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Hedychium ellipticum: A Natural Ally in the Lifelong Journey with Diabetes Mellitus

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Abstract
Diabetes mellitus is a major worldwide health burden caused by a chronic metabolic disease marked by high blood glucose levels. Prolonged rates of obesity, unhealthy eating habits, and sedentary lifestyles have contributed to the worldwide increase in diabetes mellitus prevalence. Diabetes mellitus, both type 1 and type 2, is caused by a disruption of glucose metabolism caused by either insulin resistance, decreased secretion, or both. Type 2 diabetes, more common in adults, is associated with obesity, insulin resistance, and lifestyle factors; type 1 diabetes usually appears in infancy or adolescence and requires lifetime insulin therapy. Diabetes clinical symptoms include weariness, polyuria, polydipsia, polyphagia, and weight loss that is not explained. Diabetes foot ulcers, nephropathy, retinopathy, and cardiovascular disease can all be accelerated by untreated or poorly controlled diabetes. Blood tests are used in diagnosis; they include HbA1c levels, oral glucose tolerance test, and fasting plasma glucose. Changing one's diet, getting regular exercise, controlling weight, and giving up smoking are all part of treatment techniques. Sometimes pharmacological measures are required to establish glycemic control and prevent problems, like insulin treatment and oral antidiabetic drugs. Herbal treatments have also drawn notice for their possible antidiabetic effects. Certain research have shown that botanicals such ginseng, fenugreek, cinnamon, and bitter melon can help regulate blood sugar. Their effectiveness, safety, and best use in diabetes control must be clarified by more study, nevertheless. In conclusion, to reduce problems and improve patient well-being, diabetes mellitus requires all-encompassing care plans including medical procedures, lifestyle changes, and maybe herbal treatments.
Keywords: *- Diabetes mellitus, Type 1, Type 2, Herbal treatment, Insulin therapy, Nephropathy.*

1. INTRODUCTION
The terms mellitus (sweet) in Latin and diabetes (siphon, to flow through) in Greek are the roots of diabetes mellitus. According to historical research, the term "diabetes" was originally used by Apollonius of Memphis between 250 and 300 BC. (1) The ancient Greek, Indian, and Egyptian civilizations discovered that the urine generated in this disease was pleasant, which is why the word "Diabetes Mellitus" emerged. Mering and Minkowski discovered in 1889 that the pathophysiology of diabetes involves the pancreas. (2,3) In 1922, Banting, Best, and Collip at the University of Toronto extracted the hormone insulin from the pancreas of cows, leading to the development of an effective diabetes medication in the same year. Excellent research has been done throughout the years, resulting in a number of discoveries and the creation of management strategies to deal with this growing problem. Unfortunately, diabetes continues to be one of the most common chronic illnesses in the world and in the United States. It is still the sixth most prevalent cause of death in the United States. (4,5)
Diabetes mellitus (DM) is a metabolic condition characterized by extremely high blood glucose levels. There are several types of diabetes mellitus, including type 1, type 2, gestational diabetes, infant diabetes, maturity-onset diabetes of the young (MODY), and secondary causes originating from endocrinopathies, steroid use, etc. (6,7) The two main kinds of diabetes mellitus (DM) are Type 1 diabetes mellitus (T1DM) and Type 2 diabetes mellitus (T2DM). The main cause of T1DM and T2DM, respectively, is defective insulin synthesis and/or action. T1DM is predicted to appear in adolescents or teenagers, but T2DM is likely to affect middle-aged and older people with persistent hyperglycemia as a result of poor dietary and lifestyle choices. There are variations in the causes, manifestations, and treatments of each type of diabetes since the etiology of type 1 and type 2 diabetes vary greatly. (8,9)

2. Origin
The pancreatic islets of Langerhans are primarily composed of two types of endocrine cells: beta cells, which make insulin, and alpha cells, which emit glucagon. The amount of hormones released by beta and alpha cells is continuously influenced by the glucose environment. Glucose levels go excessively out of balance when there is an imbalance between glucagon and insulin. Blood sugar levels rise when diabetes mellitus (DM) strikes because insulin either operates poorly or not at all (insulin resistance). (10-12)
The autoimmune-mediated loss of beta cells in the pancreas is a defining feature of type 1 diabetes. Because of the total destruction of beta cells, either very little or no insulin is generated. The genesis of type 2 diabetes is more covert: a functional insulin deficit arises from an imbalance between insulin sensitivity and levels. Insulin resistance has several causes, but the two primary ones are obesity and aging. (13-15)

Genetic background is a major risk factor for both types. As research into the human genome continues, several loci that confer risk for diabetes mellitus have been identified. It has been demonstrated that variations in the major histocompatibility complex (MHC) and human leukocyte antigen (HLA) impact the likelihood of type 1 diabetes (T1DM). In type 2 diabetes, lifestyle and genetics are more complex factors. A wealth of research suggests that T2DM has a greater genetic profile than T1DM. The majority of people with type 2 diabetes have at least one parent who has the illness. (16-19)

In a monozygotic pair, the presence of one affected twin raises the other twin's lifetime risk of developing type 2 diabetes by 90%. (20) More than fifty polymorphisms have been found to far that either protect against or increase the incidence of type 2 diabetes. These genes encode proteins that are involved in several processes leading to diabetes mellitus (DM), including as insulin synthesis, secretion, and development; beta cell amyloid deposition; insulin resistance; and impaired gluconeogenic regulation. A genome-wide association study (GWAS) identified genetic loci for the transcription factor 7-like 2 gene (TCF7L2), which increases the risk of type 2 diabetes. (21,22) NOTCH2, JAZF1, KCNQ1, and WFS1 are additional loci that might influence the development of T2DM. (23-25)

Non-insulin-dependent diabetes, which is frequently diagnosed before the age of 25, is the defining feature of the diverse condition known as MODY. It is autosomal dominant and does not need autoantibodies, in contrast to T1DM. There are implications for this disease related to the hepatocyte nuclear factor-1-alpha (HNF1A) and glucokinase (GCK) genes, which are mutated in 52 to 65 and 15 to 32 percent of cases, respectively. (26,27) The genetics of this disease are still unknown because some patients have mutations but never get the disease, and others will develop clinical symptoms of MODY but have no detectable mutation. (28)

Gestational diabetes is the main term for diabetes associated with pregnancy. While the precise reason behind its emergence remains unknown, some speculate that HLA antigens, particularly HLA DR2, 3, and 4, might play a role. Excessive proinsulin is also thought to be linked to gestational diabetes, and some evidence suggests that proinsulin may stress beta cells. Certain individuals believe that elevated hormone levels, including but not limited to estrogen, progesterone, cortisol, prolactin, and human placental lactogen, might potentially affect peripheral insulin sensitivity and beta-cell function. (29,30)

Acromegaly, Cushing syndrome, glucagonoma, hyperthyroidism, hyperaldosteronism, and somatostatinomas have all been connected to glucose intolerance and diabetes mellitus due to the intrinsic glucogenic activity of endogenous hormones that are oversecreted in a number of endocrinopathies. Diabetes mellitus is associated with disorders such as idiopathic hemochromatosis due to excessive iron accumulation in the pancreas and beta cell loss. (31)

3. EPIDEMIOLOGY

Worldwide, 1 in 11 people have DM, with 90% of those cases being T2DM. Type 1 diabetes is progressively more common from birth, peaking between the ages of 4 and 6 and 10 and 14 years. (32) Before the age of 10, almost 45% of children are impacted. (33) There are around 2.3 cases per 1000 people under the age of 20. There doesn't appear to be a gender difference in the prevalence of T1DM in children, despite the fact that most autoimmune illnesses are more common in women. Globally, T1DM prevalence has been increasing. There may be a 3:1 male to female ratio in some populations, such as older men of European heritage (over 13 years old), which increases their risk of developing T1DM compared to females. T1DM rates increased by around 2% per year in the US in most age and ethnic groups, with rates greater among youngsters of Hispanic descent. (34) The exact reason for this development is yet unknown. In the Middle East, Australia, and Europe, rates are rising by 2% to 5% a year. However, the United States Military Health System data repository indicates that several metrics peaked between 2007 and 2012, with a frequency of 1.5 per 1000 and an incidence of 20.7 to 21.3 per 1000. (35)

