# Effects of Traditional Indian Antidiabetic Herbs and Their Role in Glycaemic Control: A Systematic Review.

**Abstract:** Nearly 100 million people worldwide suffering from diabetes, the most prevalent endocrine illness. Over the past ten years, the number of diabetics in India—also referred to as the diabetes capital of the world—has alarmingly increased. It poses a significant public health challenge, driven by sedentary lifestyles, rapid urbanization, and shifts in dietary patterns. Indian texts such as Ayurveda have long highlighted the use of herbs for addressing various human health issues. Throughout history, numerous traditional Indian medicinal plants known for their anti-diabetic properties have been incorporated into our diets. India boasts an extensive array of indigenous medicinal plants that have been scientifically validated for their ability to lower blood sugar levels It evaluates the mechanisms of key herbs—including Gymnema sylvestre, Momordica charantia, Trigonella foenum-graecum, Cinnamomum verum, and Syzygium Cumini —which encompass enhanced insulin secretion, improved insulin sensitivity, and inhibition of glucose absorption.The relevant data were obtained by reading many sources from various publications and electronic literature searches of Medline, PubMed, ScienceDirect, Scopus, and Google Scholar that included keywords like "hyperglycaemia," "herbal medications,". This integrative approach shows potential as a supplementary method for managing diabetes. Furthermore, the utilization of these therapeutic herbs as an antidiabetic medication requires further investigation.

**Key Words:** *endocrine illness, Gymnema sylvestre, hyperglycaemia*



**Introduction:**

Over 463 million adults worldwide suffer with diabetes, and by 2045, that number is expected to rise to 700 million, resulting in consequences like renal failure and cardiovascular disease as well as significant yearly economic expenses of over $760 billion. Over 77 million adults in India suffer from lifestyle diseases, which are made worse by dietary changes, urbanization, and sedentary lifestyles and greatly increase death rates [1]. Though there are various approaches to reduce the ill effects of diabetes and its secondary complications, herbal formulations are preferred due to lesser side effects and low cost. A list of medicinal plants with proven antidiabetic and related beneficial effects and of herbal drugs used in treatment of diabetes is compiled. These include, Momordica charantia,Cinnamomum spp., Swertia chirata, Gymnema sylvestre, Syzygium cumini, Trigonella foenum-graecum,Tinospora cordifolia[2].

**Historical scenario of Diabetes mellitus:**

In India, traditional remedies have been utilized for treating diabetes mellitus since the era of Charaka and Sushruta. Diabetes mellitus (DM) has its origins in Ayurveda, where it was formerly categorized as Madhumeha ("honey urine") under the more general diagnostic category of Prameha, a condition marked by increased frequency of urination (polyuria)[3]. It also mentioned in Ayurveda as Madhumeha, a metabolic condition that results from dysregulation of the doshas (Pitta, Kapha, and Vata), which impairs insulin activity and pancreatic function. Ayurvedic medicine takes a customized strategy based on pathological imbalance (Vikriti) and individual constitution (Prakriti) [4]. Due to their proven hypoglycaemic potential, medicinal herbs including Momordica charantia, Trigonella foenum-graecum, and Curcuma longa are essential to therapeutic formulations. Furthermore, Ayurveda emphasizes lifestyle control through a sattvic routine that includes stress management, physical exercise, and a balanced diet[5].The World Health Organization (WHO) has given Ayurveda a high priority in the Indian setting through its Traditional Medicine (TRM) efforts. WHO actively promotes and supports studies on the efficacy, safety, and standardization of Ayurvedic herbal remedies. Ayurveda is fundamentally focused on treating lifestyle-related diseases, which are becoming more common in all age groups as a result of stress and other factors[6].

**Prevalence of diabetes in India:**

Diabetes is already affecting more than half a billion adults, and is projected to rise towards 900 million by 2050, with the highest burden in older adults, and in men, urban dwellers and middle-income countries. Without efficient, focused prevention and control efforts in place the global diabetes epidemic will continue to escalate.

Diabetes poses a significant public health challenge in India, leading to considerable morbidity and mortality[7]. In a comprehensive epidemiological analysis conducted by Chauhan et al., examines the trends across different states and projects future estimates of the diabetes burden in India by utilizing Global Burden of Disease (GBD) data from 1990 to 2021, merging type 1 and type 2 diabetes to calculate incidence, prevalence, mortality, and disability-adjusted life years (DALYs) for each state and union territory[8].

