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"PHYTOCHEMISTRY & MEDICINAL PLANTS USED IN THE TREATMENT OF DIABETES MELLITUS"

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ABSTRACT

Diabetes mellitus (DM)is a chronic metabolic disease characterized by elevated blood glucose levels caused by insufficiencies in either insulin secretion or action, or both. A significant section of the world's population is affected by it, making it the major global health concerns. Due to its long-term complications, diabetes management is an important area for the medical research, which include retinopathy, neuropathy and cardiovascular disorders. Although many synthetic drugs are available to treat diabetes mellitus, long-term use of drugs can occasionally be ineffective and have a number of side effects. The use of natural or herbal remedies, particularly medicinal plants, is becoming more popular as a safer and more effective way to treat this illness. For centuries, traditional medical systems have employed medicinal plants to regulate blood levels of glucose. These plants are rich amount of phytochemicals and various substance are present,such as terpenoids, flavonoids,tannins,alkaloids, Saponins, and phenolic compounds. These phytochemicals have potent antidiabetic properties and aid in regulating glucose metabolism and secretion of insulin through a variety of mechanisms. They may protect pancreatic β-cells from oxidative damage, enhance insulin secretion, and improve the insulin sensitivity, and reduce intestinal glucose absorption. As a result, studies on phytochemicals derived from plants have grown in significance in the contemporary era.

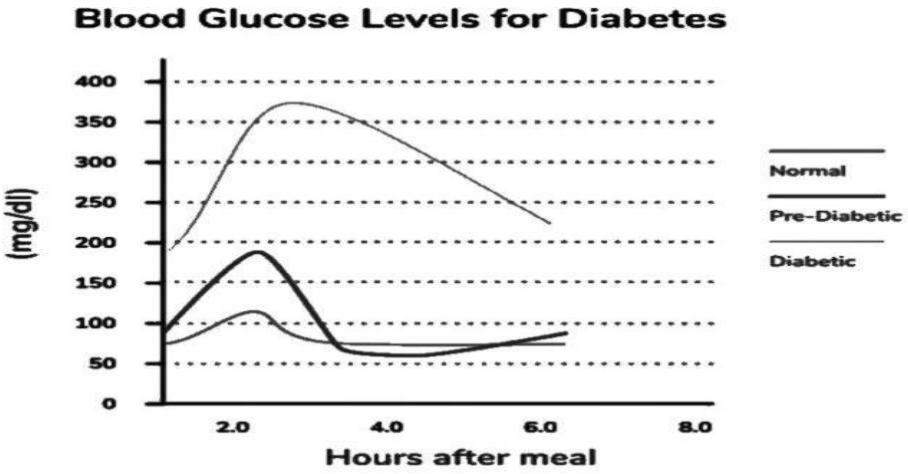
KEYWORDS: Phytochemicals, insulin sensitivity, medicinal plants, diabetes mellitus, herbal medicines.

INTRODUCTION

Elevated blood glucose levels brought on by either decreased insulin action or secretion, or both, are the hallmark of diabetes mellitus, a chronic metabolic disease. Diabetes mellitus is one of the most significant non-communicable diseases in the world and a major public health concern. According to estimates from the International Diabetes Federation, 537 million adults worldwide had diabetes in 2021, and this number is expected to rise significantly in the years to come[1].

The three primary forms of diabetes are type 1, type 2, and gestational diabetes. The majority of diabetes cases are type 2, which is primarily brought on by lifestyle choices like inactivity, poor eating habits, and obesity[2].Persistent hyperglycemia in diabetic patients can have several harmful effects, such as impaired vision, cardiovascular issues, kidney damage, and nerve dysfunction. Conventional antidiabetic drugs that are commonly prescribed to control blood glucose levels include metformin, insulin, and sulfonylureas[3].

For centuries, conventional medical Traditional Chinese medicine, Ayurveda, Unani medicine have all made extensive use of medicinal plants. These plants contain phytochemicals, which are physiologically active compounds that give them their therapeutic qualities. Among the classes of naturally occurring chemicals are flavonoids, alkaloids, terpenoids, phenolic compounds, tannins, glycosides, and saponins, elements present in plants. plants. It is known that these compounds have a range of pharmacological attributes like antioxidant, anti-inflammatory, and anti-diabetic properties[4].



Graph no.1 Blood glucose levels.

Phytochemicals from medicinal plants can help treat diabetes in a number of ways, according to numerous studies. These mechanisms include stimulating insulin secretion from pancreatic

β-cells, improving insulin sensitivity, improving glucose (sugar) uptake in peripheral tissues, and inhibiting enzymes that break down carbohydrates, such as α-amylase and α glycosides additionally, several phytochemicals have strong antioxidant properties that help reduce oxidative stress, which is essential for the development, course, and complications of diabetes mellitus [3,4].

