International Research Journal of Pharmacy and Medical Sciences
ISSN (Online): 2581-3277

# Exploring Herbal Remedies for Diabetes Management: A Comprehensive Review of Efficacy, Epidemiology, and Quality of Life Considerations

V. V. Rajesham[*1], A. Mutya Aparna[1], Potharaju Kalyani[1], M. Balaji[1], K. Sreenath Reddy[1], T. Rama Rao[1]

[*1]CMR College of Pharmacy, Kandlakoya (V), Medchal (M & D), Hyderabad– 501401, Telangana, India

***Abstract*—***Diabetes mellitus, characterized by abnormal insulin function or production, poses a significant global health challenge, ranking among the leading causes of mortality worldwide. Its complications, such as hyperglycemia-induced damage to various bodily systems, underscore the urgency of effective management strategies. Herbal treatments have gained attention due to concerns about adverse effects associated with conventional medications. The present study aims to compare the quality of life (QoL) assessment of patients using herbal and allopathic additionally, we outline the epidemiology, etiology, and pathophysiology of diabetes, underscoring the rising global prevalence and associated risk factors. The role of herbal plants in diabetes management is discussed, emphasizing their potential as effective and safer alternatives to conventional treatments. We review the hypoglycemic effects of several medicinal plants, including Trigonella foenum-graecum, Momordica charantia, Eugenia jambolana etc, shedding light on their mechanisms of action and therapeutic benefits. Overall, our findings underscore the importance of individualized approaches in diabetes management and highlight the potential of herbal medicines in improving patient outcomes. Customized tools like SF-36 (Short-form survey) and QOLID (Quality of life instrument for indian diabetic patients) hold promise for evaluating the efficacy of herbal medications, warranting further research in this direction to enhance clinical effectiveness and patient satisfaction.medicines, employing generic (SF-36) and disease-specific (QOLID) tools. Our analysis of SF-36 health profiles reveals that herbal treatment places a greater emphasis on patient comfort, particularly in domains related to treatment satisfaction (TS) and general health (GH), thereby enhancing overall QoL. QOLID data further corroborates these findings, indicating increased treatment satisfaction, vitality, and reduced symptom irritability with herbal medicine compared to synthetic medication. Notably, herbal therapy demonstrates superior QoL in most specific domains except diet satisfaction (DS), suggesting areas for further research and clinical improvement.*

***Keywords*—** *Diabetes mellitus, prevalence, incidence, herbal treatment, type 1 diabetes, type 2 diabetes, gestational diabetes, monogenic diabetes, therapeutic efficacy, quality of life.*

## I. INTRODUCTION

Diabetes is a chronic disease that arises from the body's inability to adequately utilise the insulin produced by the pancreas or from insufficient production of it. Hyperglycemia, sometimes referred to as elevated blood glucose or elevated blood sugar, is a frequent consequence of uncontrolled diabetes mellitus that eventually causes major harm to numerous bodily systems, particularly the blood vessels and neurons. It is currently the sixth greatest cause of death globally and is becoming one of the most common illnesses affecting people, second only to cardiovascular disorders (WHO). From an etiological perspective, diabetes mellitus (DM) is a diverse illness typified by aberrant insulin resistance and glucose homeostasis. Diabetes is mostly caused by intricate systems [1]. The pancreatic mass is made up of around 90 percent exocrine and 2–5% endocrine components, respectively. Endocrine dysfunction and aberrant glucose metabolism can result from disorders of the exocrine pancreas, such as pancreatitis and pancreatic cancer. Diabetes mellitus (DM) has been linked to acute pancreatitis (AP). The data on the prevalence of diabetes following AP, however, is debatable and ranges from a few uncommon cases to over sixty percent of all patients acquiring DM [2].

Diabetes means "to pass through" in Greek, while the Latin term for honey (sugar) is mellitus. With about one fatality every ten seconds, diabetes is a major cause of protracted illness and early mortality. It also takes more lives annually than HIV/AIDS. The standard and the extensively disparate data collection methods across the globe make it extremely difficult to determine an accurate measure of prevalence; however, according to recent surveys, the prevalence of adult diabetes will rise from 4% in 1995 to 6.4% by 2025 [3]. As the condition worsens, tissue or vascular damage develops, which can result in serious complications from diabetes, including ulceration, neuropathy, retinopathy, and nephropathy. As a result, diabetes encompasses a broad spectrum of diverse illnesses [4].

The adverse effects of oral hypoglycemic medications for the treatment of diabetes mellitus have led to a current surge in interest in herbal treatments. Therefore, the majority of conventional herbal medications used to treat diabetes are derived from plants. Around one thousand plant species are utilized as traditional medicine to treat diabetes. Plant or herbal supplies are abundant in flavonoids, phenolic compounds, terpenoids, coumarins, and other components that lower blood sugar levels [5]. Only a few numbers of these herbal plants have had their mechanistic activities defined, thus further research is necessary. There are few reports on their impact on human pancreatic amylase (HPA), if any, and



V. V. Rajesham, A. Mutya Aparna, Potharaju Kalyani, M. Balaji, K. Sreenath Reddy, and T. Rama Rao, "Exploring Herbal Remedies for Diabetes Management: A Comprehensive Review of Efficacy, Epidemiology, and Quality of Life Considerations," *International Research Journal of Pharmacy and Medical Sciences (IRJPMS)*, Volume 7, Issue 2, pp. 67-73, 2024.

the majority of the tests have been conducted on salivary and porcine pancreatic α-amylase (PPA) [6].

*Types of Diabetes*

Each clinical stage, etiological type of diabetes, and many classifications of hyperglycemia are included in the kinds. The new diabetes classification has stages that correspond to the various symptom severities in individual patients with any of the disease processes that might result in diabetes. These were reflected in the tenth revision of the International Classification of Diseases (ICD-10), which was released in 1992, and the subsequent International Terminology of Diseases (IND), which was released in 1991 [7].

