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Botanical remedy for diabetes mellitus: Roadmap of last 10 years

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Abstract : The mankind has received a gift from mother-nature in the form of natural laboratories present within diversified plant kingdom. The plants create secondary metabolites for their own safety and many of these secondary metabolites are useful for human beings in various kinds of ailments. Diabetes is not an exception to this, there are many secondary metabolites isolated from plants which are now being utilized for treatment. The significance of isolating metabolites from plants is that they have comparatively very less side effects as compared to allopathic system of medicine (oral hypoglycaemic agents). This review takes into account, the recent updates in the treatment of diabetes mellitus using herbal products and phytochemical constituents reported so far.A total number of 150 plant species belonging to numerous families are presented in this review which is useful in the treatment of diabetes mellitus. Article also contains more than fifty medicinal compounds recently updated in literature. The most important families in present review are fabaceae and cucurbitaceae. The plants from these families are found to be of high therapeutic value to treat diabetes mellitus however families like musaceae, punicaceae and aloaceae have been found to contain least number of effective plant species. The plant parts contributing mostly active compounds are leaves, fruit & seeds.

Keywords : Diabetes, Medicinal plants, Fabaceae, Cucurbitaceae.

Introduction

Diabetes is a deadly disease and millions of people are affected worldwide. The disease is characterised by abrupt increase in blood glucose levels. It is estimated that by 2030, the population of approximately 400 million people will be affected by this disease and the cases are increasing at exponential rate. Still the patients are dependent upon allopathic system of treatment like oral hypoglycaemic agents but some of the patients are not well treated by these agents and therefore they are dependent upon synthetic insulin for reducing their blood glucose levels. The mankind has received a gift from mother-nature in the form of natural laboratories present within diversified plant kingdom. The plants create secondary metabolites for their own safety and many of these secondary metabolites are useful for human beings in various kinds of ailments. Diabetes is not an exception to this, there are many secondary metabolites isolated from plants which are now being utilized for treatment.

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The significance of isolating metabolites from plants is that they have comparatively very less side effects as compared to allopathic system of medicine (oral hypoglycaemic agents).

This review takes into account, the recent updates in the treatment of diabetes mellitus using herbal products and phytochemical constituents reported so far.

For example, recently many researchers have reported medicinally active phytoconstituents from plants like *Annona squamosa,Withania coagulans, Mangifera indica, Rosmarinus officinalis* etc. which have hypoglycaemic activity comparable with standard drug like metformin in streptozotocin induced rat model or alloxan induced rat model.

Current review contains wide information on anti-diabetic medicinal plants cultivated throughout world.[1-3]

Types of diabetes mellitus

They are categorised into two types-Type I and Type II diabetes mellitus.

Type I diabetes is also known as insulin dependent diabetes mellitus, while type II is known as non-insulin dependent diabetes mellitus.

In IDDM (Type I), the immune system of body recognises insulin as foreign body and the insulin is destroyed or the immune system may also destroy the cells that release insulin and ultimately without insulin, the body cells cannot absorb sugar eventually increasing blood sugar levels.

NIDDM (Type II) can be developed in any age of patients. It is also a lifestyle based progression of disease which becomes more prominent in the age group 30-40 years. NIDDM accounts for 90-95% of total diabetic population. In this case the insulin production by the β cells of pancreas is normal but due to insulin resistance the body cells are unable to make use of released insulin. In some cases the pancreas are producing less quantity of insulin known as insulin deficiency.

Complications of diabetes mellitus

There are two types of complications observed micro vascular and macro vascular complication of diabetes.

(a) Micro vascular complications-

Diabetes retinopathy can cause blindness in both type I and Type II diabetes. Most of the patients develop this complication within 15-20 years of diagnosis.

Diabetic nephropathy causes renal failure. In diabetic nephropathy the protein content (proteinuria) is more than 500 mg/ 24hrs. Microalbuminuria is also observed at excretion rate of 100-300 mg/24hrs.

Diabetic neuropathy causes injury to neurons which ultimately results in death of neurons causing severe neurogenic disorders in patients.

(b) Macro vascular complications-

One of the complications is process of atherosclerosis causing narrowing of arteries due to injury in arterial wall. Because of this endothelial injury and inflammation, the low density lipid molecules start depositing at the place of injury blocking coronary artery causing atheroma ultimately leading to IHD (Ischemic Heart Disease). Myocardial infarction is very prominent in patient of diabetes.

Accumulation of excess glucose causes lipogenesis increasing the fat content of body ultimately causing obesity.

Since sugars are high molecular weight compounds therefore diabetic patients develops hypertension.[4]

Etiology of diabetes mellitus

In Type I diabetes, insulin can be damaged by once own immune system. This can be due to genetics or environmental factors for example virus which can trigger the disease.

In Type II diabetes most of the cells become insulin resistant or the pancreas is not generating enough insulin. Patients with excess body fat, high blood pressure, high cholesterol are also under the risk factors. Certain medications also increase the risk of type II diabetes for e.g. Statins, β-blockers, thiazides and some corticosteroids, stress has been linked recently to type II diabetes.

Medicinal plants used in diabetes management

From very early times many effective plants are known to humankind to treat diabetes mellitus.Plants can create natural compounds which are non-toxic and very effective against diabetes. Despite increase in synthetic drugs, still the natural products are more economical and significant. And now-a-days there is much demand for alternative medicine from plant origin. We present in this review an avalanche of plants which are used traditionally to cure diabetes (Table1).

Table 1: List of Antidiabetic plants

S. no.	Name of plant	Family	Common name	Plant part used	Reference No.
1	*Acacia auriculiformis*	Fabaceae	Auri, ear leaf acacia	Leaf	[5]
2	*Acacia arabica*	Mimosaceae	Babul	Gum	[6]
3	*Acacia ligulata*	Fabaceae	Sandhill wattle, umbrella bush, marpoo, dune wattle	Whole plant	[7]
4	*Aerva lanata*	Amaranthaceae	Sunny khur	Bark, roots	[8]
5	*Aegle marmelos*	Rutaceae	Bael	Fruit, leaves	[9]
6	*Allium cepa*	Liliaceae	Pyaj	Bulb	[10]
7	*Aloe vera*	Aloaceae	Ghee kunwar	Leaf	[11]
8	*Andrographis paniculata*	Acanthaceae	Kalmegh	Leaf, roots	[12]
9	*Annona squamosa*	Annonaceae	Sharifa	Seed, fruits	[8]
10	*Areca catechu*	Arecaceae	Supari	Seeds	[8]
11	*Artemisia pallens*	Compositae	Davana	Aerial parts	[13]
12	*Azadirachta indica*	Meliaceae	Neem	Seed, leaves, bark	[14]
13	*Artemisia herba alba*	Asteraceae	White worm wood	leaves	[15]
14	*Allium sativum*	Alliceae	Lahasun	Bulb	[16]
15	*Annona muricata*	Annonaceae	Soursup, custard apple	Fruit	[17]
16	*Aloe marlothii*	Asphodelaceae	Mountain aloe	Leaf	[18]
17	*Allium porrum*	Amaryllidaceae	Leek	Stem	[19]
18	*Acosmium panamense*	Fabaceae	Malvecino	Leaves	[20]
19	*Ammoides pusilla*	Apiaceae	Cerfolium	Whole plant	[21]

