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ANTIDIABETIC ACTIVITY OF PLANTS WITH THEIR PHYTOCONSTITUENTS: A REVIEW

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ABSTRACT: Diabetes mellitus is characterized by elevated plasma glucose concentrations resulting from insufficient insulin. A comprehensive herbal drug therapeutic regimen offers time tested safe and effective support to conventional therapy in the management of diabetes. This is a combination with adequate dietary management, and physical activity would provide an integrated approach to the management of this deadly disease, particularly Type 2 diabetes. In this paper, an attempt has been made to give an overview of certain Indian plants with their phytoconstituents and mechanism of action which have been studied for their antidiabetic activity. The present work offers a review addressing the detailed phytochemistry of different plants contains this article.

INTRODUCTION: Diabetes mellitus is one of the most common and serious chronic diseases in the United States. About 16 million Americans have diabetes, 5.4 million of whom do not know they have the disease. Diabetes is the leading cause of adult blindness, end-stage renal disease, and nontraumatic lower-extremity amputations (as a result of nerve disease). People with diabetes are 2–4 times more likely to have coronary heart disease and stroke than people without diabetes. Also, poorly controlled diabetes can complicate pregnancy - congenital disabilities are more common in babies born to women with diabetes.

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Diabetes is a metabolic disease in which the body does not produce or properly use insulin, a hormone that is needed to convert sugar, starches, and other food into energy needed for daily life.

There are three main types of diabetes, all of which are characterized by high levels of blood glucose (sugar).

Type 1 Diabetes: Also called insulin-dependent diabetes mellitus (IDDM) or juvenile- onset diabetes.

Type 2 Diabetes: Also called noninsulin-dependent diabetes mellitus (NIDDM) or adult-onset diabetes. Diabetes is called a self-managed disease, meaning that your loved one can probably take responsibility for his or her day-to-day care. Much daily care involves keeping blood glucose near normal levels at all times. Studies show that controlling blood sugar levels lowers the risk of

some complications of diabetes, such as eye and heart disease and nerve damage, so it's important for your loved one to stick to his or her diabetes management plan as closely as possible. This article has an objective to collect scattered scientific information on the herbs of hypoglycemic activity and to provide the present status of plants on which antidiabetic activity has been done.

2. MATERIAL AND METHOD: The information on the plants having antidiabetic activity was collected from different websites Journal and books available. These were further studied specifically to analyze the phytoconstituent and different mechanism which can alter the blood glucose metabolism. Based upon the hypothesis plants belong to the specific family may have a similar type of chemical composition and similar type of mechanism of action. After compilation of data, the method has opted from generalization to specification. **Table 1** contains a list of plants having antidiabetic activity with their chemical constituents and mode of action. Whereas Constituent *vs.* Mode of Activity has been described in **Table 2**. To understand the mechanism of action **Fig. 1** has been provided along with figures of phytoconstituent in **Fig. 2**.

