

Diabetes Mellitus Type II: Treatment Strategies and Options: A Review

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Abstract

Traditional medicines are practiced worldwide for treatment of type II diabetes mellitus since ancient times. This review provides a comprehensive summary of medicinal plant throughout the world regarding their traditional usage by various tribes/ethnic groups for treatment of type II diabetes mellitus. Various treatment options are available in allopathic system of medicine. The prevalence of type II diabetes mellitus is increasing in all over the world. The need for achieving better control of blood glucose level has been evident in type II diabetes mellitus management. A wide number of herbal products are employed in the treatment of type II diabetes mellitus for their better efficacy and safety compared to synthetic medicine. Objective of study is to review conventional and herbal treatment of type II diabetes mellitus and document the medicinal plants used for treatment of type II diabetes mellitus that will help the physician in their practice. The material for this review was taken mostly from endocrinology textbooks & electronic journal up to date. To collect publication Pub Med, Google scholars and the Cochrane database of systematic reviews was used. Some other relevant references were collected from personal database of papers on type II diabetes mellitus. World health organization (WHO) is also supporting the research on herbal medicine regarding type II diabetes mellitus. Various hypoglycemic agents from medicinal plants have been found that are effective and safe. The medicinal plants used for the treatment of type II diabetes mellitus were reviewed based on the ethno botanic, some chemical and biochemical reports. Various plants species belonging to different families have been documented used for treatment of type II diabetes mellitus.

Keywords: Type II diabetes mellitus; Medicinal plants; Efficacy; Herbal medicine; Literature review

Introduction

Type II diabetes mellitus is a clinical syndrome due to relative or absolute deficiency of insulin or resistance to the action of insulin at the cellular level as a result hyperglycemia and glycosuria occurs [1]. Various new therapies have been introduced such as inhibition of enzymes that are involved in hydrolysis of dietary polysaccharides in the gut which can lead to reduction in blood glucose levels after a meal by reducing the absorption of monosaccharide by the enterocytes of the small intestine. Enzymes that are involved in hydrolysis of dietary polysaccharides are pancreatic amylase and glycosidase. With the advancement in treatment strategy there is risk of side effect such as excessive inhibition of pancreatic amylase may lead to abdominal distention, flatulence and diarrhea. Currently available therapies for type II diabetes mellitus are as follows oral insulin secretagogues, sulfonylureas, repaglinide, nateglinide, biguanides, thiazolidinediones, alpha-glucosidase inhibitors, insulin, pramlintide and exenatide. Oral hypoglycemic drugs are valuable in the treatment of patients with type II diabetes mellitus (NIDDM). Sulphonylureas and biguanides are traditional drugs which are mainstay of treatment while there are certain new drugs available now [2,3]. Insulin is used as hypoglycemic agent in Type II diabetes mellitus [4]. The use of herbal medicines (medicinal plants or phytotherapy) has recently gained popularity in all over the world for their efficacy in Type II diabetes mellitus (Table 1) and some plants have minor side effects when given in large doses (Table 2). But there is lack of understanding the actual mechanism of action of these medicines. These medicines are used since centuries in Unani system of medicine and they have more efficacy and fewer or no side effects therefore emphasis should be given on herbal medicine because allopathic system of medicine has failed in providing health to all. Herbal medicines are only alternative medicine that can relieve the patients. Various research studies have been carried in all over the world to evaluate the efficacy of herbs in the treatment of Type II diabetes mellitus [5]. Medicinal plants have been used for the treatment of type II diabetes mellitus since ancient times, and for a long time type

II diabetes mellitus has been treated orally with herbal medicines or their extracts, because plant products are frequently prescribed due to their less toxicity than conventional medicines. Shanmugam et al. reported medicinal plants used for the treatment of type II diabetes mellitus [6]. Type II diabetes mellitus is associated with disturbances in learning, memory, and cognitive skills in the diabetic patients. A study was conducted to evaluate the effect of chronic intraperitoneal administration of *Apium graveolens* on learning and memory in diabetic rats using passive avoidance and Y-maze tests. As a conclusion, it was suggested that *Apium graveolens* enhances the consolidation and recall capability of stored information in diabetic animals [7]. *Zingiber officinale* has been used in type II diabetes mellitus [8-11]. Thomson et al. study shows that *Allium sativum* has anti-diabetic and hypolipidemic properties in streptozotocin-induced diabetic rats [12]. According to one study, it has been determined that the *Withania somnifera* root and leaf extracts possess antidiabetic activities in alloxan-induced diabetic rats. *Withania somnifera* root extract contained more flavonoids than leaf extract [13]. In one study, the hypoglycemic effect of the rhizomes of *Smilax glabra* (Liliaceae) was investigated in normal and diabetic mice. The methanol extract of *Smilax glabra* reduced the blood glucose of normal mice and also significantly lowered the blood glucose of diabetic mice. This study shows that *Smilax glabra* has hypoglycemic effect [14]. The discovery and use of modern medicine led to a dramatic decline in the occurrence of diseases. The harmful toxic effects of synthetic drugs

