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Plants Having Potential Antidiabetic Activity: A Review

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Abstract

The aim of present review is to establish the use of plants, plant parts or extract in curing Diabetes mellitus. It also collates available data on plants with hypoglycemic effects. In the present investigation, interest is focused on experimental studies performed on hypoglycemic plants and their bioactive components. A brief description is given about the, type of diabetes, related physiological disorders and available herbal plants which can be further exploited for antidiabetic activity. Overall, this review presents the profiles of plants with hypoglycemic properties, reported in the literature.

Key words: diabetes, antidiabetic activity, herbal medicine

INTRODUCTION

Diabetes mellitus is a serious health problem with continuously increasing rates of incidence and mortality. Diabetes mellitus is characterized by elevated plasma glucose concentrations resulting from insufficient insulin and insulin resistance, or both, leading to metabolic abnormalities in carbohydrates, lipids and proteins [1]. If not cured or controlled it may even lead to acute or chronic complications causing ketoacidosis, microangiopathy and other related infections. Different types of reported diabetes mellitus can be classified under following two categories:
Type 1 is insulin-dependent diabetes mellitus (IDDM), in which the body does not produce any insulin. It most often occurs in children and young adults. Type 1 diabetes accounts for 5–10% of diabetes.

Type 2 is noninsulin-dependent diabetes mellitus (NIDDM), in which the body does not produce enough, or improper use of secreted insulin is the most common form of the disease, accounting

for 90–95% of diabetes. Type 2 diabetes is nearing epidemic proportions, due to an increased number of elderly people, and a greater prevalence of obesity and sedentary lifestyles.

Basis of Diabetes Mellitus treatment:

- Patient education concerning the disease
- Physical exercise
- Diet and
- Hypoglycemic agents

As a very common chronic disease, diabetes is becoming the third "killer" of the health of mankind along with cancer, cardiovascular and cerebrovascular diseases because of its high prevalence, morbidity and mortality. Therefore once diagnosed, it is well regulated by means of various therapeutically effective drugs. Besides, the therapy based on chemotherapeutic agents, the present century has progressed towards naturopathy. Thus, medical plants have an ever emerging role to play in treatment or management of lifelong prolonging diseases like diabetes mellitus, especially in developing countries where resources are meager. Diabetes mellitus alone is accompanied with several other diseases infecting healthy individuals. The treatment of each of such disease can be done by exploiting the herbal integrity of India. The plants in parts or as full can be used for curing any disorder related with diabetes mellitus. Moreover, in some cases extracts of plants are self capable of treating the related disorders such as polyuria, polydipsia, glucosuria, etc. along with curing the chronic disorders such as diabetes mellitus [2, 3].

Our Vedic literatures like *Charak Samhita* already report the use of plants, herbs and their derivatives for treatment of diabetes mellitus. More than 400 plants have been incorporated in approximately 700 recipes which are used to treat diabetes mellitus in almost two thirds of the world population. A large number of *in vivo* studies have been conducted on animals to test the claimed activity have demonstrated the hypoglycemic property of many plants, already reported in various literatures [4].

The plant families, including the species most studied for their confirmed hypoglycemic effects include, Leguminoseae, Lamiaceae, Liliaceae, Cucurbitaceae, Asteraceae, Moraceae, Rosaceae, Euphorbiaceae and Araliaceae.

Many studies have confirmed the benefits of medicinal plants with hypoglycemic effects in the management of diabetes mellitus. The effects of these plants may delay the development of diabetic complications and even assist in correcting the metabolic abnormalities. Moreover, during the past decade and especially in last few years some of the new bioactive drugs isolated from hypoglycemic plants showed antidiabetic activity with more efficacy than synthetic oral hypoglycemic agents. Therefore, plants, as folk remedies, are widely used to treat diabetes mellitus.

In modern allopathic medicine, however, their role is limited to the use of natural polymers like guar gum, gumacacia, gum arabic, etc. [5]. The therapeutic benefit of gums derived from natural origin resides in their ability to reduce the calorific value of consumed diet by reducing absorption of carbohydrates from the gastrointestinal tract [6]. Therefore, search for a novel antidiabetic drug from plants, plant parts and their aqueous or alcoholic extracts should be

advocated, since they have well been recognized as an important source of providing new drugs [7].

