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Review Article

Clinical Evidence Of Herbal Efficacy In Diabetes Clinical Studies Supporting Herbal Antidiabetic Therapies

Kunde Prachi*[1], Tapule Saloni[2], Dalvi Deryani[3]

Pravara Rural College of Pharmacy, Loni Tal. Rahata, Dist. Ahmednagar

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ABSTRACT

Diabetes mellitus is a chronic metabolic disorder characterized by persistent hyperglycemia due to impaired insulin secretion, insulin action, or both. [1] With the global rise in diabetic populations, especially in developing countries, there is growing interest in exploring cost-effective and safer alternatives to synthetic antidiabetic drugs. Herbal medicines have gained attention for their long-standing use, minimal side effects, and holistic benefits in managing blood glucose levels. This review focuses on the antidiabetic potential of commonly used medicinal plants such as Neem (Azadirachta indica), Turmeric (Curcuma longa), Cinnamon (Cinnamomum verum), Fenugreek (Trigonella foenum-graecum), Bitter melon (Momordica charantia), and Jamun (Syzygium cumini)[29].These plants exert hypoglycemic effects through various mechanisms, including enhancing insulin secretion, improving insulin sensitivity, inhibiting carbohydrate-digesting enzymes, and protecting pancreatic β-cells. The review also discusses traditional usage, phytochemical constituents, suggested methods of administration, and recent scientific findings supporting their efficacy. In addition, the future scope of integrating herbal therapies with conventional treatment protocols for better glycemic control is explored.

INTRODUCTION

Diabetes mellitus is one of the most prevalent chronic metabolic disorders affecting millions globally. It is primarily characterized by persistent hyperglycemia resulting from insulin deficiency, insulin resistance, or both. As of 2024, the International Diabetes Federation (IDF) reports that over 537 million adults worldwide are living with diabetes—a number projected to rise drastically over the coming decades.[2]

While conventional treatment options such as insulin therapy and oral hypoglycemic drugs play a significant role in glycemic control, they are often associated with long-term side effects, high

***Corresponding Author:** Kunde Prachi
Address: *Pravara Rural College of Pharmacy, Loni Tal. Rahata, Dist. Ahmednagar*
Email ✉: kisna1.618@gmail.com
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costs, and patient compliance issues. In this context, the search for safer, cost-effective, and sustainable alternatives has led to renewed interest in traditional and herbal medicine systems.

For centuries, medicinal plants have been used across diverse cultures for managing various ailments, including diabetes. Numerous herbs have demonstrated antidiabetic effects through multiple mechanisms such as enhancing insulin secretion, improving glucose uptake, reducing oxidative stress, and preserving pancreatic β-cell function. This review highlights major antidiabetic medicinal plants, their phytochemicals, modes of action, and clinical evidence supporting their efficacy.

Pathophysiology of Diabetes and the Role of Herbal Intervention

Diabetes mellitus is a chronic metabolic disorder primarily categorized into Type 1 (T1DM) and Type 2 (T2DM). Type 1 is characterized by autoimmune destruction of pancreatic β-cells, leading to an absolute insulin deficiency. In contrast, Type 2 diabetes involves a combination of insulin resistance and inadequate insulin secretion.

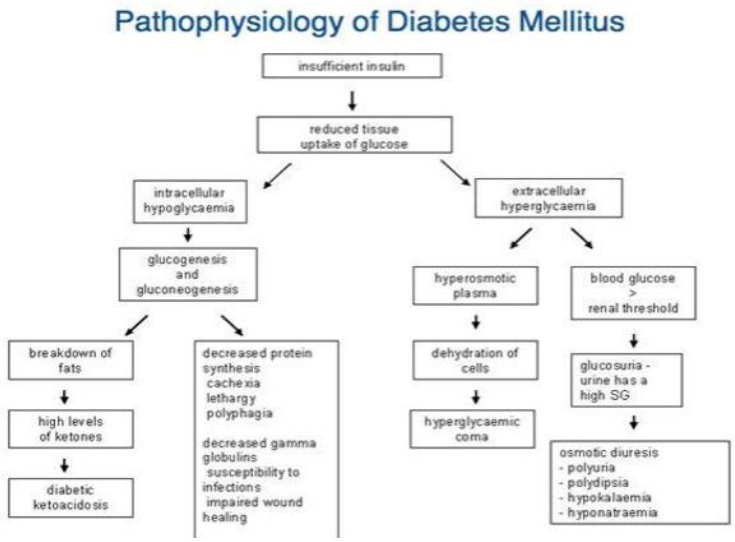
The pathophysiology of T2DM involves multiple defects:

