Formulation of Herbal Antidiabetic Medicine Review

Mr. Krushna Kumar Khalole 1. Mr. Rahul M., Ms Mayuri B., Ms. Vijayalaxmi Z.

1, Guide, Gondia College of Pharmacy, Gondia, India.
2,3, Student, Gondia College of Pharmacy, Gondia, India.

Abstract:

Diabetes mellitus is a chronic metabolic disease that affects millions globally. It is characterized by elevated blood glucose levels due to insufficient insulin production or resistance to insulin action. Despite the availability of conventional antidiabetic medications, herbal remedies are gaining popularity due to their fewer side effects and potential for long-term management. This review explores various medicinal plants with antidiabetic properties, such as Neem, Bitter Gourd, Jamun, Holy Basil, Giloy, and Fenugreek. It highlights their phytoconstituents and mechanisms of action like insulin mimicking, beta-cell regeneration, and inhibition of glucose absorption. This paper aims to bridge the gap between traditional medicine and modern pharmacology.

Introduction:

Diabetes mellitus is one of the most prevalent metabolic disorders worldwide. According to the International Diabetes Federation, more than 537 million adults were living with diabetes in 2021. This number is projected to rise significantly in the coming decades.

The condition is primarily categorized into Type 1 and Type 2 diabetes. Type 1 is an autoimmune disease where insulin-producing beta-cells are destroyed. Type 2 is associated with insulin resistance and is often linked to obesity, sedentary lifestyle, and genetic factors.

In recent years, the global burden of diabetes has reached alarming proportions, with low- and middle-income countries witnessing a particularly sharp rise in prevalence. The increasing trend can be attributed to several socio-economic and environmental factors including urbanization, poor dietary habits, physical inactivity, and the rising incidence of obesity. According to the World Health Organization (WHO), diabetes was the direct cause of 1.5 million deaths in 2019, with many more dying from complications such as cardiovascular disease, kidney failure, and infections resulting from poor glycemic control.

Diabetes management typically involves lifestyle modifications and pharmacological interventions aimed at maintaining optimal blood glucose levels. While conventional antidiabetic drugs such as metformin, sulfonylureas, insulin, and DPP-4 inhibitors have proven effective, their long-term use may be associated with

adverse effects such as hypoglycemia, gastrointestinal disturbances, and weight gain. Moreover, the high cost and limited accessibility of synthetic medications in rural and underserved areas necessitate the exploration of alternative therapeutic options.

In this context, herbal medicines have garnered significant attention due to their historical use in traditional systems of medicine such as Ayurveda, Traditional Chinese Medicine, and Unani. Many medicinal plants have demonstrated potent hypoglycemic properties

and have been validated through modern pharmacological and clinical research. Their mechanisms of action range from enhancing insulin secretion and sensitivity to delaying carbohydrate absorption and improving lipid metabolism.

The utilization of herbal antidiabetic agents is not only considered safer and more holistic but also culturally acceptable in many parts of the world. Furthermore, these natural remedies are often readily available, cost-effective, and pose fewer risks of toxicity when used appropriately. However, rigorous scientific evaluation, standardization of extracts, and clinical trials are essential to confirm their efficacy, safety, and dosage.

This literature survey aims to explore and summarize the existing knowledge on commonly used herbal medicines with antidiabetic potential, including their phytoconstituents, mechanisms of action, and clinical relevance.

1. Herbal Antidiabetic Drugs and Their Mechanisms

Although synthetic drugs such as Metformin, Sulfonylureas, and insulin injections are commonly used, they often come with side effects like gastrointestinal disturbances, hypoglycemia, and long-term resistance. Therefore, there is a growing interest in exploring alternative treatments using herbal medicines.

Herbal remedies have been used for centuries in various traditional medicine systems including Ayurveda, Traditional Chinese Medicine (TCM), and Unani. These natural therapies are considered safer, more accessible, and often more affordable than conventional drugs. This review compiles scientific evidence on various antidiabetic herbs and explains their bioactive compounds and mechanisms of action.

