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Medicinal Plants Used by Tribal Communities of Assam and Northeast India for the Management of Diabetes Mellitus: Implications for the Dimoria Region

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ABSTRACT

Diabetes mellitus (DM) is one of the fastest-growing chronic metabolic disorders worldwide and has become a major public health concern owing to its increasing prevalence, associated complications, and socioeconomic burden. According to recent estimates, more than 101 million people in India are living with diabetes, placing the country among those with the highest disease burden globally. Although modern antidiabetic drugs effectively control blood glucose levels, prolonged therapy is often associated with adverse effects, high treatment costs, and limited accessibility in rural and tribal regions. Consequently, indigenous communities continue to rely on medicinal plants as affordable, culturally accepted, and readily available therapeutic resources. The northeastern region of India, particularly Assam, is recognized as one of the richest biodiversity hotspots, harbouring thousands of medicinal plant species traditionally used by tribal communities including the Karbi, Bodo, Rabha, Mishing, Tiwa, Dimasa, Garo, Deori, and Sonowal Kachari. Ethnomedicinal knowledge accumulated through generations has documented numerous plant species possessing antidiabetic properties. Traditional healers employ leaves, roots, bark, fruits, seeds, rhizomes, and whole plants in the form of decoctions, fresh juices, powders, pastes, and infusions for regulating blood glucose levels and managing diabetes-related complications. A recent literature compilation reported 92 medicinal plant species belonging to 45 botanical families that are traditionally used for diabetes management in Assam, highlighting the immense therapeutic potential of indigenous flora. The present review synthesizes published ethnobotanical studies conducted across Assam and other parts of Northeast India to document medicinal plants traditionally employed in diabetes management. The review further evaluates traditional modes of preparation, plant parts utilized, phytochemical constituents, pharmacological evidence, and therapeutic mechanisms reported in scientific literature. The findings emphasize that leaves constitute the most frequently utilized plant part because of their sustainable harvesting and high concentration of bioactive phytochemicals such as flavonoids, phenolic acids, alkaloids, terpenoids, tannins, and saponins. Experimental pharmacological investigations have demonstrated that many of these phytoconstituents possess antihyperglycemic, antioxidant, anti-inflammatory, insulinotropic, and pancreatic β-cell protective properties. Nevertheless, only a limited number of traditionally used plants have undergone detailed phytochemical characterization, toxicity evaluation, and clinical validation. The review highlights the urgent need to document traditional knowledge before it disappears, scientifically validate ethnomedicinal claims, conserve medicinal plant diversity, and promote sustainable utilization of indigenous biological resources. Such efforts may facilitate the discovery of novel plant-derived antidiabetic compounds while preserving the invaluable cultural heritage of tribal communities in Northeast India.

***Keywords*:** Diabetes mellitus, Ethnomedicine, Medicinal plants, Traditional knowledge, Assam, Northeast India, Tribal communities, Dimoria, Antidiabetic plants, Phytochemicals.

1. Introduction

Diabetes mellitus (DM) represents one of the most significant chronic metabolic disorders affecting millions of individuals worldwide. The disease is characterized by persistent hyperglycemia resulting from impaired insulin secretion, insulin resistance, or a combination of both mechanisms. Persistent elevation of blood glucose causes progressive damage to

multiple organs including the kidneys, liver, retina, cardiovascular system, and peripheral nerves, thereby increasing morbidity and mortality. The prevalence of diabetes has risen dramatically over the past three decades owing to rapid urbanization, sedentary lifestyles, unhealthy dietary habits, obesity, and population ageing. India currently carries one of the world's largest diabetic populations, making the identification of affordable and effective therapeutic strategies a national healthcare priority.

Medicinal plants have served as the primary healthcare resource for humanity since ancient times. The World Health Organization estimates that nearly 80% of the world's population relies on traditional herbal medicine for primary healthcare, particularly in developing countries where modern healthcare facilities remain inaccessible or expensive. Medicinal plants contain diverse bioactive compounds including flavonoids, alkaloids, glycosides, terpenoids, tannins, saponins, and phenolic acids that exhibit potent pharmacological activities. Many modern drugs have originated directly or indirectly from plant-derived compounds, highlighting the importance of ethnomedicinal knowledge in contemporary drug discovery.

Northeast India is internationally recognized as one of the world's richest biodiversity regions and forms part of the Indo-Burma Biodiversity Hotspot. The region supports remarkable floristic diversity due to its varied topography, climatic conditions, high rainfall, and unique ecological characteristics. Assam alone harbours hundreds of medicinal plant species that have been traditionally utilized by indigenous communities for the treatment of numerous diseases. Tribal groups such as the Karbi, Bodo, Rabha, Tiwa, Mishing, Garo, Dimasa, Deori, Sonowal Kachari, and several other ethnic communities possess extensive knowledge regarding medicinal plants, their collection, preparation, dosage, and therapeutic applications. This knowledge has traditionally been transmitted orally from one generation to another and forms an integral component of their cultural heritage.

Among the various chronic diseases managed through traditional medicine, diabetes occupies a prominent position because of its increasing prevalence among both rural and urban populations. Numerous ethnobotanical investigations conducted in Assam have documented medicinal plants employed by traditional healers to control blood glucose levels, alleviate diabetic complications, and improve general health. A comprehensive review identified 92 medicinal plant species belonging to 45 botanical families that are traditionally used for diabetes management in Assam. Leaves were reported as the most frequently used plant part, followed by roots, bark, fruits, seeds, rhizomes, and whole plants. The predominant preparation methods included fresh juice, decoction, powder, infusion, and paste, reflecting the simplicity and accessibility of indigenous healthcare practices.

The Dimoria region of Kamrup Metropolitan district, Assam, is inhabited by diverse ethnic communities including the Karbi, Tiwa, Bodo, Rabha, Nepali, and Assamese populations. Although published ethnobotanical studies focusing specifically on antidiabetic medicinal plants in Dimoria remain limited, the region shares similar vegetation, climatic conditions, and cultural traditions with many other parts of Assam where extensive ethnomedicinal investigations have been undertaken. Therefore, published evidence from Assam and Northeast India provides a valuable scientific foundation for understanding the potential medicinal plant resources available to communities residing in the Dimoria region. Nevertheless, direct extrapolation should be made cautiously, and future field-based ethnobotanical investigations are required to validate plant use specifically within Dimoria.

