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Few promising medicinal plants as anti-diabetic agent

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Abstract
Research has demonstrated the health benefits of natural goods, which include species such as plants, animals, and microorganisms, for both humans and animals. The World Health Organization estimates that 80% of people in underdeveloped nations still rely on folk medicines, or traditional medicines, which are primarily made from plants to prevent or treat illnesses. Compared to current pharmaceuticals, traditional medicine based on plant extracts has shown to be more cost-efficient, clinically successful, and less likely to cause side effects. Many drugs and complementary therapies have been used to treat diabetes; among these, a number of herbs have been shown to be effective in both curing and managing the disease. This document aims to compile a list of plants that have anti-diabetic properties and other therapeutic benefits that come from throughout the globe. Because these herbal remedies have hypoglycemic qualities as well as other advantageous qualities that have been documented in scientific literature, history demonstrated that medicinal plants have been utilized in traditional treatment around the world for a very long time to cure diabetes.

Keywords: Herbs, anti-diabetic, tree, chemical compound, remedies

1. Introduction
One of the most common illnesses in the world, diabetes mellitus is rapidly endangering the health of humanity [1]. It is a complicated, diverse category of metabolic illnesses that include hyperglycemia and are linked to abnormalities in the metabolism of fat, protein, and carbohydrates [2]. The World Health Organization states that "Diabetes mellitus is a chronic disease caused by an ineffective amount of insulin produced by the pancreas, or by an inherited and/or acquired deficiency in insulin production." A deficit of this kind causes elevated blood glucose levels, which harm numerous bodily systems, including the blood vessels and nerves [3]. Diabetes mellitus management is seen as a global issue. In contemporary allopathic medicine, diabetes is managed through the use of insulin and oral hypoglycemic medications; nevertheless, their limited tolerance, cost, and various side effects limit their widespread use. This may be the primary cause of the current trend among the general public to switch from the allopathic system to Ayurveda [4, 5].
Traditional herbal remedies with a variety of phytoconstituents and therapeutic qualities have been utilized for a long time to cure a variety of illnesses [6]. Herbal remedies are thought to be inherently safe because of their effectiveness, tendency to occur naturally, and lack of adverse effects [7]. Herbal medicine offers fewer negative effects and more beneficial results while treating diabetes. These herbal medications function through various processes, which protect the β-cells in diabetes patients and lower blood glucose levels [8, 9]. The goal of the diabetic mellitus drugs currently on the market is to regulate and bring blood glucose levels in the vessel down to a healthy level. Nevertheless, a number of contemporary medications have adverse effects that might result in severe health issues while being treated [10]. As a result, traditional medications have been around for a while and are still useful in addition to alternative therapies. Furthermore, a number of novel bioactive medications derived from plants have demonstrated greater efficacy in treating diabetes than oral hypoglycemic medications utilized in clinical settings in recent years.
Ayurveda and other traditional medical systems list several plants that are utilized as herbal remedies for the treatment of diabetes. Because of their inexpensive cost and low side effect profile, they are valuable as an alternative treatment. The active ingredients found in medicinal plants have been shown to have the ability to release insulin, regenerate pancreatic

beta cells, and combat insulin resistance [11]. The genesis of the development of diabetic problems involves hyperglycemia. Herbs that lower blood sugar levels stimulate insulin secretion, improve muscle or adipose tissue's absorption of glucose, and prevent the liver and intestines from producing glucose [12]. The two mainstays of diabetes care remain insulin and oral hypoglycemic medications like biguanides and sulphonyl-ureas, but efforts are underway to create more potent anti-diabetic medications.

2. Herbal remedies for diabetes

Many commonly used medications, including aspirin, quinine, vincristine, vinblastine, and digitalis, have been derived either directly or indirectly from medicinal plants, which have long been a valuable source of pharmaceuticals [13, 14]. The majority of plant-based antidiabetic medications belong to the phytochemical class, which includes steroids, terpenoids, polyphenols, and tannins. These have an impact on several metabolic cascades, which in turn have an impact on the body's glucose levels [15]. Using Google Scholar, EMBASE, PubMed, and other scientific databases, a literature search was carried out. The goal was to locate published information on medicinal plants that have been used traditionally to treat and manage diabetes mellitus.

3. Management of diabetes mellitus

The goal of the current diabetes treatment is to bring blood glucose levels in the vessel down to a normal level [16]. Both conventional and modern medications work by stimulating the pancreatic islet's beta-cell to release more insulin; blocking hormones that raise blood glucose levels; increasing the sensitivity of the insulin receptor site; preventing the liver's breakdown of glycogen; and enhancing the body's ability to use glucose [17-19]. Biguanides (metformin), sulfonylureas, thiazolidinediones (glitazones), meglitinides (glinides), alpha-glucosidase inhibitors, and DPP-4 inhibitors are the names given to the tablets. Insulin and incretin mimetics are the two drug classes administered intravenously [20, 21]. These drugs' mechanisms have been documented. Unfortunately, the majority of contemporary medications include a wide range of negative side effects that can seriously impair health when using medication.