2. Pathophysiology of Diabetes Mellitus

Diabetes is characterized by elevated blood glucose levels, which result from defects in insulin production, insulin action, or both. In normal conditions, the pancreas releases insulin in response to increased blood sugar levels, promoting glucose uptake by cells.

In Type 1 diabetes, autoimmune destruction of pancreatic beta-cells leads to an absolute deficiency of insulin. Patients require lifelong insulin therapy. In contrast, Type 2 diabetes involves insulin resistance-where body cells fail to respond properly to insulin-along with eventual beta-cell dysfunction.

Key physiological abnormalities include:

- Impaired insulin secretion
- Increased hepatic glucose production
- Decreased glucose uptake by muscles and adipose tissue
- Inflammation and oxidative stress contributing to beta-cell apoptosis

Chronic hyperglycemia leads to complications such as neuropathy, nephropathy, retinopathy, and cardiovascular diseases.

1. Herbal Antidiabetic Plants and Their Active Constituents

Herbal medicines play a significant role in the management of diabetes mellitus, especially in traditional and alternative medical systems. Numerous medicinal plants have demonstrated antidiabetic effects through various mechanisms, such as enhancing insulin secretion, improving insulin sensitivity, inhibiting carbohydrate- digesting enzymes, and providing antioxidant protection to pancreatic beta cells.

Below is a categorized list of some well-studied herbal antidiabetic plants along with their active constituents and mechanisms of action:

1. Azadirachta indica (Neem)

   Active Constituents: Nimbidin, nimbin, azadirachtin, flavonoids.

   Mechanism: Exhibits insulinotropic activity, improves glucose uptake, and enhances antioxidant defense. Effect: Reduces fasting blood glucose and promotes pancreatic function.

2. Momordica charantia (Bitter Gourd)

Active Constituents: Charantin, polypeptide-p, vicine.

Mechanism: Mimics insulin (insulin-like peptides), improves glucose uptake in tissues, and reduces intestinal glucose absorption.

Effect: Effective in both Type 1 and Type 2 diabetes models.

3. Syzygium cumini (Jamun)

Active Constituents: Jamboline, ellagic acid, anthocyanins.

Mechanism: Slows down the conversion of starch to sugar; enhances glucose tolerance and insulin activity.
Effect: Stabilizes blood sugar levels and provides antioxidant protection.

4. Ocimum sanctum (Holy Basil/Tulsi)

Active Constituents: Eugenol, ursolic acid, flavonoids, essential oils.

Mechanism: Enhances insulin secretion, improves beta-cell function, and offers antioxidant protection. Effect: Lowers blood glucose and protects against oxidative stress.

5. Tinospora cordifolia (Giloy)

Active Constituents: Alkaloids (berberine), glycosides (tinosporin, cordifolioside).

Mechanism: Improves insulin sensitivity, modulates glucose metabolism, and exhibits immune-modulatory effects.

Effect: Enhances insulin signaling and reduces insulin resistance.

6. Trigonella foenum-graecum (Fenugreek)

Active Constituents: 4-hydroxyisoleucine, galactomannan, trigonelline.

Mechanism: Delays carbohydrate digestion and absorption; improves insulin sensitivity and lipid metabolism.
Effect: Reduces postprandial and fasting blood glucose levels.

7. Emblica officinalis (Amla/Indian Gooseberry)

Active Constituents: Ascorbic acid (Vitamin C), tannins, emblicanin.

Mechanism: Protects pancreatic beta-cells, enhances insulin secretion, and exhibits antioxidant properties.
Effect: Improves glucose tolerance and reduces oxidative stress.

8. Gymnema sylvestre (Gudmar)

Active Constituents: Gymnemic acids, saponins.

Mechanism: Suppresses taste of sweetness, regenerates pancreatic beta-cells, and inhibits intestinal glucose absorption.