**Table No. 1: From 1990–2021, new diabetes cases per 100,000 people**

| State/Region | Incidence 1990 (per 100k) | Incidence 2021 (per 100k | APC (%) |
|---|---|---|---|
| **India (Overall)** | **162.74** | **264.53** | **0.63** |
| Goa | **168.08** | **314.30** | **0.87** |
| Karnataka | **182.92** | **306.99** | **0.68** |
| Bihar | **149.61** | **225.72** | **0.51** |
| Kerala | **215.09** | **284.92** | **0.32** |
| Jharkhand | **170.27** | **234.42** | **0.38** |

**Table No.1:** From 1990–2021, new diabetes cases per 100,000 people rose substantially overall, with especially rapid increases in the late 1990s and mid-2000s. Deaths due to diabetes also increased, but at a slower rate than incidence**.**

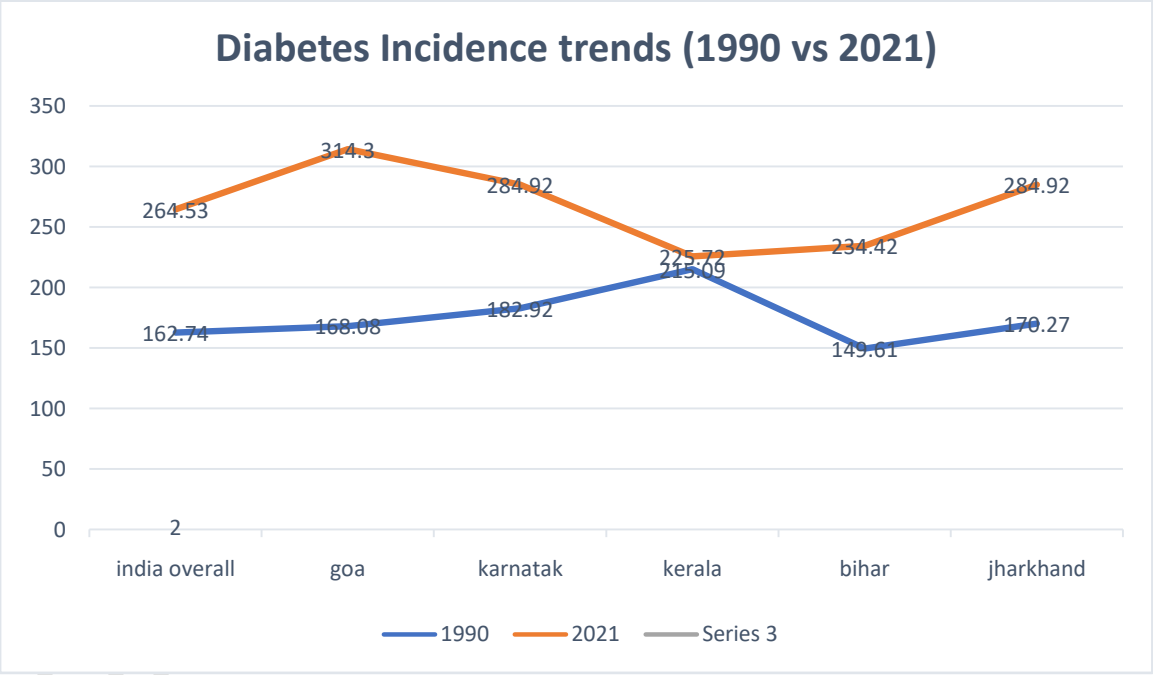


**Figure 1: Diabetes Incidence trends (1990 vs 2021):** Diabetes has risen dramatically in all the world's regions, with India's national rate increasing from about 163 to 264 per 100,000. Goa and Jharkhand have the highest levels in 2021 (around 314 and 285, respectively), whereas Bihar is lower but experience a distinct increase since 1990.

