Plants with antidiabetic potential: A comprehensive review of ethnomedicinal plants used by tribal communities of Madhya Pradesh (Central India) for diabetes management

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Review

Abstract

Background: Diabetes mellitus constitutes a significant global health issue, with the rate rising, especially in rural and resource-constrained regions where access to conventional treatment is challenging. In these conditions, traditional medical systems are crucial in disease management. This review article examines and analyzes the ethnomedicinal-based practices related to antidiabetic therapy among indigenous peoples of Madhya Pradesh, India.

Methods: A comprehensive review of the literature was conducted utilizing various scientific resources, including "Google Scholar," "ScienceDirect," "PubMed," and "Scopus." Keywords used to identify relevant studies were *"ethnomedicinal plants," "diabetes," "Madhya Pradesh,"* and *"antidiabetic."* Studies were screened based on established inclusion criteria that included detailed ethnomedicinal usage information.

Results: An aggregate of 85 belonging to 78 genera and 45 distinct families were recorded, featuring Fabaceae as the predominant family. Trees and herbs were the most frequently represented growth forms and leaves, roots and bark were primarily utilized plant components. The primary modes of preparation were powder and decoction. The study additionally provides detailed information about the mode of use, such as dosage, frequency of administration and duration of treatment and explores the relationships between plant habit, plant parts, and preparation methods, revealing consistent ethnomedicinal patterns across the studies.

Conclusions: The findings highlight the diversity and uniformity of traditional antidiabetic knowledge systems in the state of Madhya Pradesh and their importance for affordable health care resources. The structured documentation of usage practices offers a foundation for forthcoming pharmacological validation and emphasizes the necessity of standardization, experimental evaluation, and the conservation of medicinal plant resources.

Keywords: Antidiabetic plants, Diabetes mellitus, Ethnomedicinal Plant, Madhya Pradesh, Traditional medicine

Background

Diabetes is a type of chronic metabolic disorder marked by persistently increased blood glucose levels, leading to long-term consequences that impact the cardiovascular system, blood vessels, vision, renal function, and neurons (WHO 2024). Diabetes has emerged as a worldwide health issue, exhibiting a rising prevalence. The International Diabetes Federation (2025b) reports that roughly 589 million individuals aged 20-79 globally are afflicted with diabetes, representing 11.1% of the entire adult population worldwide. India constitutes a central hub of the diabetic outbreak. The International Federation of Diabetes projects that 89.8 million individuals aged 20-79 in India will have diabetes by 2024, positioning the country as the second highest internationally, following China (International Diabetes Federation 2025a). The diabetes prevalence among Indian adults is approximately 10.5%, accounting for over 84% of total diabetes cases in the South-East Asia region (International Diabetes Federation 2025c). This substantial increase reflects rapidly changing lifestyles and dietary patterns in urban and semi-urban areas (Sun *et al.* 2022). Current antidiabetic medications are effective in controlling blood glucose; however, they are frequently associated with side effects such as hypoglycemia, weight gain, gastrointestinal issues, and cardiovascular risks. Additionally, high costs and limited accessibility in many regions drive the need for safer, cheaper, and more widely available therapeutic alternatives.

Medicinal plants represent a critical source of bioactive compounds for treating various diseases. Plant-based therapeutics provide diverse phytochemicals, including flavonoids, terpenoids, saponins, alkaloids, and glycosides, recognized for their pharmacological activities (Afrisham *et al.* 2015). Globally, approximately 35,000 to 70,000 plant species contribute to human healthcare (Adhikari & Paul 2018). For centuries, medicinal plants have been documented as important sources for managing diabetes. These plants offer more accessible and cost-effective alternatives to conventional medicines, particularly for populations with limited healthcare access. The growing scientific interest in medicinal plants reflects the need to identify novel plant-derived antidiabetic agents. India possesses exceptional ethnobotanical knowledge applied to treat diseases since ancient times. India boasts approximately 45,000 plant species, with about 2,000 scientifically documented and around 500 actively used in traditional medicine systems. This rich ethnobotanical heritage is especially prominent in regions with significant tribal populations, including Madhya Pradesh, Maharashtra, Odisha, Rajasthan, and Gujarat (Jain 1991).

Ethnobotany is an interdisciplinary field of biological and social sciences that studies the interaction between human societies and plants, including their use, management, cultural importance, ecological relations, and traditional knowledge systems (Harshberger 1895, Schultes & Reis 1995). Ethnomedicine, a specialized branch of ethnobotany, focuses on traditional healthcare practices and medicinal plant use among indigenous communities and provides an important foundation for identifying plant-derived therapeutic agents (Albuquerque *et al.* 2019). Madhya Pradesh, which is a central Indian state with an abundance of tribal communities and several indigenous languages, including Bhili, Gondi, and Korku, offers an exceptional case study. According to the Census of India (2011), the two largest tribal groups in the state are Bhil and Gond, which constitute around 37.7% and 35.6% of the total Scheduled Tribe population, respectively. Other important tribal communities are Kol (7.8%), Korku (4.0%), Sahariya (2.7%), Baiga (2.5%), Bhariya (0.9%), and Korwa (0.3%) of the tribal population. Ethnobotanical studies have repetitively documented these groups for their traditional knowledge in identifying medicinal plants and local health care practices. The Gond tribes are renowned for their traditional Gond art, which features elaborate designs and vibrant depictions of nature and everyday life, demonstrating an intense cultural tie to forest habitats. Baiga communities are well known for their knowledge of traditional healing and medicinal plants and are classified as the Particularly Vulnerable Tribal Groups (PVTGs) of India. Korku communities are mainly located in forested areas of central India and have preserved traditional plant-use practices. Bhariya and Korwa communities still maintain indigenous knowledge of local healthcare and resource utilization. Spread across different ecological regions in Madhya Pradesh, these communities significantly contribute to the state's ethnomedicinal diversity and plant-based healthcare practices.

Recent ethnomedicinal studies in Madhya Pradesh show that tribal health care systems still treat diabetes and continue to use plant-based interventions. Mishra (2021) reported 19 species of medicinal plants used for the management of diabetes in the Khandwa district in Korku, Gond, and Nihal communities. The documented practices were mostly based on the bark, leaves, roots, fruits, and whole plant preparations. Powders, decoctions, juices, tablets, and paste formulations were the major modes of administration. Most remedies were administered orally, once, or twice a day, with certain preparations particularly suggested on an empty stomach. Wagh and Sharma (2025) also found diabetes to be a significant ethnomedicinal category in Western Madhya Pradesh and recorded 17 plant species with 407 use reports for oral administration. Collectively these findings show that antidiabetic ethnomedicinal practices of Madhya Pradesh still remain intact and have comprehensive therapeutic knowledge on plant selection and usage patterns. Early ethnobotanical studies in the region were largely based on descriptive accounts of plant species, their traditional uses, and methods of preparation. Although quantitative indices are available in individual studies, an integrated synthesis and comparison across studies is lacking.

Several ethnobotanical studies have reported antidiabetic plants in Madhya Pradesh; however, most of the studies are descriptive and mainly focused on plant identity, parts used, and preparation methods. The current review contributes to this body of knowledge by systematically gathering explicit usage protocols via quantified dosages (ml, tsp), frequency of administration (once/twice daily), duration of treatment (days/weeks), and usage combinations. The comprehensive documentation of ethnomedicinal data, including dose, frequency of administration, treatment duration, plant identity, plant parts utilized, and preparation methods, enables a more comprehensive understanding of traditional antidiabetic knowledge, which allows for more accurate assessment of ethnomedicinal practices and facilitates future pharmacological validation studies, which have received limited attention in previous review studies. Moreover, the ethnomedicinal data are presented in a structured framework, integrating botanical, ethnobotanical, and usage information for each species. In addition, correlation-based analysis is performed to investigate relationships between plant habits, plant parts, and preparation methods that reveal underlying ethnomedical patterns. Together, this approach allows for a more holistic and application-oriented understanding of traditional antidiabetic practices and their potential relevance for future pharmacological research. Future studies should concentrate on integrating ethnomedicinal knowledge to phytochemical and pharmacological validation to recognize potential antidiabetic species, along with standardization of traditional usage methods and conservation of medicinally important taxa. Hence, this current review aims to systematically compile and document ethnomedicinal plants used for diabetes management among tribal communities of Madhya Pradesh, India with emphasis on mode of use, preparation practices, conservation status and associations among plant growth habit, plant parts, and preparation methods. Overall, the review aims to contextualize traditional knowledge into proper perspective and establish a foundation for future pharmacological investigation and conservation prioritization in this biodiversity-rich region.

Materials and Methods

A comprehensive literature review was conducted to identify ethnomedicinal plants employed in the management of diabetes among tribal populations of Madhya Pradesh, India. Relevant studies were retrieved from various scientific databases, including “PubMed,” “Scopus,” “Google Scholar,” “ScienceDirect,” and “ResearchGate,” to ensure comprehensive literature retrieval. The search strategy was established using a combination of keywords, including “ethnomedicinal plants,” “diabetes,” “Madhya Pradesh,” “Central India,” “antidiabetic,” “hypoglycaemic,” and “mode of use.” The review was executed using a “PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses)” based methodology for the identification, screening, and selection of relevant studies.

Studies were selected according to the following criteria: (i) ethnobotanical or ethnomedicinal research conducted in Madhya Pradesh; (ii) documentation of plant utilization for diabetes management; (iii) reporting of ethnomedicinal data, including methods of use (dosage, preparation, and administration details); and (iv) publications in English from January 2010 to December 2023. Studies were excluded if they (i) did not specify ethnomedicinal use related to diabetes, (ii) lacked comprehensive usage information, (iii) were review articles, (iv) contained incomplete or duplicate data, or (v) were published in languages other than English. Selected studies were analyzed for scientific names, common names, families, plant habits, plant parts used, preparation methods, documented ethnomedicinal applications, and conservation status and organized into a structured dataset for subsequent analysis. In the included ethnobotanical studies, plant specimens were often collected during field investigations, identified based on regional flora and taxonomic references, and deposited in established institutional herbaria according to standard ethnobotanical documentation practices whenever reported. The conservation status of recorded plant species was assessed using the International Union for Conservation of Nature (IUCN) Red List database and verified for taxonomic consistency with Plants of the World Online (POWO) where applicable. Supplementary ethnobotanical characteristics of included studies, including informant groups, survey approaches, and plant validation procedures, were extracted wherever available and summarized in Supplementary Table S1.

Results

Diversity of Antidiabetic Plants

To provide an overview of the documented ethnomedicinal diversity, plant species used in diabetes management among tribal communities of Madhya Pradesh were compiled and analyzed. An aggregate of 85 species belonging to 78 genera and 45 distinct families were documented for their use in diabetes management among tribal groups in Madhya Pradesh (Table 1). The taxonomic distribution is uneven, predominantly concentrated within a few families, with Fabaceae exhibiting the highest representation (14 species), accompanied by Apocynaceae (8 species), Malvaceae (5 species), and Cucurbitaceae (4 species). The other families were represented by a smaller number of species, indicating a broad but uneven distribution of ethnomedicinal taxa in the region. Overall, the dataset is associated with a large degree of taxonomic diversity and a small number of families with a relatively large proportion of antidiabetic plant species.