There have been reports of several medicinal plants having antidiabetic qualities, includingTrigonella foenum-graecum, Gymnema sylvestre, and Momordica charantia (bitter gourd)(fenugreek) and Azadirachta indica (neem). These plants contain significant phytochemicals, including trigonelline, charantin, gymnemic acids, and flavonoids, aid in enhancing metabolic procedures and regulate blood glucose levels [5].

Therefore, in modern pharmaceutical research, the examination of medicinal plants and their phytochemical components have drawn a lot of interest.

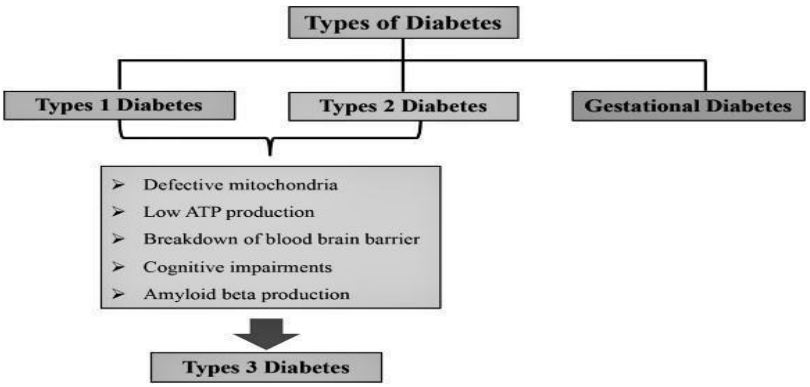
Diabetes Prevalence Forecast for the World (2000–2045)

Year's	**Estimated no of diabetes patients**
2000	151 Million
2010	228 Million
2021	537 Million
2030	643 Million
2045	783 Million

Source:- The source is the International Diabetes Federation Diabetes Atlas (2021).

Types of Diabetes Mellitus

1. Type 1 Diabetes Mellitus (T1DM)
2. Type 2 Diabetes Mellitus (T2DM)
3. Gestational Diabetes Mellitus (GDM)



1. Type 1 Diabetes Mellitus (T1DM):- Type 1 diabetes mellitus (T1DM) is an autoimmune disease that develops when the immune system destroys the insulin-producing pancreatic β-cells. As a result, the body is unable to produce enough insulin to regulate blood glucose levels. This type of diabetes usually appears in childhood or adolescence, though it can occur in adults. Insulin is necessary for people with type 1 diabetes to survive for the rest of their lives. It is believed that environmental factors like genetic susceptibility and viral infections are important in the growth and development of this disease [6].

2. Type 2 Diabetes Mellitus (T2DM):- Type 2 diabetes mellitus (T2DM) is the most prevalent form of the disease, accounting for 90–95% of cases worldwide. Its main features are impaired pancreatic β-cell function and insulin resistance. Numerous risk factors, such as obesity, sedentary

lifestyles, poor eating habits, aging, and genetic predisposition, are major contributors to type 2 diabetes. Inadequate treatment of this illness could have detrimental effects like such as retinopathy, neuropathy, kidney damage, and cardiovascular conditions[7].

3. Gestational Diabetes Mellitus (GDM):- Gestational diabetes mellitus (GDM) is the term used when glucose intolerance is first discovered during pregnancy. Hormonal shifts that interfere with It usually occurs in the second or third stage trimester due to increased insulin activity and insulin resistance. Although blood glucose levels usually return to normal after delivery, women with gestational diabetes mellitus are more likely to develop type 2 diabetes in the future. Additionally, Uncontrolled gestational diabetes increases the risk of problems such as early birth, macrosomia,and metabolic disorders in new-borns [8].

FDA approved drugs used in the treatment of diabetes mellitus:- Numerous pharmaceutical agents have been approved in the United States. The Food and Drug Administration for the management of diabetes. These medications are primarily used to regulate blood glucose levels by either increasing insulin secretion, increasing insulin sensitivity, or reducing the body's absorption and reabsorption of glucose.

Table no.01 lists the main FDA-approved medication classes used to treat diabetes mellitus.