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1	<i>Viscum album</i>	Viscaceae	Gray and Flatt 1999 [71]
2	<i>Butea monosperma</i>	Fabaceae	Sharma and Garg 2009 [72]
3	<i>Syzygium alternifolium</i>	Myrtaceae	Rao and Rao 2001 [73]
4	<i>Catharanthus roseus</i>	Apocynaceae	Karuna et al. 2010 [74]
5	<i>Capsicum frutescens</i> L.	Solanaceae	Islam and Choi 2008 [10,11]
6	<i>Brassica juncea</i>	Brassicaceae	Yadav et al. 2004 [75]
7	<i>Asparagus racemosus</i>	Asparagaceae	Hannan et al. 2011 [76]
8	<i>Asparagus officinalis</i> L.	Asparagaceae	Zhao et al. 2011 [77]
9	<i>Piper betle</i>	Piperaceae	Santhakumari et al. 2006 [78]
10	<i>Psidium guajava</i>	Myrtaceae	Ojewole et al. 2008 [79]
11	<i>Mangifera indica</i>	Anacardiaceae	Aderibigbe et al. 1999 [80]
12	<i>Sesamum indicum</i>	Pedaliaceae	Takeuchi et al. 2001 [48]
13	<i>Ferula persica</i>	Apiaceae	Hamdan and Afifi 2004 [81]
14	<i>Artemisia dracunculus</i>	Asteraceae	Ribnicky et al. 2005 [82]
15	<i>Abutilon hirtum</i>	Malvaceae	Krisanapun et al. 2009 [83]
16	<i>Abroma augusta</i>	Sterculiaceae	Tariqul et al. 2012 [84]
17	<i>Helicteres isora</i> L.	Sterculiaceae	Suthar et al. 2009 [85]
18	<i>Garuga pinnata</i> Roxb	Burseraceae	Shirwaikar et al. 2006 [86]
19	<i>Breynia retusa</i>	Euphorbiaceae	Kripa et al. 2011 [87]
20	<i>Albizia odoratissima</i>	Fabaceae	Kumar et al. 2011 [88]
21	<i>Ageratum conyzoides</i> L.	Asteraceae	Agunbiade et al. 2012 [89]
22	<i>Aerva lanata</i>	Amaranthaceae	Vetrichelvan et al. 2002 [45]
23	<i>Syzygium cumini</i>	Myrtaceae	Sharma et al. 2012 [90]
24	<i>Solanum surattense</i>	Burm Solanaceae	Poongothai et al. 2011 [91]
25	<i>Ocimum canum</i> L.	Lamiaceae	Nyarko et al. 2002 [92]
26	<i>Enicostemma hyssopifolium</i>	Gentianaceae	Patel and Mishra 2011 [93]
27	<i>Azadirachta indica</i>	Meliaceae	Khosla et al. 2000 [94]
28	<i>Artemisia herba</i>	Asteraceae	Al-Shamaony et al. 1994 [95]
29	<i>Costus speciosus</i>	Costaceae	Bavarva et al. 2008 [96]
30	<i>Oenanthe javanica</i>	Apiaceae	Yang et al. 2000 [97]
31	<i>Gymnema sylvestre</i>	Asclepiadaceae	Al-Romaiyan et al. 2010, Baskaran et al. 1990 [98,99]
32	<i>Catharanthus roseus</i>	Apocynaceae	Rasineni et al. 2010 [74]
33	<i>Moringa oleifera</i>	Moringaceae	Gupta et al. 2012 [100]

Table 1: List of plants having hypoglycemic activity.

Plant Name	Side effects in human	Dose
<i>Anacardium occidentale</i> linn	Dermatitis	2-25 grams per day
<i>Tribulus terrestris</i>	Sleep disturbance and irregular periods. <i>Tribulus terrestris</i> can interact with some heart medicine and increase their effect in the body such as beta blockers and digoxin	5-7 grams per day
<i>Ricinus communis</i> L.	Excessive use in any form is harmful for stomach	Seeds 3-5 in number, leaves 7-12 gram, fixed oil 25-50 ml
<i>Aloe vera</i>	Aloe should not be taken internally during pregnancy, since it can stimulate contraction	125-500 mg
<i>Hyssopus officinalis</i>	Its use is contraindicated in patients suffering from liver affections	3-7 grams
<i>Trigonella foenum-graecum</i> L.	Long term use may produce headache and nausea	3-5 grams
<i>Smilax chinensis</i>	Excessive use may produce dryness	5-7 grams
<i>Urginea indica</i>	Nausea, convulsion and paralysis	3-5 grams
<i>Acacia nilotica</i>	Prolonged use causes constipation	Bark: 3-5 gram, gum: 1-3 grams, extract: 1 gram
<i>Achyranthes aspera</i>	The plant seeds may cause emesis and decrease appetite	5-7 grams (Plant) 500 mg (Salt)
<i>Aegle marmelos</i>	Excessive use may cause obstruction and hemorrhoids	Fresh fruit: 24-48 grams Dry pulp (in powdered form) 2-3 grams
<i>Laurus nobilis</i>	Stomatitis, cheilitis and dermatitis	1-2 grams
<i>Curcuma longa</i>	Curcuminoids may possibly cause stomach ulcer	1-3 grams
<i>Sesamum indicum</i>	Flatulence	7-12 grams
<i>Allium cepa</i> L.	Headache and hyperuricemia	Juice: 24-36 grams Seeds: 1-3 grams
<i>Semecarpus anacardium</i> linn	Blisters, swelling, painful micturation, inflammation, and pharyngitis	Seeds kernels: 250-500 Juice of pericarp:12-25
<i>Matricaria chamomilla</i>	Large doses may cause emesis	1-3 grams
<i>Gymnema sylvestre</i>	When chewed, it temporarily paralyses the sense of taste for sweet and bitter substances	3-7 grams
<i>Ficus bengalensis</i>	It may cause harmful effects on stomach and intestine	3-5 grams