The following broad categories can be used to group diabetes:

1. Type 1 diabetes (IDDM), which typically results in complete insulin insufficiency, is caused by autoimmune destruction of β-cells.
2. Diabetes type 2 (NIDDM, caused by a progressive loss of sufficient β-cell insulin secretion, often in conjunction with insulin resistance)
3. Diabetes mellitus associated with gestation (diabetes not evidently associated with overt diabetes prior to pregnancy) diagnosed in the second or third trimester of pregnancy
4. Certain types of diabetes that result from other causes, such as drug- or chemical-induced diabetes, diseases of the exocrine pancreas (like pancreatitis and cystic fibrosis), monogenic diabetes syndromes (like neonatal diabetes and maturity-onset diabetes of the young), and organ transplant-related diabetes [8].

*Etiology of Diabetes*

The MHC gene encodes a genetic vulnerability to IDDM-like disorders. Other genetic variables influence an effector lymphocyte population that targets the β-cell. This effector cell is typically suppressed and only becomes active when there is no regulatory mechanism in place. Other factors, like as the aging-gene family, may influence the thymus's development and govern the entire process. Susceptibility to NIDDM varies based on several factors. The obesity gene family is more important than the MHC. Other important aspects include β-cell response to glucose, β-cell regeneration, insulin receptor loss, and post receptor abnormalities [9]. Monogenic diabetes is characterized by decreased insulin production from pancreatic β-cells due to a single gene mutation. These kinds of diabetes are genetically diverse, and include maturity-onset diabetes of the young (MODY), permanent or temporary neonatal diabetes, and mitochondrial diabetes. MODY is the most frequent kind of monogenic diabetes, caused by the autosomal dominant transmission of one of multiple genes that code for a main insulin secretion deficiency [10].

*Epidemiology of Diabetes*

There isn't a globally accepted standard research methodology for the study of diabetes mellitus epidemiology. The epidemiological studies that have been published thus far have been conducted in various locations (geographical localization) and over different spans of time (chronological extent), looking into the population as a whole or a specific age group, as well as specific nationalities and ethnic groups.

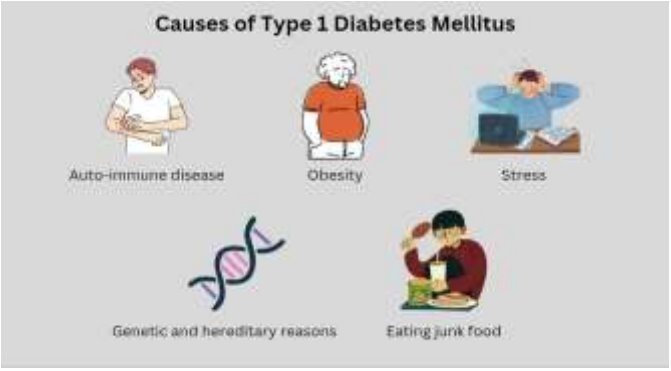


Figure 1: Causes of T1DM

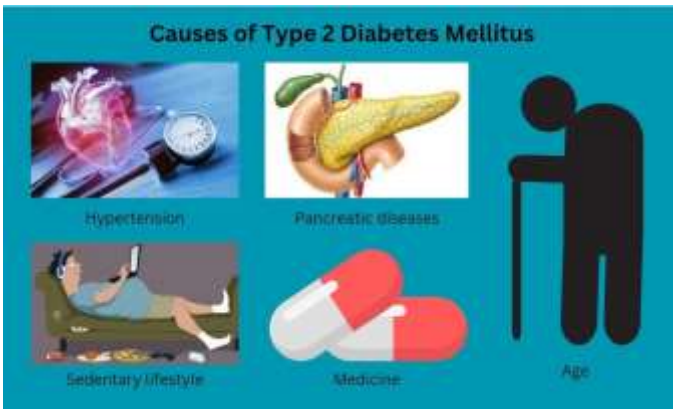


Figure 2: Causes of T2DM

These investigations have produced important but widely differing statistical data, either immediately or over the course of one or more years. Globally, the prevalence of diabetes mellitus has increased over the past 40 years, and this trend is expected to continue across all age categories, across all ethnic groups, and for all genders. Particular attention was paid to the observed rise in type 2 diabetes mellitus cases (T2DM) [11].

According to the most recent data available from the International Diabetes Federation, 415 million persons worldwide between the ages of 20 and 79 are anticipated to have diabetes in 2015. This figure is projected to increase to 642 million by 2040, with a rise in prevalence from 8.8 to 10.4%. Even though DM is highly common and can be diagnosed in up to 193 million people, nearly half of all DM patients are not aware that they have the disease. Geographically, 3.8% of Africa, 7.3% of Europe, 10.7% of the Middle East and North Africa, 11.5% of North America and the Caribbean, 9.6% of South and Central America, 9.1% of Southeast Asia, and 8.8% of the Western Pacific have age-adjusted prevalence of diabetes mellitus [12].

From an epidemiological perspective, the first important finding is that merely avoiding overweight and obesity might prevent over 80% of diabetes cases. The second important factor is that the disease tends to start earlier in life according to global trends. The third reason is that older people, who use the greatest amount of health care resources overall, are



V. V. Rajesham, A. Mutya Aparna, Potharaju Kalyani, M. Balaji, K. Sreenath Reddy, and T. Rama Rao, "Exploring Herbal Remedies for Diabetes Management: A Comprehensive Review of Efficacy, Epidemiology, and Quality of Life Considerations," *International Research Journal of Pharmacy and Medical Sciences (IRJPMS)*, Volume 7, Issue 2, pp. 67-73, 2024.

primarily responsible for the rising prevalence of diabetes in developed nations. Diabetes is becoming more prevalent globally, especially in developing nations [13].