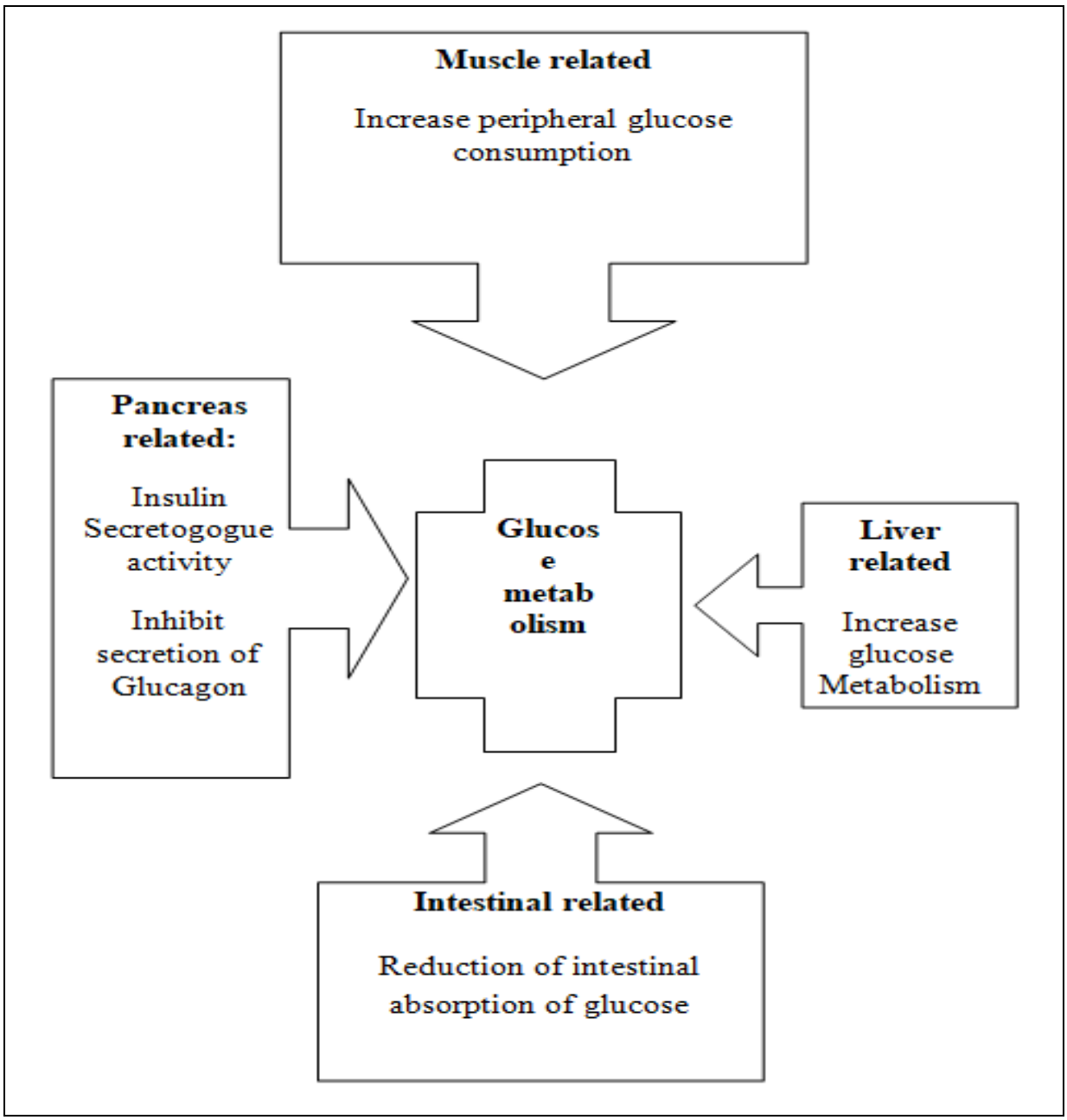
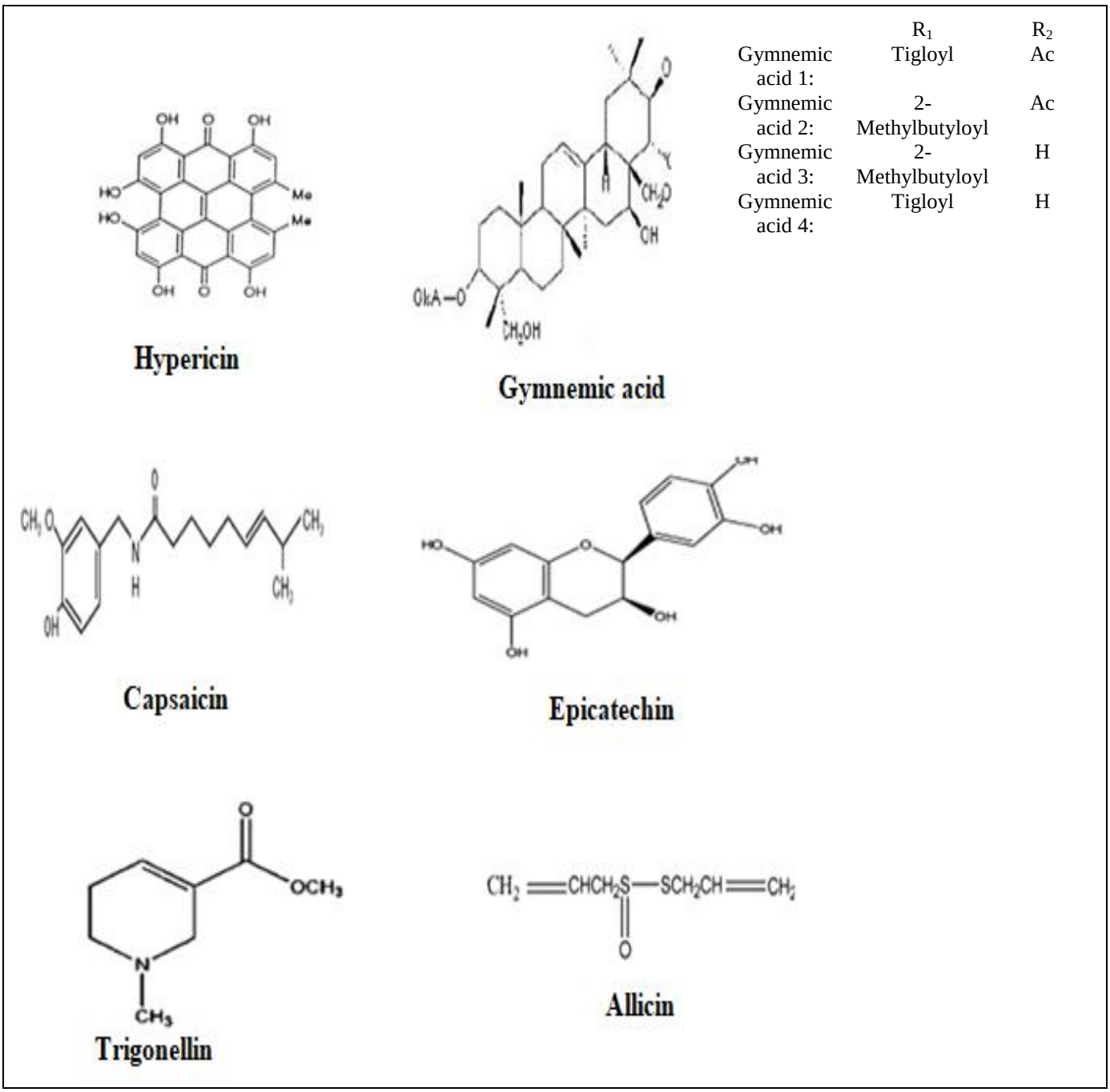


