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A REVIEW ON ANTIDIABETIC HERBAL DRUGS

Amrapali S. Borde[1*], Dr. G. R. Sitaphale[2], *Dr.* P. R. Tathe[3]

[1*] M. Pharm Student, *Department of Pharmacognosy, Samarth* College of pharmacy**,** Deulgaon Raja, Buldana

[2]Professor, *Department of Pharmacognosy, Samarth* College of pharmacy, Deulgaon Raja, Buldana

[3]Professor, Department of Pharmacology, *Samarth* College of pharmacy, Deulgaon Raja, Buldana

***Abstract*:**

Diabetes mellitus is a widespread metabolic disorder affecting millions globally, with a significant prevalence in India, particularly in urban areas. Despite advancements in conventional therapies, the use of herbal medicines remains a preferred approach due to their affordability, minimal side effects, and therapeutic potential. Traditional medicinal plants have played a crucial role in diabetes management, offering bioactive compounds with proven antidiabetic properties. This review highlights various Indian herbal drugs and medicinal plants commonly used in diabetes treatment. A comprehensive list of plants with demonstrated antidiabetic effects is compiled, including Allium sativum, Eugenia jambolana, Momordica charantia, Ocimum sanctum, Phyllanthus amarus, Pterocarpus marsupium, Tinospora cordifolia, C. indica, Helicteres isora, Stevia rebaudiana, Gymnema sylvestre, and Enicostemma littorale Blume. The pharmacological actions, mechanisms, and potential benefits of these herbal formulations in diabetes management are discussed, emphasizing their role as complementary and alternative therapies.

Keywords: Medicinal plants, Antidiabetic drugs, Herbal medicine, Diabetes, Phytotherapy.

I. INTRODUCTION

Herbal medicine, also known as botanical medicine or phytomedicine, involves the therapeutic use of plant-derived substances, including seeds, berries, roots, leaves, bark, and flowers. Traditionally practiced outside conventional medicine, herbalism is gaining mainstream acceptance as modern research validates its efficacy in disease treatment and prevention (Ang-Lee & Moss, 2000). In recent years, there has been exponential growth in the field of herbal medicine, with increasing global recognition due to its natural origin and minimal side effects. Traditional medicinal systems incorporate plant-based formulations, minerals, and organic compounds, many of which have been used for over a millennium. In Indian traditional medicine, several plants classified as Rasayana are integral to healthcare practices, often formulated and dispensed by practitioners based on indigenous knowledge. The World Health Organization (WHO) has documented approximately 21,000 plant species used for medicinal purposes worldwide, with India contributing around 2,500 species, 150 of which are commercially significant. Recognized as the "Botanical Garden of the World," India is the largest producer of medicinal herbs.This review focuses on herbal drug preparations and medicinal plants employed in the management of diabetes mellitus—a prevalent metabolic disorder causing significant health and economic burdens globally (Barrett et al., 1999). By exploring the potential of herbal medicines in diabetes treatment, this study aims to highlight their therapeutic benefits and role as alternative or complementary treatments.

1.1. How Do Herbs Work?

For most medicinal herbs, the specific active ingredient responsible for their therapeutic effects remains unidentified. Whole herbs contain multiple bioactive compounds that likely work synergistically to produce the desired medicinal effects (Patel et al., 2012). Various environmental factors, such as climate, soil quality, and exposure to pests, influence the chemical composition of these plants. Additionally, the timing of harvest, processing methods, and storage conditions can significantly impact their efficacy.

1.2. How Are Herbs Used?

Due to the complex interactions among plant constituents, herbalists prefer using whole plants rather than isolating single components. Whole-plant extracts contain multiple active compounds that not only enhance therapeutic effects but also reduce the risk of side effects associated with any single ingredient. Additionally, multiple herbs are often combined in formulations to maximize efficacy through synergistic interactions while minimizing toxicity (D'Epiro, 1999). Herbalists consider several factors when prescribing herbal treatments, including plant species and variety, habitat, harvesting and storage methods, processing techniques, and potential contamination risks (Fugh-Berman, 2000). These variables contribute to the overall effectiveness and safety of herbal remedies, reinforcing the importance of proper selection and preparation in traditional and modern herbal medicine.

