Journal of Community Pharmacy Practice
ISSN: 2799-1199
Vol: 02, No. 02, Feb-Mar 2022
http://journal.hmjournals.com/index.php/JCPP
DOI: https://doi.org/10.55529/jcpp.22.16.26

Exploring Nature's Remedy: Medicinal Plants Combatting Diabetes in Animal Studies

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Received: 22 October 2021 **Accepted:** 11 January 2022 **Published:** 16 February 2022

Abstract: Diabetes is a persistent hormonal disorder that is widespread worldwide and its occurrence is on the rise. Diabetes is a significant health problem that affects people of all ages due to its involvement in multiple body systems and the potential for devastating complications. Despite advancements in drug discovery and therapeutic approaches, effectively treating diabetes continues to be a formidable issue. Consequently, global research efforts are concentrated on discovering alternative methods. Through extensive analysis, a multitude of conventional remedies have been discovered for diabetes. Compounds and extracts derived from many natural sources, notably plants, have always been a popular tool for managing and treating complex genetic illnesses and the associated complications. therapeutic herbs have demonstrated encouraging effects in experimental animals, which can be extended to people as well. This research will examine different medicinal plants that have demonstrated anti-diabetic effects in experimental animals.

Keywords: Diabetes, Medicinal Plants, Ayurveda, Unani.

1. INTRODUCTION

Diabetes mellitus is a contemporary global epidemic that is rapidly expanding. It is characterized by poor glucose tolerance, which impairs the functioning and sensitivity of pancreatic beta cells. This ultimately leads to the development and progression of diabetes and its related consequences. It is a persistent medical condition affecting the metabolism of carbohydrates, fats, and proteins. This condition is characterized by elevated levels of blood sugar during periods of fasting and after meals, and it also increases the likelihood of developing vascular issues. It is the prevailing endocrine problem in both men and women,

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and a significant public health issue of widespread proportions. Previously believed to be a condition only affecting Western countries, it is now becoming more prevalent in our country as our population becomes more modernized and urbanized [1]. According to Ayurvedic literature dating back to ancient times, herbal plants in various oral formulations have been used to treat Madhumeha (diabetes mellitus) from the time of Charak and Sushrut. There are confident claims of cure documented for this.Diabetes Mellitus (DM) is now the prevailing endocrine disorder worldwide, resulting from an impairment in the functioning of insulin. By the year 2030, it is projected that over 439 million individuals would be impacted by diabetes. India is a major center of the worldwide diabetes mellitus pandemic. Furthermore, diabetes is rapidly emerging as a possible epidemic in India, with an alarming number of over 62 million individuals being diagnosed with diabetes year. By the year 2030, it is projected that the number of such instances may rise to 79.4 million, presenting a potential risk associated with diabetes [2]. Extensive research has been conducted on a wide array of herbal plants that possess potential antidiabetic properties. These plants may encompass: Azadirachtaindica, Grewiaasiatica, Eugenia jambolana, Cinamomumzeylanicum, Allium sativum, and Allium cepa have been found to possess various hypoglycemic activities. Azadirachtaindica increases insulin secretion from pancreatic beta-cells, Grewiaasiatica exhibits antioxidant and radical scavenging activity, Eugenia jambolana inhibits alpha-glucosidase activity, Cinamomumzeylanicum increases serum insulin level through its chief active constituent cinnamaldehyde, Allium sativum shows significant hypoglycemic activity through its active compound allicin, and Allium cepa significantly controls blood glucose levels through its active constituent S-methyl cysteine sulphoxide. Other plants such as Aeglemermelos, Aralia elata, Phyllanthusamarus, and Tinosporacordifolia also possess hypoglycemic properties [3]. The World Health Organization (WHO) recently recommended the use of medicinal plants to treat Diabetes Mellitus and promoted additional scientific research on the anti-diabetic characteristics of various plant species. As a result, recent estimates indicate that more than 70% of the world's population uses resources obtained from traditional plant-based remedies to control and alleviate diabetes mellitus (DM) and its problems. There is a significant increase in the field of traditional herbal medicine, and these drugs are gaining popularity in both developing and developed countries due to their natural origin and less adverse effects. Numerous conventional remedies are developed from medicinal plants, minerals, and organic substances. The World Health Organization (WHO) has cataloged a total of 21,000 plant species that are now utilized for medical purposes worldwide [4].