One biguanide medication that can lower glucose molecule synthesis in the human liver and raise insulin sensitivity is metformin. Nevertheless, metformin also has some major adverse effects, such as initial gastrointestinal symptoms like dyspepsia, nausea, and diarrhea. People with severe liver disease, decompensated heart failure, highly reduced renal function, or other serious medical issues should not use metformin. Thiazolidinediones have been shown to reduce insulin resistance, increase insulin sensitivity, and lower cardiovascular risk in the treatment of diabetes. However, weight gain and fluid retention - which can result in peripheral edema and heart failure - are the most frequent side effects of thiazolidinediones. Patients with heart failure and serious liver issues were among the similar circumstances for whom the medications were not prescribed. Rosiglitazone may raise the chance of a heart attack and have cardiovascular concerns. Some nations have prohibited the use of pioglitazone because of worries about an elevated risk of bladder cancer.

In addition to contemporary medicine, traditional medicines have been around for a while and are significant complementary therapies [22, 23]. Approximately 75–80% of the world's population still relies primarily on a traditional medical system based on plants, mostly in poorer nations with a wide variety of plants, according to the WHO [24, 25]. In poor nations, traditional medicines are typically the first option for primary healthcare due to their greater cultural acceptability, more bodily compatibility, and lower side effects when compared to modern remedies. Some medicinal plants have been used empirically as antidiabetic and anti-hyperlipidemic medicines and have recently been reported to be helpful in diabetes worldwide. There are over 400 plant species with hypoglycemic activity that have been documented in the literature. Despite this, there is still interest in finding novel antidiabetic medications derived from natural plants because these drugs contain phytoconstituents that show safe and alternative ways to treat diabetes mellitus.

4. Medicinal plants with beneficial properties related to diabetes and prevention

4.1 *Achyranthes aspera* L (Amaranthaceae)

It is found all throughout the tropical world. Both normal and diabetic rabbits experience a notable dose-related hypoglycemia response when given *A. aspera* powder orally. Both normal and alloxan diabetic rabbits' blood glucose levels are lowered by the water and methanol extracts. At oral quantities of up to 8 g/kg, there are no negative effects or side effects from this folk remedy, according to an acute toxicity study conducted on rabbits. One way the plant may help is by giving the beta-cells essential nutrients including calcium, zinc, magnesium, manganese, and copper [26].

Fig 1: Fruits of *Achyranthes aspera*

4.2 *Ajuga Iva* L. *Schreberr* (Lamiaceae)

A species that originated in Africa, Asia, and Europe. When 10 mg/kg of A. iva L (AT) water extract is given orally once or twice a week, normal rats have a small but substantial drop in plasma glucose levels six hours and three weeks following therapy. A. iva has a robust hypoglycemic impact in diabetic rats, as seen by the continuous decline and quick normalization that follows. This finding confirms the plant's traditional usage in the management of diabetes mellitus [27].

4.3 *Allium cepa* L. (onion), (Liliaceae)

Allium cepa is only known to be grown, although related wild species are found in Central Asia. Different ether soluble fractions and insoluble fractions of dried onion powder have been shown to have anti-hyperglycemic activity in diabetic rabbits. A. cepa is also known to have antioxidant and hypolipidemic activity. S-methylcysteine sulphoxide (SMCS) is an amino acid that contains sulfur; when administered to rats induced with alloxan, it significantly controlled blood glucose levels and lipids in serum and tissues. It also normalizes the activities of liver hexokinase, glucose 6-phosphatase, and HMG Co A reductase. In diabetic patients, a single oral dose of 50 g of onion juice significantly controlled blood glucose levels [28, 29].

Fig 2: Whole plant of *Allium cepa*

4.4 *Allium sativum* L. (Garlic): (Liliaceae)

It is an evergreen plant that is grown all throughout India. When compared to the antidiabetic medication glibenclamide, oral treatment of the garlic extract dramatically lowers serum glucose, total cholesterol, triglycerides, urea, uric acid, creatinine, AST, and ALT levels while increasing serum insulin in diabetic rats but not in normal rats. The extract has a greater anti-diabetic impact than glibenclamide. The plant should be given serious consideration as a top option for further research on diabetes mellitus, it is selected [30].