20	*Allium hirtifolium*	Amaryllidaceae	Persian shallot	Bulb	[22]
21	*Barleria lupulina*	Acanthaceae	Snake bush	Aerial parts	[23]
22	*Beta vulgaris*	Chenopodiaceae	Chukandar	Stem	[24]
23	*Begonia roxburghii*	Begoniaceae	East himalayan begonia	Leaves	[25]
24	*Benincasa hispida*	Cucurbitaceae	Wax gourd	Fruit	[26]
25	*Biophytum sensitivum*	Oxalidaceae	Lajjalu	Leaf	[24]
26	*Boerhavia diffusa*	Nyctanginaceae	Punarnava	Leaf	[27]
27	*Bombox ceiba*	Bombaceae	Semul	Leaves	[28]
28	*Brassica juncea*	Brassicaceae	Rai	Seeds	[29]
29	*Bridelia ferruginea*	Euphorbiaceae	Fula pulaar, manding maninka	Leaves	[17]
30	*Cucumeropsis mannii*	Cucurbitaceae	White seed melon	Fruit	[30]
31	*Caesalpinia bonducella*	Cesalpinaceae	Kantkarej	Seeds	[31]
32	*Canjanus cajan*	Fabaceae	Tuvar	Leaves	[32]
33	*Camellia sinesis*	Theaceae	Chai ki patti	Leaves	[33]
34	*Capparis deciduas*	Capparidaceae	Keekar, kirir, karril	Fruit	[24]
35	*Casearia esculenta*	Flacourtiaceae	Saptarangi	Roots	[8]
36	*Cassia auriculata*	Cesalpinaceae	Tanner	Flowers	[34]
37	*Catharanthus roseus*	Apocynaceae	Sadabahar	Flowers and leaf	[8]
38	*Citrullus colocynthis*	Cucurbitaceae	Indryan	Fruit, leaves, stem	[35]
39	*Coccinia indica*	Cucurbitaceae	Kundru	Aerial part	[36]
40	*Curcuma longa*	Zingiberaceae	Haldi	Rhizome	[8]
41	*Cynodon dactylon*	Poaceae	Doob	Stem	[36]
42	*Cinnamomum tamala*	Lauraceae	Indian bay leaf, tejpatta, malabar leaf	Leaf	[37]
43	*Crataeva nurvala*	Capparaceae	Varuna	Bark	[5]
44	*Citrullus lanatus*	Cucurbitaceae	Watermelon	Fruit	[30]
45	*Curcurbita moschata*	Cucurbitaceae	Crookneck pumpkin	Fruit	[30]
46	*Cassia abbreviata*	Fabaceae	Long tail cassia	Stem	[20]
47	*Cecropia obtusifolia*	Urtiaceae	Trumpet tree	Bark	[20]
48	*Cydonia oblonga*	Rosaceae	Quince	Fruit	[19]
49	*Cinnamomum verum*	Lauraceae	True cinnamon	Bark	[38]
50	*Calamus pseudotenuis*	Arecaceae	Slender rattan cane	Whole plant	[39]
51	*Callicarpa arborea*	Verbenaceae	Ghiwala, kumhar	Leaves	[39]
52	*Cuscuta reflexa*	Convolvulaceae	Giant dodder	Whole plant	[39]
53	*Cassia fistula*	Fabaceae	Golden shower tree	Fruit	[40]
54	*Dendrocalamus*	Poaceae	Hamilton's	Stem	[37]

	hamiltonii		bamboo		
55	*Diospyros abyssinica*	Ebenaceae	giant diospyros	Bark, roots leaves	[5]
56	*Dillenia indica*	Dilleniaceae	Elephant apple	Fruit	[39]
57	*Diplazium esculentum*	Athyriaceae	Vegetable fern	Whole plant	[39]
58	*Dracocephalum modavica*	Lamiaceae	Moldavian dragonhead	Whole plant	[5]
59	*Eniocostemma littorale*	Gentiaceae	Chhota chirata	Whole plant	[41]
60	*Eucalyptus globules*	Myrtaceae	Safeda	Leaves	[42]
61	*Eugenia uniflora*	Myrtaceae	Surinam cherry	Leaves	[8]
62	*Eugenia jambolana*	Myrtaceae	Java plum	Seed	[43]
63	*Emblica officinalis*	Phyllanthaceae	Indian gooseberry, amla	Fruit	[44]
64	*Ficus racemosa*	Moraceae	Gular	Fruits	[45]
65	*Ficus bengalensis*	Moraceae	Bargad	Fig	[46]
66	*Ficus glomerata*	Moraceae	Cluster fig tree	Fruit	[37]
67	*Ficus microcarpa*	Moraceae	Malayan banyan	Root, bark, leaf	[5]
68	*Ficus religiosa*	Moraceae	Sacred fig	Bark, leaf	[43]
69	*Glycyrrhiza glabra*	Fabaceae	Licorice	Roots	[47]
70	*Glymnema montanum*	Asclepiadaceae	Madhu nashini	Leaf	[48]
71	*Gymnema sylvestre*	Asclepiadaceae	Gudmar	Leaf	[49]
72	*Gardenia ternifolia*	Rubiaceae	forest gardenia	Fruit	[17]
73	*Geranium sanguineum*	Geraniaceae	Bloody geranium	Flower	[5]
74	*Gymnosporia buxifolia*	Celastraceae	Spikethorn	Whole plant	[20]
75	*Helicteres isora*	Streailiaceae	Maror phali	Bark	[50]
76	*Hibiscus rosa sinensis*	Malvaceae	Gudhal	Flowers	[51]
77	*Hygrophila auriculata*	Acanthaceae	Talim khana	Aerial parts	[52]
78	Mimusops zeyheri	Sapotaceae	milkwood	leaves	[18]
79	*Hypoxis iridifolia*	Hypoxidaceae		Whole plant	[18]
80	*Helianthus tuberosus*	Asteraceae	Jerusalem artichoke, sunroot	Root	[19]
81	*Indigofera mysorensis*	Fabaceae	Mysore panicled indigo	Whole plant	[53]
82	*Ipomaea botatas*	Convolvulaceae	Sweet potato	Roots	[54]
83	*Khaya senegalensis*	Meliaceae	Khaya wood, cailcedrat	Bark	[17]
84	*Lantana camara*	Verbenaceae	Caturang	Leaves	[24]
85	*Lactuca indica*	Asteraceae	Indian lettuce	Seeds	[8]
86	*Langenaria siceraria*	Cucurbitaceae	Calabash	Fruit	[30]
87	*Lactuca gracilis*	Asteraceae		Whole plant	[39]
88	*Millingtonia hortensis*	Bignoniaceae	Indian cork	Leaves	[39]
89	*Mangifera indica*	Anacardiaceae	Aam	Leaf	[55]