*Prevalence Algorithms*

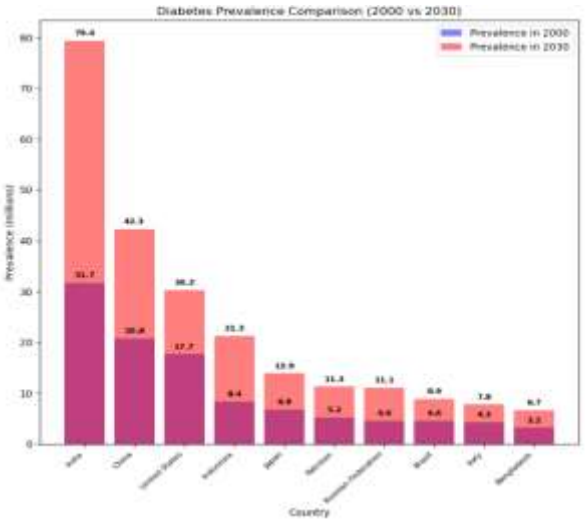


Figure 3: Countries With the Highest Estimated Prevalence of Diabetes, 2000 vs 2030

According to projected bar graph, over 82 million persons over 64 in poor nations and over 48 million in affluent nations will have diabetes by 2030. By 2030, 366 million individuals worldwide are expected to have diabetes. India, China, and the United States remain the top three countries with the largest number of people with DM [14].

*Pathophysiology of Diabetes*

The body's ability to use insulin and the amount of insulin present are factors in the pathophysiology of diabetes. Type 1 diabetes is characterized by an absolute lack of insulin, whereas peripheral tissue resistance to insulin's actions characterizes type 2 diabetes [15]. Plasmid concentrations of glucose signal the central nervous system to release stored energy, which is part of the pathophysiology of diabetes. It is dependent on arterial plasma glucose, the rate at which plasma glucose concentrations decrease, cerebral blood flow, tissue integrity, and other accessible metabolic fuels. Autonomic activity increases in response to low plasma glucose [16].

The rate at which the autoimmune destroys the pancreatic β-cells determines how type 1 diabetes mellitus progresses as a result. Patients with diabetes may experience a serious condition known as diabetic ketoacidosis (DKA). The body breaks down fat more quickly than usual, which causes the fat to be converted by the liver into ketones and acidifies the blood. Insulin resistance and deficiency, which have been connected to high levels of fatty acids and inflammatory cytokines in the plasma, are key components of the pathophysiology of type 2 diabetes mellitus. These factors result in inadequate glucose transport into target cells, increased fat breakdown, and elevated production of glucose in the liver [17].

While there is a period of relative insulin sensitivity in the early stages of pregnancy, this sensitivity dramatically declines in the second and early third trimesters. As a result, the insulin-dependent glucose absorption in tissues like muscle and fat is decreased, and the mother's body adapts to save carbohydrates for the developing fetus. In women without a history of diabetes, the insufficient insulin secretory response often results in hyperglycemia and the diagnosis of Gestational Diabetes Mellitus (GDM) [18]. Since chronic insulin resistance during pregnancy often precedes β-cell malfunction, both tissue insulin resistance and β-cell impairment play a crucial role in the pathogenesis of GDM. These deficits typically predate pregnancy and have the potential to worsen over time, increasing the risk of type 2 diabetes after pregnancy. Numerous other organs and systems either cause GDM or are impacted by it. The brain, fatty tissue, muscle, liver, and placenta are a few of those [19].

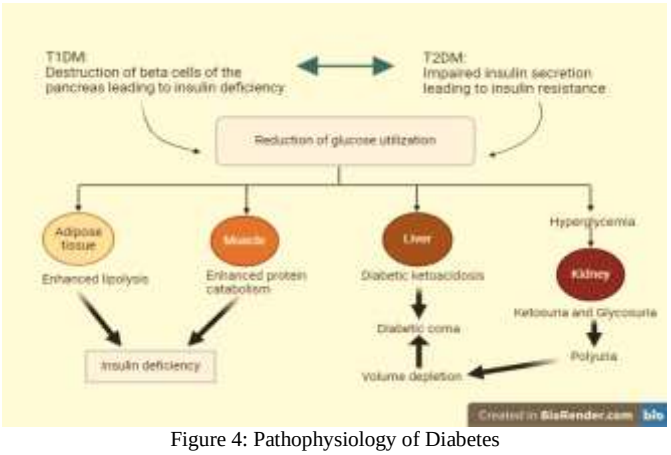


Figure 4: Pathophysiology of Diabetes

*Statistical data related to DM*

Current data on the prevalence and incidence of diabetes and prediabetes, risk factors for complications, acute and long-term complications, mortality, and expenditures may be found in the "*National Diabetes Statistics Report*".

*Fast Facts on Diabetes*

*Diabetes*

- Total: 38.4 million people have diabetes (11.6% of the US population)
- Diagnosed: 29.7 million people, including 29.4 million adults
- Undiagnosed: 8.7 million people (22.8% of adults are undiagnosed)

*Prediabetes*

- Total: 97.6 million people aged 18 years or older have prediabetes (38.0% of the adult US population)
- 65 years or older: 27.2 million people aged 65 years or older (48.8%) have prediabetes

A 2019–2021 survey carried out in India revealed that 4% of men and women between the ages of 35 and 49 reported having diabetes. Indians aged 15 to 19 had the lowest prevalence of diabetes throughout the same period [20].