Fig 3: *Allium sativum* Linn

4.5 *Momordica charantia* (Bitter Melon)

One of the most widely grown vegetables in the tropical world is *Momordica charantia* (MC), especially in East Africa, South and North Asia, Vietnam, India, China, and Central and South America [31]. Common names for it include bitter melon and bitter gourd. It belongs to the Cucurbitaceae family. In addition to being utilized as a vegetable, MC is also believed to be an herbal remedy used in folk medicine. Its bioactivities, particularly its anti-diabetic action, include anti-inflammatory, anti-oxidant, anti-viral, anti-cancer, and antibacterial properties [32].

Fig 4: Whole plants of *Momordica charantia*

4.6 *Panax ginseng*

Therapeutic drugs should be used to improve insulin resistance, enhance glucose absorption, lower blood glucose concentration, and protect or regenerate cells from pancreatic islets, since diabetes mellitus is characterized by insulin resistance and-cell dysfunction. Numerous studies have looked at the panax ginseng root's anti-diabetic properties in both *in vitro* and *in vivo* tests [33]. The most significant class of phytochemicals found in Panax ginseng are termed ginsenosides, which are saponins unique to ginseng. Ginsenosied Rb2 was shown to be the most effective ingredient in treating diabetic rats generated by streptozotocin, as it effectively reduced blood glucose levels [34]. Furthermore, oral administration of 100 or 200 mg/kg extracts dissolved in water, given orally at 10 a.m. daily for three weeks, resulted in significantly lower blood glucose levels and increased plasma insulin levels in streptozotocin-induced diabetic rats. This was due to the fermented red ginseng extracts' higher content of ginsenoside Rg2, Rg3, and Rh2 [35].

Fig 5: *Panax ginseng* tree

4.7 *Aloe vera* (L) Burm. (Asphodelaceae)

It is extensively found in Africa, India, and other desert regions and flourishes in dry conditions. In diabetic rats,

aloe vera gel at a dose of 200 mg/kg 1 has strong cardioprotective and antidiabetic properties. It also lowers elevated TBARS, keeps catalase and superoxide dismutase activity at normal levels, and raises reduced glutathione by four times. In both IDDM and NIDDM rats, the leaf pulp extract demonstrated hypoglycemic action; in contrast to glibenclamide, this extract was more beneficial for treating type II diabetes [36].

Fig 6: *Aloe vera*

4.8 *Brassica nigra* (L) Koch (Brassicaceae)

It is a weedy annual plant native to Europe's southern Mediterranean region that is grown for its seeds. When diabetic rats are given an aqueous extract 200 mg/kg body weight once a day for a month, their fasting serum glucose (FSG) levels decrease, whereas the untreated group's FSG levels stay higher. When compared to the levels in untreated diabetic controls, the rise in blood lipids and glycosylated hemoglobin (HbAlc) is significantly lower in the treated animals [37].

4.9 *Cassia auriculata* L. (Caesalpinaceae)

It is found in the arid areas of Sri Lanka and India. When CLEt-is given orally to rats with mildly (MD) and severely (SD) diabetes at a dose of 400 mg/kg once daily for 15 days, there is a noticeable decrease in fasting blood glucose. Hepatic phosphofructokinase and hexokinase activity are also enhanced, and glucose-6-phosphatase and fructose-l, 6-bisphosphatase are suppressed in both MD and SD rats.

In both SD and MD rats treated with CLEt, the number of islets and beta-cells is enhanced, according to histopathological analysis of pancreatic sections [38].

Fig 7: *Cassia auriculata* L

4.10 *Helicteres isora* L., As. (Sterculiaceae)

Extensively distributed throughout India's jungles. The fruit of H. isora has a hot water extract that has been shown to have strong antioxidant and moderate antidiabetic properties [39, 40]. It also has glucose uptake activity at a dosage of 200 mg/mL and is shown to be as active as metformin and insulin. The ethanolic extract may be used to treat type 2 diabetes since it exhibits hypolipidemic and insulin-sensitizing properties.

Fig 8: Flower and stem of *Helicteres isora* Linn

4.11 *Nigella sativa* L (Ranunculaceae)

The ethanol extract of N. sativa seeds (300 mg/kg body weight/day) was given orally to streptozotocin-induced diabetic rats for 30 days. This resulted in a significant reduction of the elevated levels of blood glucose, lipids, and plasma insulin, as well as an improvement in the altered levels of antioxidant enzymes such as catalase, superoxide dismutase, reduced glutathione, and glutathione peroxidase in the liver and kidney. The findings validate the N. sativa seeds extract's antidiabetic properties [41].