FIG. 1: EXPLAINING THE MECHANISM OF ACTION TO CONTROL GLUCOSE METABOLISM

TABLE 2: CONSTITUENTS v/s MODE OF ACTIVITY

S. no.	Constituents	Mode of Activity
1	Alkaloids	Inhibit alpha glucosidase and decrease glucose transport through the intestinal epithelium [137]
2	Imidazoline compounds	Stimulates insulin secretion in glucose dependent manner [138]
3	Polysaccharides	Increased the levels of serum insulin, reduce the blood glucose levels and improve tolerance of [139]
4	Flavonoids	Suppressed the glucose level, reduced plasma cholesterol, and triglycerides significantly and increased their hepatic glucokinase activity probably [140]
5	Dietary fibers	Effectively adsorbed glucose, retard glucose diffusion and inhibit the activity of alpha-amylase and may be responsible for decreasing the rate of glucose absorption and concentration of postprandial serum glucose [141]
6	Saponin, (Triterpenoid + steroidal)	Stimulates the release of insulin and [142]



	R_1	R_2
Gymnemic acid 1:	Tigloyl	Ac
Gymnemic acid 2:	2-Methylbutyloyl	Ac
Gymnemic acid 3:	2-Methylbutyloyl	H
Gymnemic acid 4:	Tigloyl	H

