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A review on ethnic florae with antihyperglycemic efficacy

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ABSTRACT

Diabetes mellitus is a stipulation predominantly delineated by the level of hyperglycemia giving ascends to risk of micro vascular damage such as retinopathy, nephropathy and neuropathy. It is allied with abridged life expectation, considerable morbidity due to specific diabetes related micro vascular complications, augmented risk of macro vascular complications include ischemic heart disease, stroke and peripheral vascular disease. Indians are genetically more vulnerable to diabetes. It is envisaged that by 2030, India, China and the United States will have largest number of people with diabetes. The use of medicinal plants has been a central module of health care in many cultures for centuries. Plants can endow with biologically active molecules and lead structures for the progress of modified derivatives with enhanced and reduced toxicity. The participation of medicinal plants in the advancement of conventional medicines should never be underrated. In view of the restorative effectiveness of the aboriginal medicinal plants, there are an enormous compilation of plants which were acknowledged as antidiabetic. The plants (33 plants belonging to 21 families) presented in this review illustrate the efficiency of medicinal plants in management of Diabetes mellitus. The consequences of these plants may setback the development of diabetic complication and correct the metabolic abnormalities. Persistent research is obligatory to explicate the pharmacological behavior of herbal medicines.

Keywords: Diabetes mellitus, hyperglycemia, antidiabetic, herbal medicines

1. Introduction

Diabetes mellitus is a disease typified by chronic hyperglycemia, due to supreme or comparative insufficiency or reduce efficacy of circulating insulin. Chronic hyperglycemia during diabetes generate glycation of body proteins pursued by secondary complications such as affecting eyes, kidneys, nerves and arteries [1]. The escalating occurrence of diabetes mellitus in adults comprises a universal civic wellbeing saddle. The World Health Organization estimates that approximately 150 million people have DM worldwide, and that this number might well double by the year 2025. Much of this raise will happen in developing countries and will be due to population growth, ageing, unhealthy diets and obesity and deskbound lifestyles [2]. India is slate to be the diabetic capital of the world, with 50.8 million diabetics.

Several oral hypoglycemic agents and insulin therapy are the chief forms of treatment for diabetes. Enduring use of insulin and other oral hypoglycemic agent will generate redundant side effects, ensuing uncontrolled increase in blood sugar as well as obstacle with heart diseases also diabetes are highly inclined to dissimilar types of microorganism and it will afflict immune system of body. In order to surmount these tribulations it is indispensable to explore an alternative medication. The use of such alternative medications has become ever more admired in the urbanized world. Plants have played a significant role in supporting human fitness and civilizing the excellence of human life [3]. Plants are always an exceptionally good source of drugs, indeed many of the presently accessible drugs were directly extracted from plants and others are made from the transformation of chemicals found within them. The WHO has listed 21,000 plants, which are used for curative purpose around the world. Among these, 2500 species are in India [4]. Many plant species have been used to treat life- menacing ailment including diabetes mellitus. The temperament has endowed with plentiful plant prosperity for all living being, which own therapeutic merits. Numerous explorations reported the usefulness of plants for the curative of diverse ailment.

In such a way the present review intended to make available an insight of conservatively available plant vegetation which has depicted likely for management of diabetes.

Aegle marmelos (Family: *Rutaceae*)
Aegle marmelos (vilvam) commonly known as Bael is a medium sized tree found wild, especially in dry forests and is also cultivated throughout India. It is famous by name holy fruit tree. The studies have reported that aqueous extract of the leaves (1 gm/kg for 30 days) significantly controlled blood glucose, urea, body weight, liver glycogen and serum cholesterol of alloxanized (60 mg/kg IV) rats as compared to controls and this effect was similar to insulin treatment. Acute and subacute toxicity studies have been studied by Veerappan *et al*., [5]. The active principle of *A. marmelos* extract had similar hypoglycemic effect to that of insulin [6].