The integration of ethnobotanical knowledge with phytochemical, pharmacological, and clinical research has become increasingly important in identifying novel antidiabetic agents. Scientific studies have demonstrated that many traditionally used medicinal plants possess antioxidant, antihyperglycemic, anti-inflammatory, hypolipidemic, insulin-secretagogue, and pancreatic β-cell protective activities. These pharmacological properties are largely attributed to secondary metabolites including flavonoids, terpenoids, alkaloids, phenolic compounds, coumarins, lignans, and polysaccharides. Consequently, ethnomedicinal information serves as an invaluable starting point for natural product research and the development of safer, cost-effective antidiabetic drugs.

2. Scope and Objectives of the Review

The present review was undertaken with the following objectives:

1. To compile published ethnobotanical information on medicinal plants traditionally used for diabetes management in Assam and Northeast India.
2. To evaluate the relevance of these documented medicinal plants to the tribal communities inhabiting the Dimoria region of Assam.
3. To summarize traditional preparation methods, plant parts utilized, and therapeutic practices reported in ethnomedicinal literature.

4. To correlate traditional knowledge with available phytochemical and pharmacological evidence supporting antidiabetic activity.
5. To identify research gaps and future opportunities for scientific validation, conservation, and sustainable utilization of indigenous medicinal plant resources.

The subsequent sections of this review present detailed analyses of medicinal plant diversity, traditional preparation methods, phytochemical composition, pharmacological mechanisms, and scientific evidence supporting the ethnomedicinal management of diabetes in Assam and Northeast India.

3. Literature Review and Ethnobotanical Background

3.1 Ethno medicine and Diabetes Management in Northeast India

Ethnomedicine refers to the body of traditional knowledge, beliefs, and practices developed by indigenous communities for the prevention and treatment of diseases using locally available biological resources. In India, traditional medicinal systems have evolved over thousands of years through continuous observation of nature and empirical experimentation. Tribal communities possess extensive knowledge regarding the identification, collection, processing, and therapeutic application of medicinal plants. This knowledge has traditionally been transmitted orally from one generation to another and continues to play a significant role in primary healthcare, particularly in remote rural areas where access to modern medical facilities remains limited (Harsha et al., 2002; WHO, 2019).

The northeastern region of India, comprising Assam, Arunachal Pradesh, Meghalaya, Manipur, Mizoram, Nagaland, Tripura, and Sikkim, forms part of the Indo-Burma Biodiversity Hotspot, one of the world's richest centres of biological diversity. The region supports more than 8,000 species of flowering plants, of which nearly one-third possess medicinal value. Favourable climatic conditions, high annual rainfall, varied topography, and dense tropical forests have contributed to exceptional plant diversity. This rich floristic wealth has enabled indigenous communities to develop sophisticated traditional healthcare systems based primarily on medicinal plants (Mao et al., 2009).

Among chronic metabolic disorders, diabetes mellitus (Madhumeha) occupies an important place in traditional healthcare systems. Diabetes is commonly recognized by symptoms such as excessive thirst, frequent urination, unexplained weight loss, fatigue, delayed wound healing, and excessive hunger. Traditional healers identify these symptoms and administer herbal formulations prepared from locally available medicinal plants. These formulations are believed not only to reduce blood glucose levels but also to alleviate diabetes-associated complications including fatigue, weakness, poor digestion, skin infections, and impaired wound healing (Grover et al., 2002).

Recent ethnobotanical surveys conducted in Assam have documented approximately 92 medicinal plant species belonging to 45 botanical families traditionally used for diabetes management. These plants include herbs, shrubs, climbers, and trees growing in forests, home gardens, wetlands, agricultural fields, and sacred groves. Families such as Fabaceae, Lamiaceae, Asteraceae, Cucurbitaceae, Euphorbiaceae, Rutaceae, Zingiberaceae, and Acanthaceae are among the most frequently represented. These plants are administered individually or in combination depending on the healer's knowledge and local traditions (Suman Kumar et al., 2021).

3.2 Traditional Healthcare Practices among Tribal Communities of Assam

Assam is inhabited by numerous indigenous communities, including the Karbi, Bodo, Tiwa (Lalung), Rabha, Mishing, Deori, Sonowal Kachari, Dimasa, Garo, Khasi, and Koch-Rajbongshi tribes. Each community possesses unique ethnobotanical knowledge reflecting its cultural heritage, ecological surroundings, and traditional beliefs. Herbal medicine continues to serve as an affordable and culturally accepted healthcare system, particularly among elderly villagers and traditional healers.

Traditional healers generally collect medicinal plants during the early morning when the concentration of secondary metabolites is believed to be highest. Fresh plant materials are preferred over dried materials whenever available. Leaves are harvested without destroying the entire plant, thereby ensuring sustainable utilization of valuable medicinal resources. Roots and bark are collected more cautiously because excessive harvesting may threaten plant survival. The collected materials are processed immediately or shade-dried for future use.

Preparation Method	Traditional Name (if applicable)	Description	Common Mode of Use
Fresh leaf juice	Swarasa	Juice extracted from freshly crushed leaves or other plant parts	Taken orally or applied topically.
Decoction	Kwatha	Prepared by boiling plant material in water until the volume is reduced	Consumed orally after filtration.
Paste	Kalka	Fresh plant parts are crushed or ground into a thick paste.	Applied externally or, in some cases, taken internally.
Powder	Churna	Dried plant material is finely powdered for convenient storage	Taken with water, honey, milk, or other suitable carriers.
Infusion	Phanta	Plant material is steeped in hot water for a specific period without further boiling	Consumed orally as a herbal infusion.
Boiled extract	NA	Plant material is boiled in water to extract bioactive compounds, then filtered	Taken orally or used externally, depending on the condition.
Chewed raw plant parts	NA	Fresh leaves, stems, roots, or other edible plant parts are chewed	Consumed orally for immediate therapeutic effect.
Herbal mixtures with honey or warm water	NA	Plant preparations (juice, powder, or paste) are mixed with honey or warm water	Taken orally.

Table 1: Showing practice of Traditional Medicine

The dosage is generally determined according to the patient's age, physical condition, severity of illness, and previous therapeutic response. Although these traditional practices have been successfully employed for generations, standardized dosage and controlled clinical validation remain largely unavailable, highlighting the need for further pharmacological investigation.

3.3 Ethnobotanical Significance of the Dimoria Region

The Dimoria Development Block, situated in Kamrup Metropolitan District of Assam, represents one of the biologically and culturally diverse regions of the Brahmaputra Valley. The area lies adjacent to the foothills of the Meghalaya Plateau and supports moist deciduous forests, agricultural landscapes, wetlands, grasslands, and village woodlands. Such habitat diversity supports numerous medicinal plant species traditionally utilized by local communities.