1.3. What Is Herbal Medicine Good For?

Herbal medicine is used to treat a wide range of health conditions, including asthma, eczema, premenstrual syndrome, rheumatoid arthritis, migraines, menopausal symptoms, chronic fatigue, and irritable bowel syndrome. While herbal preparations can offer therapeutic benefits, they should be used under the guidance of a trained professional. Consulting a doctor or a qualified herbalist is essential before self-treatment to avoid potential risks and interactions.

1.4. Several commonly used herbs and their therapeutic effects include:

- **Ginkgo (Ginkgo biloba)** – A standardized extract known as EGb 761 has shown promising results in improving awareness, judgment, and social function in individuals with Alzheimer's disease and dementia. A year-long study involving 309 participants demonstrated that those taking EGb 761 showed consistent improvement, while the placebo group experienced cognitive decline.
- **Kava Kava (Piper methysticum)** – Traditionally used to manage anxiety, kava has gained popularity for its calming effects. However, reports of liver toxicity have led to regulatory warnings. The U.S. FDA has issued caution regarding its use, and countries such as Germany and Canada have banned it from the market.
- **St. John's Wort (Hypericum perforatum)** – Known for its antidepressant properties, St. John's Wort has been extensively studied. An analysis of 27 studies involving over 2,000 participants confirmed its effectiveness in treating mild to moderate depression.
- **Valerian (Valeriana officinalis)** – Traditionally used as a natural sleep aid, valerian promotes relaxation and improves sleep quality without causing a hangover effect the next day.
- **Echinacea (Echinacea purpurea and related species)** – Commonly used to boost immunity, echinacea has been shown to reduce the frequency and severity of cold symptoms. In a study of 160 volunteers with flu-like symptoms, echinacea extract demonstrated immune-enhancing properties.

II. THE FUTURE OF HERBAL MEDICINE

Herbal medicine is experiencing a resurgence in popularity, particularly in the United States, where increasing scientific research supports its therapeutic potential. However, regulatory challenges remain. The U.S. Food and Drug Administration (FDA) classifies herbs as dietary supplements, restricting manufacturers from making claims about their ability to treat or prevent specific diseases. This regulatory approach limits the integration of herbal medicine into mainstream healthcare. In contrast, several European countries classify herbal medicines as drugs, subjecting them to rigorous evaluation and regulation. The German Commission E, a specialized medical panel, conducts extensive research on the safety and efficacy of medicinal herbs, ensuring quality control and evidence-based use (Fugh-Berman, 2000). As global interest in natural and holistic treatments grows, the future of herbal medicine will likely involve increased scientific validation, improved standardization, and greater regulatory oversight. Advancements in pharmacognosy, biotechnology, and integrative medicine may enhance the credibility and acceptance of herbal therapies, bridging the gap between traditional remedies and modern healthcare.

III. DIABETES MELLITUS

Diabetes mellitus is a metabolic disorder characterized by abnormally high blood glucose levels (hyperglycemia) due to a combination of genetic and environmental factors. Blood glucose levels are regulated by a complex interplay of multiple chemicals and hormones, particularly insulin, which is produced by the beta cells of the pancreas. Diabetes mellitus encompasses a group of diseases that result from defects in either insulin secretion or insulin action (Tierney et al., 2002).

The condition primarily manifests in two forms:

- **Type 1 Diabetes** – Caused by an autoimmune destruction of pancreatic beta cells, leading to diminished insulin production.
- **Type 2 Diabetes** – Associated with insulin resistance, where the body's cells do not respond effectively to insulin.

Both types result in hyperglycemia, which contributes to acute symptoms such as excessive urination (polyuria), increased thirst (polydipsia), blurred vision, unexplained weight loss, lethargy, and altered energy metabolism. Additionally, monogenic forms like Maturity Onset Diabetes of the Young (MODY) account for 1-5% of all cases.The term diabetes, without qualification, typically refers to diabetes mellitus, which is associated with excessive sugar in the urine (glycosuria). However, a rarer form known as diabetes insipidus exists, where urine lacks sweetness (insipidus meaning "without taste" in Latin). This condition results from kidney (nephrogenic DI) or pituitary gland (central DI) dysfunction.