Impaired insulin action in peripheral tissues (muscle and adipose)

Increased hepatic glucose production

β-cell dysfunction

Inflammation and oxidative stress[3]



These metabolic abnormalities lead to chronic hyperglycemia and the development of microvascular and macrovascular complications, such as nephropathy, neuropathy, retinopathy, and cardiovascular diseases.[4,5]

Herbal medicines provide therapeutic potential through multiple pathways that can counteract these dysfunctions. Some of the well-established mechanisms by which herbal extracts exert antidiabetic effects include:

Mechanisms of Herbal Action in Diabetes:

Sr.no	Biological Source of herbal drugs	Mechanism of action	Description
1	Neem (Azadirachta indica) obtained from leaves and seeds of Azadirachta indica belonging to Family Meliaceae[6]	Stimulates insulin secretion, improves insulin sensitivity, and reduces oxidative stress.[9]	Herbs that act like insulin to promote glucose uptake
2	Turmeric (Curcuma longa) –obtained from Dried rhizomes of Curcuma longa belonging to Family Zingiberaceae[11]	Improves insulin sensitivity, reduces inflammation and oxidative stress, and protects pancreatic β-cells.[13]	Stimulate pancreatic β-cells to release insulin
3	Cinnamon (Cinnamomum verum) obtained from Dried inner bark of Cinnamomum verum belonging to Family: Lauraceae[16]	Exhibits insulin-mimetic activity, enhances glucose uptake, and inhibits α-glucosidase enzyme[18]	Inhibit α-glucosidase and α-amylase to delay carbohydrate absorption
4	Fenugreek (Trigonella foenum-graecum) – obtained from ripe seeds of Trigonella foenum-graecum belonging to Family: Fabaceae[21]	Stimulates insulin secretion, delays glucose absorption, and improves insulin receptor sensitivity.[23]	Neutralize oxidative stress and protect β-cells
5	Bitter Melon (Momordica charantia) obtained from Fresh fruits and seeds of Momordica charantia belonging to Family Cucurbitaceae[26]	Possesses insulin-like activity, enhances peripheral glucose uptake, and inhibits gluconeogenesis.[28]	Enhance insulin receptor response in cells
6	Jamun (Syzygium cumini) obtained from Seeds and fruits of Syzygium cumini belonging to Family Myrtaceae[31]	Regulates insulin activity, delays carbohydrate absorption, and provides antioxidant protection to pancreatic β-cells.[33]	Providing decreased effects of insulin while decreasing absorption.

These multiple targets make plant-based treatments promising for integrated diabetes management, especially in early or moderate stages of the drugs involved in Diabetes

Key Herbal Plants Used in Diabetes Management

Sr no	Name	Active Constituents	Role in Diabetes Management	Dosage forms

1	Neem (Azadirachta indica 	Nimbin, Azadirachtin	Stimulates insulin secretion, reduces blood glucose levels, exhibits antioxidant activity, improves insulin sensitivity	 Capsule
2	Turmeric (Curcuma longa) 	Curcumin	Improves insulin sensitivity, reduces inflammation and oxidative stress, protects pancreatic β-cells	 Capsules
3	Cinnamon (Cinnamomum verum) 	Cinnamaldehyde	Mimics insulin action, enhances glucose uptake, inhibits α-glucosidase, lowers postprandial glucose Powder, capsules, tea, extracts	 Powder

4	Fenugreek (Trigonella foenum-  graecum)	4-Hydroxyisoleucine	Stimulates insulin release, delays carbohydrate absorption, improves glucose tolerance Seeds, powder, capsules	 Powder
5	Bitter Melon (Momordica  charantia)	Charantin, Polypeptide-P	Exhibits insulin-like activity, enhances glucose uptake, reduces blood glucose levels	 Liquid
6	 Jamun (Syzygium cumini)	Jamboline, Ellagic acid,Anthocynins	Delays glucose absorption, improves insulin activity, protects against diabetic complications	 Powder

Clinical Evidence of Herbal Efficacy in Diabetes Clinical Studies

Clinical Evidence of Herbal Efficacy in Diabetes Clinical Studies Supporting Herbal Antidiabetic Therapies Several herbs used in traditional medicine systems have progressed from lab research to human clinical trials. Below are examples of clinical studies that validate the efficacy of the herbs discussed:-