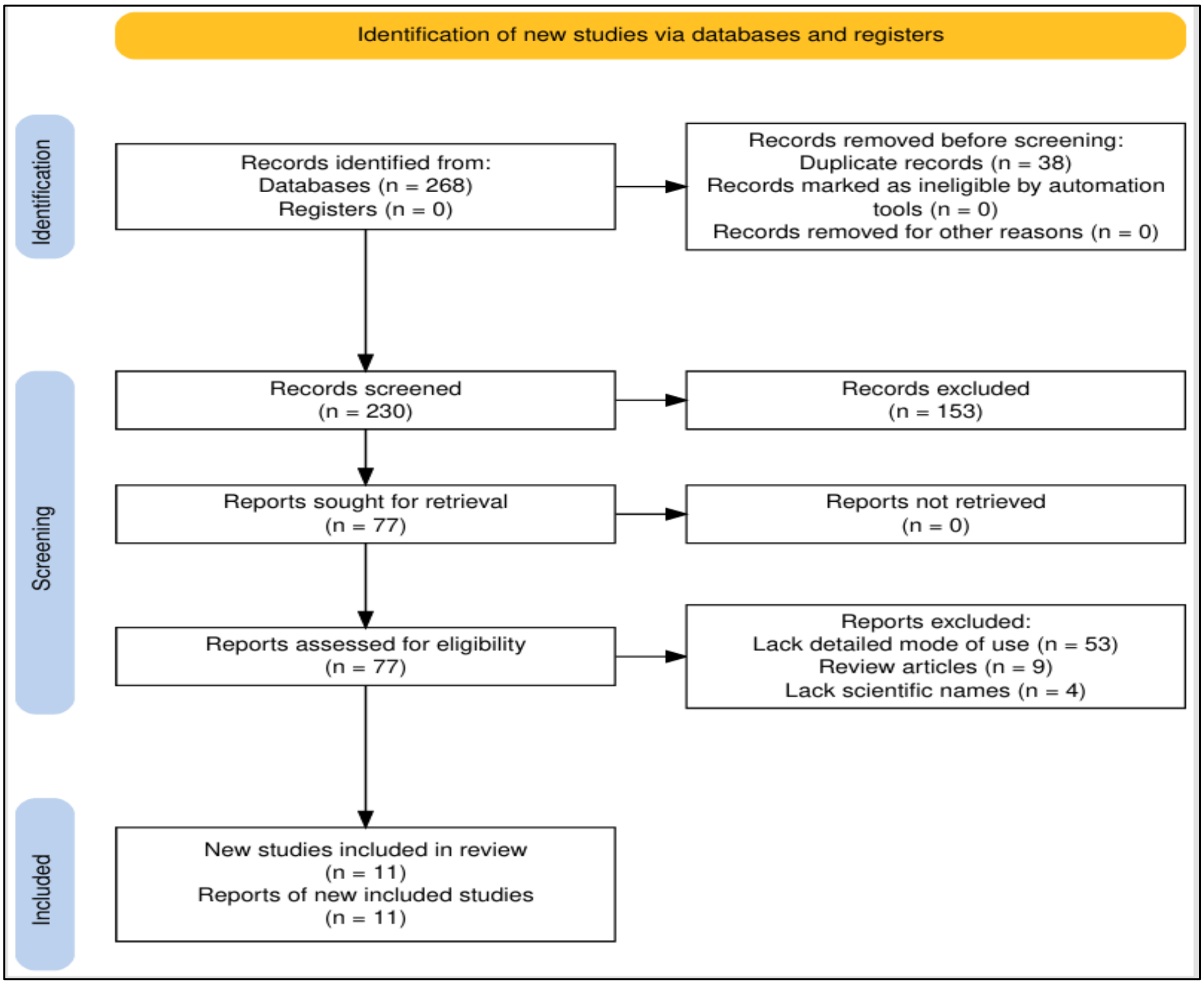

Figure 1. PRISMA flow diagram of study selection for ethnomedicinal antidiabetic plants in Madhya Pradesh, India.

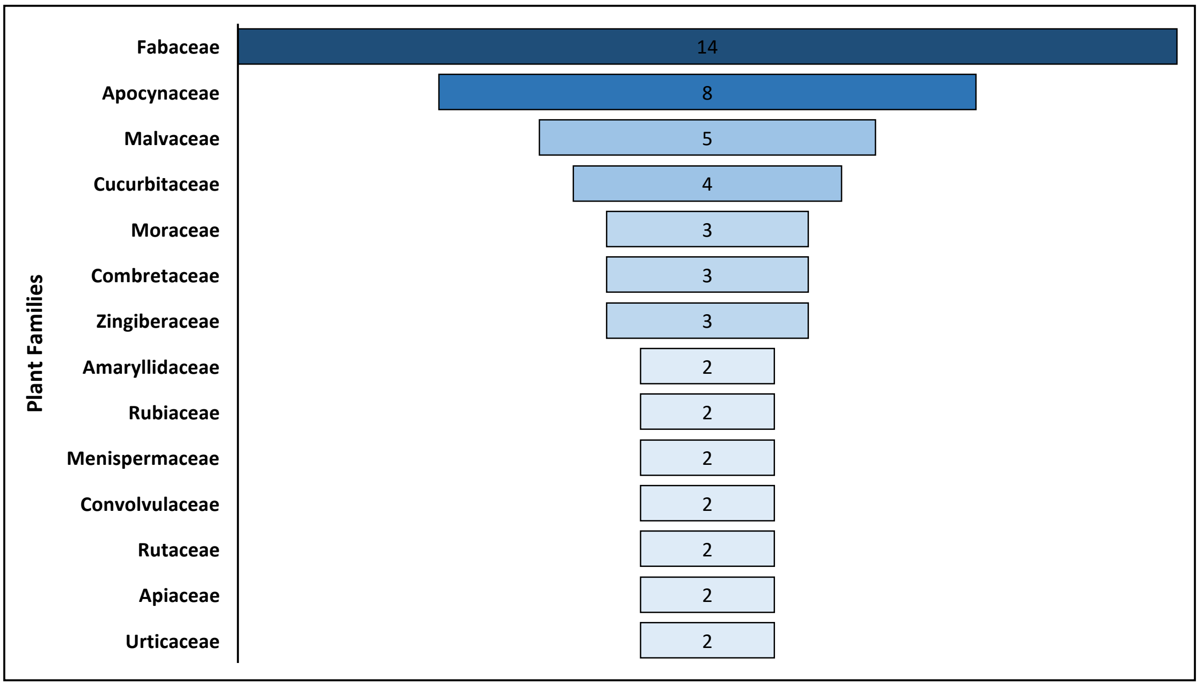

Figure 2. Distribution of dominant plant families contributing to antidiabetic species in Madhya Pradesh.

Distribution of Growth Habit

To characterize the botanical composition of the documented species, the distribution of plant growth habits was analyzed. Figure 3 illustrates the distribution of plant growth habits among the recorded antidiabetic species. Among the documented plants, 74 species were dicotyledonous and 11 species were monocotyledonous. Tree species represented the dominant growth habit, accounting for 29 species, followed by herbs (24 species), climbers (16 species), shrubs (10 species), and subshrubs (6 species).

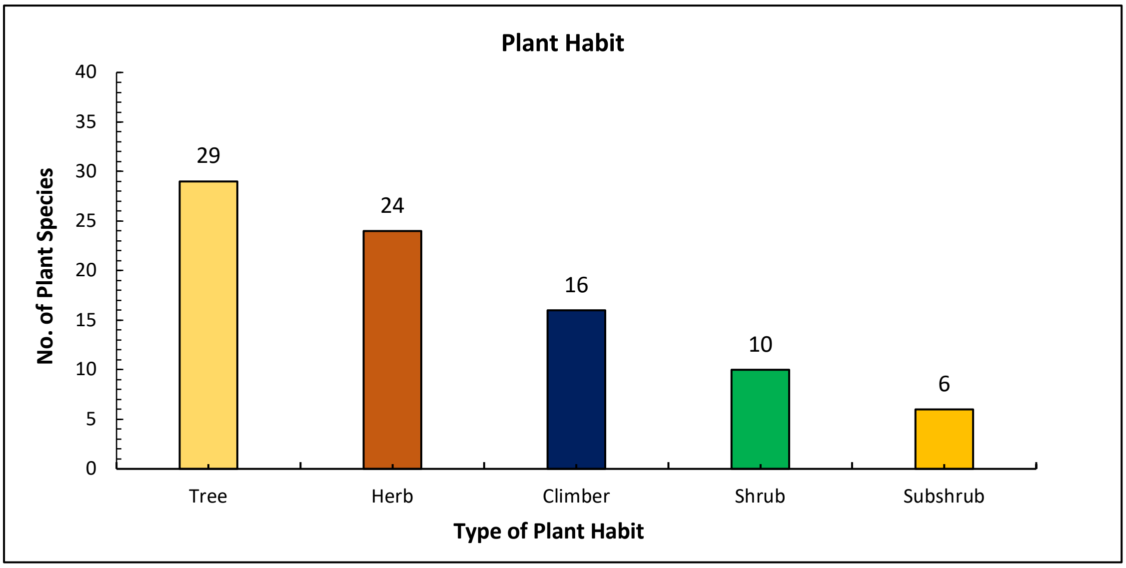

Figure 3. Distribution of antidiabetic plant species by growth habit.

Plant Part Utilization

To assess patterns of resource use, the distribution of plant parts utilized in antidiabetic treatments was examined. Figure 4 illustrates the distribution of parts of plants used in antidiabetic therapies. Substantial amounts of plant components were documented, including leaves, roots, bark, stem bark, flowers, stems, heartwood, rhizomes, root bark, tubers, aerial parts, bulbs, tender shoots, and in some cases, the entire plant. A widely used plant part of the plant was leaves, which were utilized more than any other part (26 reports), followed by roots (16 reports), fruits (14 reports), bark (14 reports), and seeds (11 reports). The relative number of species representing other parts of the plants was low. In general, the data indicate that the primary plant component used in ethnomedicinal practices to treat diabetes in the study area is leaves.

