WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

A Review on Diabetes

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DOI : https://doi.org/10.55248/gengpi.6.0425.1487

ABSTRACT

Diabetes mellitus is a prevalent metabolic disorder that poses significant health risks globally, with its prevalence among adults increasing and affecting million of people individuals. The disease's complex pathophysiology is influenced by various factors, including obesity, hormonal imbalances, and genetic predispositions. Traditional treatments primarily focus on insulin management, but there is growing interest in herbal therapies that may enhance insulin function and reduce oxidative stress. Compounds such as ellagic acid and flavonoids like quercetin show promise in improving glucose metabolism and providing a safer alternative for long-term diabetes care. However, further research is essential to understand their mechanisms and efficacy in clinical settings. The paper emphasizes the need for a comprehensive approach that integrates evidence-based natural remedies with conventional medical treatments to improve diabetes management and patient outcomes.

Keywords:- Diabetes Mellitus (DM), Type 1 Diabetes (T1DM), Type 2 Diabetes (T2DM), Insulin Resistance, Hyperglycemia, Insulin Secretion, Epidemiology.

1. Introduction

Diabetes mellitus (DM) indeed has a profound impact globally, affecting millions and posing significant health challenges.

One of the most common metabolic disorders, diabetes mellitus is becoming frighteningly more common all over the world. The global prevalence of diabetes in adults over the age of 18 has risen from 4.7% in 1980 to 8.5% in 2014, and the number of people with the disease has quadrupled in just 34 years, from 108 million in 1980 to 422 million in 2014.

The disorder stems from issues with insulin production or function, leading to imbalances in blood glucose levels. Its complications can be severe, targeting crucial body systems such as blood vessels, eyes, kidneys, heart, and nerves. (1)

People with DM spend around twice as much on medical care. Mellitus diabetes The chance of dying young can double. According to trends, rates will rise regularly or continuously.

Blood glucose levels are controlled by the pancreatic hormone insulin. Diabetes affects how well the body uses or produces insulin, which can result in a number of immediate and long-term issues. (2,3)

The pancreas secretes the hormones glucagon and insulin. The islets of Langerhans contain beta (ß) cells that release insulin and alpha (α) cells that secrete glucagon. Insulin transports glucose into the muscles, liver, and adipose tissue while lowering blood glucose levels through glycogenesis. While erythrocytes and neural tissue do not require insulin for glucose utilization, alpha (α) cells are crucial for blood glucose regulation because they produce glucagon, which raises blood glucose levels by speeding up glycogenolysis. (4,5,6)

Epidemiology

The prevalence of diabetes mellitus has risen considerably over the last few decades, making it a major global health concern. As per the International Diabetes Federation (IDF), over 537 million persons aged 20-79 had diabetes globally as of 2021, taking into consideration 10.5% of the adult population. If current trends continue, it is predicted that this number will rise to 643 million by 2030 and 783 million by 2045. Diabetes affects people all across the world, with 90% of adults with the disease living in low- and middle-income nations without a diagnosis. Population expansion, age, urbanization, increased rates of obesity, and physical inactivity are some of the causes of the rising prevalence. Notably, around 50% of individualswith diabetes go undiagnosed, underscoring the necessity of better screening and early detection initiatives. (7)

Prevalence

In 2013, persons under 60 years old accounted for over half of all diabetes-related deaths. Deaths from diabetes occur every six seconds, and these deaths occur in less developed areas. The prevalence of diabetes is quite high, exceeding 12%, in 35 out of 219 countries, or 16% of the total. These nations primarily belong to the Middle East, North Africa, and Western Pacific areas. (8,9)

Risk factors for diabetes

There are several aspects that make Indians more susceptible to diabetes. Multiple studies on native Asian Indians and migrant Indian populations around the world have shown a high racial the susceptibility to diabetes. (10)