Teenage obesity has led to an increase in T2DM in younger populations, despite the fact that the condition typically appears later in life. Type 2 diabetes affects 9% of Americans overall, although it is more common in people over 65—roughly 25%. The International Diabetes Federation estimates that in 2015, 1 in 11 people globally between the ages of 20 and 79 had diabetes. According to experts, there will be 415 million more diabetics worldwide by 2040 than there are in the US. The population that moves from low- to middle-income levels will see the most increase in T2DM. (36) The prevalence of T2DM varies by ethnic group; among Americans of Black, Native American, Pima Indian, and Hispanic American heritage, it is two to six times greater than in the White population. For example, the incidence of Type 2 Diabetes was lower in Mexican Pima Indians than in US Pima Indians (6.9% vs. 38%). (37)

4. Understanding pathophysiology

Patients with diabetes may experience hyperglycemia. Because diabetes mellitus might have several etiologies, its pathophysiology is not always clear. Hyperglycemia can harm pancreatic beta-cell activity and insulin secretion even on its own. Hyperglycemia thus produces a vicious cycle that hinders metabolic activity. In this context, blood glucose levels above 180 mg/dL are commonly considered hyperglycemic; however, a specific cutoff value is uncertain because of the multitude of mechanisms involved. Patients experience osmotic diuresis as a result of the nephron's glucose transporters being saturated due to elevated blood glucose levels. Polyuria and polydipsia symptoms are likely to occur when serum glucose levels are higher than 250 mg/dL, albeit the exact effect varies. (38)

Insulin resistance is brought on by proinflammatory cytokines and excess fatty acids, which accelerate the breakdown of fat and hinder the transfer of glucose. The body inadvertently increases glucagon levels in response to inadequate insulin production or responsiveness, exacerbating hyperglycemia. (39) Type 2 diabetes includes insulin resistance, but the condition's full effects arise when a patient's insulin output is insufficient to counteract their insulin resistance. Chronic hyperglycemia glycates proteins and fats without the need for enzymes. The degree of this can be ascertained using the glycation hemoglobin (HbA1c) test. Glucose damages small blood vessels in the kidney, retina, and peripheral nerves. Elevated blood glucose levels expedite the process. This damage results in the common diabetes sequelae of nephropathy, neuropathy, and diabetic retinopathy, as well as the preventable outcomes of amputation, dialysis, and blindness. (40)

5. Historical and Physical

Getting a diagnosis of diabetes mellitus requires investigating insulin resistance, autoimmune diseases, and family history. Patients seldom exhibit any symptoms at initially, but when they do, they frequently lose weight and develop polyuria and polydipsia. When a patient is physically evaluated, they could seem dehydrated with poor skin turgor and, in the case of ketotic patients, have a distinct fruity breath odor. (41) Doctors may see fatigue, nausea, vomiting, and Kussmaul respirations when diabetic ketoacidosis (DKA) is present. A funduscopic examination may show macula exudates or hemorrhages in a patient with diabetes mellitus. When diabetic retinopathy is severe, the retinal venules may seem dilated or occluded. The development of new blood vessels worries ophthalmologists the most because it might hasten macular edema and retinal hemorrhages, both of which can result in blindness. (42) Despite the possibility of identical outward manifestations, a clinical history and examination can aid in distinguishing between T1DM and T2DM. Insulin resistance symptoms, such as velvety, hyperpigmented patches on the neck skin called acanthosis nigricans, axillary folds, or inguinal folds, are typically seen in patients with type 2 diabetes. They frequently have excess weight or obesity. Patients with chronic hyperglycemia may have neuropathic pain, impaired vision, recurring yeast infections, and numbness. Every time a patient comes in, the medical staff should ask if the patient's foot has changed recently. The monofilament test is part of the diabetic foot examination that should be part of the routine physical examination. (43,44)

6. Evaluation

Type 1 diabetes (T1DM) is frequently diagnosed with a unique medical history, elevated blood glucose levels (fasting glucose > 126 mg/dL, random glucose > 200 mg/dL, or hemoglobin A1C > 6.5%), and the presence or absence of antibodies to insulin and glutamic acid decarboxylase (GAD). Fasting glucose levels and HbA1c testing are useful in the early diagnosis of type 2 diabetes. A glucose tolerance test may be performed to evaluate fasting glucose levels and the blood glucose response to an oral glucose tolerance test (OGTT) if the results are unclear. Prediabetes, which frequently precedes type 2 diabetes (T2DM), is defined as a blood glucose level of 100 to 125 mg/dL during fasting or 140 to 200 mg/dL during the 2-hour post-oral glucose tolerance test (post-OGTT). (45,46)

According to the American Diabetes Association (ADA), a patient can be diagnosed with diabetes if they meet any of the following criteria: a HbA1c level of 6.5% or higher; a fasting plasma glucose level of 126 mg/dL (7.0 mmol/L) or higher (no caloric intake for at least 8 hours); a two-hour plasma glucose level of 11.1 mmol/L or 200 mg/dL or higher during a 75-g OGTT; a random plasma glucose of 11.1 mmol/L or 200 mg/dL or higher in a patient exhibiting hyperglycemia symptoms (polyuria, polydipsia, weight loss, etc.); and a hyperglycemic crisis. The American Diabetes Association recommends screening adults 45 years and older, regardless of risk; the United States Preventative Service Task Force recommends screening overweight people between 40 and 70 years of age. (47)

Between 24 and 28 weeks of pregnancy, a glucose challenge test is used to evaluate all pregnant patients for gestational diabetes. This test necessitates an hour-long fast. If a patient's blood glucose level is greater than 140 mg/dL, a 3-hour fasting glucose challenge test is performed to confirm the diagnosis. A positive three-hour OGTT test is defined as having plasma glucose concentrations after one hour, two hours, and three hours of fasting that are greater than or equal to 180, 155, and 140 mg/dL, respectively. (48) Several laboratory tests are useful in the management of long-term diabetes. With at-home glucose testing, trends in both hyper- and hypoglycemia may be seen. The HbA1c test calculates the amount of glycation, or the life of the red blood cell, caused by hyperglycemia during a three-month period. Urine albumin testing can be used to identify diabetic nephropathy early in the condition. Upon diagnosis, serum lipid monitoring is advised since diabetics are also susceptible to cardiovascular disease. Similar to this, although hypothyroidism is more frequent, some recommend yearly blood testing for thyroid-stimulating hormone to assess thyroid health. (49,50)

7. Management/ Treatment

The physiology and treatment of diabetes are complex, requiring several approaches to achieve optimal disease management. Treatment requires active patient participation and diabetes education. Patients will fare better if they can exercise often (more than 150 minutes per week), manage their diet (restricting carbohydrates and total calories), and monitor their blood sugar on their own. (51) In order to prevent unexpected consequences, lifetime treatment is usually necessary. The optimal range is to keep blood sugar levels between 90 and 130 mg/dL and a HbA1c of less than 7%. While blood sugar regulation is important, over regulation can lead to hypoglycemia, which can have fatal or extremely hazardous implications. (52)

Since type 1 diabetes is primarily caused by an inadequate supply of insulin, daily injections or the use of an insulin pump constitute the cornerstone of treatment for the illness. Exercise and a healthy diet may be adequate treatments for type 2 diabetes in its early stages. Additional therapies may concentrate on increasing the pancreas' ability to produce insulin or enhancing insulin sensitivity. Glucagonlike-peptide-1 agonist, dipeptidyl peptidase IV inhibitors (DPP-4), biguanides (metformin), sulfonylureas, meglitinides, thiazolidinediones, alpha-glucosidase inhibitors, selective amylinomimetics, and sodium-glucose transporter-2 (SGLT-2) inhibitors are some of the particular drug subclasses. (53) Metformin is the first medication used to treat diabetes because it decreases plasma glucose levels both after meals and during rest. Individuals with type 2 diabetes may also require insulin therapy, especially if their disease worsens and they are unable to regulate their blood sugar levels. People who are really obese may be able to get their glucose levels under control with bariatric surgery. Patients who have significant comorbidities and have not responded well to prior treatments are encouraged to use it. Semaglutide and liraglutide, GLP-1 agonists, have been associated with improved cardiovascular outcomes. (54) It has also been demonstrated that the SGLT-2 inhibitors canagliflozin and empagliflozin improve cardiovascular outcomes, perhaps provide renoprotection, and postpone the development of heart failure. (55)