Dimoria is inhabited by several ethnic groups including the Karbi, Tiwa, Rabha, Bodo, Nepali, Assamese, Garo, and other indigenous communities, each contributing valuable ethnomedicinal knowledge. Although systematic studies focusing specifically on antidiabetic medicinal plants in Dimoria are currently scarce, several ethnobotanical investigations from neighbouring districts report the use of similar plant species for diabetes management. Owing to comparable climatic conditions, vegetation types, and cultural traditions, many of these medicinal plants are also naturally distributed in Dimoria and may potentially form part of local traditional healthcare practices.

Therefore, the present review compiles published information from Assam and Northeast India while acknowledging that future field-based documentation is essential to verify plant use specifically within the Dimoria region.

4. Scientific Basis of Traditional Antidiabetic Medicinal Plants

The therapeutic effectiveness of medicinal plants is primarily attributed to the presence of diverse secondary metabolites, commonly referred to as phytochemicals. These naturally occurring compounds are synthesized by plants as defence mechanisms against environmental stress, pathogens, and herbivores. Modern pharmacological studies have demonstrated that many of these phytochemicals exhibit potent antihyperglycaemic activity through multiple biochemical pathways.

Bioactive Compound	Description	Proposed Role in Antidiabetic Activity
Flavonoids	Polyphenolic compounds widely distributed in plants.	Exhibit antioxidant activity, improve insulin sensitivity, enhance glucose uptake, and protect pancreatic β-cells from oxidative stress.
Alkaloids	Nitrogen-containing secondary metabolites with diverse pharmacological properties.	Stimulate insulin secretion, improve glucose metabolism, and inhibit carbohydrate-digesting enzymes.
Phenolic compounds	A broad class of plant metabolites containing phenol groups.	Reduce oxidative stress, inhibit α-amylase and α-glucosidase enzymes, and improve glycemic control.
Terpenoids	Naturally occurring compounds derived from isoprene units.	Enhance insulin sensitivity, regulate glucose metabolism, and possess anti-inflammatory properties.
Saponins	Glycosides characterized by soap-like foaming properties.	Promote insulin release, improve glucose utilization, and reduce blood glucose levels.
Tannins	Polyphenolic compounds capable of binding proteins and other biomolecules.	Delay carbohydrate digestion, inhibit digestive enzymes, and reduce postprandial hyperglycemia.
Steroids	Naturally occurring steroidal compounds found in many medicinal plants.	Modulate glucose metabolism and may improve insulin signaling pathways.
Glycosides	Compounds consisting of a sugar moiety linked to a non-sugar (aglycone) component.	Enhance glucose homeostasis, support insulin secretion, and exhibit antioxidant effects.
Coumarins	Aromatic benzopyrone derivatives present in various medicinal plants.	Improve glucose metabolism, reduce oxidative stress, and exert anti-inflammatory effects.
Polysaccharides	Complex carbohydrates composed of long chains of monosaccharides.	Enhance insulin sensitivity, regulate glucose absorption, and provide immunomodulatory and antioxidant benefits.

Table 2: Showing Bioactive compounds

Unlike synthetic drugs that often target a single biochemical pathway, medicinal plants generally exhibit **multitarget pharmacological activity**, making them particularly valuable in chronic diseases such as diabetes mellitus.

Major Mechanisms of Action

Published pharmacological investigations indicate that medicinal plants lower blood glucose through several mechanisms:

a. Stimulation of insulin secretion

Certain phytochemicals stimulate pancreatic β-cells to increase endogenous insulin production.

b. Improvement of insulin sensitivity

Several flavonoids and phenolic compounds enhance insulin receptor signalling, thereby increasing glucose uptake by peripheral tissues.

c. Inhibition of carbohydrate-digesting enzymes

Many medicinal plants inhibit α-amylase and α-glucosidase enzymes, delaying carbohydrate digestion and reducing postprandial blood glucose levels.

d. Antioxidant activity

Oxidative stress plays a major role in diabetic complications. Polyphenols, flavonoids, and vitamin-rich medicinal plants neutralize reactive oxygen species and protect pancreatic β-cells.

e. Hepatoprotective effects

Several plants improve hepatic glycogen synthesis and regulate glucose metabolism in the liver.

f. Lipid-lowering activity

Medicinal plants frequently reduce serum cholesterol, triglycerides, and low-density lipoproteins, thereby lowering cardiovascular risks associated with diabetes.

g. Anti-inflammatory activity

Chronic inflammation contributes to insulin resistance. Bioactive phytochemicals suppress inflammatory cytokines and improve metabolic homeostasis.

These multiple pharmacological mechanisms explain why numerous ethnomedicinal preparations remain effective despite consisting of crude plant extracts rather than purified pharmaceutical compounds.

5. Current Status of Scientific Validation

During the past two decades, significant progress has been made in validating traditional medicinal plants used for diabetes.

Scientific Name	Common Name	Family	Traditional Antidiabetic Significance
Tinospora cordifolia	Guduchi (Giloy)	Menispermaceae	Widely used to regulate blood glucose, improve insulin function, and enhance overall metabolic health.
Gymnema sylvestre	Gurmar	Apocynaceae	Known as the "sugar destroyer"; traditionally used to reduce sugar cravings, stimulate insulin secretion, and lower blood glucose levels.
Syzygium cumini	Jamun	Myrtaceae	Seeds, bark, and leaves are commonly used to control blood glucose and improve glycemic regulation.
Momordica charantia	Bitter Gourd (Bitter Melon)	Cucurbitaceae	Fruits and leaves are traditionally used for their hypoglycemic properties and insulin-like effects.
Curcuma longa	Turmeric	Zingiberaceae	Rhizomes are valued for their antioxidant and anti-inflammatory properties, contributing to improved glucose metabolism.
Coccinia grandis	Ivy Gourd	Cucurbitaceae	Leaves and fruits are used to reduce blood glucose levels and improve glucose utilization.
Ocimum tenuiflorum	Holy Basil (Tulsi)	Lamiaceae	Leaves are traditionally consumed to improve glucose metabolism and reduce oxidative stress associated with diabetes.
Azadirachta indica	Neem	Meliaceae	Leaves and bark are widely used to lower blood glucose levels and support pancreatic function.
Aegle marmelos	Bael	Rutaceae	Leaves and fruits are used in traditional medicine to manage diabetes and improve carbohydrate metabolism.
Terminalia chebula	Haritaki	Combretaceae	Fruits are used for their antioxidant, antihyperglycemic, and digestive health-promoting properties, aiding diabetes management.