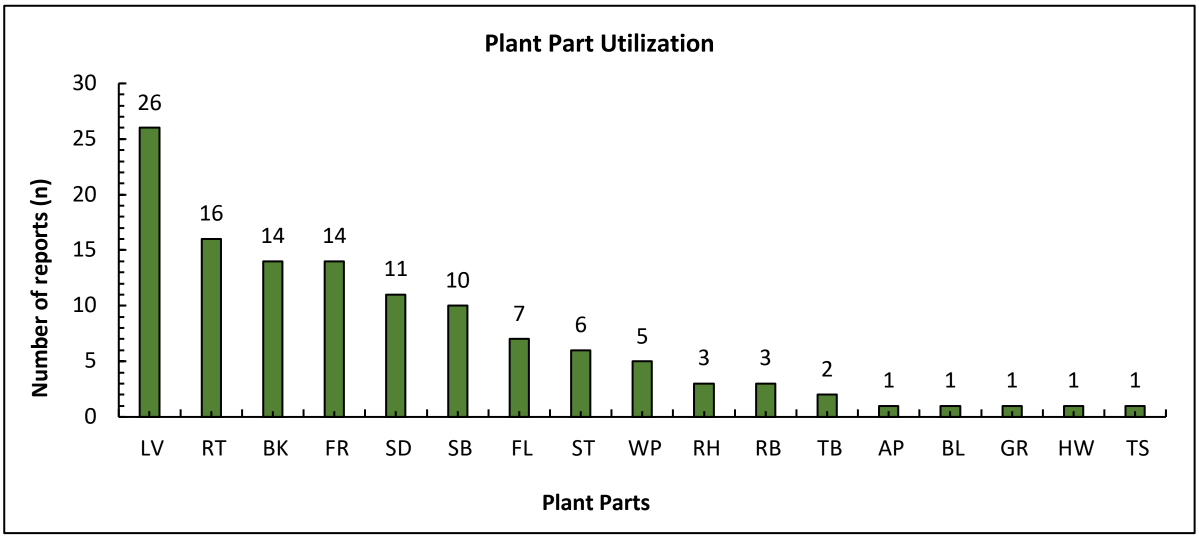

Figure 4. Distribution of plant parts used in antidiabetic ethnomedicinal practices. (Legend: AP: Aerial parts; BK: Bark; BL: Bulb; FL: Flowers; FR: Fruits; GR: Gum resin; HW: Heartwood; LV: Leaves; RH: Rhizome; RB: Root bark; RT: Roots; SD: Seeds; ST: Stem; SB: Stem bark; TS: Tender shoots; TB: Tuber; WP: Whole plant.)

Preparation methods utilized

To evaluate traditional formulation practices, the modes of preparation employed in antidiabetic treatments were analyzed. Figure 5 presents the distribution of the preparation methods involved in ethnomedicinal practices for antidiabetic treatments. Preparations of various types were recorded, such as powders, decoctions, raw consumption, extracts, juices, tablets, and other minor types, including paste, infusion, and chewing. Powder was the predominant reported form of preparation (35 reports), then decoction (25 reports). Raw consumption (16 reports), extracts (14 reports), juices (13 reports), and tablets (9 reports) were other common methods used. The less common methods of preparation were reported in relatively fewer cases. In general, the frequently reported methods of preparation in the recorded ethnomedicinal practices are powder and decoction. Most of the treatments were prescribed twice a day (59 reports), while 10 reports involved administration three times a day. In general, powder and decoction preparations are the most popular type of preparation; twice-daily dosage is the most frequently used pattern of administration of the documented ethnomedicinal practices.

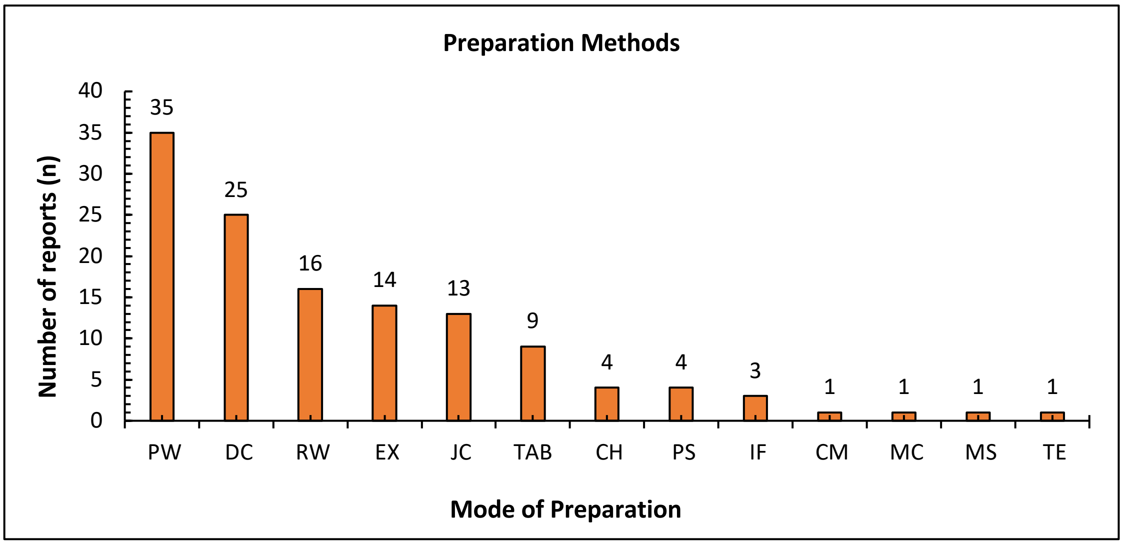

Figure 5. Distribution of preparation methods used in antidiabetic ethnomedicinal practices. (Legend: CH: Chewing; CM: Cold maceration; DC: Decoction; EX: Extract; IF: Infusion; JC: Juice; MC: Maceration; MS: Mash; PS: Paste; PW: Powder; RW: Raw; TAB: Tablet; TE: Tea.)

Conservation Status of Documented Plant Species

The conservation status of the recorded plant species was assessed to identify ecological and conservation implications. The current state of conservation of the reported antidiabetic plant species indicates that most taxa are classified as Not Evaluated (NE; 41 species) and Least Concern (LC; 35 species). A limited number of species were classified as Data Deficient (DD; 6 species) and Near Threatened (NT; 3 species), which include *Aegle marmelos*, *Pterocarpus marsupium*, and *Rauvolfia serpentina*. This distribution indicates that numerous ethnomedicinal species of plants utilized in diabetes therapy remain either unassessed or inadequately assessed concerning their conservation status.

To consolidate ethnomedicinal knowledge documented across tribal and rural regions of Madhya Pradesh, Table 1 presents a comprehensive compilation of plant species traditionally used for diabetes management. Each entry includes botanical and vernacular names, family classification, growth habit, plant parts utilized, modes of preparation, and detailed documented ethnomedicinal uses, including dosage, administration frequency, and treatment duration as reported in primary studies. Plant parts were retained exactly as reported in the source literature; therefore, categories such as bark and stem bark, as well as root and root bark, were maintained separately to preserve consistency and avoid assumptions during data standardization. The inclusion of explicit mode-of-use information distinguishes this synthesis from conventional reviews and provides a structured framework for comparing traditional practices across studies.

Table 1. Ethnomedicinal plants used for the treatment of diabetes in Madhya Pradesh.

Botanical Name	**Vernacular Name(s)**	**Family**	**Habit**	**Plant Part(s) Used**	**Mode of Preparation**	**Documented Ethnobotanical Use**	**Conservation Status**
Abroma augustum (L.) L.f.	Ulatkambal	Malvaceae	Shrub	Stem Bark, Leaves	Decoction	1) 10-20 mL decoction of stem bark or leaves is taken (Sahu 2017).	NE
Abrus precatorius L.	Ratti	Fabaceae	Climber	Leaves, Seeds	Juice, Powder	1) 2 tsp juice of leaves is taken twice a day (Yadav *et al.* 2012). 2) Powder of seed is mixed with honey and taken twice a day, morning, and evening for 20-25 days (Kumhar *et al.* 2017).	NE
Abutilon indicum (L.) Sweet.	Atibala	Malvaceae	Shrub	Stem Bark, Fruits	Decoction, Paste	1) A 25-50 mL of decoction of stem bark is taken twice a day (Sahu 2017). 2) Fruits are cooked with little water and made into a paste, and then 1 tsp of water is added and taken once daily in the early morning for 21 days (Mishra 2021).	NE
Aconitum palmatum D. Don.	Monkshood	Ranunculaceae	Herb	Roots	Decoction	1) A 10-15 ml decoction of root is taken for 7-10 days (Sahu 2017).	NE
Aegle marmelos (L.) Corrêa	Bael	Rutaceae	Tree	Fruits, Leaves	Juice, Mash, Powder, Extract	1) 50 mL juice of fruit is taken with ghee on an empty stomach for 1 week (Choudhary 2025). 2) 15 mL of juice of fruit or leaves and mash of leaves are taken twice a day (Kumhar *et al.* 2017). 3) Powder of leaves is taken with cow's milk and black pepper daily for 1 month (Yadav *et al.* 2012). 4) 1 cup extract of leaves is taken daily for 10 days (Ahirwar & Singh 2011).	NT
Allium cepa L.	Pyaz	Amaryllidaceae	Herb	Bulb	Raw	1) 50 g bulb is taken raw thrice a day for 4 weeks (Choudhary 2025).	NE
Allium sativum L.	Lahsun	Amaryllidaceae	Herb	Tuber	Raw	1) 1 clove is taken on an empty stomach daily (Choudhary 2025).	NE
Aloe vera (L.) Burm.f. (syn. *Aloe barbadensis*)	Ghritkumari	Asphodelaceae	Herb	Leaves	Raw	1) 40-50 g of pulp from leaves is taken for 10-12 weeks (Sahu 2017).	NE
Alstonia scholaris (L.) R.Br.	Saptaparni, Chitvan	Apocynaceae	Tree	Stem Bark	Infusion	1) Stem bark is soaked overnight in water, and 1 cup is taken in the morning for 7 days (Choudhary 2025).	LC

Andrographis paniculata (Burm.f.) Wall. ex-Nees	Kalmegh	Acanthaceae	Herb	Leaves	Decoction, Raw, Powder	1) 50 mL decoction of the leaves is taken thrice a day after food, or fresh raw leaves are taken daily (Yadav *et al.* 2012). 2) 2-3 fresh leaves are taken raw in the morning on an empty stomach for 5 days (Choudhary 2025). 3) 1 tsp of powder of leaves is taken with cow milk twice a day for 2-3 months (Kumhar *et al.* 2017).	NE
Annona squamosa L.	Sitaphal, Sharifa	Annonaceae	Tree	Stem Bark, Leaves	Decoction, Raw	1) 40-50 mL of decoction of stem bark is taken daily for 7 days (Choudhary 2025). 2) 25 g leaves are taken raw with milk daily in the morning (Yadav *et al.* 2012).	LC
Anogeissus latifolia (Roxb. ex-DC.) Wall.	Dhaura, Bakli	Combretaceae	Tree	Bark	Powder	1) 1-2 tsp powder of bark is taken twice a day for 30 days (Mishra 2021).	NE
Aristolochia indica L.	Isharmul, Kidamari	Aristolochiaceae	Climber	Seeds	Paste	1) Powder of seeds is mixed with black pepper and made into a paste and taken thrice a day for 15 days (Yadav *et al.* 2012).	NE
Asparagus racemosus Willd.	Shatavari	Asparagaceae	Climber	Whole Plant, Tender Shoots	Tablet, Decoction	1) Tablets are made from the paste of whole plants and are taken twice a day with cow milk (Mishra 2021). 2) 25 mL decoction of tender shoots is taken once a day for 6-8 weeks (Sahu 2017).	NE
Azadirachta indica A. Juss.	Neem	Meliaceae	Tree	Bark, Leaves	Decoction, Juice, Powder, Raw, Extract	1) Powder of bark is mixed with 150 g of *Piper nigrum* and is taken twice a day, in the morning and evening for 30-35 days (Kumhar *et al.* 2017). 2) 1 tsp juice or powder of leaves or decoction of bark is taken twice a day for 7 days (Ahirwar & Singh 2011). 3) 7 leaves are taken raw in the morning for 7 days (Choudhary 2025). 4) 3-5 mL extract of leaves is taken on an empty stomach twice a day (Kumhar *et al.* 2017).	LC
Baccharoides anthelmintica (L.) Moench (syn. *Centratherum anthelminticum*)	Kalijiri	Asteraceae	Herb	Seeds	Powder	1) 2 g powder of seeds is taken daily in the morning for 7 days (Choudhary 2025).	NE