Table 2 Side effects in human and dose [101].

led to alternative sources which would be safe and effective in various diseases. The present study is to document the medicinal plants used in type II diabetes mellitus.

Materials and Methods

The material for this review was taken mostly from endocrinology textbooks & electronic journal up to date. To collect publication Pub Med, Google scholars and the Cochrane database of systematic reviews was used. Some other relevant references were collected from personal database of papers on type II diabetes mellitus.

Treatment of Type II Diabetes Mellitus

Oral hypoglycemic drugs

Sulfonylureas: Sulfonylureas include tolbutamide, glibenclamide, chlorpropamide, glipizide, acetohexamide, gliclazide and tolazamide [15].

Biguanides: Phenformin and metformin [16].

Miscellaneous: Acarbose and guar gum.

New drugs for NIDDM

These include insulin sensitizers, drugs which reduce insulin resistance by interaction with the PPAR- (peroxisome proliferators-activated receptor-) a nuclear receptor which regulates genes involved in lipid metabolism. The effect on insulin sensitivity may result from decreased production of nonesterified fatty acids. They have the capacity to potentiate the effect of endogenous insulin. One of these, troglitazone, which belongs to the thiazolidinedione group, is used in Type II diabetes mellitus. Repaglinide, a benzoic acid derivation which stimulates insulin production at meal times has been used in type II diabetes mellitus patients [17].

DPP-4 inhibitors: Drugs targeting the incretin pathway are the latest addition to the available antidiabetic agents. Incretin-based therapy is either delivered orally (dipeptidyl peptidase-4 [DPP-4]) inhibitors or injected subcutaneously (glucagon-like peptide-1 [GLP-1] mimetics and analogues). Dipeptidyl peptidase-4 inhibitors are effective either as a single or combination therapy in lowering glycated hemoglobin, fasting and postprandial glucose levels, with a low incidence of hypoglycemia and no weight gain. There are 3 DPP-4 inhibitors currently available (sitagliptin, saxagliptin, and vildagliptin), with more expected to be available in the future. DPP-4 inhibitors are effective in the treatment of patients with type 2 diabetes [18].

Incretin mimetics: Incretin-related therapies offer great potential for the treatment of people with type II diabetes mellitus. Major incretins that affect glucose metabolism are GLP-1: glucagon-like peptide-1 and GIP: glucose-dependent insulinotropic polypeptide. These therapies have a unique mechanism of action that addresses glucose appearance as well as glucose disappearance [19].

Thiazolidinediones: The thiazolidinediones also known as glitazones, are a class of medications that are used in the treatment of diabetes mellitus type 2. They were introduced in the late 1990s [20].

Alpha glucosidase inhibitors: One alternative approach of the treatment of overweight patients with NIDDM is to use drugs which inhibit the enzymes involved in the breakdown of carbohydrates in the intestine. Acarbose is a sham sugar that competitively inhibits α -glucosidase enzymes situated on the brush border of the intestine. As a result, dietary carbohydrates are poorly absorbed, and the

postprandial rise in blood glucose is reduced. Undigested starch enters the large intestine where it is broken down by fermentation. Abdominal discomfort, flatulence and diarrhea can result, and dosage needs careful adjustment to avoid these side effects. Very little acarbose enters the circulation, since it is mainly inactivated in the gut, but liver dysfunction may rarely occur with high doses [21].

Medicinal Plants Possessing Alpha -Glucosidase Inhibitory Activities

Glycosidases are involved in metabolic disorders including type II diabetes mellitus. Inhibition of these glycosidase may be proved effective in type II diabetes mellitus. Various medicinal plants have been evaluated for their efficacy to inhibit glucosidase. *Euonymus sachalinensis*, *Rhododendron schlippenbachii*, *Astilbe chinensis* and *Juglans regia* have inhibitory effect on glucosidase, therefore can be a potential natural source for the treatment of type II diabetes mellitus [22].