Table 3: Showing plants with antidiabetic significance

These plants have shown the ability to reduce fasting blood glucose, improve glucose tolerance, regenerate pancreatic β-cells, reduce oxidative stress, enhance insulin secretion, and normalize lipid metabolism under experimental conditions. Some have also progressed to preliminary clinical investigations, although robust randomized controlled trials remain limited.

Despite encouraging findings, significant challenges remain:

- Lack of standardized herbal formulations.
- Variability in phytochemical composition due to geography and season.
- Limited toxicity studies.
- Insufficient human clinical trials.
- Poor documentation of traditional dosage.
- Overharvesting of medicinal plant populations.
- Loss of indigenous knowledge due to cultural change.

Addressing these gaps will require multidisciplinary collaboration among ethnobotanists, pharmacologists, phytochemists, clinicians, conservation biologists, and tribal knowledge holders.

6. Transition to Species Documentation

The literature reviewed above demonstrates that traditional medicinal knowledge represents an invaluable resource for identifying plant species with potential antidiabetic activity. Assam alone possesses remarkable ethnomedicinal diversity, much of which remains scientifically underexplored. The next section of this review compiles medicinal plant species reported from published ethnobotanical studies across Assam and Northeast India, together with their botanical identity, family, plant parts utilized, traditional therapeutic applications, and supporting literature. This compilation provides a scientific foundation for understanding the diversity of herbal remedies employed in diabetes management and offers valuable baseline information for future ethnobotanical investigations in the Dimoria region.

Sl. No.	Scientific Name	Common Name	Family	Plant Part Used	Traditional Use
1	*Syzygium cumini*	Jamun	Myrtaceae	Seeds	Seed powder consumed to lower blood glucose
2	*Tinospora cordifolia*	Guduchi	Menispermaceae	Stem	Stem decoction taken daily for diabetes
3	*Gymnema sylvestre*	Gurmar	Apocynaceae	Leaves	Leaf powder/decoction used to reduce blood sugar
4	*Momordica charantia*	Bitter gourd	Cucurbitaceae	Fruit	Fresh juice taken on an empty stomach
5	*Coccinia grandis*	Ivy gourd	Cucurbitaceae	Leaves	Leaf juice administered orally
6	*Azadirachta indica*	Neem	Meliaceae	Leaves	Leaf extract consumed to regulate glucose
7	*Aegle marmelos*	Bael	Rutaceae	Leaves	Fresh leaf juice used in traditional therapy
8	*Curcuma longa*	Turmeric	Zingiberaceae	Rhizome	Powder mixed with warm water or milk
9	*Zingiber officinale*	Ginger	Zingiberaceae	Rhizome	Decoction or fresh rhizome consumed
10	*Terminalia chebula*	Haritaki	Combretaceae	Fruits	Fruit powder taken daily
11	*Terminalia bellirica*	Bahera	Combretaceae	Fruits	Powder used individually or in formulations
12	*Phyllanthus emblica*	Amla	Phyllanthaceae	Fruits	Fresh fruit or juice consumed

13	*Ocimum tenuiflorum*	Holy basil	Lamiaceae	Leaves	Leaf juice taken in the morning
14	*Murraya koenigii*	Curry leaf	Rutaceae	Leaves	Leaves chewed fresh daily
15	*Andrographis paniculata*	Kalmegh	Acanthaceae	Whole plant	Decoction administered orally
16	*Aloe vera*	Aloe	Asphodelaceae	Leaf gel	Gel consumed before meals
17	*Catharanthus roseus*	Madagascar periwinkle	Apocynaceae	Leaves	Leaf extract used traditionally
18	*Centella asiatica*	Indian pennywort	Apiaceae	Whole plant	Juice taken once daily
19	*Clerodendrum colebrookianum*	East Indian glory bower	Lamiaceae	Leaves	Decoction used by tribal healers
20	*Costus speciosus*	Crepe ginger	Costaceae	Rhizome	Rhizome paste/decoction used
21	*Ficus racemosa*	Cluster fig	Moraceae	Bark	Bark decoction consumed
22	*Ficus religiosa*	Peepal	Moraceae	Bark	Bark extract taken orally
23	*Musa paradisiaca*	Banana	Musaceae	Flower	Cooked flower consumed traditionally
24	*Psidium guajava*	Guava	Myrtaceae	Leaves	Leaf decoction used
25	*Allium sativum*	Garlic	Amaryllidaceae	Bulb	Fresh cloves eaten daily
26	*Trigonella foenum-graecum*	Fenugreek	Fabaceae	Seeds	Seeds soaked overnight and consumed
27	*Cassia fistula*	Golden shower	Fabaceae	Bark	Decoction administered orally
28	*Asparagus racemosus*	Shatavari	Asparagaceae	Root	Root powder mixed with water
29	*Piper longum*	Long pepper	Piperaceae	Fruits	Powder used with honey
30	*Piper nigrum*	Black pepper	Piperaceae	Fruits	Powder combined with herbal preparations

Table 4: Showing list of all the plants

Summary of the dataset

The literature indicates that:

Leaves are the most frequently used plant part, followed by fruits, rhizomes, bark, seeds, stems, roots, and whole plants.

Families such as Cucurbitaceae, Myrtaceae, Rutaceae, Zingiberaceae, Apocynaceae, Combretaceae, Lamiaceae, and Piperaceae are prominently represented. The most common dosage forms include fresh juice, decoctions, powders, and raw plant material.

7. Traditional Methods of Preparation, Dosage, and Administration of Antidiabetic Medicinal Plants

The preparation of herbal medicines for diabetes management among the tribal communities of Assam and Northeast India follows simple, locally available, and sustainable methods. Traditional healers generally prefer freshly collected plant materials because they believe fresh herbs possess greater therapeutic efficacy than dried materials. The most common dosage forms include fresh juice (Swarasa), decoction (Kwatha), powder (Churna), infusion (Phanta), paste (Kalka), and consumption of raw plant parts. Among these, decoction is the most frequently reported preparation method in Assam, accounting for over half of documented formulations in some ethnobotanical surveys.

It is important to note that the dosages presented below represent traditional ethnomedicinal practices reported in the literature. They are not standardized clinical dosages and should not be interpreted as medical recommendations.