2. RELATED WORK

Studying the use of medicinal plants to treat diabetes in animals is a fascinating field of research that could have important ramifications for human health. This topic focuses on the medicinal effects of several plant-derived substances in the management of diabetes mellitus, a chronic metabolic condition defined by decreased insulin action or synthesis. Animal studies are useful preclinical models for examining the effectiveness, safety, and mechanisms of action of medicinal plants in the therapy of diabetes.

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1. The research focuses on screening various plant species to find those that have potential anti-diabetic characteristics. Screening procedures may involve conducting ethnobotanical surveys, doing phytochemical analysis, and conducting in vitro experiments to evaluate the bioactivity of plant extracts or isolated chemicals.

2. The anti-hyperglycemic effects of medicinal plant extracts or chemicals on blood glucose levels in diabetic animal models are assessed by animal experiments. The objective of these investigations is to clarify the capacity of plant-derived compounds to reduce blood glucose levels by many mechanisms, including improving the responsiveness of cells to insulin, promoting the release of insulin, or hindering the breakdown and absorption of carbohydrates.

3. Research is being conducted to evaluate the effects of medicinal plants on insulin sensitivity and resistance in diabetic mice, with the goal of improving insulin sensitivity. These studies examine the potential of plant-derived chemicals to enhance cellular responses to insulin, leading to improved glucose absorption and utilization by tissues.

4. Medicinal plants are being studied for their ability to protect against diabetic sequelae, including neuropathy, nephropathy, retinopathy, and cardiovascular problems, in animal models of diabetes. The purpose of these investigations is to evaluate the antioxidant, anti-inflammatory, and anti-glycation characteristics of plant extracts in order to decrease oxidative stress and inflammation related to diabetic problems.

5. Mechanistic Studies: The research focuses on understanding the precise mechanisms via which medicinal plants produce their anti-diabetic properties. Mechanistic research encompass molecular and cellular investigations aimed at identifying precise molecular targets or signaling pathways responsible for modulating the biological actions of chemicals obtained from plants.

6. Safety and Toxicity Assessment: Animal studies are conducted to assess the safety and potential harmful effects of medicinal plant extracts or phytochemicals used for managing diabetes. These evaluations aid in guaranteeing the safety of herbal treatments and provide guidance for optimizing dosage in human clinical studies.
Research investigates the possible synergistic benefits of medicinal herbs when used with conventional anti-diabetic drugs in animal models. The objective of combination therapy studies is to ascertain whether plant-derived chemicals can augment the effectiveness or mitigate the undesirable effects of conventional diabetic medications. The findings obtained from animal studies examining the use of medicinal plants for diabetes treatment offer important preclinical data to endorse further investigation and advancement of herbal medicines as supplementary or alternative treatments for diabetes mellitus. Translating the results obtained from animal models to human clinical trials shows possibilities for utilizing the healing properties of natural remedies to fight against diabetes and enhance patient outcomes.

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3. METHODOLOGY

This study seeks to explore the potential of medicinal plants in controlling diabetes by conducting animal trials. The methodology employs a methodical approach that includes reviewing relevant literature, selecting appropriate plants, designing experiments, collecting data, analyzing the data, and interpreting the results.At first, an extensive literature search was performed on pertinent databases including PubMed, ScienceDirect, and Google Scholar using specific keywords such as "medicinal plants," "diabetes," and "animal studies." Articles that discuss the antidiabetic effects of medicinal herbs in animal models will be included.After conducting a thorough examination of the available literature, we have chosen medicinal plants that have shown potential in treating diabetes for further study. The selection criteria encompass factors such as accessibility, safety record, and proven effectiveness in preclinical trials. The purpose of the animal trials was to assess the ability of specific medicinal plants to treat diabetes. The experimental procedures involved inducing diabetes in animal models, administering plant extracts or active substances, measuring glucose levels, and evaluating biochemical and histological characteristics associated with diabetes.The data obtained from animal trials will be examined using suitable statistical techniques to ascertain the efficacy of medicinal plants in fighting diabetes. The interpretation of the findings would be done within the framework of the available literature and the potential mechanisms of action. This study seeks to offer significant insights into the therapeutic potential of medicinal plants for treating diabetes. It also serves as a basis for future research and clinical investigations in this sector.

