



Anti-Diabetic Activity and Phytochemical Estimation of Extracts of *Withania coagulans*, *Picrorhiza kurroa*, and *Gymnema sylvestre*

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Abstract: This review explores the anti-diabetic activity and phytochemical constituents of three prominent medicinal plants: *Withania coagulans*, *Picrorhiza kurroa*, and *Gymnema sylvestre*. These plants have long been utilized in traditional medicine systems for the treatment of diabetes mellitus. This paper consolidates data from experimental, clinical, and phytochemical studies to present a comparative analysis of their efficacy. The review also highlights the underlying mechanisms of anti-diabetic action, identifies major bioactive compounds, and suggests directions for future research.

Keywords: Diabetes mellitus, *Withania coagulans*, *Picrorhiza kurroa*, *Gymnema sylvestre*.

1. Introduction

Diabetes

Diabetes mellitus is a metabolic disorder marked by chronic hyperglycemia, resulting from defects in insulin secretion or action. The incidence of diabetes is increasing worldwide, with type 2 diabetes being the most prevalent. Despite the availability of several synthetic antidiabetic agents, their side effects and limited efficacy have driven the exploration of alternative therapies. Medicinal plants like *Withania coagulans*, *Picrorhiza kurroa*, and *Gymnema sylvestre* offer promising anti-diabetic properties owing to their bioactive phytochemicals. This review aims to summarize the pharmacological actions, phytochemical constituents, and therapeutic potential of these plants [1].

There's an ever-adding interest in reciprocal and indispensable drug to combat habitual ailments. The motivation to exploit similar indispensable curatives lies in the intent to identify new moieties that may potentially be more effective than being medicines, with possibilities of reduced side effects. Also, the advantage of using the traditional system of drug lies in the fact that numerous of these naturally attained excerpts offer an early intervention and health conservation approach in easing conditions. The demand for nutraceutical, especially from developing husbandry, i.e., Brazil, China, India, etc., is on the rise, whereby recent estimates reflect that the global nutraceuticals request will reach USD 578.23 billion by 20252]

Antidiabetic

These drugs are used to treat or help prevent diabetes. Anti diabetic drugs are often used on conjunction with lifestyle changes like diet and exercise to manage diabetes [3].



Classification of Antidiabetic Herbal Drugs

Here are some of the commonly studied anti diabetic herbal drugs:

- **Bitter Melon (*Momordic acharantia*):** Bitter melon is a popular traditional remedy in Asian countries and is believed to have blood sugar-lowering effects. It contains active compounds like charantin, polypeptide-p, and vicine that may help improve insulin sensitivity.
- **Cinnamon (*Cinnamomum verum*):** Cinnamon is a common spice with potential anti diabetic effects. Studies have suggested that cinnamon may enhance insulin sensitivity and lower blood glucose levels.
- **Fenugreek (*Trigonella foenum-graecum*):** Fenugreek seeds have been used traditionally to manage diabetes. They contain soluble fiber and other compounds that may help lower blood sugar levels and improve insulin sensitivity.
- **Gymnema (*Gymnema sylvestre*):** Gymnema, also known as "Gurmar," has a long history of use in Ayurvedic medicine for diabetes management. Some studies indicate that Gymnema may reduce sugar absorption in the intestines and enhance insulin production.
- **Ginger (*Zingiber Officinale*):** Ginger has been studied for its potential to improve insulin sensitivity and reduce blood glucose levels. It may also have anti-inflammatory properties that could benefit people with diabetes.
- **Withania *coagulans*:** belongs to the family Solanaceae is one of the important ayurvedic medicinal shops generally known as vegetable rennet, Indian cheesemaker, Indian rennet, Paneer ke phool, Paneer band or Paneer dodiis extensively used over 3,000 times in India. *Withania coagulans* (Indian Rennet), covering its botanical identity, phytochemistry, pharmacological parcels, traditional uses, and remedial eventuality, especially in the environment of antidiabetic exertion *Withania coagulans* is a potent medicinal condiment with scientifically proven antidiabetic goods. Its multi-targeted mechanisms, including enzyme inhibition, antioxidant defense, and insulin sensitization, make it a promising natural remedy for diabetes and its complications. Its integration into polyherbal phrasings could offer an effective and safer volition to synthetic antidiabetic medicines.
- **Picrorrhiza kurroa** is a small imperishable seasoning set up in the Himalayan region at mound between 3,000 – 5,000 measures. It thrives in cool, damp climates and is known for its bitter- tasting rhizomes, which are the main medicinal corridor. An alcoholic extract of *Picrorrhiza kurroa* was set up to lower blood glucose in rudimentary conditions and after a heavy glucose weight in normal rats. Maximum reduction in serum glucose was observed after 2 h at a cure position of 75 mg extract/ kg of body weight. *P. kurroa* extract was also set up to reduce the increase of blood sugar in alloxan- induced diabetic rats (43 at 75 mg/ kg body weight and 60 at 150 mg/ kg body weight) [3].
- **Aloe Vera (*Aloe Barbadensis Miller*):** Aloe vera geland extracts have been investigated for their anti-diabetic properties. Some studies suggest that the aloe vera may improve blood glucose levels and lipid profiles [4].