## ANTIDIABETIC POTENTIAL OF INDIAN HERBS

Traditional medicines are often the preferred option for primary healthcare in developing countries due to their greater cultural acceptance, better compatibility with the human body, and fewer adverse effects compared to contemporary treatments. At present, numerous medicinal plants have been documented globally as being effective for diabetes and have been used traditionally as antidiabetic agents. The literature contains references

to over 400 medicinal plants that exhibit hypoglycaemic properties [9]. A brief information on some Indian herbs is described below:

**BITTER GOURD*(Momordica charantia)***

Bitter gourd (Momordica charantia) is a crop that belongs to the plant kingdom and the family Cucurbitaceae. In addition to having higher levels of calcium and iron, this plant is rich in vitamins including B1, B2, B3, and C. It also contains various biologically active compounds such as momordicin I, II, and cucurbitacin B. [10]. Various reports indicate that M. charantia and its assorted extracts and components manifest hypoglycaemic properties, suggesting that M. charantia may directly facilitate a decrease in blood glucose concentrations[11]. Prior research has demonstrated that both theaqueous and alcoholic extracts derived from the fruit of M. charantia possess the capacity to inhibit the enzymatic activities of fructose 1,6-diphosphatase and glucose-6-phosphatase, concomitantly enhancing the activity of glucose-6-phosphate dehydrogenase[12].the research conducted by Shetty et al. indicated that incorporating 10% desiccated bitter gourd powder into the diets of streptozotocin-induced diabetic rats enhanced their overall diabetic condition, including a reduction of approximately 35% in urinary glucose excretion and improved control over fasting blood glucose levels. Additionally, the supplementation helped reduce typical diabetic symptoms like frequent urination (polyuria) and increased thirst (polydipsia), emphasizing the potential therapeutic benefits of bitter gourd in managing diabetes[13].

**FENUGREEK*(Trigonella foenum-graecum)***

Fenugreek has been employed in both Ayurvedic and Chinese medicinal practices for numerous centuries, with its applications encompassing lab or induction, facilitation of digestion, and enhancement of metabolic processes. The fraction containing the Testa and the defatted endosperm (designated as A subfraction) are associated with the hypoglycaemic properties of fenugreek[14].Germination increases the antioxidant capacity of fenugreek seeds, which is partially due to flavonoids and polyphenols. HPLC analysis indicated notable concentrations of these bioactives, implying a mechanistic connection to health advantages[15].

**JAMUN *(Syzygium Cumini)***

Jamun (Syzygium cumini Skeels), which is endemic to India, has been utilized as a therapeutic agent within the Unani and Ayurveda medical frameworks for over a century[16]. The tree serves as a promising reservoir of various bioactive compounds, including anthocyanins, glucosides, ellagic acid, isoquercetin, kaempferol, and myricetin. The bioactive constituents found in the leaves, bark, fruit, stems, and roots of jamun—such as alkaloids, tannins, phenols, lipids, and flavonoids[17]. The active presence of these compounds engenders pharmacological effects characterized by antioxidant, antimicrobial, antidiabetic, central nervous system (CNS) activity, chemo preventive, anti-inflammatory, antiallergic, and hepatoprotective properties, thereby affirming the beneficial impact of jamun consumption on human health and metabolic processes[18]. The seeds are reported to contain the alkaloid Jambosine and the glycoside jambolin, or antimellin, which impede the diastatic conversion of starch into glucose[19].

**GURMAR*(Gymnema Sylvestre)***

Gymnema sylvestre (Asclepiadaceae), widely referred to as “gurmar,” is a celebrated herbal remedy in Ayurveda, mainly acknowledged for its antidiabetic properties. In addition to its function in glycaemic regulation, the herb displays various therapeutic benefits and has been historically employed in treating inflammatory, metabolic, cardiovascular, respiratory, and microbial condition[20].Leaves of Gymnema sylvestre possess oleanane- and dammarane-type triterpenoid saponins, such as gymnemic acids and gymnemosides. Methanolic extracts from leaves and callus showed antidiabetic effects in diabetic rats induced by alloxan by enhancing body and organ weights, boosting hepatic glycogen levels, and maintaining the structure of pancreatic β-cells[21].

**NEEM*(Azadirachta indica)***

Neem (Azadirachta indica) has been extensively utilized in Ayurvedic, Unani, and Homeopathic medical. The plant produces a wide range of biologically active compounds that are chemically varied and structurally intricate, supporting its significant therapeutic potential[22].Different components of the neem tree (Azadirachta indica) are conventionally utilized in treating ailments like cancer, heart diseases, high blood pressure, and diabetes[23]. The therapeutic benefits of neem extracts are linked to their capacity to influence essential cellular and molecular processes, such as antioxidant function, DNA repair, regulation of the cell cycle, apoptosis and

autophagy, immune system modulation, as well as anti-inflammatory, anti-angiogenic, and anti-metastatic effects by regulating various signaling pathways[24].