Abroma augusta (Family: *Malvaceae*)
Abroma augusta (sivapputtuti) universally known as Ulatkambal found in tropical Asia, South and eastern Africa, and Australia. Leaves are useful in treating uterine disorders, diabetes, rheumatic pain of joints, and headache with sinusitis [7]. Different parts like roots, leaves and barks of the plant of *A. augusta* are used in the treatment of diabetes. *A. augusta* have hypoglycemic effect on alloxan induced diabetic rats [8]. Abromine (identified as betaine) is the active constituent of the *A. augusta* is responsible for antihyperglycemic activity. The leaves contain octacosanol, taraxerol, β-sitosterol acetate, Lupeol, an aliphatic alcohol and mixture of long chain fatty diols [9]. The methanolic extracts are effective in the diabetic rats at a dose of 300 mg/kg body weight when administered for seven days. The ethanolic extract of the roots of *Abroma augusta* also exhibit the hypoglycemic effect in alloxan (100 mg/kg) induced diabetic rats [10].

Aloe vera (Family: Aloaceae)
Aloe vera (sotrukatrazhai) is a hardy, perennial, tropical, drought resistant, succulent plant also known as "Lily of the desert". It has been used for a variety of medicinal purposes. The leaf pulp extract showed hypoglycemic activity on IDDM and NIDDM rats, the effectiveness being enhanced for type II diabetes in comparison with glibenclamide [11]. The extract has shown significant hypoglycemic activity (200–300 mg/kg p.o) in streptozocin induced diabetic rats and maintained glucose homeostasis by controlling the carbohydrate metabolizing enzymes [12]. Hypoglycemic effect by bitter principle of *Aloe vera* in the rats is mediated through stimulation of synthesis or release of insulin from the beta-cells of Langerhans [13].

Andrographis paniculata **(**Family: *Acanthaceae*)
Andrographis paniculata (nilavembu) commonly known as "King of Bitters"or Kalmegh is a perennial herb native to India and Sri Lanka. Andrographolide, a diterpenoid lactone is the active constituent generally extracted from leaves and aerial parts of *A. paniculata*. Oral administration of *Andrographis* significantly increases the activity of SOD and Catalase. Also decreases blood glucose levels due to its antioxidant properties [14]. The blood glucose lowering activity was determined after oral administration at doses of 50, 100 and 150 mg/kg body weight in acute study. Also the extract is useful in preventing the incidence of long-term complication, diabetic nephropathy [15].

Azadirachta Indica (Family: *Meliaceae*)
Azadirachta indica (vembu) is an indigenous plant widely available in India and Burma. It is commonly known as neem. The neem leaf extract was found to reduce the serum concentrations of glucose, urea, total cholesterol and creatinine. [16]. Nimbidin, a major crude bitter principle extracted from the oil of seed kernels of *A. indica* demonstrated several biological activities. Biologically most active compound is azadirachtin. Azadirachtin is actually a mixture of seven isomeric compounds labeled as azadirachtin A-G and azadirachtin E is more effective Apart from having anti-diabetic activity, this plant also has anti-bacterial, antimalarial, antifertility, hepatoprotective and antioxidant effects [17].

Cajanus cajan (Family: *Fabaceae*)
Cajanus cajan (thuvarai) also known as red gram and is one of the major grain legume (pulses) crops grown in the semiarid tropics. Single doses of unroasted seeds (60% and 80%) on administration to normal as well as alloxanized mice shows significant reduction in the serum glucose levels after 1-2 hrs. and a significant rise at 3 hrs. The extract also significantly suppressed the peak postprandial rise in blood glucose of normal rats by 101.8 and 57.40% respectively [18]. The methanolic leaf extract of the plant was evaluated for hypoglycemic activity in alloxan-induced diabetic and normal rats.