90	*Momordica charantia*	Cucurbitaceae	Karela	Fruit	[56]
91	*Memecylon umbellatum*	Melastomataceae	Anjani	Leaves	[24]
92	*Momordica cymbalaria*	Cucurbitaceae	Kadavanchi	Fruits	[24]
93	*Morus alba*	Moraceae	Shetut	Leaves	[24]
94	*Mucuma pruriens*	Leguminosae	Kavach	Seeds	[57]
95	*Murraya koeingii*	Rutaceae	Kadhi patta	Leaves	[58]
96	*Musa sapientum*	Musaceae	Kela	Flowers	[59]
97	*Moringa oleifera*	Moringaceae	Drumstick tree	Leaves, seeds	[18]
98	*Mimusops zeyheri*	Saptoaceae	Milkwood	Fruit	[18]
99	*Momordica balsamina*	Cucurbitaceae	Balsam pear	Fruit	[20]
100	*Morinda citrifolia*	Rubiaceae	Cheese fruit	Fruit	[60]
101	*Nelumba nucifera*	Nymphaeaceae	Kamal	Rhizome	[61]
102	*Nigella sativa*	Ranunculaceae	Black cumin	Seeds	[62]
103	*Ocimum sanctum*	Lamiaceae	Tulsi	Leaves	[63]
104	*Oxalis griffithii*	Oxalidaceae		Flower	[39]
105	*Phyllanthus amarus*	Euphorbiaceae	Jangli amla	Whole plant	[20]
106	*Picorrhiza kurroa*	Scrophulariaceae	Kutka	Roots	[64]
107	*Pongamia pinnata*	Fabaceae	Karanja	Flower	[65]
108	*Pterocarpus marsupium*	Fabaceae	Vijaysar, Malabar kino	Leaves, flower	[66]
109	*Punica grantum*	Punicaceae	Pomegranate	Flower	[66]
110	*Premna integrifolia*	Lamiaceae	Agnimantha, arani	Whole plant	[37]
111	*Psidium guajava*	Myrtaceae	Common guava	Fruit	[17]
112	*Parkia biglobosa*	Mimosaceae	Chenduphal	Seeds	[17]
113	*Plumeria obtuse*	Apocynaceae	Singapore graveyard flower	Bark	[18]
114	*Pistacia lentiscus*	Anacardiaceae	Mastic tree	Whole plant	[5]
115	*Psoralea coryfolia*	Fabaceae	Bavanchiyani baschi	Seeds	[60]
116	*Portulaca oleracea*	Portulacaceae	Common purslane	Seeds	[67]
117	*Ricinus communis*	Euphorbiaceae	Eranda	Roots	[68]
118	*Rosmarinus officinalis*	Labiatae	Rosemary	Bark seed	[69]
119	*Salacia oblonga*	Celastaceae	Saptrangi	Roots	[70]
120	*Salacia reticulata*	Celastaceae	Kothala himbutu	Stem	[71]
121	*Scoparia dulcis*	Scrophulariaceae	Sweet broom weed	Leaves	[72]
122	*Sida cordifolia*	Malvaceae	Bala	Aerial and root parts	[73]
123	*Swertica chirayita*	Gentianaceae	Kariyat	Flowers	[74]
124	*Syzigium cumini*	Myrtaceae	Jamun	Seed	[75]
125	*Sarcocephalus lantifolius*	Rubiaceae	African peach	Fruit	[17]
126	*Securidaca longepedumculata*	Polygalaceae	Violet tree	Root	[17]

127	*Sargentodoxa cuneata*	Lardizabalaceae	Hong teng	Leaves	[5]
128	*Senna italica*	Fabaceae	Port royal senna	Leaves, seeds	[20]
129	*Santalum spicatum*	Santalaceae	Australian sandlewood, waang, wollgat	Bark	[76]
130	*Solanum viarum*	Solanaceae	The tropical soda apple	Fruit	[39]
131	*Terminalia catappa*	Combretaceae	Badam	Fruit	[77]
132	*Terminalia pallida*	Combretaceae	Harad	Fruit	[78]
133	*Trigonella foenum graecum*	Fabaceae	Fenugreek, methi	Seed	[79]
134	*Tinospora cordifolia*	Menispermaceae	Giloe	Stem, leaves	[20]
135	*Tetraclinis articulata*	Cupressaceae	Thuja articulate	Leaves, fruits,	[15]
136	*Tragia involucrata*	Euphorbiaceae	Climbing nettle	Whole plant	[37]
137	*Terminalia bellirica*	Combretaceae	Bahera	Fruit	[37]
138	*Trichosanthes cucumerina*	Cucurbitaceae	Snake gourd	Fruit	[37]
139	*Thymelaea hirsuta*	Thymelaeaceae	Mitnan	Whole plant	[21]
140	*Teucrium polium*	Lamiaceae	Felty germander	Whole plant	[5]
141	*Telfairia occidentalis*	Cucurbitaceae	Fluted pumpkin	Fruit	[39]
142	*Tinospora fragrosa*	Menispermaceae		Leaves	[20]
143	*Tribulus terrestris*	Zygophyllaceae	Bindii	Fruit	[38]
144	*Tinospora cordifolia*	Menispermaceae	Heart leaved moonseed	Leaves	[80]
145	*Urtica dioica*	Urticaceae	Common nettle	Leaves	[21]
146	*Vinca rosea*	Apocynaceae	Rose periwinkle, madagascar periwinkle	Flower	[37]
147	*Vernonia amygdalina*	Asteraceae	Gymnanthemum amygdalinum	Whole plant	[81]
148	*Withania coagulans*	Solanaceae	Paneer ke phool	Fruit	[82]
149	*Waltheria indica*	Malvaceae	Sleepy morning, basora prieta	Leaves	[20]
150	*Zingiber officinale*	Zingiberaceae	Adrak	Rhizome	[83]

