ORIGINAL RESEARCH PAPER
Volume - 11 | Issue - 07 | July - 2022 | PRINT ISSN No. 2277 - 8179 | DOI : 10.36106/ijsr
INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH

PLANTS WITH ANTI-DIABETIC POTENTIAL

Botany

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ABSTRACT

Diabetes Mellitus (Diabetes) is characterized by the metabolic disorder primarily of carbohydrate metabolism, manifested by hyperglycemia resulting from reduced insulin action, defects in insulin secretion or both. It is a serious metabolic condition and plenty of medicinal plants are used in traditional medicines to treat diabetes. These plants have no side effects and many existing medicines are derived from the plants. The purpose of this systematic review is to study diabetes and to summarize the available treatments for this disease and especially focusing on its' herbal medicine.

KEYWORDS

Diabetes Mellitus, Hyperglycemia, Insulin, Medicinal Plants

INTRODUCTION:

Changes in human lifestyle and behaviour over the past century have resulted in a dramatic increase in the rate of diabetes worldwide. The word "Diabetes" is derived from the Greek word "Diabainein" which means "to flow through". Diabetes is a disease that affects many people in the 21st century and is known as the fifth leading cause of death [1]. It is a chronic metabolic disorder with life threatening complications including cardiovascular diseases, nephropathy, neuropathy and retinopathy that can eventually lead to death [2]. The symptom of Diabetes is high blood glucose levels [3]. Different kinds of diabetes can occur and managing the condition depends on the type. Type- 1 diabetes is also known as juvenile or insulin dependent diabetes. It occurs when the body fails to produce insulin by the pancreatic beta cells. People with type-1 diabetes are insulin dependent, which means they must take artificial insulin daily to stay alive. Type-2 diabetes is also called as adult-onset diabetes. That's because it used to start almost always in middle and late adulthood. However, now more and more children and adolescents are developing this condition. Type-2 diabetes is much more common than type- 1 diabetes. It affects the way the body uses insulin. While the body still makes insulin, unlike in type-1, the cells in the body do not respond to it as effectively as they once did. Gestational diabetes occurs in women due to insulin blocking hormones produced during pregnancy. It does not occur in all women and usually resolves after giving birth. Prediabetes or borderline diabetes occurs when blood sugar is usually in the range of 100 to 125 milligrams per decilitre (mg/dL). Normal blood sugar levels sit between 70 and 99 mg/dL, whereas a person with diabetes will have a fasting blood sugar higher than 126 mg/dL.

Despite significant advances in diabetes treatment during the last three decades, treatment outcomes in patients are still far from perfect. These treatments have many drawbacks, including drug resistance, side effects and even toxicity.

Plants have always been a source of drugs for humans since time immemorial. According to the World Health Organization, up to 90% of the population in developing countries uses plants and its products as traditional medicine for primary health care [4]. In nature, various plants are an exceptional source of antidiabetic medicines.

The present paper presents the antidiabetic efficacy of some of the important plants used in the traditional system of medicine for the management of type-2 Diabetes mellitus.

Some Plants with Antidiabetic Potential:

Aegle marmelos (Family: Rutaceae) is commonly known as Bael or Sirphal in Hindi and Holy Fruit Tree in English. The researches have shown that the aqueous leaf extract (1 gm/kg for 30 days) significantly controlled blood glucose, urea, liver glycogen, serum cholesterol and body weight, of alloxanized (60 mg/kg IV) rats as compared to controls. Studies also revealed that the extract is equally effective in comparison to insulin in restoring blood glucose and body weight to normal levels. [5,89]

Allium sativum (Family: Amaryllidaceae) is commonly called as Garlic in English and Lahsun in Hindi. In Ayurveda, A. sativum is used against a variety of problems including headache, intestinal worms, insect bites and tumours [6]. The leaves and bulbs are the most frequently used parts of the garlic plant. It has been reported that garlic may act as an antidiabetic agent by increasing either the pancreatic secretion of insulin from the beta cells or the release of bound insulin [7]. The main bioactive components present in A. sativum are ajoene, allicin, allixin and other organosulphur compounds. Allicin, a sulphur-containing compound, is supposed to enhance serum insulin by combining with cysteine and sparing it from SH group reactions [8]. Researches revealed that the consumption of garlic significantly decreased fasting blood sugar levels [9]. Studies have also proved that the incorporation of garlic juice resulted in better utilization of glucose in glucose tolerance tests performed in rabbits, while allicin at a dose of 250 mg/kg was 60% as effective as tolbutamide in alloxan-induced diabetic rabbits [8].