Cassia auriculata L. (Family: *Leguminosae*)
Cassia auriculata (avaram) occurs in the dry regions of India and Sri Lanka. Leaves and flowers are used for treatment of diabetes and for religious function in sacred grove of Pallapatti village (reserved forest), Madurai District, Tamil Nadu [19]. Oral administration of 0.45 g/kg body weight of the aqueous extract of the flower for 30 days resulted in a significant reduction in blood glucose and an increase in plasma insulin [20]. Histopathological examination of pancreatic sections reveals increased number of islets and β-cells in *C. auriculata* treated mildly diabetic mellitus (MD) as well as severely diabetic (SD) rats [21].

Catharanthus roseus (Family: Apocynaceae)
Catharanthus roseus (nithyakalyani) is extensively cultivated in northern India. The plant contains about 130 alkaloids of the indole group out of which 25 are dimeric in nature. vinblastine and vincristine are the two dimeric alkaloids mainly present in the aerial parts. The reports indicate blood glucose lowering activity in the alcoholic extract of the leaves of *C. roseus* The ethanolic leaf extract of (500 mg/kg p.o., for 7 and 15 days) *C. roseus* was able to increase the metabolization of glucose in streptozocin induced diabetic rats [22]. Oral administration at dose-dependent of 0.5, 0.75 and 1.0 ml/kg body weight reduced the blood glucose of both normal and diabetic rabbits comparable with that of the standard drug, glibenclamide [21].

Centella asiatica *(*Family: *Apiaceae)*
Centella asiatica (vallarai) a clonal, perennial herbaceous creeper found throughout India growing in moist places up to an altitude of 1800 m. *C. asiatica*, commonly known as "Gotu kola, Asiatic pennywort, Indian pennywort, Indian water navelwort, wild violet, and tiger herb" in English. It is a popular herb that is either consumed fresh, or processed into tea or juice. *Centella asiatica* is a constituent part of the ayurvedic diet for diabetics. The major chemical class found in the plant are triterpene saponosides, asiatic

acid, madecassic acid (6-hydroxy-asiatic acid), asiaticoside, madecassoside, and madasiatic acid (Figure 2), betulinic acid, thankunic acid, and isothankunic acid [23, 24]. The whole plant is used for medicinal purposes. The ethanolic leaf extract of *Centella asiatica* at the test doses used and the reference drug glibenclamide (2 mg/kg) exhibited a time dependent significant ($p<0.05$) reduction of the blood glucose levels of the alloxan-induced diabetic rats with different levels of percentage reduction at the 3rd hour when compared to the negative control rats [25].

Citrullus colocynthis (Family: *Cucurbitaceae*)
Citrullus colocynthis (kommatti) commonly known as 'bitter apple'. *C. colocynthis* found throughout India and Ceylon, both wild and cultivated. It is one of the plants with a long history of anti-diabetic use in traditional medicine [26]. The fruit of the plant includes saponin glycosides such as cucurbitacin E and G, alkaloids, and caffeic acid derivatives like chlorogenic acid [27, 28]. It was reported that *C. colocynthis* fruit treatment had a beneficial effect on improving the glycemic profile without severe adverse effects in type II diabetic patients [29]. Administration of the ethanol extract of the dried seedless pulp of *Citrullus colocynthis* at 300 mg/kg, p.o had insulinotropic actions in alloxan-induced diabetic rats [30].

Cichorium intybus (Family: Asteraceae)
Cichorium intybus (kasni) commonly known as Chicory, has been used in traditional medicine to treat a variety of diseases including high blood sugar [31-33]. It is a common roadside woody herb, flowering from July to October with bright blue flowers, rarely white or pink. Roots contains up to 20% inulin, it is a polysaccharide which is a storage carbohydrate. Chicoric acid from chicory and basil leaves was found to enhance insulin release by pancreatic β cells and glucose uptake by muscle cells in culture [34]. The tuberous root of *C. intybus* contains number of medicinally important compounds such as inulin, bitter sesquiterpene lactones, coumarins, flavonoids and vitamins [35].

