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Insight the role of Herbal medicine for the Management of Diabetes Mellitus: Comprehensive Review

Monika Pandey, Mahesh Kumar Gupta
PhD Schlor, Professor and Principal
School of Pharmacy, Career Point University, Professor and Principal

Abstract

Diabetes mellitus is a chronic metabolic disorder affecting millions worldwide, necessitating effective management strategies to mitigate its impact on public health. Herbal medicine has garnered significant attention as a complementary and alternative approach in the management of diabetes. This comprehensive review aims to provide insights into the role of herbal medicine for the management of diabetes mellitus. The review begins by outlining the global prevalence and burden of diabetes mellitus, highlighting the limitations of conventional treatment approaches and the need for alternative therapies. It delves into the diverse herbal remedies used in traditional medicine systems across various cultures, emphasizing their long-standing history and widespread utilization for diabetes management. This comprehensive review provides valuable insights into the role of herbal medicine in the management of diabetes mellitus. It underscores the potential of herbal remedies as adjunctive therapies to conventional treatments, promoting the integration of traditional knowledge with modern scientific research. However, it also calls for further well-designed clinical trials and standardized research methodologies to establish robust evidence supporting the use of herbal medicine for diabetes management.

Keywords: - Diabetes mellitus, Herbal medicine, conventional treatment, clinical trials,

1.INTRODUCTION

Diabetes mellitus is a chronic metabolic disorder characterized by elevated blood glucose levels due to either insufficient insulin production or ineffective utilization of insulin by the body. It is a major global health concern, affecting millions of people worldwide [1]. The prevalence of diabetes mellitus has been steadily increasing worldwide. According to the International Diabetes Federation (IDF) in 2019, approximately 463 million adults (aged 20-79 years) were living with diabetes globally, and this number is expected to rise to 700 million by 2045 [2].

Type of Diabetes

Diabetes cand be divided in different following category as figure no.1

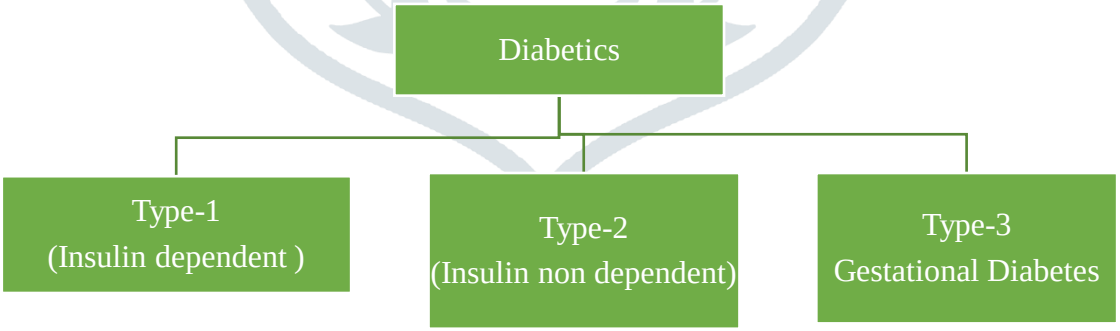


Figure No.1: Types of diabetes

1.Type 1 Diabetes:

Type 1 diabetes, also known as insulin-dependent diabetes or juvenile-onset diabetes, is characterized by the autoimmune destruction of insulin-producing beta cells in the pancreas [3-4].

2.Type 2 Diabetes:

Type 2 diabetes, also known as non-insulin-dependent diabetes or adult-onset diabetes, is the most common form of diabetes and is primarily associated with insulin resistance and impaired insulin secretion [5-6].

3. Gestational Diabetes:

Gestational diabetes mellitus (GDM) is a form of diabetes that develops during pregnancy and is associated with increased risks to both the mother and the child [6-8]

Other Types of Diabetes:

There are other less common forms of diabetes, including monogenic diabetes, cystic fibrosis-related diabetes, and drug-induced diabetes [9-10].