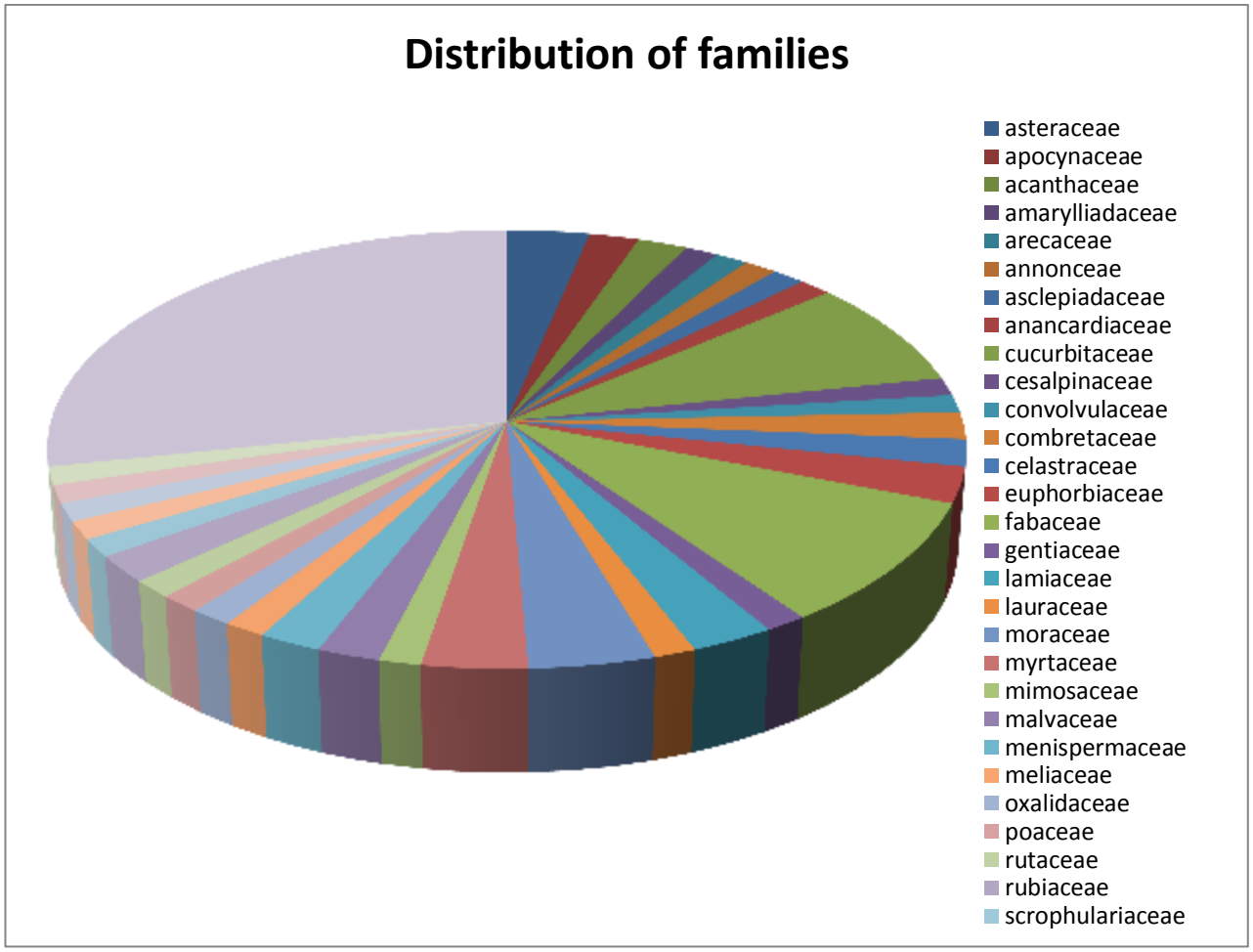


Figure 1: Distribution of families with Antidiabetic activity

***Others :** amaranthaceae, aloaceae, alliceae, asphodelaceae, apiaceae, athyriaceae, brassicaceae, begoniaceae, bombaceae, bignoniaceae, compositae, capparidaceae, capparaceae, cupressaceae, chenopodiaceae, dilleniaceae, ebenaceae, flacourtiaceae, geraniaceae, hypoxidaceae, liliaceae, leguminoseae, lardizabalaceae, labiatae, melastomataceae, musaceae, moringaceae,nyctanginaceae, nymphaeaceae, phyllanthaceae, punicaceae, portulaceae, polygalaceae, rosaceae, ranunculaceae, streailiaceae, saptoaceae, santalaceae, theaceae, thymelaeaceae, zygophyllaceae