Recent Regulatory Developments:

Herbal drugs, as defined by regulatory measures constitute only those traditional medicines, which primarily use medicinal plant preparations for therapy. WHO has recently defined traditional medicine (including herbal drugs) as comprising therapeutic practices that have been in existence, almost for several hundreds of years, before the development and spread of modern medicine and others which are still in use. In recent years FDA and EMEA have took keen interest and also have reviewed the regulatory frameworks governing the development and use of botanical drug. This keen interest has provided a significant fillip to the natural products industry and has significantly lowered the entry barriers for botanicals and related products. These new guidelines more importantly also provide guarantees of market exclusivity for botanicals as well as the acceptance of synergistic combinations of plant derived bioactives products. Developing and developed countries such as India and China have clearly a natural advantage over the others.

Plants with Antidiabetic Activity

1) *Aegle marmelos* (Rutaceae)

Aegeline 2 extracted from the leaves of *A. marmelos* an alkaloidal-amide, is found to have antihyperglycemic activity. This is evidenced by lowering the blood glucose levels to about 12.9% and 16.9% when monitored at 5h and 24h respectively, in sucrose challenged streptozotocin induced diabetic rats (STZ-S) model at the dose of 100 mg/kg body weight. Aegeline 2 has also significantly decreased the plasma triglyceride (Tg) levels by 55% ($P < 0.001$), total cholesterol (TC) by 24% ($P < 0.05$), and free fatty acids (FFA) by 24%, accompanied with increase in HDL-C by 28% and HDL-C/TC ratio by 66% in dyslipidemic hamster model at the dose of 50 mg/kg body weight as evidenced in literatures [10].

2) *Agrimonia pilosa Ledeb.* **(**Rosaceae)

This plant has been used solely as a secret recipe to treat diabetes. The clinical reports show that diabetes of some patients had even disappeared [11]. The extract of the herb is experimentally proved to be effective to lower blood glucose in normal and alloxan-induced diabetic mice [12].

3). *Allii Cepa Bulbus* (Liliaceae)

Commonly called Onion, is a common vegetable, has strong anti-diabetic activity. Onion feeding has shown to improve metabolic status in diabetic conditions, probably because of hypoglycemic and hypocholesterolemic effect [13]. The plant extract has proved to medicate diabetic nephropathy by lowering blood cholesterol levels and decreasing lipid peroxidation [14]. The research results about active principles showed that allyl propyldisulfide and *S*-methyl cysteine sulfoxide have an anti-diabetic and anti-hyperlipidemic effect, the latter being comparable to glibenclamide and insulin [15].

4) *Allii Sativi Bulbus* (Liliaceae)

The bulbs of *Allium sativum* L., provide useful antidiabetic extract. Oral administration of the ethanol extract, juice and oil of garlic has remarkably lowered blood sugar in normal and alloxan-induced diabetic rats or rabbits, with efficiency as compared closely to drug tolbutamide

[16, 17]. The garlic extract can prevent diabetic cardiovascular complications. Allicin (diallyldisulfide-oxide) and *S*-allyl cysteine sulfoxide (the precursor of allicin and garlic oil) are the active constituents. The anti-hyperglycemic mechanism is by stimulation of in vitro insulin secretion from parital cells of pancreatic islet which increases serum insulin level and improves glucose tolerance and increase liver glycogen synthesis (18, 19).

5) *Andrographis paniculata*
These are the commonly used herbs by the diabetic patients in Pampanga, Philippines. The anti-diabetic potential of *Andrographis paniculata* in alloxan-induced diabetic rat has not been studied. Neither the effects of these herbs on estrous cyclicity of alloxan induced diabetic rats has been elucidated. *Andrographis paniculata* had higher body weight (BW) compared with diabetic positive control ($P < 0.01$) from day 22 to day 27 (D27) but exhibited lower effect than the non-diabetic control ($P < 0.05$). These rats had lower feed ($P < 0.05$) and liquid intakes ($P < 0.01$) compared with diabetic positive control during study period, but were similar with the non-diabetic control. The blood glucose levels in these groups were significantly reduced during study period, as compared with diabetic positive control ($P < 0.01$) [20].

6) Anisodus tanguticus *(Maxim.) Pascher* (Solanaceae)
It is used for the treatment of type 2 diabetes by Chinese doctors. It is quiet effective in improving complications while lowering blood glucose.

7) *Catharanthus roseus (L.) G. Don* (Apocynaceae)
The extract of *Catharanthus roseus* leaves have a remarkable effect in lowering blood glucose level. The medicinal preparations of this plant have been formulated and developed to treat diabetes in clinic instead of the use of insulin in Eastern Asia and Southern Africa. The active constituents include alkaloids vindoline, vindolinine and vleurosine [21].

