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Herbal Tablets for the Treatment of Diabetes Mellitus: A Comprehensive Review

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Abstract: *Diabetes mellitus is a chronic metabolic disorder characterized by persistent hyperglycemia resulting from impaired insulin secretion, insulin resistance, or both. The global prevalence of diabetes has increased rapidly due to changes in lifestyle, obesity, unhealthy dietary habits, and genetic predisposition. Conventional antidiabetic drugs are effective but are often associated with adverse effects such as hypoglycemia, gastrointestinal disturbances, and long-term complications. Herbal medicines have gained considerable attention because of their natural origin, affordability, therapeutic efficacy, and fewer side effects. Herbal tablets containing medicinal plant extracts have emerged as promising alternatives and complementary therapies for diabetes management. Medicinal plants such as Gymnema sylvestre, Momordica charantia, Trigonella foenum-graecum, Azadirachta indica, Syzygium cumini, and Pterocarpus marsupium possess significant antidiabetic activity. These plants act through various mechanisms including stimulation of insulin secretion, enhancement of glucose uptake, inhibition of carbohydrate-digesting enzymes, antioxidant activity, and regeneration of pancreatic β-cells. This review discusses the pathophysiology of diabetes, herbal antidiabetic agents, formulation strategies for herbal tablets, mechanisms of action, evaluation parameters, clinical studies, advantages, limitations, and future prospects. The review highlights the importance of standardization, quality control, and scientific validation for the successful development of herbal antidiabetic tablet formulations*

Keywords: Diabetes mellitus, Herbal tablets, Antidiabetic plants, Medicinal herbs, Phytochemicals, Herbal formulations

I. INTRODUCTION

Diabetes mellitus is one of the most common endocrine disorders affecting millions of people worldwide [1]. It is characterized by elevated blood glucose levels due to inadequate insulin production or impaired insulin utilization. The disease is broadly classified into Type 1 diabetes mellitus (T1DM), Type 2 diabetes mellitus (T2DM), gestational diabetes mellitus, and secondary diabetes [2]. Among these, Type 2 diabetes accounts for nearly 90–95% of all cases globally.

The incidence of diabetes has increased dramatically because of urbanization, sedentary lifestyle, obesity, stress, and unhealthy food habits [3]. Chronic hyperglycemia is associated with severe complications including cardiovascular diseases, nephropathy, neuropathy, retinopathy, and diabetic foot ulcers. These complications significantly reduce the quality of life and increase mortality.

Conventional antidiabetic medications such as insulin, sulfonylureas, biguanides, thiazolidinediones, α-glucosidase inhibitors, and DPP-4 inhibitors are commonly used for diabetes management [4]. However, prolonged use of synthetic drugs may lead to side effects including hypoglycemia, liver toxicity, gastrointestinal disturbances, and drug resistance.

Traditional medicinal systems such as Ayurveda, Siddha, Unani, and Traditional Chinese Medicine have long utilized medicinal plants for the treatment of diabetes [5]. Herbal medicines contain biologically active compounds that exhibit antihyperglycemic, antioxidant, anti-inflammatory, and hypolipidemic activities.

Herbal tablets are solid dosage forms prepared from powdered herbs or plant extracts combined with suitable excipients. They provide advantages such as accurate dosing, improved stability, patient convenience, and enhanced

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therapeutic efficacy. The present review focuses on herbal tablets used for diabetes treatment and discusses medicinal plants, phytochemicals, mechanisms of action, formulation methods, evaluation parameters, and clinical significance.

II. DIABETES MELLITUS: OVERVIEW

Diabetes mellitus is a metabolic disorder involving abnormalities in carbohydrate, protein, and lipid metabolism [6]. Insulin is a peptide hormone produced by pancreatic β-cells that regulates glucose uptake and utilization.

In Type 1 diabetes, autoimmune destruction of pancreatic β-cells leads to absolute insulin deficiency. In Type 2 diabetes, insulin resistance develops in peripheral tissues such as liver, skeletal muscle, and adipose tissue [7].

Major symptoms of diabetes include:

- Polyuria
- Polydipsia
- Polyphagia
- Fatigue
- Weight loss
- Blurred vision
- Delayed wound healing

Persistent hyperglycemia can damage blood vessels and organs, resulting in microvascular and macrovascular complications.

III. PATHOPHYSIOLOGY OF DIABETES

The pathogenesis of diabetes involves impaired insulin secretion, insulin resistance, or both [8]. In Type 2 diabetes, insulin resistance develops initially, causing reduced glucose uptake by tissues. To compensate, pancreatic β-cells increase insulin secretion. Over time, β-cell dysfunction occurs, leading to chronic hyperglycemia.