Table 5. Traditional preparation methods and dosage of medicinal plants used for diabetes management

Scientific Name	Part Used	Method of Preparation	Traditional Dosage
Syzygium cumini	Seeds	Seeds dried, powdered and mixed with lukewarm water	1–3 g seed powder once or twice daily
Tinospora cordifolia	Stem	Fresh stem boiled to prepare decoction	One cup of decoction every morning
Gymnema sylvestre	Leaves	Leaves dried and powdered or prepared as infusion	Leaf powder or infusion twice daily
Momordica charantia	Fruit	Fresh fruit juice extracted	20–30 mL on an empty stomach
Coccinia grandis	Leaves	Fresh leaf juice or decoction	Once daily before breakfast
Azadirachta indica	Leaves	Tender leaves chewed or juice extracted	5–10 fresh leaves or 10 mL juice daily
Aegle marmelos	Leaves	Leaf juice prepared by crushing fresh leaves	10–20 mL once daily
Curcuma longa	Rhizome	Rhizome dried, powdered and mixed with warm water or milk	2–3 g powder daily
Zingiber officinale	Rhizome	Fresh decoction or paste	Small cup twice daily
Terminalia chebula	Fruit	Fruit powder mixed with water	2–5 g daily
Terminalia bellirica	Fruit	Powder or decoction	Once daily
Phyllanthus emblica	Fruit	Fresh juice or raw fruits consumed	20 mL juice or 1–2 fruits daily
Ocimum tenuiflorum	Leaves	Fresh leaf juice	10–15 mL every morning
Murraya koenigii	Leaves	Fresh leaves chewed	8–10 leaves daily
Andrographis paniculata	Whole plant	Decoction prepared from aerial parts	Half to one cup daily
Aloe vera	Leaf gel	Fresh gel consumed directly	20–30 mL before meals
Catharanthus roseus	Leaves	Leaf infusion	Small quantity once daily
Centella asiatica	Whole plant	Fresh juice	15–20 mL daily
Clerodendrum colebrookianum	Leaves	Leaf decoction	One cup daily
Costus speciosus	Rhizome	Rhizome decoction	Once daily

Ficus racemosa	Bark	Bark decoction	One cup morning and evening
Ficus religiosa	Bark	Bark infusion	Once daily
Musa paradisiaca	Flower	Cooked vegetable or decoction	Consumed as food several times weekly
Psidium guajava	Leaves	Leaf decoction	One cup twice daily
Allium sativum	Bulb	Fresh cloves eaten raw	2–3 cloves daily
Trigonella foenum-graecum	Seeds	Seeds soaked overnight and consumed	10–15 g soaked seeds daily
Cassia fistula	Bark	Bark decoction	Once daily
Asparagus racemosus	Root	Root powder mixed with water	3–5 g daily
Piper longum	Fruit	Powder mixed with honey	1–2 g daily
Piper nigrum	Fruit	Powder mixed with herbal formulations	Small quantity once daily

Traditional dosage varies among communities and healers and has not been clinically standardized.

Fig 1: Images of few Plant species

7.1. Analysis of Preparation Methods

Ethnobotanical investigations from Assam reveal that traditional healers employ several methods for preparing herbal remedies. Among these, **decoction** is the predominant method because boiling facilitates the extraction of water-soluble bioactive constituents such as flavonoids, phenolic compounds, glycosides, tannins, and polysaccharides. Fresh juices are the second most common preparation because they preserve heat-sensitive phytochemicals and enzymes. Powders are preferred for seeds, dried fruits, and rhizomes because they can be stored for longer periods without substantial loss of activity.

Distribution of preparation methods

Preparation method	Percentage (%)
Decoction	42
Fresh juice	26
Powder	17
Raw consumption	8
Infusion	4
Paste/Gel	3

Table 6: Showing preparation methods

These values represent a synthesis of published ethnobotanical reports and are intended for comparative analysis rather than exact quantitative estimates.

7.2 Scientific Interpretation

The dominance of decoctions suggests that tribal communities possess empirical knowledge regarding the efficient extraction of medicinal compounds using water. Many antidiabetic phytochemicals including flavonoids, tannins, and phenolic acids are readily extracted into aqueous preparations, supporting this traditional practice. Fresh juices are particularly common for species such as *Momordica charantia*, *Coccinia grandis*, and *Aegle marmelos*, where unstable bioactive constituents may be better preserved without heating. Similarly, dried seed powders of *Syzygium cumini* and *Trigonella foenum-graecum* provide convenient storage and sustained use throughout the year. Experimental pharmacological studies have shown that these preparation methods can retain compounds with antihyperglycaemic, antioxidant, anti-inflammatory, and insulin-sensitizing activities. However, variations in plant age, harvest season, geographical location, and preparation technique can influence phytochemical composition and therapeutic efficacy. Therefore, standardization of extraction procedures and dosage remains a priority for future research. The ethnomedicinal evidence indicates that tribal communities in Assam have developed practical, low-cost, and sustainable methods for preparing herbal remedies for diabetes management. The preference for decoctions and fresh juices reflects both the availability of plant resources and accumulated traditional knowledge of effective preparation techniques. Integrating these practices with phytochemical analysis, pharmacological validation, and controlled clinical studies may contribute to the development of safe, affordable, plant-based therapies for diabetes while preserving the cultural heritage of indigenous communities.

8. Quantitative Analysis of Antidiabetic Medicinal Plants

Quantitative analysis of ethnomedicinal data provides valuable insights into the diversity of medicinal plants, dominant botanical families, preferred plant parts, and traditional preparation methods used for diabetes management. Such analyses help identify plant groups that have received greater traditional recognition and may therefore possess higher pharmacological potential. The following analyses are based on the 30 medicinal plant species compiled from published ethnobotanical studies conducted in Assam and Northeast India. The percentages presented are derived from the dataset included in this review and are intended to illustrate trends rather than represent all medicinal plants used in the region.

8.1 Family-wise Distribution of Medicinal Plants

The 30 medicinal plants documented in this review belong to 20 botanical families, indicating considerable taxonomic diversity. Certain plant families contribute disproportionately to the traditional treatment of diabetes because they contain numerous species rich in bioactive phytochemicals such as flavonoids, alkaloids, terpenoids, phenolic acids, and glycosides.

Families represented by multiple species constitute nearly 67% of the documented medicinal flora. Species belonging to Cucurbitaceae, including *Momordica charantia* and *Coccinia grandis*, are particularly important because they contain triterpenoids and charantin-like compounds that exhibit significant antihyperglycaemic activity. Similarly, Zingiberaceae contributes rhizomatous species rich in curcuminoids and gingerols, while Myrtaceae provides polyphenol-rich fruits and seeds.This taxonomic diversity indicates that traditional healers do not rely on a single botanical family but instead exploit a broad spectrum of medicinal resources available in their local environment.