Due to the lack of epidemiologically reliable data on the prevalence and incidence of type 1 diabetes worldwide and in the area, the special study was planned and carried out as a



V. V. Rajesham, A. Mutya Aparna, Potharaju Kalyani, M. Balaji, K. Sreenath Reddy, and T. Rama Rao, "Exploring Herbal Remedies for Diabetes Management: A Comprehensive Review of Efficacy, Epidemiology, and Quality of Life Considerations," *International Research Journal of Pharmacy and Medical Sciences (IRJPMS)*, Volume 7, Issue 2, pp. 67-73, 2024.

systematic review and meta-analysis, allowing for a more effective geopolitical mapping of policies related to the disease's prevention and treatment. A librarian to look at the incidence and prevalence of type 1 diabetes worldwide for this systematic review and meta-analysis carried out a thorough search of resources [21].

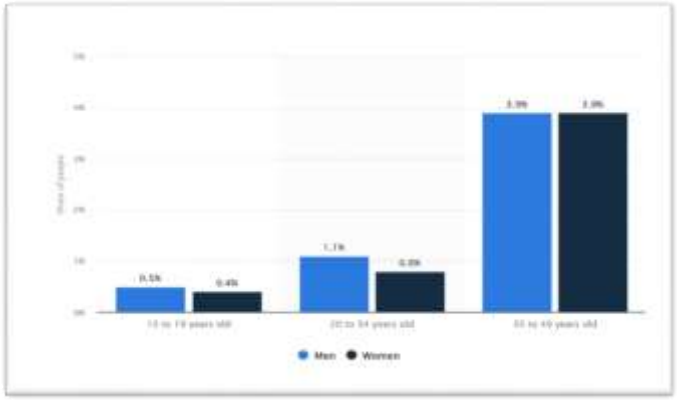


Figure 5: Share of the Indian population with diabetes between 2019 and 2021, by age group and gender.

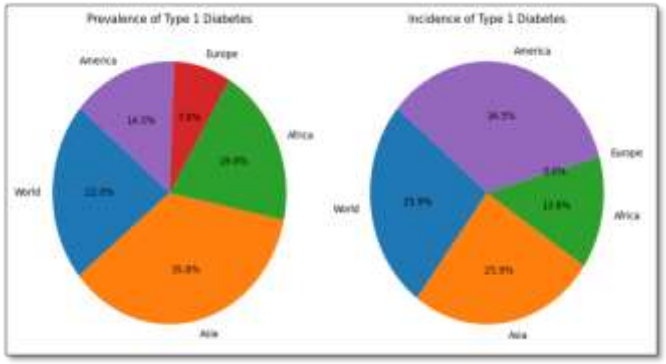


Figure 6: Pie charts showing the prevalence and incidence of type 1 diabetes

*Role of Herbal Plants in Treating Diabetes*

Numerous plants have long been recognized as a primary source of effective anti-diabetic medications. However, insulin and artificial oral hypoglycemics are the primary methods of managing diabetes. Nevertheless, they showed notable adverse reactions and were unable to stop the progression of its problems. This is the driving force behind the search for substitutes, primarily from the plant kingdom, with less severe or perhaps no adverse effects [22]. The benefits of medicinal plants with hypoglycemic effects in the treatment of diabetes mellitus have been demonstrated by numerous investigations. Furthermore, some of the newly developed bioactive agents derived from several plants have demonstrated antidiabetic action in recent years that is more effective than oral hypoglycemic medications used in clinical therapy [23]. It has been reported that the following substances have antidiabetic activity: polysaccharides; peptides; alkaloids; glycopeptides; triterpeniods; amino acids; steroids; xanthone; flavonoids; lipids; phenolics; coumarins; iridoids; alkyl disulphides; inorganic ions; and guanidines. Up to 600 traditional plant remedies for diabetes have been documented in India as of late [24].

Native vegetables and medicinal plant products, such as amalanth leaves, hare lettuce leaves, nightshade leaves, spider plant leaves, okra pods, moringa leaves and seeds, soursop leaves, black plum back, avocado seed, and lemongrass, were the most widely used traditional medicines [25]. Because of their anti-diabetic properties, medicinal plants and herbs are being used in extract form. Numerous clinical investigations have verified that extracts from medicinal plants exhibit anti-diabetic properties and restore the function of pancreatic β-cells [26]. According to ethano-pharmacological studies, traditional medicine employed over 1200 herbs for their purported hypoglycemic action, albeit few of these have been the subject of scientific or medical analysis to determine their effectiveness [27].

*1. Trigonella foenum-graecum*

Rats with normal and alloxan-diabetic blood were used to investigate the hypoglycemic potential of the aqueous and alcoholic extracts of *Trigonella foenum-graecum* leaves. When both normal and alloxan-diabetic rats were given graded quantities (0.06, 0.2, 0.5, 1 g/kg, i.p. and 1, 2, 8 g/kg, p.o.) of the *Trigonella foenum-graecum* leaf aqueous extract, there was a noticeable reduction in blood glucose concentration. However, when 0.8 g/kg of the ethanolic leaf extract was administered intraperitoneally to diabetic rats, the blood glucose concentration of the rats decreased significantly ($p<0.02$) only at the 2- and 24-hour marks. In contrast, the ethanolic leaf extract of *Trigonella foenum-graecum* did not lower blood glucose levels in normal rats [28].

*2. Momordica charantia*

In India and other Asian nations, *Momordica charantia* is frequently used as an antidiabetic and an antihyperglycemic medication. In a number of animal models, fruit pulp, seed, leaf, and whole plant extracts were demonstrated to have hypoglycemic effects. When polypeptide p was given subcutaneously to langurs and humans, it significantly reduced blood sugar levels [29]. Polypeptide p was extracted from the fruit, seeds, and tissues of *M. charantia*. In both normal and STZ diabetic rats, ethanolic extracts of *M. charantia* (200 mg/kg) demonstrated antihyperglycemic and hypoglycemic effects. This could be due to stimulation of hepatic glucose-6-phosphate dehydrogenase activities and inhibition of glucose-6-phosphatase in addition to fructose-1, 6-biphosphatase in the liver [30].

