HERBAL MEDICINES USED IN THE TRADITIONAL INDIAN MEDICINAL SYSTEM AS A THERAPEUTIC TREATMENT OPTION FOR DIABETES MANAGEMENT: A REVIEW

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ABSTRACT
Diabetes is an important human ailment afflicting many from various walks of life in different countries. In recent years, diabetes has become a major health problem worldwide, affecting people across all ages, sex, ethnicities, and races, and its prevalence has been increasing at an alarming rate. Currently, pharmacologic agents available to treat diabetes carry high costs and serious side effects. In contrast, natural products used in the conventional Indian medicinal system have been applied effectively in clinical practice and may be potential targets in the development of future cost effective anti-diabetic drugs with less side effects. In the modern era, various medicines have been developed for hyperglycemic, but nearly all are chemical or biochemical agents. A list of medicinal plants with proven anti-diabetic and related beneficial effects and of herbal drugs used in treatment of diabetes is compiled. There is a need to create awareness regarding the evidence for and use of herbal medicines in the management and treatment of diabetes. The wealth of tribal knowledge on medicinal plants points to a great potential for research and the discovery of new drugs to fight diseases including diabetes, obtaining new foods and other new uses. The purpose of this review was to examine medicinal plants that may be promising alternative treatments in the management and treatment of diabetes, especially in India.

KEYWORDS: Diabeyes, Herbal Medicine, Medicinal Plant.
INTRODUCTION

Diabetes, a dreadful lifestyle metabolic disorder with every 5th Indian as diabetic by 2025 (40 million diabetics in India expected to be 70 million by 2025) [WHO/IDF 2006]. It has been estimated that the global burden of type 2 diabetes mellitus (T2DM) for 2010 would be 285 million people (2010) which is projected to increase to 438 million in 2030; (Snehalatha and Ramachnadaran 2009). In India the increase is estimated to be 58%, from 51 million people in 2010 to 87 million in 2030 (Snehalatha and Ramachnadaran 2009). It is a silent epidemic that directly affects glucose catabolism leading to energy yielding changes. The chronic effects include blindness (2%); visual handicap (10%); diabetic retinopathy and neuropathy; sensory loss and damage to limbs [WHO 2002]. In India, the difference in number of cases being affected in urban population with respect to rural is 8% because of changes in lifestyle and consumption patterns [WHO 2004]. Globally Type I diabetes, affects 10% of diabetic population while 90% cases falls into category of Type II wherein down regulation of receptors leads to insulin non-responsiveness [WHO 1999].

The traditional (herbal) medicines acquire a significant proportion of >83 billion dollars annual production increasing exponentially [WHO 2005]. In developing countries like, 70-95% of the population relies on herbal medicines for primary care. This is because the cost imperatives or unavailability of conventional drugs. In India, more than 80% of the population dependent upon herbal drugs. it shared less than 2.5% of the total global market. More than 60% market share is being controlled by European Union and North America [WHO 2002, 2004]. World Health Organization (WHO), estimated that about 80% of the world population still uses herbs and other traditional medicines for fulfilling their primary health care needs [WHO 2012]. At present, herbal formulations are used more as therapeutic agents for diabetics, arthritics, liver diseases, cough remedies, memory enhancers and adoptogens [Patel PM 2006]. In spite of such wide acceptability, the number of standardized herbal drugs is less due to lack of regulatory standards and implementation protocols. Standardization requires a lead/natural plant product to be certified at origin itself by borrowing of good agricultural practices [Bauer R 1999] collection techniques from wild and good manufacturing practices for extraction modes and related parameters [Straus SE et al 2002, NISCAIR 2002, NISCAIR 1996, WHO 1996].

There are more than 1000 plants which are used in anti diabetic herbal formulations and among them about 100 plants have been scientifically validated [Jarald 2008]. However, no
single approved herbal drug is available till date for mass usage. It is essentially due to lack of standardization methodologies adopted prior to development of drug. Herbal medicinal therapy is the unique alternative for diabetic people. Thus far, the majority of the various different types of remedies developed are chemical or biochemical agents. This review focuses on Indian Herbal drugs and plants used in the treatment and management of diabetes, especially in India

**Drugs commonly used to control diabetes**

Currently there are wide range of oral hypoglycemic agents available according to their mode of action.