8) *Ephedra sinica Stapf., and Ephedra distachya L.* **(**Ephedraceae)
The glycans and ephedrans A, B, C, D and E were isolated from *Ephedra distachya* herbs, which have been confirmed to have anti-hyperglycemic activity to alloxan-induced diabetic mice. The alkaloid extract of *Ephedra distachya* herbs and l-ephedrine have shown suppression on the hyperglycemia of diabetic induced mice. The mechanism is supposed to regenerate atrophied pancreatic islets, restore the secretion of insulin, and thus finally treating hyperglycemia [22].

9) *Euonyrnus alatus (Thunb.) Sieb.* (Celastraceae)
Various research results on the chemistry, pharmacology and clinical use indicated that this plant possesses an activity to lower blood glucose and lipid levels [23, 24]. It is a promising natural source to be developed for the treatment of diabetes mellitus.

10) *Fructus Coini Sieb* (Cornaceae)
The pulp of *Cornus officinalis* Sieb. et Zucc., is responsible for antidiabetic activity. Fructus Coini is a traditional tonic with actions to invigorate the liver and kidney, astringe and preserve essence. The extract of Corni Fructus has potent anti-diabetic activity towards streptozotocin-induced diabetic rats. Ursolic acid and oleanolic acid found in the extract were found to be responsible for the activity [25]. Based on decreasing postprandial plasma glucose and insulin level of noninsulin-dependent diabetic rats, further research was carried out. The results

indicated that the alcoholic extract of *Cornus officinalis* can increase GLUT4 mRNA and its protein expression in NIDDM rats by promoting proliferation of pancreatic islets and by increasing postprandial secretion of insulin and therefore accelerating the glucose transport.

11) *Fructus Hordei Germinatus* (Gramineae)
The germinant fruits of *Hordeum vulgare* L., family *Gramineae* have potent antidiabetic activity. It is used in anti-diabetic prescriptions also to strengthen the stomach and improve digestion. With hypoglycemic and hyperinsulinemic effects in NIDDM subjects, barley seems to mobilize insulin in NIDDM. This makes it a suitable cereal for diabetes mellitus [26].

12) *Gymnema sylvestre (Retz.) Schult* (Asclepiadaceae**)**
This is a promising plant to be developed into a new drug for diabetes therapy. There are many reports about the action and active constituents of *Gymnema sylvestre*. After gymnemic acids I, II, III, IV, V, VI, VII and gymnemosides a, b, c, d, e, f as well as protein-bound polysaccharide components and glycosaminoglycans were isolated and administrated to diabetic animals and humans [27, 28]. Gymnemic acids III, IV, V, VII and gymnemosides b were identified as the anti-hyperglycemic active constituents. A polyol, conduritol A, are also responsible for the cataract-suppressing effect by inhibiting lens aldose reductase [29]. GS4, an extract from the leaves of *Gymnema sylvestre*, has reported to be an excellent effect in controlling hyperglycemia of both types 1 and 2 diabetic patients [29, 30].

13) *Herba Epimedii* (Berberidaceae)
The branches and leaves of *Epimedium sagittatum* Maxim. or *Epimedium brevicornum* Maxim., family *Berberidaceae* show potent antidiabetic activity. It is prescribed for diabetic complications because of the actions to invigorate the kidney and strengthen *yang,* which is a masculine element.

14) *Momordica charantia* (Cucurbitaceae)
The plant is a member of Cucurbitaceae, commonly known as kugua, karela, bitter gourd or bitter melon. It is popular herbal resource [31] and is often used to treat diabetes [32]. The anti-diabetic potential of *Momordica charantia* is well established in streptozocin- or alloxan-induced diabetic rats, mice and rabbit [33-36], genetically diabetic mice and in humans with Type 2 diabetes [37]. *Momordica charantia* increases the renewal of parital cells in the pancreas or may permit the recovery of partially destroyed cells [38] and stimulates pancreatic insulin secretion [39]. These could likely explain the significant increase in the plasma insulin level when streptozocin-induced diabetic rats were treated with *Momordica charantia* [40].
Furthermore, *Momordica charantia* displays insulin-like properties [41], remarkably stimulating glycogen storage by the liver [42] and improving peripheral glucose uptake [43].

15) *Nymphaea stellata* (Nymphaeaceae)
The ethanolic extract of leaves of Nymphaea stellata given by oral route to diabetic rats at dose of 100 and 200 mg/kg/day as reported, for seven days reduced significantly by 31.6 and 42.6 % the plasma glucose level increased by intraperitoneal injection of 120 mg/day of alloxan [44]. It is well known that alloxan monohydrate induces diabetes mellitus in rats by selective necrotic action on the beta cells of pancreas [45] leading to insulin deficiency. Insulin deficiency leads to

various metabolic aberrations in animals, increased blood glucose level [46], decreased protein content [47], increased levels of cholesterol and triglyceride [48, 49].