S.No.	Drug's classes	Examples of approved Drug's	Mechanism of action of drugs	Reference
1.	Biguanides	Metformin	Enhances insulin sensitivity and reduces hepatic glucose production.	(9)

2.	Sulfonylureas	Glyburide, Glipizide	Encourage pancreatic βcells to secrete insulin	(10)
3.	Meglitinides	Nateglinide, Repaglinide	Rapid abstract of insulin release	(11)
4.	Thiazolidinediones	Pioglitazones	Boost muscle and adipose tissue's sensitivity to insulin	(12)
5	DPP-4 Inhibitors	Sitagliptin Saxaglitin	Boost insulin secretion and raise incretin levels	(13)
6	GLP-1 Receptor Agonists	Liraglutide	Enhance glucosedependent insulin secretion	(14)
7.	SGLT2 Inhibitors	Canagliflozin	Reduce glucose reabsorption in kidneys	(15)

LITRATURE REVIEW :-

1.. JP et al.(2025): It has published the article and define the trizepide sersus in senaglutide once weekly in patient with type-2 diabetis mellitus. The object oassessment in questionry Series about type -2 diabetes mellitus. Because diabetis mellitus is a metabolic disorder and Affect the health of patients. In World about millions of people can die due to this disease .this Drugs can used to treat the type -2 diabetis mellitus.

2. J. Meta-Anal et al.(2023): In this area focused on their review in genetic, environmental and lifestyle factors. Unhealthy life style can cause various types of diseases so life style management are very important. In this review mainly focused on genetic factors basically diabetis are transferred from one generation to another generation through genetic factors. So multidisciplinary plinary are essential to reduce it's impact.

3. Z. Ur Rehman et al.(2020): Has carried out an awareness survey about diabetes and how to manage it.In Peshawar, Pakistan, among diabetic patients. This study's primary goal was to Assess and contrast the degree of knowledge about diabetes mellitus and its consequenc and management in both male and female diabetic patients in Peshawar, Pakistan, and they the conclusion that both male and female diabetics had a low general level of awareness, with female patients having a lower level than male patients.

4. A. Patowary et al.(2016): has investigated the evaluation of diabetes mellitus knowledge And awareness in Majuli, Assam, India: The purpose of this study is to determine the degree of diabetes mellitus knowledge and awareness among the residents of the Indian river island Of Majuli in Assam. This information will be very helpful in identifying knowledge gaps that May need to be filled with more work. It is possible to draw the conclusion that, despite the

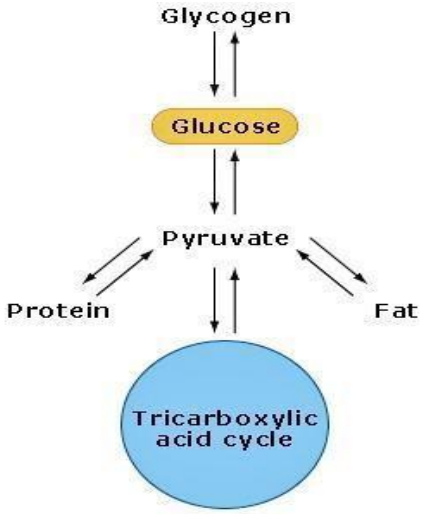
government and other organizations' efforts to raise public awareness of the prevalence of various diseases, their effects on the study area's society falls short of expectat.

5. S. Mustafa et al.(2016): has carried out research on Kuwaiti adolescents' awareness and Understanding of diabetes mellitus. The purpose of this study was to assess adolescents' awareness and knowledge of diabetes, which will greatly aid in lowering their risk of developing the condition and its complications. 4333 students in all made contributions. The Students' primary score was 63.2% of the highest possible score. The scores for the section On "General knowledge about diabetes" were 71.0%. 63% of respondents said they knew the Risk factors for diabetes, 55.8% said they knew the symptoms and complications, 62.7% said They knew about treatment and management, and 72.3% said they knew how to monitor diabetes.

MECHANISM OF DIABETES MELLITUS:

1. Gluccose Metabolism:-The basic biological process of glucose metabolism whereby glucose is produced and used by the human body as its primary energy source. Proteins, fats, and carbohydrates are the main sources of glucose, which circulates in the bloodstream prior to entering bodily cells via particular transport mechanisms within the membrane of the cell Glycolysis, glycogenesis, glycogenolysis, and gluconeogenesis are some of the important biochemical pathways involved in this process[21].

ATP is the energy produced by glycolysis by converting glucose to pyruvate. The muscles and liver change blood that has too much glucose in it into glycogen for storage via glycogenesis. During a fast, the glucagon in order to release glucose and maintain blood sugar levels, hormones promote the breakdown of glycogen. The liver uses precursors that are not carbohydrates to produce glucose through gluconeogenesis when there is insufficient energy or starvation. This process is mostly under control by the hormones insulin, glucagon, and cortisol. Generally speaking, glucose metabolism balances the glucose production, utilization, and storage by the body to maintain energy homeostasis [22].



