



Antidiabetic effects of medicinal plants in albino rats: A review

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Abstract

Day by day, diabetes mellitus is becoming a huge problem for healthcare systems, and to resolve this problem, it is important to research and innovate many cost-effective, low-toxicity, and novel policies and strategies. Traditional medicinal plants are a rich source of bioactive compounds that are capable of having anti-diabetic properties to support and cure metabolic health. The aim of this article is to collect information on medicinal flora investigated for antidiabetic activities and their phytochemicals present in these plants in the form of primary and secondary metabolites. These metabolites are mainly flavonoids, alkaloids, terpenoids, and polyphenols.

Keywords: Diabetes, metabolites, ethnomedicinal plants, antihyperglycemic, healthcare, phytochemicals

Introduction

Diabetes mellitus, generally known as “MADHUMEHA”, is a chronic metabolic disorder characterized by the low or no production of insulin by pancreatic beta cells or improper utilization of produced insulin by the tissues or body properly. Day by day, it is growing rapidly and globally affecting all people in different countries. As per the data analyzed in 2019, about 9.3% of adults were found to be diabetic of the total global adult population (Statista Diabetics Percentage Worldwide. 2019) ^[42]. According to reports of the International Diabetes Federation (IDF) in 2017, the risk of type 2 diabetes affected 352 million people. Data collected from health forecasts suggested that by the year 2030, about 439 million adults will have been affected by diabetes (Shaw *et al.*, 2010) ^[40]. These reports and collected data suggested how much diabetes affects the global population. Treatment and control of diabetes are very much important because uncontrolled diabetes can cause various damages and complications, which are further classified as microvascular (neuropathy, nephropathy & retinopathy) (American Diabetes Association, 2006) ^[1] and macrovascular (cardiovascular disease, strokes, and peripheral vascular diseases) complications (Roglic, 2016) ^[37]. It is important to slow down this drastic spread of diabetes to make the world well-functioning. Not only diabetes but also the combinations of various infections and diseases can cause permanent health issues.

India is rich in its flora and fauna. Flora, which is related to plant life in a particular area, is important and has various vital functions, such as the production of oxygen, food, medicines, maintaining the environment, and ecological processes. Not from the present time, but from the ancient times, various plants and their parts have been utilized to control or prevent many medical illnesses (Bharadwaj & Ojha, 2026) ^[6]. Because of the more effective, fewer side effects, and cost-friendly nature of these plant products,

nowadays people are shifting their thoughts from drugs to plant-based natural products to cure diseases (Arumugam *et al.*, 2013) ^[3]. This is because of the presence of bioactive compounds with antioxidant, antidiabetic, anti-allergenic, and anti-inflammatory properties (Nasser Singab & Youssef, 2014; Salehi *et al.*, 2019) ^[32, 38].

Traditional medicinal plants have many phytoconstituents in the form of terpenoids, saponins, flavonoids, carotenoids, alkaloids, glycosides, etc., which contain antidiabetic activity (Chhetri *et al.*, 2005; Chinsebu, 2019; Przeor *et al.*, 2020; Tajner-Czopek *et al.*, 2020) ^[10, 11, 36, 43]. The complex plant matrix is a carrier of many phytoconstituents, which determines the specific interaction of these compounds; this is, however, difficult to reproduce and brings health benefits (Durazzo *et al.*, 2018) ^[16]. Chan *et al.* (2008) investigated that the leaves (greater than 35% of observed plants) contain more antidiabetic ingredients than the other plant parts, which are 3 times less frequent, that is about 10% each (Chan *et al.*, 2012) ^[8].

According to reports of ethnobotanical information, it can be estimated that about 800 plants may have antidiabetic properties (Patil *et al.*, 2011) ^[35]. Also, bioactive compounds found in these trees show antidiabetic properties. There are so many plants having antidiabetic properties, but some of them are mentioned here: *Pterocarpus santalinus*, *Swertia punicea*, *Gymnema sylvestre*, *Allium sativum*, *Allium cepa*, *Aloe barbadensis*, *Benincasa hispida*, *Tinospora cordifolia*, *Aegle marmelos*, *Phyllanthus emblica*.