Bauhinia variegata L.	Kachnar	Fabaceae	Tree	Bark, Flowers	Decoction, Paste	1) Decoction of bark is taken twice a day for a week (Ahirwar & Singh, 2011). 2) A paste of flower is mixed with jaggery, and 4 tsp are taken on an empty stomach once a day (Mishra 2021).	LC
Benincasa hispida (Thunb.) Cong.	Petha	Cucurbitaceae	Climber	Fruits	Raw	1) 4 tsp pulp of fruit is taken on an empty stomach once a day (Mishra 2021).	NE
Berberis aristata DC	Daruharidra, Chitra	Berberidaceae	Shrub	Root Bark	Extract	1) 5-10 mL extract of root bark is taken twice a day for 1-2 days (Sahu 2017).	LC
Boenninghausenia albiflora (Hook.) Rchb. ex Meisn.	Badrangi	Rutaceae	Herb	Whole Plant	Paste	1) The crushed whole plant is taken without water once or twice a day for 3-4 weeks (Sahu 2017).	NE
Biancaea sappan (L.) Tod. (syn. *Caesalpinia sappan*)	Patang, Bakam	Fabaceae	Tree	Roots	Tablet	1) Tablets are prepared from powder of roots and taken twice a day (Baghel *et al.* 2024).	LC
Brassica juncea (L.) Czern.	Sarson	Brassicaceae	Herb	Seeds	Powder	1) Powder of seeds is mixed with lime juice and taken for 15 days (Yadav *et al.* 2012).	NE
Butea monosperma (Lam.) Kuntze	Palash	Fabaceae	Tree	Flowers, Roots	Raw, Cold Maceration, Powder	1) 7 flowers are taken raw every morning for 14 days (Choudhary 2025). 2) Eleven flowers are soaked in 200 mL of water in a copper pot overnight, then mashed the next morning and filtered. Filtrate is taken as a single dose each day, on empty stomach, for 30 days (Mishra 2021). 3) 20 g of root powder mixed with an equal quantity of root powder of *Bombax cieba* is taken twice a day (Mishra 2021).	LC
Calamus rotang L.	Bet (Bait)	Arecaceae	Climber	Fruits	Chewing	1) 1-2 fruits are taken raw as masticatory twice a day (Sahu 2017).	NE
Calotropis gigantea (L.) W.T. Aiton	Safed Aak	Apocynaceae	Shrub	Flowers	Raw	1) 7 flowers are taken raw in the morning for 21 days (Choudhary 2025).	NE
Cannabis sativa L.	Bhang	Cannabaceae	Herb	Leaves	Extract	1) 5-10 mL of extract of leaves is taken daily (Sahu 2017).	NE

Caralluma adscendens (Roxb.) Haw.	Caralluma	Apocynaceae	Subshrub	Tuber	Extract	1) 3-5 mL extract of tuber is taken on an empty stomach for 45-55 days (Kumhar *et al.* 2017).	Lc
Carica papaya L.	Papaya	Caricaceae	Tree	Fruits	Juice	1) Juice of unripe fruits is taken in a cup twice a day for 7 days (Ahirwar & Singh 2011).	DD
Carissa spinarum G. Lodd	Karonda,	Apocynaceae	Shrub	Bark	Decoction	1) Decoction of bark is taken as 1/2 a cup in a small disposal of tea (Baghel *et al.* 2024).	LC
Chamaecrista absus (L.) H.S. Irwin & Barneby (syn. *Cassia absus*)	Chaksu	Fabaceae	Herb	Roots	Powder	1) 20 g powder of root is mixed with an equal quantity of root powder of *Bombax cieba* and taken twice a day (Mishra 2021).	LC
Cassia fistula L.	Amaltas	Fabaceae	Tree	Stem Bark, Seeds, Fruits	Powder, Raw	1) 1 tsp powder of stem bark is taken with water twice a day (Mishra 2021). 2) 1 tsp powder of seeds is taken once in the morning for 15 days or more (Yadav *et al.* 2012). 3) 3-6 g powder of seeds is used (Bijachurna) (Vishwakarma *et al.* 2023). 4) 10-20 g of pulp of fruit is used (Vishwakarma *et al.* 2023).	LC
Cassia occidentalis L.	Kasondi	Caesalpiniaceae	Subshrub	Seeds	Raw	1) 1 tsp seeds are taken raw with water for 15 days (Yadav *et al.* 2012).	LC
Cassia tora L.	Chakramard	Fabaceae	Subshrub	Roots	Juice	1) Juice is prepared by boiling 10 g of root in 400 mL of water, which is taken once a day for about 15 days (Yadav *et al.* 2012).	NE
Catharanthus roseus (L.) G. Don	Sadafuli	Apocynaceae	Subshrub	Flowers, Leaves	Extract, Chewing, Tea	1) 20 mL extract of flower is taken once a day on empty stomach (Mishra 2021). 2) 10 leaves or 10 flowers are boiled in water to prepare a tea, which is taken throughout the day (Choudhary 2025). 3) 1-2 raw leaves are chewed daily for 2 weeks (Sahu 2017).	NE
Centella asiatica (L.) Urb.	Mandukparni, Brahmi	Apiaceae	Herb	Whole Plant	Extract	1) 5ml extract of the whole plant is mixed with a cup of water and taken once daily for 21 days (Ahirwar 2017).	LC
Cinnamomum tamala (Buch.-	Tejpatta, Tamalpatra	Lauraceae	Tree	Stem Bark	Decoction	1) Decoction of stem bark is taken thrice a day for 3-4 weeks (Sahu 2017).	LC

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Cissampelos pareira L.	Patha, Akanadi	Menispermaceae	Climber	Root Bark	Extract	1) 5-10 mL extract of root bark is taken daily for 2-3 weeks (Sahu 2017).	NE
Coccinia grandis (L.) Voigt	Kundru	Cucurbitaceae	Climber	Leaves, Roots	Juice, Extract, Powder	1) 1 cup juice of leaves is taken once a day on an empty stomach for 3 months (Mishra 2021). 2) 5-10 mL extract of root is taken for 3-4 weeks (Sahu 2017). 3) Powder of root is mixed with sugar and taken thrice a day for 35-45 days (Kumhar *et al.* 2017).	NE
Convolvulus arvensis L.	Hiranpudi	Convolvulaceae	Herb	Leaves, Whole Plant	Tablet, Decoction	1) Tablets are prepared from powder of leaves and taken twice a day (Baghel *et al.* 2024). 2) A 15 g decoction of leaves or the whole plant is prepared and taken twice or thrice a day (Kumhar *et al.* 2017).	NE
Cheilocostus speciosus (J.Koenig) C.D. Specht (syn. *Costus speciosus*)	Keukand	Costaceae	Herb	Leaves	Powder	1) 1 tsp powder of leaves is taken with cow milk twice a day for 2-3 months (Kumhar *et al.* 2017).	LC
Curculigo orchioides Gaertn.	Kali Musli	Hypoxidaceae	Herb	Roots	Tablet	1) Tablets are made from 50 g root and 100 g seeds of *Syzygium jambos*, ground with 50 mL juice of *Momordica charantia,* and 1 tablet is taken with lukewarm water twice a day (Mishra 2021).	NE
Curcuma aromatica Salisb.	Jangli Haldi, Van Haldi	Zingiberaceae	Herb	Rhizome	Powder	1) 1 g of powder of rhizome mixed with 1/2 tsp of ghee and taken daily (Vishwakarma *et al.* 2023).	NE
Curcuma longa L.	Haldi, Haridra	Zingiberaceae	Herb	Rhizome	Powder	1) Powder of rhizome is taken twice a day with a cup of milk (Choudhary 2025).	DD
Dalbergia sissoo Roxb. ex-DC.	Shisham	Fabaceae	Tree	Leaves	Powder	1) 1 tsp powder of leaves is taken twice a day (Baghel *et al.* 2024).	LC
Embelia ribes Burm.f.	Vidanga	Primulaceae	Climber	Fruits, Roots	Powder	1) 3-5 g powder of fruit or root is taken once a day (Vishwakarma *et al.* 2023).	NE
Ficus benghalensis L.	Banyan	Moraceae	Tree	Fruits, Stem Bark, Bark	Raw, Decoction, Powder	1) 3-4 ripe fruits are taken daily (Baghel *et al.* 2024). 2) 50 mL decoction of stem bark is taken per dose (Choudhary 2025).	NE

						3) Powder of bark mixed with honey is taken twice a day for 21 days (Yadav *et al.* 2012).	
Ficus racemosa L.	Gular	Moraceae	Tree	Stem Bark, Fruits	Decoction, Juice, Raw	1) 1/2 cup decoction of stem bark is taken in the morning for 7 days (Ahirwar & Singh 2011). 2) 20-25 mL juice of fruits is taken for 4-8 weeks (Sahu 2017), 3) 2-3 ripe fruits are taken daily (Baghel *et al.* 2024).	LC
Ficus religiosa L.	Peepal	Moraceae	Tree	Bark	Powder	1) 1 tsp powder of bark is taken twice a day for 1 month (Mishra 2021).	LC
Girardinia diversifolia (Link) Friis	Bichhu Buti	Urticaceae	Subshrub	Bark, Roots	Juice, Decoction	1) 1 tsp juice of bark is used (Vishwakarma *et al.* 2023). 2) 25-50 mL decoction of root is taken daily for 4-8 weeks (Sahu 2017).	NE
Grewia tiliifolia Vahl	Dhaman	Malvaceae	Tree	Leaves	Decoction	1) 10 mL of decoction of leaves is taken twice a day for 15 days (Mishra 2021).	LC
Guilandina bonduc L. (syn. *Caesalpinia bonduc)*	Kuberakshi	Fabaceae	Climber	Leaves	Powder	1) Powder of leaves is taken thrice a day for 40-45 days (Kumhar *et al.* 2017).	LC
Gymnema sylvestre (Retz.) R.Br. ex Sm.	Gurmar, Madhunashini	Apocynaceae	Climber	Leaves, Whole Plant	Powder, Chewing, Raw, Extract	1) 1 tsp powder of leaves is taken twice a day (Baghel *et al.* 2024). 2) 2-3 leaves are chewed twice a day regularly (Mishra 2021). 3) 1 leaf is taken raw in the morning on an empty stomach for 10 days (Choudhary 2025). 4) 1 tsp extract of leaves and 1 tsp seed powder of *Trigonella foenum-graecum* L. are mixed and taken twice daily before meals for 7 days. (Ahirwar & Singh 2011), 5) 50 mL of extract of leaves or whole plant is taken twice a day, on an empty stomach early in the morning and 3-4 hours after meals in the evening before dinner (Kumhar *et al.* 2017).	NE
Helicteres isora L.	Marodphali	Malvaceae	Shrub	Leaves, Roots, Root Bark	Chewing, Juice	1) Leaves or root or root bark are chewed twice daily (Baghel *et al.* 2024). 2) 20 mL of juice of root is taken twice a day after meals (Mishra 2021).	LC
Holarrhena pubescens Wall. ex G. Don	Indrayava	Apocynaceae	Tree	Bark	Powder, Decoction	1) Powder of bark is taken in small quantities for 15-21 days, morning and evening (Rao *et al.* 2022).	LC