16) *Nelumbo nucifera Gaertn* (Nymphaeaceae)
The root nodes of lotus are used in China to treat diabetes of patients in folks. Modern pharmacological and chemical research results supported the use. Oral administration of the ethanolic extract of *Nelumbo nucifera* rhizomes can markedly reduce the blood sugar level of normal, glucose-fed and streptozotocin-induced hyperglycemic rats [50]. The activity-guided isolation resulted in the isolation of tryptophan from the node of lotus rhizome. The pharmacological tests showed that tryptophan could lower the blood glucose level significantly in glucose-fed hyperglycemic mice and exhibited over 44% of activity compared with tolbutamide [51]. The crude protein isolated from lotus seeds, a tonic nourishment and medicine, also caused a significant decrease in the blood glucose level of diabetic albino rats after 2 weeks of treatment [52].

17) *Poria cocos* (Polyporaceae)
The sclerotium of *Poria cocos* (Schw.) shows potential antidiabetic activity. The triterpene dehydrotrametenolic acid have been isolated from dried sclerotia of *Poria cocos*, and demonstrated to have an anti-hyperglycemic effect in a mouse model of noninsulin-dependent diabetes mellitus as an insulin sensitizer [53]. This natural product is a promising candidate for a new type of insulin-sensitizing drug [54].

18) Prunella vulgaris L. (Labiatae)
Anti-hyperglycemic effect of the ethanol extract of *Prunella vulgaris* L has been already reported in mice. Before this report, a compound, *Jiangtangsu*, had been isolated from this plant and confirmed to have a remarkable effect to lower blood sugar levels in mice with diabetes mellitus induced by alloxan. The possible mechanism of *Jiangtangsu* is to repair cells of pancreatic islet to release insulin.

19) *Psidium guajava L.* (Myrtaceae)
The aqueous extract of *Psidium guajava* leaves has a good effect to lower blood glucose [55]. Flavonoid glycosides such as strictinin, isostrictinin and pedunculagin are the effective constituents, which have been used in clinical treatment of diabetes to improve the sensitivity of insulin. A glycoprotein was also identified as active component for anti-diabetes.

20) *Radix Aconiti and Radix Aconiti Praeparata* (Ranunculaceae)
Radix Aconiti is the axial roots of *Aconitum carmichaeli* Debeaux., family *Ranunculaceae*, prepared by soaking in water or in saturated lime water and then boiled until the white core disappears and no numbness occurs when tasted, then sliced and dried. Radix Aconiti Praeparata is the roots of *Aconitum carmichaeli*, prepared into salty aconiti, black aconiti, white aconiti and bland aconiti using different procedures.

The two medicines are often used to invigorate liver and kidney to activate *yang*, and to expel wind and dampness in the body. Aconitians A, B, C, D were isolated from *Aconitum carmichaeli* roots and showed remarkable effect to lower the blood glucose in normal and alloxan-diabetic mice [56 a,b,c,d].

21) *Radix Angelicae Sinensis* (Umbelliferae)
The roots of *Angelica sinensis* (Oliv.) are used for medical purpose. Radix Angelicae Sinensis is a traditional medicine well known as agent to enrich blood and promote blood circulation, which is often used in anti-diabetic prescriptions for therapy of diabetic complications.

22) *Radix Astragali seu Hedysari* (Leguminosae)
The roots of Astragalus membranaceus (Fisch.) Bunge var. mongholicus (Bunge) Hsiao and Astragalus membranaceus(Fisch.) Bunge are used. This medicine almost appears in every anti-diabetic Compound Recipe. Astragalus polysaccharides have an effect to two-dimensionally regulate the level of blood glucose, which can increase the blood glucose of hypoglycemic animals or humans to normal level, and significantly lower the level of blood glucose, triglyceride and myocardial calcium, improve the abnormalities of myocardial ultra structure and the metabolism of diabetic rats and mice [57, 58], and inhibit the onset of type 1 diabetes in non obese diabetic mice [59]. Astragalus membrane aceus was reported to have an effect for diabetic complications, such as protecting the myocardium in diabetic nephropathy by inhibiting lipid peroxidation [59], prolonging the incubation period of late diabetic neuropathy by decreasing the motion nerve conduction velocity as an aldose reductase inhibitor [60], and exerting a beneficial effect on experimental diabetic nephropathy by suppressing the renal hypertrophy and microalbuminuria [61].

23) *Radix Clematidis* (Chinensis)
The roots and rhizomes of this plant are of major importance. It is used in prescriptions for diabetic complications because of the actions to expel wind and dampness, and dredge the channel.