Detailed Overview of Selected Medicinal Plants

***Withania coagulans*:** belongs to the family Solanaceae is one of the important ayurvedic medicinal shops generally known as vegetable rennet, Indian cheesemaker, Indian rennet, Paneer ke phool, Paneer band or Paneer dodiis extensively used over 3,000 times in India. *Withania coagulans* (Indian Rennet), covering its botanical identity, phytochemistry, pharmacological parcels, traditional uses, and remedial eventuality, especially in the environment of antidiabetic exertion *Withania coagulans* is a potent medicinal condiment with scientifically proven antidiabetic goods. Its multi-targeted mechanisms, including enzyme inhibition, antioxidant defense, and insulin sensitization, make it a promising natural remedy for diabetes and its complications. Its integration into polyherbal phrasings could offer an effective and safer volition to synthetic antidiabetic medicines [5].



Figure 1: *Withania coagulans*



- **Botanical Name:** *Withania coagulans* Dunal
- **Common Names:** Indian Rennet, Paneer Doda, Rishyagandha
- **Family:** Solanaceae
- **Parts Used:** Dried fruits and leaves
- **Phytochemical Constituents** *Withania coagulans* is rich in a diverse range of bioactive phytochemicals, including: Withanolides (steroidal lactones) – responsible for many of its therapeutic effects Flavonoids Phenolic compounds Tannins Alkaloids Saponins Glycosides Steroids These constituents contribute to its antioxidant, antidiabetic, anti-inflammatory, and hepatoprotective effects.
- **Pharmacological Activities**
 - O Antidiabetic Activity Hypoglycemic effect: Reduces elevated blood glucose levels in diabetic models. Enhances insulin sensitivity: Supports better glucose uptake by cells. Inhibits carbohydrate digestion enzymes: Demonstrated α -amylase and α -glucosidase inhibition, which slows the breakdown and absorption of carbohydrates. Protects pancreatic β -cells: Due to its antioxidant properties, it helps preserve insulin-producing cells in the pancreas.
 - O Antioxidant Activity Scavenges free radicals and reduces oxidative stress, a major contributor to diabetes and other chronic conditions.
 - O Anti-inflammatory Properties Reduces inflammation, which is linked to metabolic disorders and complications in diabetes.
 - O Hepatoprotective Activity Improves liver function, which is critical for glucose metabolism and detoxification.
- **Traditional Uses** (Ayurveda & Folk Medicine) Used in Ayurvedic medicine for managing diabetes, inflammation, and liver disorders. The fruit is soaked in water overnight and the infusion is consumed by diabetics. Also used for wound healing, asthma, and urinary disorders [5.6].

***Picrorhiza kurroa* (Kutki)**



Figure 2: *Picrorhiza kurroa* (Kutki)

- **Name** *Picrorhiza kurroa*
- **Antonyms & Common Names** Kutki, Katuki, Katuka Rohini
- **Family** Plantaginaceae (formerly classified under Scrophulariaceae)
- **Used Parts** Rhizomes and roots
- **Botanical Overview** *Picrorhiza kurroa* is a hardy, low- growing imperishable condiment indigenous to the Himalayan belt, flourishing at elevations ranging from 3,000 to 5,000 measures. It's well- acclimated to alpine climates with cool temperatures and high moisture. The factory is honored for its characteristically bitter rhizomes, which are deified in traditional drug systems for their potent remedial parcels.
- **Phytochemical Profile** The medicinal efficacy of *P. kurroa* stems from a different array of phytoconstituents, specially Iridoid glycosides – Kutkin (a synergistic mix of picroside I and II) serve as the top bioactive with strong antidiabetic action. Apocynin – shows anti-inflammatory and free radical scavenging goods. Flavonoids & Phenolics – Offer antioxidant and cellular defensive benefits. Cucurbitacins – Possess immunomodulatory and hepatoprotective traits. Androsin & Vanillic acid – Contribute to antimicrobial and metabolic nonsupervisory goods. These composites serve inclusively to deliver a broad diapason of pharmacological goods.