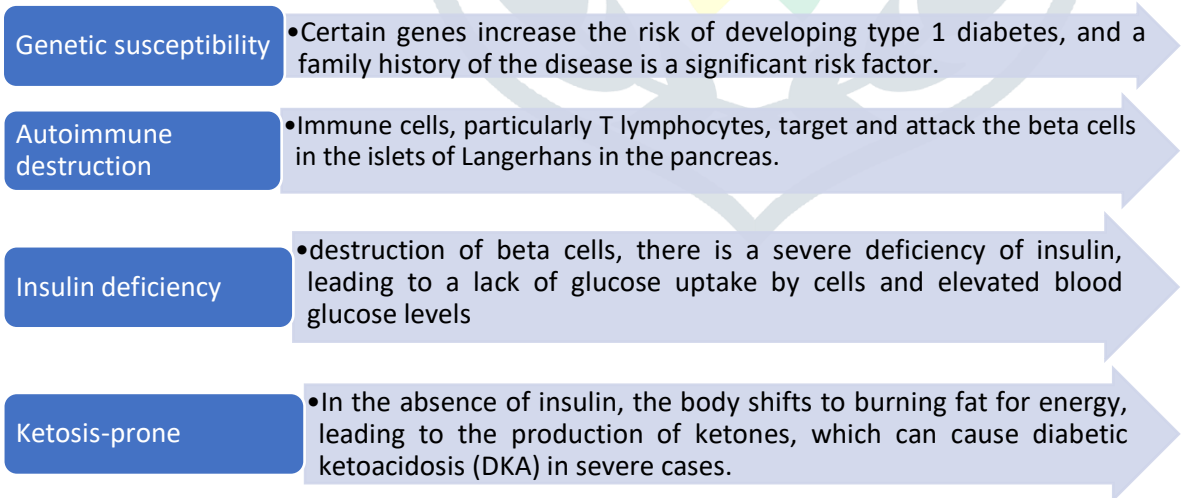
Causes of Diabetes: A diagrammatic presentation (figure no.2) is given as figure no.2 which depicts the different causes of diabetic.

Figure No.2 Causes of Diabetics

Other reasons that may also exist like, Endocrine diseases, such as Cushing syndrome, induce insulin resistance, pancreatic diseases include pancreatitis, pancreatic cancer, and cystic fibrosis, prescription drugs (such as diuretics and steroids), gestational diabetes is a kind of diabetes that affects around 4% of pregnant women and is caused by a loss of insulin sensitivity, surgical intervention or a traumatic event, If the person is affected by the dawn phenomenon (a rush of hormones produced by the body every morning between 4 and 5 a.m.)[11-12].

2. **PATHOPHYSIOLOGY**

The pathophysiology of diabetes mellitus involves a complex interplay of genetic, environmental, and lifestyle factors that lead to chronic hyperglycaemia (elevated blood glucose levels). There are primarily two types of diabetes mellitus: type 1 diabetes and type 2 diabetes, each with distinct pathophysiological mechanisms is given in as figure no. 4 and 5 respectively: [13-15]



FigureNo.3: pathophysiological mechanisms of diabetics I

Type 2 Diabetes Mellitus: Type 2 diabetes is characterized by insulin resistance, where cells fail to respond effectively to insulin's action, and inadequate insulin secretion by the pancreas.