3.1. Classification of Diabetes Mellitus

Diabetes mellitus is broadly categorized into:

- **Type 1 Diabetes** – Previously referred to as childhood-onset diabetes, juvenile diabetes, or insulin-dependent diabetes mellitus (IDDM).
- **Type 2 Diabetes** – Previously known as adult-onset diabetes, obesity-related diabetes, or non-insulin-dependent diabetes mellitus (NIDDM).
- **Other Forms:**
    - **Gestational Diabetes** – Diabetes occurring during pregnancy.
    - **Latent Autoimmune Diabetes in Adults (LADA)** – Sometimes referred to as Type 1.5 Diabetes.
    - **Maturity Onset Diabetes of the Young (MODY)** – A monogenic form of diabetes that appears before 30 years of age and has a strong genetic component (Ailloux, 2007).

IV. AYURVEDIC HERBS IN THE TREATMENT OF DIABETES MELLITUS

In Ayurveda, diabetes mellitus is referred to as Madhu-meha and has been treated with herbal and mineral formulations for centuries. Ayurvedic treatment focuses on balancing bodily functions using natural remedies, including medicinal plants with proven antidiabetic properties. Several herbs have been extensively studied for their efficacy in controlling blood glucose levels.

4.1. Some commonly used Ayurvedic antidiabetic herbs include:

- **Momordica charantia** (Bitter melon) – Enhances insulin secretion and improves glucose utilization.
- **Gymnema sylvestre** (Gurmar) – Known as the "sugar destroyer," it reduces sugar absorption and enhances insulin function.
- **Enicostemma littorale** – Exhibits blood sugar-lowering properties.
- **Pterocarpus marsupium** (Indian kino tree) – Protects pancreatic beta cells and regulates blood sugar levels.
- **Salacia reticulata** – Inhibits carbohydrate absorption, reducing postprandial glucose spikes.
- **Coccinia grandis** (Ivy gourd) – Mimics insulin action and helps control diabetes.
- **Trigonella foenum-graecum** (Fenugreek) – Contains soluble fiber that slows glucose absorption and enhances insulin sensitivity.

These herbs are often prescribed individually or in combination (polyherbal formulations) to maximize therapeutic benefits. Scientific studies have validated the chemical composition and antidiabetic potential of these medicinal plants, supporting their role in diabetes management (Sadhu, 2005).Herbal medicine, especially Ayurvedic formulations, continues to play a significant role in diabetes treatment due to their natural origin, minimal side effects, and cost-effectiveness. Ongoing research aims to further understand the mechanisms and optimize the use of these traditional remedies in modern healthcare.

Medicinal Plants with Antidiabetic Potential

4.1. Aegle marmelos Corr. ex Roxb. (Bilva)

Family: **Rutaceae**

Common Name: **Wood Apple**

Parts Used: **Fruit & Leaves**

Geographical Source: **India**

Chemical Constituents:

- Tannins
- Active principle: Marmelosin
- Alkaloids: Aegelin & Aegelinin
- Coumarin: Marmesin

Pharmacological Studies:

Das, Padayatil, and Paulose (1996) studied the hypoglycemic activity of the leaf extract of Aegle marmelos in streptozotocin-induced diabetic rats. The extract significantly reversed altered metabolic parameters in the experimental group, suggesting a potential role in pancreatic repair (Das et al., 1996).

4.2. Allium sativum (Garlic / Lahsun)

Family: **Liliaceae**

Synonyms: **Lasan (Gujarati), Lasun (Hindi), Lashuna (Sanskrit)**

Parts Used: **Ripe Bulbs**

Geographical Source: **Central Asia, Southern Europe, USA, India**

Chemical Constituents:

- Sulfur compounds (notably Allicin, derived enzymatically from Alliin)
- 65% water, 28% carbohydrate, 2.3% organosulfur compounds
- 2% proteins, 1.2% free amino acids (mainly arginine)
- 1.5% fiber, 0.15% lipids, 0.08% phytic acid, 0.07% saponins (Rangari, 2007)

Pharmacological Studies:

S-allyl cysteine sulfoxide (SACS), a precursor of Allicin and garlic oil, has shown superior control over lipid peroxidation compared to glibenclamide and insulin. SACS also stimulated in vitro insulin secretion from beta cells isolated from normal rats. Additionally, Allium sativum exhibits antimicrobial, anticancer, and cardioprotective activities (Patel et al., 2012).