Coccinia indica (Family: Cucurbitaceae)
Coccinia indica (kovai) widely used in traditional treatment of diabetes mellitus in sub-Saharan Africa and Southeast Asia. The common name of the plant is Ivy-Gourd. It found to contain the chemical constituents such as β-amyrin and its acetate, lupeol and cucurbitacin B. The composite extract of *coccinia indica* in STZ-treated rats, reversed the levels of fasting blood glucose, serum insulin and glycosylated hemoglobin (GHb) towards the control level it also has shown an insulin secretagogue effect [36]. Oral administration (2 gm/kg/day) of pectin isolated from *C. indica* fruit showed a significant hypoglycemic action in normal rats due to stimulation of glycogen synthetase activity and reduction of phosphorylase activity.

Dioscorea bulbifera (Family: *Dioscoreaceae*)
Dioscorea bulbifera (kattucirakavalli) commonly known as air potato, air yam and bitter yam widely distributed in Asia and Africa in wild state [37]. *D. bulbifera* tubers contain furanoid norditerpenes, norditerpene glycosides, diosbulbinoside D & F and diosbulbin B and D [38]. Yam leaves and tubers are used to treat a variety of ailments. *D. bulbifera* has been highly recommended for treating diabetes disorder [39]. Oral administration of 500 and 1000 mg/kg p.o. produced a highly significant antihyperglycemic effect ($P<0.001$) [40].

Elaeodendron glaucum (Family: *Celastraceae*)
Elaeodendron glaucum (karuvali/kanniramaram) is a medium sized tree which is distributed throughout India, Australia America, and South Africa & Tropical Asia. Chemical investigations suggested that the plant leaves consisting of numerous biologically active compounds such as elaeodendrosides B, C, F, G, K and L, elaeodendrosides A, D, E, H, I, J and elaeodendrogenin. The bark containing n-octacosanol, friedelin, β-sitosterol, betulonic acid, 23-hydroxy betulin and β- sitosterol-β-D-glucoside, elaeodendrosides T and U, nor-triterpenes [41]. Methanolic extract of this plant shows antidiabetic activity in normal and alloxan induced Inbreed adult male Charles-Foster (CF) albino rats [42].

Eugenia jambolana (Family: *Myrtaceae*)
Eugenia jambolana (naaval pazham) commonly known as Jamun or black plum, is being widely used to treat diabetes by the traditional practitioners over many centuries. In India decoction of kernels of *Eugenia jambolana* is used as household remedy for diabetes. The whole plant of *Eugenia jambolana* is reported to show antioxidative defence due to numerous phytochemical constituents present in it. The berries contain only one seed. The oral administration of the extract resulted in the enhancement of insulinemia in normoglycemic and diabetic rats. Preliminary studies on seeds and decoction of dry leaves of *E. jambolana* have shown anti-hyperglycemic activity [43, 44, 45]. *Eugenia jambolana* fruit juice is diuretic and has been reported to provide a soothing effect on human digestive system [46]. Ethanolic extract of dried seed of *E. jambolana* has been reported to have antidiabetic effects on streptozotocin induced diabetes. Apart from hypoglycemic effect, seed has been reported to have anti-inflammatory, neuropsychopharmacological, antibacterial, anti-HIV and antidiarrheal effects [47].

Gymnema sylvestre (Family: Asclepiadaceae)
Gymnema sylvestre (sirukurinjan) came to be known as ″destroyer of sugar″ or gurmar is a woody, climbing plant of tropical forests of central and southern India and in parts of Africa is one of the important medicinal plants of India widely used in the treatment of diabetes mellitus [48]. The leaves of *Gymnema sylvestre* has been used in India for the treatment of diabetes for over 2,000 years. It is currently being used in all natural ingredients for diabetes with other plant-based medication. The main constituents are gymnemic acid, gurmarin, a polypeptide of 35 amino acids and saponins [49, 50]. The antidiabetic ability of gymnemic acids is due to retardation of glucose absorption in the blood. Oral administration of *G. sylvestre* to rats has been reported to result in increased utilization of glucose and/or by decreasing mobilization of fat [51]. *G. sylvestre* enhances the production of endogenous insulin [52].