- **Genetic susceptibility** :- Asian Indians are genetically more likely to develop diabetes, as research in India and elsewhere has shown, and this predisposition is easily manifested when adverse environmental variables are present. 45. It appears that there is a high degree of familial aggregation in this population, as over 75% of Indian people with type 2 diabetes have a first-degree family history. (11)
- **Environmental factors** :- Adiposity in Indians, including body fat percentage, insulin resistance, abdominal adiposity, and general adiposity (BMI), and age are risk factors that Asian Indians are vulnerable to. (12)
- **Impact of urbanization** :- The subcontinent of India is gradually becoming more urbanized. Modernization is associated with several changes in lifestyle, such as major dietary changes, a decrease in physical activity due to improved transportation, the availability of energy-saving devices, and increased stress levels. Gaining weight and lowering energy expenditure are two more variables behind the current insulin inertia. (13)
- **Stress factors** :- Today's successful urban professionals often exhibit the impacts of stress, sedentary lives, and bad eating habits. (14)
- **Cardiometabolic risk factors :-** Indians have a higher probability to have cardiometabolic risk factors such as insulin resistance, dyslipidemia, and abdominal obesity. (15,16)
- **Chronic complications of diabetes** :- Diabetes has a huge financial impact due to diabetics require continuous care, which rises sharply as vascular issues develop. There is a dearth of population-based data regarding the prevalence of macrovascular and microvascular issues in different developing countries. (17)
- **Cost of treating diabetes** :- The cost of managing and treating diabetes is significant for both the patient and the healthcare system. The direct costs of care are borne by diabetic patients, their families, and healthcare providers. Indirect and intangible costs are higher. The indirect costs include early retirement, disability-related incapacity to work, lost output from frequent absences from work, and even early death from complications. (18)
- **Prevention of diabetes** :- India must implement preventative strategies to lower the prevalence of diabetes since the country's diabetes care budget does not adequately treat the condition. (19)

Signs and symptoms of diabetes

Diabetes is a chronic condition, thus many people choose to ignore its symptoms. This is not a major problem because, in contrast to many other disorders, the symptoms of hyperglycemia take time to manifest. Most people aren't aware that damage can start years before symptoms show up. This is undesirable because early detection of symptoms can help prevent vascular issues and expedite the management of the condition. (20)

- **Warning signs & classic symptoms of diabetes**

➢ The warning signs of type 2 diabetes should be recognized because it is frequently ignored in its early stages. Some of these symptoms include erectile dysfunction or impotence, frequent weariness, impatience, intermittent infections, dry mouth, burning, discomfort, numbness in the feet, itching, blurred vision, and the inability to explain weight loss.

➢ Polyuria, polydypsia, and polyphagia are common symptoms of both type 1 diabetes, which rapidly progresses to severe hyperglycemia, and type 2 diabetes, which has extremely high levels of hyperglycemia. Type 1 diabetes and long-term uncontrolled type 2 diabetes are the only illnesses where experiencing significant weight loss is typical. Other common symptoms of undiagnosed diabetes include fatigue, agitation, discomfort, and inexplicable weight loss. It's also possible to ignore weak symptoms or those that appear gradually. (21)

Causes of Diabetes Milliteus

Diabetes Milliteus is brought on by abnormalities or disruptions in the gluco-receptor of the ßeta cell, which makes the cells respond to high glucose levels or a relative lack of ßeta cells. Both situations impair insulin secretion, which may result in ß cell failure. (22) The theory of principle in microvascular disease that results in brain hypoxia and the direct effect of hyperglycemia on neuronal metabolism. (23)

1. The "down regulation" of insulin receptors and a reduction in their number result in peripheral tissues being less sensitive to insulin. Many persons have normal blood sugar levels but hypersensitivity and hyperinsulinemia; they also have dyslipidemia, hyperuriemia, and belly fat. Thus, there is relative insulin resistance, particularly in the fat, muscle, and liver. Hyperinsulinemia is one factor that may contribute to angiopathy.
2. A specific receptor imbalance may lead to diabetes mellitus. Examples of specific receptors include the glucagon-like peptide-1 (GLP-1) receptor, the peroxisome proliferator activated (γ) receptor (PPARγ), the beta3 (ß3) ardent-receptor, and certain enzymes such as α glycosidase and dipeptidyl peptidase IV enzyme. (24)

