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Healing Beyond Insulin: A Modern- Herbal Perspective On Diabetes

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Abstract: **Objective:**

To explore the therapeutic potential of traditional herbal remedies in the prevention and management of diabetes mellitus, particularly type 2 diabetes (T2DM), and to highlight the importance of integrating herbal and modern medical approaches for improved patient outcomes.

Significance:

Globally, over 800 million people suffer from diabetes, with T2DM accounting for 95% of cases. Despite advancements in pharmaceutical treatments such as GLP-1 agonists and metformin, many patients—especially in low- and middle-income regions—remain inadequately treated. Herbal medicines, with their antidiabetic, antioxidant, and lipid-lowering properties, offer promising, cost-effective alternatives or adjuncts to conventional therapies.

Methods:

A comparative review of literature and recent studies was conducted on five major antidiabetic medicinal plants—karela (Momordica charantia), neem (Azadirachta indica), jamun (Syzygium cumini), guggul (Commiphora wightii), and saptarangi (Salacia oblonga)—evaluating their bioactive compounds, mechanisms of action, and clinical relevance.

Results:

Findings indicate that these herbs enhance insulin sensitivity, stimulate insulin secretion, inhibit glucose absorption, and reduce oxidative stress. Clinical and preclinical data support their ability to improve lipid profiles and protect vital organs. Kerala's community-based lifestyle interventions further demonstrate the efficacy of integrated preventive approaches.

Conclusions:

Standardizing herbal extracts, validating active constituents, and conducting large-scale human trials are essential next steps. Combining herbal medicine with evidence-based modern therapy may revolutionize diabetes management, offering a holistic, affordable, and sustainable path to better global metabolic health.

I. INTRODUCTION

1. The study of epidemiology

Globally, an estimated 537 million adults aged 20 to 79 had diabetes in 2021; by 2045, that number is expected to rise to 783 million. Since 1990, the prevalence has more than doubled, rising from about 7% to about 14% by 2022 ..(1) About 60% of people over 30 with diabetes do not receive treatment, and the disease is disproportionately prevalent in low- and middle-income nations where access to treatment is still

restricted.(2) According to recent estimates, over 800 million people worldwide currently have diabetes, with type 2 diabetes accounting for 95% of cases.(3)

2. Pathophysiology

Insulin resistance in muscle, fat, and liver tissue is usually the first sign of type 2 diabetes (T2DM). Progressive β-cell dysfunction eventually results in over hyperglycemia, although early β-cell compensation can postpone symptoms for three to seven years.(4) Chronic inflammation, oxidative stress, obesity (particularly visceral), and genetic predisposition are all contributing factors.(5)

3. Grouping

An autoimmune disease known as type 1 diabetes (T1DM) causes the destruction of pancreatic β-cells, which leaves the patient completely insulin deficient. In children and young people, it frequently manifests acutely(6). Over 90% of cases of diabetes are type 2 diabetes (T2DM), which is caused by insulin resistance and β-cell exhaustion. (7)The onset of gestational diabetes mellitus (GDM) is frequently subtle, and many cases go years without a diagnosis. First detected during pregnancy, hyperglycemia puts both the mother and the unborn child at risk for future metabolic problems.(8) Other particular kinds: Incorporate neonatal diabetes, LADA, monogenic forms (like MODY), and secondary diabetes brought on by illness or medication.(9)

4. Risk Elements

Genetic predisposition: Lifestyle is often more decisive, but family history confers a 2–4× higher risk, with genome-wide studies identifying over 60 susceptibility loci.Obesity and lifestyle: Stress, smoking, inactivity, poor diet (sugary drinks, ultra-processed foods), and excess adiposity (which accounts for about 64% of cases in men and 77% in women) are all major contributors.Age and ethnicity: Age-related increases in risk peak between the ages of 50 and 70; South Asian, African, and Hispanic populations have higher prevalences.(10)Type 1 triggers: In people who are genetically predisposed, environmental agents like viruses cause autoimmunity.Maternal obesity, advanced age, a personal or family history of glucose intolerance, PCOS, and excessive pregnancy weight gain are among the factors specific to GDM.(11)