• Crucial Pharmacological conduct

O Antidiabetic parcels improvement of Insulin Responsiveness Activates the PI3K/ Akt signaling waterfall, promoting glucose uptake in adipose apkins. Inhibition of Carbohydrate Hydrolyzing Enzymes Suppresses α -amylase and α -glucosidase exertion, leading to delayed intestinal glucose immersion. Bettered Metabolic effectiveness Facilitates better glucose application and promotes systemic metabolic harmony. Liver Function Support Offers hepatoprotective goods pivotal for glucose homeostasis in diabetic cases.

O Liver-Defensive goods Traditionally employed in Ayurveda for the treatment of hepatic diseases similar as hostility, hepatitis, and hepatic steatosis (adipose liver). Acts as a natural detoxifier by enhancing hepatic enzyme function and promoting corrosiveness stashing — essential for metabolic stability, particularly in diabetic individualities.

O Antioxidant & Anti-inflammatory goods Shields pancreatic β - cells from oxidative stress, thereby supporting endogenous insulin product. Attenuates pro-inflammatory cytokine release, reducing insulin resistance and associated metabolic complications [7].

Gymnema sylvestre – The Gold Standard in Natural Diabetes Management



Figure 3: *Gymnema sylvestre*

• **Botanical Name:** *Gymnema sylvestre* R. Br.

• **Common Names:** Gurmar, Madhunashini (Sanskrit: “Sugar Destroyer”), Cow plant

• **Family:** Apocynaceae

• **Plant Parts Used:** Primarily leaves; also stems and roots

• **Botanical Overview** *Gymnema sylvestre* is a perennial, woody climber indigenous to the tropical forests of India and Southeast Asia. Aptly named Gurmar—“the destroyer of sugar”—this plant has been a cornerstone of Ayurvedic medicine for centuries due to its profound ability to suppress sugar perception and regulate blood glucose levels.

• **Phytochemical Composition** The therapeutic potential of *Gymnema sylvestre* lies in its diverse and potent array of phytoconstituents:

O Gymnemic acids – Competitive inhibitors of sugar absorption in the intestine

O Gurmarin – Peptide that temporarily desensitizes taste buds to sweetness

O Saponins

O Flavonoids

O Tannins

O Glycosides

O Alkaloids

O Phenolic compounds

These compounds exhibit synergistic effects, enhancing the herb’s ability to modulate glucose metabolism and insulin dynamics.



• Pharmacological Significance

O Anti-Diabetic Action Taste Suppression: Gymnemic acids mimic glucose molecules, occupying taste receptors and inhibiting sweet sensation—helping to control sugar cravings. Sugar Absorption Blockade: These acids also bind to intestinal receptors, thereby inhibiting glucose uptake into the bloodstream. Insulin Secretion & Pancreatic Support: Promotes the regeneration of β -cells, improving endogenous insulin production and release. Improves Insulin Sensitivity: Facilitates cellular glucose uptake, reducing insulin resistance—key in Type 2 diabetes.

O Antioxidant & Anti-inflammatory Properties Protects pancreatic tissue from oxidative stress. Suppresses pro-inflammatory markers linked to metabolic dysfunction. Slows progression of diabetic complications by enhancing redox balance.

• Traditional Applications in Ayurveda, *Gymnema sylvestre* has been employed for over two millennia in the management of Madhumeha (diabetes mellitus).

Other traditional uses include: Obesity control Hyperlipidemia (high cholesterol) Indigestion and metabolic fatigue Anti-inflammatory therapy Typically consumed as powdered leaf, decoction, or in capsule form, it remains a key component in many polyherbal formulations used in integrative diabetes care [8].

Methodology of Literature Collection

This review was conducted using a systematic search of online databases including PubMed, ScienceDirect, Scopus, and Google Scholar. Keywords such as 'anti-diabetic plants', '*Withania coagulans* diabetes', '*Picrorhiza kurroa* phytochemistry', and '*Gymnema sylvestre* hypoglycemic effect' were used. Studies published between 2010 and 2024 were considered. Only peer-reviewed articles, original research, and relevant reviews were included [9].

Phytochemical Composition of Selected Plants

Withania coagulans contain steroidal lactones (withanolides), alkaloids, flavonoids, and phenolic compounds. These constituents contribute to its antioxidant and anti-diabetic activities.

Picrorhiza kurroa is rich in iridoid glycosides (picroside I, picroside II), cucurbitacins, apocynin, androsin, and phenolic compounds. These phytochemicals have hepatoprotective and anti-hyperglycemic properties [10].