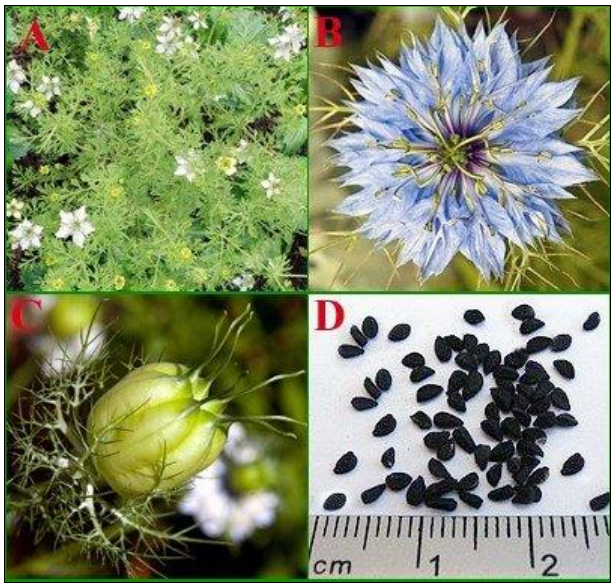

Fig 9: (A) Plant, (B) Flower, (C) Capsule or fruit, (D) Seeds

4.12 *Syzigium cumini* (L) (Myrtaceae)

Often referred to as "Jamun," this substance is frequently utilized in Indian traditional medicine to treat diabetes mellitus. Over the course of six weeks, oral treatment of 2.5

and 5.0 g/kg body weight of the seed's aqueous extract causes a substantial decrease in blood glucose and an increase in total hemoglobin; however, the impact is not statistically significant in the case of 7.5 g/kg body weight. Additionally, the aqueous extract reduces the production of free radicals, demonstrating its antioxidant qualities. Accordingly, the study demonstrates the hypoglycemic activity of Jamun seed extract (JSEt) [42].

Fig 10: Fruits of *Syzigium cumini*

4.13 *Trigonella foenum graecum* L. (fenugreek) (Papilionaceae)

Grown all over the world as a semi-arid crop, it is used as a spice (the seed) and as an herb (the leaves). In both normal and diabetic rats, oral treatment of 2 and 8 g/kg of plant extract results in a dose-dependent drop in blood glucose levels. Giving diabetic rats fenugreek seeds enhances their ability to metabolize glucose and returns creatinine kinase activity to normal in their liver, heart, and skeletal muscle. Additionally, it lowers the activity of fructose -1, 6-biphosphatase and liver and kidney glucose-6-phosphalase [43].

4.14 *Cuminum cyminum* L (Apiaceae)

A blooming plant indigenous to East India and the East Mediterranean region. Blood glucose, glycosylated hemoglobin, creatinine, blood urea nitrogen, and serum insulin levels are all lowered by the C. cyminum (CC) seed extract, while the amount of glycogen in the liver and skeletal muscle is increased. AGE and renal oxidative stress are much lower than in glibenclamide-treated diabetic control. The antioxidant state of the diabetic rats' kidney and pancreas was enhanced by CC and glibenclamide [44].

Fig 11: Cumin seeds

4.15 *Ocimum sanctum* (L) (Lamiaceae)

Each of the parts of *Ocimum sanctum* have been shown to have phytochemistry, which includes a variety of nutrients and bioactive components. However, a variety of natural circumstances, including as growing, harvesting, and storage conditions, affect how much of these elements are present [45]. Volatile oil was isolated from *O. sanctum* leaf extract and its chemical makeup was determined. It included many main components, including p-caryophylen, methyleugenol, and eugenol. This herb's essential oil includes a variety of bioactive substances, including phenolic acids, aliphatic aldehydes, terpenoids, and esters. A variety of secondary metabolites, such as phenolics, flavonoids, terpenoids, lignans, steroids, fatty acids, and their derivatives, are also present in this plant. Due to these substances' biological and pharmacological effects - which include antidiabetic, anti-inflammatory, anticancer, and antibacterial properties - their major focus in research has been on therapeutic applications [45]. It was determined how this compound's antidiabetic and hypoglycemic properties increased pancreatic insulin production from \-cells and improved glucose utilization [46]. It was proposed that this triterpenoid be investigated for possible development as an anti-diabetic medication. The available data indicates that Oryza sanctum has several advantages in the treatment of diabetes, and it is important to promote this plant as a possible anti-diabetic agent.

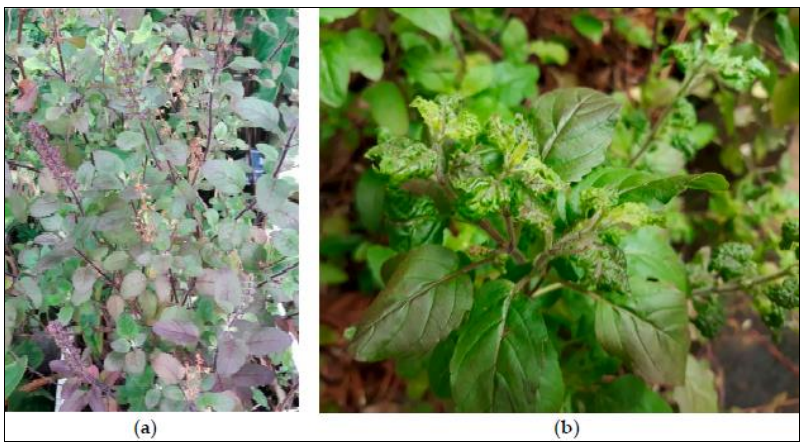

Fig 12: *Ocimum sanctum* L.: (a) whole plant and (b) leaves. Copyright from [47]