(24) *Radix Panacis Quinquefolii* (Araliaceae)
The roots and rhizomes have active ingredient. It is often compound recipes for therapy of diabetes and complications instead of ginseng. The polysaccharides quinquefolans and C were isolated from this plant, which displayed anti-hypoglycemic effect in normal and alloxan-hyperglycemic mice [62].

26) *Radix rehmanniae and Radix rehmanniae praeparata* Libosch (Scrophulariaceae)
Radix rehmanniae is the roots of *Rehmannia glutinosa* libosch., family *Scrophulariaceae*; Radix Rehmanniae Praeparata is also the roots of *Rehmannia glutinosa*, prepared by steaming it with wine and drying repeatedly. The pectin type polysaccharide, obtained from the rhizome of *Rehmannia glutinosa* Libosch. f. *hueichingensis* Hsiao, exhibited hypoglycemic activity in normal and streptozotocin induced diabetic mice. The mechanism of the hypoglycemic activity works by stimulating the secretion of insulin and reduce the glycogen content in the liver of normal mice [63, 64]. Some preparations of this plant like, Seishin-kanro-to [65] and Shokatsu-cha (Xiao-Ke-Ca) [66] have been developed and clinically used for the treatment of diabetics. Besides polysaccharides, iridoids [67 a, b], iridoid glycosides rehmannioside A, B, C, and D [68], phenethyl alcohol derivatives leucosceptoside A, purpureaside C and monocyclic sesquiterpenes and their glycosides were isolated from the roots of *Rehmannia glutinosa* as the active ingredients for treatment of diabetic complications.

28) *Radix Trichosanthis* (Cucurbitaceae)
The roots of this plant are useful. This medicine has long been used, as history used in prescriptions for diabetes therapy in China. Bioactivity-guided fractionation obtained five glycans termed as trichosans A, B, C, D and E, showing an anti-hypoglycemic effect to normal mice. The main glycan, trichosan A, also exhibited activity in alloxan-induced hyperglycemic mice.

30) *Rhizoma Atractylodis* (Compositae)
The rhizomes act as active ingredient in *Atractylodes lancea* (Thunb.) DC. or *Atractylodes chinensis* (DC.) Active constituents for anti-hyperglycemic activity are atractans A, B, C [68a, b, c, d, e]. Eudesmol, a sesquiterpenoid alcohol isolated from *Atractylodes lancea*, can potentiate succinylcholine-induced neuromuscular blockade, while the potentiating effect is greater in diabetic muscles than in normal ones [69].

31) *Rhizoma Pinelliae* (Areaceae)
The Rhizomes of plant *Pinellia ternata* (Thunb.) Breit., serve as medicative constituent. The so-called Flavone C-glycoside was isolated from the rhizomes of *Pinellia ternate* for anti-diabetes. The dose of 100mol/l of flavone C-glycoside could inhibit 64.7% of aldose reductase, proving that it is suitable to treat diabetic complications [71].

32). *Rhizoma Phragmitis* (Gramineae)
The fresh or dried rhizomes of *Phragmites communis* Trin., belonging to family *Gramineae* have effective drug like potential. It is used in diabetic prescriptions for diabetic complications because of the actions to clear away heat and promote the production of fluid.

33) *Semen Coicis* (Gramineae)
The dried and mature seeds of *Coix lacryma-jobi* L. var. *ma-yuen* (Roman.) Stapf., serve the medicinal use. Active constituents are the polysaccharides coixan A, B and C [73]. Coixans were isolated and puri-fied from the dried coix seeds, and showed an effect to decrease blood glucose in normal rats, while the serum insulin level increased. The anti-diabetic mechanism of coixans may be to prevent beta-cells of pancreatic islet from injury induced by alloxan [74, 75].

34) *Semen Cuscutae* (Convolvulaceae)
The seeds of *Cuscuta chinensis* serve the medicinal purpose. It is used in prescriptions for diabetic complications because of the actions to invigorate the kidney and supplement essence.

35) *Semen Litchi* (Sapindaceae)
The seeds of *Litchi chinensis* Sonn., are used for medicinal purpose. The aqueous extract of Semen Litchi (5 g/kg, i.g.) lowered the blood glucose levels in normal and alloxan-reduced diabetic mice, the hypoglycemic effect nearly equals to glibenclamide and phenformin [76]. Lychee nut has been developed into a medicinal tablet to treat diabetes, especially pregnancy diabetes in clinic in China [77].