Hemidesmus indicus (Family: Asclepiadaceae)
Hemidesmus indicus (nanaari) is a twining shrub, used in folk medicine as well as in ayurvedic and unani preparations. The root gives cooling effect and used in fever, diabetes, cough, cures blood disorders, and has got diuretic effect [53]. The phytoconstituents, β-sitosterol and tannins have been reported in *H. indicus* [54]. Oral administration of *Hemidesmus indicus* roots extract protects the pancreas from oxidative damage which may be due to the attenuation of hyperglycemia and its mediated oxidative stress. Four weeks treatment of diabetic rats with *Hemidesmus indicus* Linn root (40 mg/g body weight/day) showed significant hypoglycemic effect [55].

Hibiscus rosa-sinensis (Family: Malvaceae)
Hibiscus rosa-sinensis (sembaruthi) is widely grown as an ornamental plant throughout the tropics and subtropics native to East Asia. It is commonly known as China rose. Leaves and stems contain β-sitosterol, stigmasterol, taraxeryl acetate and three cyclopropane compounds and their derivatives. Flowers contain cyanidin diglucoside, flavonoids and vitamins, thiamine, riboflavin, niacin and ascorbic acid [56]. *Hibiscus rosa-sinensis* extract possess antioxidant, hypoglycemic and hypolipidemic activity against streptozotocin induced diabetic rats [57].

Lantana camara (Family: Verbanaceae)
Lantana camara (unnichedi) also known as wild sage, Surinam tea plant distributed throughout India. *L. camara* is an important medicinal plant with several medicinal uses in traditional medication system. *L. camara* has therapeutic potential due to the presence of natural agents. Different parts of *L. camara* are reported to contain essential oils, phenolic compounds, flavonoids, carbohydrates, proteins, alkaloids, glycosides, iridoid glycosides, phenylethanoid, oligosaccharides, quinine, saponins, steroids, triterpenes, sesquiterpenoides and tannin as major phytochemical groups [58]. Oral administration of a methanol extract of *Lantana camara* leaves in alloxan induced diabetic rats showed significant dose dependent reduction of blood glucose concentration [59].

Luffa acutangula (Family: Cucurbitaceae)
Luffa acutangula (Peerkankai) commonly known as ridge gourd, sponge gourd or angled luffa [60]. It is a widely growing vegetative climber. A bitter principle, luffeine is present in fruits and edible portion of fruit contain 94.2% water, 1.7% fiber and leaves contain different types of vitamins and minerals [61] whereas glycerides of palmitic, stearic, and myristic acids are found in seeds, as well as bitter principle Cucurbitacin B, an acid sapogenin, oleanolic acid were isolated from the seeds of *L. acutangula.* Chloroform and alcoholic extracts of fruits of Luffa acutangula has reported more significant ($p<0.01$) reduction in blood glucose level in alloxan induced diabetic Wistar rats compared to control and glibenclamide (10 mg/kg b.w.) [62]. *L. acutangula* is reported to have potent α-glucosidase inhibitory effect. α-glucosidase is an enzyme that is responsible for breakdown of carbohydrates in intestine [63].

Mimosa pudica (Family: Fabaceae)
Mimosa pudica (thotta Sinungi) also called sensitive plant, sleepy plant and the touch-me-not is a creeping annual or perennial herb. All the five parts of the plant (PANCHANG) roots, stem, leaves, flowers and fruits are used as medicines in the traditional healthcare systems. *M. pudica* contains mimosine which is a toxic alkaloid. Adrenalin like substance has been identified in the extract of its leaves. Ascorbic acid, crocetin, D-glucuronic acid, linoleic acid, linolenic acid, palmitic and stearic acids, mimosine, D-xylose and b-sitosterols were found in phytochemical analysis of *M. pudica* root [64]. Seeds were reported to yield sitosterol. Ethanolic extract of *Mimosa pudica* leaves given by oral route to mice at a dose of 250 mg/kg showed a significant hyperglycemic effect [65].