4.3. Andrographis paniculata Nees (Kalmegh)

Family: Acanthaceae

Common Name: Kalmegh

Parts Used: Whole Plant

Geographical Source: India

Chemical Constituents:

- Diterpene lactones: Andrographolide, Kalmegh, Neoandrographolide

Pharmacological Studies:

Ahmad and Asmawi (1992) reported the hypoglycemic activity of Andrographis paniculata. A significant reduction in blood glucose levels was observed in glucose tolerance tests compared to untreated controls. The study suggests that A. paniculata inhibits glucose absorption in the intestine (Ghosh et al., 1990).

4.4. Asphaltum punjabianum (Shilajit)

Common Name: Black Bitumen / Mineral Pitch

Chemical Constituents:

- Fulvic Acid
- Hippuric Acid

Pharmacological Studies:

Trivedi, Saxena, Mazumdar, Bhatt, and Hemavathi (2001) studied the effects of Asphaltum punjabianum on blood glucose, lipid profiles, and vascular function in alloxan-induced diabetic rats. Diabetes was induced using alloxan (125 mg/kg, i.p.), and three different doses of A. punjabianum (50, 100, and 200 mg/kg, p.o.) were tested. Results showed a dose-dependent reduction in blood glucose, cholesterol, and triglycerides. The extract also prevented diabetes-induced vascular dysfunction (Trivedi et al., 2001).

4.5. Azadirachta indica (Neem)

Family: Meliaceae

Common Names: Limdo (Gujarati), Neem (Hindi)

Parts Used: Whole Plant

Chemical Constituents:

- **Seed Oil:** Nimbidin (major bitter principle), Nimbin, Nimbinin, Nimbidinin
- **Active Compounds:** Nimbolide, Nimbilic Acid, Gedunin, Mahmoodin, Azadirachtin
- **Other Components:** Tannins (Gallic Acid), Margolonon, Polysaccharides

Pharmacological Properties:

- Antidiabetic
- Anti-inflammatory
- Antipyretic
- Antifungal

- Antibacterial
- Antimalarial
- Antitumor
- Immunomodulatory
- Diuretic
- Spermicidal

Pharmacological Studies:

Research from the University of Madras in the early 1990s found that high doses (40 g of dried herb daily) of Azadirachta indica extracts might help regenerate pancreatic beta cells, which are responsible for insulin production. This suggests that neem could partially reduce diabetics' need for insulin and other medications. studies indicate that A. indica does not stimulate excess insulin production in non-diabetic animals.

4.6. Caesalpinia bonducella F. (Karanja)

Family: Leguminosae

Parts Used: Seeds, leaves, and oil expressed from the kernel of seeds.

Geographical Source: Found in tropical regions of Asia and Africa.

Common Name: Nicker tree.

Chemistry: Bitter principle (bonducin).

Pharmacological Study:

Biswas and colleagues (1997) studied the hypoglycemic activity of an aqueous extract of Caesalpinia bonducella. The extract was tested on fasted, fed, glucose-loaded, and streptozotocin-induced diabetic rats. The administered dose was 250 mg/kg of rat body weight. The study found the extract effective in glucose-loaded, streptozotocin-induced, and alloxan-induced diabetic rats. The authors suggested that the drug could be considered a good oral hypoglycemic agent (Biswas, 1997).

4.7. Coccinia indica

Family: Cucurbitaceae

Parts Used: Leaves

Pharmacological Study: Antia B.S. et al. (1999) studied the effects of dried extracts of Coccinia indica (C. indica) administered at 500 mg/kg body weight to diabetic patients for six weeks. These extracts restored the activities of lipoprotein lipase (LPL), which had been reduced, and also regulated glucose-6-phosphatase and lactate dehydrogenase levels, which were elevated in untreated diabetics. Oral administration of 500 mg/kg of C. indica leaves showed significant hypoglycemia in alloxan-induced diabetic dogs and improved glucose tolerance in normal and diabetic dogs (Antia, 1999).