Plants with Hypoglycemic/Antidiabetic Effects in Experimental Animal

It has been proven that Aegle marmelos Corr. (Rutaceae) has considerable therapeutic effects associated with the control of diabetes. The metabolic enzyme malate dehydrogenase level was found to be significantly higher in STZ-induced diabetic rats than in control groups, according to the findings of investigations conducted on these animals. An effective normalization of the Km values of this enzyme was achieved through treatment with both insulin and the leaf extract of A. marmelos [5]. Incredible as it may sound, A. marmelos was just as successful as insulin in bringing back normal levels of glucose in the blood and weight in the body. In addition to this, the extract was able to minimize the oxidative stress that was brought on by alloxan, which resulted in a considerable reduction in the levels of lipid peroxidation, conjugated dienes, and hydroperoxide in both the serum and the liver tissues [6]. There are hypoglycemic qualities exhibited by the onion, which is scientifically known as Allium cepa Linn. (Liliaceae). Both synthetic dipropyldisulfide oxide and onion oil have been shown to have severe hypoglycemia effects in mice. In addition, it has been demonstrated that extracts of the bulb made using petroleum ether and chloroform can lower the levels of glucose in the blood when placed under glucose tolerance testing [7]. It has been demonstrated that Azadirachta indica Juss. (Meliaceae), more generally referred to as neem, possesses properties that are both antidiabetic and antihyperlipidemic. Neem seed kernel powder was able to effectively lower blood sugar levels in rats that had been induced with alloxan to develop diabetes. The antihyperglycemic effect of neem leaf extract was investigated in rabbits that were either normal or had been induced with STZ to develop

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diabetes. In diabetic rabbits, the extract nearly entirely stopped the reduction in peripheral glucose utilization and the glycogenolytic impact due to the action of adrenaline [8]. In normal rabbits, the extract had a lower degree of effectiveness in blocking these effects.

Using both aqueous and ethanolic extracts of Caesalpinia bonducella Roxb. (Leguminosae) seeds, researchers have shown that the seeds exhibit hypoglycemic effects in normal rats and antihyperglycemic action in STZ-diabetic rats [9]. A hypolipidemic effect was also observed in diabetic rats when these extracts were administered. Capparis decidua (Capparaceae) fruits, when powdered, have been demonstrated to reduce oxidative stress in alloxan-diabetic rats. This is accomplished by lowering alloxan-induced lipid peroxidation and altering the levels of erythrocyte superoxide dismutase and catalase enzymes. Catharanthus roseus L., which belongs to the Apocynaceae family, has been investigated for its potential to protect rats from developing diabetes caused by STZ. Its leaves and twigs were extracted with dichloromethane-methanol (DCMM), which demonstrated considerable impact on lipid peroxidation and antidiabetic activity [10]. This was most likely owing to the increased glucose consumption that was seen. When fed with ethanolic and aqueous extracts of defatted roots, Coccinia indica has been shown to have strong hypoglycemic effects in rats and rabbits that have been given alloxan. In patients with type 2 diabetes who were given concoctions made from the leaves of the Coccinia indica plant, a clinical trial that was double-blind and controlled demonstrated a significant improvement in glucose tolerance [11]. Ficus bengalensis, combined with a glycoside of leucopelargonidin that was derived from its bark, demonstrated significant hypoglycemic, hypolipidemic, and serum insulin-raising effects in rats with moderately elevated levels of diabetes. These effects were comparable to those of glibenclamide [12].

When consumed in powder or decoction form, the leaves of Gymnema sylvestre Roxb. (Asclepiadaceae) have the ability to lower the amount of glucose found in human urine. It has been demonstrated that diabetic rabbits, dogs, and humans can experience a reduction in their blood sugar levels when they are given aqueous or alcoholic extracts of leaves through oral administration [13]. It gives partial protection against pancreatic toxins such as beryllium and boosts insulin secretion or release both in vitro and in vivo while also stimulating insulin secretion. According to studies, it encourages the regeneration of islet cells that have been damaged by STZ in rats and it also boosts the activity of enzymes that are responsible for glucose consumption through insulin-dependent pathways to a greater extent [14].

In albino rats, the fruit extract of Momordica charantia Linn. (Cucurbitaceae) reduces hyperglycemia by affecting glucose tolerance. In alloxan-diabetic rabbits, the extract demonstrates hypoglycemic action. A number of studies have reported that this impact is caused by an increase in the amount of insulin that is secreted or released. There is a possibility that the hypoglycemic activity of the STZ-diabetic rat pancreas and islet cells is due to the reduction in lipid peroxidation that occurs in these cells [15].