FIG. 2: STRUCTURES OF CHEMICAL CONSTITUENTS BELONG TO HYPOGLYCEMIC ACTIVITY

TABLE 1: LIST OF PLANTS HAVING ANTI-DIABETIC ACTIVITY

S. no.	Botanical Name	Local Name	Family	Parts used	Mechanism of action	Chemical Constituents
1	*Abies pindrow* Royle	Morinda Rodha	Pinaceae	Entire plant	Insulin secretagogue activity	Volatile oil [1]
2	*Abroma augusta* Linn.	Devil's cotton	Sterculiaceae	Roots & Leaves	Lowering blood sugar	Fixed oil, Alkaloid [2]
3	*Acacia arabica willd*	Babool	Leguminosae	Seed	Initiate release of insulin	Arabin [3]
4	*Acacia Catechu*	Betal nut	Palmae	Fruits	Lowering blood sugar	Catechin [4]
5	*Achyranthus aspera* L.	Chirchiri	Amaranthaceae	Entire plant	Decrease blood sugar [5]	
6	*Acorus calamus* L.	Sweet flag	Araceae	Radix	Increase glucose consumption [6, 7]	
7	*Agrimony eupatoria* L.		Rosaceae	Leaves	Insulin releasing & insulin like activity [8]	
8	*Ajaugaiva* wall. ex. Benth	Bugle weed	Labiatae	Entire plant	Decrease plasma glucose level [9]	
10	*Allium cepa* Linn.	Pyaz	Liliaceae	Bulb	Stimulating effects on glucose utilization and antioxidant enzyme [11]	Protein, carbohydrate, vit. A,B,C, Allyl propyl disulphide
11	*Aloe vera* Tourn. ex. Linn.	Gheequar	Liliaceae	Entire plant		Aloin glycoside [12-14]
12	*Aloe barbadensis* Miller	Gheequar	Liliaceae	Leaves	Stimulating synthesis and/or release of insulin	Barbaloin, isobarbaloin, resin [15]
13	*Amaranthus spinosus* Linn.	Kataili chaulai	Amaranthaceae	Stem [16]		
14	*Anacardium occidentale* Linn	Kaju	Anacardiaceae	Entire plant		Flavonols, terpenoid, caumarin, phenolic [17]
15	*Andrographis paniculata* Nees	Kalmegh	Acanthaceae	Entire plant	Increase glucose metabolism	Diterpenoid lactone andrographolide [18, 19]
16	*Annona squamosa*	Sharifa	Annonaceae	Leaves	Hypoglycemic and antihyperglycemic activities of ethanolic leaf-extract, Increased plasma insulin level	Acetogenins-squamosin B, squamosamid, reticulation-2, isosquamosin [20]
17	*Artemisia pallens Wall*	Davana	Compositae	Aerial parts	Hypoglycemic, increases peripheral glucose utilization or inhibits glucose reabsorption	Essential oil, davanone [21]
18	*Averrhoa bilimbi*	Bilimbi	Oxalidaceae	Leaves	increase serum insulin level [22, 23]	
19	*Azadirachta indica* A. juss.	Neem	Meliaceae	Leaves	The glycogenolytic effect due to epinephrine action was blocked [24]	Nimbidin, Nimbin, Nimbidol, Nimbosterol
20	*Baccharis*	-	Asteraceae	Aerial parts	Increase glucose	

	trimerea L.				metabolism [25]	
21	*Barleria lupulina*	-	Acanthaceae	Aerial parts	Reduce blood glucose level by [26, 27]	
22	*Bauhinia forficate* L.	Pata de Vaca	fabaceae	Leaves	In preventing diabetic complication [28, 29]	
23	*Berberis ariatata*	Barberries	Berberidaceae	Root	Increase glucose metabolism [30]	
24	*Beta vulgaris* Linn.	chukandar	Chenopodiaceae	Leaves	Reduce blood glucose level by regeneration of β cells [31]	
25	*Bidens pilosa*		composite	Aerial parts		Polyacetylenic glucoside [32]
26	*Bixa orellana* L.	Annotta	Bixaceae	Entire plant	Increase plasma insulin conc. & increase insulin binding on insulin receptor	Oleo-resin [33]
27	*Boerhaavia diffusa* L.	Punarnava	Nyctaginaceae	Leaves & Entire plant	Increase in hexokinase activity, decrease in glucose-6-phosphatase and fructose bis-phosphatase activity, increase plasma insulin level [34]	Alkaloid punarnavaine, punarnavoside
28	*Butea monosperma* L.	Flame of forest	Papilionaceae	Bark, Leaves	Free radicle scavenging [35-38]	
29	*Brassica juncea* L.	Rai	Cruciferae	Leaves & seed	Food adjuvants for diabetic patients [39]	Isothiocyanate glycoside singrin
30	*Caesalpinia bonducella* Flem.	Karanju	Leguminosae	Seed kernels	Free radicle scavenging [40]	Fatty oil
31	*Camellia sinensis*	Green tea (chai)	Theaceae	Leaves	Increase insulin secretion	Polyphenolic constituents (EGCG) [41]
32	*Capparis deciduas* Edgew	Karer	Capparidaceae	Powder	Hypoglycemic, antioxidant, hypolipidaemic [42]	
33	*Capsicum frutescens* Linn.	Mirch	Solanaceae	Entire plant	Increase insulin secretion & reduction of insulin binding on the insulin receptor	Capsaicin, protein [43]
34	*Carum carvi* Linn.	Shia jira	Umbelliferae	Fruits		V.oil, resin, carvone, fixed oil [44]
35	*Cassia alata*	Ringworm senna	Caesalpiniaceae	Leaves 45		
36	*Cassia auriculata*	Tarwar	Caesalpiniaceae	Flower	Increase utilization of glucose through increase glycolysis [46]	
37	*Casearia esculenta*	-	Sallacaceae	Root	Increase insulin secretion [47, 48]	
38	*Catharanthus roseus* G. Don	Sadabahar	Apocynaceae	Leaves, twig & flower	Increase metabolization of glucose	Indole alkaloid, vincristine