Several biochemical pathways contribute to diabetic complications:

1. Polyol pathway activation
2. Oxidative stress
3. Protein kinase C activation
4. Formation of advanced glycation end products (AGEs)
5. Inflammatory cytokine production

Oxidative stress plays a major role in diabetes progression and complications. Herbal medicines rich in antioxidants may help reduce oxidative damage and improve glycemic control.

IV. ROLE OF HERBAL MEDICINES IN DIABETES MANAGEMENT

Medicinal plants have been used for centuries for treating metabolic disorders [9]. Herbal medicines contain phytochemicals such as flavonoids, alkaloids, glycosides, terpenoids, tannins, and saponins that possess antidiabetic properties.

Herbal antidiabetic agents act through multiple mechanisms:

- Stimulating insulin secretion
- Enhancing insulin sensitivity
- Regenerating pancreatic β-cells
- Inhibiting intestinal glucose absorption
- Improving peripheral glucose uptake
- Reducing oxidative stress
- Modulating carbohydrate metabolism enzymes

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Herbal formulations are increasingly preferred because they are considered safer and more economical than synthetic drugs.

V. ADVANTAGES OF HERBAL TABLETS

5.1 Improved Patient Compliance

Tablets are easy to administer and convenient for long-term use.

5.2 Accurate Dose Delivery

Herbal tablets provide uniform and precise dosing.

5.3 Better Stability

Compared to syrups and decoctions, tablets possess superior physical and chemical stability.

5.4 Cost-Effective Therapy

Herbal formulations are often more affordable than conventional medications.

5.5 Reduced Adverse Effects

Natural products generally produce fewer side effects when used appropriately.

5.6 Multiple Therapeutic Effects

Herbal tablets may exhibit antioxidant, anti-inflammatory, antihyperlipidemic, and cardioprotective activities in addition to antidiabetic effects.

VI. MEDICINAL PLANTS USED IN HERBAL ANTIDIABETIC TABLETS

6.1 Gymnema sylvestre

Gymnema sylvestre is commonly known as Gurmar or "sugar destroyer" [10]. It contains gymnemic acids and saponins.

Mechanism of Action

- Stimulates insulin secretion
- Regenerates pancreatic β-cells
- Reduces glucose absorption
- Suppresses sweet taste sensation

6.2 Momordica charantia

Momordica charantia (bitter melon) contains charantin, vicine, and polypeptide-p [11].

Mechanism of Action

- Exhibits insulin-like activity
- Enhances glucose utilization
- Improves insulin sensitivity
- Reduces hepatic gluconeogenesis

6.3 Trigonella foenum-graecum

Fenugreek seeds contain alkaloids, fibers, and 4-hydroxyisoleucine [12].

Mechanism of Action

- Delays carbohydrate absorption
- Enhances insulin release
- Improves glucose tolerance
- Lowers postprandial glucose

6.4 Azadirachta indica

Neem possesses antidiabetic and antioxidant activities [13].

Mechanism of Action

- Improves peripheral glucose uptake

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- Reduces oxidative stress
- Enhances insulin receptor sensitivity

6.5 Syzygium cumini

Jamun seeds contain jamboline, anthocyanins, and ellagic acid [14].

Mechanism of Action

- Delays starch conversion into glucose
- Improves insulin function
- Reduces oxidative damage

6.6 Pterocarpus marsupium

This medicinal plant contains epicatechin and pterosupin [15].

Mechanism of Action

- Regenerates β-cells
- Reduces blood glucose
- Enhances insulin secretion

6.7 Ocimum sanctum

Tulsi is widely used in Ayurvedic medicine [16].

Mechanism of Action

- Improves glucose metabolism
- Possesses antioxidant activity
- Enhances insulin secretion

6.8 Aloe vera

Aloe vera contains phytosterols and polysaccharides [17].

Mechanism of Action

- Improves insulin sensitivity
- Reduces fasting blood glucose
- Exhibits antioxidant effects

VII. PHYTOCHEMICAL CONSTITUENTS RESPONSIBLE FOR ANTIDIABETIC ACTIVITY

7.1 Alkaloids

Alkaloids stimulate insulin secretion and improve glucose metabolism.

7.2 Flavonoids

Flavonoids possess antioxidant and anti-inflammatory activities.

7.3 Tannins

Tannins inhibit digestive enzymes such as α-amylase and α-glucosidase.

7.4 Saponins

Saponins improve glucose uptake and insulin sensitivity.

7.5 Terpenoids

Terpenoids exhibit insulin-mimetic actions.

7.6 Phenolic Compounds

Phenolic compounds reduce oxidative stress and inflammation.