Effect: Promotes insulin release and reduces sugar cravings.

9. Aegle marmelos (Bael)

Active Constituents: Marmelosin, aegeline, coumarins.

Mechanism: Enhances glucose utilization and modulates carbohydrate metabolism. Effect: Lowers blood glucose and supports pancreatic function.

10. Curcuma longa (Turmeric) Active Constituents: Curcumin.

Mechanism: Anti-inflammatory, antioxidant; reduces insulin resistance and protects pancreatic cells. Effect: Improves insulin sensitivity and combats diabetes-related inflammation.

11. Aloe vera

Active Constituents: Glucomannan, lectins, anthraquinones.

Mechanism: Lowers fasting glucose by enhancing insulin sensitivity and reducing glucose absorption. Effect: Shows hypoglycemic and lipid-lowering effects.

Conclusion:

Herbal medicines have emerged as promising alternatives or adjuncts to conventional therapies for the management of diabetes mellitus. A wide range of medicinal plants, such as Gymnema sylvestre, Momordica charantia, Trigonella foenum-graecum, and Tinospora cordifolia, have demonstrated significant antidiabetic activity through various mechanisms, including stimulation of insulin secretion, enhancement of insulin sensitivity, inhibition of glucose absorption, and regeneration of pancreatic β-cells.

These plant-based remedies not only offer glycemic control but also possess antioxidant, anti-inflammatory, and lipid-lowering properties, making them beneficial in managing diabetes and its complications. Moreover, their relatively low cost and fewer side effects make them particularly valuable in resource-limited settings.

However, despite their traditional use and encouraging pharmacological evidence, further standardized clinical trials, toxicity studies, and mechanistic investigations are required to ensure their safety, efficacy, and integration into mainstream medical practice. In conclusion, herbal antidiabetic medicines hold great potential and should be explored further through scientific validation and modern drug development approaches.

References:

1. Tarannum, Nazia, et al. "Nanoparticles assisted intra and transdermic delivery of antifungal ointment: an updated review." Discover Nano 19.1 (2024): 11.
2. Nagasa, Gamachu Diba, and Anteneh Belete. "Review on nanomaterials and nano-scaled systems for topical and systemic delivery of antifungal drugs." Journal of Multidisciplinary Healthcare (2022): 1819-1840.
3. Singh, Sumita, et al. "Nanotechnology-based Drug Delivery of Topical Antifungal Agents." Pharmaceutical Nanotechnology 12.3 (2024): 185-196.
4. Soliman, Ghareb M. "Nanoparticles as safe and effective delivery systems of antifungal agents: Achievements and challenges." International journal of pharmaceutics 523.1 (2017): 15-32.
5. Nagpal, Manju, and Malkiet Kaur. "Nanomaterials for skin antifungal therapy: An updated review." Journal of Applied Pharmaceutical Science 11.1 (2021): 015-025.