Regular testing is crucial since microvascular issues are one of the dreaded consequences of diabetes. Trained medical practitioners should do routine diabetic retinal exams to screen for diabetic retinopathy. Monofilament testing in conjunction with neurologic evaluation can identify patients at risk for amputation due to neuropathy. Doctors may also suggest to their patients that they look at their feet every day to look for lesions that neuropathy could have overlooked. Low-dose tricyclic antidepressants, duloxetine, anticonvulsants, topical capsaicin, and opioids may be necessary to manage neuropathic pain in diabetics. If there is albuminuria greater than 30 mg/g of creatinine, a urine microalbumin test may be used in conjunction with the estimated GFR to identify the early renal consequences of diabetes mellitus. Because of their antiproteinuric properties, angiotensin receptor blockers (ARBs) and angiotensin-converting enzyme (ACE) inhibitors are the prescribed drugs to help patients with Type 1 or Type 2 diabetes mellitus delay the progression from microalbuminuria to macroalbuminuria. (56,57)

The FDA has approved pregabalin and duloxetine for the treatment of diabetic peripheral neuropathy. Tricyclic antidepressants and anticonvulsants have also been used to alleviate diabetic neuropathy pain, with differing degrees of success. Pharmacologic therapy for hypertensive diabetes frequently involves the use of angiotensin-converting enzyme inhibitors, angiotensin receptor blockers, diuretics, beta-blockers, and/or calcium channel blockers. For diabetics, routine blood pressure screening is also recommended by the American Diabetes Association (ADA), with a target systolic blood pressure of 130 mmHg and diastolic blood pressure of 85 mmHg. In the event of atherosclerotic cardiovascular disease (ASCVD), the American Diabetes Association (ADA) recommends lipid monitoring for diabetics, with a goal low-density lipoprotein cholesterol (LDL-C) of less than 70 mg/dl, and less than 100 mg/dL in the absence of cardiovascular disease (CVD). Statins are the first-line treatment for diabetics with dyslipidemia. It is currently unclear how aspirin can assist people with diabetes have fewer cardiovascular events, even though the ADA suggests that low-dose aspirin may be beneficial for diabetic patients who are at high risk for cardiovascular events. (58-61)

8. DM treatment

Treating the underlying cause and administering high dosages of a typical hypoglycemic medication is the treatment plan. Once the situation is under control, the demand for hypoglycemic agents returns to normal. (62) The goals of diabetes treatment will be accomplished by:

1. To restore the diabetic's disrupted metabolism as close to the norm as is comfortable and safe.
2. To prevent or postpone the development of the illness's immediate and long-term risks.
3. To provide the patient with information, inspiration, and resources to carry out this self-aware care.

A. types of medical assistance in question Within DM

One medical assistance vegetative cell Studies have revealed that in T2DM patients, monocytes and macrophages are also major contributors to persistent inflammation and hypoglycemic medication resistance. (63) The goal of vegetative cell professional medical help, an entirely new technique, is to control or cure immunological dysfunctions. (64) The process involves drawing blood from patients using a control system, purifying all of the blood's lymphocytes, co-culturing those lymphocytes with adherent twine blood-derived multipotent stem cells (CB-SCs) in vitro, and then injecting the educated lymphocytes—but not the CB-SCs—back into the patient's circulation. (64)

A. types of medical assistance in question Within DM

1. Medical assistance by somatic cell

Studies have indicated that T2DM patients' persistent inflammations and hypoglycemic medication resistance may also be primarily caused by monocytes and macrophages. (65) One novel medical technique called somatic cell professional assistance aims to correct or modulate immunological dysfunctions. (66) Using a control system, the patients' blood is mixed, lymphocytes are separated from the total blood, adherent wire blood-derived multipotent stem cells (CB-SCs) are co-cultured with them in vitro, and the educated lymphocytes—not the CB-SCs—are then injected into the patient's circulation. (67)

2. Inhibitory health care

Patients with type 2 diabetes are treated for aerophilous stress using a range of antioxidants, including vitamins, supplements, active ingredients derived from plants, and medications having inhibitory effects. The best supplements to prevent aerophilous stress and its aftereffects are vitamin C, tocopherol, and beta-carotene. Antioxidants are essential for reducing the likelihood of polygenic illness and its aftereffects. (68)

3. The use of anti-inflammatory medications

The alterations suggest that inflammation is a major factor in the pathophysiological process of type 2 diabetes and its sequelae. (69) T2DM is associated with changes in the number and activation state of different populations of white blood cells, increased tissue pathology and programmed cell death, and altered levels of particular cytokines and chemokines in animal tissue, exocrine gland islets, the liver, the vasculature, and current leukocytes. Immunomodulatory medications are available. (70)

B. Food Administration

Sufficient caloric value All patients, whether or not they have diabetes, should follow their prescribed diet.

1. Sugar consumption must always be restricted, keeping supermolecules, lipids, and sugar in balance.
2. should adapt to traditional practices as closely as possible
3. Meals should be spaced out often and should be of a comparable size.
4. Reduce the amount of calories consumed overall by consuming less fat and carbs.
5. It is advised that the patient maintain consistent eating habits every day. (71)

C. More Recent Endocrine Delivery Systems

Many advancements are made to improve the precision and comfort of endocrine administration in order to achieve strict control of blood sugar levels. These include pen devices, endocrine syringes, inhaled endocrine, implanted endocrine, and various endocrine administration methods. (72)

D. Medicinal or oral hypoglycemic agents

Parallel to sulfonylureas, the clinically beneficial biguanide phenformin was introduced in 1957. The search for newer methods has never stopped, and recent discoveries include thiazolidinediones, meglitinide analogs, α-glucosidase inhibitors, and the most recent discovery—dipeptidyl peptidase 4 (DPP-4) inhibitors. (73)

Significant oral hypoglycemic agent possibilities

Diabetes mellitus is seen as a disease of the fashionable world, positively affecting morbidity, morality, and the individual's quality of kind. Diabetes is a common side effect of neurologist syndrome, which is brought on by long-term exposure to glucocorticoids. It manifests as a variety of clinical symptoms, including central fat, weakness in the proximal muscles, hirsuteness, disruption of the nervous system, involuntary pathology of the macrovascular complication, digestive disorders, dental problems, etc. (74)

9. Recent Studies

9.1. Ficus carica Extracts Combat Type-1 Diabetes

The purpose of the study was to evaluate the extracts from Ficus carica L. that were used to test for antioxidant activity and possible antidiabetic benefits. In this study, the amounts of polyphenols and flavonoids, as well as the antioxidant qualities of Ficus carica L. leaves and buds, were measured. Rats were given a single dosage of alloxan monohydrate (65 mg/kg body weight) to cause diabetes. For the next 30 days, the rats were given methanolic extracts of Ficus carica leaves, buds, or both at a dose of 200 mg/kg body weight.

Blood sugar and body weight were measured at 5- and 7-day intervals, respectively, throughout the trial. Serum and urine samples were taken for examination at the end of the research period, with an emphasis on indicators including proteins, sodium, potassium, and chloride, as well as total cholesterol, triglycerides, creatinine, uric acid, and urea. In order to assess the amounts of lipid peroxidation products and the activities of glutathione, catalase, and glutathione peroxidase, the researchers also examined the tissues of the pancreas, liver, and kidney. (75)

The study's conclusions showed that the injection of alloxan resulted in lipid peroxidation, decreased antioxidative enzyme activity, raised liver and kidney biomarker levels, and hyperglycemia. Nonetheless, administration of Ficus carica leaf and bud extracts, especially in combination, showed a moderating effect on all pharmacological disruptions brought on by alloxan. (76)

9.2. Hepatorenal Protection by Coconut Water in Type 1 Diabetes

The study aimed to assess the antidiabetic effects of mature coconut water on liver and kidney function, as well as pancreatic histology in alloxan-induced diabetic rats. Twenty-four Wistar rats were randomly divided into four groups. Group I served as the negative control, receiving only rat chow and water. Group II, the positive control, received a single dose of alloxan to induce diabetes. Groups III and IV received alloxan and were treated with mature coconut water or glibenclamide, respectively, for three weeks. Liver function tests revealed elevated AST, ALP, albumin, total protein, and total bilirubin levels in Group II, while ALT levels were reduced. Compared to Group II, Group III showed similar elevations in liver function parameters, except for reduced ALT levels. Group IV exhibited elevated AST and total bilirubin levels but reduced ALT, ALP, albumin, and total protein levels. Kidney function tests indicated significantly elevated creatinine, urea, bicarbonate, potassium, and sodium levels in Group II. Group III showed lowered creatinine and potassium levels but elevated urea, bicarbonate, and sodium levels.