5. Difficulties

Persistent hyperglycemia is linked to: Microvascular: peripheral neuropathy, which raises the risk of foot ulcers and amputations2, kidney dysfunction (possible renal failure), retinal damage (the primary cause of adult blindness), and peripheral vascular disease. Macrovascular: Increased risk of peripheral arterial disease, heart attacks, and strokes due to accelerated atherosclerosis. Every year, diabetes causes more than 2 million deaths worldwide, including those from kidney disease.(12)

6. Management: Benefits and Drawbacks Benefits of Treatment Drawbacks Lifestyle modifications can postpone the onset and progression

of type 2 diabetes; enhances metabolic parameters and is economical for high-risk individuals. Limited long-term adherence; socioeconomic factors influence the results Metform in reduces hepatic glucose synthesis, helps the heart, reduces the risk of hypoglycemia, and is reasonably priced.(13)discomfort in the stomach; uncommon lactic acidosis in liver or kidney disease; Risk of B12 deficiency Sulfonylureas Quick and inexpensive glucose lowering Gaining weight, experiencing hypoglycemia, and gradually losing effectiveness α-glucosidase inhibitors and thiazolidinediones Reduced hypoglycemia, mild lipid benefits, and increased insulin sensitivity GI side effects, edema, fractures, heart failure risk, and fluid retention GLP-1 receptor agonists and SGLT2 inhibitors Encourage weight loss, protect the heart and kidneys, and lower blood sugar levels.Costly; genitourinary infection risk; little information on pregnancy Delivery and Insulindelivery tools (CGMs, pumps)vital for advanced type 2 diabetes and type 1 diabetes; better glycemic control; increased accuracy in dosage Weight gain, hypoglycemia, complicated devices, training needs, and infection/DKA risk(14)

Here's a clear comparison of the **advantages and disadvantages of Ayurvedic vs. Allopathic (modern medicine)** approaches in the **management of diabetes**:

⚖️ Ayurvedic vs. Allopathic Medicine in Diabetes Management

Aspect	Ayurvedic Medicine	Allopathic Medicine
Approach	Holistic – focuses on balancing the body (doshas), improving digestion, detoxification, and lifestyle changes	Symptomatic – targets specific physiological issues (e.g., high blood sugar) using pharmaceuticals
Advantages		
1. **Natural Ingredients**	Uses herbs and natural compounds (e.g., karela, jamun, neem) with fewer synthetic chemicals	Uses synthetic drugs; fast-acting
2. **Fewer Side Effects**	Generally mild side effects when properly administered	Risk of side effects like hypoglycemia, weight gain, gastrointestinal issues
3. **Long-term Lifestyle Focus**	Emphasizes diet, exercise, stress reduction (yoga, meditation) – aims at root cause	Focus is on controlling symptoms, not curing
4. **Supports Organ Health**	Many Ayurvedic herbs also support liver, kidney, and pancreas function	Some drugs may strain organs over time (e.g., kidneys in long-term metformin use)
5. **Cost-Effective**	Often more affordable in the long run, especially for early-stage or prevention	Can be expensive, especially for insulin therapy or newer drugs
6. **Preventive Value**	Strong focus on **preventing** diabetes in high-risk individuals	Primarily focuses on **treating** established diabetes
Disadvantages		
1. **Lack of Standardization**	Variability in formulation, dosage, and quality of herbal products	Highly standardized with precise dosing and clinical protocols
2. **Slower Onset of Action**	Herbal treatments may take weeks/months to show effects	Fast action – immediate blood sugar control
3. **Limited Emergency Use**	Not suitable for acute diabetic emergencies like DKA or severe hyperglycemia	Effective in acute situations and emergencies
4. **Less Clinical Evidence**	Some herbs lack robust, large-scale clinical trials	Extensive evidence from randomized controlled trials
5. **Risk of Self-Medication**	People may misuse or overuse herbs without proper guidance	Physicians closely monitor dosage and effects
6. **Herb-Drug Interactions**	Potential interactions if used alongside allopathic drugs without supervision	Generally better understood interaction profiles

Best Practice Recommendation

- **Ayurveda** can be highly effective in **early-stage diabetes**, **prevention**, or as **supportive therapy** (adjunct).
- **Allopathic medicine** is essential for **moderate-to-severe cases**, **rapid glycemic control**, and **emergency care**.
- **Integrated/Complementary Approach**: Many modern protocols recommend combining both under medical supervision for better long-term outcomes.