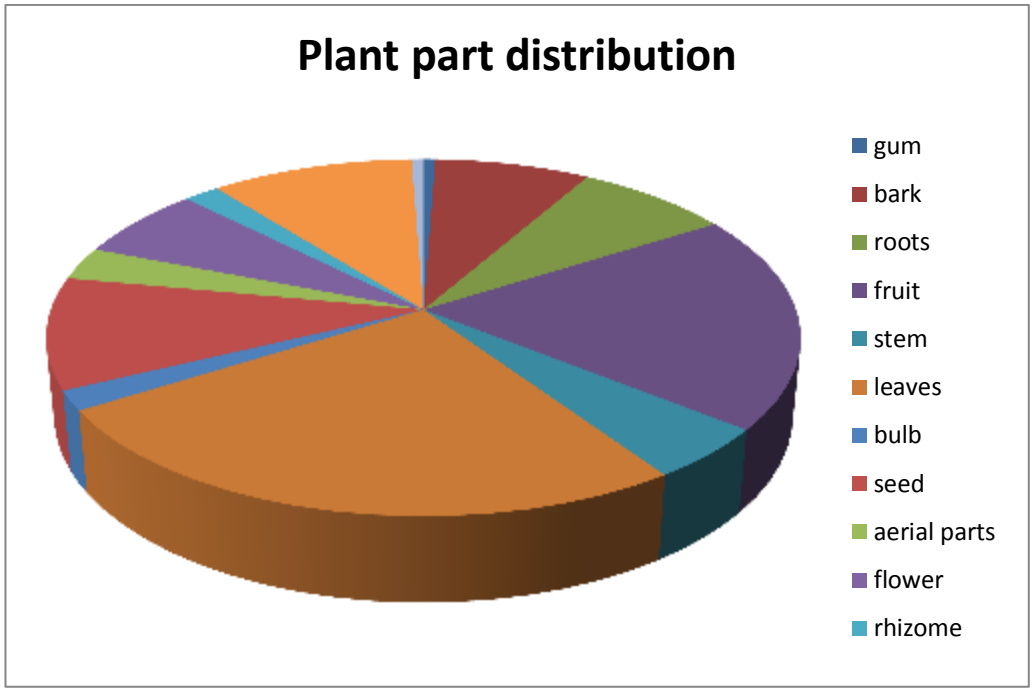


Figure 2: Distribution of part of plant used to extract Antidiabetic compounds

Novel isolated anti diabetic compounds from plants

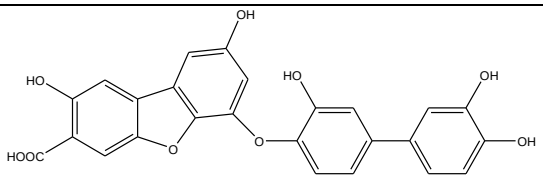
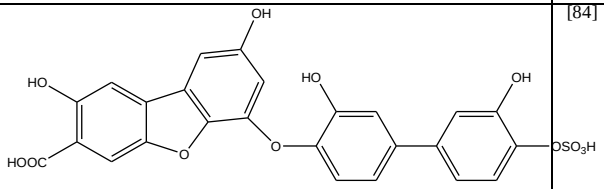
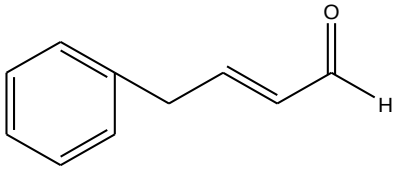
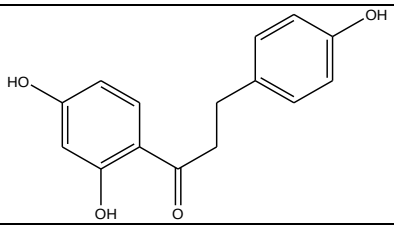
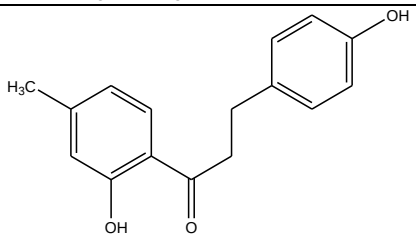
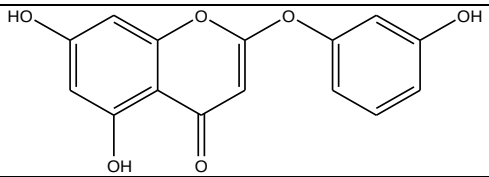
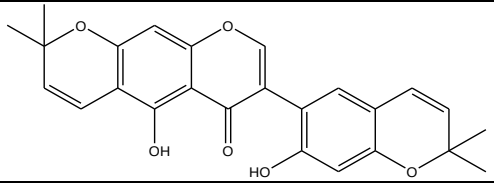
In the recent years many anti-diabetic natural compounds have been isolated from different species of plants. Green algae *Cladophora socialis* cause potent inhibition of protein tyrosine phosphatase 1B, an enzyme which helps in regulation of insulin receptors.[84]

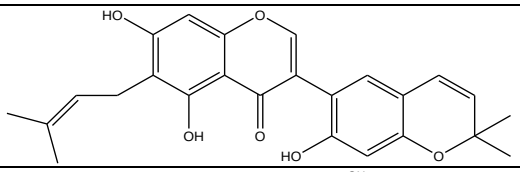
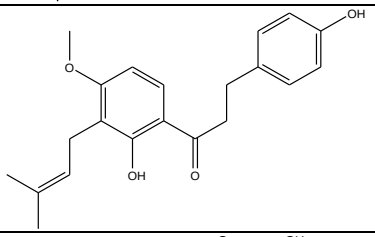
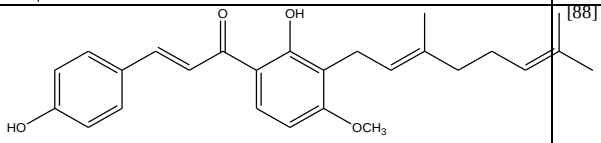
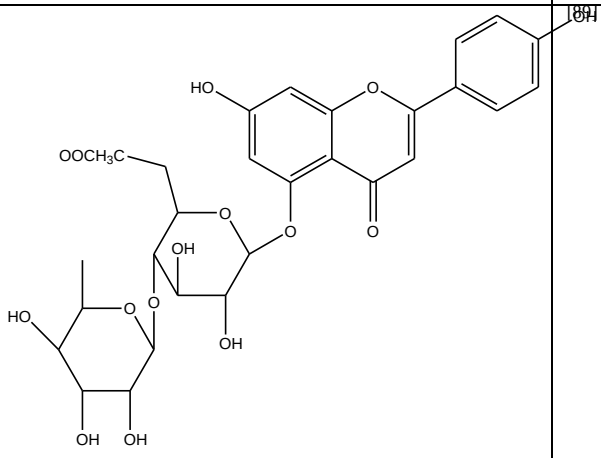
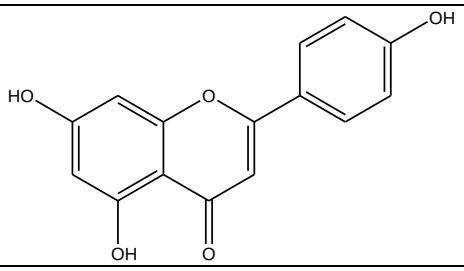
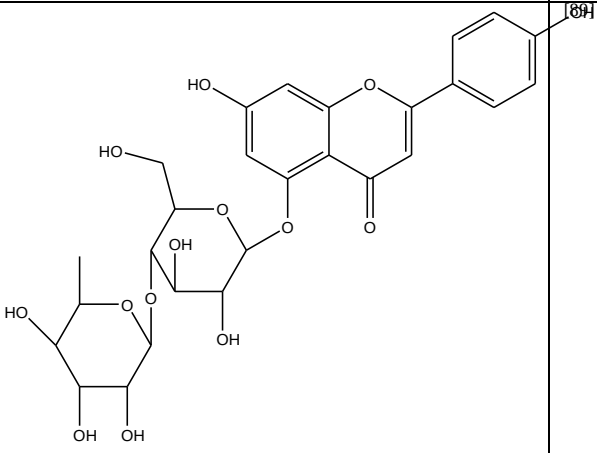
Compounds cinnamaldehyde obtained from *cinnamonum zeylanicum* possesses anti diabetic activity and was able to lower blood glucose level up to 63% as compared with glibenclamide in STZ induced rat model.[85]

