data deficient, EN: Endangered, LC: Least Concern, LR: Low risk, NE: Not evaluated, NT: Near threatened, NDA: No data available, V: Vulnerable. H: Herb, S: Shrub, T: Tree, C: Climber, Tw: Twiner, G: Grass. L: Leaves, Ap: Aerial part, W: Whole plant, S: Seeds, B: Bark, St: Stem, R: Root, T: Tubers, F: Flowers, Fr: Fruit, St.b: Stem bark, F.buds: Flower buds, Y.fr: Young fruit, H.W: Heart wood, E.oil: Essential oil, La: Latex, G: Gum, U: Unknown, \* Verified by authors, 2021-22, # Species mentioned in API

**Table 2:** Documented formulations and the major phytochemicals of the species used for treatment of diabetes in Telangana

Botanical name	Method of preparation	Major phytochemicals
<b><i>Andrographis paniculata</i></b>	<p>1. Dried leaf powder mixed with cow/goat's milk and taken orally by the tribes of Adilabad and Ananthagiri hills<sup>[18,32]</sup></p> <p>2. Leaves (powder/pill) is taken alone or with honey twice a day depending upon the severity by the tribes of Warangal district<sup>[35,61]</sup></p> <p>3. Leaves powdered with the leaves of <i>Syzygium jambolanum</i>, <i>Zizyphus rugos</i>, <i>Aegle marmelos</i>, <i>Gymnema sylvestre</i>, and the tubers of <i>Corollocarpus epigaeus</i> (2:1 ratio) is given with hot water for 20 days in the areas of Bhadrachalam &amp; Khammam<sup>[42]</sup></p> <p>4. Leaves are chewed with Betel leaves by the tribal communities of Achampet forest division<sup>[4]</sup></p> <p>5. Plant powder is taken regularly after meals by Lambadas of Nizamabad district<sup>[39]</sup></p>	Andrographolide <sup>62</sup>
<b><i>Aristolochia indica</i></b>	Root is made into paste and consumed by the tribal communities of Achampet forest division <sup>[4]</sup>	Stigmast-5-en-3 $\beta$ -ol <sup>[63]</sup> .
<b><i>Asparagus racemosus</i></b>	Freshly collected tubers are consumed for 3 days by Itikyall villagers of Nirmal district*	Shatvarin I to VI, Quercetin, Diosgenin <sup>[64]</sup> .
<b><i>Azadirachta indica</i></b>	Villagers of Argonda grind the leaves of <i>Azadirachta indica</i> , <i>Bergera koenigii</i> , <i>Tinospora cordifolia</i> and whole plant of <i>Andrographis paniculata</i> in equal proportion to make pea sized tablets. They are consumed orally on empty stomach once in a week.*	Azadirachtin, Nimbin, <sup>[65]</sup> .
<b><i>Bambusa arundinacea</i></b>	Oral consumption of stem bark decoction by people of Narsampet, Warangal Rural <sup>[9]</sup> .	Stigmast-5,22-dien-3 $\beta$ -ol <sup>[66]</sup>
<b><i>Bergera koenigii</i></b>	Powder leaves of <i>Bergera koenigii</i> , <i>Tinospora cordifolia</i> , <i>Azadirachta indica</i> and whole plant of <i>Andrographis paniculata</i> are mixed in equal proportions to make pea sized tablets and consumed orally on empty stomach once in a week*.	Mahanimbine <sup>[67]</sup> Mahanine <sup>[68]</sup>
<b><i>Boerhavia diffusa</i></b>	Two teaspoons of whole plant juice are taken orally twice a day for 40 days by the tribes of Adilabad district <sup>[18]</sup>	D-Limonene, 9-(4-Methoxyphenyl) xanthene <sup>[69]</sup>
<b><i>Capparis zeylanica</i></b>	Ripen fruits are consumed daily twice for a fortnight by the ethnic groups of Medak, Mancheri, Jannaram <sup>[16,56]</sup>	$\beta$ -carotene <sup>[70]</sup>
<b><i>Caralluma umbellata</i></b>	Stem juice is taken by the tribals groups of Amrabad forest division <sup>[26]</sup>	$\beta$ -tocopherol, Vitamin E <sup>[71]</sup>