						2) 1/2 cup decoction of bark is taken twice a day (Choudhary 2025).	
Ipomoea batatas (L.) Lam	Shakarkand	Convolvulaceae	Herb	Aerial Parts	Juice	1) 25-30 mL juice of the aerial part is taken for 3-4 weeks (Sahu 2017).	DD
Lagenaria siceraria (Molina) Standl.	Lauki	Cucurbitaceae	Climber	Seeds	Powder	1) Powder of 5 seeds is taken twice a day (Mishra 2021).	NE
Lantana camara L.	Ghaneri, Raimuniya	Verbenaceae	Shrub	Leaves	Decoction	1) Decoction of leaves in a small cup with black pepper and honey and taken twice daily (Rao *et al.* 2022).	NE
Lawsonia inermis L.	Mehndi, Henna	Lythraceae	Shrub	Flowers, Leaves	Decoction	1) Decoction of leaves or flowers is taken once a day for 14-21 days (Yadav *et al.* 2012).	LC
Leea asiatica (L.) Ridsdale	Bhandari	Vitaceae	Shrub	Roots	Powder	1) 1 tsp powder of root is taken once a day for 7 days (Vishwakarma *et al.* 2023).	LC
Madhuca longifolia (J. Koenig ex L.) J.F. Macbr.	Mahua	Sapotaceae	Tree	Stem Bark	Decoction	1) Decoction of stem bark is taken twice a day (Choudhary 2025).	LC
Mangifera indica L.	Mango	Anacardiaceae	Tree	Seeds	Powder	1) 3-6 g of powder of seeds is taken in the morning for 7 days (Choudhary 2025).	DD
Mirabilis jalapa L.	Gulabasa	Nyctaginaceae	Herb	Roots	Tablet	1) Tablets are prepared from powder of roots and taken twice a day (Baghel *et al.* 2024).	NE
Momordica charantia L.	Karavella	Cucurbitaceae	Climber	Fruits, Leaves, Roots, Stem	Extract, Juice	1) 50 mL juice of fruits is taken on an empty stomach (Choudhary 2025). 2) 25 mL extract of fruit is taken twice a day for 12-14 weeks (Sahu 2017). 3) An extract of stem, leaves and roots is taken for 7 days (Ahirwar & Singh 2011). 4) 20 mL juice of leaves is taken with water twice a day (Mishra 2021).	NE
Moringa oleifera Lam.	Sahjan	Moringaceae	Tree	Bark	Decoction	1) Decoction of bark is taken every morning for 15 days (Ahirwar & Singh 2011).	LC
Murraya koenigii (L.) Spreng.	Kadi Patta	Rutaceae	Shrub	Leaves	Decoction	1) 10-15 leaves boiled with mint and taken daily for 5 days (Choudhary 2025).	LC

Musa × paradisiaca L.	Kela	Musaceae	Herb	Stem	Extract	1) 1 cup extract of stem is taken daily for 15 days (Ahirwar & Singh, 2011).	NE
Nelumbo nucifera Gaertn.	Kamal	Nelumbonaceae	Herb	Flowers	Juice	1) Juice is prepared from flowers and taken for about 15 days (Yadav *et al.* 2012).	DD
Ocimum tenuiflorum L. (syn. *Ocimum sanctum*)	Tulsi	Lamiaceae	Herb	Leaves	Juice	1) 15-20 mL juice of leaves is taken twice a day (Kumhar *et al.* 2017).	NE
Paederia foetida L.	Gandhali	Rubiaceae	Climber	Fruits, Roots	Tablet	1) Tablets are prepared from powder of fruits or roots and taken twice a day (Baghel *et al.* 2024).	NE
Phanera vahlii (Wight & Arn.) Benth. (syn. *Bauhinia vahlii*)	Mahul, Jallari	Fabaceae	Climber	Stem	Powder	1) 1 tsp powder of stem is taken twice a day (Baghel *et al.* 2024).	NE
Phyllanthus emblica L. (syn. *Emblica officinalis*)	Amla	Phyllanthaceae	Tree	Fruits	Powder	1) 1 tsp powder of fruit is taken twice a day (Choudhary 2025).	LC
Pterocarpus marsupium Roxb.	Vijaysar	Fabaceae	Tree	Bark, Gum Resin, Heartwood, Leaves, Stem Bark	Infusion, Extract, Decoction, Powder	1) Infusion of bark is taken on an empty stomach daily for 3 months (Ahirwar 2017). 2) An extract of leaves is taken twice a day for 10 days (Ahirwar & Singh 2011). 3) 3-5 mL of extract of bark-gum resin is taken on an empty stomach twice a day in the forenoon and 3-4 hours after meals in the evening before dinner (Kumhar *et al.* 2017). 4) 20 mL decoction of heartwood is taken with water twice a day (Mishra 2021). 5) 1 tsp of stem bark powder is taken twice a day (Choudhary 2025).	NT
Rauvolfia serpentina (L.) Benth. ex-Kurz	Sarpagandha	Apocynaceae	Subshrub	Roots	Powder	1) Powder of root is taken with honey twice a day for 1 week (Rao *et al.* 2022).	NT
Rubia cordifolia L.	Manjistha	Rubiaceae	Climber	Roots, Stem	Powder	1) 1/4 to 1/2 tsp of powder of root or stem in warm water is taken twice a day (Choudhary 2025).	NE

Schleichera oleosa (Lour.) Oken	Kusum	Sapindaceae	Tree	Bark	Tablet	1) Tablets are prepared from powder of bark (Baghel *et al.* 2024).	LC
Senegalia catechu (L.f.) P.J.H. Hurter & Mabb. (syn. *Acacia catechu*)	Khair	Fabaceae	Tree	Stem	Decoction	1) 1 cup of decoction of stem is taken thrice a day for 1 or 2 days (Gwalwanshi *et al.* 2014).	LC
Syzygium cumini (L.) Skeels	Jamun	Myrtaceae	Tree	Bark, Fruits, Leaves, Seeds	Decoction, Powder, Infusion, Raw	1) A decoction of bark, leaves and seeds is taken every morning for 15 days (Ahirwar & Singh 2011). 2) 5 g of powder of seeds is taken twice a day (Upadhyay & Rajhy 2017). 3) A 10 mL infusion of fruits or 1 tsp of powder of seeds and bark is taken thrice a day for 3 weeks (Choudhary 2025). 4) 1/2 tsp fruit pulp is taken thrice a day (Vishwakarma *et al.* 2023).	LC
Terminalia arjuna (Roxb. ex-DC.) Wight & Arn.	Arjun	Combretaceae	Tree	Bark	Powder	1) 1 tsp powder of bark in a glass of water and taken twice a day (Rao *et al.* 2022).	LC
Terminalia chebula Retz.	Harad	Combretaceae	Tree	Fruits	Tablet	1) Tablets are prepared from powder of fruit and taken twice a day (Baghel *et al.* 2024).	LC
Thespesia populnea (L.) Sol. ex Corrêa	Paras Peepal	Malvaceae	Tree	Bark, Leaves	Powder	5) 1 tsp powder of bark and leaves is taken with water (Baghel *et al.* 2024).	LC
Tinospora cordifolia (Willd.) Hook.f. & Thomson	Giloy, Amrita	Menispermaceae	Climber	Stem, Leaves	Powder	1) Powder of twigs/stems is taken twice a day for 7 days (Choudhary 2025). 2) Powder of leaves is mixed with 150 g of *Piper nigrum* and 60 g of bark powder of *Azadirachta indica*. Take 2 tsp of tea daily for 20-25 days (Yadav *et al.* 2012).	NE
Trachyspermum ammi (L.) Sprague	Ajwain	Apiaceae	Herb	Seeds	Tablet	1) Tablets are prepared from the powder of seeds and taken twice a day (Baghel *et al.* 2024).	NE
Trigonella foenum-graecum L.	Methi	Fabaceae	Herb	Seeds	Raw, Decoction, Powder	1) 10 g of seeds soaked overnight and taken on an empty stomach for 5 days (Choudhary 2025). 2) Decoction or powder of seed is taken with milk twice a day for 10 days (Ahirwar & Singh 2011).	NE

Vachellia nilotica (L.) P.J.H. Hurter & Mabb. (syn. *Acacia nilotica*)	Babul, Kikar	Fabaceae	Tree	Flowers	Maceration	1) Flowers are immersed in saccharine (sugar solution) for 15 days and are taken twice a day for 15 days (Ahirwar & Singh 2011).	LC
Zingiber officinale Roscoe	Adrak	Zingiberaceae	Herb	Rhizome	Extract, Powder	1) 2 tsp of extract or powder of rhizome is taken twice a day for 15 days (Ahirwar & Singh 2011).	DD

Association Between Growth Habit and Plant Part Utilization:

To examine patterns in plant utilization, the association between growth habit and plant parts used was analyzed. Figure 6 illustrates the association between plant growth habit and the use of plant parts. The wide diversity of plant parts was contributed to by tree species, with a generous representation of bark (12 reports), leaves (8 reports), fruits (8 reports), and stem bark (8 reports). Climbers showed a preference for leaves (6 reports), along with fruits (5 reports) and roots (5 reports). Herbaceous species were mainly related to fruits (6 reports), roots (4 reports), and seeds (4 reports), with further representation of rhizomes and whole plant use. Shrubs had moderate levels of utilization, especially leaves (5 reports) and roots (2 reports), with subshrubs having relatively low levels of representation, with roots (3 reports) being the most frequently recorded part of the plant. Generally, the distribution shows that different growth habits use various plant components in the documented ethnomedicinal practices.