**TULASI (*Ocimum sanctum)***

Tulasi (Ocimum sanctum), sometimes known as Holy Basil, is a strong. O. sanctum is recognized by its high essential oil concentration[25]. The primary component of the essential oil, according to gas-liquid chromatography tests, is eugenol (70%), however O. sanctum also contains alkaloids, glycosides, tannins, and saponins. Furthermore, O. sanctum may include an active insulinogenic substance that helps to reducehyperglycaemia in diabetic animals[26].A study by Jyoti Sethi et. al., reported that treating with Ocimum sanctum leaves dramatically reduced blood glucose levels in hyperglycaemic and diabetic rat models. This is likely due to improved pancreatic β-cell activity and insulin production. The hypoglycaemic impact is directly linked to enhanced antioxidant status, as seen by increased glutathione, glutathione-S-transferase, and superoxide dismutase activity, as well as decreased lipid peroxidation, indicating regulation of cellular antioxidant defence systems[27].

**CHIA SEEDS*(Salvia hispanica L.)***

Chia seeds come from the edible seeds of Salvia hispanica. It essentially belongs to the mint family (Lamiaceae). Various studies indicate that chia seeds possess an excellent nutritional profile and significant health-enhancing properties[28].Chia seeds were determined to be safe, showing heavy metal levels within food safety thresholds, no trace of mycotoxins, and they are inherently gluten-free. When incorporated into the diets of rats, chia resulted in a significant decrease in serum triglycerides and LDL cholesterol, while also raising HDL and ω-3 polyunsaturated fatty acids. These benefits were observed without negative impacts on immune function, as both thymic structure and serum IgE levels remained normal[29].Researches indicates that chia possesses properties that are hypoglycaemic, antimicrobial, anticancer, anti-inflammatory, antioxidant, antihypertensive, anti-obesity, and cardioprotective. The intake of chia has increased due to its positive effects on obesity, heart disease, diabetes, and various types of cancer[30]. These benefits largely arise from the significant levels of essential fatty acids, dietary fiber, antioxidants, flavonoids, anthocyanins, vitamins, carotenoids, and minerals present in this seed. Ultimately, toxicological studies have shown that higher doses of chia seed extracts are considered safe[31].

The findings indicate that Chia therapy successfully counteracts oxidative stress-mediated free radical damage caused by diabetes and may be employed as a therapeutic drug to reduce oxidative damage in diabetic patients[32].

**GUDUCHI*(Tinospora cordifolia)***

Guduchi (Tinospora cordifolia) belonging to the Menispermaceae family, is a significant medicinal herb in Ayurveda. The name ‘Guduchi’ originates from Sanskrit, meaning "that which safeguards the body from illness." It is widely utilized in treating various clinical conditions, such as febrile diseases, diabetes mellitus, urinary tract issues, anaemia, jaundice, asthma, and heart diseases[33]. In finding of Rani and colleagues, suggest that TC extracts and satva have therapeutic promise as nutritional supplements for addressing polycystic ovary syndrome and its related clinical manifestations. The authors also stress the importance of future investigations to elucidate the molecular mechanisms through which TC supplementation affects metabolic dysregulation associated with PCOS[34]. Studies have demonstrated that root extracts can effectively lower glycosylated haemoglobin and markers of oxidative stress in diabetic rats[35].*Sharma*et al., found that JBGC, KBGC, and SBGC showed significant antihyperglycemic effects in mice during oral glucose tolerance tests at a dosage of 520 mg/kg, with peak effects noted at 90 minutes [36].