*3. Allium sativum*

Garlic, a perennial herb cultivated in India, contains allicin, responsible for its pungent odor and hypoglycemic effects. Research suggests it enhances hepatic metabolism, insulin release, or insulin sparing. Administering garlic to sucrose-fed rabbits increased hepatic glycogen, reduced fasting blood glucose, and triglyceride levels, indicating potential antidiabetic benefits. Administration of it at a dose of 200 mg/kg body weight decreased significantly the concentration of serum lipids, blood glucose [31].

*4. Eugenia jambolana*

*Eugenia jambolana*, commonly known as jamun, is utilized in India as a household remedy and a key component



V. V. Rajesham, A. Mutya Aparna, Potharaju Kalyani, M. Balaji, K. Sreenath Reddy, and T. Rama Rao, "Exploring Herbal Remedies for Diabetes Management: A Comprehensive Review of Efficacy, Epidemiology, and Quality of Life Considerations," *International Research Journal of Pharmacy and Medical Sciences (IRJPMS)*, Volume 7, Issue 2, pp. 67-73, 2024.

in various herbal diabetes treatments. Extracts from its kernels exhibit significant antihyperglycemic effects, with reductions in blood glucose levels varying according to the severity of diabetes [32]. In mild diabetes cases, a 73.51% reduction is observed, while in moderate and severe cases, reductions are 55.62% and 17.72%, respectively. These effects are attributed to increased insulin secretion and inhibition of insulinase activity, with both the pulp and seeds showing hypoglycemic activity, albeit with different onset times in animal studies [33].

*5. Ocimum sanctum*

Most people refer to it as Tulsi. This herb has long been recognized for its therapeutic qualities. Both normal and alloxan-induced diabetic rats had significantly lower blood sugar levels after consuming the *Ocimum sanctum* leaf aqueous extract. When a plant extract (200 mg/kg) was taken orally for 30 days, the plasma glucose level decreased by about 9.06 and 26.4% on days 15 and 30, respectively. In diabetic rats, compared to control, the amount of glycogen in the kidneys increased tenfold, while the amounts in the skeletal muscle and liver decreased by 68 and 75%, respectively [34].

*6. Tinospora cordifolia*

It is a big, perennial climbing shrub that belongs to the Menispermaceae family. It is glabrous. It is sometimes referred to as Guduchi and is extensively available throughout India. In alloxan diabetic rats, oral administration of the extract from the roots of *Tinospora cordifolia* (*T. cordifolia*) for six weeks led to a considerable reduction in blood and urine glucose levels as well as in serum and tissue lipid levels [35]. Alloxan diabetic rats' blood glucose and brain lipid levels were decreased after an aqueous *T. cordifolia* root extract was given to them orally. Even though the aqueous extract could significantly reduce blood sugar levels in a variety of animal models when administered at a dose of 400 mg/kg, this effect was only equal to one unit of insulin per kilogram. Aqueous or alcoholic *T. cordifolia* extract has been shown to lower blood glucose levels and improve glucose tolerance in animals when given regularly [36].

*7. Eclipta alba*

Native to tropical and subtropical regions of Asia, Africa, and South America, *Eclipta alba* is a plant that is rich in flavonoids, alkaloids, triterpenes, and glycosides, among other chemical components. It is known to be an important hypoglycemic agent in rural southern India [37]. Oral treatment of *E. alba* leaf suspension at doses of 2 and 4 grams per kilogram for 60 days led to significant reductions in blood glucose, glycosylated hemoglobin, glucose-6-phosphatase, and fructose-1, 6-bisphosphatase levels in studies with alloxan-induced diabetic rats. In the liver, there was also an increase in hexokinase concentration [38].

*8. Annona squamosa*

The *Annona squamosa* leaf extract in water exhibits a range of antioxidant properties. It was given orally to rats for 30 days who had diabetes caused by streptozotocin (STZ), and it significantly decreased lipid levels, blood glucose, and lipid peroxidation. Additionally, it increased the activity of antioxidant enzymes like superoxide dismutase and catalase as well as plasma insulin. On the other hand, it caused glutathione and glutathione peroxidase activity to decline. Overall, in experimental diabetic rats, this extract is helpful in controlling blood glucose levels, raising plasma insulin levels, and favorably affecting lipid metabolism. It also helps to reduce the risk of diabetes problems brought on by lipid peroxidation and changes in antioxidant systems [39].

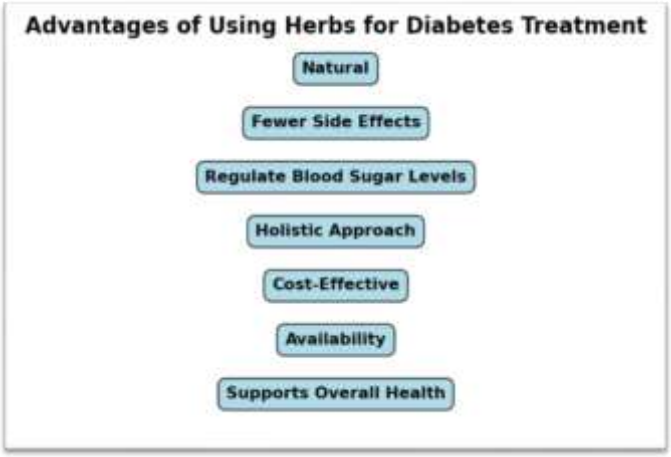


Figure 7: Advantages of Herbs

*A tool to measure quality of life for diabetic patients in India:*

It is a technique for evaluating Indian individuals' diabetes-specific quality of life (QOL). The questionnaire, which consists of 8 domains with 34 items covering all facets of quality of life such as general health (GH), physical health (PH), mental health (MH), symptom irritability (SB), financial worries (FW), diet satisfaction (DS), and physical endurance (PE), was designed to reflect both HRQOL and DSQOL. Of the eight domains, DS, SB, FW, TS, and MH are associated with DSQOL, whereas PH, PE and GH are placed under HRQOL [40].