Annona squamosa Linn. (Family: Annonaceae) is commonly called as Custard apple in English and Sharifa in Hindi. It is cultivated throughout India. The pharmacological active ingredients are present in seeds, leaves and aerial parts of the plant [10]. The researches revealed that the plant possesses both hypoglycemic and antidiabetic properties. It acts by enhancing insulin level from the pancreatic islets, increases utilization of glucose in muscle and inhibits the glucose output from liver. It has been also reported that the leaf extract of plant is useful in maintaining healthy blood sugar and cholesterol levels [11].

Boerhaavia diffusa Linn. (Family: Nyctaginaceae) is a small perennial creeping herb, commonly known as "Punarnava" in Hindi and Red hogweed in English. The root and the whole plant of Boerhaavia are used in Ayurvedic and Unani system of medicine for the treatment of diabetes, jaundice, abdominal pain, inflammation, congestive heart failure, stress, dyspepsia, enlargement of spleen and bacterial infections [12,13,14]. It has been reported that the aqueous leaf extract of the plant has antidiabetic effect in alloxan-induced diabetic rats [15,16]. Studies also revealed that the herb possesses antidiabetic property and it mainly acts by increasing insulin sensitivity [17] and reducing blood glucose level.

Bougainvillea spectabilis Linn. (Family: Nyctaginaceae) is an ornamental plant commonly grown in gardens. The plant has antidiabetic properties. The blood glucose lowering potential of leaf extract of B. spectabilis has been reported in streptozotocin-induced type-I diabetic albino rats [18]. Researches revealed that the antihyperglycemic activity of ethanolic extract of the Bougainvillea leaves is due to increased uptake of glucose by enhanced glycogenesis in the liver and also due to increase in insulin sensitivity [19].

Canavalia ensiformis DC. (Family: Leguminosae) is known as Horse bean. It has been reported that the seeds of Canavalia possess hypoglycemic [20] and anti-hypercholesterolemic [21] properties. Antidiabetic properties of aqueous extract of C. ensiformis seeds on hyperlipidemia and hyperketonemia in alloxan-induced diabetic rats have proved it as an active antidiabetic herb. The studies have shown that the oral administration of aqueous extracts of C. enciformis seeds lowers urine and blood sugar levels and also high levels of ketone bodies, cholesterol and triacylglycerol associated with Diabetes mellitus.[22]

Catharanthus roseus Linn. (Family: Apocynaceae) is commonly known as "Periwinkle" in English and "Sadabahar" in Hindi. In tropical and subtropical areas of the world, the hot water decoction of the leaves or the whole plant is used for the treatment of diabetes [23]. It

is also used as an anticancer agent. The blood glucose lowering activity in the alcoholic extract of the leaves of C. roseus has been reported. The antidiabetic activity of dichloromethane-methanol extract of the leaves and twigs has been evaluated and its effect on the enzymes of carbohydrate metabolism was studied. It mainly acts by increasing insulin secretion. The researches also reported that extract of C. roseus may be helpful in the prevention of damage caused by oxygen free radicals and increase in glucose consumption [24].

Cinnamomum verum (Family: Lauraceae) is commonly called as Dalchini in Hindi and Ceylon Cinnamon in English. Cinnamon is an evergreen tree characterized by oval-shaped leaves, thick bark and a berry fruit. The bark and leaves are the primary parts of the plant used. The bark of Cinnamon is reddish or yellowish brown in colour with pleasant aroma. The medicinal use of this plant has been documented in Ayurveda for more than 6000 years. Cinnamon improves the metabolism of glucose and lipids in patients with type-2 Diabetes and may be used as an alternative for the treatment of diabetes. Several polyphenols have been isolated from cinnamon. These polyphenols include catechin (1.90%), rutin (90.067%), quercetin (0.172%), kaempferol (0.016%) and isorhamnetin (0.103%) [25,26]. Researches have shown that the cinnamon polyphenols exhibit insulin-like activity in cells, animals and people with type-2 diabetes [27]. A substance from cinnamon has been isolated and coined as "insulin-potentiating factor" (IPF) [28], while the antidiabetic effects of cinnamon bark have been shown in streptozotocin-induced diabetic rats [29]. In a recent study, suitable doses of cinnamon (5, 10, and 20 mg/kg) of the linalool chemotype were found to help with glycemic control in diabetics due to enhanced insulin secretion [30].