VIII. MECHANISMS OF ANTIDIABETIC ACTION OF HERBAL TABLETS

8.1 Stimulation of Insulin Secretion

Certain phytochemicals stimulate pancreatic β-cells to release insulin.

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8.2 Regeneration of β-Cells

Some herbs promote regeneration of damaged pancreatic cells.

8.3 Inhibition of Carbohydrate Digestive Enzymes

Herbal compounds inhibit α-glucosidase and α-amylase enzymes.

8.4 Increased Peripheral Glucose Uptake

Medicinal plants enhance glucose uptake by muscles and adipose tissues.

8.5 Reduction of Oxidative Stress

Antioxidants neutralize free radicals and protect tissues from oxidative damage.

8.6 Improvement of Lipid Profile

Several herbs reduce cholesterol and triglyceride levels.

IX. FORMULATION OF HERBAL ANTIDIABETIC TABLETS

9.1 Selection of Herbal Ingredients

Plants are selected based on traditional use and scientific evidence.

9.2 Extraction Methods

Common extraction techniques include:

- Maceration
- Percolation
- Soxhlet extraction
- Ultrasonic extraction

9.3 Granulation

Granulation improves flow properties and tablet compressibility.

Types of Granulation

1. Wet granulation
2. Dry granulation
3. Direct compression

9.4 Excipients Used

- Binders
- Lubricants
- Disintegrants
- Fillers
- Glidants

9.5 Compression

Tablet compression converts granules into compact tablets.

9.6 Coating

Coating improves tablet appearance and stability.

X. EVALUATION PARAMETERS OF HERBAL TABLETS

10.1 Weight Variation Test

Ensures uniformity of tablet weight.

10.2 Hardness Test

Determines mechanical strength.

10.3 Friability Test

Measures resistance to abrasion.

10.4 Thickness Test

Ensures uniform dimensions.

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10.5 Disintegration Test

Measures tablet breakdown time.

10.6 Dissolution Test

Evaluates drug release characteristics.

10.7 Stability Studies

Determine shelf life and storage conditions.

XI. CLINICAL STUDIES ON HERBAL ANTIDIABETIC TABLETS

Clinical studies have shown promising outcomes for herbal formulations [18]. Gymnema-based tablets significantly reduced fasting blood glucose and HbA1c levels. Bitter melon formulations improved insulin sensitivity and glucose utilization.

Fenugreek tablets reduced postprandial hyperglycemia and improved lipid profiles. Combination herbal formulations demonstrated synergistic antihyperglycemic effects.

Despite encouraging findings, large-scale randomized clinical trials are required to confirm long-term efficacy and safety.

XII. MARKETED HERBAL ANTIDIABETIC TABLETS

Examples of commercially available herbal antidiabetic tablets include:

1. Diabecon
2. BGR-34
3. Madhumehari
4. Gurmar tablets
5. Karela tablets
6. Neem tablets
7. Jamun seed tablets

These products contain combinations of medicinal plants with proven antihyperglycemic activity.

XIII. CHALLENGES ASSOCIATED WITH HERBAL TABLETS

13.1 Lack of Standardization

Variability in plant materials affects consistency.

13.2 Poor Bioavailability

Some phytochemicals exhibit low absorption.

13.3 Quality Control Issues

Contamination and adulteration remain concerns.

13.4 Limited Clinical Evidence

Many formulations lack extensive clinical validation.

13.5 Regulatory Challenges

Regulatory guidelines differ among countries.

XIV. FUTURE PROSPECTS

The future of herbal antidiabetic tablets is promising because of growing interest in natural medicines. Advanced technologies such as nanotechnology, phytosomes, and sustained-release systems may improve bioavailability and therapeutic efficacy.

Future research should focus on:

- Identification of novel phytochemicals
- Standardization of herbal extracts

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- Large-scale clinical studies
- Development of targeted delivery systems
- Safety evaluation

Integration of traditional medicine with modern pharmaceutical science may lead to innovative antidiabetic therapies.

XV. CONCLUSION

Diabetes mellitus is a major global health challenge requiring effective and safe therapeutic approaches. Herbal tablets represent promising alternatives and complementary therapies because of their natural origin, affordability, multiple mechanisms of action, and lower incidence of side effects.

Medicinal plants such as *Gymnema sylvestre*, *Momordica charantia*, *Trigonella foenum-graecum*, *Azadirachta indica*, *Syzygium cumini*, and *Pterocarpus marsupium* possess significant antidiabetic activity supported by traditional use and scientific evidence.

Although herbal tablets offer numerous advantages, challenges related to standardization, quality control, and clinical validation must be addressed. Future advancements in herbal drug formulation and scientific research may enhance the efficacy and acceptance of herbal antidiabetic tablets worldwide.

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