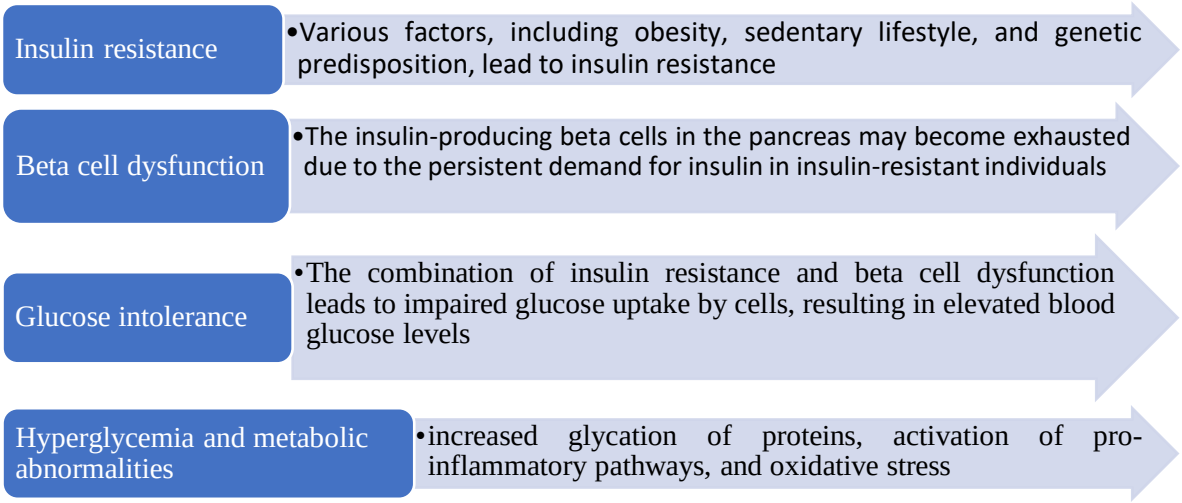


Figure No.4 :pathophysiological mechanisms of diabetics-II

Both types of diabetes mellitus share certain pathophysiological aspects, such as the development of long-term complications like nephropathy, neuropathy, retinopathy, and cardiovascular disease. These complications are driven by chronic hyperglycemia, advanced glycation end products (AGEs), oxidative stress, and inflammation [16-17].

Understanding the pathophysiology of diabetes mellitus is crucial for developing effective treatment strategies, including lifestyle interventions, antidiabetic medications, and insulin therapy. Ongoing research aims to identify novel targets for therapeutic interventions and develop personalized approaches for diabetes management [18-20].

3. NEED OF NATURAL SOURCES AS ANTI-DIABETIC

The astronomic increase in the prevalence of diabetes has made diabetes a major public health challenge for India and is become important human ailment afflicting many from various walks of life in different countries and once again the whole world being looked upon ayurvedic the oldest healing system of medicine for the treatment of diabetes .Although there are many synthetic medicines developed for patients, but it is the fact that it has never been reported that someone had recovered totally from diabetes. The modern oral hypoglycemic agents produce undesirable and side effects. Thus, in the recent years considerable attention has been directed towards the antidiabetic potential of medicinal plants and their herbal formulation in the management of disease. [21-24]

More than 400 traditional plant treatments for diabetes mellitus have been recorded, but only a small number of these have received scientific and medical evaluation to assess their efficacy. Ancient Indian medicine mentions several indigenous plants and mineral preparations for the treatment of diabetes mellitus [25]. A hypoglycemic action from some treatments has been confirmed in animal models and non-insulin-dependent diabetic patients, and various hypoglycemic compounds have been identified. A botanical substitute for insulin seems unlikely, but traditional treatments may provide valuable clues for the development of new oral hypoglycaemic agents and simple dietary adjuncts [26].

4.NATURAL RESOURCES

Antioxidants play a vital role in controlling diabetes by neutralizing harmful molecules known as free radicals and reactive oxygen species (ROS). Diabetes is associated with chronic hyperglycemia, which leads to the production of excessive ROS and oxidative stress [27-28]. This oxidative stress contributes to the development and progression of diabetes and its complications. Antioxidants help combat oxidative stress and offer several benefits in managing diabetes which are as follows: [29-30]

- **Protection of Beta Cells:** Antioxidants can protect the insulin-producing beta cells in the pancreas from damage caused by oxidative stress. Preserving beta cell function is essential for maintaining insulin secretion and glucose regulation [31-32].
- **Improved Insulin Sensitivity:** Antioxidants have been shown to enhance insulin sensitivity in cells, allowing them to respond more effectively to insulin. Improved insulin sensitivity helps lower blood glucose levels and reduces the risk of insulin resistance, a hallmark of type 2 diabetes [33-34].
- **Reduced Inflammation:** Antioxidants possess anti-inflammatory properties that help reduce chronic low-grade inflammation observed in individuals with diabetes. Inflammation is closely linked to insulin resistance and complications of diabetes [35-36].
- **Protection Against Diabetic Complications:** Antioxidants help prevent or mitigate complications associated with diabetes, such as diabetic nephropathy (kidney damage), diabetic retinopathy (eye damage), and diabetic neuropathy (nerve damage). These complications are often driven by oxidative stress and inflammation [37-38].
- **Regulation of Glucose Metabolism:** Some antioxidants have been found to modulate glucose metabolism and promote glucose uptake by cells. This can help lower blood glucose levels and improve overall glycemic control [39-40].
- **Cardiovascular Protection**: Diabetes increases the risk of cardiovascular diseases. Antioxidants can protect the blood vessels and the heart by reducing oxidative stress and inflammation, thus lowering the risk of cardiovascular complications in diabetic patients [41].