3. The ß cells lag behind due to a relative insulin shortage brought on by obesity, elevated glucagon and hyperglycemia levels, and other causes. Two hypotheses have connected increased perineural blood flow and nerve injury to anomalies in nitric oxide metabolism. (25).
4. Research on diabetic neuropathy is currently concentrated on protein kinase C, oxidative stress, the polyol pathway, and advanced glycation-end products. (26)
5. previously This increases the likelihood because other factors influence the disease's development.
6. Some of the diseases caused by viruses include measles, chickenpox, infectious hepatitis, and others. Some infections have an impact on when diabetes develops. especially for the people who are in danger.
7. 7. Anxiety and irritation. Avoiding stress and irritability is advised.
8. Young. Every ten years as one ages, the chance of developing diabetes rises. (27)

Classification of Diabetes Mellitus

Diabetes mellitus can be classified into two main type are :-

A. Type 1 Diabetes Mellitus (T1DM) :- The hallmarks of type 1 diabetes include a complete lack of insulin and the loss of pancreatic beta cells. This subtype is the most frequently diagnosed in people under the age of twenty and makes up around five to ten percent of all cases.

The cause is uncertain. Conversely, a combination of hereditary and environmental factors are believed to be at play. The autoimmune process that kills the beta cells in the pancreas that make insulin is the basic mechanism. To diagnose diabetes, one uses the A1C, or blood sugar level. One cannot prevent type 1 diabetes. In order to guarantee survival, insulin therapy is usually required. An insulin pump may also be used to administer insulin therapy, but injections are frequently given directly under the skin. Consistent exercise and a diabetic diet are essential parts of the treatment of diabetes. If diabetes is not treated, it can lead to a number of complications. (28)

B. Type 2 Diabetes Mellitus (T2DM) :- This most prevalent kind of diabetes causes about 90% of all cases. It is a chronic illness that alters the body's glucose (sugar) metabolism. Rather than being utilized by the organism, glucose accumulates in the bloodstream in type 2 diabetes. High blood sugar levels have the potential to cause major health issues over time, such as stroke, heart disease, kidney failure, nerve damage, and visual issues.

This kind of disease primarily affects adults over 40, though it may occur to children if certain risk factors are present. Sometimes a combination of diet, exercise, and weight control can help treat type 2 diabetes.

Insulin injections or oral glucose-lowering drugs, however, could potentially be part of the treatment. (29)

Pathophysiology of Diabetes Mellitus

Hyperglycemia is directly linked to both physiological and behavioral reactions. The brain sends nerve impulses to the pancreas and other organs to lessen the symptoms of hyperglycemia.

A. Type 1 diabetes mellitus :- The chronic autoimmune condition known as type 1 diabetes is linked to the specific loss of pancreatic beta-cells that produce insulin. Type 1 diabetes is the result of beta-cell death in the last stage of clinical illness. As an autoimmune disease, type 1 diabetes is distinguished by a number of characteristics.

- presence of immunocompetent and accessory cells in the infiltrating pancreatic islets
- A connection between the major histocompatibility complex's class II genes and illness risk.
- There are islet cell-specific autoantibodies recognized.
- The immunoregulation changes brought on by T cells.
- The role of TH1 cells, which generate monokines and interleukins, in its development of disease.
- Response to immunotherapy.
- Frequent incidence of additional autoimmune illnesses specific to particular organs in those who are affected or in their relatives.

The majority of patients had detectable anti-insulin antibodies before beginning insulin therapy, and about 85% of patients had islet cell antibodies in their blood. Glutamic acid decarboxylase (GAD) on pancreatic B cells is the target of the majority of islet cell-produced antibodies.