- Alpha-glucosidase inhibitors- *Acarbose, Miglitol, Voglibose*
- Amylin mimetics-*Pramlintide*
- Biguanides- *Metformin, Phenformin, Buformin, Proguanil*
- Dipeptidy peptidase-4 (DPP4) inhibitors-*Saxagliptin, Sitagliptin, Linagliptin, Septaglibitin, Alloglitin*
- Glycosurics- *Cangliflogin, Dapagliflogin*
- Incretin mimetics- *Exenatide, Liraglutide, Exendin, Liraglutide, Vildaglitipin, Sitagliptin*
- Meglitinide –*Repaglinide, Nateglinide*
- Sulfonylureas – *Glipizide, Glimepiride, Glyburide, Glibenclamide, Gliclazide*
- Thiazolidinediones- *Rosiglitazone, Pioglitazone, troglitazone*

No single diabetes treatment is best for everyone, and what works for one person may not work for another. Your doctor can determine how a specific medication or multiple medications may fit into your overall diabetes treatment plan and help you understand the advantages and disadvantages of specific diabetes drugs.

Herbal medicinal therapy is the unique alternative for diabetic people. Thus far, the majority of the various different types of remedies developed are chemical or biochemical agents. The purpose of this review was to examine medicinal plants that may be promising alternative treatments in the management and treatment of diabetes.

**Medicinal Plant in Indian with Anti-diabetic effect**

Hypoglycemic activity has been reported in many plants during the last twenty years (*Anon 1992*). There are many herbal remedies suggested for diabetes and diabetic complications.
Acacia arabica: (Babul)
Acacia arabica is found all over India mainly in the wild habitat. The extract of this plant acts as secretagouge (insulin releasing agent) agent. Hypoglycemic activity is found in control rats but not in alloxanized animals. Powdered seeds of Acacia arabica when administered (2.3 and 4 g/kg body weight) to normal rabbits induced hypoglycemic effect by initiating release of insulin from pancreatic beta cells [Wadood A 1989].

Aegle marmelos: (Bengal Quince, Bel or Bilva)
It is found that the reduction of blood sugar and urea, serum cholesterol in alloxanized rats as compared to control after administering the aqueous extract of leaves of Aegle marmelos. Along with exhibiting hypoglycemic activity, this extract also prevented peak rise in blood sugar at 1h in oral glucose tolerance test [Karunanayake E.H 1984]

Allium cepa: (onion)
Allium cepa is also known to have antioxidant and hypolipidaemic activity. Administration of a Allium cepa, to alloxan induced diabetic rats significantly controlled blood glucose as well as lipids in serum and tissues and normalized the activities of liver hexokinase, glucose 6-phosphatase and HMG Co A reductase [Kumari K 1995]. When diabetic patients were given single oral dose of 50 g of onion juice, is ignificantly controlled post-prandial glucose levels [Mathew PT 1975].

Allium sativum: (garlic)
This is a perennial herb cultivated throughout India. Allicin, a sulfur-containing compound is responsible for its mordacious, odour. It has been shown significant hypo-glycemic activity. This effect is thought to be due to increased hepatic metabolism, increased insulin release from pancreatic beta cells [Sheela CG 1992]. S-allyl cystein sulfoxide the precursor of allicin and garlic oil, which controlled lipid peroxidation. S-allyl cystein sulfoxide also stimulated in vitro insulin secretion from beta cells isolated from normal rats [Zacharias, NT 1996]. Aqueous homogenate of garlic (10 g/kg/day in water for two months) administered orally to sucrose fed rabbits. It significantly increased free amino acid content and hepatic glycogen, decreased fasting blood glucose, and triglyceride levels in serum as compare to sucrose controls [Zacharias, NT 1980].
Aloe vera and Aloe barbadensis

Aloe vera has been widely grown as an ornamental plant. The plant can be separated into two basic products: gel and latex. Aloe vera gel is the leaf pulp or mucilage, aloe latex, commonly referred to as “aloe juice,” is a bitter yellow exudate from the pericyclic tubules just beneath the outer skin of the leaves. Extracts of aloe gum effectively increases glucose tolerance in both normal and diabetic rats [Al-Awadi 1987]. It is found that that Aloe barbadensis leaves have the hypoglycemic effect in alloxanized diabetic rats. Single as well as chronic doses of bitter principle of the same plant also exhibited hypoglycemic effect in diabetic rats. This action of Aloe vera and its bitter principle is through stimulation of synthesis and/or release of insulin from pancreatic beta cells [Ajabnoor MA 2006].