36) *Tribuluks terrestris L.* (Zygophyllaceae)

The extract of *Tribuluks terrestris* significantly decreased blood glucose level in normal and alloxan-induced diabetic mice, increased serum insulin level in alloxan-induced diabetic mice, and improved glucose tolerance of normal and alloxan-induced diabetic mice [78].

37) *Trigonella foenum-graecum L.* (Leguminosae)
Trigonella foenum-graecum (Fenugreek) is traditionally used as food or medicine for diabetes care. The extracts, powder and gum of fenugreek seeds and leaves have been reported to have anti-diabetic and hypocholesterolemic properties in both model animals and humans [79, 80, 81]. Activity has been attributed largely to fenugreek's saponins fiber content [83], the amino acid 4-hydroxyisoleucine [82] and the major alkaloid trigonelline Anti-hyperglycemic effect was linked to delayed gastric emptying caused by the high fiber content, inhibiting of carbohydrate digestive enzymes [83] and stimulating of insulin secretion [82].

38). Triticum repens (Graminae)
Triticum repens P. Beauv. (TR) locally named as "N'jm L'bouri or outara" is a spontaneous plant belonging to the Graminae family. The hypoglycaemic effect of an aqueous extract of *Triticum repens* (TR) rhizomes was investigated in normal and streptozotocin (STZ) diabetic rats. After a single oral administration of the aqueous extract (20 mg/kg) a significant decrease on blood glucose levels in STZ diabetic rats ($p < 0.001$) was observed; the blood glucose levels were normalized after 2 weeks of daily oral administration of TR aqueous extract (20 mg/kg) ($p < 0.001$). Significant reduction on blood glucose levels were noticed in normal rats after both acute ($p < 0.001$) and chronic treatment ($p < 0.001$). In addition, no changes were observed in basal plasma insulin concentrations after treatment in either normal or STZ diabetic rats indicating that the underlying mechanism of this pharmacological activity seems to be independent of insulin secretion [84]. According to an ethnopharmacological survey in the Tafilalet region, TR is prescribed by traditional healers for diabetes control [85]. The mechanism involved in this pharmacological effect, therefore is extra-pancreatic. The TR aqueous extract may exert its hypoglycaemic action by other mechanisms such as stimulating of glucose uptake by peripheral tissues [86], inhibition of endogenous glucose production [87] or inhibition of renal glucose reabsorption [88].

List of Plants Having Antidiabetic Activity

Sr. NO	PLANTS	ACTIVE PRINCIPLE	FAMILY	PARTS USED
1.	Acacia Arabica	Flavonoid	Rubaceae	Seeds
2.	Aconitum carmichaeli (wolfsbase root)	Glycan A,B,C,D	ranunculacea	Roots
3.	Adansonnia digitata	Glycosides, tannins, alkaloids, lupeol, semigossypal	Bombacaceae	Stem Bark

4.	Adhtoda vasica (justica adhtoda)	Pegain-type alkaloid. Volatile oil, vasicine,vasicinone,vasicinol	Acanthaceae	Leaves
5.	Aegle marmelos (bael)	Aegelin, coumarins, alkaloids	Rutaceae	Flower, leaves
6.	Allium cepa (tukhm piaz)	Onion.essential oil principally allyl sulphide	Liliaceae	Bulbs (oil), Stems, tops
7.	Aloe barbadensis	Arboran A and arboarn B, Aloesin,	Liliaceae	Leaves
8.	A. sativum (garlic, lahsan,)	Allyl propyl disulfide Allicin or diallyl disulfide oxide Ether soluble	Liliaceae	Bulbs
9.	Aloe vera (Ab ghiakwar)	Pentosides-barbaloin,isobarbaloin, betabarbaloin, aloin	Liliaceae	Leaves
10.	Althaea officinalis	Mucilage	Malvaceae	Leaves, whole plants
11.	Anacardium occidentale	Unsaturated Anacardic acids	Anacardiaceae	Bark
12.	Amaranthus spinosus	Alkaloids, fixed oil beta-sitosterol	Amaranthaceae	Stem
13.	Andrographis paniculata	Flavones, glucosides , lactones	Acanthaceae	Root
14.	Anemarrhena asphodeloids	Anemarans A,B,C,D	Annoaceace	Rhizomes
15.	Atractylode japonica	Atractans A,B & C	Compositae	Rhizomes
16.	Azadirachta indica	Neutral substance, Nimbidin	Meliaceae	Seed oil, leaves
17.	Bauhinia rectusa (kandla,samla)		leguminoseae	Seeds
18.	Barleria lupulina	Alkaloids, tannins, diterpinoids, cyanogenetic	Acanthaceae	Aerial Part