INGREDIENT

Karela

Other names: Bitter Melon, Bitter Gourd Momordica charantia L. is its botanical name. Cucurbitaceae is the plant family. Source: The term "karela" describes the unripe green fruits that are harvested from the Cucurbitaceae plant Momordica charantia. Components: Numerous nutritional and bioactive substances are present in the fruit, such as: Mordicin Charantin It also includes: The carbohydrate Minerals Alkaloids Glycosides The proteins The Lipids(15)

Kerala is a leader in the advancement of therapeutic interventions and microvascular retinal research, especially when it comes to diabetic retinopathy. Treatment-wise, research from Kerala showed that intravitreal dexamethasone implants and ranibizumab injections were effective in controlling diabetic macular edema, enhancing visual acuity and patient satisfaction. A group-based, peer-support lifestyle intervention, the Kerala Diabetes Prevention Program (K-DPP) was designed to lower the risk of type 2 diabetes in high-risk individuals. Changes in clinical, biochemical, and behavioral risk factors that are known to raise the risk of diabetes, such as weight, waist circumference, waist-to-hip ratio, and systolic and diastolic blood pressure, were among the secondary objectives.(16)

measurements of body composition, plasma glucose, HbA1c, and total

cholesterol, LDL cholesterol, alcohol and tobacco use, diet, and physical activity at 24 months

The jamun seed
Other name :Syzygium cumini

Because of its hypoglycemic and antioxidant qualities, jamun (Syzygium cumini) seed powder has demonstrated promise in the treatment of diabetes. According to review papers, jamun seed extract—including powder—can help diabetics with their blood sugar levels, lipid profiles, and oxidative stress. (17)

Hypoglycemic Effects: Numerous investigations, such as those conducted on rats and rabbits with diabetes induced by alloxan, have demonstrated

extracts from jamun seeds, especially those that are aqueous, can dramatically lower blood sugar levels. Supplementing with jamun seed powder has also been shown to improve HbA1c levels, a measure of long-term blood sugar control, in people having type 2 diabetes. Antioxidant Activity: Packed with flavonoids and phenolics, jamun seeds can help fight oxidative stress, a key contributor to complications from diabetes. Jamun seed powder may prevent damage to pancreatic beta cells and other diabetic tissues by lowering oxidative stress.

Lipid: profile Improvement: According to certain research, taking supplements of jamun seed powder may lower levels of LDL and total cholesterol, which are frequently higher in diabetics. Mechanisms of Action: There are several ways that jamun is believ to have its antidiabetic effects, including: Increased Insulin Secretion: Jamun may help low blood glucose by encouraging the pancreas to release more insulin. Improved Insulin Sensitivity: It might also make the body react better to insulin, which would make it easier for cells to absorb glucose. Decreased Glucose Absorption: Jamun may prevent the enzymes that break down carbohydrates from working, which lowers the quantity of glucose that enters the blood. Antioxidant Activity: Jamun's antioxidants can shield beta cells in the pancreas from

harm brought on by free radicals, assisting in maintaining their function(18)

Neem

other name:Azadirachta

Neem, has a long history of use in medicine, especially in traditional systems like Ayurveda. It is also being studied for its potential to prevent diabetes. Neem tree extracts and other parts have shown encouraging anti-diabetic and other positive effects (ANTI-DIABETIC ACTIVITY OF NEEM OIL - AN IN VITRO RESEARCHNeem's ability to prevent diabetes Blood sugar regulation: It has been demonstrated that neem leaf extracts can assist both hyperglycemic and diabetic individuals in maintaining appropriate blood glucose levels. Protective Effects: Neem can guard against diabetes-related metabolic abnormalities. Neem oil's anti-diabetic properties: an in vitro investigation The Indian subcontinent is home to a large population of neem (Azadirachta indica), an evergreen tree native to southeast Asia. This tree is about 15 to 20 meters tall. 15–20 m, and occasionally even 35–40 m. The Persian language is where the word "A. indica" originated. "I" stands for "Indian origin," "dirakht" for "tree," and "Azad" for "free.". An Indian traditional remedy with a contemporary molecular foundation is neem (Azadirachta indica).(19)

saptrang

othername:Salacia oblanga

Research indicates that it might have anti-hyperglycemic (lowering high blood sugar) and hypoglycemic (lowering blood sugar) effects. Group B comprised individuals with chronic type-2 diabetes mellitus who were taking contemporary medications, while Group A comprised individuals with type-2 diabetes who had just been diagnosed and were not taking any regular medications pancreatic β-cell function in the setting of worsening insulin resistance.