4.8. Curcuma longa (Turmeric)

Family: Zingiberaceae (Ginger Family)

Chemistry: Contains curcumin, turmeric extract, food color E100, diferuloylmethane, and 1,7-Bis(4-hydroxy-3-methoxyphenyl)-1,6-heptadiene-3,5-dione.

Chemical Formula: $C_{21}H_{20}O_6$

Clinical Study:

These statements have not been evaluated by the FDA. These products are not intended to diagnose, treat, cure, or prevent any disease. Pregnant or lactating women, diabetics, hypoglycemics, and individuals with known medical conditions or taking medications should consult a licensed physician or pharmacist before using dietary supplements (Subbaraj, 1995).

4.9. Enicostemma littorale Blume (Majmakbooti)

Family: Gentianaceae

Parts Used: Whole plant

Geographical Source: Found throughout India, up to an altitude of 1500 ft.

Chemistry: Contains a bitter principle (swertiamarine), two alkaloids (one identified as gentianine, the other not confirmed), ophelic acid, and tannins.

Pharmacological Study:

Maroo et al. (2003) studied the hypoglycemic and antioxidant activity of a methanol extract of Enicostemma littorale. Administration of the extract (2.5 g/kg body weight/day) to diabetic rats for 20 days reduced blood glucose levels from 466.5 ± 37.07 mg/dL to 237.20 ± 28.22 mg/dL. The extract not only increased serum insulin levels but also improved the antioxidant status of the rats (Maroo, 2003).

4.10. Gymnema sylvestre R. Br. (Gurmar Booti)

Family: Asclepiadaceae

Chemistry:

- **Dried Leaves:** Contains resin, pararabin, triterpene glycoside (gymnemic acid 6%), peptide (gurmarin), alkaloids (gymnamine), bitter principles with sialagogue activity, lupenol, quercitol, coloring matter, and anthraquinones.
- **Bark:** Contains calcium and starch.
- **Alcoholic Extract:** Contains saponins.
- **Ash:** Contains alkali, phosphoric acid, and manganese.

Use as Herbal Medicine:

The active ingredient, gymnemic acid, has a structure similar to sucrose. Extracts of Gymnema sylvestre are claimed to reduce sugar cravings and have been used for treating hyperglycemia, obesity, high cholesterol levels, anemia, and digestive issues. According to Sushruta Samhita (Ayurveda), it helps treat Madhumeha (glycosuria) (Hishali et al., 2002).

Pharmacological Study:

Shanmugasundaram et al. (1991) tested the hypoglycemic activity of a water-soluble acidic fraction of Gymnema sylvestre leaves in streptozotocin-induced diabetic rats. The study concluded that G. sylvestre increases insulin levels, though the exact mechanism remains unclear. Gymnemic acid is identified as one of its active constituents (Shanmugasundaram, 1990).

4.11. Helicteres isora

Family: Sterculiaceae

Parts Used: Roots

Chemistry: In traditional medicine, the root juice is claimed to be useful in diabetes, empyema, and as a favorite cure for snakebite. From the roots, betulic acid, daucosterol, sitosterol, and isorin were isolated. Cucurbitacin B and isocucurbitacin B were also isolated and reported to possess cytotoxic activity. This study aims to verify these claims and evaluate the anti-diabetic property of Helicteres isora roots.

Pharmacological Study: The different extracts of H. isora roots were tested for anti-diabetic activity using a glucose tolerance test in normal rats and alloxan-induced diabetic rats. Aqueous ethanol and butanol extracts significantly reduced blood glucose levels in the glucose tolerance test. In alloxan-induced diabetic rats, the maximum reduction in blood glucose was observed after 3 hours at a dose of 250 mg/kg body weight. The percentage protections by aqueous ethanol and butanol extracts were 30% and 48%, respectively. In long-term treatment of alloxan-induced diabetic rats, blood glucose, triglycerides, cholesterol, and urea levels were measured on days 0, 3, 5, 7, and 10. Both extracts showed significant anti-diabetic activity comparable to glibenclamide. Histopathological studies showed amelioration of biochemical damages caused by alloxan, indicating significant anti-diabetic activity of Helicteres isora roots. (Venkatesh et al., 2007)