Azadirachta indica: (Neem)

Azadirachta indica is widely distributed all over India, Pakistan and Bangaldesh. Its common name is neem. Hydroalcoholic extracts of this plant showed anti-diabetic activity in streptozotocin treated rats. This effect is because of increase in glucose uptake and glycogen deposition in isolated rat hemidiaphragm [Chattopadhyay RR 1987]. Apart from having anti-diabetic activity, this plant also has so many activity like anti-bacterial, antimalarial, antifertility, hepatoprotective and antioxidant effects [Biswas K 2002].

Betula alnoides

Methenolic extract (100-400 mg/kg) of Betula alnoides significantly inhibited the increase of serum glucose levels in rats after oral administration of 20% sucrose at 30 and 60 min. Similarity, a standard acarbose (5-10 mg/kg, p.o.) also significantly inhibited the increase of blood glucose levels in sucrose-loaded rats at 30 and 60 min. These results indicate that Betula alnoides may benefit in the treatment of diabetes mellitus as α-glucosidase inhibitory activity and lowering of the blood glucose levels. (Yutana Pongpiriyadacha 2013)

Caesalpinia bonducella

Caesalpinia bonducella is widely distributed throughout the coastal region of India. Both the aqueous and ethanolic extracts showed hypoglycemic activity in chronic type II diabetic models. These extracts also increased glycogenesis thereby increasing liver glycogen content [Chakrabarti, S 2003]. It was found that the aqueous and 50% ethanolic extracts of Caesalpinia bonducella seeds have antihyperglycemic and hypolipidemic activities in streptozotocin (STZ)-diabetic rats [Sharma SR 1997]. This herb has the potential activity antidiabetic as well as antihyperlipidemic [Kannur DM 2006]
Capparis decidua
This is found throughout India, especially in dry areas. Hypoglycemic effect was seen in alloxanized rats when the 30% extracts of Capparis decidua (C. decidua) fruit powder was administered orally in rats for 3 weeks. This extract also reduced alloxan induced lipid peroxidation significantly in erythrocytes, kidney and heart. C. decidua was also found to change superoxide dismutase and catalase enzyme levels to decrease oxidative stress [Yadav P 1997]. C. decidua additionally showed antihyperlipidaemic activity [Agarwal V 1988].

Coccinia indica
Coccinia indica (C. indica) (500 mg/kg body weight) dried extracts were administered orally to diabetic patients for 6 weeks. These extracts recover the activities of enzyme lipoprotein lipase (LPL) that was reduced and glucose-6-phosphatase and lactate dehydrogenase, which were raised in untreated diabetics [Kamble SM 1998]. Oral administration of 500 mg/kg of C. indica leaves exhibits significant hypoglycemia in alloxanized diabetic dogs and increased glucose tolerance in normal and diabetic dogs.

Eugenia jambolana: (Indian gooseberry, jamun)
Decoction of kernels of Eugenia jambolana is frequently used as household remedy for diabetes in India. Aqueous and alcoholic extract as well as lyophilized powder of Eugenia jambolana showed reduction in blood glucose level. This varies with different level of diabetes. In mild diabetes (plasma sugar >180 mg/dl) it shows 73.51% reduction, whereas in moderate (plasma sugar >280 mg/dl) and severe diabetes (plasma sugar >400 mg/dl) it is reduced to 55.62% and 17.72% respectively [Sheela CG 1992]. The extract jamun showed to increase in serum insulin levels after oral administration in rats. Insulin secretion was found to be stimulated on incubation of plant extract with isolated islets of Langerhans from normal as well as diabetic animals. These extracts also inhibited insulinase activity from liver and kidney [Acherekar S 1991].

Euccalyptus globulus
Aqueous extract of Euccalyptus globulus (0.5 g/L of solution) increased peripheral glucose utilization in the mouse abdominal muscle and increased insulin secretion from the clonal pancreatic beta cell line. [Singh LW 2011]
Hibiscus rosa sinensis (Malvaceae)
Ethanol extract of Hibiscus rosa sinesis at 250 mg/kg, p.o. showed mild but significant hypoglycemia when administered orally. It was possible due to insulin release by stimulation of pancreatic beta cells [Grover JK 2002].