Tussilago farfara

Family: Asteraceae. **Chemical constituents:** It contains mucilage, tannin, phytosterol, dihydride alcohol and faradiol. **Medicinal uses:** It is used in catarrh, colds, whooping cough, respiratory problems, spasmodic lung problem, stomach trouble, inflammation and bleeding. **Pharmacological activity:** It is anti-inflammatory, anti-spasmodic and hypoglycemic. **Study:** Gao et al. reported the α -glucosidase inhibitory activity of this plant and concluded that flower bud of *Tussilago farfara* is useful in type II diabetes mellitus [23].

Medicinal Plants Used as Hypoglycemic Agents

Prinsepia utilis Royle

Family: Rosaceae, **Parts used:** Aerial parts. **Chemical constituents:** It contains pentacyclic triterpenoids. **Medicinal uses:** Oil from seeds is rubefacient and is applied locally in rheumatism. **Pharmacological activity:** It is anti-inflammatory, anti-arthritis and hypoglycemic. **Study:** A study was conducted to investigate the anti-hyperglycemic activity of flavonoids from *Prinsepia utilis* Royle in alloxan-induced diabetic mice. Study duration was four weeks. Drug was administered orally. Dose of drug was 300 mg/kg of flavonoids from *Prinsepia utilis* Royle. There was significant hypoglycemic activity of Flavonoids from *Prinsepia utilis* Royle compared with model control group ($P < 0.01$) [24].

Ricinus communis L.

Family: Euphorbiaceae, **Common name:** Harnoli. **Parts used:** Root, leave, oil. **Chemical constituents:** It contains ricinolein, flavonoids, ricin, ricinolic acid, sodium ricinoleate, tristearin. **Medicinal uses:** It is used in constipation, pain and inflammation. **Pharmacological activity:** It is anti-inflammatory, laxative and hypoglycemic. **Study:** Hypoglycemic activity of 50% ethanolic extract of roots of *Ricinus communis* was investigated. Effective dose was 500 mg/kg body weight. There was significant decrease in fasting blood glucose level. Hypoglycemic activity was observed in normal as well as diabetic animal model. Study duration was 20 days. There was significant reduction in lipid profile and liver and kidney functions were normal during the study period. Fractionation of this extract was done and these were tested for antihyperglycemic activity. Fraction (R-18) exhibited significant hypoglycemic activity. This drug was safe because there was no effect on liver and kidney function and all enzymes were normal [25].

Aloe vera

Family: Xanthorrhoeaceae, **Chemical constituents:** It contains anthraquinone glycosides, free anthraquinones, resins, glucomannan, steroids, organic acids, enzymes, antibiotic principles, amino acids, cinnamic acid and salicylic acid, essential oil. **Medicinal uses:** It is used in inflammation, wounds and bacterial infections. **Pharmacological activity:** It is soothing, anti-inflammatory, emmenggogue, emollient, and antibacterial. **Study:** Rajasekaran et al. reported the hypoglycemic effect of *Aloe vera* gel on streptozotocin-induced hyperglycemia in experimental rats [26]. Okyar et al. reported the antidiabetic effect of *Aloe vera* in type II diabetic rat models [27].

Crataeva nurvala Buch

Family: Cappariaceae. **Parts used:** Leaves. **Chemical constituents:** It contains tannin and saponin. **Medicinal uses:** It is used in diabetes mellitus. **Pharmacological activity:** It is hypoglycemic. **Study:** Sikarwar and Patil reported the antidiabetic activity of *Crataeva nurvala* stem bark extracts in alloxan-induced diabetic rats [28].

Hyssopus officinalis

Family: Lamiaceae. **Chemical constituents:** It contains glycosides, essential oil, tannins, resins, fats, sugar, mucilage, flavonoid glycoside. **Medicinal uses:** It is used in abdominal pain, respiratory tract infections, insomnia, constipation, viral infections and gastrointestinal disorders. **Pharmacological activity:** It is antispasmodic, expectorant, sedative, carminative, diaphoretic, antiviral, astringent, tonic and stomachic. **Study:** Miyazaki et al. has studied the inhibitory effect *Hyssopus officinalis* extracts on intestinal alpha-glucosidase activity and postprandial hyperglycemia [29].

Trigonella foenum-graecum L.

Family: Fabaceae, **English Name:** Fenugreek. **Local Name:** Maithi. **Chemical constituents:** It contains trigonelline, flavonoid, glycosides, saponin, ascorbic acid, fenugreekine. **Medicinal uses:** It is used in type II diabetes mellitus, respiratory tract infections, swelling, body pain, stomach pain, piles, dandruff, baldness, breast pain, lungs infection, ulcer and diarrhea. **Pharmacological activity:** It is anti-inflammatory, tonic and hypoglycemic. **Study:** Trigonelline produces hypoglycemic effect in diabetic rats which lasts for 24 hours [30].