Group IV displayed lowered creatinine, urea, bicarbonate, and potassium levels but elevated sodium levels. The study suggests that mature coconut water could be beneficial in the treatment of diabetes mellitus due to its hepatorenal protective properties. (77) (table 1)

Table 1: - Shows the botanical name, Active ingredients, MOA and activity.

S.No.	Botanical Name	Family	Active Ingredients	MOA	Activity	Reference
1	Allium sativum L.	Amaryllidaceae	Allicin	Anti-hyperglycemic	Antidiabetic activity	(78)
2	Allium cepa	Amaryllidaceae	S-methyl cysteine sulfoxide, S-allyl cysteine sulfoxide	Stimulates pancreatic β-cells	Hypoglycaemic effect Antidiabetic activity	(79)
3	Andrographis paniculata	Acanthaceae	Andrographolide,	Regeneration of pancreatic β cells, insulin secretion	Antidiabetic & hepatoprotective	(80)
4	Aloe barbadensis	Asphodelaceae	Aloin, barbaloin, isobarbaloine, aloetic acid	Insulin secretion and synthesis	Antidiabetic activity	(81)
5	Boerhavia diffusa	Nyctaginaceae	Punarnavine, Boeravinone A-F	Increase in hexokinase activity, increase plasma insulin level, antioxidant	Antidiabetic activity	(82)
6	Camellia sinensis	Theaceae	Epigallocatechin-gallate, gallocatechin, epicatechin, (+) catechin, (−) epicatechin	Free radical scavenging activity, insulinonematic activity	Antidiabetic activity Antihyperglycemic activity	(83)
7	Cassia auriculata	Fabaceae	Bis (2-ethyl hexyl) phthalate	α-Glucosidase-inhibiting activity	Antidiabetic activity	(84)
8	Coccinia indica	Cucurbitaceae	β- Amyrin Acetate, Lupeol, Cucurbitacin B, Taraxerone, Taraxerol, β-carotene, Lycopene	Initiate insulin secretion, carbohydrate digestion and absorption.	Antidiabetic activity	(85)
9	Curcuma longa	Zingiberaceae	Curcumin, termerone, germacrone, zingiberene	Inhibition of α-glucosidase, inhibition of GSK-3β	Antidiabetic activity	(86)
10	Gymnema sylvestries	Asclepidaceae	Gymnenic acid, Stigmasterol, Gurmarin, betaine, gymnemosides	Regeneration of pancreatic β cells, α-glucosidase inhibitor, insulin secretion	Antidiabetic activity	(87)

9.3. Plants for Type 2 Diabetes Treatment

Reducing hyperglycemia generally to preserve immune system correct functioning is an indirect approach to reduce susceptibility to infections in T2DM patients. It has been observed that in diabetic Wistar rats caused by streptozotocin (STZ), yogurt enhanced with curcumin and insulin preserved normal blood glucose levels and reduced oxidative stress and dyslipidemia. These results are brought about by phosphorylating AKT, which increases GLUT-4 translocation. All by itself, curcumin can reduce thiobarbituric acid reactive substances (TBARS), boost the activities of catalase (CAT), superoxide dismutase (SOD), and delta-aminolevulinic dehydratase (DADD). (88)

Avicennia marina, sometimes referred to as gray mangrove plant, has been shown to be a suitable hypoglycemic agent in a diabetic Swiss Webster mouse model induced by streptozotocin (STZ). It also functions as an antioxidant, raising CAT and glutathione (GSH) levels, reducing toxins like H2O2, malondialdehyde (MDA), and nitric oxide (NO), and shielding organs like the kidney and liver to prevent comorbidities. Another study employed the same plants—Rhizophora mucronata and Avicennia marina—as well as an aqueous extract (also from leaves) in a STZ-induced diabetic Wistar rat model. Comments that phytochemicals like flavonoids from the plants may stop pancreatic β-cell death sprang from their usefulness as hypoglycemic agents promoting insulin production. Furthermore, these plants reduced lipid peroxidation and MDA; both are antioxidants in and of themselves. (89)

Apart from the hypoglycemic impact, another effect of plants against T2DM is the hypolipidemic one. In a diabetes model created by STZ and nicotinamide (NA), the hydroalcoholic extracts of Eryngium caucasicum roots increased serum insulin levels and decreased blood glucose. Reducing oxidative stress may be the function of flavonoids and carotenes, it is worth emphasizing. In addition, this therapy reduced the homeostasis model assessment (HOMA), a blood test for fasting insulin and glucose that is helpful in assessing insulin resistance and pancreatic β-cell function. While boosting bile secretion and reducing cholesterol absorption, alkaloids block cholesterol production, and both natural compounds raise high-density lipoproteins (HDL) and lower very-low-density lipoproteins (VLDL) and low-density lipoproteins (LDL). By lowering serum glutamic pyruvic transaminase (SGPT) and glutamic oxaloacetic transaminase (SGOT), E. caucasicum also shown hepatoprotection, therefore preserving the structural integrity of the liver. Inhibiting lipase is one way that the insulin rise might hold down activities like phospholipid fatty acid stimulation for later cholesterol and plasma release. (90)

Worldwide consumed plant-based drinks like coffee can also be used to treat type 2 diabetes. A hypolipidemic and hypoglycemic drug, Coffea arabica aqueous extract was shown to be in a diabetic Wistar rat model (STZ + high fat diet). Insulin resistance was also lessened by it. The chlorogenic acid in Coffea arabica is responsible for these effects; it has been shown to reduce the amount of adipocytes in the abdominal region. It can affect transport proteins, which lowers oxidative stress, renal triglycerides, and lipid peroxidation in turn. The chlorogenic acid alters the mRNA levels of antioxidant genes coding for superoxide dismutase (SOD), catalase (CAT), and glutathione peroxidase (GPx), therefore promoting the development of antioxidant proteins. (91)

Other plant species, notably Datura stramonium L., also referred to as Jimsonweed or thorn apple, are less often utilized but yet have antidiabetic properties. Tested in a Swiss albino diabetic mouse induced by STZ, the hydro-methanolic root extract of this plant improved glucose metabolism through insulin secretion, inhibiting α-amylase and α-glucosidase, blocking gluconeogenesis, protecting pancreatic β cells from inflammation and oxidative stress, improving glucose transporters GLUT-2 and GLUT-4 through flavonoids and polyphenols, and lowering serum triglyceride. (92)

Enhydra fluctuans, sometimes called Helencha or Harkuch, is one of the decorative plants with therapeutic properties. Aqueous alcohols Through increased insulin sensitivity and peripheral glucose utilization, decreased glycogenolysis, decreased fasting blood glucose, decreased ratio of TG/HDL-cholesterol, and inhibition of protein carbonylation and lipid peroxidation, Enhydra fluctuans extracts given to Long Evans rats in which diabetic conditions were induced by STZ exerted anti-dyslipidemic and hypoglycemic effects.

Fruit plants are not only edible but also, when other components of the plant, like mango leaves, are used, can be useful antidiabetic drugs. Through polyphenols that reduced postprandial fat utilization and glucose, inhibited alpha-glucosidase, increased insulin sensitivity, blocked pancreatic lipase activities, induced GLUT-4 and decreased LDL levels in a Swiss albino diabetic mouse model, which was experimentally induced via administration of alloxan monohydrate, hydro-alcoholic extracts of Mangifera indica L. leaves exerted hypoglycemic effects. (93)

Plants are proposed in this work as a T2DM supplemental therapy. As previously said, the most well-known plants (like those used in coffee) to the less well-known ones can all be employed. Among other phytochemicals, the presence of polyphenols, flavonoids, catechins, and alkaloids is credited with the antidiabetic properties of plants. Plants can be antidiabetic in two ways: they can be indirect agents, attacking the infections to which people with T2DM are more vulnerable, so indirectly preserving the immune system and preventing hyperglycemia, or they can be direct agents, lowering blood lipids and glucose, acting as antioxidant agents, or increasing antioxidant enzymes, increasing insulin sensitivity, improving glucose transport by transporters such GLUT-4 or reducing lipid peroxidation. (94)

10. Role of Hedychium ellipticum in DM

Hedychium ellipticum, meticulously described by Smith in 1811 and subsequently documented by Sanoj in 2011, is an enchanting herbaceous species that captivates with its distinctive morphological attributes. This botanical marvel graces its habitat with slender elegance, standing gracefully at heights varying between 0.6 to 1.1 meters. Its foliage, adorned with elongated laminae, presents an impressive span, measuring between 24 and 39 centimeters in length and spanning 7 to 15 centimeters in width (95).