Review

The review work involved a detailed study of research articles from various online databases, including ResearchGate, Google Scholar, Science Direct, etc. Along with this, antidiabetic properties of various medicinal plants were gathered and analyzed to validate the data from various sources.

Medicinal plants to cure diabetes-

***Pterocarpus santalinus* (Fabaceae), Red Sanders / Lal Chandan (Common Name)**

The plant is popularly recognized as red sandalwood or red sanders, and Saunders wood is an indigenous tree majorly distributed throughout South India. It has many chemical compounds that give this plant many therapeutic properties. These chemical compounds are carbohydrates, steroids, anthocyanins, saponins, tannins, phenols, triterpenoids, flavonoids, and glycosides (Narayan *et al.*, 2007) [31]. Santalin is the major bioactive compound of the plant, with other compounds such as pterocarpol, pterocarptriol, ispterocarpolone, pterocarpo-diolones with β -eudeslols and cryptomeridol. It also has antidiabetic, anthelmintic, and aphrodisiac properties, and is utilized in the remediation of inflammation and ulcers. The heartwood cups for the consumption of water are traditionally made from the plant for therapeutic purposes in the management of diabetes (Nagaraju & Rao, 1989) [30]. Kameswara Rao *et al.* studied the glucose-lowering activity at a dose level of 0.25 g/kg body weight/day in the ethanol-based compounds of the plant (Kameswara Rao *et al.*, 2001) [22]. 250 mg/kg of plant water-based extract, combined with vitamin E in streptozotocin-induced diabetic rats, resulted in a significant decline in blood pressure.

***Swertia punicea* (Gentianaceae), Red Swertia / Red Chirata (Common Name)**

Swertia punicea is normally found in India, China, Japan, and other Asian countries. It consists of a major group of secondary metabolites such as xanthonoids, terpenoids, flavonoids, alkaloids, iridoid glycosides, etc. Within this group, xanthonoids are the predominant class of compounds (Brahmachari *et al.*, 2004) [7]. Their utilization for therapeutic purposes includes hypoglycemic, liver-protective, anti-inflammatory, antimalarial, oxidative stress inhibitor, anti-microbial, etc. Many studies demonstrated the antidiabetic property. Tian *et al.* said that xanthone derivatives such as Methylswertianin and Bellidifolin, isolated from the plant at a dose of 200mg/kg body weight/day, show significant antidiabetic effects in the Streptozotocin (STZ)-induced type 2 diabetic male BABL/c mice (Tian *et al.*, 2010) [45].

***Gymnema sylvestre* (Asclepiadaceae), Gymnema / Gurmar (Common Name)**

G. sylvestre is an important antidiabetic plant used in Ayurvedic treatments. Gymnema leaf extract stimulates the pancreas, increasing insulin release in diabetic patients (Kanetkar *et al.*, 2007) [23]. It is known to have an effect on lowering diabetes by blocking sugar-binding sites and stopping sugar molecules from accumulating in the body. The primary bioactive component of *G. sylvestre* is gymnemic acids, a class of triterpenoid saponins that have been successfully extracted and characterized. Numerous studies indicate that the main biological function of this plant is antidiabetic (Khan *et al.*, 2019) [24]. Tropical locations of Australia, Africa, and India are the main places to cultivate this perennial woody vine. Gymnemic acid is the plant's primary active ingredient. Flavones, anthraquinones, hentriacontane, pentatriacontane, α and β -chlorophylls, phytin, resins, tartaric acid, formic acid, d-quercitol, and so on are additional active ingredients (Thakur *et al.*, 2012) [44]. Daisy *et al.* found that the gurmar's

crude extracts and its separated component, dihydroxy gymnemic triacetate, are effectively hypoglycemic in a dose-dependent and time-dependent manner, in streptozotocin-induced diabetic rats (Daisy *et al.*, 2009) [12].