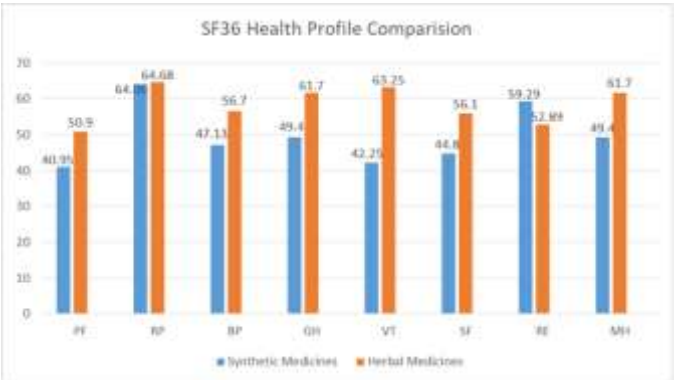


Figure 8: Pie charts showing the SF36 Health Profile of Herbal and Synthetic medicines

Herbal treatment for diabetic patients' demonstrated superior quality of life compared to synthetic medication, evident from higher mean and maximum scores. There was a less positive correlation between general health perceptions in patients receiving herbal versus synthetic treatment, indicating differences in perception. QOLID analysis revealed increased



V. V. Rajesham, A. Mutya Aparna, Potharaju Kalyani, M. Balaji, K. Sreenath Reddy, and T. Rama Rao, "Exploring Herbal Remedies for Diabetes Management: A Comprehensive Review of Efficacy, Epidemiology, and Quality of Life Considerations," *International Research Journal of Pharmacy and Medical Sciences (IRJPMS)*, Volume 7, Issue 2, pp. 67-73, 2024.

treatment satisfaction, vitality, and reduced symptom irritability with herbal medicine, emphasizing its efficacy and patient preference [41].

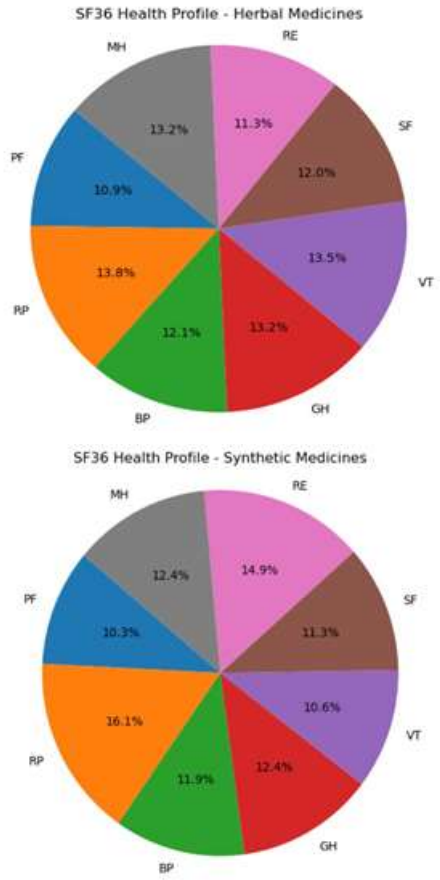


Figure 9: Graph showing the effect of treatment on generic health outcome measures (mean scores) of diabetic patients

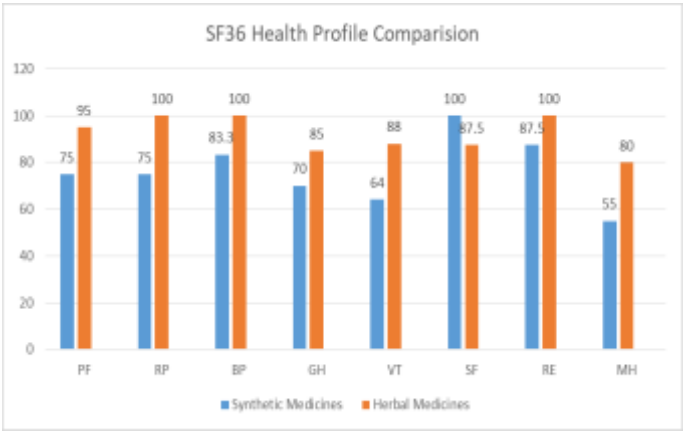


Figure 10: Graph showing the effect of treatment on generic health outcome measures (maximum scores) of diabetic patients

To enhance the therapeutic efficacy of the medication, future studies on herbal medicine should focus on these particular areas of patient-reported outcomes. Using the SF-36 and QOLID instruments, the study examined quality of life evaluations in individuals taking allopathic and herbal medications. The findings showed that when using herbal medicine, comfort factors including overall health and treatment satisfaction were given more attention, especially in these areas. In these domains, herbal therapy demonstrated a higher quality of life than synthetic treatment. The results underline the need for more studies concentrating on particular domains to improve clinical efficacy and point to the possibility of customized tools like the SF-36 and QOLID in assessing herbal medications for the treatment of diabetes [42].

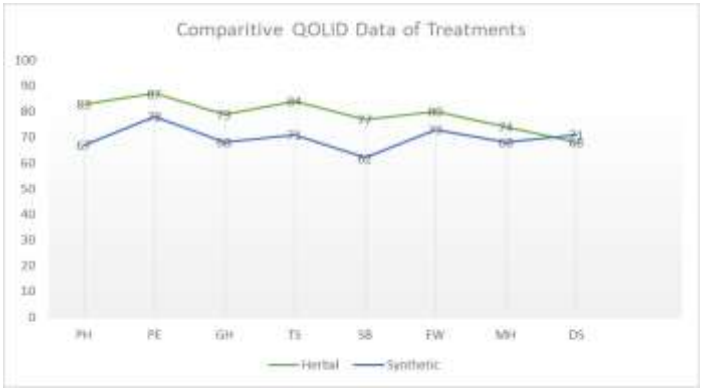


Figure 11: Effect of Treatment groups on the Quality of life of Indian diabetic patients.