Mangifera indica: (Mango)
Mangifera indica is widely distributed all over India. The leaves of this plant are used as an antidiabetic agent, although when aqueous extract given orally showed no alteration in blood glucose level in either normoglycemic or streptozotocin induced diabetic rats. While antidiabetic activity was seen when the extract and glucose were administered simultaneously. The results indicated that aqueous extract of Mangifera indica possessed hypoglycemic activity. This may be due to an intestinal reduction of the absorption of glucose [Aderibigbe, A.O 1999].

Momordica charantia: (bitter gourd)
Momordica charantia is more frequently used as an antihyperglycemic agent in India. All part of this plant like extracts of fruit pulp, seed, leaves and whole plant was shown to have hypoglycemic effect in various animal models. Polypeptide p, was isolated from fruit, seeds and tissues of M. charantia showed significant hypoglycemic effect when subcutaneously administration was carried out in langurs and humans [Khanna P 1981]. Ethanolic extracts of M. charantia (200 mg/kg) showed an antihyperglycemic and also hypoglycemic effect in normal and STZ diabetic rats. This may be because of inhibition of glucose-6-phosphatase besides fructose-1, 6- biphosphatase in the liver and stimulation of hepatic glucose 6-phosphate dehydrogenase activities [Shibib BA 1993].

Ocimum sanctum: (holy basil)
Ocimum sanctum is widely found in most of the families and widely distributed all over India. It is commonly known as Tulsi. Since ancient times, this plant is known for its medicinal properties. The aqueous extract of leaves of Ocimum sanctum showed the significant reduction in blood sugar level in both normal and alloxan induced diabetic rats [Vats, V 2002]. Significant reduction in fasting blood glucose, uronic acid, total amino acid, total cholesterol, triglyceride and total lipid indicated the hypoglycemic and hypolipidemic effects of tulsi in diabetic rats [Rai, V 1997]. This plant also exhibited antiasthemitic, antistress, antibacterial, antifungal, antiviral, antitumor, gastric antiulcer activity, antioxidant, antimutagenic and immunostimulant activities.
Panax Ginseng
The anti-diabetic potential of different ginseng species has been evaluated. This activity is mediated by a number of different mechanisms, including regulation of pancreatic b-cell function by stimulation of insulin secretion and biosynthesis. This activity has been assigned to its saponin and polysaccharide constituents e.g. ginsenoside Rh2 and panaxan B, respectively, which were exhibited to promote the plasma insulin level by stimulating insulin release and biosynthesis in a glucose-independent manner. ([Suzuki Y 1989, Li G D 1987, Han KL 2006] Moreover, DPG-3-2, a polysaccharide fraction was isolated from ginseng, has been shown to elevate insulin biosynthesis in different pancreatic preparations from hyperglycaemic animals. ([Waki I 1982])

Phyllanthus amarus
It is commonly known as Bhuiamala. It is occupied throughout the hotter parts of India, mainly Deccan, Konkan and south Indian states. Traditionally it is used as hypoglycemic agent. Methanolic extract of Phyllanthus amarus was found to have potent antioxidant activity. This extract also decreased the blood sugar in alloxanized diabetic rats ([Raphael KR 2002]). The plant also have so many activity other than hypoglycemic like antiinflammatory, antimutagenic, anticarcinogenic, antidiarrhoeal activity.

Psidium guajava
Psidium guajava is Widely cultivated in tropical and subtropical regions around the world, guava fruits can range in size from as small as an apricot to as large as a grapefruit. It is frequently cultivated in north east India. Flavonoid glycosides such as strictinin, isostrictinin and pedunculagin are the effective constituents of Psidium guajava, which have been used in clinical treatment of diabetes due to improved sensitivity of insulin ([Chauhan A 2010])

Pterocarpus marsupium
It is a deciduous moderate to large tree found in India mainly in hilly region. Pterostilbene, a constituent derived from wood of this plant caused hypoglycemia in dogs ([Haranath, PSR.K 1958]). Hypoglycemic activity of this extract is expressed because of presence of tannates in the extract. Flavonoid fraction from Pterocarpus marsupium has been exhibited to cause pancreatic beta cell regranulation ([Chakravarty, B.K 1980]). Marsupin, pterosupin and liquiritigenin obtained from this plant showed antihyperlipidemic activity ([Jahromi, M.A 1993]). The active principle constituent of Pterocarpus marsupium is epicatechin, has been
found to be insulinogenic, enhancing insulin release and conversion of proinsulin to insulin in vitro. Like insulin, epicatechin induces oxygen uptake in fat cells and tissue slices of various organs, promote glycogen content of rat diaphragm in a dose-dependent manner [Ahmad, F. 1989].