Smilax chinensis

Family: Liliaceae, **Chemical constituents:** It contains beta sitosterol, oil, diosgenin, smilacin, resin, tannin, starch, gum, sarsapogenin, sapogenins, parallin, sarsaponin and saponins. **Medicinal uses:** It is used in inflammation, cancer and type II diabetes mellitus. **Pharmacological activity:** It is anti-inflammatory and anti-diabetic. **Study:** The anti-diabetic effects of the methanol extracts of the *Smilax chinensis* L. (MESC) on alloxan induced hyperglycemia were evaluated on albino wistar rats. Ethanolic extract of *Smilax chinensis* exhibited potential hypoglycemic effect with potential hypolipidemic effect (Venkidesh et al. 2010) [31]. The anti-diabetic effects of the methanol extracts of the *Smilax chinensis* L. on alloxan induced hyperglycemia were evaluated on albino wistar rats. Ethanolic extract of *Smilax chinensis* exhibited a potential hypoglycemic effect with potential hypolipidemic effect [32].

Salvadora oleoides Decne

Family: Salvadoraceae, **Common name:** Peelu. **Parts used:** Fruit, root, seed. **Medicinal uses:** It is used in anemia, constipation and pyorrhea. **Pharmacological activity:** It is anti-anemic, laxative and

anti-septic. **Study:** Yadav et al. reported the hypoglycemic activity of ethanolic extract of *Salvadora oleoides* [33].

Urginea indica

Family: Liliaceae. **Tibbi name:** Jangli Piyaz. **Chemical constituents:** It contains glycosides, scillaren A and scillaren B. **Medicinal uses:** It is used in urinary tract infections and type II diabetes mellitus. **Pharmacological activity:** It is anti-septic and hypoglycemic. **Study:** The extract of this plant has hypoglycemic activity [34].

Acacia nilotica

Family: Fabaceae; **Local name:** Kikar; **Parts used:** Wood, leaf and gum. **Chemical constituents:** It contains gum arabic, tannins, mucilage, magnesium, potassium, calcium, catechin, arabic acid, malic acid and flavonoid compounds. **Medicinal uses:** It is prescribed for treatment of type II diabetes mellitus. **Pharmacological activity:** It is astringent and hypoglycemic. **Study:** Usmanghani et al. documented its anti-diabetic activity [35].

Achyranthes aspera

Family: Amaranthaceae; **Parts used:** Leaves, stems and roots. **Chemical constituents:** Saponins, ecdysterone, inokosterone, achyranthine, and potassium, ash of leaves, stems and root contains considerable amount of potassium. **Medicinal uses:** It is used in diabetes mellitus. **Pharmacological activity:** It is hypoglycemic. **Study:** A study was conducted to evaluate its efficacy in diabetic rat. Alcoholic extract of whole plant was given to albino rat. Alcoholic extract exhibited hypoglycemic activity in albino rats [36].

Luffa aegyptiaca Mill

Family: Cucurbitaceae; **Medicinal uses:** It is used in joint pain, backache, colic, splenitis and phlegmatic diseases. **Pharmacological activity:** It is anti-inflammatory and hypoglycemic. **Study:** El-Fiky et al. investigated the efficacy of oral administration of the ethanolic extracts of *Luffa aegyptiaca* on blood glucose levels both in normal and streptozotocin diabetic rats. Hypoglycemic activity was observed significantly in streptozocin diabetic rats during the first three hours of treatment. In normal rats, hypoglycemic activity was insignificant compared to glibenclamide treatment [37].

Citrus paradisi

Family: Rutaceae; **Medicinal uses:** It is used in diabetes mellitus type II and bacterial infections. **Pharmacological activity:** Anti-bacterial and hypoglycemic. **Study:** Adeneye reported that methanol seed extract of *Citrus paradisi* lowers blood glucose, lipids and cardiovascular disease risk indices in normal Wistar rats [38].

Aegle marmelos

Family: Rutaceae; **Part used:** Fruits, leaves. **Medicinal uses:** It is used in chronic constipation, piles, dysentery, hyperacidity, abdominal pain and type II diabetes mellitus. **Pharmacological activity:** It is mucilaginous, antidiabetic and antidysentric. **Study:** A study was conducted on normal and diabetic rats. Fruit of this plant exhibited hypoglycemic activity in normal rats [39].

Cymbopogan citratus

Family: Poaceae; **Medicinal uses:** It is used in type II diabetes mellitus, gouty arthritis and tuberculosis. **Pharmacological activity:** It is anti-inflammatory and hypoglycemic. **Study:** Mirghani et al. documented the hypoglycemic activity [40].

Momordica balsamina L.

Family: Cucurbitaceae. **Common name:** Jangli Kareela. **Parts used:** Fruit and seeds. **Chemical constituents:** It contains vitamin C and momordicin. **Medicinal uses:** It is used in type II diabetes mellitus, gas trouble, constipation, flatulence, obesity, boils and pimples. **Pharmacological activity:** It is hypoglycemic, stomachic and blood purifier. **Study:** Leung et al. stated its anti-diabetic and hypoglycemic activity [41].