<b><i>Catharanthus pusillus</i></b>	10g of whole plant powder is mixed with 100 ml of water and taken orally by the tribal communities in the Bhadrachalam <sup>[27]</sup>	-
<b><i>Catharanthus roseus</i></b>	10 g whole plant powder is mixed with 100 ml of cow's milk and taken orally by the tribes of Adilabad district <sup>[18]</sup>	Vindoline, vindolidine, vindolinine <sup>[72]</sup>
<b><i>Coccinia grandis</i></b>	1. About 20 ml of whole plant extract is given orally by the tribal groups of Adilabad district <sup>[18]</sup> 2. Two spoonfuls of leaf extract is administered twice a day for about 10 days as recommended by the local medicinal practitioners of Adilabad district <sup>[73]</sup> 3. 10 ml of fruit juice is given internally once a week by the local medicine practitioners of Vikarabad and Rangareddy districts <sup>[6]</sup>	β- Amyrin Acetate, Cephalandrin A and B <sup>[74,75]</sup>
<b><i>Cynodon dactylon</i></b>	Root powder is used by tribes of Husnabad village <sup>[49]</sup>	-
<b><i>Cyperus rotundus</i></b>	Dry tuber powder is administered twice everyday by the ethnic people of Medak district <sup>[16]</sup>	Cassigarol E, scirpusin A, and scirpusin B <sup>[76]</sup>
<b><i>Dioscorea alata</i></b>	Boiled tubers are given for general debility in diabetic patients by the Lambadi tribes of Eturnagaram Wildlife sanctuary <sup>[46]</sup>	Diosgenin <sup>[77]</sup>
<b><i>Emblica officinalis</i></b>	1. Dried fruit powder is mixed with turmeric powder along with the leaves of <i>S. auriculata</i> by the tribes of Medaram and Narlapura villages <sup>[35]</sup> 2. Quarter cup of fruit juice is given orally with a pinch of turmeric paste and honey once in a day by the traditional healers of Khammam & Nizamabad districts <sup>[59]</sup>	Vitamin E, phyllembin <sup>[65]</sup>
<b><i>Ficus benghalensis</i></b>	Bark is mixed with the leaves of <i>Tinospora cordifolia</i> and taken orally by the traditional medicine practitioners of Achampet forest division <sup>4</sup>	α-amyrin acetate, leucopelargonidin-3-O-α-L rhamnoside <sup>[78]</sup>
<b><i>Gymnema sylvestre</i></b>	1. Leaves are eaten directly or 5 g dried leaf powder is mixed with water and taken orally once in a day by the tribal groups of Nirmal and Adilabad <sup>[18,73]</sup> 2. 10ml leaf decoction is given internally early in the morning for 30 days by the local practitioners of Vikarabad, and Rangareddy <sup>[6]</sup> 4. Leaves powdered along with leaves of <i>Aegle marmelos</i> , <i>Andrographis paniculata</i> , <i>Syzygium cumini</i> , <i>Zizyphus rugosa</i> and the tubers of <i>Carallocarpus Epigaeus</i> in 2:1 ratio approx. 1 spoonful of powder along with hot water is given twice a day for 1 week by the locals of Parnasala Sacred Grove <sup>[42]</sup> 5. Leaf powder is mixed with cow's milk and taken orally by the local herbal medicine practitioners in Ananthagiri hills <sup>[32]</sup>	Gymnemagenin <sup>[72]</sup> , Gymnemic acids <sup>[76]</sup>
<b><i>Helicteres isora</i></b>	Direct consumption of dried root powder is used by the tribes of Amrabad <sup>[26]</sup>	Kaempferol 7-O-coumaroylhexoside <sup>[79]</sup>
<b><i>Litsea glutinosa</i></b>	Juice of bark with water is taken by tribes of Medaram and Narlapura villages, Thadvai Mandal <sup>[35]</sup>	(3β)-Stigmast-5-en-3-ol <sup>[80]</sup>
<b><i>Luffa acutangula</i></b>	Powdered fruit epicarp is mixed with water and consumed by the tribal of Bhadrachalam <sup>[27]</sup>	Insulin like peptides <sup>[81]</sup>
<b><i>Mimusops elengi</i></b>	A spoonful of dried seed powder mixed with 100 ml water is taken orally early morning by the tribal groups of Adilabad district <sup>[43]</sup>	taraxerol, taraxerone, betulinic acid <sup>[82]</sup>
<b><i>Momordica charantia</i></b>	Dried leaf powder (10g) is mixed with 200 ml water is given orally early in the morning or 100 ml of fruit juice is taken orally by the tribal groups of Adilabad district <sup>[18]</sup>	Momordicin, Charantin <sup>[83]</sup>
<b><i>Oroxylum indicum</i></b>	Decoction of the fresh peelings of bark and outer covering of the root is taken by the locals of Godavari basin from Nirmal to Mancheril districts <sup>[37]</sup>	Oroxylum A, Baicalein <sup>[84]</sup>
<b><i>Pergularia daemia</i></b>	The root paste is consumed by the Chenchus of Mahaboobnagar district <sup>[33]</sup>	β-sitosterol and quercetin <sup>[85]</sup>
<b><i>Psidium guajava</i></b>	Leaves (4-5) are soaked overnight and in the morning, the water is drunk or the decoction of the leaves is taken by the traditional medicine practitioners of Achampet forest division and some tribes of	Gallic acid, Guavanoic acid <sup>[86]</sup> psidiumlanostenoic acid <sup>[87]</sup>