4.16 *Ficus bengalensis* L. (Moraceae)

A well-known plant that is referred to as "banyan tree" in Ayurvedic literature. When compared to a diabetic control group, there is a notable decrease in blood and urine sugar, specific lipid components in serum and tissues, and glucose-6-phosphatase activity in the liver at a dose of 100 mg/kg for one month. However, there is an increase in body weight, hexokinase, and HMG-COA reductase activities in tissues. The protective or inhibitory effect of the principle against the mechanisms that degrade insulin may be the mechanism of action [48].

Fig 13: A full grown tree *Ficus bengalensis*

5. Herbal medicine

Since they are natural items, herbs are not classified as medications but rather as food and have been utilized for healing and health promotion since ancient times. Herbal remedies, dietary supplements, and health products are all over the market these days [49]. Many diseases may be effectively and safely treated when used properly, albeit the patient ultimately determines how successful the treatment is. Genetic variety, growth environment, harvesting schedule and technique, exposure to light, air, and moisture, and method of herb storage all affect how potent the plants are. Herbal remedies are potent nutritional agents that support the body naturally and may be used for healing as well as to promote wellbeing. They are neither addictive nor habit-forming. They have no negative side effects and are great healers that advance health. Chinese herbs may nourish the body's most fundamental components and are used as tonics to improve both physical and mental health.

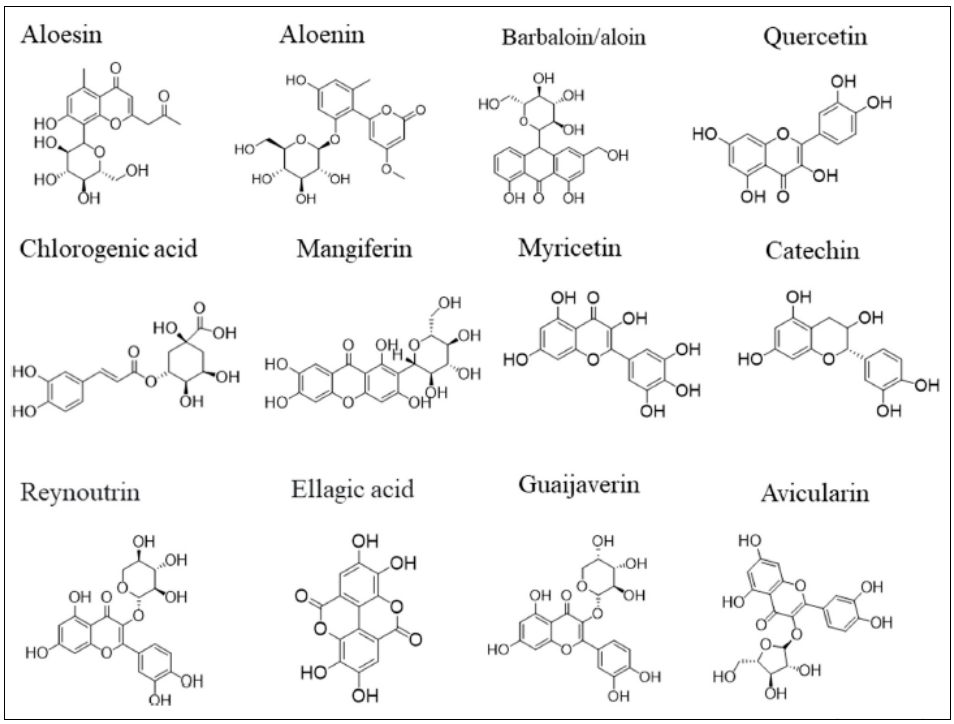

Fig 14: Some phytochemicals found in nature that works as antidiabetic substances. Copyright from Usai *et al*. [52]

Herbal medications are excellent body balancers that assist the body's balancing process and provide the nutrients the body lacks from an unbalanced diet or environmental inadequacies in the soil and air. In addition to being used to maintain overall health, they can be used to treat a wide range of illnesses, including diabetes, asthma, eczema, rheumatoid arthritis, migraine, menopausal symptoms, chronic tiredness, and irritable bowel syndrome. Herbal remedies are thought to be safer than conventional ones when used as directed. Many people select herbal medications as a safe and all-natural alternative to synthetic pharmaceuticals for a variety of health issues because they are worried about the effectiveness and negative effects of many synthetic treatments. Herbs are always the major source and alternative medicine, and their usage is rising widely. There are several benefits to taking herbal remedies.