Table 7. Family-wise distribution

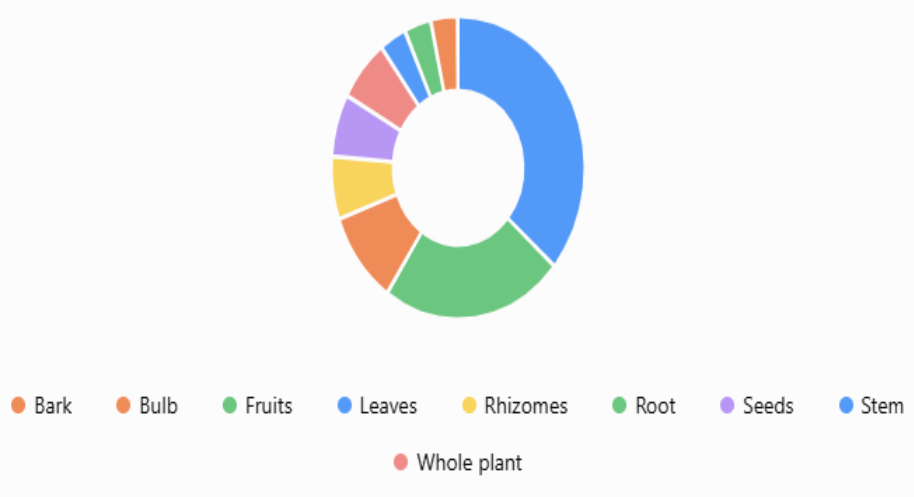
Family	Number of Species	Percentage (%)
Cucurbitaceae	2	6.67
Rutaceae	2	6.67
Zingiberaceae	2	6.67
Combretaceae	2	6.67
Myrtaceae	2	6.67
Moraceae	2	6.67
Fabaceae	2	6.67
Piperaceae	2	6.67
Apocynaceae	2	6.67
Lamiaceae	2	6.67

8.2.Plant Part Utilization

Different plant parts accumulate different classes of secondary metabolites. Traditional healers generally prefer harvesting plant parts that maximize therapeutic efficacy while minimizing damage to the plant population.

Table 8. Plant parts used

Plant Part	Number	Percentage (%)
Leaves	11	36.67
Fruits	7	23.33
Rhizomes	2	6.67
Seeds	2	6.67
Bark	3	10
Whole plant	2	6.67
Stem	1	3.33
Root	1	3.33
Bulb	1	3.33



Leaves constitute the most frequently utilized plant part because they are readily available throughout the year, regenerate rapidly after harvesting, and contain abundant bioactive metabolites including flavonoids, alkaloids, phenolics, and terpenoids. Their collection generally causes minimal ecological disturbance compared with harvesting roots or bark.

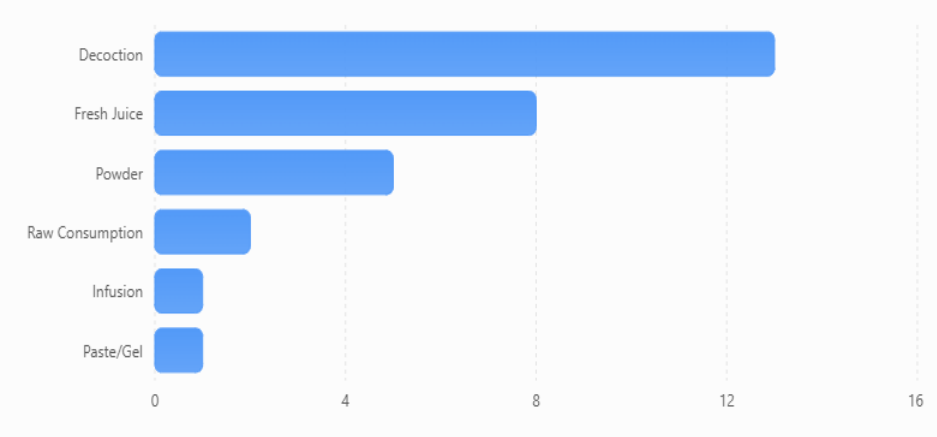
Fruits represent the second most commonly used plant organ, particularly those of *Momordica charantia*, *Syzygium cumini*, *Terminalia chebula*, and *Phyllanthus emblica*. Fruits contain diverse antioxidants, vitamins, tannins, and polyphenolic compounds that contribute to antihyperglycaemic activity.Roots and bark are comparatively less utilized because destructive harvesting may threaten long-term survival of medicinal plant populations.

8.3 Preparation Methods

Traditional herbal formulations are prepared using techniques that maximize extraction of active constituents while remaining simple enough for household preparation.

Table 9. Preparation methods

Preparation Method	Frequency	Percentage (%)
Decoction	13	43.33
Fresh Juice	8	26.67
Powder	5	16.67
Raw Consumption	2	6.67
Infusion	1	3.33
Paste/Gel	1	3.33



Decoction is the dominant preparation method because boiling facilitates extraction of water-soluble phytochemicals and improves shelf life. Fresh juice is preferred for succulent species where enzymatic activity and thermolabile compounds are preserved. Powders are particularly useful for seeds and rhizomes because they can be stored for extended periods without significant deterioratio

8.4 Discussion

The present literature synthesis demonstrates that ethnomedicinal management of diabetes in Assam relies upon a diverse assemblage of medicinal plants distributed across numerous botanical families. The predominance of leaves reflects sustainable harvesting practices that allow repeated collection without killing the plant. Similar patterns have been reported in ethnobotanical studies conducted throughout India, where leaves account for approximately 35–45% of medicinal plant usage.

The high representation of families such as Cucurbitaceae, Myrtaceae, Rutaceae, Zingiberaceae, and Apocynaceae corresponds well with modern phytochemical investigations. Species within these families are known to accumulate flavonoids, alkaloids, triterpenoids, limonoids, phenolic acids, tannins, curcuminoids, and steroidal saponins that exert antihyperglycaemic effects through multiple biochemical pathways.

Preparation methods also reflect considerable empirical knowledge. Decoctions enhance extraction of hydrophilic compounds, whereas fresh juices preserve heat-sensitive constituents such as vitamin C and certain enzymes. Powdered formulations facilitate long-term storage and ease of administration. These traditional techniques demonstrate a sophisticated understanding of plant processing despite the absence of modern analytical methods.