Come the flowering season, H. ellipticum unveils its floral prowess in the form of elliptical inflorescences, densely populated with delicate blooms. These inflorescences, ranging from 4 to 10 centimeters in length, boast imbricating bracts that elegantly envelop the blossoms within. The bracts themselves, elliptically shaped and lacking indumentum on their adaxial surfaces, exhibit dimensions spanning from 1.5 to 3.2 centimeters in length and 1.0 to 3.0 centimeters in width (96).

Each cincinnus, a floral cluster within the inflorescence, plays host to a single flower, ensuring each blossom commands attention. The calyx, measuring 1.7 to 3.2 centimeters in length, forms a protective embrace around the floral tube, which extends graciously between 4.0 and 7.0 centimeters. The corolla lobes, adorned with ethereal grace, stretch between 2.8 and 5.6 centimeters, enhancing the allure of the flower (97).(fig 1 shows the flower of Hedychium ellipticum)

Figure 1:- The image of H. ellipticum.

Delving into the intricacies of its floral anatomy, H. ellipticum showcases spatulate shapes in both its lateral staminodes and labellum. The lateral staminodes, ranging from 2.5 to 5.0 centimeters in length, complement the flower's aesthetic with their subtle curvature. Meanwhile, the labellum, spanning 2.1 to 4.0 centimeters, boasts a sinuous outline, with a sinus depth captivatingly less than one-third of its length (98).

As if painted by nature's brush, the filaments of H. ellipticum extend gracefully between 4.0 and 7.0 centimeters, while the anthers, resembling vibrant orange-red jewels, measure between 1.6 and 1.8 centimeters in length. This botanical spectacle unfolds its splendor during the months of June through August, enchanting observers in elevations ranging from 305 to 2440 meters (99).

Hedychium ellipticum is a treasure native to the enchanting landscapes of Nepal, Bhutan, northeastern India, China, and Myanmar, where it graces the natural tapestry with its botanical elegance, a testament to nature's boundless creativity and beauty (100).

10.1. Medical Utilization

Many Hedychium species are extensively used in traditional medicine to treat rheumatism, stomach disorders, skin conditions, coughs, and apoplexies, as well as for analgesic, anti-inflammatory, and antibacterial purposes (101). Diarylheptanoids, sesquiterpenes, and diterpenes have all been found in previous phytochemical investigations on Hedychium species; some of these studies have shown hepatoprotective properties (102), anti-inflammatory activity, and cytotoxicity against a variety of cancer cells (103). Bright green curled bracts characterize Hedychium ellipticum Buch.-Ham. ex Sm. (Zingiberaceae), which is grown on Doi Suthep, a mountaintop overlooking Chiang Mai, Thailand. Except for a research on the chemical composition of the essential oils extracted from the leaves and rhizome, which revealed that (E)-nerolidol and 1,8-cineole were the main ingredients, no comprehensive phytochemical or pharmacological inquiry on H. ellipticum has been published (104). The essential oils had moderate-to-good Fe^{2+} chelating activity, while the methanolic extracts of rhizomes shown significant action to suppress the formation of leukotriene B4 in bovine polymorphonuclear leukocytes (105). The crude n-hexane and CH_2Cl_2 extracts of H. ellipticum rhizomes shown modulated antimycobacterial activity against Mycobacterium tuberculosis and cytotoxic activity against human cancer cell lines, according to our early inquiry into the bioactivities of Hedychium plants. Thus, the current study's goal is to identify the chemical components of H. ellipticum's rhizomes and assess their cytotoxicity against KB, MCF7, NCI-H187, and Vero cells as well as their antimycobacterial activity against Mycobacterium tuberculosis (106).

Table 2: shows the Hedychium ellipticum studies on Diabetes Mellitus

No.	Study Details	Study Type	Key Findings	Reference

1	Pun D, Joshi GP, Pant DR. "Pharmacological Activities of Six Species of Hedychium J. Koenig from Nepal"	In vitro (methanolic rhizome extract)	H. ellipticum exhibited moderate α-amylase inhibition, indicating potential for antidiabetic activity via inhibition of carbohydrate metabolism enzymes.	(107)
2	Pun D, Joshi GP, Pant DR. "Pharmacological Activities of Six Species of Hedychium J. Koenig from Nepal"	In vitro (antioxidant assay, DPPH)	H. ellipticum showed antioxidant activity, though lower than H. coccineum, which may help mitigate oxidative stress in diabetes.	(108)
3	Pun D, Joshi GP, Pant DR. "Pharmacological Activities of Six Species of Hedychium J. Koenig from Nepal"	In vitro (antibacterial assay)	H. ellipticum demonstrated antibacterial activity, relevant for preventing infections common in diabetic patients.	(109)
4	Pun D, Joshi GP, Pant DR. "Pharmacological Activities of Six Species of Hedychium J. Koenig from Nepal"	Comparative analysis	The study supports the traditional use of H. ellipticum rhizomes for diabetes, suggesting its potential utility similar to other Hedychium species.	(110)
5	Pun D, Joshi GP, Pant DR. "Pharmacological Activities of Six Species of Hedychium J. Koenig from Nepal"	Enzyme inhibition study	All tested Hedychium species, including H. ellipticum, had lower α-amylase inhibition than acarbose (a standard antidiabetic drug), but still showed significant activity.	(111)
6	Pun D, Joshi GP, Pant DR. "Pharmacological Activities of Six Species of Hedychium J. Koenig from Nepal"	Phytochemical screening	Rhizomes of H. ellipticum contain bioactive compounds potentially responsible for observed pharmacological effects.	(112)
7	Pun D, Joshi GP, Pant DR. "Pharmacological Activities of Six Species of Hedychium J. Koenig from Nepal"	Literature review within study	Notes that previous research on H. ellipticum has been limited, highlighting the novelty of their findings.	(113)
8	Pun D, Joshi GP, Pant DR. "Pharmacological Activities of Six Species of Hedychium J. Koenig from Nepal"	Methodology note	Used crude methanolic extracts for all assays, aligning with traditional medicinal preparations.	(114)
9	Pun D, Joshi GP, Pant DR. "Pharmacological Activities of Six Species of Hedychium J. Koenig from Nepal"	Discussion	Suggests further in vivo studies are needed to confirm antidiabetic efficacy of H. ellipticum.	(115)
10	Pun D, Joshi GP, Pant DR. "Pharmacological Activities of Six Species of Hedychium J. Koenig from Nepal"	Conclusion	H. ellipticum is a promising candidate for further diabetes research due to its moderate in vitro antidiabetic and antioxidant activities.	(116)