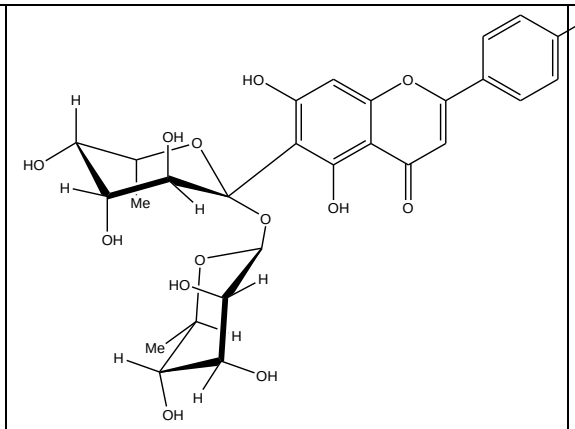
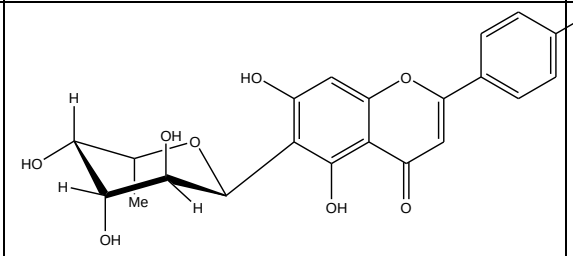
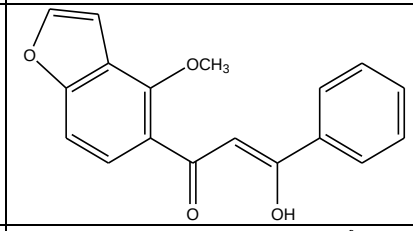
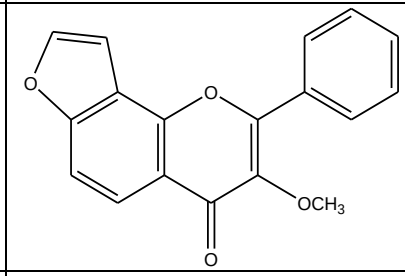
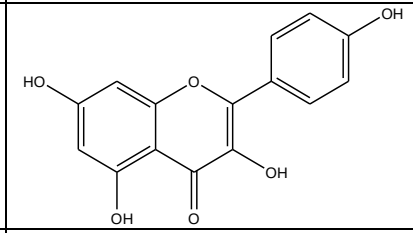
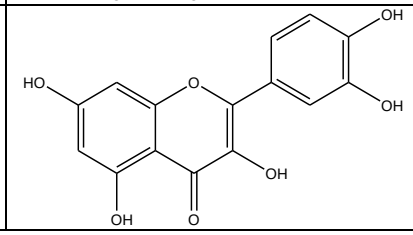
Artemisia dracunculus L. afforded a potent compound davidigenin and two more compounds from this plant also known as Russian tarragon were found to be potent anti-diabetic compounds. These compounds were able to activate PI3K pathway similar to insulin.[86]Roots of *Eriosema kraussianum* N.E.Br. yielded twobioactive compound kraussianone I and kraussianone II which have vasodilatory and hypoglycaemic properties.[87]4-hydroxyderricin and xanthoangelol were obtained from ethanolic extract of *angelica keiskeikoideumi* were found to have activity similar to insulin by PPAR-γ receptor activation pathway. These compounds were effective against diabetes mellitus and were able to decrease insulin resistance when compared with drug pioglitezone.[88]Ethanolic extracts of leaves of cephalotaxussinensus afforded threeflavonoids apigenin-5-O-[α-L-rhamnopyranosyl-(1-4)-6-O-β-D-acetylglucopyranoside, apigenin &apigenin-5-O-[α-L-rhamnopyranosyl-(1-4)-6-O-β-D-glucopyranoside which have anti hyperglycaemic affect compared to standard control insulin.[89]Leaves of *Averrhoa carambola* L. yielded compound Apigenin-6-C-(20-O-α-L-rhamnopyranosyl)-β-L-fucopyranoside which showed anti hyperglycaemic activity in alloxan induced diabetic rat model. Compound Apigenin-6-C-β-L-fucopyranoside from the same plant was able to promote glucose induced insulin secretion and stimulated glycogenesis.[91]Fruits of *Pongamia pinnata* L. Pierre afforded pongamol and karanjin which showed anti-hyperglycemic activity STZ induced rat model. Both the compounds has similar efficacy as compared to standard drug metformin.[92]*Euonymus alatus* yielded two compounds kaempferol, quercitin were found to have anti hyperglycaemic effect. They were able to improve insulin stimulated glucose uptake in mature adipocytes and are also found to have partial agonism in PPAR-γ in a competitive ligand binding assay.[93]Machilus philippoinense Merr from lauriaceae family afforded acylated compound kaempferol-3-O-α-L-rhamnopyranosides by BDFI (bioassay dependent extraction & isolation) method were able to inhibit α-glucosidase enzyme and had similar activity to acarbose.[36]*Aspalthus linearis* from fabaceae afforded aspalathin was found to enhance glucose reuptake and increase insulin secretion. This compound was able to improve impaired glucose tolerance in different rat models.[96]*Tetracerascandens* afforded many isoflavons such as