The autoimmune loss of pancreatic β-cells results in a shortage of insulin synthesis, which leads to the metabolic abnormalities associated with type 1 diabetes. T1DM patients exhibit increased glucagon secretion, abnormal pancreatic α-cell activity, and reduced insulin secretion. Hyperglycemia typically reduces glucagon secretion; however, in individuals with type 1 diabetes, hyperglycemia has no effect on glucagon secretion. The metabolic problems linked to insulin deficiency are exacerbated by the consequently excessively elevated glucagon levels.The main abnormality associated with type 1 diabetes is insulin insufficiency, but there is also an issue with the administration of insulin. Because insulin deficiency causes high levels of free fatty acids in the plasma and unchecked lipolysis, it inhibits the consumption of glucose in peripheral tissues, including skeletal muscle. The GLUT 4 class of glucose transporters in adipose tissue and glucokinase in the liver are two examples of genes whose expression is reduced by insulin deficiency and which

are essential for target tissues to respond to insulin in the proper way. It makes sense why the main metabolic anomalies brought on by insulin insufficiency in type 1 diabetes are reduced metabolism of glucose, lipids, and proteins.

B. **Type 2 diabetes mellitus** :- There are two main metabolic issues linked to type 2 diabetes: decreased insulin synthesis because of β-cell malfunction and decreased insulin activity because of "insulin failure." The beta cells alter as a result of insulin resistance, making more insulin accessible. In general, the plasma level of insulin is too high and insufficient to maintain appropriate glucose homeostasis. The final outcome of "hyperinsulinemia" and "insulin resistance" is "impaired glucose tolerance". With the exception of "maturity-onset diabetes of the young (MODY)," type 2 diabetes inherits in an unknown manner. A mutation in chromosome 7p's glucokinase quality may cause an autosomal dominant characteristic in children with maturity-onset diabetes. When insulin is not used for more than five years and hyperglycemia is diagnosed before the age of 25, it is referred to as mature-onset diabetes of the young. (30)

2. Review of Antidiabetic Activity of Herbal Drug

S.No.	Scientific Name	Common Name	Traditional Uses	Pharmacological Effects
1	Azadirachta indica	Neem	Diabetes, malaria skin diseases, infections, cardiovascular diseases, intestinal worms	Promotes pancreatic beta-cell function, lowers blood glucose levels, improves insulin production, inhibits the action of alpha-amylase and alpha-glucosidase, and improves glucose absorption.(31)
2	Acacia arabica	Babul acacia	Diabetes, astringent, diarrhea, parasitic worms, diuretic, liver tonic	Enhances insulin production, improves glucose tolerance and absorption, and lowers blood glucose levels.(32)
3	Allium sativum	Garlic	Diabetes, fever, hypertension, rheumatism, dysentery, bronchitis, intestinal worms	Promotes cells to become more sensitive to insulin and secrete more of it.(33)
4	Aloe barbadensis miller	Aloe vera	Diabetes, constipation, infections, ulcer, dysentery, piles, rheumatoid arthritis	Enhances glucose tolerance, decreases insulin resistance, raises insulin secretion, and lowers blood glucose levels.(34)
5	Balanites aegyptiaca	desert date	Diabetes, wounds, asthma, malaria, diarrhea, emorrhoids, fever, infections	Increases glucose absorption, suppresses alpha-glucosidase activity, and increases insulin secretion.(35)
6	Brassica juncea	brown mustard	Diabetes, arthritis, heumatism, back pain, coughs, paralysis	Increases the production of insulin and the use of glucose.(36)
7	Calendula officinalis	Marygold	Diabetes, fever, infections, wounds,menstrual irregularity, poor eyesight, inflammation, ulcers	Reduces blood sugar and raises insulin levels in plasma.(37)
8	Capsicum frutescens	Chili pepper	Diabetes, gastrointestinal disorders, toothache, pain, muscle spasms, fever, infections	Increases glucose absorption and raises insulin sensitivity and secretion.(38)
9	Cassia fistula	Golden Shower Tree	Diabetes, wounds, constipation, piles, skin diseases, asthma, liver diseases, rheumatism, leprosy	Improves insulin secretion, lowers blood glucose levels, and enhances glucose absorption and utilization.(39)
10	Cinnamomum zeylanicum	Dalchini	Diabetes, common cold, flu, gastrointestinal disorders, bacterial infections, headache, stomach pain	Decreases alpha-amylase activity, raises insulin sensitivity, and raises plasma insulin levels.(40)