Coccinia indica Wight & Arn. (Family: Cucurbitaceae) is also known as Kundru in Hindi and Ivy gourd in English. It is widely used in traditional treatment of Diabetes mellitus. It has been reported that the pectin isolated from the fruits of C. indica has hypoglycemic activity [31]. Researches showed that the alcoholic extract of plant is active in reducing blood glucose level. The alcoholic extract on further fractionation to evaluate its biochemical parameters effecting diabetes suggest that the toluene is an active fraction. The exact action of these principles may be due to their β-cell restorative properties against alloxan induced damage [32].

Cocculus hirsutus Linn. (Family: Menispermaceae) is also known as Patalagarudi. The plant grows all over India, especially in dry regions. It is a straggling shrub, with softly villous young parts. Its roots are acrid, bitter, demulcent, laxative and antiperiodic in fever, tonic and diuretic [18]. Researches revealed the antihyperglycemic activity of aqueous extract of leaves of C. hirsutus (L) Diels in alloxan-induced diabetic mice. The antihyperglycemic properties of aqueous extract of C. hirsutus may be due to lowering of serum glucose level in diabetic mice and increased glucose tolerance.[33]

Coscinium fenestratum Colebr. (Family: Menispermaceae) is also known as Jhar- haldi in Hindi. It has been mainly used for diabetes mellitus in the traditional Ayurvedic and Siddha systems of medicine [18]. The researches revealed that the alcoholic extract of stem regulates metabolism and improves antioxidant status in streptozotocin, nicotinamide-induced diabetic rats. It has been reported that the alcoholic extract of C. fenestratum regulates glucose homeostasis and decreased gluconeogenesis. The study also revealed that the extract has protective action on cellular antioxidant defence [34]

Dioscorea dumetorum Pax. (Family: Dioscoreaceae) is commonly known as bitter yam. It possesses hypoglycemic effect. The plant is used in the treatment of diabetes in traditional medicine. It has been reported that an alkaloid dioscoretine, present in the extract of plant tuber possess hypoglycemic effect [35].The studies revealed that the aqueous extract of plant tuber control hypercholesterolemia, hyperketonemia and hyperlipidemia.The plant mainly acts as an active hypoglycemic agent and works on the complications of diabetes [36].

Eugenia jambolana (Family: Myrtaceae) is commonly called as Jamun in Hindi and Black plum in English. Studies have shown that jamun has been used in many of India's complementary and alternative systems of medicine and was also a frontline antidiabetic drug in Europe before the discovery of insulin. It has been reported that the blood glucose-lowering effect of Eugenia may be due to inhibition of insulin degradation or by increased secretion of insulin from the pancreas [37]. The most commonly used parts of Eugenia jambolana are leaves, fruits, seeds and bark. The bark of jamun contains several bioactive compounds including betulinic acid, bergenin[38], B- sitosterol, eugenin, ellagic and gallic acid and quercetin[39], tannins[40] and flavonoids. The fruits are rich in glucose,fructose, raffinose[41], malic acid [42] and anthocyanins[43]; leaves contain acylated flavonol glycosides [44],myricetin, tannins and quercetin [45,46], all of which have hypoglycemicability. It has also been reported that the seeds and decoctionof dry leavesof Eugenia have anti-hyperglycaemic activity [47].