2. Glucose transport and defects in transport activity :- The regulated mechanism through a glucose transport is the process by which molecules enter body cells with the help of Specialized carrier proteins known as glucose transporters (GLUT1–GLUT5). Of these, the Insulin-dependent and insulin-mediated glucose absorption, particularly in the heart, adipose tissue, and skeletal muscles, depends on the transporter GLUT4.

This process ensures that glucose is effectively absorbed into cells to maintain adequate energy levels. Impaired insulin signaling reduces cell uptake and utilization of glucose, which in turn reduces GLUT4 translocation to the cell membrane. Therefore, inappropriate glucose transport disrupts glucose homeostasis, which may ultimately result into the development of metabolic disorders such as diabetes mellitus [23].

3. Hormonal regulation of glucose metabolism :- Glucagon and insulin are the two primary pancreatic hormones that work together to preserve blood glucose homeostasis and control glucose metabolism. By promoting the absorption of glucose into adipose and muscle tissues and stimulating the pancreatic β cells secrete insulin, which lowers blood glucose levels and aids in the synthesis of glycogen in the muscles and liver. However, when low blood sugar or fasting occurs, pancreatic glucagon, which is released by α-cells, promotes glycogen breakdown and the synthesis of gluconeogenesis to produce glucose [24].

These complementary mechanisms ensure a steady supply of energy for body cells. Thus, the equilibrium between insulin and glucose is necessary to maintain normal glucose levels glucagon metabolism. Metabolic diseases like diabetes mellitus arise when this hormonal balance is disrupted, such as when β-cell dysfunction or insulin resistance occur. In addition to glucagon and insulin, growth hormone, cortisol, and adrenaline metabolism also affect glucose by modifying its synthesis and utilization during fasting or stress [25].

IMPORTANT MEDICINAL PLANTS :- Plants with naturally occurring bioactive compounds that can aid in the prevention and treatment of a variety of illnesses are known as medicinal plants. Due to their therapeutic qualities, these plants have been utilized for many centuries in traditional medical systems. Alkaloids, flavonoids, tannins, glycosides are among the abundant phytochemicals that give them their therapeutic properties. Numerous medicinal plants have been shown to help control blood glucose(sugar) levels and enhance general metabolic health in the treatment of diabetes mellitus[25].

Table no.02 Medicinal plants with antidiabetic activity and their major Phytochemicals.

S.No.	**Common Name**	**Botanical Name**	**Part used**	**Major Phytochemicals**	Antidiabetic **role**
1.	Gumar	Gymnema Sylvester	Leaves	Gymnemic acids, Saponins, flavonoids	enhances insulin secretion and decreases the absorption of glucose
2.	Drumstick	Moringa oleifera	Leaves	Flavonoids, quercetin,chlorogenic acid	enhances insulin sensitivity and lowers blood sugar
3.	Bitter gourd	Momordica Charantia	Fruits	Charantin, alkaloids	lowers blood sugar and functions as an insulin-like substance.
4.	Neem	Azadirachta Indica	Leaves	Nimbin,Nimbidin, Flavonoids	Helps to control blood glucose level
5.	Jamun	Syzygium cumini	Seeds	Jamboline, ellagic acid, flavonoids	Helps to conversion of starch to glucose
6.	Fenugreek	Trigonella foenumgraecum	Seeds	Trigonelline, Saponins	Improve glucose tolerance and insulin action
7.	Aloe vera	Aloe vera	Leaves	Aloin, anthraquinone	Reduce fasting blood glucose level

METHODOLOGY (PREPARATION OF HERBAL FORMULATION) :-

Medicinal plants with antidiabetic qualities were chosen to create the herbal formulation. To create a homogenous mixture, the plant or materials were thoroughly cleaned, shade-dried, and finely powdered. A polyherbal composition was created by blending the powdered ingredients with appropriate excipients. The mixture was then processed to create tablets with the right stability and consistency[26].

Table no.03:- Composition of polyherbal tablet.

S.No.	Ingredients	Quantity (for 100) Tablets
1.	Gurmar leaf powder	30gm
2.	Drumstick leaf powder	30gm
3.	Bitter gourd fruit powder	30gm
4.	Starch	5gm
5.	Talc	3gm
6.	Magnesium stearate	2gm

Method for preparation of polyherbal tablets:-

1.Preperation of plant powder:- A mechanical grinder was used to wash, shade-dry, and powder the fruits of Momordica charantia and the leaves of Gymnema sylvestre and Moringa oleifera. The powder was passed through a 60-mesh sieve to obtain uniform particle size.

2.weighing of ingredients:- In accordance with the formulation table, the necessary amount of each plant powder and excipient was precisely weighed.