6. Future direction

Even though synthetic drugs are widely used, they come with a number of side effects, such as hypoglycemia (in the case of glinides and sulphonylureas), weight gain (in the case of sulphonylureas and thiazolidinediones), cardiovascular risk (in the case of sulphonylureas and thiazolidinediones), pancreatitis (in the case of DPP-4 inhibitors and GLP-1 agonists), hepatitis (for thiazolidinediones and DPP-4 inhibitors), cancer risk (in the case of DPP-4 inhibitors and GLP-1 agonists), gastrointestinal effects (in the case of biguanides and GLP-1 agonists). The difficulties and limitations posed by the widely used synthetic pharmaceuticals force researchers to look for antidiabetic therapies derived from plants that have superior safety and effectiveness profiles. Diabetes mellitus has long been treated using plant-based drugs, similar to many other diseases, because of its notable efficacy, reduced toxicity and side effects, affordability, and accessibility [50]. Isolated phytochemicals can be obtained as chemical leads or their analogues for the synthesis of physiologically active substances, or they can be used as medications. A survey of all approved medications registered worldwide during the 25 years before to 2007 can be used to determine the prevalence of phytochemicals in the pharmaceutical industry. Approximately 50% of these medications were either synthetically manufactured plant-based medicines or their natural counterparts [51]. To fully understand the precise mechanism of action of these compounds - which would enable their development as pharmaceuticals or chemical leads - more research is necessary. In fact, plant-derived chemicals have uses beyond just being pharmaceuticals or drug templates; they also aid in the identification and discovery of intricate and unusual biochemical pathways and targets related to the ailment. Therefore, more investigation into these phytochemicals may make it possible to identify a number of targets for therapeutic intervention against diabetes mellitus. Furthermore, despite the previously indicated predating benefit as plant-based products, elucidating the practicality and toxicity profile is a critical area of study interest.

7. Conclusion

Diabetes mellitus is thought to be a significant factor that impacts patients', their families', and society's finances. Moreover, blindness, renal failure, and heart failure are among the major chronic consequences that result from untreated diabetes. The goal of research on novel antidiabetic medicines is to lessen this issue. Numerous traditional treatments have been observed as a result of the negative effects of contemporary therapy. Additionally, modern combinatorial medicines can include herbal extracts in addition to conventional medications. The benefits of using herbal remedies to treat and control diabetes mellitus have been emphasized in this study.

Conflict of interest: None declared.

Data availability: Not applicable.

References

1. Onal S, Timur S, Okutucu B, Zihnioglu F. Inhibition of α-Glucosidase by Aqueous Extracts of Some Potent Antidiabetic Medicinal Herbs. Prep. Biochem Biotechnol. 2005;35(1):29-36.
2. Lin Y, Sun Z. Current views on type 2 diabetes. J Endocrinol. 2009;204(1):01-11.
3. World Health Organization. Diabetes mellitus [Internet]. World Health Organization. Available from: https://www.who.int/mediacentre/factsheets/fs138/en/ [Accessed 7 Aug 2020].
4. Parasuraman S, Thing G, Dhanaraj S. Polyherbal formulation: concept of Ayurveda. Pharmacogn. Rev. 2014;8(16):73.
5. Rajib M, *et al*. A study on anti-diabetic prescription along with patients in Bangladeshi perspective. World J Adv. Res. Rev. 2023;20(03):1705-1712. Available from: https://doi.org/10.30574/wjarr.2023.20.3.2705.
6. Calixto JB. Efficacy, safety, quality control, marketing and regulatory guidelines for herbal medicines (phytotherapeutic agents). Braz. J Med. Biol. Res. 2000;33(2):179-89.
7. Prabhakar P, Kumar A, Doble M. Combination therapy: A new strategy to manage diabetes and its complications. Phytomedicine. 2014;21(2):123-130.
8. Jeeva S, Sheebha A. A review of antidiabetic potential of ethnomedicinal plants. Med Aromat Plants. 2014;3(4):01-08.
9. Hoque M, Emon K, Malo PC, Hossain MH, Tannu SI, Roshed MM. Comprehensive guide to vitamin and mineral sources with their requirements. Indiana J Agric. Life Sci. 2023;3(6):23-31. Available from: https://doi.org/10.5281/zenodo.10284736.
10. Hoque M, *et al*. Survey on perception for over the counter medicine use without prescription among the general people in the Gazipur, Bangladesh. Open Access Res. J Biol. Pharm. 2023;09(01):019-026. Available from: https://doi.org/10.53022/oarjbp.2023.9.1.0041.
11. Welihinda J, Arvidson G, Gylfe E, Hellman B, Karlsson E. [Ada Biol. MetLGer 1982, 41, 1229].
12. Hongxiang Hui, Tang G, Go VLW. Hypoglycemic herbs and their action mechanisms. Chin Med. 2009;4:11-14.
13. Jasmin R, Ganesh Kumar R, Rajaram R. Probing the mechanism of the anti-diabetic potential of terpenoids from *Elephantopus scaber* L., an Indian ethnomedicinal plant in STZ diabetic rats *In-vivo* and *In-silico* analysis. Indian J Biochem Biophys. 2018;55:384-388.
14. Hoque M. *Centella asiatica*: A mini review of its medicinal properties and different uses. World J Adv.