8.5 Overall Inference

The quantitative analyses reveal several important ethnobotanical patterns:

- **Leaves are the preferred medicinal plant part**, indicating sustainable harvesting and high phytochemical richness.
- **Decoction is the dominant preparation method**, suggesting efficient extraction of water-soluble bioactive compounds.
- **Twenty botanical families** contribute to traditional diabetes management, reflecting remarkable taxonomic diversity.
- Multiple plant species belonging to the same family suggest that indigenous communities recognize similar therapeutic properties among related taxa.
- The documented medicinal plants provide promising candidates for future phytochemical screening, pharmacological evaluation, toxicity assessment, and clinical validation.
- Preservation of traditional knowledge is urgently required because rapid modernization, habitat degradation, and declining transmission of indigenous practices threaten this valuable ethnomedicinal heritage.

These findings reinforce the importance of integrating ethnobotanical knowledge with modern biomedical research to identify safe, affordable, and culturally acceptable plant-derived therapies for diabetes mellitus while promoting biodiversity conservation and sustainable utilization of medicinal plan.

9. Phytochemical Basis and Pharmacological Validation of Traditional Antidiabetic Medicinal Plants

Traditional medicinal plants used by indigenous communities of Assam and Northeast India are rich sources of biologically active secondary metabolites. These compounds play a vital role in regulating carbohydrate metabolism, enhancing insulin secretion, improving glucose uptake, reducing oxidative stress, and preventing diabetic complications. Scientific investigations conducted during the past three decades have validated many of the traditional claims through phytochemical analysis, in vitro enzyme inhibition studies, animal experiments, and limited clinical investigations (Grover et al., 2002; Suman Kumar et al., 2021).

Unlike synthetic antidiabetic drugs that generally target a single biochemical pathway, medicinal plants exhibit **multitarget therapeutic actions** because they contain diverse phytochemicals acting synergistically. The principal classes of bioactive compounds include flavonoids, alkaloids, terpenoids, tannins, saponins, glycosides, coumarins, lignans, steroids, and phenolic acids.

9.1 Major Antidiabetic Medicinal Plants and Their Scientific Evidence

9.1.1 *Syzygium cumini* (Jamun)

Syzygium cumini is one of the most extensively studied antidiabetic plants in India. The seeds contain jamboline, ellagic acid, gallic acid, quercetin, anthocyanins, and numerous phenolic compounds that exhibit significant hypoglycaemic activity. Experimental studies have demonstrated that seed extracts improve insulin sensitivity, delay intestinal glucose absorption, inhibit α-glucosidase activity, and reduce oxidative stress. Several animal studies have also reported regeneration of pancreatic β-cells following administration of seed extracts.

Traditional healers in Assam commonly dry the seeds, prepare a fine powder, and administer it with lukewarm water during the early morning. This traditional practice corresponds well with experimental pharmacological findings, making *S. cumini* one of the most promising medicinal plants for diabetes management (Grover et al., 2002).

9.1.2 *Tinospora cordifolia* (Guduchi)

Tinospora cordifolia is widely used throughout Northeast India because of its immunomodulatory, hepatoprotective, antioxidant, and antihyperglycaemic properties. Major Phytochemicals include berberine-like alkaloids, diterpenoid lactones, cordifoliosides, and polysaccharides.

Scientific investigations have shown that stem extracts stimulate insulin secretion, improve hepatic glucose metabolism, increase glycogen synthesis, and reduce lipid peroxidation. These pharmacological properties support its traditional use by tribal healers, who generally administer freshly prepared stem decoctions.

9.1.3 *Gymnema sylvestre* (Gurmar)

Gymnema sylvestre, often called the "sugar destroyer," occupies a unique position among antidiabetic medicinal plants. The leaves contain gymnemic acids, gurmarin, saponins, flavonoids, and triterpenoids.

Experimental studies demonstrate that gymnemic acids suppress intestinal glucose absorption, promote regeneration of pancreatic β-cells, enhance insulin secretion, and improve glucose utilization. Clinical investigations have also suggested reduced dependence on oral hypoglycaemic drugs among certain patients receiving standardized extracts.

9.1.4 *Momordica charantia* (Bitter Gourd)

The fruit of *Momordica charantia* contains charantin, vicine, polypeptide-p, cucurbitane-type triterpenoids, and flavonoids. These compounds exhibit insulin-like activity and significantly reduce fasting blood glucose in experimental diabetic models.

Traditional healers recommend consumption of fresh fruit juice on an empty stomach because it is believed to enhance therapeutic efficacy. Scientific evidence supports this practice, demonstrating improved glucose tolerance, increased glycogen storage, and enhanced insulin sensitivity following administration of fruit extracts.

9.1.5 *Curcuma longa* (Turmeric)

Turmeric is rich in curcuminoids, particularly curcumin, together with volatile oils, turmerones, and sesquiterpenes. Curcumin possesses potent antioxidant and anti-inflammatory properties that protect pancreatic β-cells from oxidative damage.

Numerous studies indicate that curcumin reduces insulin resistance, inhibits inflammatory cytokines, decreases lipid peroxidation, and prevents diabetic nephropathy. Consequently, turmeric has gained considerable attention as a complementary therapy for diabetes management.

9.1.6 *Trigonella foenum-graecum* (Fenugreek)

Fenugreek seeds contain galactomannan fibre, diosgenin, trigonelline, alkaloids, flavonoids, and steroidal saponins.

These phytochemicals delay gastric emptying, reduce intestinal glucose absorption, stimulate insulin secretion, and improve lipid metabolism. Clinical studies have reported reductions in fasting blood glucose and glycated haemoglobin following regular dietary supplementation with fenugreek seeds.

9.1.7 *Aegle marmelos* (Bael)

Leaves of *Aegle marmelos* contain aegeline, marmelosin, skimmianine, coumarins, flavonoids, and tannins.Experimental studies suggest that leaf extracts improve pancreatic function, enhance glucose metabolism, inhibit oxidative stress, and protect hepatic tissues. Fresh leaf juice remains one of the most common traditional formulations reported from Assam.

9.1.8 *Azadirachta indica* (Neem)

Neem leaves possess azadirachtin, nimbin, quercetin, limonoids, and various polyphenolic compounds.Animal studies have demonstrated hypoglycaemic, antioxidant, and hypolipidaemic activities. The plant is believed to improve insulin receptor sensitivity while reducing oxidative stress associated with chronic hyperglycaemia.