3.Mixing of ingredients:- To create a consistent polyherbal mixture, all plant powders and this were thoroughly combined in a sanitized mortar. After that, starch was added as a binding(For better result)agent and thoroughly mixed.

4.granulation:- Granules were created by passing a damp mass through a sieve after a small amount of distilled or purified water was added. The granules were dried at room temperature.

5.Lubrication:- Following drying, the granules were gently mixed with talc and magnesium stearate to enhance their flow characteristics.

6.Tablet compression:- To create polyherbal tablets with a consistent weight, the prepared granules were compressed using a tablet compression machine.

7.Evalution of tablet's :- To guarantee quality, the prepared tablets were assessed for factors like weight fluctuation, hardness, friability, and disintegration time.

RESULT:- The physical and pharmaceutical properties of the polyherbal tablet formulation made with Gymnema sylvestre, Moringa oleifera, and Momordica charantia were satisfactory. The tablets had a smooth surface with no obvious flaws or cracks, were light green in color, and had a consistent appearance. The tablets' average weight was determined to be within the permissible pharmacopeia limits, suggesting that the ingredients were distributed uniformly.

The tablets' friability value was within the acceptable range, indicating good mechanical strength, and their hardness was sufficient to withstand mechanical handling. The tablets' disintegration time was found to be within the typical ranges, guaranteeing appropriate tablet breakdown following administration.

The chosen medicinal plants may have antidiabetic properties due to the presence of bioactive phytochemicals like flavonoids, alkaloids, and saponins. The produced polyherbal tablets showed good quality and stability based on the formulation and evaluation criteria, indicating their potential utility as a natural therapeutic option for the management of diabetes mellitus.

DISCUSSION:- The current study demonstrates how certain medicinal plants can be used to create a polyherbal formulation for the treatment of diabetes mellitus. Plants with well-known antidiabetic qualities, like Gymnema sylvestre, Moringa oleifera, and Momordica charantia, have long been used in a variety of herbal remedies. Because these plants contain a variety of bioactive phytochemicals, combining them in a single formulation may increase their therapeutic efficacy.

These plants contain phytochemicals that are known to be crucial for controlling blood glucose levels and enhancing insulin sensitivity, including flavonoids, alkaloids, saponins, and phenolic compounds. Because several plant components can act through various mechanisms to produce a combined therapeutic effect, using a polyherbal approach is frequently regarded as beneficial.

The formulation process was appropriate for creating a stable herbal dosage form, according to the evaluation of the prepared Procedure.

CONCLUSION:- Phytochemicals from medicinal plants are used to treat diabetes mellitus plants are essential. Alkaloids are among the many bioactive compounds present in medicinal plants Strong antidiabetic effects are shown by flavonoids, tannins, saponins, and phenolic compounds these phytochemicals help regulate blood glucose levels through a number of mechanisms, including enhanced insulin secretion, increased insulin sensitivity, inhibition of carbohydratedegrading enzymes, and protection of pancreatic β-cells from oxidative damage. The medicinal properties of plants such as Momordica, Gymnema sylvestre, and Moringa oleifera many studies have been conducted on the use of charantia and Azadirachta indica in the treatment of diabetes.The natural phytoconstituents of these plants offer a more affordable and secure substitute for many synthetic medications. Additionally, these plant-based

compounds often show fewer negative have additional benefits like antioxidant and anti-inflammatory qualities. All things considered, there is a lot of promise for developing new antidiabetic therapies thanks to the phytochemicals present in medicinal plants. Further scientific research, clinical trials, and suitable standardization are needed to fully explore their therapeutic potential. By fusing traditional knowledge with modern scientific techniques, safe and efficient plant-based treatments for diabetes mellitus may be discovered in the future.

Future Prospective :-There has been an increase in interest in the application of medicinal phytochemicals found in plants can be used to treat diabetes. Despite the fact that many plant-based further research is required to fully understand the mechanisms of action and therapeutic efficacy of substances that have shown encouraging antidiabetic activity in studies. Future studies should concentrate on isolating, identifying, and characterizing bioactive phytochemicals with glucose-lowering properties. Pharmacological studies, clinical trials examples of cutting-edge scientific techniques that will be essential include analysis and molecular research in verifying these natural substances' efficacy and safety. Furthermore, plant-derived modern drug delivery may improve the bioavailability and effectiveness of antidiabetic agents techniques. Additionally, new and safer antidiabetic drugs could be found by combining modern pharmaceutical research with traditional herbal knowledge. Plants used for medicine have the potential to provide diabetes treatment options that are both affordable and sustainable with continued research and technological advancements.

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