Studies in high-risk populations have demonstrated that during progression to diabetes, β-cells have declining function and lose the first phase of insulin secretion, resulting in less than adequate suppression of hepatic glucose production following meals. In addition, oscillations of insulin secretion become unmatched from their normal coupling with glucose. Several mechanisms are thought to be responsible for impaired β-cell function, including glucose toxicity and lipotoxicity and potentially contribute to β-cell loss.(20)

Guggul

Other name :Commipora wighti

Type 2 Diabetes Mellitus impairs glucose utilization and is an endocrine metabolic disease. Both commercial medications and herbal remedies are used to treat this illness, with varying degrees of interaction. This study examines one such interaction between guggul extract (GE) from Commiphora wightii and saxagliptin (SAXA, CYP3A4 substrate). In addition to lowering total glycogen and oxidative stress indicators, the concurrent administration of SAXA and GE had restored levels of blood glucose and biochemical parameters that had previously increased. efficiently in contrast to SAXA or GE that are only consumed. Histopathological analysis supported these findings, demonstrating that the combination treatment improved the mitigation of induced diabetes-related tissue damage in the liver, kidneys, and pancreas. Additionally, it was found that combination therapy decreased the expression levels of CYP3A11 mRNA (the mouse homolog of human CYP3A4) to non-diabetic levels, which would not have been possible otherwise. The co-existence of both ligands at distinct binding sites of the metabolizing enzyme was confirmed by the molecular docking studies, which predicted improved interaction between CYP3A4 and the bioactive content of GE, i.e., guggulsterone E-Z, with a binding energy of −9.96 kcal/mol in conjunction with SAXA. The combined effects of GE and SAXA improved tissue damage repair and raised CYP3A11 mRNA expression levels brought on by induce dibetes(21)

🌿 Medicinal Plants and Diabetes Interventions – Summary Table

Plant / Program	Other Names	Key Components / Compounds	Main Effects	Mechanisms of Action	Notes
Karela	Bitter Melon, Bitter Gourd*Momordica charantia*	Charantin, Mordicin, Alkaloids, Glycosides, Proteins, Lipids, Carbohydrates	Hypoglycemic effect, improved glucose metabolism	Enhances insulin sensitivity, glucose uptake, may inhibit glucose absorption	Commonly used in traditional remedies
Kerala Diabetes Research	—	—	Diabetes prevention, macular edema treatment	Lifestyle changes (K-DPP), intravitreal dexamethasone and ranibizumab injections for macular edema	Kerala is a leader in diabetes research and intervention
Jamun Seed	*Syzygium cumini*	Flavonoids, Phenolics	↓ Blood glucose, ↓ HbA1c, ↓ LDL and total cholesterol, antioxidant protection	↑ Insulin secretion, ↑ sensitivity, ↓ glucose absorption, protects β-cells from oxidative stress	Effective in both human and animal models
Neem	*Azadirachta indica*	Various phytochemicals, Neem oil	Blood sugar regulation, protection from metabolic abnormalities	Anti-hyperglycemic, supports pancreatic function	Widely studied in Ayurveda and modern in vitro research

Plant / Program	Other Names	Key Components / Compounds	Main Effects	Mechanisms of Action	Notes
Saptarangi / Saptrang	*Salacia oblonga*, *Casearia esculenta*	—	Anti-hyperglycemic and hypoglycemic effects	Preserves β-cell function, counters glucose/lipotoxicity	Used in Ayurveda; shown effective in early and chronic diabetes
Guggul	*Commiphora wightii*	Guggulsterone E-Z	↓ Blood glucose, ↓ oxidative stress, tissue protection	Enhances effects of Saxagliptin (SAXA); ↓ CYP3A11 mRNA expression; improved metabolic enzyme interaction	Effective in combination therapy with modern drugs

Future research objectives

Moving Forward with Herbal Diabetes Treatments

We all know that herbal medicines show great promise for managing diabetes, but there's a lot of work to be done to make them a standard part of treatment. The main goal is to bring traditional herbal knowledge into the modern scientific world.