Furthermore, biochemical studies have demonstrated that there are modifications in the activity of glucose-6-phosphatase, fructose-1,6-biphosphatase, and glucose-6-phosphate dehydrogenase in the liver. Momordin Ic and oleanolic acid 3-O-glucuronide, two

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hypoglycemic compounds that were extracted from the plant, shown dose-dependent effects in lowering serum glucose levels in rats that were given oral glucose. Additionally, both chemicals reduced glucose uptake in the small intestine in vitro [16].

It is a Pterocarpus marsupium. Roxb. wood is a source of pterostilbene, which is known to lower the levels of sugar in the blood of dogs. Decoctions made from its bark have been shown to increase glucose tolerance and reduce blood sugar levels in diabetic individuals. When administered to rabbits, alcoholic extracts of heartwood have been shown to drastically lower blood sugar levels and increase glucose tolerance [17]. There was a considerable antihyperglycemic action demonstrated by three phenolic components derived from Vijayasar in rats with STZ-induced diabetes. Insulin mimetic effects of (-) epicatechin, a benzopyran extract from the bark, were detected. These findings suggest that insulin and (-) epicatechin may have distinct mechanisms of action, while at the same time offering protective benefits on the osmotic fragility of human red cells [18].

In rats with alloxan-induced diabetes, preparations of Syzygium cumini (Caesalpiniaceae) have demonstrated hypoglycemic and antioxidant effects. By administering a dose of 100 milligrams per kilogram of body weight, alcoholic extracts of seeds were able to drastically lower levels of blood glucose, urine sugar, and lipids in the serum and tissues of alloxan-diabetic rats, while simultaneously increasing total hemoglobin levels [19].

In both normal and diabetic rats, the administration of Trigonella foenum-graecum, also known as fenugreek, has been shown to result in significant dose-related drops in blood glucose levels. Additionally, it was found to considerably lower a variety of serum lipids in rats that were not diabetic, as well as lower increased levels of HDL cholesterol and lipids in rats who were diabetic [20]. Zingiber officinale Rosc., which belongs to the Zingiberaceae family, has been shown to offer considerable protection against hyperglycemia and hypoinsulinemia in rats that have been induced with 5-HT. When administered to STZ-diabetic rats, Z. officinale treatment results in an increase in insulin levels and a drop in fasting glucose levels. Over the course of oral glucose tolerance tests, it has been observed that the area under the glucose curve in STZ-diabetic rats is greatly reduced, while the area under the insulin curve is significantly increased [21]. When administered to diabetic rats, Z. officinale has been shown to reduce serum cholesterol levels, serum triglyceride levels, and blood pressure. The aqueous extract of Ziziphus jujube Linn. (Rhamnaceae) has demonstrated hypoglycemic action in rats that were induced with alloxan to develop diabetes [22-24].

The use of herbal formulations such as D-400, which includes Eugenia jambolana, Pterocarpus marsupium, Ficus glomerulata, and Ocimum sanctum, amongst other plants, has been demonstrated to have positive responses to alloxan-induced hyperglycemia and kidney impairment in rabbits. There was a normalization of glucose levels, a suppression of glycogen levels, and an improvement in the uptake of 14C-glucose by liver slices in diabetic rats when D-400 was administered [24-26].

Ayush-82, which is a combination of seeds from Mangifera indica, Syzygium cuminii, and Momordica charantia, as well as leaves from Gymnema sylvestre, shown a significant reduction in both fasting blood sugar (FBS) and postprandial blood sugar (PPBS) levels in a clinical trial that included 350 patients with type 2 diabetes [26-29]. The combination of Enicostema littorale, Phyllanthus niruri, Eugenia jambolana, Melia

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azadirachta, Terminalia arjuna, Aegle marmelos, and shilajit, known as MA-471, has been shown to exhibit strong hypoglycemic and hypolipidemic actions in patients who are resistant to oral hypoglycemic medications. It is recommended that it be utilized in conjunction with these drugs in order to achieve superior outcomes [29-33].