Common Antioxidants and Their Sources are as:

Vitamin C: Found in fruits and vegetables like oranges, strawberries, and bell peppers.

Vitamin E: Present in nuts, seeds, and vegetable oils.

Selenium: Found in nuts, seafood, and whole grains.

Polyphenols: Abundant in green tea, berries, and dark chocolate.

Carotenoids: Found in carrots, sweet potatoes, and spinach. [42-45]

5. ROLE OF HERBAL MEDICINE

Several plants have been traditionally used for their anti-diabetic properties. These plants contain bioactive compounds that help in managing diabetes by improving insulin sensitivity, reducing blood glucose levels, and protecting pancreatic beta cells. It's important to note that while these plants may have beneficial effects. Here are some plants with known anti-diabetic activity [46-48]:

Plant	**Family**	**Part of part**	**Mechanism**	**Active constituents**
Momordica charantia[49]	Cucurbitaceae	fresh juice or unripe fruit	pancreatic cells that regenerate, release insulin, and combat insulin resistance	Charantin
Curcuma longa [50-51]	Zingiberaceae	Rhizome	Improved Insulin Sensitivity	*curcumin*
Aegle marmelos [52]	Rutaceae	Leaf extract	reducing lipid peroxidation by boosting the antioxidant capacity	glutathione (GSH)
Eugenia Jambolana[53]	Myrtaceae	Seeds	improve pancreatic tissue function by increasing insulin production or inhibiting glucose absorption in the intestine or facilitating metabolite transport in insulin-dependent processes.	gallic acid and polyphenolic compounds
Caesalpinia bonducella [[54-55]	Leguminosae	Seeds	improved insulin production and glycogenesis in isolated islets	flavonoids, tannins, phenols, and saponins.
Allium cepa (onion) [56-58]	Liliaceae	globose bulb	In rats, insulin secretion and action were stimulated, resulting in increased glucose uptake and utilisation.	S-methyl cysteine sulphoxide (SMCS), allyl propyl disulfide (APDS)
Aloe barbadensis[59]	Liliaceae	green, dagger-shaped leaves that are fleshy	Insulin production and/or release from pancreatic beta cells is stimulated. Aloe vera, for example, may have a genuine anti-diabetic impact due to its antioxidant potential3.	Emodin, Aloesin
Allium sativum (garlic) [60]	Liliaceae	bulb of the plant	Improved hepatic metabolism, increased insulin release from beta cells in the pancreas, and/or insulin sparing effect	allicin, a sulphur-containing
Emblica officinalis[61]	*Phyllanthaceae*	fruit	by increasing peripheral glucose utilization and enhancing glucose uptake by cells, resulting in better glycemic control	polyphenols, including gallic acid, ellagic acid, and corilagin
Rhizoma Coptidis [62]	Ranunculaceae	Rhizome	This helps improve glucose uptake by cells and reduces insulin resistance, a hallmark of type 2 diabetes It also Activates AMP-activated protein kinase (AMPK)	Berberine
Ocimum sanctum[63]]	Lamiaceae	Leaves	boosting insulin secretion from isolated islets2	Eugenol
Tinospora cordifolia[64]	Menispermaceae	Root	In rats, it lowers blood glucose levels and increases glucose tolerance.	The isoquinoline alkaloid rich fraction from stem, includes palmatine, jatrorrhizine, and magnoflorine
Coccinia indica[65]	Cucurbitaceae1	leaves and the shoot	Increased PPAR-expression increases insulin sensitization and peripheral glucose consumption by restoring the activity of the enzymes lipoprotein lipase (LPL), glucose-6-phosphatase, and lactate dehydrogenase.	triterpenes compound (dehydrotrametenolic acid
Mangifera indica [66]	Ancardiaceae	Leaves	Intestinal glucose absorption is reduced.	mangiferin, rhamnetin, catechin, epicatechin, iriflophenone 3-C-β-D-glucoside, gallic acid and other phenolic and flavonoid compounds