6. Nami, Sanam, Ali Aghebati-Maleki, and Leili Aghebati-Maleki. "Current applications and prospects of nanoparticles for antifungal drug delivery." EXCLI journal 20 (2021): 562.
7. Waghule, Tejashree, et al. "Emerging role of nanocarriers based topical delivery of anti-fungal agents in combating growing fungal infections." Dermatologic therapy 33.6 (2020): e13905.
8. Kumar, Lalit, et al. "Eradication of superficial fungal infections by conventional and novel approaches: a comprehensive review." Artificial cells, nanomedicine, and biotechnology 42.1 (2014): 32-46.
9. Ahuja, Ashima, and Meenakshi Bajpai. "Nano formulations insights: a novel paradigm for antifungal therapies and future perspectives." Current Drug Delivery 21.9 (2024): 1241-1272.
10. Ren, M-Y., et al. "Current status and research progress of nanoparticle application in superficial fungal infection." European Review for Medical & Pharmacological Sciences 27.11 (2023).
11. Gupta, Madhu, Vikas Sharma, and Nagendra S. Chauhan. "Promising novel nano pharmaceuticals for improving topical antifungal drug delivery." Nano-and Microscale Drug Delivery Systems. Elsevier, 2017. 197-228.
12. Srivastava, Rajat, et al. "Advancements in nanotechnology for enhanced antifungal drug delivery: A comprehensive review." Infectious Disorders-Drug TargetsDisorders) 24.2 (2024): 24-36.
13. Lengert, Ekaterina V., et al. "Prospective nanotechnology-based strategies for enhanced intra-and transdermal delivery of antifungal drugs." Skin Pharmacology and Physiology 33.5 (2020): 261-269.
14. Santos, Rafael Silva, et al. "Innovative nanocompounds for cutaneous administration of classical antifungal drugs: a systematic review." Journal of Dermatological Treatment 30.6 (2019): 617-626.
15. Rai, Mella, et al. "Nanotechnology for the treatment of fungal infections on human skin." The microbiology of skin, soft tissue, bone and joint infections. Academic Press, 2017. 169-184.
16. Akhtar, Nida, Anurag Verma, and Kamla Pathak. "Topical delivery of drugs for the effective treatment of fungal infections of skin." Current pharmaceutical design 21.20 (2015): 2892-2913.
17. Abd-Alla MS, Atalla KM, El-Sawi MAM. 2001. Effect of some plant waste extracts on growth and aflatoxin production by Aspergillus flavus. Annals Agric. Sci., Ain Shams Univ., Cairo, 46:579-592.
18. Bauer, A.W., Kirby, W.M., Truck, H., Shreeies, J.C., 1996. Antibiotic susceptibility testing by standardized single disc method. Am. J. Clin Pathol, 45(4): 493-496.
19. Kaushik K, Sharma RB, Sharma A, Agarwal S. Formulation and evaluation of antifungal activity of gel of crude methanolic extract of leaves of Ipomoea carnea Jacq. Journal of Research in Pharmacy. 2020 May 1;24(3):368-79.
20. Berman J., Krysan D.J. Drug resistance and tolerance in fungi. Nat. Rev. Microbial. 2020;18(6):319–331. Doi: 10.1038/s41579-019-0322-2.

21. El Mahrab Robert, Majdeline, and Yogeshvar N. Kalia. "New developments in topical antifungal therapy." American Journal of Drug Delivery 4 (2006): 231-247.
22. Güngör, Sevgi, M. Sedef Erdal, and Buket Aksu. "New formulation strategies in topical antifungal therapy." Journal of Cosmetics, Dermatological Sciences and Applications 3.1 (2013): 56-65.
23. Kaushik, Kusum, and S. H. W. E. T. A. Agarwal. "The role of herbal antifungal agents for the management of fungal diseases: a systematic review." Asian J Pharm Clin Res 12.7 (2019): 34-40.
24. Wu, Shunyu, et al. "A comparison of antifungal drugs and traditional antiseptic medication for Otomycosis Treatment: a systematic review and Meta-analysis." Frontiers in Surgery 8 (2021): 739360.
25. Pandey, Preeti, and Vivekanand Kashid. "TRANSFERSOMES AS NANO CARRIERS USING HERBAL OINTMENT FOR TREATMENT OF FUNGAL INFECTION." Biochemical & Cellular Archives 24.2 (2024).
26. Baran, Robert, Rod J. Hay, and Javier I. Garduno. "Review of antifungal therapy and the severity index for assessing onychomycosis: part I." Journal of Dermatological Treatment 19.2 (2008): 72-81.
27. Durdu, Murat, et al. "Topical and systemic antifungals in dermatology practice." Expert review of clinical pharmacology 10.2 (2017): 225-237.
28. Kaur, Indu Pal, Cheena Rana, and Harinder Singh. "Development of effective ocular preparations of antifungal agents." Journal of Ocular Pharmacology and Therapeutics 24.5 (2008): 481-494.