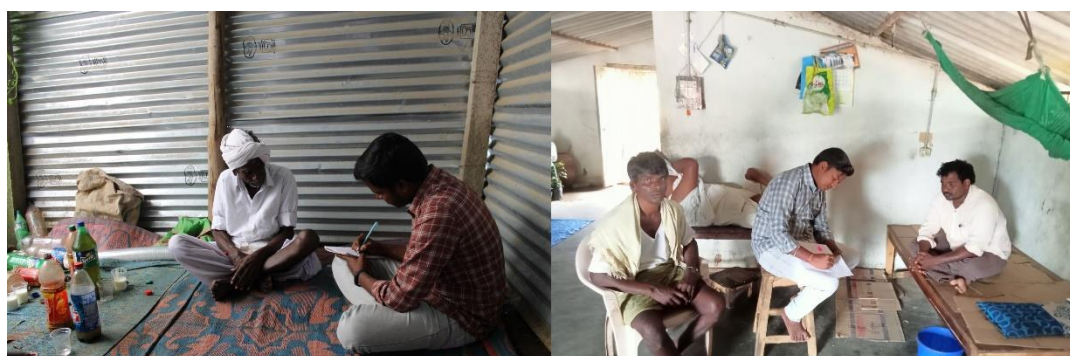
	Nizamabad district <sup>[4,39]</sup>	strictinin <sup>[14]</sup>
<b><i>Pterocarpus marsupium</i></b>	Wood extract is used by the Gonds of Adilabad district <sup>[48]</sup>	Resin <sup>[65]</sup> , Epicatechin <sup>[76]</sup>
<b><i>Phyllanthus niruri</i></b>	Grind the leaves and cumin seeds into paste. Take it into a glass of curd and consume on empty stomach in the morning for 3 days by the villagers of Thuniki, Kowdipally mandal of Telangana*	Beta sitosterol, Rutin, Quercetin <sup>[88]</sup>
<b><i>Senna auriculata</i></b>	<ol style="list-style-type: none"> <li>1. Seed powder (5 to 7 gm) is mixed with honey and taken orally by the local tribes of Adilabad district<sup>[18,32]</sup></li> <li>2. Powdered seeds (2g) twice a day by the Koya tribes of Karimnagar district<sup>[47]</sup></li> <li>3. All parts are taken in equal quantity and prepared by adding water or honey by the Koya tribes of Medaram and Narlapura villages, Thadvai Mandal<sup>[35]</sup></li> <li>4. 20 g of matured stem powder is given along with one glass of water once a day for a month by the local medicine practitioners of Vikarabad &amp; Rangareddy district<sup>[6]</sup></li> <li>5. Root decoction is used by the rural healers of Nizamabad district<sup>[40]</sup></li> <li>6. One teaspoon of gum, dried leaves, and flowers are given by the tribes of Nizamabad district<sup>[39]</sup></li> </ol>	Polyphenols <sup>[89]</sup>
<b><i>Solanum nigrum</i></b>	The seeds are ground in to crystallized form and mixed with water and honey in the Bhadrachalam agency forest area <sup>[27]</sup>	apigenin-7-O-glucuronide astragalin <sup>[90]</sup>
<b><i>Soymida febrifuga</i></b>	Daily consumption of infusion, about 10 ml prepared by the bark is used by the Naikpods of Kammarpally Forest Range <sup>[55]</sup>	-
<b><i>Sphaeranthus indicus</i></b>	The leaves are ground with pepper and the extract is taken orally by the Koya tribes of Medaram and Narlapura villages, Thadvai Mandal <sup>[35]</sup> .	-
<b><i>Strychnos nux-vomica</i></b>	Stem bark is soaked overnight in the water and this water is consumed by the tribes of Achampet forest division <sup>[4]</sup>	Strychnine, brucine <sup>[91]</sup>
<b><i>Syzygium cumini</i></b>	<ol style="list-style-type: none"> <li>1. The paste of fresh seeds along with honey is taken one dose early in the morning for 40 days by the Chenchus of Mahaboobnagar district<sup>[33]</sup></li> <li>2. Seed is dried, powered and taken before meals by the Koya tribes of Medaram and Narlapura villages, south of the Godavari River, Thadvai mandal, Warangal district<sup>[35]</sup></li> <li>3. 1-2 spoons of powder of dried seeds is taken twice a day after meals by the tribals living in Amrabad forest division of Nallamali<sup>[26]</sup></li> <li>4. Seeds are chewed by the tribes of Achampet forest division<sup>[4]</sup>.</li> <li>5. Fruit Juice of Syzygium cumini is used in the rural areas of Narsampet, Warangal Rural<sup>[8]</sup></li> </ol>	Mycaminose <sup>[72]</sup>
<b><i>Terminalia arjuna</i></b>	One spoonful of stem bark decoction is administered along with a pinch of <i>Saccharum officinarum</i> twice a day for 21 days by the local tribes of Parnasala Sacred Grove area, Khammam district <sup>[42]</sup>	Arjunolic acid <sup>[92]</sup> , Arjunic acid <sup>[93]</sup>
<b><i>Thespesia lampas</i></b>	<ol style="list-style-type: none"> <li>1. Dried roots are powdered and mixed with sugar. This mixture is taken orally for a week in the folklore of Thiryani Mandal<sup>[53]</sup> and by the indigenous community of Mirzaguda village, Ranga Reddy district<sup>[60]</sup></li> <li>2. The seed paste is used by the Chenchus of Mahaboobnagar district<sup>[33]</sup></li> </ol>	-
<b><i>Tinospora cordifolia</i></b>	<ol style="list-style-type: none"> <li>1. The leaves are eaten as such in the folklore of Thiryani Mandal<sup>[53]</sup></li> <li>2. 100ml of leaf decoction is given internally by the local tribes of Adilabad district<sup>[18]</sup></li> <li>3. Leaf stalk powder is mixed with neem paste by the tribal people of Mahabubnagar district<sup>[3]</sup></li> <li>4. Dried leaf powder or 1 teaspoon of Juice is taken by the locals of Thadvai Mandal<sup>[35]</sup></li> <li>5. Whole plant extract is mixed with banyan tree bark paste and is consumed by the tribes of Achampet</li> </ol>	Berberine <sup>[94]</sup>