**Chirata*(S. Chirata)***

Swertia chirata (Gentianaceae) is a well-known medicinal plant indigenous to the temperate Himalayas. The primary chemical components include Swertiamarin, Amarogentin, Swechirin, Mangiferin, Sweroside, Gentianine, Amaroswerin, Oleanolic acid, Swertanoone, Ursolic acid. Phytochemical examination reveals the presence of alkaloids, flavonoids, steroids, glycosides, triterpenoids, saponins, xanthones, and ascorbic acid in every sample[37].Chirata includes the bitter glucoside chiratin, which produces bioactive substances like amarogentin and gentiopicrin, in addition to amino acids, xanthones, and triterpenoids such as β-amyrin and oleanolic acid[38].The research was carried out to investigate the potential antidiabetic effects of Swertia chirayata. The extract of Swertia chirayata at a dosage of 500 mg/kg of body weight significantly lowered levels of glucose, cholesterol, triglycerides, ALT, and AST, while increasing insulin levels in diabetic rats induced by streptozotocin. Additionally, Swertia chirayata helped to repair the morphological damage induced by streptozotocin in the pancreas by fostering the regeneration of beta cells in the islets of Langerhans [39].

**Cinnamon (*Cinnamomum spp.*)**

Cinnamomum verum is a spice known for its medicinal and therapeutic properties. It has historically been utilized to enhance food taste and in medicinal formulations to address numerous health issues[40]. The plant

contains a variety of volatile oils, mainly cinnamaldehyde, cinnamic acid, and cinnamate. The primary constituents of the Cinnamomum verum plant consist of eugenol, cinnamaldehyde, cinnamyl acetate, copane, and camphor[41]. P. Ranasinghe et al. noted that Cinnamomum zeylanicum shows strong antidiabetic properties by blocking α-amylase and α-glucosidase, increasing glucose uptake through GLUT-4 translocation, promoting glycogen formation, reducing gluconeogenesis, and boosting insulin secretion and receptor functioning[42]. In animal studies, it enhanced fasting glucose, lipid levels, HbA1c, and insulin concentrations, reduced diabetes-associated weight loss, and helped ease complications like neuropathy and nephropathy, showing no major liver or kidney toxicity and a broad therapeutic range[43].

**Table no. 2: List of Antidiabetic plants used in the treatment of diabetes mellitus**

| S.N. | Botanical name | Plant (Part Used) | Methodology | Major Components | Findings | Reference |
|---|---|---|---|---|---|---|
| **1.** | Bitter Gourd | *Momordica charantia* (Fruit extract) | High-fat diet–fed mice model and L6 muscle cell culture; biochemical assays (glucose uptake, insulin signaling proteins, acyl-carnitine profiling) | Charantin, vicine, polypeptide-p, antioxidants | Enhanced insulin signaling (↑ IRS-1, PI3K, GLUT4, Akt), reduced muscle lipid accumulation, improved glucose metabolism | Wang et al., 2011[44] |
| 2 | Neem (*Azadirachta indica*) | Leaves, bark, seeds, oil | Aqueous, ethanolic, chloroform extracts; in-vitro & animal studies | Limonoids, nimbidin, nimbolide, tannins, flavonoids, epoxy-azadiradione | Antidiabetic (↓ blood glucose, ↑ antioxidant enzymes), anti-inflammatory, anticancer effects | Islas et al., 2020, Journal of Functional Foods[24] |
| 3 | Syzygium cumini | Seeds, Bark, Leaves, Fruit | In-vitro studies, animal models (rats, mice), phytochemical screening | Tannins, flavonoids, alkaloids (jambosine), gallic acid, ellagic acid, quercetin, glycosides, minerals | Antidiabetic (α-amylase & α-glucosidase inhibition), antioxidant, anti-inflammatory, cardioprotective, gastroprotective, radioprotective, antimicrobial | Kumar & Singh, IJP, 2021[45] |
| 4 | Tulasi (*Ocimum sanctum*) | Leaves (powder) | Animal study in alloxan-induced diabetic rats (diet supplementation for 30 days) | Eugenol, tannins, saponins, alkaloids, fiber | Lowered blood sugar and serum/tissue lipids (hypoglycaemic & hypolipidemic effect) | Rai et al., 1997[46] |
| 5 | Cinnamon (*Cinnamomum spp.*) | Bark (mainly), leaves | Review of in-vitro, animal and human studies | Cinnamaldehyde, cinnamic acid, polyphenols, flavonoids, essential oils | Improved glycaemic control, insulin sensitivity, antioxidant and anti-inflammatory effects | Rao & Gan, Evid Based Complement Alternat Med, 2014[47] |
| 6 | Fenugreek (*Trigonella foenum-* | Seeds (powder solution) | Clinical trial in newly diagnosed type II diabetic patients (30 days intervention) | Saponins, fiber, 4-hydroxyisoleucine, polyphenols | Significantly reduced TC, TG, LDL and increased HDL (improved lipid metabolism & | Geberemeskel al., J Diabetes Res, |