						vinblastin [49]
39	*Citrullus vulgaris*	Watermelon	Cucurbitaceae	Peel of fruits	Reduce blood glucose level by regeneration of β cells [50]	
40	*Citrus sinensis*	Sweet orange	Rutaceae	Peel of fruits	Increase glucose consumption [51-54]	
41	*Citrus paradisi*	Grapefruits	Rutaceae	Seed	Reduce blood glucose level by regeneration of β cells [55]	
42	*Cinnamomum zeylanicum* Nees	Dalchini	Lauraceae	Bark	Elevation in plasma insulin [56]	V.oil, tannin, mannitol, ca.oxalate,
43	*Clausena anisata* Burm. f.		Rutaceae	Roots	Stimulate secretion of insulin [57]	
44	*Coccinia indica* W& A	Kundaru	Cucurbitaceae	Fruits, Leaves	Reduce blood glucose level by regeneration of β cells [58]	Beta sitosterol, Cucurbitacin
45	*Coriandrum sativum* Linn.	Dhania	Umbelliferae	Seed		V.oil, fixed oil, protein [59]
46	*Coscinium fenestratum Calebr*	Jharhaldi	Menispermaceae	Stem	Increase enzymatic antioxidants	Barberini, glycoside, saponin [60]
47	*Croton cajucara* Benth	Jamalgota	Euphorbiaceae	Bark		Fixed oil [61]
48	*Cryptolepis sanguinolenta* R.	Anantmul	Asclepiadaceae	Entire plant	Increase glucose uptake by 3T3-L1 cells	Cryptolepine [62]
49	*Curcuma longa* L.	Turmeric	Zingiberaceae	Rhizome	Inhibition of human pancreas alpha-amylase	Curcumin [63]
50	*Dendrobium Chrysotoxum*	Fried egg orchid	Orchidaceae	Stem	Increase enzymatic antioxidants [64]	
51	*Dioscorea Polygonoids*	Jamaican bitter yam	Dioscoreaceae	Root	Increase enzymatic antioxidants [65]	
52	*Eclipta alba* Linn.	Bhringraj	Compositae	Leaves	Decrease activity of glucose-6-phosphatase& fructose-1-6,bisphasphatase	Ecliptic alkaloid [66]
53	*Emblica Officinalis* Gaertn.	Amla	Euphorbiaceae	Fruits	Reduce 5-hydroxymethylfurfural, creatinine albumin level	Vit.C, tannin [67]
54	*Enicostemma littorale* Blume	Chhota chirayata	Gentianaceae	Entire plant	Decrease glycosylated Hb & glucose 6 phosphatase	Swertiamarine glycoside [68-70]
55	*Eugenia jambolana* Lam.	Jamun	Myrtaceae	Seed, fruit, leaves, kernel	Lowers plasma glucose level [71-73]	
56	*Eucalyptus globulus* Labill.	Eucalyptus	Myrtaceae	Leaves	Increase insulin secretion from a clonal pancreatic beta line (BRIN-BD 11)	Essential oil, cineol [74]
57	*Euphrasia*	Eyebright	Scrophulariaceae	Leaves [75]		