	forest division <sup>[4]</sup>  6. Leaves of <i>Tinospora cordifolia</i> , <i>Bergera koenigii</i> , <i>Azadirachta indica</i> , and whole plant of <i>Andrographis paniculata</i> are taken in equal proportions and ground to make pea sized tablets by the villagers of Argonda. They are taken orally once in a week on empty stomach*	
<b><i>Trigonella foenum-graecum</i></b>	The water in which seeds are soaked overnight is taken orally by the Chenchu, Erukala and Lambada tribes of Achampet forest division of Nallamalais <sup>[4]</sup>	Trigonelline, nicotinic acid <sup>[72]</sup>
<b><i>Vitex negundo</i></b>	1. The dried tender leaves of <i>Vitex negundo</i> , <i>Tylophora indica</i> , <i>Diospyros Chloroxylon</i> , <i>Cassia fistula</i> , <i>Encostema axillare</i> , <i>Maytenus emarginata</i> are powdered along with sugar. Pea sized tablets (i.e., 1-2 gm) are made by adding water to the powder. They're taken orally once a day for 9 days in Thiryani Mandal of Komram Bheem district. Food: only rotis made of jowar (seeds of <i>sorghum vulgare</i> ) with red chilli powder are eaten during the treatment <sup>[53]</sup>  2. The leaf juice is used by the Chenchus of Mahaboobnagar district <sup>[33]</sup>	Agnuside, Casticin, Negundoside, Vitexin <sup>[95]</sup>
<b><i>Ximenia americana</i></b>	Stem bark extract is administered by the ethnic people of Medak district <sup>[16]</sup>	9,12-Octadecadienoic acid <sup>[96]</sup>