Gymnema sylvestre [67]	Asclepiadaceae	Leaves	Molecules bind to receptor sites on the taste buds, preventing sugar molecules in the meal from activating them and therefore reducing sugar cravings.	Gymnemic-1 acid
Cinnamomum zeylanicum[68]	Lauraceae	bark	increased insulin receptor phosphorylation and translocation of glucose transporter GLUT4 to the plasma membrane	Cinnamon
Capparis Decidua [69]	Capparidaceae	Dried fruits seeds, flowers	G6Pase activity was reduced by 44%, while liver and muscle glycogen content increased2. Inhibition of carbohydrate hydrolysing enzymes, amylase and glucosidase in the digestive tract.	phenolic compounds, as well as in glucosinolates
Amarus Phyllanthus [70]	*Euphorbiaceae*	Leaves1	Repaired damaged ß-cells of the islet of pancreas, enhance insulin.	Polyphenolic compounds
Pterocarpus marsupium [71]	Fabaceae	Bark,Wood Seed	insulinogenic in vitro, stimulates pancreatic beta cell regranulation, increasing insulin secretion and proinsulin conversion	Pterostilbene epicatechin
Acacia arabica [72]	Leguminosae	Seeds	Insulin release from pancreatic beta cells is triggered by the activation of the insulin receptor. Enhance glucose absorption into muscle and adipose tissues, also blocking hepatic gluconeogenesis.	Tannins, Quercetin through its anti-oxidant property.
Azadirachta indica[73]	Meliaceae3	leaf extract and seed oil 2	G6PD activity significantly increased	quercetin
Trigonella foenum graecum [74]	Fabaceae2	seed	Overexpression of the glucose transporter (GLUT-2) (and sterol regulatory element-binding protein (SREBP1C) mRNA levels1 causes enhanced glucose absorption in HepG2 cells.	alkaloid gonelline, nicotinic acid, and coumarin

6. FUTURE PROSPECTS OF HERBAL MEDICINE

The future prospects of herbal medicine in diabetic treatment are promising and continue to garner significant attention from researchers and healthcare professionals. Herbal medicines have been used for centuries in traditional medicine systems, and there is growing interest in exploring their potential as complementary or alternative therapies for diabetes management. As scientific interest in herbal medicine grows, more rigorous and evidence-based research studies are being conducted to evaluate the safety and efficacy of various herbal remedies for diabetes[75]. Clinical trials are exploring the effects of herbal extracts and compounds on blood glucose control, insulin sensitivity, and diabetes-related complications. These studies aim to provide robust evidence to support the use of specific herbal medicines in diabetes management. With advances in technology and analytical techniques, researchers are identifying and isolating active compounds present in herbal medicines responsible for their antidiabetic effects. Understanding the mechanisms of action of these compounds can lead to the development of targeted therapies and the potential for designing novel drugs based on natural products. Herbal medicines are often used in combination with conventional medications to enhance the overall efficacy of diabetes management. Research is focusing on identifying safe and effective combinations of herbal remedies with standard antidiabetic drugs to optimize treatment outcomes and minimize side effects.

While the future prospects of herbal medicine in diabetic treatment are promising, it's essential to approach their use with caution. Herbal medicines can interact with conventional medications, and their efficacy and safety may vary among individuals. Therefore, it is crucial for people with diabetes to work closely with qualified healthcare professionals who can provide personalized advice and monitor their progress effectively.

7. SUMMARY AND CONCLUSION

Herbal medicine holds promising future prospects in the treatment of diabetes. With a rich history of use in traditional medicine systems, herbal remedies are gaining increasing attention from researchers and healthcare professionals. Evidence-based research is exploring the safety and efficacy of various herbal medicines for diabetes management. Active compounds in herbs, such as berberine in Rhizoma Coptidis and curcumin in turmeric etc., have shown antidiabetic effects, leading to the development of targeted therapies. Combining herbal medicines with conventional drugs may enhance treatment outcomes, and personalized medicine approaches based on genetic analysis are being explored. The antioxidant and anti-inflammatory properties of herbal medicines can contribute to better glycemic control and prevent diabetes-related complications. Herbal nutraceuticals and functional foods provide convenient ways to integrate herbal remedies into daily diets.

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