Murraya koenigii (Family: Rutaceae)
Murraya koenigii (kariveppilai) commonly known as curry leaf tree is grown for its aromatic leaves and is widely used condiment and spice in India. *M. koenigii* is used as a stimulant, anti-dysenteric and for the management of diabetes mellitus [66]. Mahanimbine a chemical constituent of *M. koenigii* was isolated from the petroleum ether extract of dried plant. Mahanimbine showed appreciable alpha amylase inhibitory effect as compared with acarbose [67]. *M. koenigii* suppresses blood glucose level and was found to have beneficial effect on carbohydrate metabolism [68]. A diet of curry leaves treated for 5 weeks in STZ induced diabetic rats has shown significant anti- hyperglycemic effect [69]. The fruits are known to have very high nutritional values with many medicinal properties. In normal and alloxan diabetes the aqueous extract of the leaves of *M. koenigii* produced hypoglycemic effect. The anti-diabetic activity was performed on the streptozotocin induced wistar rats by using pure compound at a dose of 50 mg/kg and 100 mg/kg.

Nyctanthes arbor-tristis (Family: *Oleaceae*)
Nyctanthes arbor-tristis (pavazhamalli) known as Harsingar or Night Jasmine is a perennial medicinal plant native to southern Asia. The leaves of *N. arbor-tristis* found to contain an alkaloid nyctanthine. A minor iridoid glucoside, arborside D and its acetyl derivatives were identified from the plant [70].Traditionally Administration of *N. arbor-tristis* leaf extract restored the blood sugar level in alloxan induced diabetic rabbits near to the normal level. In glucose tolerance test, the *N. arbor-tristis* leaf extracts at the doses of 250 mg/kg and 500 mg/kg markedly reduced the external glucose load [71].

Ocimum sanctum **(**Family: Labiatae)
Ocimum sanctum (tulsi) commonly known as holy basil is an herb found throughout India, up to an altitude of 1.800 m. in the Himalayas and it's cultivated in temples and gardens. Antidiabetic properties of tulsi were appreciated in Ayurveda [72]. Tulsi leaves oil contains eugenol, ursolic acid, carvacrol, linalool, limatrol, and caryophyllene along with eugenol. Seeds oil is known to have fatty acids and sitosterol while seed mucilage contains some sugars. The aqueous extract of leaves shows significant reduction in blood sugar level in both normal and alloxan induced diabetic rats [73]. The extract significantly decreased elevated level of serum glucose and also reversed the cholesterol, triglyceride, and LDL values [74].

Olea europaea (Family: *Oleaceae*)
Olea europaea (saidun) commonly known as Olive is a small evergreen tree, from 12 to 20 feet high, with hoary, rigid branches, and a grayish bark. Olive is a rich source of valuable nutrients and bioactives of medicinal and therapeutic interest. Olive fruit contains phenolic acids, phenolic alcohols, flavonoids and secoiridoids) and lipophilic (cresols) phenolic compounds. Olive is used in traditional medicine to treat hyperglycemia and diabetes [75]. Other important compounds present in olive fruit are pectin, organic acids, and pigments. The most abundant polyphenol in olive leaves is oleuropein, which accounts for approximately 20% of phenolic compounds in the olive leaf, which has been shown to suppress improved insulin secretion in H_2O_2-exposed cells [76]. The oral administration of olive leaf extract significantly decreased serum glucose while simultaneously increasing serum insulin in streptozotocin-induced diabetic rats, but not controls, an effect described by the investigators as more effective than the antidiabetic effect of glibenclamide [77].