		compound, saponin		
19.	Berberis aristata (darhald)	Berberine, palmitine, jatrorrhizine, columbamine	Berberidaceae	Stem Bark
20.	Bhighia sapida	Hypogylcin A & C	sapindaceae	Unripe fruits & seeds
21.	Bougainvillea spectabilis	Alcohol (pinitol)	Rubiaceae	Seeds
22.	Caesalpinia bonducella	Tannins, alkaloids	Leguminosae	Seed
23.	Caeseria esculanta	Tannins	Caesalpinoideace	Roots
24.	Cannabis indica	Cannabinoids, cannabinol	Cannabinaceae	Whole plant, Leaves
25.	Capparis sepiaria (Bikh kabar)	Alkaloids- stachydrine, glucocapparin flavinoids, sterols, terpenes	Capparaceae	Leaves
26.	Cassia auriculata	Sennoside mixture	Leguminoseae	Roots
27.	C. fistula	Sennoside mixture	Leguminoseae	Seeds
28.	Catharanthus roseus	Alkaloid- catharanthine, leurosine, lochnerine, vindoline,etc.	Apocynaceae	Flower, Leaves, Stem & Root
29.	Ceiba pentandra	Saponins, tannins	Malvaceae	Roots Leaves
30.	Centratherum anthelminticum	Alkaloids	Asteraceae	Seed
31.	Clerodendron phlomoides	Valeporiates	Verbenaceae	Whole plant
32.	Cryptostegia grandiflora	Triterpenes, alkaloids	Asclepiadaceae	Aerial parts

33.	Cuminum nigrum (zira siyah)	Volatile oil	umbelliferae	Flowers, Seeds
34.	Cyamposis tetragonolobus	Guar gum	Leguminasae	Fruits, seeds
35.	Cynodon dactylon	Mucilage, arabinose, xylose, uronic acid derivatives	Roaceae	Whole Plant
36.	Discorea batalas	Mucilage, Saponins, alkaloids	Discoreaceae	Tubers
37.	D.dumentorum (kunth)	Mucilage, Saponins	Discoreaceae	Tubers
38.	D. japonica	Discoran A,B,C,D,E	Discoreaceae	
39.	Ephedra distachya	Ephedarns A,B,C,D,E	Ephedereaceae	Aerial stems
40.	Eucalyptus globules	Calytoside	Myrtaceae	Leaves
41.	Euphorbia prostrate	Triterpenoids, euphol, euphorbol	Euphorbiaceae	Whole plant
42.	Ficus bengelensis (Anjir jangli, katumani)	Bengalinoside, Phytosterolin, flavonoid, glycoside, glycosidal fraction	Moraceae	Root bark, bark, milky stap
43.	F. glomerata	Sitosteryl glucoside	Moraceae	Bark
44.	Fumaria parviflora	Sanguinarine, alkaloids	Papaveracea	Whole plant
45.	Galega officinalis	Alkaloids	Leguminoseae	Leaves
46.	Glycine max (Soya oil)	Fatty acids- linoleic, oleic, palmitic, linolenic, stearic acid	Leguminoseae	Seeds
47.	Gymnema sylvestre	Glycosamine glycan and protein bound polysaccharide		Leaves, whole plants

48.	Hamada salicornica	Hamamelitannin, hamamelose	Hamamelidaceae	Whole plant
49.	Humulus lupulus	Humulon & lupulon	Cannabinaceae	Strobiles
50.	Inula racemoma	volatile oil	Tubuliflorae	Roots
51.	Lagerstroemic speciosa (Jarul)	Alkaloids	Lythraceae	Bark, Root, Seed, Leave & ripe fruits
52.	Lepidium ruderale	Lepidine	Crucifarae	Aerial part
53.	Launaea nudicaulis	Glycosides		Roots
54.	Leucaena leucocephala	Mimosine	Leguminoseae	Seed
55.	Lithospermum erythrorhizon	Lithosperman A,B & C	Boraginaceae	Seeds
56.	Lupus albus	Lupelol	Papilionaceae	Seeds
57.	Lythrum salicaria	Alkaloids, tannins	Lythraceae	Stem flower
58.	Momordica charantia	Charantin, polypeptide, plant insulin	Meliaceae	Fruits, seeds, leaves
59.	Momordica cochinchinemis	Glycosides	Meliaceae	Fruits
60.	Morus alba	Moran A	Moraceae	Leaves, root bark
61.	Mucuna pruriens	l-DOPA [1-6%]	Leguminoseae	Seeds
62.	Murraya koienigii	Bis-indole alkaloid	Rutaceae	Leaves
63.	Musa paradisiacal	Fructosans, phenolic acid, anthocyanin, terpenoids, sterols	Musaceae	Flowers
64.	Nymphaea nouchali	Alkaloids, starch	Nymphaeceae	Roots