	officinale					
58	*Ficus religiosa* Linn.	Peepal	Moraceae	Entire plant	Initiating release of insulin	Tannin [76]
59	*Ficus bengalensis* Linn.	Bargad	Moraceae	Bark	Rising serum insulin	Tannin [77]
60	*Ficus carica*	Anjir	Moraceae	Leaves [78]		
61	*Gymnema montanum* hook f.		Asclepiadaceae	Leaves	Antioxidant & antiperoxidative [79]	
62	*Gymnema Sylvestre* R.	Gudmar	Asclepiadaceae	Leaves	Lowers plasma glucose level	Gymnemic acid, quercital [80-83]
63	*Gentiana olivieri* Griseb.		Gentianaceae	Flowers	Lowers plasma glucose level	Iso-orientin C-glycoside [84]
64	*Glycyrrhiza glabra* Linn.	Mulethi	Leguminosae	Root	Lowers plasma glucose level	Triterpenoid, saponin, glycyrrhizin [85]
65	*Gynura procumbens*		Compositae	Leaves	Lowers plasma glucose level [86]	
66	*Hibiscus rosa sinensis* Linn.	Gudhal (China rose)	Malvaceae	Entire plant	Stimulate insulin secretion from beta cells	Vit.B,C, Fat [87]
67	*Helicteres isora* Linn.	Indian screw tree	Sterculiaceae	Root	Decrease plasma triglyceride level & insulin-sensitizing activity	Saponin, tannin, lignin [88]
68	*Hordeum vulgare*	Jau	Graminaeae	Barley [89]		
69	*Hovenia dulcis* Thunb	Sicka	Rhamnaceae	Entire plant		Flavonoids [90]
70	*Ipomoea aquatica* Forsk.	Kalmisag	Convolvulaceae	Leaves	Reduce fasting blood sugar level & serum glucose level	Carotene [91]
71	*Ipomoea batata* Linn.	Shakarkand	Convolvulaceae	Tubers	Reduce insulin resistance & blood glucose level [92]	
72	*Juniperus communis* Linn.	Hauber	Pinaceae	Fruits	Increase peripheral glucose consumption & induce insulin secretion [93]	
73	*Lupinus albus* Linn.	Turmas	Fabaceae	Seed	Lower serum glucose level	Alkaloid, fatty oil, asparagines [94]
74	*Luffa aegyptiaca* Mill.	Ghiatori	Cucurbitaceae	Seed	Lactagogue activity	Fatty oil [95]
75	*Leucas lavandulaefolia* Rees	Kumbha	Labiatae	Entire plant	Reduce blood glucose level [96]	
76	*Lagerstronemia speciosa*	Jarul	Lythraceae	Leaves [97]		
77	*Lepidium sativum*	Halim, huff	Cruciferae	Seeds [98]		
78	*Mangifera*	Mango	Anacardiaceae	Leaves	Reduction of intestinal	Mangiferin [99]

	indica Linn.				absorption of glucose	
79	*Myrtus communis* L.	Vilayati mendhi	Myrtaceae	Leaves	Lower blood glucose level	V. oil mirtii oleum [100]
80	*Memecylon umbellatum Burm*	Anjani	Melastomataceae	Leaves	Lower serum glucose [101]	
81	*Momordica cymbalania* Fenzl ex naud in	kadavanchi	Cucurbitaceae	Fruit powder	Reduce blood glucose level [102]	
82	*Mucuna pruriens* L.	Kiwach	Leguminosae	Seed	Reduce blood glucose level [103]	
83	*Musa sapientum* Linn.	Banana	Musaceae	Flower	Reduce blood glucose &glycosylated Hb [104]	
84	*Momordica charantia* Linn.	Karela	Cucurbitaceae	Fruit	Reduce blood glucose level	Momordicine alkaloid, ascorbic acid [105]
85	*Morus indica* L.	Shehtoot	Moraceae	Leaves	Increase glucose uptake [106]	
86	*Murraya koeingii* (L) spreng	Curry leaf	Rutaceae	Leaves	Increase glycogenesis, decrease glycogenolysis & gluconeogenesis [107]	
87	*Nelumbo nucifera* Gaertn.	Lotus	Nymphaeaceae	Rhizome	Reduce blood sugar level	Nuciferin, nornuciferin [108]
88	*Ocimum sanctum* Linn.	Tulsi	Labiatae	Leaves	Lowering blood sugar level	V. oil, phenol, aldehyde, fixed oil, alkaloid, tannin, ascorbic acid [109]
89	*Olea europium* Linn.	Olive	Oleaceae	Leaves	Potentiation of glucose, induced insulin released, & increase peripheral uptake of glucose	Oleuropeoside [110]
90	*Opuntia Ficus indica* Mill	Indian fig	Cactaceae	Stem [111]		
91	*Pandanus odors* Linn.	Kevra	Pandanaceae	Root	Decrease plasma glucose level	Essential oil [112]
92	*Panax ginseng* Mey.	Pannag	Araliaceae	Root & entire plant	Lowering blood sugar level	Glycans, panaxans I, J, K & L [113]
93	*Punica granatum* Linn.	Anar	Punicaceae	Seed	Reduce blood sugar level	Vit.C, protein, tannin, gallic acid, pelletierine [114]
94	*Picrorrhiza kurroa* Royle ex. Benth	Katuka	Scrophulariaceae	Entire plant	Decrease serum glucose	Picrorrhizin, kutkin [115]
95	*Phyllanthus amarus*	Bhui amla	Euphorbiaceae	Entire plant	Decrease blood glucose level	Alkaloids [116]
96	*Phaseolus vulgaris*	Lobia	Papilionaceae	Pod, seed, whole plant	Hypoglycemic, hypolipidemic, inhibit alpha-amylase activity, antioxidant [117]	