## II. Conclusion

Diabetes mellitus is a complex chronic illness characterized by hyperglycemia resulting from insulin resistance or insufficient insulin production. Its etiology involves diverse factors such as genetic susceptibility, autoimmune destruction of pancreatic β-cells, and environmental influences. Epidemiological studies reveal a global increase in diabetes prevalence, with significant implications for healthcare systems. The pathophysiology of diabetes involves impaired insulin action or secretion, leading to metabolic dysregulation. Herbal treatments have gained attention due to their potential efficacy and fewer adverse effects compared to conventional medications. Various medicinal plants have demonstrated hypoglycemic effects, offering alternative options for managing diabetes. Additionally, research on quality of life measures highlights the importance of considering patient-reported outcomes when evaluating treatment efficacy. Further studies are needed to explore the mechanisms of action of herbal remedies and optimize their therapeutic use in diabetes management.

## References

1. Abudawood M. (2019). Diabetes and cancer: A comprehensive review. Journal of research in medical sciences: the official journal of Isfahan University of Medical Sciences, 24, 94.
2. Zhi, M., Zhu, X., Lugea, A., Waldron, R. T., Pandol, S. J., & Li, L. (2019). Incidence of New Onset Diabetes Mellitus Secondary to Acute Pancreatitis: A Systematic Review and Meta-Analysis. Frontiers in Physiology, 10.
3. Kaul, K., Tarr, J.M., Ahmad, S.I., Kohner, E.M., Chibber, R. (2013). Introduction to Diabetes Mellitus. In: Ahmad, S.I. (eds) Diabetes. Advances in Experimental Medicine and Biology, vol 771. Springer, New York, NY.
4. Salim Bastaki. (2005). International Journal of Diabetes and Metabolism, 13 (3): 111–134.



V. V. Rajesham, A. Mutya Aparna, Potharaju Kalyani, M. Balaji, K. Sreenath Reddy, and T. Rama Rao, “Exploring Herbal Remedies for Diabetes Management: A Comprehensive Review of Efficacy, Epidemiology, and Quality of Life Considerations,” *International Research Journal of Pharmacy and Medical Sciences (IRJPMS)*, Volume 7, Issue 2, pp. 67-73, 2024.