11	Dalbergia sissoo	Indian rosewood	Diabetes, stomach disorders, dysentery, skin diseases, syphilis, nausea, gonorrhea	lowers serum cholesterol, triglyceride, and blood glucose levels.(41)
12	Eugenia jambolana	jamun	Diabetes, skin ulcers, gastritis, constipation, sore throat, liver, and kidney diseases	Reduces blood sugar, enhances insulin secretion, enhances pancreatic β-cell function, suppresses the activities of sucrase and maltase, and enhances glucose absorption and metabolism.(42)
13	Eucalyptus globulus	blue gum	Diabetes, cough, cold, wounds, fungal infections, fever, sore throat, pain	Increases glucose absorption and raises insulin secretion.(43)
14	Ficus benghalensis	banyan tree	Diabetes, hypertension, dysentery, diarrhea, pain, ulcers, asthma	Reduces the absorption and digestion of carbohydrates, lowering blood glucose levels.(44)
15	Glycine max	soybean	Diabetes, cardiovascular diseases, obesity, cancer	Reduces insulin resistance and increases tolerance to glucose.(45)
16	Gymnema sylvestre	gurmar	Diabetes, asthma, bronchitis, constipation, jaundice, dyspepsia, hemorrhoids, obesity	Improves glucose tolerance, raises insulin secretion, regenerates beta cells, and lowers blood glucose levels.(46)
17	Hibiscus esculentus	ladies' fingers	Diabetes, gastric irritations, inflammatory diseases, wounds, and boils	Enhances insulin production, enhances β-cell activity, and lowers blood glucose levels.(47)
18	Hibiscus rosa-sinensis	Chinese hibiscus	Diabetes, cough, diarrhea, dysentery, pain, contraceptive	Enhances insulin secretion and hepatic glucose utilization, decreases blood glucose levels, decreases glucose absorption, enhances glucose tolerance, and inhibits DPP-IV action.(48)
19	Jatropha curcas	physic nut	Diabetes, fever, bacterial and fungal infections, jaundice, muscle pain	Reduces blood glucose levels during fasting and enhances the absorption and utilization of carbohydrate.(49)
20	Linum usitatissimum	oilseed flax	Diabetes, diarrhea, gastrointestinal infections, asthma, bronchitis, atherosclerosis	Enhances glucose absorption and metabolism, raises insulin production, and lowers blood glucose levels.(50)
21	Momordica charantia	bitter gourd	Diabetes, malaria, hypertension, scabies, liver diseases, obesity, ulcers, measles	Reduces gluconeogenesis, inhibits α-glucosidase activity, improves glucose tolerance, raises insulin secretion and glucose absorption, and lowers blood glucose levels.(51)

22	Moringa oleifera	drumstick tree	Diabetes, asthma, enlarged liver, bacterial infections, eye problems, piles, influenza, diuretic	Increases glucose uptake, decreases blood glucose levels, decreases glucose absorption, and inhibits α-amylase activity.(52)
23	Nigella sativa	Kalonji	Diabetes, hypertension, gastrointestinal disorders, back pain, paralysis, heart diseases, bacterial infections, malaria	Reduces blood glucose levels, enhances glucose uptake and utilization, raises insulin secretion and sensitivity, and lessens the digestion and absorption of carbohydrates.(53)
24	Ocimum sanctum	tulsi	Diabetes, ringworm, skin diseases, dysentery, dyspepsia, bronchitis, asthma	Enhances glucose absorption and utilization, and increases insulin secretion.(54)
25	Punica granatum	pomegranate	Diabetes, urinary tract infections, arthritis, sore throat, skin diseases, anemia	Improves β-cell activity and secretes more insulin.(55)
26	Sesamum indicum	sesame	Diabetes, constipation, hypertension, high cholesterol, athlete's foot	Inhibits the activity of α-amylase and α-glucosidase and has antioxidant properties.(56)
27	Santalum album	sandalwood	Diabetes, jaundice, diarrhea, dysentery, liver tonic, inflammation, hypertension	Enhances insulin secretion, lowers blood glucose levels, and enhances glucose absorption and utilization.(57)
28	Tinospora cordifolia	Giloy	Diabetes, dysentery, diarrhea, snake bites, asthma, fever, jaundice	Inhibits gluconeogenesis, boosts insulin sensitivity, and enhances insulin secretion.(58)
29	Terminalia Catappa linn.	Indian Almond	Diabetes, Inflammation, hypertension, Cholestrol lowering, Wound healing	Increase your sensitivity to insulin.(59)
30	Zingiber officinale	ginger	Diabetes, nausea, high cholesterol, heartburn, indigestion, diarrhea, asthma	Reduces fasting blood sugar and boosts insulin production.(60)