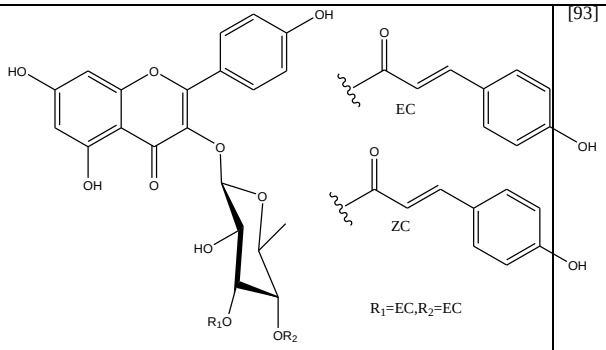
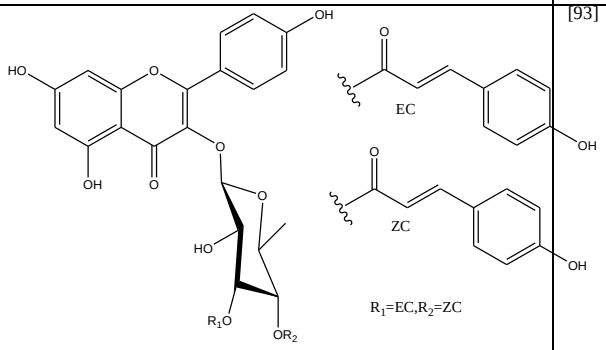
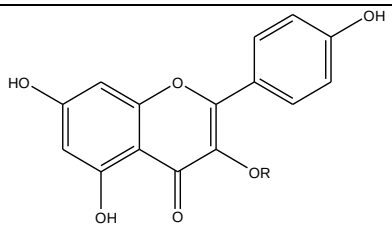
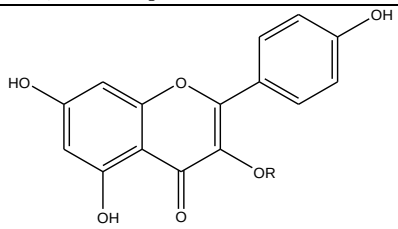
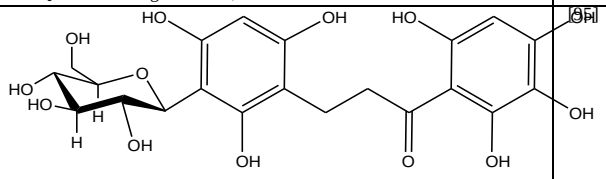
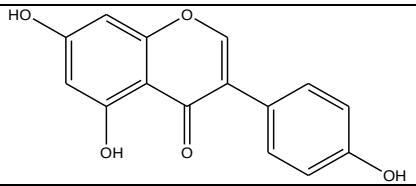
genisteins and its derivatives genistein, 3',5'-diprenylgenistein, 6,8-diprenylgenistein, derroneand alpinumis of lavone were able to stimulate insulin secretion by AMPK activation. These compounds were also able to inhibit protein, tyrosine phosphatase as compared to ursolic acid.[97]In recent years a number of antidiabetic natural products have been discovered. Some of the important anti diabetic compounds have been summarized in Table 2.

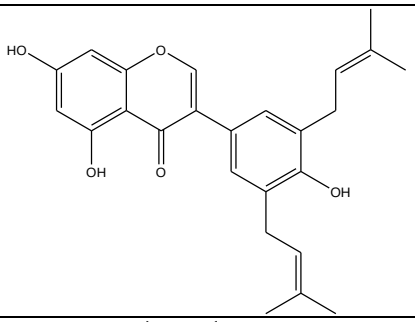
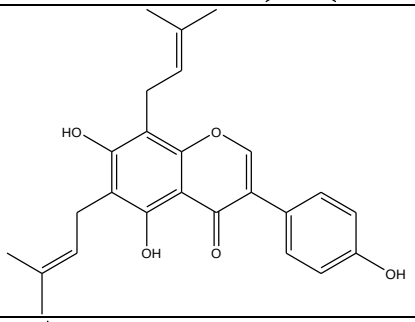
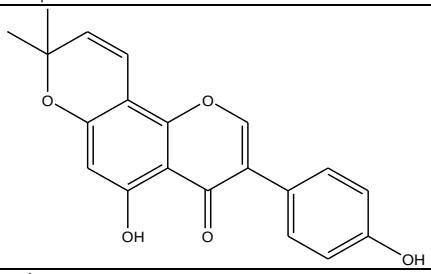
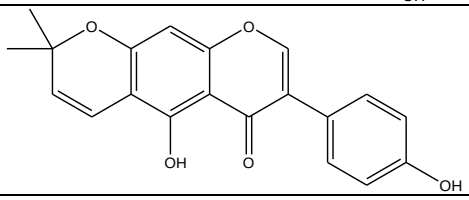
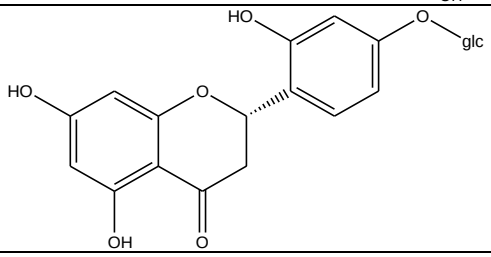
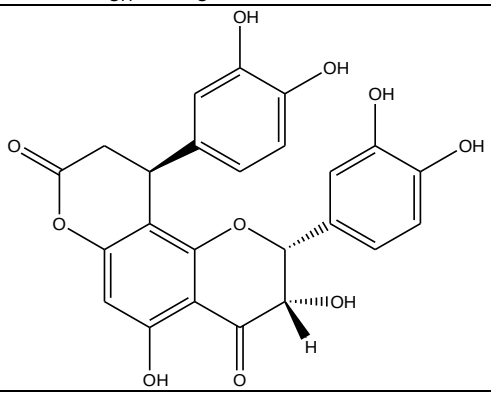
Table2: Novel isolated anti diabetic compounds from plants along with botanical names & structures