4.12. Jambul (Syzygium cumini)

Family: Myrtaceae

Pharmacological Study: The hypoglycemic activity of different parts of Syzygium cumini seeds, including the whole seed, kernel, and seed coat, was evaluated in streptozotocin-induced diabetic rats. Administration of ethanolic extract of the kernel at 100 mg/kg body weight significantly decreased blood glucose, blood urea, and cholesterol levels, improved glucose tolerance, increased total protein and liver glycogen levels, and reduced glutamate oxaloacetate transaminase and glutamate pyruvate transaminase activities in diabetic rats. Whole seed exhibited a moderate hypoglycemic effect, while the seed coat showed no hypoglycemic activity. The hypoglycemic efficacy was compared with glibenclamide, a standard hypoglycemic drug. (Ravi et al., 2004)

4.13. Momordica charantia (Bitter melon/Karvellaka)

Family: Cucurbitaceae

Pharmacological Study: Ahmed et al. (1999) studied the mechanism of action of Momordica charantia juice in diabetic rats. Diabetes was induced by a single injection of streptozotocin (60 mg/kg body weight). One week after injection, treated animals were fed M. charantia juice (10 ml/kg) daily for three weeks. The juice significantly improved glucose uptake and modulated insulin-induced glucose uptake. (Ahmed, 1999)

4.14. Musa paradisiaca (Banana)

Common Name: Banana, Pisang

Family: Musaceae

Parts Used: Seed, Fruit

Chemistry: Musa paradisiaca is a rich source of carbohydrates and contains vitamins and minerals. Unripe fruit contains starch (amylose-20.5%) and proteins such as albumin, globulin, glutelin, and prolamine. It also contains free amino acids (e.g., glutamic acid, gamma-aminobutyric acid) and essential minerals such as calcium, iron, potassium, magnesium, sodium, and phosphorus. The fruit is also a source of vitamins including carotene, niacin, ascorbic acid, riboflavin, folic acid, biotin, pyridoxine, and inositol.

Pharmacological Study: Diabetes mellitus is a debilitating hormonal disorder requiring strict glycemic control. This study evaluated the hypoglycemic effect of methanolic extract of mature green Musa paradisiaca fruits (MEMP) in normoglycemic and streptozotocin (STZ)-induced hyperglycemic mice, using chlorpropamide as a reference anti-diabetic agent. MEMP (100-800 mg/kg, p.o.) induced significant, dose-related reductions ($p < 0.05$-0.001) in blood glucose concentrations in both normal and diabetic mice. Chlorpropamide (250 mg/kg, p.o.) also significantly reduced blood glucose concentrations ($p < 0.01$-0.001). The findings indicate that MEMP possesses hypoglycemic activity, potentially due to stimulation of insulin production and glucose utilization. This supports the traditional use of Musa paradisiaca in managing type 2 diabetes among Yoruba-speaking people in Southwestern Nigeria. (Chhanda, 2006)

4.15. Ocimum sanctum Linn. (Tulsi)

Family: Labiatae

Chemistry: Contains volatile oils (eugenol and caryophyllene), triterpenoids (rosmarinic acid and ursolic acid), flavonoids, and saponins.

Clinical Study: Agraval, Rai, and Singh (1996) conducted a randomized, placebo-controlled, single-blind, crossover trial to study the effects of Ocimum sanctum (dried leaf, 2.5g daily) on fasting and postprandial blood glucose and serum cholesterol levels in patients with non-insulin-dependent diabetes mellitus. The study included 40 patients—20 receiving oral hypoglycemic drugs and 20 newly diagnosed without prior anti-diabetic drug use. Results showed a significant decrease in fasting and postprandial blood glucose levels compared to placebo, with a mild reduction in total cholesterol levels. The hypoglycemic mechanism remains unknown.

4.15. Phyllanthus niruri

Family: Euphorbiaceae

Chemistry: Contains alkaloids, astragalin, brevifolin, carboxylic acids, corilagin, cymene, ellagic acid, ellagitannins, gallocatechins, geraniin, hypophyllanthin, lignans, lintetralins, lupeols, methyl salicylate, niranthin, nirtetralin, niruretin, nirurin, nirurine, niruriside, norsecurinines, phyllanthin, phyllanthine, phyllanthenol, phyllochrysine, phyltetralin, repandusinic acids, quercetin, quercetol, quercitrin, rutin, saponins, triacontanal, and tricontanol.