Azadirachta indica

Fig No. 1 ***Azadirachta indica***

Scientific classification

Kingdom	Plantae
Clade	Tracheophytes
Clade	Angiosperms
Clade	Eudicots
Clade	Rosids
Order	Sapindales
Family	Meliaceae
Genus	Azadirachta
Species	A. indica

Chemical constitute

- Triterpenoids (e.g., Azadirachtin) - Help regulate blood sugar levels and improve insulin sensitivity.
- Flavonoids (e.g., Quercetin) - Have antioxidant properties that help reduce oxidative stress, which is linked to diabetes complications.
- Alkaloids (e.g., Azadirachtiin) - Show potential in lowering blood glucose levels.
- Saponins - Help in improving glucose metabolism.
- Fatty Acids (e.g., Oleic acid, Linoleic acid) - Have anti-inflammatory effects, helping manage diabetes-related inflammation.

Pharmacological activities

- Antidiabetic: Helps lower blood sugar levels and improves insulin sensitivity.
- Antimicrobial: Exhibits antibacterial, antifungal, and antiviral properties.
- Anti-inflammatory: Reduces inflammation, helping manage conditions like arthritis.
- Antioxidant: Protects cells from oxidative stress and damage.
- Hepatoprotective: Supports liver health and detoxification.
- Anticancer: Inhibits cancer cell growth and promotes apoptosis (cell death).
- Immunomodulatory: Enhances immune system function.(61)

Cinnamomum zeylanicum

Fig No. 2 *Cinnamomum zeylanicum*

Scientific classification

Kingdom	Plantae
Clade	Tracheophytes
Clade	Angiosperms
Clade	Magnoliids
Order	Laurales
Family	Lauraceae
Genus	Cinnamomum
Species	C. verum

Chemical constitute

- Cinnamaldehyde - The primary active compound in cinnamon, which helps improve insulin sensitivity and lower blood sugar levels.
- Coumarins - Have antioxidant properties, which can help reduce oxidative stress associated with diabetes.
- Polyphenols - Powerful antioxidants that improve insulin sensitivity and help regulate blood glucose levels.
- Tannins - Possess anti-inflammatory properties that may help reduce inflammation linked to diabetes complications.
- Cinnamic acid - Enhances insulin action and improves glucose metabolism.

Pharmacological activities

- Antidiabetic: Improves insulin sensitivity and helps lower blood sugar levels.
- Antioxidant: Protects cells from oxidative damage, reducing diabetes complications.
- Anti-inflammatory: Reduces inflammation, which is beneficial for managing diabetes-related conditions.
- Antimicrobial: Exhibits antibacterial, antifungal, and antiviral properties.
- Cardioprotective: Helps regulate cholesterol and triglyceride levels, supporting heart health in diabetics.(62)

Eugenia jambolana

Fig No. 3 *Eugenia jambolana*

Scientific classification

Kingdom	Plantae
Clade	Tracheophytes
Clade	Angiosperms
Clade	Eudicots
Clade	Rosids
Order	Myrtales
Family	Myrtaceae
Genus	Syzygium
Species	S. cumini

Chemical constitute

- Jambosine - An alkaloid that helps regulate blood sugar levels by inhibiting the conversion of starch to sugar.
- Ellagic acid - A polyphenol with antioxidant and anti-inflammatory properties, helping to reduce oxidative stress in diabetics.
- Tannins - Compounds that help control glucose levels and have antioxidant effects.
- Anthocyanins - Flavonoids with strong antioxidant properties, which help in reducing diabetic complications by protecting cells from damage.
- Flavonoids - Improve insulin sensitivity and help in managing blood sugar levels.