Paspalum scrobiculatum (Family: *Poaceae*)
Paspalum scrobiculatum (varaku/karuvaraku), commonly known as "Kodo millet" is an important millet crop cultivated almost throughout India. Kodo millets are rich sources of phenolics, tannin

and phytates, which can also be active as antioxidants and show beneficial role in protecting against oxidative stress and maintaining blood glucose response. The grains of *P. scrobiculatum* are used in the management of diabetes mellitus [78]. Whole grain flour of kodo millet showed a greater reduction in blood glucose (42%) and cholesterol than those fed the finger millet [79]. Aqueous and ethanolic extracts of *P. scrobiculatum* (Poaceae) in diabetic rats at 250 and 500 mg/kg, *p.o.* for 15 days treatment, significantly reduced the blood glucose level and lipid parameters [80].

Prunus amygdalus (Family: *Rosaceae*)
Prunus amygdalus (kaippu vaadhumai) commonly known as bitter almond is a deciduous tree native to the Middle East and South Asia. Almonds are useful in treating gastro-enteritis, kidney pains, diabetes, head lice, facial neuralgia and gastric ulcers. *P. amygdalus* contain proteins and certain minerals such as calcium and magnesium. Seeds of almonds are rich in polyphenolic compounds especially flavonoids and phenolic acids [81]. The edible portion of the *P. amygdalus* is its nuts, which are commonly known as almonds or badam, and it is a popular, nutritious food [82]. There are two main types of almond as bitter and sweet, which differ from each other in the presence of amygdalin [83]. The flower and seed extracts, at a dose of 500 mg/kg b. w., showed significant reduction ($P<0.001$) in the blood glucose levels of the diabetic mice on the 15th day of the study [84].

Pterocarpus Marsupium **(**Family: Fabaceae)
Pterocarpus marsupium (vengai) commonly known as Indian Kino Tree is a deciduous large tree found in India mainly in hilly region. Plant parts used most commonly are heart wood, leaves, flowers, bark, and gum. *P. marsupium* is known for its antidiabetic activity [85]. The heart wood of this leguminous tree is medicinally important and possess novel anti-diabetic principle. The paste of heart wood is useful in body pain and diabetes [86]. One of the active principles of Pterocarpus, (-) epicatechin, has insulinogenic action. Flavonoids fraction from *P. marsupium* has been shown to cause pancreatic beta cell regranulation. An aqueous extract of *P. marsupium* wood, at an oral dose of 250 mg/kg, shows significant hypoglycemic activity [87].

Punica granatum **(Family: Punicaceae)**
Punica granatum (madulai) commonly known in India as 'Pomegranate', 'Anar' or 'Dalim', is a highly ornamental large deciduous shrub or small tree widely distributed and cultivated in many parts of India [88]. *P. granatum* seeds have been shown to contain the estrogenic compounds, estrone and estradiol [89]. *Punica granatum* is found to contain hydrolysable tannins as major active chemical constituents and phytoconstituents, namely, corilagin, ellagic acid, kaempferol, luteolin, myricetin, quercetin, quercimetrine, and quercetin- 3-o-rutinoside which were previously isolated from the fruits of *Punica granatum* [90]. Pomegranate peel aqueous extract can reduce blood sugar through regeneration of ß cells. Significant blood glucose lowering activity was reported when treated with 50% (v/v) ethanol flower extract in glucose fed and alloxan induced hyperglycemic rats [91].

Tinospora Cordifolia **(**Family: Menispermaceae)
Tinospora Cordifolia (shindilakodi) is widely distributed throughout India and commonly known as Guduchi. The main constituents are found to be alkaloids, diterpenoid lactones, glycosides, steroids, Sesquiterpenoid, phenolics, aliphatic compounds and Polysaccharides [92]. *T. cordifolia* is widely used in Indian ayurvedic medicine for treating diabetes mellitus [93]. Oral administration of an aqueous *T. cordifolia* root extract to alloxan diabetic rats causes a significant reduction in blood glucose and brain lipids. The stem of the *Tinospora cordifolia* is one of the constituents of several ayurvedic preparations. It is reported that the daily administration of either alcoholic or aqueous extract of *T. cordifolia* decreases the blood glucose level and increases glucose tolerance in rodents.