Res. Rev. 2023;19(02):1185–1191. Available from: https://doi.org/10.30574/wjarr.2023.19.2.1699.
15. Zhang L, Reddy N. Bioactive molecules from medicinal herbs for life threatening diseases. J Mol. Sci. 2018;2(4):01-11.
16. Knight K. A systematic review of diabetes disease management programs. Am J Manag Care. 2005;11:242-250.
17. Colberg SR, Sigal RJ, Yardley JE, Riddell MC, Dunstan DW, Dempsey PC, *et al*. Physical activity/exercise and diabetes: A position statement of the American Diabetes Association. Diabetes Care. 2016;39:2065-2079.
18. Bhoyar PK, Tripathi AK, Baheti JR, Biyani D. Herbal antidiabetics: A review. Int. J Res. Pharm. Sci. 2011;2:30-37.
19. Wang Z, Wang J, Chan P. Treating Type 2 Diabetes Mellitus with Traditional Chinese and Indian Medicinal Herbs. Evid Based Complement Alternate Med. 2013;2013:343594.
20. Singh S, Loke YK, Furberg CD. Thiazolidinediones and heart failure: A teleo-analysis. Diabetes Care. 2007;30:2148-2153.
21. Lebovitz HE. Thiazolidinediones: The Forgotten Diabetes Medications. Curr Diabetes Rep. 2019;19:151.
22. Yakubu OE, Imo C, Shaibu C, Akighir J, Ameh DS. Effects of Ethanolic Leaf and Stem-bark Extracts of Adansonia digitata in Alloxan-induced Diabetic Wistar Rats. J Pharmacol Toxicol. 2020;15:01-07.
23. Chan CH, Ngoh GC, Yuso R. A brief review on anti-diabetic plants: Global distribution, active ingredients, extraction techniques and acting mechanisms. Pharmacogn. Rev. 2012;6:22-28.
24. Evans M. A Guide to Herbal Remedies. Delhi, India: Orient Paperbacks; c1994. ISBN-10: 8122201628.
25. Sabbir MS, *et al*. Preclinical Hemotoxicological Profile Investigations of an Ayurvedic Medication Following Long-Term Administration to Male Sprague-Dawley Rats. South Asian Res. J Pharm Sci. 2023;5(6):213-220. Available from: https://doi.org/10.36346/sarjps.2023.v05i06.001.
26. Akhtar MS, Iqbal J. Evaluation of the hypoglycaemic effect of *Achyranthes aspera* in normal and alloxan-diabetic rabbits. J Ethnopharmacol. 1991;31:49-57.
27. El Hilaly J, Lyoussi B. Hypoglycaemic effect of the lyophilised aqueous extract of Ajuga ivain normal and streptozotocin diabetic rats. J Ethnopharmacol. 2002;80:109-113.
28. Kumari K, Mathew BC, Augusti KT. Antidiabetic and hypoHpidaemic effects of S-methyl cysteinesulfoxide, isolated from *Allium cepa* Linn. Ind. J Biochem Biophys. 1995;32:49-54.
29. Roman-Ramos R, Flores-Saenz JL, Alarcon-Aguilar FJ. Antihyperglycemic effect of some edible plants. J Ethnopharmacol. 1995;48:25-32.
30. Eidi A, Eidi M, Esmaeili E. Antidiabetic effect of garlic (*Allium sativum* L.) in normal and streptozotocin-induced diabetic rats. Phytomedicine. 2005;13:624-629.
31. Li WL, Zheng HC, Bukuru J, De Kimpe N. Natural medicines used in the traditional Chinese medical system for therapy of diabetes mellitus. J Ethnopharmacol. 2004;92:1-21.
32. Saeed F, Afzaal M, Niaz B, Arshad MU, Tufail T, Hussain MB, Javed A. Bitter melon (*Momordica charantia*): A natural healthy vegetable. Int. J Food Prop. 2018;21:1270–1290.
33. Ratan ZA, Haidere MF, Hong YH, Park SH, Lee JO, Lee J, Cho JY. Pharmacological potential of ginseng and its major component ginsenosides. J Ginseng Res.; c2020.
34. Yokozawa T, Kobayashi T, Oura H, Kawashima Y. Studies on the mechanism of the hypoglycemic activity of ginsenoside-Rb2 in streptozotocin-diabetic rats. Chem. Pharm Bull. 1985;33:869–872.
35. Kim HJ, Chae IG, Lee SG, Jeong HJ, Lee EJ, Lee IS. Effects of Fermented Red Ginseng Extracts on Hyperglycemia in Streptozotocin-induced Diabetic Rats. J Ginseng Res. 2010;34:104-112.
36. Okyar A, Can A, Akev N, Baktir G, Sütlüpinar N. Effect of Aloe vera leaves on blood glucose level in type I and type II diabetic rat models. Phytother Res. 2001;15:157-161.
37. Anand P, Murali KY, Tandon V, Chandra R, Murthy PS. Preliminary studies on antihyperglycemic effect of aqueous extract of *Brassica nigra* (L.) Koch in streptozotocin induced diabetic rats. Indian J Exp. Biol. 2007;45:696-701.
38. Gupta S, Sharma SB, Singh UR, Bansal SK, Prabhu KM. Elucidation of mechanism of action of Cassia auriculata leaf extract for its antidiabetic activity in streptozotocin-induced diabetic rats. J Med Food. 2010;13:528-534.
39. Gupta RN, Pareek A, Suthar M, Rathore GS, Basniwal PK, Jain D. Study of glucose uptake activity of *Helicteres isora* Linn, fruits in L-6 cell lines. Int J Diabetes Dev Ctries. 2009;29:170-173.
40. Suthar M, Rathore GS, Pareek A. Antioxidant and Antidiabetic Activity of *Helicteres isora* (L.) Fruits. Indian J Pharm Sci. 2009;71:695-699.
41. Kaleem M, Kirmani D, Asif M, Ahmed Q, Bano B. Biochemical effects of *Nigella saliva* L seeds in diabetic rats. Indian J Exp Biol. 2006;44:745-748.
42. Prince PS, Menon VP, Pari L. Hypoglycaemic activity of *Syzigium cumini* seeds: Effect on lipid peroxidation in alloxan-diabetic rats. J Ethnopharmacol. 1998;61:01-07.
43. Khosla P, Gupta DD, Nagpal RK. Effect of Trigonella foenum graecum (fenugreek) on blood glucose in normal and diabetic rats. Indian J. Physiol. Pharmacol. 1995;39:173-174.
44. Jagtap AG, Patil PB. Antihyperglycemic activity and inhibition of advanced glycation end product formation by Cuminum cyminum in streptozolocin induced diabetic rats. Food Chem. Toxicol. 2010;48:2030-2036.
45. Rahman S, Islam R, Kamruzzaman M, Alam MK. *Ocimum sanctum* L.: A review of phytochemical and pharmacological profile. Am Drug Discov Dev. 2011;01-15.
46. Patil R, Patil R, Ahirwar B, Ahirwar D. Isolation and characterization of anti-diabetic component (bioactivity-guided fractionation) from *Ocimum sanctum* L. (Lamiaceae) aerial part. Asian Pac. J Trop. Med. 2011;4:278–282.
47. Tran N, *et al*. Bioactive Compounds in Anti-Diabetic Plants: From Herbal Medicine to Modern Drug Discovery. Biology. 2020;9:252. DOI:10.3390/biology9090252.