\* Verified by authors, 2022.

**Table 3:** Authors field visit to the villages of Telangana and interactions with the villagers, 2022

Village/Mandal/District	Latitude	Longitude	Authors verified Species useful for diabetes
Argonda/Rajampet/Kamareddy	18.2305	78.2787	<i>Tinospora cordifolia</i>
Itkyal/Pembi/Nirmal	19.2147	78.6566	<i>Bergera koenigii</i>
Thuniki/Kowdipally/Medak	17.8066	78.4058	<i>Andrographis paniculata</i>
Sarlapally/Amrabad/Nagarkurnool	18.0415	80.3972	<i>Azadirachta indica</i>
Vattavarlapally/Amrabad/Nagarkurnool	18.0415	80.3972	<i>Asparagus racemosus</i>
Damarathogu/Gundala/Bhadradi Kothagudem	18.0415	80.3972	<i>Phyllanthus niruri</i>



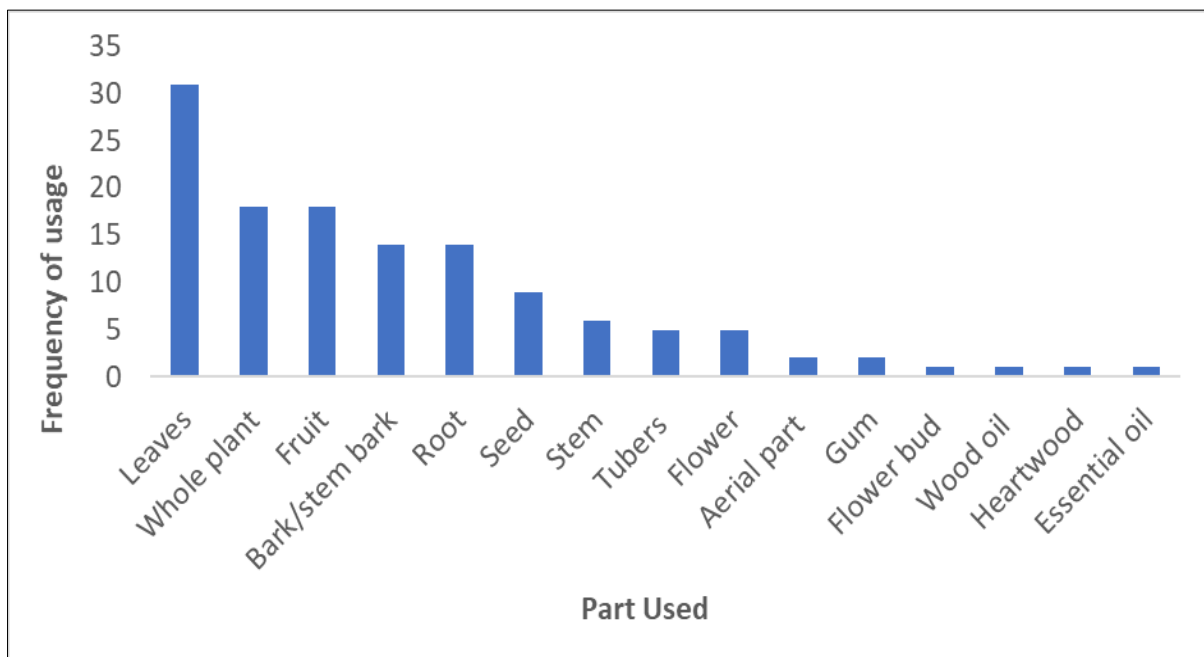
**Figure 1:** Interaction with the traditional medicine practitioners of Telangana