Here's what needs to happen:

Make it Consistent: Right now, herbal extracts can be a bit all over the place. A key step is to create a reliable method for standardizing them. This means we need to figure out exactly which active ingredients (like those in karela, neem, and jamun) are responsible for the health benefits and make sure every product has a consistent amount of them. This way, we'll get the same results every time.

Test on People, Not Just Animals: While we've learned a lot from lab and animal studies, the next big step is to conduct thorough clinical trials on humans. We need to see how these herbal compounds affect things like insulin levels, how the body uses sugar, and even cholesterol. This will help us understand exactly how they work and if they're truly effective.

Improve How We Take Them: Taking an herbal remedy shouldn't be a hassle. Researchers are looking into new ways to make these medicines more effective and easier to use. This includes things like nanoformulation and encapsulation, which can help the body absorb the active ingredients better. We can also explore combining different herbs to see if they work better together.

Check for Safety: Many people with diabetes already take traditional medicines like metformin. We absolutely have to figure out if it's safe to take these herbal products at the same time and what the long-term effects are. This is crucial for making sure patients are safe.

Specific Plants We're Focusing On research will hone in on few specific plants to start :

Standardising herbal extracts , conducting human clinical trial , improving how the medicines are delivered and confirming their safety especially when used with conventional drugs .

Specific plants been studied include karela, neem ,guggul ,saptrangi and jamun seeds .

The ultimate goal is to apply the same scientific characteristic to this plant based remedies as is used for conventional medicines .

Essentially, it’s all about applying the same rigorous scientific standards we use for conventional medicine to these traditional plant-based treatments.

Conclusion

One of the most difficult health issues in the world today is diabetes mellitus, especially type 2 diabetes, w hose prevalence is rapidly increasing as a result of sedentary lifestyles, urbanization, poor eating habits, and g enetic predispositions.

Even with the availability of contemporary pharmaceutical treatments like insulin therapy, GLP-

1 agonists, metformin, and SGLT2 inhibitors, many patients continue to receive inadequate care, particularly in low- and middle-income nations.

Furthermore, the efficacy of these traditional treatments is frequently constrained by problems with long-term adherence, expense, adverse effects, and accessibility.

A complementary and all-encompassing method of managing diabetes is offered by traditional herbal medicine. Certain medicinal plants, including guggul (Commiphora wightii), jamun (Syzygium cumini), neem (Azadirachta indica), karela (Momordica charantia), and saptarangi (Salacia species), have shown strong antidiabetic potential through mechanisms such as improving insulin sensitivity, enhancing insulin secretion, inhibiting the absorption of carbohydrates, lowering oxidative stress, and modifying lipid profiles. Additionally, these phytomedicines appear to be promising in preventing diabetic complications like retinopathy, nephropathy, and neuropathy.

But there are lot of obstacles to overcome, even with promising preclinical and some clinical data. Their incorporation into mainstream therapy is still hampered by issues with extract standardization, bioavail ability, active constituent variations, safety, and a lack of large-scale human trials. Furthermore, to guarantee safe concurrent use with traditional antidiabetic medications, herb–drug interactions need to be thoroughly investigated.
To ensure efficacy and safety, future studies should focus on standardizing plant extracts, identifying and vali dating bioactive molecules, creating sophisticated formulations (like nano-encapsulation), and conducting extensive, randomized clinical trials.
Furthermore, the investigation of functional food formulations and polyherbal combinations may open up ne w possibilities for the treatment of diabetes.

In conclusion, the treatment of diabetes may be revolutionized by combining herbal remedies with contem porary scientific evidence.
These natural solutions can enhance current treatment approaches and help patients worldwide manage their diabetes more affordably, easily, and holistically by fusing conventional wisdom with evidence-based research.

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