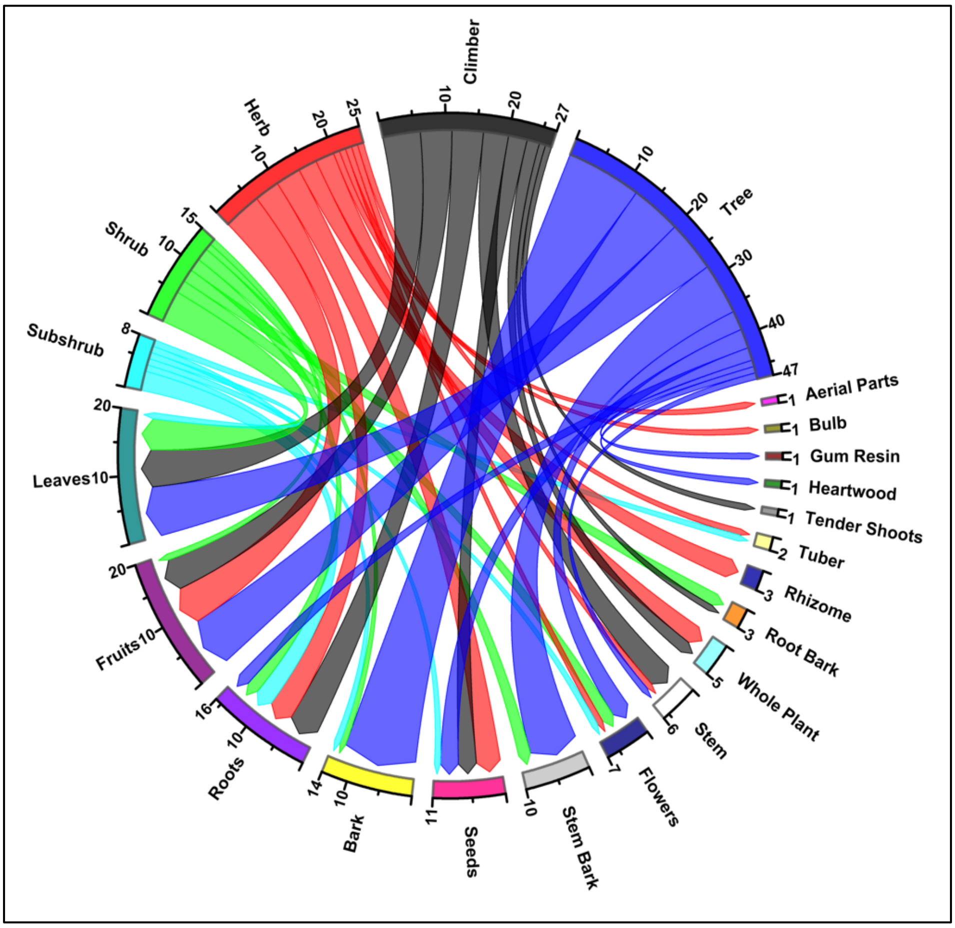

Figure 6. Association between growth habit and plant part utilization in antidiabetic ethnomedicinal practices.

Relationship Between Plant Parts and Preparation Methods:

To further understand preparation practices, the relationship between plant parts and modes of preparation was evaluated. Figure 7 depicts the relationship between parts of plants and preparation modes. The analysis shows that the highest frequency of association was presented in leaves when the methods of preparation included powder (9 reports), decoction (8 reports), extract (6 reports), and juice (5 reports), with other representation in the consumption of raw and other minor forms of preparation. Among the documented preparation methods, bark and stem bark were most frequently reported in decoction-based preparations (6 and 7 records, respectively), followed by powder formulations. Roots were often associated with powder (7 reports) and tablet preparations (4 reports) but were also found in decoction, extract, and juice formulations. The seeds were primarily associated with powder usage (8 times) and, to a lesser extent, with decoction and raw use. Fruits demonstrated heterogeneous relations, especially with the intake in the raw (5 reports) or the preparation based on juice (4 reports). The relative and more variable representation of other parts of the plant, such as flowers, rhizomes, stems, and the whole plant, was also found to be comparatively lower and more variable in different preparation methods. Altogether, the distribution shows unique patterns of correlation between certain parts of plants and certain methods of preparation in the recorded ethnomedicinal practices.

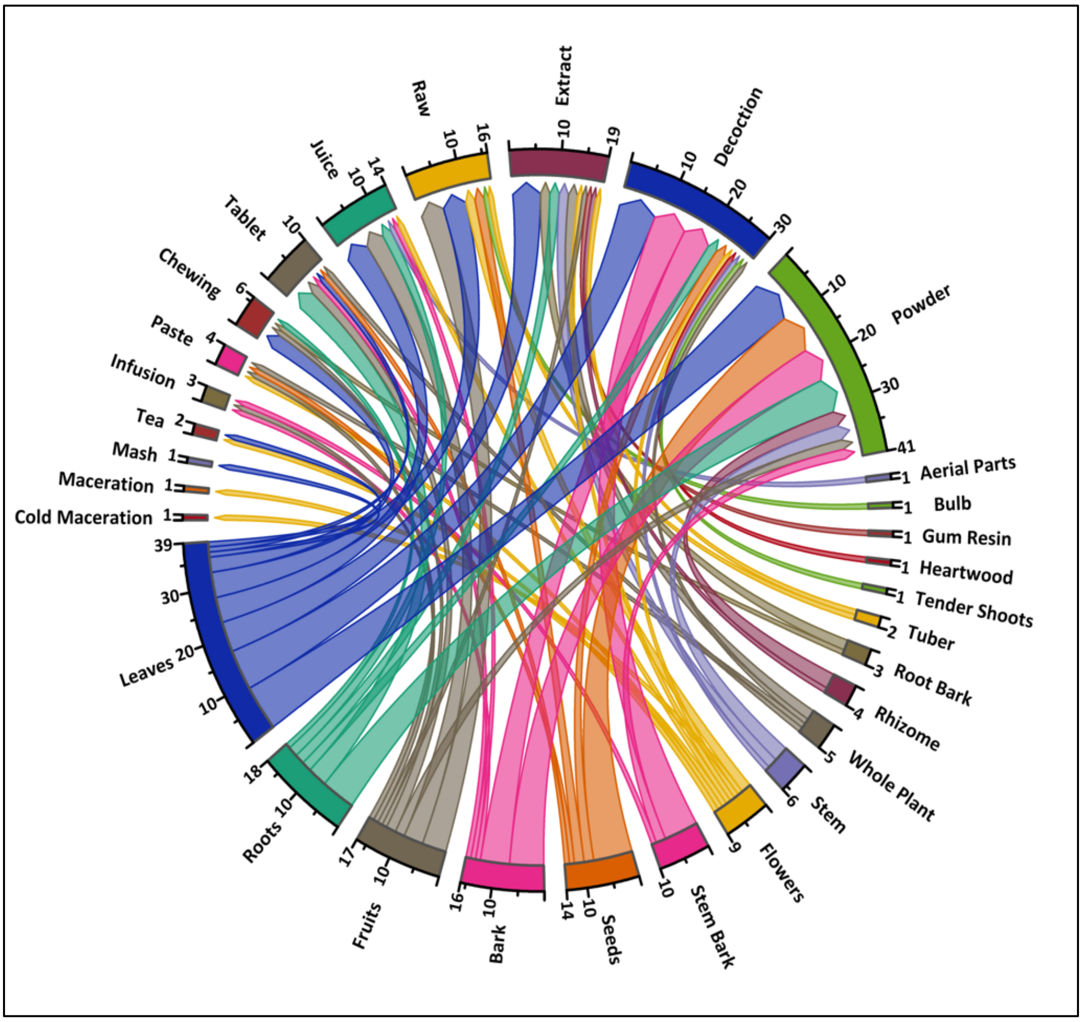

Figure 7. Association between plant parts and preparation methods in antidiabetic ethnomedicinal practices.

Linkages Between Growth Habit, Plant Parts, and Preparation Methods:

To integrate ethnomedicinal patterns, the combined linkages between plant growth habit, plant parts, and preparation methods were analyzed. The synergistic relationships which are seen to exist between the plant growth habit, plant parts used, and modes of preparation indicate a complex, integrated ethnobotanical framework with which native practitioners have intuitively optimized the harvest, processing, and delivery of phytopharmaceuticals. Figure 8 indicates the correlations between plant growth habit and parts of the plant used alongside modes of preparation. The largest proportion (39.86) of ethnomedicinal usage was contributed by tree species, with significant linkages to tree juices of powder (PW; 27.7%), decoction (DC; 20.27%), and extract (EX; 12.84) preparation. Climbers were significantly associated with leaves (LV) and fruits (FR) and frequently linked with powder (PW), juice (JC; 9.46%), and raw (RW; 10.81%) forms. There was also a predominance of herbaceous species that were linked to leaves (LV), roots (RT), and seeds (SD; 9.46%) and had different forms of preparation, including powder, decoction, and tablet (TAB; 6.76%). Shrubs and subshrubs exhibited comparatively lower representation but maintained consistent associations with leaves, roots, and selected preparation methods such as decoction and extract. In general, the distribution identifies integrated patterns of ethnomedicinal use across growth habits, plant parts, and preparation procedures; tree-derived components and powder-based formulations represent the most prominent combinations. Minor plant parts grouped under “other” (including bulb, aerial parts, gum resin, heartwood, and tender shoots) and less frequently reported preparation methods (cold maceration, maceration, mash, and tea) showed limited but consistent representation, reflecting their occasional yet context-specific use in ethnomedicinal practices.

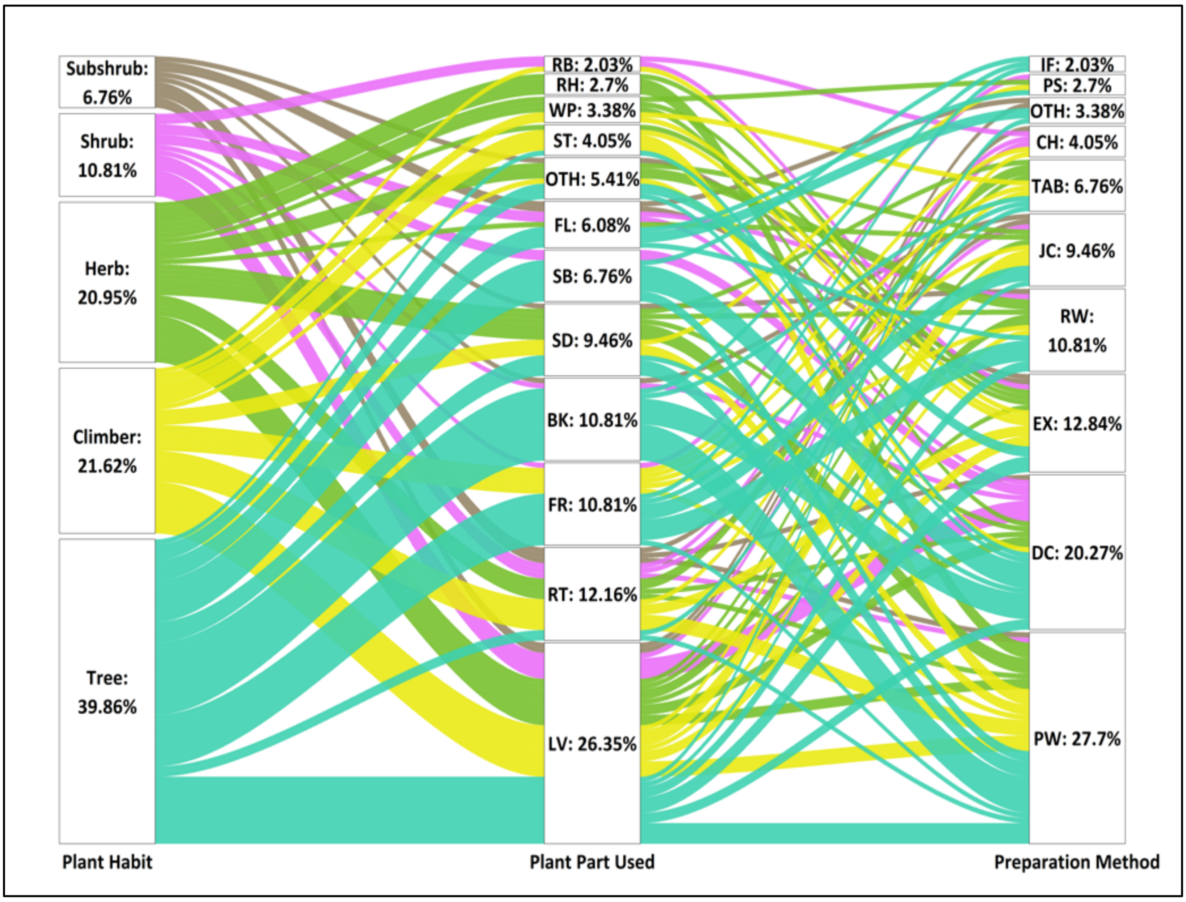

Figure 8. Linkages between growth habit, plant parts, and preparation methods in antidiabetic ethnomedicinal practices. (Legend: BK: Bark; FL: Flowers; FR: Fruits; LV: Leaves; RH: Rhizome; RB: Root bark; RT: Roots; SD: Seeds; ST: Stem; SB: Stem bark; WP: Whole plant; OTH: Other; CH: Chewing; DC: Decoction; EX: Extract; IF: Infusion; JC: Juice; PS: Paste; PW: Powder; RW: Raw; TAB: Tablet.)