Clinical Study: Chakrabarti et al. (1995) reported a significant reduction in blood sugar levels in human subjects. Studies in rabbits and rats confirmed hypoglycemic effects. Another study documented aldose reductase inhibition (ARI) properties, suggesting its role in preventing diabetic neuropathy and macular degeneration, attributed in part to ellagic acid.

4.16. Polyalthia longifolia var. Angustifolia

Family: Annonaceae

Parts Used: Bark

Chemistry: Contains alkaloids, glycosides, saponins, polyphenolic compounds, diterpenoids, and tannins.

Pharmacological Study: Andier (1990) evaluated the chloroform extract of stem bark for antidiabetic activity in alloxan-induced diabetic and euglycemic rats. A single 200 mg/kg oral dose and prolonged 100 mg/kg treatment for 10 days showed significant antihyperglycemic activity ($P<0.01$). Glibenclamide showed hypoglycemic activity, but the extract did not in euglycemic rats.

4.17. Pterocarpus marsupium

Family: Fabaceae

Chemistry: Contains pterostilbene, flavonoids (marsupin, pterosupin, and liquiritigenin), (-)-epicatechin.

Pharmacological Study: The wood extract demonstrated hypoglycemic activity in dogs due to tannates. Flavonoid fractions caused pancreatic beta-cell regranulation. (-)-Epicatechin was found to be insulinogenic, enhancing insulin release and proinsulin conversion. It also stimulated oxygen uptake in fat cells and increased glycogen content in rat diaphragm tissue. (Chakrabarti et al., 1996).

4.18. Pterocarpus santalinus L.F.

Family: Fabaceae (Papillionaceae)

Chemistry: Contains santalin, ether, alkaloids, crystalline santal, pterocarpin, homopterin, tannin, kino tannic acid, isoflavone, calocedrin, triterpenes, lignans, savinin, glucosides-savinin. (Sivaranjan, 2004).

Medicinal Importance: Ethanol extract of stem bark (0.25 g/kg body weight) showed anti-hyperglycemic activity.

4.19. Salacia reticulata and Salacia oblonga Wall (Saptachakra)

Family: Hippocrateaceae

Chemistry: Contains flavonoids (salacinol and kotalanol).

Pharmacological Study: Augusti, Joseph, and Bapu (1995) studied the hypoglycemic activity of the chloroform-eluted fraction of the petroleum ether extract of root bark, demonstrating potent hypoglycemic effects in rats compared to tolbutamide.

4.20. Saraca indica (Ashoka Bark)

Synonyms: Ashok (Hindi), Asok (Bengali)

Family: Leguminosae

Chemistry: Contains condensed tannins (6%), anthocyanin derivatives, catechol, sterol, haemotoxyline, phlobaphenes, organic calcium compound, ktosterol, phenolic and non-phenolic glycosides, (-)-epicatechin, procyanidin B2, (-)-epicatechol, anthocyanin pigments, kaempferol. (Rangari, 2007).

Uses: Treats diabetes mellitus, uterine disorders, menorrhagia, intrinsic hemorrhages, and burning sensation. Dried flowers are used in diabetes treatment.

4.21. Satureja khuzestanica

Family: Lamiaceae

Chemistry: Contains essential oils (0.5%), carvacrol, flavones, triterpenoids, and steroids.

Pharmacological Study: Sanaz Vosaugh-Ghanbari et al. (2000) investigated the effects of Satureja khuzestanica supplementation on metabolic parameters in hyperlipidemic patients with type 2 diabetes mellitus. The study reported a significant decrease in blood glucose levels and improved glucose tolerance, attributed to inhibition of intestinal glucose absorption.

4.22. Scoparia dulcis

Family: Scrophulariaceae

Chemistry: Contains flavones and terpenes. Major chemical constituents include scopadulcic acids A & B, scopadiol, scopadulciol, scopadulin, betulinic acid, acacetin, amyrin, apigenin, benzoxazolin, cirsimarin, cirsitakaoside, coixol, dulcinol, dulcionic acid, friedelin, gentisic acid, glutinol, stigmasterol, taraxerol, vicenine, and vitexin.