***Allium sativum* (Amaryllidaceae), Garlic/Lahsun (Common Name)**

Allium sativum plant, often known as garlic, is extensively dispersed throughout India and is native to Central Asia and north-eastern Iran. Essential oil, which is composed of sulfur compounds like disulfides and trisulfides, makes up the majority of it. Among its pharmacological advantages are antibacterial, antifungal, antiparasitic, antiviral, antihypertensive, and antithrombotic properties. Numerous studies have shown that eating garlic significantly reduces fasting blood sugar levels (Drobiova *et al.*, 2011) [15]. In alloxan-induced diabetic rabbits, allicin at a dose of 250 mg/kg was 60% more effective than tolbutamide, and garlic juice ingestion enhanced glucose utilization in rabbit glucose tolerance tests (Mathew & Augusti, 1973) [29]. Garlic serves as an antidiabetic by either increasing the pancreatic production of insulin or the release of bound insulin (Jain & Vyas, 1975) [20]. Eidi *et al.* explained the biological effects of garlic in avoiding diabetes by regulating the excretion of insulin from β -cells and enhancing glucose tolerance and glycogen formation, in streptozotocin-induced diabetic rats at the dosages of 0.1, 0.25, and 0.5 g/kg (Eidi *et al.*, 2006) [17].

***Allium cepa* (Amaryllidaceae), Onion / Pyaz (Common Name)**

It is rich in flavonoids like quercetin and sulphur compounds with antidiabetic qualities like cysteine and allyl propyl disulphide (Dorant *et al.*, 1995) [14]. *Allium cepa* has antidiabetic qualities like cysteine and allyl propyl disulphide, which come from quercetin and sulphur, the abundant flavonoids of this plant (Banerjee & Maulik, 2002) [4]. When it is taken orally, it produces a hydroalcoholic extract that has a prominent hypoglycemic activity and a positive health impact on the model organism. This effect is due to the enhanced and potentially regenerated beta-cells (Eldin *et al.*, 2009) [18]. The bulb section contains the antidiabetic components such as S-methyl cysteine sulfoxide and S-allyl cysteine sulfoxide. These are mainly responsible for lowering the blood glucose levels and have potent antioxidant qualities (Das, 2002) [13]. S-methylcysteine sulfoxide functions as an antidiabetic in three ways: (1) it raises pancreatic output and encourages the body's production of insulin; (2) it obstructs the absorption of glucose from food; and (3) it effectively uses insulin (Kumari & Augusti, 2002) [27].

***Aloe barbadensis* (Asphodelaceae), Aloe vera / Ghrithkumari (Common Name)**

Aloe vera gel is an effective antihyperglycemic drug for type 2 diabetes (Kim *et al.*, 2009) [25]. It reduces blood glucose levels without impairing normal blood lipid levels or liver/kidney function (Anand *et al.*, 2010) [2]. Beppu *et al.* studied the effects of aloe vera water extract in diabetic rats (Beppu *et al.*, 2006) [5]. They explained the improvement of the cells' sensitivity to insulin by lowering the glucose level of blood and reducing the negative effects of fat in the liver in diabetic rats.

***Benincasa hispida* (Cucurbitaceae), Wax gourd / Petha (Common Name)**

All the parts of the *Benincasa hispida* plant, such as fruit, the rind, the pulp, seeds, leaves, stems, and roots, have hypoglycemic and anti-hyperglycemic effects, so the whole plant is important because of its antidiabetic property. The hypoglycemic qualities of *Benincasa hispida* herbal plant extract may help prevent the worst effects of diabetes (Patil *et al.*, 2011) [35]. Jayashree *et al.* demonstrated drastic changes in blood glucose levels at 200 mg/kg bw after administration of *Benincasa hispida* stem chloroform extract (Jayashree *et al.*, 2011) [21].

***Tinospora cordifolia* (Menispermaceae), Guduchi / Giloy (Common Name)**

Different parts of *T. cordifolia* have properties to treat a wide range of diseases. Pharmacologically, this plant is important because of its anti-spasmodic, anti-inflammatory, anti-arthritis, anti-allergic, and anti-diabetic properties, from ancient times to till now (Gupta *et al.*, 2024; Manoharachary & D Dr, 2016) [19]. The primary phytoconstituents of *Tinospora cordifolia* that have been demonstrated to have anti-diabetic effects include alkaloids, tannins, cardiac glycosides, flavonoids, saponins, and steroids (Patel & Mishra, 2011) [33]. The stem of *Tinospora cordifolia* is mostly used in Indian medicine to treat diabetic people with diabetes by regulating blood sugar levels. It is said to control blood sugar levels by raising insulin production and reducing gluconeogenesis and glycogenolysis (Sangeetha *et al.*, 2011) [39].