Discussion

The present review integrates ethnomedicinal knowledge on antidiabetic plant usage by tribal communities of Madhya Pradesh and offers a unified interpretation of reported traditional practices. The review documents the plant's diversity and also covers the patterns of plant part selection, preparation methods, conservation status, and administration practices, including dosage, duration of a treatment, frequency of use, and formulation combinations. Additionally, associations between plant growth habit, plant parts used, and preparation methods were examined to reveal broader ethnomedicinal trends across the studies. When combined, these findings reveal insights into traditional systems of antidiabetic knowledge and provide a basis for future ethnobotanical, pharmacological, and conservation research. Documentation of 85 antidiabetic plant species under 78 genera and 45 families revealed significant ethnomedicinal biodiversity maintained among indigenous peoples of Madhya Pradesh. However, the abundance of species within relatively few families, especially Fabaceae, Apocynaceae, Malvaceae, and Cucurbitaceae, suggests selective dependence rather than random exploitation of the available flora. The dominance of selected families was also reported in ethnomedicinal studies on diabetes from other regions, where Fabaceae was the leading family due to its high species richness and long-standing medicinal importance (Abo *et al.* 2008, Kadir *et al.* 2012). Such patterns may be indicative of accumulated traditional knowledge gained by observing repeated therapeutic effects and transmitting them down through the generations.

The predominance of tree species observed in the present study aligns partially with findings from other ethnomedicinal investigations on diabetes, where trees (31.3%) and herbs (22.9%) were also reported as dominant growth forms among antidiabetic plants (Kadir *et al.* 2012). The uniformity arises because both woody and herbaceous species are important in the traditional use of antidiabetic plants across various regions. The dominance of trees may also indicate their long-term availability in forest-dependent communities and their capacity to provide several usable plant parts for a single species. The substantial existence of herbs in the present review also suggests the role of availability and collection convenience in the selection of plants in traditional healthcare practices. Together, these trends strongly suggest that both the availability of plants in the surrounding environment and their practical use influence the ethnomedicinal preferences for selecting a plant species for diabetes.

The predominance of leaves in the current review corroborates prior ethnomedicinal reports on antidiabetic plants. Faruque *et al.* (2019) found that leaves (34.07%) were the most frequently used part, followed by roots and fruits. Ralte and Singh (2024) identified the major plant parts utilized in the traditional management of diabetes to be the leaves (30.39%), bark (27.45%), roots (24.51%), and fruits (13.73%). Similar findings in the present study with leaves, roots, fruits, bark, and seeds as the predominant plant parts indicate consistency in ethnomedicinal plant preference across different regions. Leaves can be preferred due to their ease of collection, availability throughout the year, and relatively low influence on plant populations compared to underground or woody plant material. Roots and bark were also strongly represented in the current review, suggesting a continued reliance on parts of plants traditionally perceived to have stronger therapeutic value, despite needing more intensive harvesting. The pattern observed overall suggests that the choice of plant parts in antidiabetic ethnomedicinal practices is driven not solely by presumed medicinal efficacy but also by the accessibility and long-term availability of plant resources.

The overall incidence of powder and decoction in the present article is not different from previous ethnomedicinal studies focusing on diabetes. In the southeast of Algeria (Ouargla province), decoction (47 reports) was reported as the preferred mode of preparation, followed by infusion (38 reports) and powder (28 reports) (Telli *et al.* 2016). This similarity indicates that aqueous and dry preparation methods are consistently employed throughout the traditional antidiabetic procedures in various regions. Similar predominance of powders and decoctions has also been reported across the South Asian ethnomedicinal systems, reflecting the long-standing reliance on the simple and accessible methods of preparation (Sulaiman *et al.* 2020). The dominance of powder-based formulations in the current article may reflect a preference for formulations that are easier to store and repeat administration over long treatment periods. Decoctions remain well represented and may signify a sustained use of water-based extraction methods that involve minimal processing and are feasible in resource-constrained environments. The fact that most of the reported studies have used twice-daily administration also indicates some level of consistency in the traditional dosage practice and may also suggest empirical knowledge about regular patterns of intake in the management of diabetes. Overall, the preparation and administration trends recorded in the present study confirm a uniformity in traditional ethnomedicinal practices and are indicative of practical adaptation to local health care conditions.

The growth habit and life history characteristics inherently limit accessibility and availability of plant parts. The apparency hypothesis, when applied to ethnobotanical research, is a hypothesis that more visible, abundant, and accessible plant species are more likely to be preferentially utilized in traditional systems of treatment (Albuquerque 2019). The pharmacological reasoning behind part-specific utilization goes beyond accessibility to the various distributions of bioactive compounds among plant parts. The key chemical compounds identified as having contributed to the medicinal action of these plants are the flavonoids and alkaloids, alongside phenolic compounds. Leaves are an important source/reservoirs of defensive and antioxidant phytochemicals. Plant phenolic compounds serve various functions, including acting as antioxidants, structural polymers (lignin), attractants (flavonoids and carotenoids), UV protectants (flavonoids), signalling molecules (salicylic acids and flavonoids), and defence chemicals (tannins and phytoalexins). This is particularly true for polyphenols, among which flavonoids, phenolic acids, and tannins have been reported to inhibit α-glucosidase and α-amylase, enzymes involved in carbohydrate metabolism (Grover & Yadav 2004). Such characteristics may partly explain the repeated selection of leaves across traditional antidiabetic practices. Similar observations have been reported in ethnomedicinal investigations where leaves remained among the dominant plant parts used for diabetes management (Kadir *et al.* 2012). Roots represented one of the frequently utilized plant parts in the documented antidiabetic practices. This preference may be partly due to the wide range of secondary metabolites identified in root tissues, such as flavonoids, alkaloids, phenolic compounds and saponins, which have been associated with a range of biological activities (Modak *et al.* 2007). Similar results have been reported in ethnobotanical studies on diabetes management, where accessibility to plant resources and perceived therapeutic efficacy are important factors in the selection of plant parts in all traditional healthcare systems (Kadir *et al.* 2012). The documented associations between growth pattern and the use of plant parts, taken together, suggest that ecological accessibility and the accretion of ethnomedicinal knowledge influence the selection processes in traditional medicine.

The processing methods have a strong impact on phytochemical retention and therapeutic efficacy. Studies have indicated that the same plant materials can contain significant variation in phytochemical content based on the method of preparation (Abong' *et al.* 2020). Decoction has been among the most popular methods of preparation in traditional medicine systems. It requires extensive boiling of plant material in water and permits the extraction of water-soluble phytochemicals through thermal rupture of cell walls of the plant tissues. This is particularly relevant for structurally rigid tissues, such as bark, roots, and seeds, where heat could promote the release of intracellular compounds (Abubakar & Haque 2020). The frequent association of decoction with leaves, bark, and stem bark in the present dataset reflects continued reliance on water-based preparations across traditional antidiabetic practices. Similar observations suggest that preparation methods are selected not only according to plant availability but also according to accumulated traditional experience regarding administration and ease of use. Powdered preparations are one of the prevalent ways of administering many plant parts, especially leaves, roots, and seeds. Such a method enables easier storage, transportability, and repeated administration over extended treatment periods (Feudjio *et al.* 2022). Thus, the high percentage of powders seen in the present review may be a reflection of practical aspects associated with traditional healthcare systems instead of pharmacological factors alone. These observations correspond with the repeated occurrence of powder formulations across different studies included in the present review. The relationship between different plant parts and their preparation methods may also have ethnobotanical and ecological implications. The prevalent utilization of renewable plant parts, such as leaves, suggests relatively sustainable harvesting practices. In contrast, increased reliance on roots and whole-plant preparations might result in greater harvesting pressure, which should be taken into account when developing future strategies for conservation and sustainable use (Subba *et al.* 2023).

In the ethnobotanical studies, ethnobotanists also investigate elements of ethnomedicinal practice, such as local knowledge systems, traditional preparation techniques, and plant use patterns, to understand the selection and processing of medicinal species, demonstrating that associations between parts and preparations are driven by traditional knowledge accumulated over time, rather than random selection (Albuquerque *et al.* 2019). The principal source for ethnomedicinal preparations for the management of diabetes is the tree species, which has also been observed in several different ethnobotanical studies with geographical and cultural diversity. In Kinshasa (DR Congo), an extensive ethnobotanical survey revealed that 35% of antidiabetic plants were tree species belonging to 38 families, with the most prevalent being Fabaceae (Chiribagula *et al.* 2023). A similar study in eastern Uganda reported trees (63.2%) and herbs (20%) as dominant life forms, with roots and leaves being the main plant parts used and mostly prepared as decoctions for oral administration (Obakiro *et al.*, 2023). The consistency between the dominance of tree-derived plant parts and powder-based preparations observed in the present study may reflect practical optimization of harvesting and administration practices. Leaves from tree species represent a comparatively renewable resource that can be repeatedly harvested with lower impact on plant survival. Decoction remained one of the dominant preparation methods and showed notable association with bark and root utilization in the present review. Together, these observations suggest that preparation choices are influenced by both plant characteristics and long-standing ethnomedicinal practices. Climber species, which are less dominant (21.62%), exhibit clear preparation preferences, especially for fruits prepared as juice and eaten raw. This pattern could be related to the botanical characteristics of climber species and a preference to utilize minimally processed plant parts in traditional practices. The observed preparation patterns reflect practical adaptation in the use of medicinal plants and suggest that preparation methods may influence the addition of different plant parts in ethnomedicinal formulations (Abong' *et al.* 2020). The herbaceous species (20.95%) exhibit more diverse plant part use, as compared to tree-derived preparations, with recorded links to leaves, roots (12.16%), and seeds (9.46%) and various preparation methods, including powder, decoction, and tablet (6.76%) formulations. The pattern is due to the compressed life cycles and structural accessibility of herbaceous taxa*,* the ability to harvest whole-plant or partial plant parts makes herbaceous species particularly useful in traditional preparations combining multiple plant resources. The observed association of herbaceous roots with powder and tablet formulations may reflect practical preparation and administration preferences in traditional antidiabetic practices. Such preparation patterns suggest that processing methods can influence the incorporation and use of underground plant parts across ethnomedicinal formulations.