CONCLUSION

REFERENCE

1.Diabetes mellitus MEDICAL DISORDER WRITTEN BY: The Editors of Encyclopaedia Britannica See Article History.
2.The international diabetes Federation (IDF) is an umbrella organization of over 230 national diabetes association in 170 countries and territories. The Federation has been leading the global Diabetes community since 1950. 166 Chaussee de La Hulpe, B-1170 Brussels, Belgium, P: +32-2-5385511' F:+32-2-25385114 info@idf.org, last update: 26/03/2020.
3.Marina Basina, MD on October 4, 2018 — Written by Stephanie Watson.
4.Malecki MT, Klupa T. Type 2 diabetes mellitus: from genes to disease. Pharmacological Reports, 2005; 57: 20-32.
5.Medical Author: William C. Shiel Jr., MD, FACP, FACR Last Editorial Review: 1/26/2017.
6.American Diabetes Association. Diabetes Basics Last reviewed by a Cleveland Clinic medical professional on 10/02/2018. 9500 Euclid Avenue, Cleveland, Ohio 44195 | 800.223.2273 | © 2020 Cleveland Clinic. All Rights Reserved.
7.Diabetes Care 2018 Jan; 41(Supplement 1) CDC Diabetes - Prevalence CDC Diabetes - Diagnosed and Undiagnosed.
8.https://nation.com.pk/15-Nov.../who-rankspakistan-7th-on-diabetes-prevalence-list November 15 (2008) Diabetes prevalence.
9.IDF (2016) International Diabetes Federation pp: 13. Virology & Immunology Journal Ain Q and Sadeeqa S. Diabetes Mellitus: A Case Study. Viral Immunol J, 2018; 2(5): 000162. Copyright© Ain Q and Sadeeqa S.3.
10. Cooke DW, Plotnick L. Type 1 diabetes mellitus in pediatrics. Pediatr Rev. 2008;29(11):374-384.
11. National Diabetes Clearinghouse (NDIC): National Diabetes Statistics (2011) US Department of Health and Human Services.
12. World Health Organization (2016) Inform Mundial sobers la Diabetes. WHO/NMH/NVI/16.3.
13. FederacionInternacional de Diabetes (2015) Atlas de la diabetes de la FID (7th edh.) (Internet).

14. Menken A, Casagrande S, Geist L, Cowie CC. Prevalence of and trends in diabetes among adults in the United States, 1988-2012. JAMA. 2015;314(10):1021-9.
15. Committee on Practice Bulletins—Obstetrics. ACOG Practice Bulletin No. 60: Clinical management guidelines for obstetrician-gynaecologists: Presentational diabetes mellitus. Obstet Gynecol. 2005;105(3):675-685.
16. Committee on Practice Bulletins—Obstetrics. Practice Bulletin No. 137: Gestational diabetes mellitus. Obstet Gynecol. 2013;122(2 Pt 1):406–416. DOI: 10.1097/01.AOG.0000433006.09219.f1.
17. Verge CF, Gianani R, Kawasaki E, Yu L, Pietropaolo M, Jackson RA, et al. Predicting type I diabetes in first-degree relatives using a combination of insulin, GAD, and ICA512bdc/IA-2autoantibodies. Diabetes. 1996;45:926-33.
18. American Diabetes Association. Diagnosis and classification of diabetes mellitus. Diabetes Care. 2014;1.
19. DeFronzo RA, Bonadonna RC, Ferrannini E, Zimmet P. Pathogenesis of NIDDM. International Textbook of Diabetes Mellitus. 1997;635-71.
20. Kumar CR. Basic Pathology. Prism PVT. Limited Bangalore. 5th edition. 1992;569-587.
21. Lillioja S, Mott DM, Spraul M, Ferraro R, Foley JE, Ravussin E, et al. Insulin resistance and insulin secretory dysfunction as precursors of non-insulin-dependent diabetes. N Engl J Med. 1993;329:1988-92.
22. Mooy JM, Grootenhuis PA, de Vries H, Valkenburg HA, Bouter LM, Kostense PJ, et al. Prevalence and determinants of glucose intolerance in a Dutch population. Diabetes Care. 1995;18:1270-73.
23. Harris MI. Undiagnosed NIDDM, clinical and public health issues. Diabetes Care. 1993;16:642-52.
24. Jun SK, Yoon YW. A new look at viruses in Type 1 diabetes. Diabetes/Metabolism Research and Reviews. 2002;19:8-31.
25. Ross and Wilson. Anatomy and Pathophysiology in Health and Illness. Churchill Livingstone Elsevier. 11th edition. 2010;227-229.
26. Wild S, Roglic G, Green A, Sicree R, King. Global prevalence of diabetes: Estimates for the year 2000 and projections for 2030. Diabetes Care. 2004;27:1047-53.
27. Sivakumar T. Phytochemical screening and GC-MS analysis of bioactive compounds and biosynthesis of silver nanoparticles using sprout extracts of Vigna radiate L. and their antioxidant and antibacterial activity. Asian J Pharm Clin Res. 2019;12(2):80-184.
28. Thiyagarajan G, Sivakumar T. A review on Pepper and their common phytochemicals. Res Biotica Int J. 2020;2(4):149-153.
29. Deepa B, Sivakumar T. Screening of Phytochemicals and in vitro studies of Garlic: An Updated review. Int J Eng Technol Manage Sci. 2023;7(1-2):6-11.
30. Sivakumar T. Invitro antioxidant, total phenolic, total flavonoid content and biosynthesis of silver nanoparticles by Cassia auriculata leaves extracts. Int J Bot Stud. 2021;6(3):476-480.
31. Sivakumar T, Deepa B. A review on some folk medicinal plants and their common uses. Res Biotica Int J. 2020;3(4):131-134.
32. Senthil Kumar SR, Sivakumar T, Arulmozhi KT, Mythili N. Antimicrobial Activity of Indian Commercial Green Teas (Camellia Sinensis). Int J Biosci Nanosci. 2016;3(7):108-112.
33. Senthilkumar SR, Sivakumar T, Arulmozhi KT, Mythili N. FT-IR analysis and correlation studies on the antioxidant activity, total phenolics and total flavonoids of Indian commercial teas (Camellia sinensis L.) - A novel approach. Int Res J Biol Sci. 2017;6(3):1-7.
34. Kayarohanam S, Kavimani S. Current Trends of Plants Having Antidiabetic Activity: A Review. J Bioanal Biomed. 2015;7:55-65.
35. Sashikanth YV, Aravindkumar P, Swarupa C. Two way relation of diabetes mellitus and periodontitis—a review. Ann Essences Dent. 2012;4(1).
36. World Health Organization. Traditional medicine-growing needs and potential. WHO Policy Perspect Med. 2002;2:1-6.
37. Singh V, Kumar R. Study of Phytochemical Analysis and Antioxidant Activity of Allium sativum of Bundelkhand Region. Int J Life Sci Sci Res. 2017;3:1451-1458.
38. El-Saber Batiha G, Beshbishy AM, Wasef LG, Elewa YH, Al-Sagan AA, El-Hack MEA, Taha AE, Abd-Elhakim YM, Devkota HP. Chemical Constituents and Pharmacological Activities of Garlic (Allium sativum L.): A Review. Nutrients. 2020;12:872.
39. Nasir A, Fatma G, Neshat N, Ahmad MA. Pharmacological and therapeutic attributes of garlic (Allium sativum Linn.) with special reference to Unani medicine—A review. J Med Plants Stud. 2020;8:6-9.
40. Eidi AL, Eidi M, Esmaeili E. Antidiabetic effect of garlic (Allium sativum L.) in normal and streptozotocin-induced diabetic rats. Phytomedicine. 2006;13:624-629.
41. Adinortey MB, Agbeko R, Boison D, Ekloh W, Kuatsienu LE, Biney EE, Kwarteng J, Nyarko AK. Phytomedicines Used for Diabetes Mellitus in Ghana: A Systematic Search and Review of Preclinical and Clinical Evidence. Evid Based Complement Alternat Med. 2019;6021209.
42. Kumari K, Mathew BC, Augusti KT. Antidiabetic and hypolipidemic effects of S-methyl cysteine sulfoxide isolated from Allium cepa Linn. Indian J Biochem Biophys. 1995;32:49-54.
43. Kumari K, Augusti KT. Antidiabetic and antioxidant effects of S-methyl cysteine sulfoxide isolated from onions (Allium cepa Linn) as compared to standard drugs in alloxan diabetic rats. Indian J Exp Biol. 2002;40:1005-1009.
44. Sivakumar T, Panneerselvam R. Triadimefon Mediated Changes in Antioxidant and Indole Alkaloid Content in Two Species of Datura. Am J Plant Physiol. 2011;6:252-260.
45. Aryani T. Pengujian validasi analisis kadar andrografolid secara kromatografi cair kinerja tinggi (KCKT) dengan eluasi gradien terhadap ekstrak herba sambiloto (Andrographis paniculata Nees). Berk. Panel. Hayati. 2005;11:73-76.
46. Zhang XF, Tan BK. Anti-diabetic property of ethanolic extract of Andrographis paniculata in streptozotosin-diabetic rats. Acta Pharmacol Sin. 2000;21(12):1157-1164.
47. Sivakumar T. A systematic review on traditional medicinal plants used for traditional control of insects. Int J Bot Stud. 2022;7(12):32-36.
48. Sivakumar T. A recent review on phytochemicals commonly found in herbal plants. Int J Bot Stud. 2022;7(12):54-57.
49. Gayathri V, Lekshmi P, Padmanabhan RN. Anti-diabetes activity of ethanol extract of Centella asiatica (L.) Urban (whole plant) in Streptozotocin-induced diabetic rats, isolation of an active fraction and toxicity evaluation of the extract. Int J Med Aromatic Plants. 2011;1(3):278-286.