Psidium guajava L.

Family: Myrtaceae. **Common name:** Amrood. **Parts used:** Leaves, fruit. **Medicinal uses:** It is used in type II diabetes mellitus and intestinal worms. **Pharmacological activity:** It is tonic and anti-diabetic. **Study:** Shen et al. reported the hypoglycemic activity of *Psidium guajava* Linn. in type II diabetic patients [42].

Syzygium cumini

Family: Myrtaceae. **Common name:** Jaman, **Parts used:** Leave, bark, fruit, nut. **Chemical constituents:** It contains myrcetin, kaemferol, isoquercetin, ellagic acid, glucosides, anthocyanins, alakloids, jambolin, jambosine and antimellin. **Medicinal uses:** It is used in fever, motion, vomiting, anemia, painful swellings and type II diabetes mellitus. **Pharmacological activity:** It is anti-inflammatory and hypoglycemic. **Study:** It prevents oxidative damage in diabetic rats [43].

Morus alba L.

Family: Moraceae. **Common name:** Shehtoot, **Parts used:** Leave, fruit. **Chemical constituents:** It contains polyphenol pigment, anthocyanins, resveratrol, vitamin C, carotene, zea xanthin, iron, magnesium, manganese and potassium. **Medicinal uses:** It is used in sore throat, cough and abdominal worms. **Pharmacological activity:** It is anthelmintic and hypoglycemic. **Study:** Mohammadi and Naik reported the hypoglycemic activity and are prescribed to treat diabetes mellitus type II [44].

Aerva lanata

Chemical constituents: It contains galactoside and kampferol. **Medicinal uses:** It is used in kidney stones, constipation and diabetes mellitus type II. **Pharmacological activity:** Diuretic, purgative, emetic and hypoglycemic. **Study:** Vetrichelvan and Jegadeesan reported the anti-diabetic activity of alcoholic extract of *Aerva lanata* in rats and concluded that this plant can be prescribed to treat diabetes mellitus type II [45].

Laurus nobilis

Parts used: Leaf and berry, **Chemical constituents:** It contains cineole, eugenol, geraniol, alpha and beta pinene, lauric acid, palmitic acid, linoleic acid, reticuline, boldine, laurostearine, methyl eugenol. **Medicinal uses:** It is used in hysteria, colic, indigestion, loss of appetite. **Pharmacological activity:** It is antirheumatic, antiseptic, bactericidal, digestive, diuretic, emmenagogue, stomachic, hypotensive and sedative. **Study:** Khan et al. reported that Bay leaves improve glucose and lipid profile of people with type II diabetes mellitus [46].

Curcuma longa

Family: Zingiberaceae. **Parts used:** Tubers and rhizomes. **Chemical constituents:** It contains essential oil, turmerol, curcumin, sesquiterpene ketone, arturmerone, bisabolane, curlone, guaiane, tumerone, zingiberone. **Medicinal uses:** It is used in whooping cough,

asthma, bronchitis, scabies, irritation, chronic skin disorders, wounds, strokes, bruises, eczema, prurigo and ringworm. **Pharmacological activity:** It is expectorant, blood purifier and hypoglycemic. **Study:** Suryanarayana et al. reported that curcumin and turmeric delay streptozotocin-induced diabetic cataract in rats [47].

Sesamum indicum

Family: Pedaliaceae. **Tibbi name:** Til, Kunjad. **Chemical constituents:** It contains molybdenum, thiamine, niacin, carbohydrates, methionine, tryptophan, lecithin, sesamin, sesamol, phytoosterol, cobalt, iodine, iron, zinc, calcium and sitosterol. **Medicinal uses:** It is used in cough, sexual debility, asthma, thorax complaints, inflammations and bleeding piles. **Pharmacological activity:** It is aphrodisiac, anti-inflammatory and hypoglycemic. **Study:** Takeuchi et al. documented hypoglycemic activity of this plant [48].

Ginkgo biloba

Family: Ginkgoaceae. **Chemical constituents:** It contains flavonoids and terpenoids. **Medicinal uses:** It is used in dementia, intermittent claudication, anxiety, glaucoma, macular degeneration, premenstrual syndrome, cardiovascular disorders and diabetes mellitus type II. **Pharmacological activity:** It is hypoglycemic and anti-oxidant. **Study:** Chen et al. reported that *Ginkgo biloba* extract reduces high-glucose-induced endothelial adhesion by inhibiting the redox-dependent interleukin-6 pathways [49].

Ziziphus mauritiana Lam.

Common names: Beri, **Parts used:** Leaves, fruit. **Medicinal uses:** It is used in type II diabetes mellitus. **Pharmacological activity:** It is hypoglycemic. **Study:** Bhatia and Mishra reported the hypoglycemic activity of *Ziziphus mauritiana* aqueous ethanol seed extract in alloxan-induced diabetic mice [50].