4. RESULTS AND DISCUSSION

Studying the effects of medicinal plants on diabetes in animals is a promising approach to developing new treatments for diabetes, which is a major global health issue. Diabetes mellitus is a long-term metabolic illness caused by problems with insulin secretion, action, or both. It leads to consistently high blood sugar levels and is linked to several consequences that greatly affect patients' quality of life and create considerable healthcare challenges globally. Although current methods of treating diabetes, such as medication, lifestyle changes, and insulin therapy, have proven to be effective, they often have drawbacks such as side effects, inadequate control of blood sugar levels, and difficulties in maintaining long-term adherence [34].Within this particular framework, the investigation of nature's therapeutic solutions, namely medicinal plants, exhibits significant potential. These botanical sources contain a wide range of bioactive chemicals, such as alkaloids, flavonoids, polyphenols, terpenoids, and saponins. Many of these substances have potential antidiabetic activities. Over the course of many centuries, medicinal plants have been extensively used in traditional healthcare systems around the world. These plants have gained recognition for their claimed effectiveness in reducing high blood sugar levels, enhancing the body's response to insulin, safeguarding pancreatic beta cells, and alleviating difficulties associated with diabetes [35].Animal studies are an essential part of preclinical research that aims to understand the pharmacological effects, modes of action, and safety profiles of medicinal plants in the treatment of diabetes. Researchers carefully assess the therapeutic effects of several herbal remedies on important metabolic pathways involved in the development of diabetes, using different animal models of the disease. These models include chemically induced models, such as rodents with diabetes induced by streptozotocin or alloxan, genetic models like mice with the ob/ob or db/db mutation, as well as dietary models of insulin resistance created by high-fat diets [36]. Medicinal plants that are chosen undergo thorough examination in animal tests to determine their effectiveness, safety, and possible ways in which they work. One example is Gymnemasylvestre, a perennial woody vine that is native to India. It has gained interest due to its claimed antidiabetic properties. Gymnemasylvestre extracts have been shown in animal tests to have hypoglycemic and hypolipidemic effects. These effects are achieved via increasing insulin production, boosting insulin sensitivity, and reducing glucose absorption in the intestine.Furthermore, there has been a significant amount of research conducted on the antidiabetic benefits of Momordicacharantia, which is more popularly referred to as bitter melon or bitter gourd. Momordicacharantia extracts have been found to have hypoglycemic, hypolipidemic, and antioxidant effects in animal experiments. These benefits are achieved by promoting glucose uptake in peripheral tissues, decreasing the production of new glucose, and improving the routes that insulin uses to signal the body.Trigonella foenum-graecum, commonly known as fenugreek, and Panax ginseng, sometimes known as Asian ginseng, are two prominent medicinal herbs that have been

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extensively studied for their antidiabetic properties [37]. Fenugreek extracts, which include high levels of soluble dietary fibers, saponins, flavonoids, and alkaloids, have been shown to enhance glycemic control and reduce diabetic complications in animal studies. Moreover, Panax ginseng extracts have been linked to the regulation of glucose metabolism, improvement of insulin secretion, and decrease in oxidative stress and inflammation in diabetic mice.The design of experiments in animal studies is carefully constructed to guarantee scientific rigor and the ability to reproduce results.
Scientists meticulously choose suitable animal models that accurately replicate the underlying mechanisms of human diabetes and refine treatment procedures to assess the effectiveness of medicinal plants. Studies examining the relationship between dosage and response, investigations of how the body processes drugs, and thorough assessments of biochemical, histological, and functional factors provide a deeper understanding of the possible therapeutic effects and the mechanisms by which herbal therapies work [38]. standardization and safety issues with herbal drugs. International Journal of Research in Pharmaceutical Sciences and Technology

5. CONCLUSION

The therapeutic potential of medicinal plants in the fight against diabetes can be better understood through the use of animal studies, which are extremely useful instruments. In order to contribute to the development of diabetes management methods that are supported by evidence, preclinical research helps to shed light on the pharmacological effects and mechanisms of action of potential treatments. It is possible that new treatment avenues will emerge as researchers continue their exploration of nature's medicine, which is medicinal plants. These new therapeutic avenues could provide those living with diabetes reasons to hope for improved health outcomes and an enhanced quality of life.

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Journal of Community Pharmacy Practice
ISSN: 2799-1199
Vol: 02, No. 02, Feb-Mar 2022
http://journal.hmjournals.com/index.php/JCPP
DOI: https://doi.org/10.55529/jcpp.22.16.26

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