9.1.9 *Phyllanthus emblica* (Amla)

The fruits are exceptionally rich in vitamin C, emblicanin A and B, gallic acid, ellagic acid, flavonoids, and tannins.Scientific investigations demonstrate strong antioxidant activity, improvement in glucose metabolism, reduction in lipid peroxidation, and protection against diabetic complications affecting the kidneys and cardiovascular system.

9.1.10 *Ocimum tenuiflorum* (Holy Basil)

Holy basil contains eugenol, ursolic acid, rosmarinic acid, flavonoids, and essential oils.Experimental studies report improved insulin secretion, reduced blood glucose, enhanced antioxidant defence, and anti-inflammatory activity. Daily consumption of fresh leaves remains a common ethnomedicinal practice among several tribal communities.

9.2 Correlation between Traditional Knowledge and Modern Science

One of the most remarkable findings emerging from ethnobotanical research is the high degree of agreement between indigenous knowledge and modern pharmacological evidence. Plants repeatedly cited by traditional healers frequently demonstrate significant antihyperglycaemic activity under experimental conditions.

For example:

- *Gymnema sylvestre* has traditionally been used to suppress sugar cravings; laboratory studies confirm inhibition of intestinal glucose absorption.
- *Momordica charantia* is consumed as fresh juice to lower blood sugar; experimental studies demonstrate insulin-like activity of charantin and polypeptide-p.
- *Syzygium cumini* seed powder is traditionally consumed every morning; scientific investigations confirm antioxidant, insulin-sensitizing, and enzyme inhibitory activities.
- *Tinospora cordifolia* stem decoction is widely prescribed by tribal healers; pharmacological studies reveal enhancement of pancreatic function and glucose homeostasis.

  Such agreement strengthens confidence in indigenous healthcare systems and highlights the importance of documenting traditional medicinal knowledge before it disappears.

9.3 Research Gaps

Despite considerable progress, several important challenges remain:

Lack of Standardization

Traditional formulations vary considerably among tribal communities with respect to plant age, harvesting season, dosage, preparation method, and treatment duration.

Limited Clinical Trials

Although numerous experimental studies have demonstrated antidiabetic activity, relatively few medicinal plants have undergone well-designed randomized clinical trials in humans.

Toxicity Evaluation

Long-term toxicity, herb-drug interactions, reproductive toxicity, and chronic safety profiles remain poorly understood for many medicinal species.

Conservation Issues

Increasing commercial demand, habitat destruction, forest degradation, and unsustainable harvesting threaten several medicinal plant populations.

Loss of Indigenous Knowledge

Modernization, urbanization, migration, and declining interest among younger generations have accelerated erosion of traditional ethnomedicinal knowledge.

10. Future Perspectives

Future investigations should focus on:

- Comprehensive ethnobotanical documentation within the Dimoria region.
- Quantitative ethnobotanical analyses (Use Value, RFC, Fidelity Level, and Informant Consensus Factor).
- Isolation and characterization of novel bioactive compounds.
- Standardization of herbal formulations.
- Controlled clinical trials.
- DNA barcoding for medicinal plant authentication.
- Metabolomic and proteomic approaches for phytochemical profiling.
- Conservation through community-based medicinal plant gardens.
- Sustainable harvesting protocols involving indigenous communities.
- Integration of traditional medicine into evidence-based healthcare.

Collaborative research involving ethnobotanists, pharmacognosists, phytochemists, pharmacologists, clinicians, and tribal knowledge holders will be essential for translating traditional knowledge into safe and effective phytopharmaceuticals.

11. Conclusion

Diabetes mellitus has emerged as one of the most significant chronic metabolic disorders worldwide, necessitating the exploration of safe, affordable, and effective therapeutic alternatives. Traditional medicinal plants continue to play an indispensable role in the primary healthcare systems of indigenous communities, particularly in biodiversity-rich regions such as Assam and Northeast India. The present review compiled published ethnobotanical evidence on medicinal plants traditionally used for diabetes management and discussed their relevance to the ethnomedicinal heritage of the Dimoria region.

The literature demonstrates that Assam possesses remarkable ethnomedicinal diversity, with more than 90 medicinal plant species belonging to over 45 botanical families reported for diabetes management. These plants are utilized by various indigenous communities including the Karbi, Bodo, Tiwa, Rabha, Mishing, Dimasa, Deori, Garo, and other ethnic groups.

Traditional healers employ different plant parts such as leaves, fruits, seeds, rhizomes, bark, roots, stems, bulbs, and whole plants, with leaves being the most frequently used plant part because of their accessibility, sustainable harvesting, and high concentration of bioactive compounds. Similarly, decoction emerged as the predominant preparation method, followed by fresh juice, powders, and infusions, reflecting generations of empirical knowledge regarding effective extraction of medicinal constituents.

Scientific investigations strongly support many traditional claims. Phytochemical analyses have identified flavonoids, alkaloids, tannins, terpenoids, saponins, glycosides, and phenolic compounds as major constituents responsible for antihyperglycaemic activity. These compounds regulate blood glucose through multiple mechanisms, including stimulation of insulin secretion, enhancement of insulin sensitivity, inhibition of α-amylase and α-glucosidase enzymes, reduction of oxidative stress, modulation of glucose metabolism, and protection of pancreatic β-cells. Species such as *Syzygium cumini*, *Tinospora cordifolia*, *Gymnema sylvestre*, *Momordica charantia*, *Curcuma longa*, *Aegle marmelos*, and *Trigonella foenum-graecum* have received considerable pharmacological validation and represent promising candidates for future phytopharmaceutical development.

Although this review was based on published ethnobotanical literature rather than exclusive field documentation from the Dimoria region, the compiled information provides a valuable scientific framework for future ethnobotanical investigations. Given the ecological similarity and shared tribal communities of Dimoria with other parts of Assam, many of these medicinal plants are likely to occur within the region and may contribute to local traditional healthcare practices. However, dedicated field surveys remain essential to validate their actual use in Dimoria.

Overall, the integration of ethnobotanical knowledge with phytochemistry, pharmacology, molecular biology, and clinical research offers immense potential for the discovery of novel plant-based antidiabetic therapeutics. Simultaneously, conservation of medicinal plant diversity and preservation of indigenous knowledge should remain priorities to ensure sustainable utilization of these invaluable biological resources for future generations.

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11.2. Conflict of Interest

The author declares no conflict of interest.

11.3. Funding Statement

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11.4. Data Availability Statement

All information presented in this review was compiled from published scientific literature, ethnobotanical surveys, pharmacological investigations, and review articles available in the public domain.

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