5. Nair, S. S., Kavrekar, V., & Mishra, A. (2013). Evaluation of in vitro antidiabetic activity of selected plant extracts. International Journal of Pharmaceutical Science Invention, 2(4), 12-19.
6. Sudha Ponnusamy, Remya Ravindran, Smita Zinjarde, Shobha Bhargava, Ameeta Ravi Kumar, "Evaluation of Traditional Indian Antidiabetic Medicinal Plants for Human Pancreatic Amylase Inhibitory Effect In Vitro", Evidence-Based Complementary and Alternative Medicine, vol. 2011, Article ID 515647, 10 pages, 2011.
7. Kumar, R., Saha, P., Kumar, Y., Sahana, S., Dubey, A., & Prakash, O. (2020). A Review on Diabetes Mellitus: Type-1 & Type-2. World Journal of Pharmacy and Pharmaceutical Sciences, 9(10), 838-850.
8. American Diabetes Association; 2. Classification and Diagnosis of Diabetes: Standards of Medical Care in Diabetes—2020. Diabetes Care 1 January 2020; 43 (Supplement_1): S14–S31.
9. Aldo A Rossini, John P Mordes, Eugene S Handler; Speculations on Etiology of Diabetes Mellitus: Tumbler Hypothesis. Diabetes 1 March 1988; 37 (3): 257–261.
10. Yau, M., Maclaren, N. K., & Sperling, M. A. (2021). Etiology and pathogenesis of diabetes mellitus in children and adolescents. Endotext [Internet].
11. Vlad, I., & Popa, A. R. (2012). Epidemiology of diabetes mellitus: a current review. Romanian Journal of Diabetes Nutrition and Metabolic Diseases, 19(4), 433-440.
12. Fan W. (2017). Epidemiology in diabetes mellitus and cardiovascular disease. Cardiovascular endocrinology, 6(1), 8–16. Bruno, G., & Landi, A. (2011, January). Epidemiology and costs of diabetes. In Transplantation proceedings (Vol. 43, No. 1, pp. 327-329). Elsevier.
13. Freeman, J. (2010). The Increasing Epidemiology of Diabetes and Review of Current Treatment Algorithms. Journal of Osteopathic Medicine, 110(s77), e2-e6.
14. Moini, J. (2019). Chapter 3 - Pathophysiology of Diabetes. In Epidemiology of Diabetes (pp. 25-43). Elsevier.
15. Banday, M. Z., Sameer, A. S., & Nissar, S. (2020). Pathophysiology of diabetes: An overview. Avicenna journal of medicine, 10(04), 174-188.
16. Ojo, O. A., Ibrahim, H. S., Rotimi, D. E., Ogunlakin, A. D., & Ojo, A. B. (2023). Diabetes mellitus: From molecular mechanism to pathophysiology and pharmacology.
Medicine in Novel Technology and Devices, 19, 100247.
17. Aoife M. Egan, Maragaret L. Dow, Adrian Vella. (2020, July). A Review of the Pathophysiology and Management of Diabetes in Pregnancy. Mayo Clinic Proceedings, 95(12), 2734-2746.
18. Egan, A. M., Dow, M. L., & Vella, A. (2020). A review of the pathophysiology and management of diabetes in pregnancy. Mayo Clinic Proceedings, 95(12), 2734-2746.
19. Mobasseri, M., Shirmohammadi, M., Amiri, T., Vahed, N., Fard, H. H., & Ghojazadeh, M. (2020). Prevalence and incidence of type 1 diabetes in the world: a systematic review and meta-analysis. Health promotion perspectives, 10(2), 98.
20. Singab, A. N., Youssef, F. S., & Ashour, M. L. (2014). Medicinal plants with potential antidiabetic activity and their assessment. Med Aromat Plants, 3(151), 2167-0412.
21. Bnouham, M., Ziyyat, A., Mekhfi, H., Tahri, A., & Legssyer, A. (2006). Medicinal plants with potential antidiabetic activity-A review of ten years of herbal medicine research (1990-2000). Dubai Diabetes and Endocrinology Journal, 14(1), 1-25.
22. Jarald, E., Joshi, S. B., & Jain, D. (2008). Diabetes and herbal medicines, 17(1), 95-106.
23. Kasole, R., Martin, H. D., & Kimiywe, J. (2019). Traditional medicine and its role in the management of diabetes mellitus: "patients' and herbalists' perspectives". Evidence-Based Complementary and Alternative Medicine, 2019.
24. Verma, S., Gupta, M., Popli, H., & Aggarwal, G. (2018). Diabetes mellitus treatment using herbal drugs. International Journal of Phytomedicine, 10(1), 1-10.
25. Rao, M. U., Sreenivasulu, M., Chengaiah, B., Reddy, K. J., & Chetty, C. M. (2010). Herbal medicines for diabetes mellitus: a review. Int J Pharm Tech Res, 2(3), 1883-1892.
26. Hegazy, G. A., Alnoury, A. M., & Gad, H. G. (2013). The role of Acacia Arabica extract as an anti-diabetic, anti hyperlipidemic, and antioxidant in streptozotocin-induced diabetic rats. Saudi medical journal, 34(7), 727–733.
27. Modak, M., Dixit, P., Londhe, J., Ghaskadbi, S., & Devasagayam, T. P. (2007). Indian herbs and herbal drugs used for the treatment of diabetes. Journal of clinical biochemistry and nutrition, 40(3), 163–173.
28. Shibib, B. A., Khan, L. A., & Rahman, R. (1993). Hypoglycaemic activity of *Coccinia indica* and *Momordica charantia* in diabetic rats: depression of the hepatic gluconeogenic enzymes glucose-6-phosphatase and fructose-1, 6-bisphosphatase and elevation of both liver and red-cell shunt enzyme glucose-6-phosphate dehydrogenase. The Biochemical journal, 292 (Pt 1) (Pt 1), 267–270.
29. Sheela, C. G., & Augusti, K. T. (1992). Anti-diabetic effects of S-allyl cysteine sulphoxide isolated from garlic *Allium sativum* Linn. Indian journal of experimental biology, 30(6), 523–526.
30. Ravi, K., Sivagnanam, K., & Subramanian, S. (2004). Anti-diabetic activity of Eugenia jambolana seed kernels on streptozotocin-induced diabetic rats. Journal of medicinal food, 7(2), 187-191.
31. Achrekar, S., Kaklij, G. S., Pote, M. S., & Kelkar, S. M. (1991). Hypoglycemic activity of Eugenia jambolana and Ficus bengalensis: mechanism of action. In vivo (Athens, Greece), 5(2), 143–147.
32. Vats, V., Yadav, S. P., & Grover, J. K. (2004). Ethanolic extract of *Ocimum sanctum* leaves partially attenuates streptozotocin-induced alterations in glycogen content and carbohydrate metabolism in rats. Journal of ethnopharmacology, 90(1), 155–160.
33. Stanely Mainzen Prince, P., & Menon, V. P. (2001). Antioxidant action of *Tinospora cordifolia* root extract in alloxan diabetic rats. Phytotherapy research: PTR, 15(3), 213–218.
34. Gupta, S. S., Verma, S. C., Garg, V. P., & Rai, M. (1967). Anti-diabetic effects of *Tinospora cardifolia*. I. Effect on fasting blood sugar level, glucose tolerance and adrenaline induced hyperglycaemia. The Indian journal of medical research, 55(7), 733–745.
35. Bhalerao, S. A., Verma, D. R., Teli, N. C., & Murukate, V. R. (2013). Eclipta alba (L): an overview. International Journal of Bioassays, 2(11), 1443-1447.
36. Ananthi, J., Prakasam, A., & Pugalendi, K. V. (2003). Antihyperglycemic activity of *Eclipta alba* leaf on alloxan-induced diabetic rats. The Yale journal of biology and medicine, 76(3), 97.
37. Kooti, Wesam, Farokhipur, Maryam & Asadzadeh, Zahra & Ashtary-Larky, Daamoon &Asadi-Samani, Majid. (2016). the role of medicinal plants in the treatment of diabetes: A systematic review. Electronic physician. 8. 1832-1842. 10. 19082/1832.
38. Gupta, R. K., Kesari, A. N., Murthy, P. S., Chandra, R., Tandon, V., & Watal, G. (2005). Hypoglycemic and anti-diabetic effect of ethanolic extract of leaves of *Annona squamosa L*. in experimental animals. Journal of ethnopharmacology, 99(1), 75-81.
39. William, H.; Polonsky. Understanding and assessing diabetes specific quality of life. Diabet. Spect., 2000, 13, 36.
40. Nagpal, J.; Kumar, A.; Kakar, S.; Bhartia, A. The development of quality of life instrument for Indian diabetes patients (QOLID): A validation and reliability study in middle and higher income groups. J. Assoc. Physicians India., 2010, 58, 295-304.
41. M. Sandhya Rani, Rao.S.Pippalla, G. Krishna Mohan, Switi B. Gaikwad and Bhanu Prasad (2014). A Comparative Quality of Life Assessment of Herbal Drugs with Allopathic Drugs for the Treatment of Diabetic Complications. Pharmaceutical Crops, 2014, 5, (Suppl 1: M7) 77-84.