**Syzygium cumini**

Syzygium cumini is widely used traditional system of medicine to treat diabetes in India. A compound, mycaminose was isolated from SC seed extract. The isolated compound mycaminose (50 mg/kg) and ethyl acetate [EA] and methanol [ME] extracted compounds of S. cumini seed (200 and 400 mg/kg) was undertaken to evaluate the anti-diabetic activity against streptozotocin (STZ)-induced diabetic rates (Kumar A 2008). Oral administration of pulp extract of the fruit of Syzygium cumini to normoglycemic and STZ induced diabetic rats exhibited hypoglycemic activity in 30 min possibly mediated by insulin secretion and inhibited insulinase activity (Grover JK 2002).

**Trigonella foenum graecum**

It is found all over India and the fenugreek seeds are usually used as one of the major constituents of Indian species., A novel amino acid 4-hydroxyleucine is active constituents of fenugreek seeds increased glucose induced insulin release by isolated islet cells in both rats and humans [Sauvaire Y 1998]. Oral administration of 2 and 8 g/kg of plant extract produced dose dependent decrease in the blood glucose levels in both normal as well as diabetic rats [Khosla, z 1995]. Administration of fenugreek seeds was shown the improvement of glucose metabolism and normalization of creatinine kinase activity in heart, skeletal muscle and liver of diabetic rats. It also minimized hepatic and renal glucose-6-phosphatase and fructose –1,6-biphosphatase activity [Gupta D 1999]. This plant also expressed antioxidant activity [Ravikumar P 1999, Dixit PP 2005].

**Tinospora cordifolia**

It is a large, glabrous, deciduous climbing shrub. It is widely distributed throughout India and commonly known as Guduchi. Oral administration of the extract of Tinospora cordifolia (T. cordifolia) roots for 6 weeks produced in a significant reduction in blood and urine glucose and in lipids in serum and tissues in alloxan diabetic rats. The extract also prevented to increase in body weight. [Stanely P 2003] T. cordifolia is widely used in Indian ayurvedic medicine for treating diabetes mellitus [Stanely M 2001, Price, PS 1999, Mathew S 1997]. Oral administration of an aqueous T. cordifolia root extract to alloxan diabetic rats caused a
significant reduction in blood glucose and brain lipids. It is reported that the daily administration of either alcoholic or aqueous extract of T. cordifolia reduced the blood glucose level and enhances the glucose tolerance in rodents [Gupta SS 1967].

Vitex negundo
Vitex negundo is widely cultivated and naturalized elsewhere. Vitex negundo, commonly known as the five-leaved chaste tree. Idopyranose is active constituent of isolated from the leaves of V. negundo (50 mg/kg bw) reduced the blood glucose level, serum urea, and cholesterol level in STZ-induced diabetic rats. It also protects to damaged pancreas helped to regenerate the pancreatic β cells and hyperglycemic in nature against STZ-induced diabetic rats (Manikandan R 2009)

Zizyphus spinachristi
Zizyphus spina-christi, the Christ's Thorn Jujube is an evergreen tree native to northern and tropical Africa and southern and Western Asia. It is also found in India. After four weeks treatment of butanol extract of Zizyphus spinachristi in diabetic rats resulted significant increase of serum insulin and pancreatic cAMP levels [Bnouham M 2006]. Major constituents of Zizyphus spina-christi leaves are saponin lycoside, christinin-A, showed the induction of insulin release in non-diabetic control rats [Manikandan R 2009].

A comprehensive chemical and pharmacological review of numerous bioactive constituents established in Indian medicinal plants used to treat diabetes was performed. A literature search was also conducted to investigate medicinal plants with anti-diabetic properties. Web- and manual-based literature surveys were conducted to assess the information available on the herbal medicines for diabetes treatment. Publications with abstract/full articles and books were reviewed. Based on the available literature, there have been very limited randomised clinical trials (RCTs) and high level of evidence studies.