97	*Salacia oblonga*	Chundan	Celastraceae	Root	inhibition of alpha-glucosidase activity [118]	
98	*Salacia reticulata* Wight.	Anukudu chettu	Celastraceae	Stem & root	inhibition of alpha-glucosidase activity [119]	
99	*Swertia chirayata* Roxb. ex. Flem	Chirayata	Gentianaceae	Entire plant	Stimulates insulin release from islets	Xanthone mangiferin, gentianine, swertisin [120]
100	*Syzygium cumini* Linn.	Jamun	Myrtaceae	Seed	Decrease blood glucose level [121]	
101	*Scoparia dulcis* Linn.	Mithi patti	Scrophulariaceae	Leaves	Decrease glycosylated Hb & Inc. total Hb, Insulin-secretagogue activity [122]	
102	*Trigonella foenum graceum*	Methi	Leguminosae	Seed	Decrease blood glucose concentration	Protein, fat, V. oil, fixed oil, carbohydrate [123]
103	*Tribulus terrestris*	Gokhru	Zygophyllaceae	Saponin	Decrease serum glucose	Harmine [124]
104	*Tinospora crispa* Linn.	Giloe	Menispermaceae	Stem	Anti-hyperglycemic stimulates insulin release from islets [125]	
105	*Tinospora cardifolia* Willd.	Giloe	Menispermaceae	Root	Decrease blood glucose & brain lipid	Berberine, starch [126]
106	*Tamarindus indica* Linn.	Imli	Caesalpimiaceae	Seed [127]		
107	*Teramnus labialis* (Roxb) Benth	Mashoni	Fabaceae	Aerial parts		Coumarin –fraxidin [128]
108	*Urtifca dioica* Linn.	Bichhu booti	Urticaceae	Leaves	Increase insulin secretion	Fatty oil [129]
109	*Vaccinium Angustifolium*	Blue berry	Erlcaceae	Root, Stem	Enhances Beta cells Proliferation [130]	
110	*Viscum album* Linn.	Vadank	Loranthaceae	Entire plant	Alpha-glucosidase inhibitor [131]	
111	*Vinca rosea*	Sadabahar	Apocynaceae	Leaves	Beta cell rejuvenation, regeneration, & stimulation	Vincristine , vinblastine [132]
112	*Withania somnifera* Dunal	Ashwagandha	Solanaceae	Root	Decrease blood sugar level	Withanine, somnine, withaferin, withanolides [133]
113	*Xanthium strumarium*	Chhota gokhru	Compositae	Fruits	Increase glucose utilization	Phenolic compound, caffeic acid [134]
114	*Zingiber officinale Roscoe*	Adrak	Zingiberaceae	Rhizome	Increase insulin level & decrease fasting glucose level	Sesquiterpene [135]
115	*Zizyphus sativa* Gaertn	Pitni-ber	Rhamnaceae	Leaves	Dose-dependent reduction in blood glucose level	Tannin [136]

CONCLUSION: Diabetes is a disorder of carbohydrate, fat and protein metabolism attributed to diminished production of insulin or mounting resistance to its action. Herbal treatments for diabetes have been used in patients with insulin-dependent and non-insulin-dependent diabetes, diabetic retinopathy, diabetic peripheral neuropathy, *etc*. Scientific validation of several Indian plant species has proved the efficacy of the botanicals in reducing the sugar level. There are several plants known for their antidiabetic activity, with a different mode of action and phyto-constituents. This is an effort to streamline the phytoconstituents of a specific family with a specific mode of action to reduce plasma glucose. Keeping in the view from the reports on their potential effectiveness against diabetes, it is assumed that the botanicals have a major role to play in the management of diabetes, which needs further exploration for necessary development of drugs and nutraceuticals from natural resources.

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