Allium cepa L.

Local name: Kashuh, **Parts used:** Leaves and bulbs. **Chemical constituents:** It contains phytoncides, vitamins, allicin, flavonoids, allylpropyl disulfide, essential oil, quercetin, scordine and fatty oil. **Medicinal uses:** It is used in ear pains, flatulence and skin diseases. **Pharmacological activity:** It is aphrodisiac and hypoglycemic. **Study:** Mathew and Augusti reported the hypoglycemic activity of *Allium cepa* and concluded that this plant can be prescribed to treat type II diabetes mellitus [51].

Ammi visnaga

Medicinal uses: It is used in angina and type II diabetes mellitus. **Pharmacological activity:** It is vasodilator and hypoglycemic. **Study:** Jouad et al. reported the hypoglycemic effect of aqueous extract of *Ammi visnaga* in normal and streptozotocin-induced diabetic rats [52].

Berberis lyceum Royle

Part used: Root, **Medicinal uses:** It is used in arthritis, osteoarthritis, inflammations, ophthalmia, mouth ulcers, skin ulcers and conjunctivitis. **Pharmacological activity:** It is hypoglycemic and anti-inflammatory. **Study:** Gulfranz et al. reported the antidiabetic activity of *Berberis lyceum* root extract and berberine in alloxan-induced diabetic rats [53].

Hippophae rhamnoides L.

Parts used: Fruit, stem, and leaves. **Medicinal uses:** It is used in skin problems, lung problems, cancer, ulcer, wounds, skin infection, joint pain, hair fall, type II diabetes mellitus, and blood pressure,

jaundice and heart problems. **Pharmacological activity:** It is anti-diabetic. **Study:** Arshad and Bibi reported the ethnomedicinal uses of *Hippophae rhamnoides* L. in type II diabetes mellitus [54].

Lavandula stoechas

Arabic name: Mumsik al-Arwah, **Persian name:** Anis al-Arwah, Ustukhudoos. **English name:** Arabian Lavender. **Chemical constituents:** It contains fenchone, sitosterol, ursolic acid, lavanol, camphor, and 7-methoxy coumarin. **Medicinal uses:** It is used in neuralgic headache, thoracic diseases and type II diabetes mellitus. **Pharmacological activity:** It is deobstuent, resolvent and tonic. **Study:** Gámez et al. reported the hypoglycemic activity in various species of the genus *Lavandula* and concluded that it can be used as hypoglycemic agent in patients with type II diabetes mellitus [55].

Panax ginseng

Family: Araliaceae. **Medicinal uses:** It is used in asthma, bronchitis, altitude sickness and type II diabetes mellitus. **Pharmacological activity:** It is anti-diabetic. **Study:** Attele et al. reported the anti-diabetic effects of *Panax ginseng* berry extract [56].

Fagopyrum tataricum

Family: Polygonaceae. **Parts used:** Leaves. **Medicinal uses:** It is used in diabetes mellitus. **Pharmacological activity:** It is hypoglycemic. **Study:** Lee et al. reported that *Fagopyrum tataricum* (buckwheat) improves high-glucose-induced insulin resistance in mouse hepatocytes and type II diabetes mellitus in fructose-rich diet-induced mice [57].

Semecarpus anacardium linn

Family: Anacardiaceae. **Parts used:** Fruit, seeds, gum, oil, juice of pericarb, seed kernels. **Chemical constituents:** It contains tryptophan, phenylalanine, nicotinic acid, riboflavin, thiamine, bhilanwanol, fixed oil, anacardol, catechol, cardol, anacardic acid. **Medicinal uses:** It is used in infected wounds, boils and type II diabetes mellitus. **Pharmacological activity:** It is antiseptic and hypoglycemic. **Study:** Khan et al. reported the antidiabetic and antioxidant effect of *Semecarpus anacardium* Linn. nut milk extract in a high-fat diet STZ-induced type 2 diabetic rat model [58].

Glycyrrhiza glabra

Family: Fabaceae. **Parts used:** Roots. **Medicinal uses:** It is used in obesity, peptic ulcers, stress, eczema, asthma, hay fever, arthritis, gastritis, abdominal colic, hyperacidity, heart burn, indigestion, constipation, cough, bronchitis and other respiratory infections. **Pharmacological activity:** It is expectorant, febrifuge, antibacterial, anti-inflammatory, anti-allergy, estrogenic, demulcent, antispasmodic, laxative, anti-allergic, antacid and antiseptic. **Study:** Aoki et al. reported the hypoglycemic activity of this plant [59].

Matricaria chamomilla

Medicinal uses: It is used in headache, chest pain and conjunctivitis. **Pharmacological activity:** It is stimulant, demulcent, brain tonic and diuretic. **Study:** Cemek et al. reported the antihyperglycemic and antioxidative potential of *Matricaria chamomilla* L. in streptozotocin-induced diabetic rats and concluded that it can be prescribed to treat hyperglycemia [60].