48. Kumar RV, Augusti KT. Antidiabetic effect of a leucocyanidin derivative isolated from the bark of *Ficus bengalensis* Linn. Indian J Biochem. Biophys. 1989;26:400-404.
49. Tamanna AJ, *et al*. Evaluation of Phytochemical Screening, Antioxidant, and Thrombolytic Activity of Methanolic Extract of *Phlogacanthus thyrsiflorus*. South Asian Res J Pharm Sci. 2024;6(1):5-11. DOI:10.36346/sarjps.2024.v06i01.002.
50. Chopra A, Saluja M, Tillu G. Ayurveda–modern Medicine Interface: A Critical Appraisal of Studies of Ayurvedic Medicines to Treat Osteoarthritis and Rheumatoid Arthritis. J Ayurveda Integr. Med. 2010;1(3):190. doi:10.4103/0975-9476.72620.
51. Kennedy DO, Wightman EL. Herbal Extracts and Phytochemicals: Plant Secondary Metabolites and the Enhancement of Human Brain Function. Adv. Nutr. 2011;2(1):32–50. DOI:10.3945/an.110.000117.
52. Usai R, Majoni S, Rwere F. Natural products for the treatment and management of diabetes mellitus in Zimbabwe-a review. Front Pharmacol. 2022;13:980819. DOI:10.3389/fphar.2022.980819.