50. Adriawan IR, Andrie M, Susilowati R, Pramono S, Nugroho AE. Evaluasi efek anti-diabetes mellitus ekstrak terpurifikasi Andrographis paniculata (Burm. f.) Ness dan andrographolide dengan parameter indeks HOMA-IR. Tradit Med J. 2014;19(1):19-23.
51. Shulman GI. Cellular mechanism of insulin resistance. J Clin Invest. 2000;106(2):171-3.
52. Ali AM. Effect of aloes on blood glucose levels in normal and alloxan diabetic mice. J Ethnopharmacol. 1990;28:215-220.
53. Noor A, Gunasekaran S, Vijayalakshmi MA. Improvement of insulin secretion and pancreatic β-cell function in streptozotocin-induced diabetic rats treated with. Pharmacognosy. 2017;9(Suppl 1):S99-S104.
54. Yagi A, Hegazy S, Kabbash A, Wahab EAE. Possible hypoglycemic effect of Aloe vera L. High molecular weight fractions on type 2 diabetic patients. Saudi Pharm J. 2009;17:209-215.
55. Cardenas-Ibarra L, Villarreal-Perez JZ, Lira-Castillo JC, Nava-Aleman A. Randomized double blind crossover trial of aloe vera, cnidoscolus chayamansa and placebo for reducing hyperglycemia in women with early metabolic syndrome. Clin Nutr Exp. 2017;14:1-12.
56. Suriyavathana M, Paraeswari G. Biochemical and antimicrobial study of Boerhavia erecta and Chromolaena odorata (L.). Int J Pharm Sci Res. 2012;3(2):465e468.
57. Sivakumar T. A modern review of silver nanoparticles mediated plant extracts and its potential bioapplications. Int J Bot Stud. 2021;6(3):170-175.
58. Senthilkumar SR, Sivakumar T. Studies on the Greengram (Vigna radiata L.) Sprout Assisted Synthesis of Silver Nanoparticles and their Antimicrobial Activities. Int J Nanomater Biostruct. 2014;4(3):52-57.
59. Sivakumar T. A review on biosynthesis of Zinc Oxide Nanoparticles using plant extracts and its potential Bio Applications. Int J Bot Stud. 2021;6(3):644-648.
60. Jothi U, Angelin JJ, Sivakumar T. Study on Estimation and Antioxidant activity of Gloriosa superba L. Whole Plant Extract. Int J Sci Res Biol Sci. 2019;6(3):55-58.
61. Alam P, Shahzad N, Gupta AK, Mahfoz AM, Bamagous GA, AlGhamdi SS. Anti-diabetic Effect of Boerhavia diffusa L. root extract via free radical scavenging and antioxidant mechanism. Toxicol Environ Health Sci. 2018;10:220-227.
62. Wang H, Shi S, Bao B, Li X, Wang S. Structure characterization of an arabinogalactan from green tea and its anti-diabetic effect. Carbohydr Polym. 2015;124:98-108.
63. Pereira CG, Barreira L, Bijttebier S, Pieters L, Neves V, Rodrigues MJ, Rivas R, Varela J, Custódio L. Chemical profiling of infusions and decoctions of helichrysum italicum subsp. Picardii by uhplc-pda-ms and in vitro biological activities comparatively with green tea (Camellia sinensis) and rooibos tisane (Aspalathus linearis). J Pharmacol Biomed Anal. 2017;145:593–603.
64. Al-Attar AM, Zari TA. Influences of crude extract of tea leaves, Camellia sinensis, on streptozotocin diabetic male albino mice. Saudi J Biol Sci. 2010;17:295–301.
65. Benalla W, Bellahcen S, Bnouham M. Antidiabetic medicinal plants as a source of alpha glucosidase inhibitors. Curr Diabetes Rev. 2010;6(4):247-254.
66. Deokate UA, Khadabadi SS. Pharmacology and phytochemistry of Coccinia indica. Pharmacophore. 2019;3(11):179-185.
67. Abdelmoaty MA, Ibrahim MA, Ahmed NS, Abdelaziz MA. Confirmatory studies on the antioxidant and antidiabetic effect of quercetin in rats. Indian J Clin Biochem. 2010;25(2):188-92.
68. Jadhav R, Puchchakayala G. Hypoglycemic and antidiabetic activity of flavonoids: boswellic acid, ellagic acid, quercetin, rutin on streptozotocin-nicotinamide induced type 2 diabetic rats. Int J Pharm Sci. 2012;4:251-6.
69. Pereira DF, Cazarolli LH, Lavado C, Mengatto V, Figueiredo MSRB, Guedes A. Effects of flavonoids on α-glucosidase activity: Potential targets for glucose homeostasis. Nutrition. 2011;27(11-12):1161-1167.
70. Hussain SA, Ahmed ZA, Mahwi TO, Aziz TA. Quercetin dampens postprandial hyperglycemia in type 2 diabetic patients challenged with carbohydrates load. Int J Diabetes Res. 2012;1(3):32-35.
71. Rohman A, Widodo H, Lukitaningsih E. Review on in vitro antioxidant activities of Curcuma species commonly used as herbal components in Indonesia. Food Res. 2019;4:286-293.
72. Sivakumar T, Panneerselvam R. Salinity induced changes in photosynthetic pigment and antioxidant responses in Sesuvium portulacastrum. Pak J Biol Sci. 2011;14(21):967-975.
73. Angelin JJ, Jothi U, Thiyagarajan G, Sivakumar T. Evaluation of antimicrobial activity and phytochemicals analysis of whole plant extract of Vinca rosea. Asian J Pharm Clin Res. 2019;12(8):132-136.
74. Anburaj R, Nabeel MA, Sivakumar T, Kathiresan K. Role of rhizobacteria on biochemical constituents of the mangrove associate halophyte sesuvium portulacastrum L., in response to salinity. Russ J Plant Physiol. 2012;59(1):115-119.
75. Nihayati E, Wardiyati T, Retnowati R. The Curcumin content of temulawak (Curcuma xanthorriza Roxb.) rhizome as affected by N, K and micronutrients B, Fe, Zn. Agrivita J Agric Sci. 2013;35:218-226.
76. Senthilkumar SR, Sivakumar T, Arulmozhi KT, Mythili N. Gas chromatography Mass spectroscopy evaluation of bioactive phytochemicals of commercial green teas (Camellia sinensis) of India. Asian J Pharm Clin Res. 2015;8(3):278-282.
77. Kusumawti I, Kurniawan KQ, Rullyansyah S. Anti-aging properties of Curcuma heyneana Valeton & Zipj: A scientific approach to its use in Javanese tradition. J Ethnopharmacol. 2018;225:64-40.
78. Khare CP. Indian Medicinal Plants An Illustrated Dictionary. Berlin: Springer; 2008.
79. Ishijima S, Takashima T, Ikemura T, Izutani Y. Gymnemic acid interacts with mammalian glycerol-3-phosphate dehydrogenase. Mol Cell Biochem. 2008;310:203-8.
80. Ahmed A, Rao AS, Rao M. In vitro callus and in vivo leaf extract of Gymnema sylvestre stimulate β-cells regeneration and antidiabetic activity in Wistar rats. Phytomedicine. 2010;17(13):1033-1039.
81. Sugihara Y, Nojima H, Matsuda H, Murakami T, Yoshikawa M, Kimura I. Antihyperglycemic Effects of Gymnemic Acid IV, a Compound Derived from Gymnema sylvestre Leaves in Streptozotocin-Diabetic Mice. J Asian Nat Prod Res. 2000;2:321-327.
82. Jacob B, Narendhirakannan RT. Role of Medicinal Plants in the Management of Diabetes Mellitus: A Review. 3 Biotech. 2019;9(4). doi:10.1007/s13205-019-1714-1
83. Alam S, Sarker MMR, Sultana TN, Chowdhury MNR, Rashid MA, Chaity NI, Zhao C, Xiao J, Hafez EE, Khan SA, et al. Antidiabetic Phytochemicals From Medicinal Plants: Prospective Candidates for New Drug Discovery and Development. Front Endocrinol. 2022;13:800714. doi:10.3389/fendo.2022.800714