Why does a hyperglycemic patient prefer herbal medicines for diabetes management? Possible reasons
Plants have always been an exemplary source of drugs and many of the currently available drugs have been derived directly or indirectly from them. Ayurveda, the Indian system of traditional medicine, provides a number of medicinal plants to treat diabetes and an indigenous remedy has been used in the treatment of diabetes since the time of Charaka and Sushruta (6th century BC). Medicinal plants continue to provide valuable anti diabetic or
hypoglycemic agents, in both modern medicine and in traditional system. The majority of diabetic patients consider these drugs to be natural and 100% safe. Ayurveda, the traditional Indian herbal medicinal system practiced for over thousands of years have reports of anti diabetic plants with no known side effects. Such plants and their products have been widely prescribed for diabetic treatment all around the world with less known mechanistic basis of their functioning. Furthermore, these drugs are readily available and can be taken without any expert supervision. Moreover, patients may hesitate to contact healthcare professionals such as physicians, pharmacists, dieticians, or nutritionists. Number of formulations/products is available in market assuring glucose reducing effects, but as usual like other herbal products, anti-diabetic herbal formulations potency is always debatable and demanding more evidences.

**Herbal anti-diabetic products and potential risks**

The general public wants an easy method to control diabetes. Anti-diabetic herbal products attract users with their health claims, assumed safety, easy availability, and extensive marketing. These products can be very heterogeneous in nature and have unpredictable levels of active ingredients, with unpredictable and potentially harmful effects. Thus, anti-diabetic herbal products can cause direct toxicity or adverse interactions with concurrent medications. Physicians and other healthcare professionals need to be aware of these potential complications. Current pharmacological modalities for diabetes are not ideal because of their side effects, reduction of response after prolonged use and are expensive. Therefore, there is a necessity to look for newer anti-diabetic agents. They should advise and warn their patients about the heterogeneous nature of these agents and the potential risks associated with their use. They should report suspected adverse reactions to their national spontaneous reporting system.

**Clinicians’ and patients’ expectation from an appropriate anti-diabetic herbal medicine:**

The pharmacological use of herbal medicine for the treatment of diabetes mellitus is developed potentially as a preliminary point in the development of alternative and inexpensive therapies for treating the disease. A high quality ant-diabetic herbal remedy should be standardized by laboratory investigations and according to quality control protocols. Its mechanism of action should be well established, and the herbal medicine should have less side effects and be cost effective in order to improve patient adherence.
Multifunctional, Conjugated Therapy by polyherbal formulation for diabetic treatment

Most of the studies performed are based on single herbal active constituent. However, in Ayurvedic system of medicine practice a combination of poly herbal formulations are prescribed. More over these formulations are not told to prescribing physician by the patients. This may due to the ignorance of patients because these poly herbal formulations are not considered as a part of active medication. The goal in successful treatment of diabetes mellitus is maintaining optimum blood sugar levels with minimal risk of hypoglycemic episodes. Drugs prescribe for the treatment of type II diabetes mellitus reduce blood sugar level either by increasing insulin secretion / insulin sensitivity or reducing glucose absorption. These effects are very much correlated with the plasma level of oral hypoglycemic agents. Alterations of plasma levels of these medication is likely to adversely influence plasma glucose level leading to failure of therapy. Keeping these things in mind the pharmacokinetic pharmacodynamic parameters may be important to know the likely hood of interactions as well as prediction of successful therapy.

CONCLUSIONS

The diabetes epidemic in the India has led to a high-priority search for Indian herbal therapies that work effectively. Many Indian and other herbs have been aggressively marketed and used for glucose reduction, but only a few products have been evaluated in rigorous trials. Although there is no magic bullet available among Indian herbs that can decrease high level of glucose in a short period, there is a need to create awareness regarding the evidence for and use of natural products in the form of raw materials, crude extracts, or isolated compounds to promote antihyperglycemic. Traditional Indian medicine is based on good clinical practice and holds much promise in the treatment of diabetes. These herbal products from Indian medicinal plants have been widely used to treat diabetes, and it is important to understand how these natural medicines from traditional medicinal plants act. Nearly all the medicines currently available to treat diabetest and diabetic patients are chemical or biochemical and greater attention should be directed towards the use and research of herbal medicines of natural origin with minimal side effects in the management and treatment of diabetes.

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