65.	Olea europaea	Sugar alcohol, saponins, tannins	Oleaceae	Leaves
66.	Opuntia sterptacanthas	Isoquinoline alkaloid, cyanogenetic alkaloids	Cactaceae	Sap
67.	Oryza saliva	Glycan	Gramineae	Roots
68.	Panax ginseng	Panaxans A,B,C,D & E	Araliaceae	Roots
69.	P.quinquefolium	Glycan	Araliaceae	Roots
70.	Phyllanthus fraternus	Flavonoid	Euphorbiaceae	Leaves
71.	Psidium guajava (Amrood/guvava)	Triterpenoid, sponins	Myrtaceae	Juice
72.	Pongamia pinnata (Karanja)	Oil	Leguminoseae	Bark
73.	Poterium ancisroides	Triterpinoids, (Tormantic acid)	Rosaceae	Leaves
74.	Prunus persica	Amygdalin	Rosaceae	Leaves
75.	Pterocarpus marsupium	Pterostilbine, flavoniod		Heart-wood, wood
76.	Rauwolfia serpentine	Total alkaloid (Ajmaline)	Apocynaceae	Leaves, roots
77.	Tecoma stans	Techomine, tecostamine		Leaves

RESULT AND DISCUSSION

Diabetes is a metabolic disorder which can be considered as a major cause of high economic loss which can in turn impede the development of nations. Moreover, uncontrolled diabetes leads to many chronic complications such as blindness, heart failure, and renal failure. In order to prevent this alarming health problem, the development of research into new hypoglycemic and potentially antidiabetic agents is of great interest. In the present review, interest is focused on the profile of herbal plants which have a hypoglycemic effect. The families of plants with the most potent hypoglycemic effects include: Leguminoseae, Lamiaceae, Liliaceae, Cucurbitaceae,

Asteraceae, Moraceae, Rosaceae, Euphorbiaceae and Araliaceae. The most commonly studied species are: Opuntia streptacantha Lem, Trigonella foenum graecum L, Momordica charantia L, Ficus bengalensis L, Polygala senega L. and Gymnema sylvestre R. The methods used in the experiments are diverse. Transient Hyperglycemia can be produced by an oral glucose tolerance test (OGTT). However, the diabetic model that was most commonly used was the streptozotocin and alloxan-induced diabetic mouse or rat to obtain type I diabetic models. Some authors have used hereditary diabetic mice e.g. KK Ay mice as a model of type II diabetes with hyperinsulinemia.

The majority of the experiments confirmed the benefits of medicinal plants with hypoglycemic effects in the management of diabetes mellitus. Numerous mechanisms of actions have been proposed for these plant extracts. Some hypotheses relate to their effects on the activity of pancreatic ß cells (synthesis, release, cell regeneration/revitalization) or the increase in the protective/inhibitory effect against insulinase and the increase of the insulin sensitivity or the insulin-like activity of the plant extracts. Other mechanisms may involve improved glucose homeostasis (increase of peripheral utilization of glucose, increase of synthesis of hepatic glycogen and/or decrease of glycogenolysis acting on enzymes, inhibition of intestinal glucose absorption, reduction of glycogenic index of carbohydrates, reduction of the effect of glutathione. All of these actions may be responsible for the reduction and or abolition of diabetic complications.

CONCLUSION

The present review has presented comprehensive details of anti-diabetic plants used in the treatment of diabetes mellitus. It shows that the plants highlighted above have potent hypoglycemic effects. Many new bioactive drugs isolated from plants having hypoglycemic effects showed antidiabetic activity equivalent to these plant,plant parts or plant extract and sometimes even more potent than known synthetic oral hypoglycemic agents. However, many other active agents obtained from plants have not been well characterized. More investigations must be carried out to evaluate the mechanism of action of medicinal plants with antidiabetic effect. The toxic effect of these plants should also be elucidated.

Future Trends

Current knowledge on altered body metabolism during diabetes mellitus can be utilized for development of new trends in herbal antidiabetic research. Polypeptides to proteins, all have efficient antidiabetic effect. Secretions from plants that are co-secreted with insulin have demonstrated to inhibit insulin release and muscle glycogenesis. Amylin is thought to play a major role in the disturbed metabolism associated with diabetes mellitus. The search for drugs that may antagonize amylin, and thus improve metabolic control in diabetic patients, is considered as a frontier in the search for novel antidiabetic agents. Medicinal plants that have been shown to improve the diabetic state without apparent enhancement of insulin secretion may be tested for amylin antagonism.

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