| | | | | | | |
|---|---|---|---|---|---|---|
| | *graecum*) | | | | antidiabetic effect) | 2019 [48] |
| 7 | Tinospora cordifolia (Giloy) | Stem (satva, oil, hydroalcoholic extract), leaves (oil) | Animal study in DHEA-induced PCOS mice (biochemical, hormonal & histological analysis) | Alkaloids (berberine, Palmetine), flavonoids (quercetin, luteolin), glycosides, polysaccharides, terpenoids | Reduced insulin resistance, blood glucose, lipid levels; normalized hormones and improved ovarian morphology | Rani et al., Nutrients, 2023[49] |
| 8 | Gymnema sylvestre (gymnemagenin) | Leaves (source of gymnemic acids → gymnemagenin) | n-vitro rat liver microsomal stability, Caco-2 permeability assay, and in-vivo pharmacokinetic study in rats | Gymnemagenin (triterpenoid saponin genin) | Rapid metabolism, poor intestinal permeability, and low oral bioavailability (~14%) | Bera et al., 2016[50] |
| 9 | Chia Seed (Salvia hispanica L.) | Seeds & Flour (Untreated and Heat-treated at 90°C for 20 min) | In vivo Wistar rat assay (28 days): Evaluated protein quality (PER, NPR, TD), biochemical plasma markers, and liver/intestinal histology | Proteins (18.2%), Lipids (32.2%), Dietary Fiber (33.4%), Phenolic compounds, and Phytates. | Chia showed good protein digestibility and quality. It significantly lowered blood glucose, TGL, LDL, and VLDL, while increasing HDL. It reduced hepatic fat and improved intestinal functionality (increased crypt depth/muscle thickness). | Da Silva et. el., [51] |
| 10 | Swertia chirata (Gentianaceae) | Whole plant of *Swertia chirata* (Buch-Ham) | 95% ethanol extract given orally to healthy albino rats in fed, fasted, and oral glucose-loaded models; blood glucose measured over time; also tested in tolbutamide-pretreated rats | Xanthones (swerchirin), alkaloids, and glycosides (amarogentin). | Significant blood sugar lowering in fed, fasted, and glucose-loaded rats; extract enhanced the hypoglycaemic effect of tolbutamide | Mukherjee B el. al., [52] |

major Indian medicinal plants such as *Momordica charantia, Cinnamomum spp.Swertia chirata*, Gymnema sylvestre, Syzygium cumini, *Trigonella foenum-graecum*, and *Tinospora cordifolia*, along with their active phytochemicals (like *momordicin, and cucurbitacin B. flavonoids,glucosides, ellagic acid,amarogentin and gentiopicrin and saponins*) and highlights their broad pharmacological roles, especially in diabetes management, antioxidant activity, infection control, and chronic disease treatment.

**Conclusion**

Many pharmaceutical medications, including biguanides, thiazolidinediones, insulin, metformin, and GLP-1 agonists, have been developed as a result of advances in contemporary medicine. Despite the hypoglycaemic effects of these medications, they are frequently linked to a number of side effects, including nephrological conditions, hypoglycaemia, and other symptoms like exhaustion, upset stomach, nausea, vomiting, diarrhoea, and abdominal pain. All of these factors have prompted researchers to reevaluate herbal therapy in order to find appropriate substitutes with fewer adverse effects and better therapeutic outcomes. Several traditional medicinal

herbs, such as Gymnema sylvestre, Momordica charantia, Trigonella foenum-graecum, Cinnamomum verum, and Syzygium cumini, have positive effects on metabolic parameters linked to diabetes and metabolic syndrome, according to data from numerous preclinical studies and a small number of clinical trials. These herbs have shown promise in lowering serum cholesterol levels, controlling blood pressure, encouraging weight loss, and enhancing glycaemic management. The presence of many bioactive components and phytochemicals with notable pharmacological activity is largely responsible for their medicinal efficacy.The findings highlighted in this review bolster the function of herbal remedies in metabolic control and point to their possible use as supplemental therapeutic agents in the prevention and treatment of diabetes mellitus. However, further research—especially clinical trials—is required to advance the application of herbs in the management of diabetes mellitus.

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