Gymnema sylvestris

Medicinal uses: It is used in cardiovascular disorders and diabetes mellitus type II. **Pharmacological activity:** It is anti-oxidant and

hypoglycemic agent. **Study:** Leach reported the antidiabetic activity of *Gymnema sylvestris* [61].

Eugenia caryophyllus

Parts used: Stems, leaves and dried flowers buds. **Chemical constituents:** It contains eugenol, beta caryophyllene and terpenic oxides. **Medicinal uses:** It is used in skin infections, digestive problems and toothache. **Pharmacological activity:** It is carminative, anti-emetic, counterirritant, expectorant, anthelmintic, antirheumatic, antineuralgic, antiseptic, antiviral and anti-oxidant [62]. **Study:** Collip reported the hypoglycemic activity of alcoholic extract of *Eugenia caryophyllus* [63].

Ajugaiva L

Family: Lamiaceae. **Medicinal uses:** It is used in diabetes mellitus type II. **Pharmacological activity:** It is hypoglycemic. **Study:** A study was conducted to investigate the hypoglycemic activity of *Ajuga iva* L. in rat model. This plant is commonly available in Asia and Africa. Water extract of *Ajuga iva* L (AT) was administered to rats at a dose of 10 mg/kg that reduced blood glucose level in rats 6 hours. This study indicates that *Ajuga iva* L. has hypoglycemic activity and validates its traditional use in hyperglycemic conditions [64].

Tribulus terrestris

Family: Zygophyllaceae. **Medicinal uses:** It is used in urinary tract infection and type II diabetes mellitus [65]. **Pharmacological activity:** It is diuretic, lithotriptic, anti-inflammatory and hypoglycemic. **Study:** A study was conducted to evaluate the efficacy of *Tribulus terrestris* in alloxan induced diabetic rats. After treatment, it was concluded that *Tribulus terrestris* has prominent antidiabetic effect [66].

Anacardium occidentale linn

Family: Anacardiaceae, **Part used:** Leaves and fruit. **Medicinal uses:** It is used in diabetes mellitus type II. **Pharmacological activity:** It is anti-diabetic. **Study:** Ojewole reported the hypoglycemic effect of *Anacardium occidentale* Linn (Anacardiaceae) stem-bark extracts in rats [67].

Bougainvillea glabra

Family: Nyctaginaceae, **Parts used:** Leaves, flowers and stems. **Chemical constituents:** It contains alkaloids, flavonoids, pinitol and betacyclin. **Medicinal uses:** It is used in inflammation and diabetes mellitus type II. **Pharmacological activity:** It is anti-inflammatory, insecticidal and hypoglycemic. **Study:** Bhat et al. reported the antidiabetic properties of *Bougainvillea spectabilis*. This study justifies its use as herbal drug in type II diabetes mellitus [68].

Ferula assafoetida

Family: Umbelliferae. **Chemical constituents:** It contains organic sulphur compounds, volatile oil, foetidae, luteolin. The gum resins contain coumarins, 5-hydroxyumbelliprenin, assafoetid, ferocolicin, asacoumarin A and B, farnesiferol A, B, C and disulphide, asadisulphide and sec-butylpropenyl disulphide. **Medicinal uses:** It is used in constipation, abdominal pain, cough, intestinal worms, urinary tract infections and sexual disorders. **Pharmacological activity:** It is stimulant, carminative, antispasmodic, expectorant, slightly laxative, anthelmintic, diuretic, aphrodisiac, emmenagogue, nerve and pulmonary surfactant. **Study:** Abu-Zaiton reported the anti-diabetic activity of *Ferula assafoetida* extract in normal and alloxan-induced diabetic rats [69].

Ficus bengalensis

Family: Urticaceae. **Parts used:** Latex, bark, fruits, roots, root bark, buds and aerial roots. **Chemical constituents:** It contains triterpene, friedelin, sitosterol, tigilic acid, quercetin, rutin, tannins, waxes, albuminoids and carbohydrates. **Medicinal uses:** It is used in diabetes mellitus type II. **Pharmacological activity:** It is hypoglycemic. **Study:** Singh et al. reported the antidiabetic effect of *Ficus bengalensis* aerial roots in experimental animals [70].

Conclusion

Many herbs and plants have been described as possessing hypoglycemic activity when taken orally. Some of these plants have also been pharmacologically tested and shown to be of some value in human type II diabetes mellitus treatment. The efficacy of herbal drugs is significant and they have fewer side effects than the synthetic allopathic medicines. Further, phytochemical characterization of medicinal plants is required to identify the specific compound(s) involved in the observed hypoglycemic.

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None of the authors have a financial or proprietary interest in the subject matter or materials discussed in the manuscript, including, but not limited to, employment, consultancies, stock ownership, honoraria, and paid expert testimony.

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