Anti-diabetic Mechanisms of Action

These plants exhibit anti-diabetic activity through multiple mechanisms:

- Enhancing insulin secretion from pancreatic β -cells
- Increasing peripheral glucose uptake
- Reducing glucose absorption in the intestines
- Modulating enzymes involved in carbohydrate metabolism
- Exhibiting antioxidant properties to reduce oxidative stress associated with diabetes [11].

Comparative Evaluation of Extracts

Withania coagulans and *Gymnema sylvestre* have been widely studied in diabetic models and have shown significant reductions in fasting blood glucose and HbA1c levels. *Picrorhiza kurroa* has demonstrated moderate anti-diabetic effects, with a focus on its hepatoprotective role. Comparative studies indicate *Gymnema sylvestre* to be the most potent, followed by *Withania coagulans*. However, all three plants exhibit complementary effects and could be used in combination therapies [12].

Numerous in vivo studies have reported the efficacy of these plants in streptozotocin-induced diabetic rats. Clinical trials with *Gymnema sylvestre* have shown notable improvement in blood glucose control in type 2 diabetes patients. *Withania coagulans* have been shown to regenerate pancreatic islets and improve insulin sensitivity. *Picrorhiza kurroa* improves liver function and may aid in glucose metabolism indirectly [13].

2. Scope of Herbal Anti-Diabetic Research**• Alternative Therapeutic Option:**

Herbal medicines such as *Withania coagulans*, *Picrorhiza kurroa*, and *Gymnema sylvestre* offer promising natural alternatives to synthetic drugs with fewer side effects.



• Multi-Target Action:

These plants act on multiple pathways—insulin secretion, insulin sensitization, glucose absorption, and oxidative stress reduction—offering a holistic approach to diabetes management.

• Drug Development Potential:

Phytochemicals like withanolides, picrosides, and gymnemic acids can serve as leads for new drug discovery and formulation of standardized herbal products.

• Nutraceutical and Functional Food Development:

These herbs have potential for incorporation into nutraceuticals, teas, dietary supplements, and functional foods for diabetic individuals.

• Integration into Integrative Medicine:

Growing acceptance of integrative and complementary medicine systems worldwide opens avenues for these botanicals to be used alongside modern anti-diabetic therapies.

3. Challenges in Herbal Anti-Diabetic Research**• Insufficient Clinical Trials:**

Although preclinical studies are promising, high-quality, randomized clinical trials in humans are still limited for these herbs.

• Safety and Toxicity Issues:

Long-term safety data is lacking for many herbal extracts, especially in combination with conventional drugs.

• Regulatory Barriers:

Herbal products often lack clear regulatory guidelines for approval, quality control, and labeling, making global commercialization difficult.

Drug-Herb Interactions:

Limited understanding of interactions with allopathic medications poses a risk for patients using herbal and synthetic drugs together.

• Scientific Skepticism and Acceptance:

Despite centuries of use, some researchers and clinicians remain skeptical about the efficacy of plant-based treatments due to lack of mechanistic clarity.

4. Discussion

The current review confirms that *Withania coagulans*, *Picrorhiza kurroa*, and *Gymnema sylvestre* possess significant anti-diabetic properties supported by both traditional usage and scientific evidence. The phytochemical diversity and multi-targeted mechanisms offer a holistic approach to diabetes management. However, standardized extracts, dose optimization, and large-scale clinical trials are needed to validate their efficacy and safety. The study focused on the extraction of *Withania coagulans*, *Picrorhiza kurroa*, and *Gymnema sylvestre* for an antidiabetic effect, including improved blood sugar control, improved insulin sensitivity, lower levels of harmful cholesterol, improved lipid profiles, and a reduced risk of developing diabetes-related complications. Additionally, some research suggests that these compounds may help to reduce inflammation, reduce oxidative stress, improve cognitive functioning, and protect against hepato-toxicity.

5. Conclusion

Herbal remedies, particularly those derived from *Withania coagulans*, *Picrorhiza kurroa*, and *Gymnema sylvestre*, represent promising candidates for alternative diabetes therapy. Their rich phytochemical profile, demonstrated efficacy, and minimal side effects make them suitable for integration into modern medicine. Continued research is essential to develop standardized herbal formulations and explore synergistic combinations. This study highlights the potential health benefits of *Withania coagulans*, *Picrorhiza kurroa*, and *Gymnema sylvestre*, particularly in managing diabetes and improving overall well-being. The extracts demonstrated promising antidiabetic properties, including improved blood sugar control, enhanced insulin sensitivity, and better lipid profiles, which may contribute



to reducing the risk of diabetes-related complications. Additionally, the presence of bioactive compounds in these plants suggests their potential to reduce inflammation, oxidative stress, and hepatotoxicity, while also supporting cardiovascular health, immune function, and cognitive performance.

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