Trigonella foenum-graecum (Family: Leguminosae)
Trigonella foenum graecum (venthayam) commonly known as fenugreek or Methi used both as an herb (the leaves) and as a spice (the seed) and cultivated worldwide as a semi-arid crop. It is found to contain mucilages, proteins, proteinase inhibitors, steroid saponins and saponin-peptide esters, sterols, flavonoids, nicotinic acid, coumarin, trigonelline and volatile oil [94, 95]. Recently, furostanol saponins called trigoneosides glycoside D and trigofaenoside A and steroidal sapogenins such as diosgenin and yamogenin [96] were isolated from this plant. Anti-hyperglycemic effect of the extracts, powder and gum of *Trigonella foenum-graecum* seeds and leaves have been linked to delayed gastric emptying caused by the high fiber content, inhibition of carbohydrate digestive enzymes and stimulation of insulin secretion [95]. The steroids present in methi have been reported to reduce blood glucose level when supplemented to diabetic rats [97]. A significant reduction was observed in diabetic rats' fasting blood glucose by approximately 300 mg% after administering the seed powder for 21 days [98].

Withania somnifera (Family: Solanaceae)
Withania somnifera (asuragandhi) also known as ashwagandha or winter cherry is one of the most valuable plants in the traditional Indian systems of medicine. Hypoglycemic effects [99] and the effects of *W. somnifera* on insulin sensitivity in noninsulin dependent DM rats [100] have been reported. The root of this plant includes some alkaloids and vitanolids [101]. Withaferin A and withanolide D are the two main withanolides that contribute to most of the biological actions of *withania* [102, 103]. The leaves of the plant are reported to contain 12 withanolides, 5 unidentified alkaloids (yield, 0.09%), many free amino acids, chlorogenic acid, glycosides, glucose, condensed tannins, and flavonoids [104]. The fruit (green berries) contain amino acids, a proteolytic enzyme, condensed tannins, and flavonoids. The tender shoots are rich in crude protein, calcium and phosphorous, and are not fibrous. They are reported to contain *scopoletin*.

Zizyphus jujuba (Family: Rhamnaceae)
Zizyphus jujuba (ilanthai pazham) is a thorny plant that is widely distributed in Europe and Southeastern Asia. Fruits of *Z. jujuba* are edible and different parts of this plant possess multiple medicinal properties such as antifertility, analgesic, and antidiabetes [105]. The fruits of *Z. jujuba* contain zizyphus saponins I, II, III and jujuboside B [106], jujuboside D [107], and jujuboside [108]. The bark of *Z. jujuba* contains 7% tannin [109]. *Zizyphus jujuba* fruit also contains specific sugars (2.17 to 6.5 percent), protein, vitamin C and minerals [110]. The leaves and stems of *Z. jujuba* contain saponins 3-o-[2-o-α Lfucopyranosyl- 3-o-β-D-glucopyranosyl-α-Larabinopyranosyl] jujubogenin. The methanolic extract of Z. jujuba administered at the doses 100 mg/kg and 200

mg/kg caused a significant decrease in the levels of glucose total cholesterol, triglycerides and LDL-cholesterol.

2. Conclusion

The current review divulges the antidiabetic prospective of a few indigenous medicinal plants. Further exploration must be carried out to appraise the precise mechanism of action of medicinal plants with antidiabetic activity. It is for eternity whispered that plant is harmless, but numerous resources are harmful for the human being, since toxicity study of these plants should furthermore be illuminated prior to utilization of these plant resources.

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