Pharmacological activities

- Antidiabetic: Helps lower blood sugar levels by improving insulin sensitivity and inhibiting starch-to-sugar conversion.
- Antioxidant: Protects cells from oxidative damage, reducing diabetes-related complications.
- Anti-inflammatory: Reduces inflammation, which helps prevent diabetic complications like neuropathy.
- Hypolipidemic: Helps regulate cholesterol and triglyceride levels, promoting heart health in diabetics.
- Antimicrobial: Exhibits antibacterial and antifungal properties.(63)

Momordica charantia

Fig No. 4 *Momordica charantia*

Scientific classification

Kingdom	Plantae
Clade	Tracheophytes
Clade	Angiosperms
Clade	Eudicots
Clade	Rosids
Order	Cucurbitales
Family	Cucurbitaceae
Genus	Momordica
Species	M. charantia

Chemical constitute

- Polypeptide-P - A protein that mimics the action of insulin, aiding in glucose metabolism.
- Momordicosides - Saponins that help in regulating blood sugar and improving insulin function.
- Flavonoids (e.g., Quercetin) - Antioxidants that reduce oxidative stress, a common issue in diabetes.
- Alkaloids - Help regulate glucose levels and enhance insulin secretion.

Pharmacological activities

- Antidiabetic: Lowers blood sugar by improving insulin sensitivity and mimicking insulin action.
- Antioxidant: Reduces oxidative stress, helping prevent complications associated with diabetes.
- Anti-inflammatory: Alleviates inflammation, which is linked to diabetic complications like neuropathy.
- Hypolipidemic: Helps in regulating cholesterol and triglyceride levels.
- Antimicrobial: Exhibits antibacterial and antifungal properties.(64)

Terminalia Catappa linn.

Fig No. 5 ***Terminalia Catappa linn.***

Scientific classification

Kingdom	Plantae
Clade	Tracheophytes
Clade	Angiosperms
Clade	Eudicots
Clade	Rosids
Order	Myrtales
Family	Combretaceae
Genus	Terminalia
Species	T. catappa

Chemical constitute

- Tannins - Have antioxidant and anti-inflammatory properties, helping to reduce blood sugar levels and diabetic complications.
- Flavonoids (e.g., Quercetin, Kaempferol) - Improve insulin sensitivity and have antioxidant effects.
- Ellagic acid - A polyphenolic compound with antidiabetic and antioxidant properties that help reduce oxidative stress.
- Alkaloids - Help regulate blood glucose levels and improve metabolic function.
- Phenolic acids - Contribute to lowering blood sugar and offer antioxidant effects.

Pharmacological activities

- Antidiabetic: Helps lower blood sugar levels and improve insulin sensitivity.
- Antioxidant: Reduces oxidative stress, preventing complications associated with diabetes.
- Anti-inflammatory: Alleviates inflammation, which helps manage diabetic complications.
- Hypolipidemic: Helps regulate cholesterol and triglyceride levels.
- Hepatoprotective: Protects the liver, which may be impacted by long-term diabetes.(65)

Conclusion

Diabetes mellitus, a complicated as well as common metabolic disease, presents serious health risks because of its complex pathophysiology and related effects. The use of herbal therapies offers a promising an additional strategy, whereas traditional treatments focused on controlling insulin production and

resistance. By improving insulin function, decreasing oxidative stress, and boosting glucose metabolism, compounds like ellagic acid and cinnamic acid have significant antidiabetic potential. For the long-term care of diabetes, these natural remedies provide a complete and possibly safer approach. More investigation is necessary to clarify their mechanisms of action and examine their effectiveness and safety in clinical settings, however, in order to fully understand their therapeutic promise. More specific, sustainable, effective diabetes care may result from embracing both evidence-based natural remedies and modern medical treatments.

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