***Aegle marmelos* (Rutaceae), Bengal quince / Bael (Common Name)**

Aegle marmelos has been utilized as a natural treatment for diabetes mellitus in Indian Ayurvedic, Unani, and Siddha medical traditions. Chandra *et al.* experimented on streptozotocin-induced diabetic Wistar rats for 28 days (Chandra *et al.*, 2024) [9]. They observed a reduction in blood glucose level as well as in serum cholesterol, triglycerides, and creatinine levels after administration of *Aegle marmelos* whole plant methanol extract.

***Phyllanthus emblica* (Phyllanthaceae), Indian Gooseberry / Amla (Common Name)**

Amla's anti-diabetic qualities are because of its high vitamin C content, which successfully manages diabetes. Consumption of amla juice, with karela juice, daily for two months, will enhance the pancreas to produce insulin, hence decrease blood sugar levels (Pathak *et al.*, 2024) [34]. It will also prevent issues related to diabetic eye diseases, promote the regeneration and renewal of beta cells, which increases insulin synthesis and secretion (Singh *et al.*, 2012) [41]. Fruits, seed infusions, and leaf and seed decoctions can also be used to treat diabetes mellitus, according to multiple research projects. With fewer adverse effects than metformin, quercetin is an exceptional antihyperglycemic medication that may be used to treat diabetes mellitus (Krishnaveni & Mirunalini, 2010) [26].

Discussion

Diabetes mellitus is a critical health problem that is mainly characterized by hyperglycemia, a high blood sugar level caused by no or absent insulin secretion and action. It is

mainly of two types, type I and type II diabetes. Diabetes can pose a high risk to life because of its microvascular and macrovascular complications. Traditionally, there are several therapeutic plants having antidiabetic properties. Among these, the most extensively studied species are *Pterocarpus santalinus*, *Swertia punicea*, *Gymnema sylvestre*, *Allium sativum*, *Allium cepa*, *Aloe barbadensis*, *Benincasa hispida*, *Tinospora cordifolia*, *Aegle marmelos*, and *Phyllanthus emblica*. So many experimental techniques, clinical trials, and methods have been studied or done to get information on the antidiabetic effects of these plant products. The oral glucose tolerance test (OGTT) used to induce a temporary condition of hyperglycemia that is transient hyperglycemia, while diabetogenic chemicals like streptozotocin- and alloxan-induced diabetic rat or mouse models are generally used to stimulate type I diabetes. These medicinal plants show antidiabetic properties by controlling and maintaining blood sugar levels and insulin levels. Clinical trials are also useful to understand the mechanisms and actions of medicines. Different medicines have their particular mechanisms to explain their effects. These mechanisms include hypoglycemic effects by the stimulation of pancreatic β -cell function, enhancement of insulin secretion, protection against insulin degradation, and improvement of insulin sensitivity or insulin-like activity. On the other hand, other mechanisms involved in maintenance and regulation of blood glucose homeostasis are enhancement of peripheral glucose utilization, high level of hepatic glycogen production, decrease in glycogen breakdown, inhibition of intestinal glucose absorption, and modulation of carbohydrate metabolism. The combination of these all are important to regulate or reduce high risk and complications caused by diabetes.

Conclusion

India has a wide variety of traditional medicinal plants to treat various diseases; diabetes is one of them. The present study aims to get information about the antidiabetic effects of various herbs and clarify their medicinal potential to cure and control diabetes through different mechanisms – by reduction in glucose absorption, enhancement of insulin actions, and other mechanisms involved in this. These therapeutic properties are because of the phytochemical compounds found in herbs. It includes alkaloids, flavonoids, and phenolic compounds. Plant-based medicines are more effective, secure, and cheap than other drugs. This is the reason that the World Health Organization recommended the development of herbal medicines. Still more clinical and experimental studies are needed to explore and explain the mechanism of action of these medicinal plant products to confirm their effects on the body. The information discussed here regarding therapeutic herbs may be helpful for further diabetes research.

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