**Figure 2:** Photo of Species recorded in nearby forest during field visit

A) *Helicteres isora* B) *Ichnocarpus frutescens* C) *Ceriscoides turgida* D) *Dioscorea alata* E) *Aegle marmelos* F) *Hemidesmus indicus* G) *Terminalia chebula* H) *Gymnema sylvestre* I) *Cassia fistula* J) *Mitragyna parvifolia* K) *Andrographis paniculata* L) *Soymida febrifuga* M) *Litsea glutinosa* N) *Ximenea americana* O) *Adiantum incisum* P) *Bergera koenigii* Q) *Cyperus rotundus* R) *Bauhinia variegata* S) *Pongamia pinnata* T) *Strychnos nux-vomica* Photo sources: Authors



**Figure 3:** Part used and its frequency of usage in the list of anti-diabetic plants

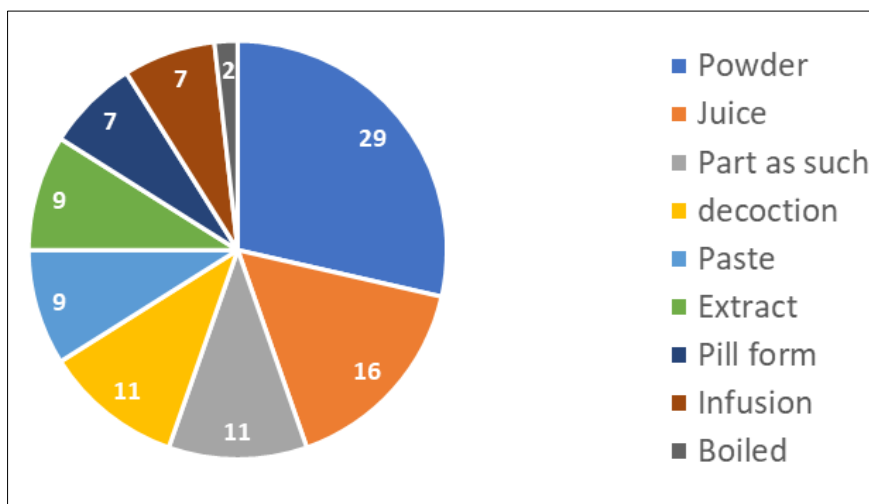


Figure 4: Type of formulations used for treatment of diabetes

## CONCLUSION

Documentation of traditional knowledge is very essential for future generations of the whole or particular to the state. The present reviews provide a path for conserving the traditional knowledge of Telangana for future bioprospecting as well as focuses on the need of conservation and cultivation of these species under *in-situ* and *ex-situ* programmes. This can lead to the sustainable supply for raw material to the benefit of the society as well as improve the livelihood of tribal/local people.

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## Disclosure

The author reports no conflicts of interest in this work.

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