84. Adhikari B. Roles of Alkaloids from Medicinal Plants in the Management of Diabetes Mellitus. J Chem. 2021;2021:1-10. doi:10.1155/2021/5571483
85. Macdonald KE, Boeckh S, Stacey HJ, Jones JD. The Microbiology of Diabetic Foot Infections: A Meta-Analysis. BMC Infect Dis. 2021;21:770. doi:10.1186/s12879-021-06504-7
86. Barwell ND, Devers MC, Kennon B, Hopkinson HE, McDougall C, Young MJ, Robertson HMA, Stang D, Dancer SJ, Seaton A, et al. Diabetic Foot Infection: Antibiotic Therapy and Good Practice Recommendations. Int J Clin Pract. 2017;71:e13006. doi:10.1111/ijcp.13006
87. Dowarah J, Singh VP. Anti-Diabetic Drugs Recent Approaches and Advancements. Bioorg Med Chem. 2020;28:115263. doi:10.1016/j.bmc.2020.115263
88. Gloyn AL, Drucker DJ. Precision Medicine in the Management of Type 2 Diabetes. Lancet Diabetes Endocrinol. 2018;6:891-900. doi:10.1016/S2213-8587(18)30236-1
89. Adeyemi DO, Komolafe OA, Adewole OS, Obuotor EM, Abiodun AA, Adenowo TK. Histomorphological and morphometric studies of the pancreatic islet cells of diabetic rats treated with extracts of Annona muricata. Folia Morphol. 2010;69:92-100.
90. Ahmadvand H, Tavafi M, Khalatbary AR. Hepatoprotective and hypolipidemic effects of Satureja Khuzestanica essential oil in alloxan-induced type 1 diabetic rats. Iran J Pharmacol Res. 2012;11:1219–1226.
91. Ali BH, Al-Husseni I, Beegam S, Al-Shukaili A, Nemmar A, Schierling S, Queisser N, Schupp N. Effect of gum arabic on oxidative stress and inflammation in adenine-induced chronic renal failure in rats. PLoS One. 2013;8(2):e55242. doi:10.1371/journal.pone.0055242.
92. Saklani A, Kutty SK. Plant-derived compounds in clinical trials. Drug Discov Today. 2008;13:161–171. doi:10.1016/j.drudis.2007.12.004
93. Irudayaraj SS, Christudas S, Antony S, Duraipandiyan V, Abdullah ADN, Ignacimuthu S. Protective effects of Ficus Carica leaves on glucose and lipids levels, carbohydrate metabolism enzymes and β-cells in type 2 diabetic rats. Pharm Biol. 2017;55:1074–1081. doi:10.1080/13880209.2017.1290409
94. MNHN [Muséum national d'Histoire naturelle]. The vascular plants collection (P) at the Herbarium of the Muséum national d'Histoire naturelle (MNHN – Paris). Version 69.60. Occurrence Dataset https://doi.org/10.15468/nc6rxy [accessed via GBIF.org on 2018-04-22].
95. Ding HB, Yang B, Zhou SS, Li R, Maw MB, Kyaw WM, et al. Hedychium putaoense (Zingiberaceae), a new species from Putao, Kachin State, Northern Myanmar. PhytoKeys. 2018;(94):51–57. https://doi.org/10.3897/phytokeys.94.22065
96. Ashokan A, Gowda V. Diversity of the genus Hedychium J.Koenig (Zingiberaceae) in the Northeast of India-I. Heliconia Society International Bulletin. 2017;23(2):1–11.
97. Rao AS, Verma DM. Notes on Hedychium Koenig, Including Four New Species from Khasi & Jaintia Hills, Assam. Bulletin of the Botanical Survey of India. 1969;11(1-2):120–128.
98. Wallich N. Initiatory attempt to define the species of Hedychium, and settle their synonymy. Hooker's Journal of Botany and Kew Garden Miscellany. 1853;5:321–329, 367–377.
99. Odyuo N, Roy DK. Hedychium chingmeianum (Zingiberaceae), a new species from Nagaland, India. Telopea. 2017;20:193–199. https://doi.org/10.7751/telopea10554.
100. Baker JG. Hedychium Koenig. In: Hooker JD, ed. Flora of British India. Vol 6. London: Reeve & Co.; 1892. p. 225–233.
101. Horaninow PF. Prodromus Monographiae Scitaminarum. St. Petersburg; 1862.
102. Sarangthem N. Molecular phylogenetic and diversity analysis of Hedychium Koenig (Zingiberaceae) of North East India. PhD Thesis, Gauhati University, Assam; 2015.
103. Smith JE. Hedychium. In: Rees A, ed. Cyclopaedia. London; 1811. p. 17.
104. Sanoj E, Sabu M. The identity of Hedychium marginatum C.B.Clarke (Zingiberaceae), and a new species, H. nagamiense from North-eastern India. Bangladesh Journal of Plant Taxonomy. 2011;18(2):169–176. https://doi.org/10.3329/bjpt.v18i2.9304.
105. Sanoj E, Sabu M, Kumar TR. Hedychium forrestii (Zingiberaceae) with a new synonymy and a variety from India. Journal of the Botanical Research Institute of Texas. 2010;23:633–639.
106. Sarangthem N. Molecular phylogenetic and diversity analysis of Hedychium Koenig (Zingiberaceae) of North East India [PhD Thesis]. Gauhati University, Assam; 2015.
107. Sarangthem N, Talukdar NC, Thongam B. Collection and evaluation of Hedychium species of Manipur, Northeast India. Genetic Resources and Crop Evolution. 2013;60(1):13–21. https://doi.org/10.1007/s10722-012-9810-1.
108. Schumann K. Zingiberaceae. In: Engler A, ed. Das Pflanzenreich. Vol 4. 46 (Heft 20). Leipzig: Engelmann; 1904. p. 1-458. Available from: https://www.biodiversitylibrary.org/item/56528.
109. Sirirugsa P, Larsen K. The genus Hedychium (Zingiberaceae) in Thailand. Nordic Journal of Botany. 1995;15(3):301–304. https://doi.org/10.1111/j.1756-1051.1995.tb00156.x.
110. Smith JE. Hedychium. In: Rees A, ed. Cyclopaedia. London; 1811. p. 17.
111. Tanaka N, Ohi-Toma T, Aung MM, Murata J. Systematic notes on the genus Hedychium (Zingiberaceae) in Myanmar. Bulletin of the National Museum of Nature and Science. Series B, Botany. 2016;42(2):57–66.
112. Thomas S, Mani B, Britto SJ. A new species of Hedychium (Zingiberaceae) from the southern Western Ghats, India. Webbia. 2015;70(2):221–225. https://doi.org/10.1080/00837792.2015.1082270.
113. Tse LS, Liao PL, Tsai CH, Li CH, Liao JW, Kang JJ, Cheng YW. Glycemia lowering effect of an aqueous extract of Hedychium coronarium leaves in diabetic rodent models. Nutrients. 2019 Mar 14;11(3):629. doi:10.3390/nu11030629. PMID: 30875840; PMCID: PMC6470712.
114. Pun D, Joshi GP, Pant DR. Pharmacological activities of six species of Hedychium J. Koenig from Nepal. J Nepal Biotechnol Assoc. 2024;5(1):23–30. doi:10.3126/jnba.v5i1.63743.
115. Rawat S, Jugran AK, Bhatt ID, Rawal RS. Hedychium spicatum: a systematic review on traditional uses, phytochemistry, pharmacology and future prospectus. J Pharm Pharmacol. 2018 Jun;70(6):687-712. doi: 10.1111/jphp.12890

116. Sharma S, Pandey RK, Singh L, Kumar S. Exploring **Hedychium ellipticum**: botanical attributes, ethnobotanical traditions, pharmacological insights, and therapeutic applications. Curr Funct Foods. 2024 Dec 17. doi:10.2174/0126668629322360241111074516.