Pharmacological Uses: Exhibits analgesic, anti-inflammatory, antitumor, antibacterial, anticancer, cardiotonic, diuretic, hypoglycemic, hypotensive, and sedative properties.

Pharmacological Study: In 2002, Indian researchers confirmed the antidiabetic and blood sugar-lowering effects of Scoparia dulcis in rats.

4.23. Stevia rebaudiana

Family: Asteraceae

Chemistry: Steviol forms the core structure of stevia's sweet glucosides. Stevioside and rebaudioside A are formed by replacing the hydrogen atom at the bottom with glucose and the top hydrogen atom with two or three linked glucose groups, respectively.

Clinical Study: Jeppesen et al. (2004) investigated the acute effects of stevioside in type 2 diabetic patients. In a paired crossover study, 12 diabetic patients consumed a standard test meal supplemented with either 1 g of stevioside or 1 g of maize starch (control). Blood samples were collected at intervals over 240 minutes. Compared to the control, stevioside reduced the incremental area under the glucose response curve by 18% ($P = .013$) and increased the insulinogenic index by approximately 40% ($P < .001$). The results suggested that stevioside reduces postprandial blood glucose levels and may be beneficial for managing type 2 diabetes.

4.24. Tinospora cordifolia (Guduchi)

Family: Menispermaceae

Chemistry: Tinospora cordifolia contains alkaloids, diterpenoid lactones, glycosides, steroids, sesquiterpenoids, phenolics, aliphatic compounds, and polysaccharides. The leaves are rich in protein (11.2%) and have substantial calcium and phosphorus content.

Medicinal Properties: T. cordifolia has been widely used in Ayurvedic medicine for treating diabetes mellitus. It is known to cause a temporary but marked fall in blood pressure and bradycardia in anesthetized dogs.

Pharmacological Study: Oral administration of an aqueous extract of T. cordifolia root significantly reduced blood glucose and brain lipid levels in alloxan-induced diabetic rats. The aqueous extract at 400 mg/kg exhibited significant antihyperglycemic effects but was equivalent to only one unit/kg of insulin. Studies reported that daily administration of alcoholic or aqueous extracts decreased blood glucose levels and increased glucose tolerance in rodents.

- The aqueous extract (400 mg/kg) significantly reduced blood sugar levels in alloxan-induced hyperglycemia in rats and rabbits.
- However, histological examination of the pancreas showed no evidence of beta-cell regeneration in the islets of Langerhans.
- The aqueous extract also inhibited adrenaline-induced hyperglycemia.
- The ethyl acetate extract of the roots yielded a pyrrolidine derivative with hypoglycemic activity in rabbits.

- Another study showed a significant hypoglycemic effect of leaf extract in both normal and alloxan-induced diabetic rabbits, though it had no substantial impact on total lipid levels.
  (Ipahimalni et al., 2004; Gangan et al., 1996)

V. CONCLUSION:

Herbal medicines have played a significant role in diabetes management for centuries, offering potential benefits as complementary therapies. Several plant-derived compounds exhibit promising antidiabetic properties through mechanisms such as insulin sensitization, inhibition of glucose absorption, and pancreatic β-cell protection.This review highlights the efficacy of Scoparia dulcis, Stevia rebaudiana, and Tinospora cordifolia**,** each demonstrating substantial hypoglycemic effects in preclinical and clinical studies. Their bioactive constituentsflavonoids, alkaloids, terpenes, and glycosides contribute to their antidiabetic activity, influencing insulin secretion, glucose metabolism, and oxidative stress reduction. Although these herbal drugs exhibit potential benefits, their clinical applications require further validation through rigorous randomized controlled trials. Standardization of dosage, identification of active constituents, and understanding potential drug-herb interactions are crucial for integrating these natural remedies into mainstream diabetes treatment.

In conclusion, antidiabetic herbal drugs offer a promising alternative or adjunct therapy for diabetes management. Continued scientific research, pharmacological studies, and regulatory approvals are necessary to establish their safety, efficacy, and therapeutic utility in modern medicine.

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