Ficus religiosa (Moraceae) is commonly known as Peepal in Hindi. It has been reported to be used in the Ayurveda for the treatment of diabetes [48]. The Ficus plant contains several bioactive principles including polyphenolic compounds, flavonoids, tannins, saponins, and sterols. The studies revealed that the F. religiosa possess a wide spectrum of in-vivo and in-vitro pharmacological properties: antidiabetic, anticonvulsant, anti-inflammatory, analgesic, antiviral, antioxidant, antitumor, antimicrobial, hypolipidemic, antiulcer, antianxiety, anthelmintic, antiasthmatic, estrogenic, endothelin, immunomodulatory, receptor antagonist, apoptosis inducer, cognitive enhancer and antihypertensive [49]. The decoction prepared from the bark of F. religiosa is used in the treatment of diabetes [50]. The studies revealed that the oral incorporation of aqueous extract of Ficus religiosa for 21 days caused a significant lowering in blood glucose levels and an elevated level of insulin.

Gymnema sylvestre (Family: Asclepiadaceae) is commonly called as Gurmar. It is a potent antidiabetic plant used in Ayurveda. G. sylvestre is a large climber, with roots at nodes. A group of triterpene saponins, known as gymnemic acids and gymnema saponins are found to be present in G. sylvestre which are responsible for its pharmacological properties. It has been reported that aqueous extract of G. sylvestre cause reversible increases in intracellular calcium and insulin secretion in mouse and human β cells with type-2 diabetes [51]. Several studies have proved that the G. sylvestre prevent adrenal hormones from stimulating the liver to produce glucose in mice, thereby reducing blood sugar levels [52]. It has been reported that oral administration of Gymnema is effective against chronic inflammation [53], obesity [54, 55] and pancreatic beta cell dysfunction [56]. Studies revealed that the G. sylvestre suspension has tremendous diabetic potential against alloxan-induced diabetic albino male rats [57]. It has been reported that the hypoglycemic effect of ethanolic extract of G. sylvestre is due to enhanced effect of insulin which becomes active by increasing either the pancreatic secretion of insulin from beta cells or its release from the bound form [58,59,60].

Momordica charantia (Family: Cucurbitaceae) is commonly known as Bitter melon, Bitter gourd or Karela. It is a very common traditional remedy for diabetes. The major compounds isolated from this plant and identified as hypoglycemic agents are Charantin, polypeptide-P and vicin. [61, 62]. It has been reported that the alcohol-extracted charantin from Bitter gourd consists of mixed steroids and it was found to be more effective than the oral hypoglycemic agent tolbutamide in an animal study. M. charantia also possesses an insulin-like polypeptide, polypeptide- P, similar in structure to bovine insulin. It was found to decrease blood sugar levels when injected subcutaneously into type-1 diabetic patients and appears to inhibit gluconeogenesis and is believed to improve glucose tolerance in type-2 diabetes. [5,14,63]

Murraya koenigii Linn. (Family: Rutaceae) is commonly known as Curry patta or Mithi Neem and is widely used as condiment and spice in India. It has been reported that in normal and alloxan diabetes the aqueous extract of the leaves of M. koenigii produced hypoglycemic effect [64]. Researches revealed that the oral feeding of this plant for 60 days diet to normal rats showed an increase in the concentration of hepatic glycogen due to hypoglycemic activity [65]. It has been reported that feeding different doses of M. koenigii leaves to diabetic rats play an important role in control of mild, moderate, and severe type- I diabetes [66]. M. koenigii suppresses blood glucose level and was found to have beneficial effect on carbohydrate metabolism [67].

Ocimum sanctum (Family: Lamiaceae) is commonly known as Holy basil or Tulsi. Every part of the plant is used against several diseases. The main bioactive constituents present in the leaves and stems of Tulsi include flavonoids, saponins, tannins, triterpenoids, rosmarinic acid, apigenin, isothymusin, isothymonin, cirsimaritin, orientin and vicenin. It has been reported that Eugenol, the active constituent present in O. sanctum L., is responsible for its medicinal properties [68]. Plant of O. sanctum is highly valued in Ayurveda for its anti-diabetic properties. It has been reported that when streptozotocin-

induced diabetic rats were supplemented with ethanolic extract of O. sanctum, a significant reduction in blood glucose, glycosylated haemoglobin and urea along with a simultaneous increase in glycogen, haemoglobin and protein [69]. Studies revealed that leaf extract of Ocimum stimulates the physiological pathways of insulin secretion [70] and also shows the serum glucose-lowering effect when the extract was given to normal rats for 30 days [71, 72]. It has been reported that the chloroform extracts of aerial parts of Ocimum plant ameliorates the imbalances in lipid metabolism caused due to D. mellitus in alloxan-induced diabetic rats. Studies also revealed the extract significantly decrease the elevated level of serum glucose and also decrease the high level of cholesterol, triglyceride and LDL values [73].