Herb (Scientific name)	Study design	Dose and duration	Key findings	Author and year	References number
Neem (Azadirachta indica)	Randomized clinical trial in Type 2 diabetic patients	500 mg neem leaf extract twice daily for 12 weeks	Significant reduction in fasting blood glucose (FBG) and HbA1c levels; improved lipid profile; no major adverse effects reported.	Usharani pingali,Mohammed abid ali,et.al 2020	[7]
Turmeric (Curcuma longa)	Double-blind placebo-controlled study	1500 mg curcumin daily for 3 months	Improved HbA1c, fasting blood glucose, and insulin sensitivity; reduced oxidative stress and inflammatory markers.	Ledyane Taynara Marton et al. Front Endocrinol (Lausanne). 2021.	[12]
Cinnamon (Cinnamomum verum)	Meta-analysis of 16 clinical trials	1–6 g/day for 40–90 days	Reduced fasting blood glucose, HbA1c, and triglyceride levels in patients with Type 2 diabetes mellitus.	Amir Hossein Moridpour et al. Phytother Res. 2024 Jan	[17]
Fenugreek (Trigonella foenum-graecum	Clinical trials	25 g seed powder/day	Improved glucose tolerance, reduced insulin resistance, and lowered cholesterol and triglyceride levels	Melina Haxhiraj et al. Int J Mol Sci. 2024.	[22]

Bitter Melon (Momordica charantia	Placebo-controlled clinical study	50 mL juice/day for 12 weeks	Reduced postprandial blood glucose levels and enhanced insulin secretion.	Soo Kyoung Kim et al. Complement Ther Med. 2020 Aug.	[27]
Jamun (Syzygium cumini)	Clinical trial	5 g seed powder twice daily for 3 months	Improved glycemic control, reduced symptoms such as polyuria and fatigue, and demonstrated good safety and tolerability.	Venkatramanan Varadharajan et al. Bioorg Chem. 2025.	[32]

Future Scope & Research Opportunities

Despite promising clinical results, several gaps remain:

Standardization: Variation in extraction methods, dosages, and phytochemical content affects reproducibility

Long-Term Trials: Most studies are short-duration. Large-scale, long-term trials are needed.

Herb-Drug Interactions: Detailed research is required on interactions with insulin or oral antidiabetics.

Formulation Development: Combining multiple herbs in synergistic formulations (polyherbal capsules, teas, or nan carriers) can enhance efficacy.

Integration into Modern Medicine: Incorporating validated herbal treatments into primary healthcare systems can reduce dependence on synthetic drugs and improve accessibility in rural areas.

The global burden of diabetes continues to rise, necessitating safer, more accessible, and cost-effective treatment options. Herbal medicines offer promising alternatives or adjuncts to conventional therapy. With diverse mechanisms such as insulin mimetic activity, β-cell protection, enzyme inhibition, and antioxidant effects, herbs like Neem, Turmeric, Cinnamon, Fenugreek, Bitter Melon, and Jamun have shown significant antidiabetic potential.

Multiple clinical studies have confirmed their ability to reduce fasting and postprandial blood sugar, lower HbA1c levels, and improve insulin sensitivity with minimal side effects. These plant-based therapies not only target hyperglycemia but may also prevent complications associated with long-term diabetes.

CONCLUSION

The global burden of diabetes continues to rise, necessitating safer, more accessible, and cost-effective treatment options. Herbal medicines offer promising alternatives or adjuncts to conventional therapy. With diverse mechanisms

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How to Use These Herbs (Traditional & Clinical Forms)

No.	Herb	Traditional form	Clinical form	References number
1	Neem	Neem leaf juice or powder	500mg neem extract capsules daily	[8,10]
2	Turmeric	Mixed in warm milk,powder in food	1500mg curcumin/day	[13,15]
3	Cinnamon	Powder with water/tea	1 to 6 grams/day as capsule or added to diet	[18,20]
4	Fenugreek	Soaked seeds or powder	25 grams seed powder/day	[23,25]
5	Bitter melon	Juice,curry, capsule	50ml juice/day or 2 to 3 capsules daily	[27,29]
6	Jamun	Seed powder,fruit juice	5g seed powder twice a day after meals	[33,35]

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