For further support of the ethnomedicinal relevance of the reported species, a selection of the most frequently referenced antidiabetic plants was subjected to assessment according to their citation frequency and experimental data of their pharmacological properties. The selected species have unique phytochemical compositions and corresponding mechanisms related to glucose regulation, insulin regulation, and metabolic pathways associated with diabetes. This aspect rather emphasizes mechanistic evidence that may validate the therapeutic reasoning behind ethnomedicinal practices recorded from indigenous groups of Madhya Pradesh instead of depending on isolated phytochemical findings for the validation of traditional uses. Many well-known plants exhibited antidiabetic activities by inhibiting carbohydrate-digesting enzymes and reducing intestinal glucose absorption. *Andrographis paniculata* (Burm.f.) Nees contains andrographolide, deoxyandrographolide and related diterpenoids that have antidiabetic effects through enzyme inhibition and metabolic control (Akhtar *et al.* 2016). In vitro studies have demonstrated inhibitory effects on α-amylase and α-glucosidase and comparable efficacy to acarbose in lowering postprandial glucose absorption (Swargiary *et al.* 2025). Aqueous extracts increased the activities of antioxidant defence enzymes and decreased the markers of oxidative stress in diabetic animal models, suggesting a supplementary preventive role against diabetic complications. (Sheeja *et al.* 2007). Flavonoid-rich extracts primarily demonstrated the antidiabetic potential of *Coccinia grandis* (L.) Voigt. The regulation of glucose metabolism has been associated with important compounds such as quercetin, kaempferol, ombuin and rutin (I Made Wisnu Adhi *et al.* 2022). Quercetin also inhibited the glucose transporter activity and the production of α-amylase and α-glucosidase, thus affecting the intestinal absorption of glucose (Kwon *et al.* 2007). Computational studies provided the evidence for the α-glucosidase inhibitory properties of the phytochemical constituents extracted from this species (Prabhakar *et al.* 2024). *Syzygium cumini* (L.) Skeels exhibits profound antidiabetic activity through inhibition of α-glucosidase, α-amylase and DPP-IV pathways (Syama *et al.* 2018). Under experimental conditions, phenolic substances including gallic acid and kaempferol showed more robust α-glucosidase inhibitory activities than acarbose (Rashid *et al.* 2022). Insulin-independent mechanisms have been suggested to provide additional benefits for lowering lipids and protecting the heart (Sanches *et al.* 2016).

A notable pharmacological pattern observed in a particular species is the stimulation of insulin secretion and the total enhancement of pancreatic β-cell function. *Gymnema sylvestre* (Retz.) R.Br. ex Sm. "gurmar" contains gymnemic acids that have been associated with regeneration of pancreatic islet cells and elevated secretion of insulin (Persaud *et al.* 1999). Experimental results showed increased insulin secretion in response to glucose and increased expression of glucose transport pathways (Kanetkar *et al.* 2007*,* Shenoy *et al.* 2018). Clinical observations showed a reduction in fasting blood glucose and glycosylated hemoglobin levels (Baskaran *et al.* 1990). *Pterocarpus marsupium* Roxb. has polyphenolic compounds, especially (-)-epicatechin, which shows insulin mimetic activity and promotes regeneration of pancreatic β-cells (Ahmad *et al.* 1991). Experimental studies indicated that pancreatic function was restored and insulin activity increased after administering extracts. *Momordica charantia* L. comprises many bioactive constituents, such as charantin, vicine, polypeptides, and glycosides, which collectively facilitate glucose reduction (Oyelere *et al.* 2022). Experimental studies have shown more effective glycemic control, improved insulin efficacy, and protective effects on pancreatic islets (Elekofehinti *et al.* 2018*,* Deng *et al.* 2023). *Aegle marmelos* (L.) Correa is enriched with coumarins, flavonoids, alkaloids and additional secondary metabolites that show antidiabetic properties (Nigam & Nambiar 2015). Experimental investigations have demonstrated the stimulating effect of coumarin-rich fractions on insulin secretion from pancreatic β-cells and their potent antidiabetic activity (Pari & Rajarajeswari 2009*,* Tiwari *et al.* 2023).

Several identified species showed pathways involving insulin signals and consumption of glucose. *Catharanthus roseus* (L.) G. Don Indole alkaloids have been associated with increased glucose uptake and metabolism (Celestina *et al.* 2025). Experimental data showed the enhancement of glucose transport and insulin-responsive pathways through the regulation of GLUT4 and IRS-1 expression (Tiong *et al.* 2013*,* Shijina *et al.* 2023). High-level polyphenol extracts have also been shown to lower levels of blood glucose in diabetic animal models (Espejel-Nava *et al.* 2018). *Azadirachta indica* A. Juss, possesses several bioactive compounds, such as flavonoids, limonoids and polyphenols responsible for exhibiting antidiabetic properties (Biswas *et al.* 2002). Experimental results demonstrated increased insulin receptor activity and inhibition of α-amylase, α-glucosidase, and DPP-IV pathways, which supports overall metabolic control (Ponnusamy *et al.* 2015*,* Satyanarayana *et al.* 2015*,* Yarmohammadi *et al.* 2021). Overall, the chosen plant species exhibit diverse but complementary pharmacological mechanisms involving diabetes management. *A. paniculata*, *C. grandis*, and *S. cumini* are mainly linked to enzyme inhibition, while *G. sylvestre*, *P. marsupium*, *M. charantia*, and *A. marmelos* are associated with insulin regulation and pancreatic support. In contrast, *C. roseus* and *A. indica* demonstrated mechanisms related to enhanced insulin signaling and glucose utilization. This mechanistic diversity provides pharmacological support to the ethnomedicinal practices and may also be a partial explanation for the ongoing utilization of polyherbal preparations in the traditional management of diabetes. Future work should focus on the comparison of phytochemical profiling between modern and traditional extraction methods, bioavailability testing for different preparation methods, and standardization frameworks to ensure the efficacy, safety, and conservation of traditional knowledge systems.

Conclusion

The present study focuses on the systematic compilation of indigenous medicinal plants used for the management of diabetes among the tribal communities of Madhya Pradesh. A total of 85 species from 45 families were recorded, among them Fabaceae was the dominant family. The analysis revealed significant ethnomedicinal patterns such as usage of tree and herb species, common occurrences of leaves, root and bark utilization and preference for powder and decoction preparations. Further ethnomedicinal context is provided by detailed documentation of mode of use (dosage, frequency and duration of treatment) that is rarely consolidated in existing review literature.

From a cultural perspective, the results highlight the significance of traditional medicine as an accessible and affordable way to provide healthcare services for tribal populations with limited access to modern medical facilities. Systematic documentation of the usage practices may contribute to the evidence-based validation of the traditional knowledge and identification of preferred species for pharmacological studies and drug development. Furthermore, the recorded ethnomedicinal usage patterns and mode of utilization findings may provide a practical foundation for future experimental approaches, pharmacological screening and conservation prioritization of medicinal plants.

However, the study is limited by the use of secondary data and variability in reporting by primary ethnobotanical studies, particularly regarding dosage standardization and experimental validation. Future studies should emphasize on standardized ethnobotanical documentation, dose validation, experimental evaluation of safety and efficacy and integration of ethnomedicinal evidence with pharmacological and clinical studies. In addition, the recorded mode of utilization information and identified ethnomedicinal patterns can be a valuable resource for selecting potential species, designing experimental protocols and guiding conservation prioritization of medicinal plant resources. The present review is a systematic and application-oriented synthesis which could help in scientific validation and future therapeutic exploration of traditional knowledge of Madhya Pradesh in the field of antidiabetic drugs.

Declarations

List of abbreviations: DPP-4: Dipeptidyl peptidase-4; GLUT2: Glucose transporter 2

Ethics approval and consent to participate: All the data related to the study is included in manuscript.

Consent for publication: Not applicable

Availability of data and materials: All the data related to the study is included in manuscript.

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Author contributions: Rut Megha carried out the conceptualization of the study design, data analysis and writing up of the manuscript. The interpretation of the data and the refinement of the manuscript were done with the substantive contribution of Shakun Mishra and Sunil Khristi. Hiren Soni was the supervisor during the entire research work and finalized the manuscript to be submitted.

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Appendix / Supplementary Material

Table S1. Ethnobotanical characteristics of studies included in the review

Author	Study Area (Madhya Pradesh)	Community / Informant Group	No. of Informants	Data Collection / Sampling Method	Herbarium / Plant Validation
Ahirwar & Singh (2011)	Shahdol district	Elderly informants, traditional healers, diabetic patients	NR	Field survey and discussion-based ethnobotanical documentation conducted during 2009-2010	Plant specimens identified at Botany Research Laboratory, Pt. S.N.S. Govt. P.G. College, Shahdol
Ahirwar (2017)	Pushprajgarh region, Anuppur district	Baiga tribal community, traditional healers (Vaidyas/Guniya)	NR	Questionnaire-based ethnobotanical survey across 11 villages; informed consent obtained	Voucher specimens collected and preserved in herbarium of Department of Botany, Pandit Sambhu Nath Shukla Govt. P.G. College, Shahdol
Baghel et al. (2024)	Achanakmar-Amarkantak Biosphere Reserve (6 districts)	Herbal practitioners	200	Structured questionnaire survey across 48 villages	Plant identification through herbarium comparison and Botanical Survey of India references
Choudhary (2025)	Satpura region, Betul district	Tribal healers (“Bhagat”)	9	Interview-based survey using structured questionnaire	Herbarium deposited in Department of Botany, Government College, Shahpur
Gwalwanshi et al. (2014)	Panna district	Local inhabitants	NR	Personal interviews and group discussions	Specimens preserved in herbarium, Department of Botany, Dr. Hari Singh Gour University
Kumhar et al. (2017)	Gondwana Vindhyan region	Gond tribal community, elderly tribal members, herbal healers	NR	Rapid roving survey and field interviews (2014-2016)	Specimens collected and identified using regional floras
Mishra (2021)	East Nimar region	Korku, Gond and Nihal tribes	NR	Field observations and repeated verification visits	Voucher specimens prepared using standard herbarium techniques
Sahu (2017)	Chitrakoot region	Tribal healers and village elders	NR	Repeated field visits and cross-validation with minimum seven informants	Taxonomic identification following herbarium collection
Shukla et al. (2010)	Madhya Pradesh	Forest guards, local Vaidyas and knowledgeable persons	NR	Field documentation and interviews	Herbarium preparation and validation using Botanical Survey of India
Upadhyay & Shukla (2017)	Shahdol district	Tribal communities	NR	Questionnaire-based ethnobotanical survey	Identification using standard floras

Vishwakarma (2023)	Amarkantak, Anuppur district	Local communities and herbal healers	NR	Stratified random sampling, interviews and group discussion	Field collection and photographic documentation

NR = Not reported.