Pterocarpus marsupium (Family: Fabaceae) is commonly called as Indian kino tree or Bijasar. The most commonly used parts of the plant are heart wood, bark, leaves, flowers and gum. In Ayurvedic system of medicine, P. marsupium is one of the most versatile therapeutic plants. Studies have shown that P. marsupium contains terpenoids andphenolic compounds: β-sitosterol, lupenol, aurone glycosides, epicatechins and iso-flavonoids [74]. Pterocarpus is known for its antidiabetic activity [75]. It has been reported that P. marsupium plant has not only hypoglycemic property but also β-cell protective and regenerative properties [76]. Studies also revealed that the blood sugar-lowering activity of P. marsupium is due to the presence of tannates in the extract of the plant.

Terminalia chebula Retz. (Family: Combretaceae) is commonly known as Harra or Harad in Hindi and is widely distributed in India. It has been widely used in diabetes in Ayurvedic system of medicines. An herbal formulation containing T. chebula named Triphala is a traditional medicine for the treatment of diabetes [18]. Researches revealed the antidiabetic and renoprotective effects of the chloroform extract of T. chebula Retz seeds in streptozotocin-induced diabetic rats. It has been reported that the T. chebula has effective renoprotective action [77].

Tinospora cordifolia (Family: Menispermaceae) is commonly known as Giloy, Guduchi or Amrita. Giloy is commonly used in Ayurveda as a vitalizer tonic and as a remedy for diabetes and metabolic disorders.[13] The main constituents of T. cordifolia are alkaloids, glycosides, steroids, sesquiterpenoid, diterpenoid lactones, phenolics, aliphatic compounds and polysaccharides.[78] Leaves of T. cordifolia are rich in protein (11.2%) calcium and phosphorus. [79] Researches revealed that oral administration of the aqueous extract of T. cordifolia root produced a significant reduction in blood glucose, brain lipid level, alkaline and lactate dehydrogenase, hepatic glucose-6- phosphatase, serum acid phosphatase and increase in total haemoglobin, body weight and hepatic hexokinase in alloxanized diabetic rats [5].

Trigonella foenum-graecum (Family: Fabaceae) is commonly called as Methi in Hindi and Fenugreek seeds in English. The leaves and seeds of fenugreek are the most frequently used parts of the plant. It has been reported that fenugreek has strong antidiabetic properties [80, 81]. The medicinal properties of fenugreek are primarily due to the presence of saponins [82], 4-hydroxyisoleucine [83] and trigonelline, an alkaloid [84] and a high-fiber content [85]. The studies have proved that the extract and mucilage of seeds and leaves of Trigonella can decrease blood glucose and cholesterol levels in humans and experimental diabetic animals [86,87,88].

It has been shown that Methi seed powder, normalize the activity of creatinine kinase in skeletal muscles, liver and heart of diabetic rats [89, 90]. Researches revealed that the steroids present in fenugreek reduce blood glucose level when supplemented to diabetic rats [91]. It has been reported that fenugreek seed extract significantly increases the area of insulin-immunoreactive beta cells [92,93]. Research on renal and intestinal disaccharidases activity in STZ-induced diabetic rats revealed the beneficial effects of fenugreek seed mucilage by enhancing the reduction in maltase activity during diabetes [94].

CONCLUSION:

The occurrence of Diabetes mellitus is increasing worldwide and treatment with oral hypoglycemic drugs ends with many side effects and huge financial expenditure. There is a growing demand by patients to use natural products with antidiabetic properties. As per Ayurveda, there exists a huge collection of plants with antidiabetic potential. This paper has presented various anti-diabetic plants that have been tested pharmacologically and which are helpful in the treatment of Diabetes Mellitus. These plants may correct the metabolic abnormalities and ameliorate diabetic complications. However, more researches should be carried out to evaluate the mechanism of action of medicinal plants with antidiabetic effect.

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