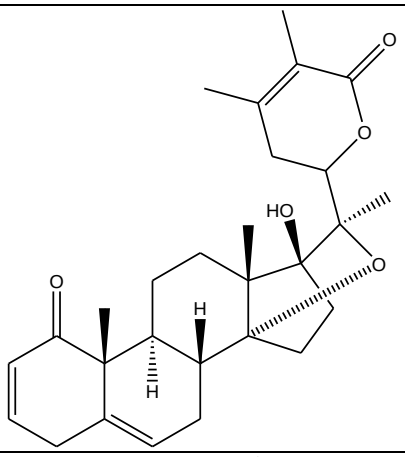
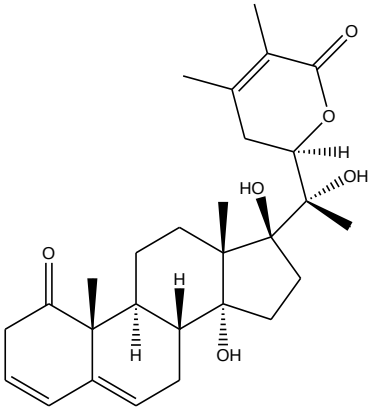
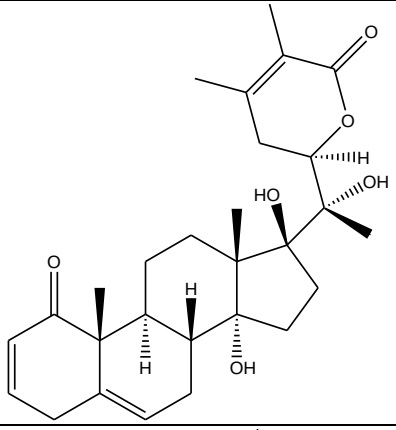
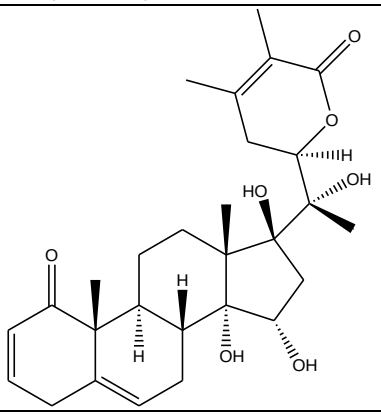
Compound No.	Species	Family	Name of compound	Structure	Ref.
1	*Cladophora socialis*	Chlorophyceae	vanillic acid derivative		[84]
2	*Cladophora socialis*	Chlorophyceae	Sulphate analog of vanillic acid derivative		[84]
3	*Cinnamonum zeylanicum* Blume	Lauraceae	Cinnamaldehyde		[85]
4	*Artemisia dracunculus* L.	Asteraceae	davidigenin		[86]
5	*Artemisia dracunculus* L.	Asteraceae	2′,4′-dihydroxy-4-methoxydihydrochalcone		[86]
6	*Artemisia dracunculus* L.	Asteraceae	6-demethoxycapillarisin		[86]
7	*Eriosema kraussianum* N. E. Br.	Fabaceae	kraussianone-1		[87]

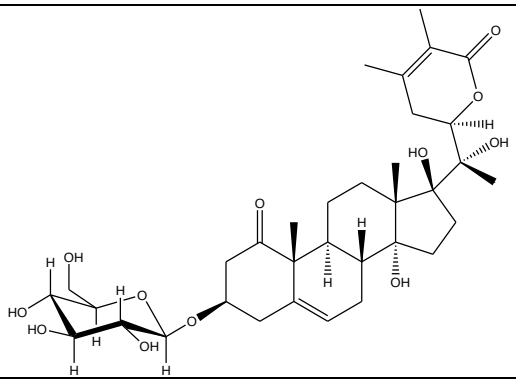
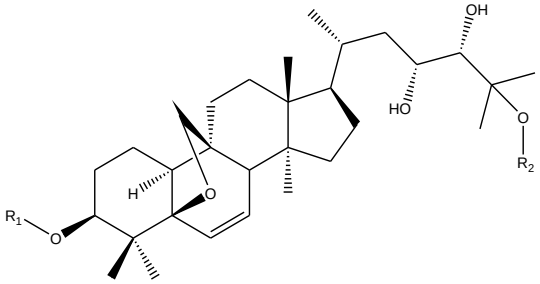
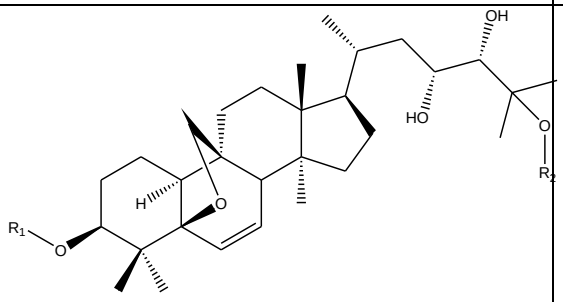
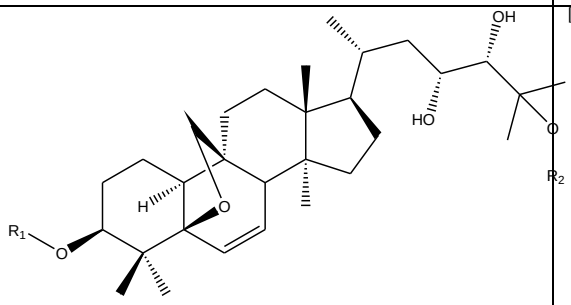
8	*Eriosema kraussianum* N. E. Br.	Fabaceae	kraussianone-2		[87]
9	*Angelica keiskei* Koidzumi	Umbelliferae	4-hydroxyderricin		[88]
10	*Angelica keiskei* Koidzumi	Umbelliferae	xanthoangelol		[88]
11	*Cephalotaxus sinensis*	Cephalotaxaceae	apigenin-5-*O*-[α-L-rhamnopyranosyl-(1→4)-6-*O*-β-D-acetylglucopyranoside]		[89]
12	*Cephalotaxus sinensis*	Cephalotaxaceae	apigenin		[89]
13	*Cephalotaxus sinensis*	Cephalotaxaceae	apigenin-5-*O*-[α-L-rhamnopyranosyl-(1→4)-6-*O*-β-D-glucopyranoside]		[89]

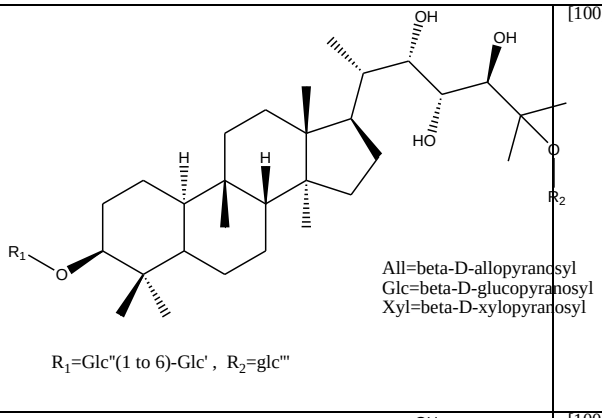
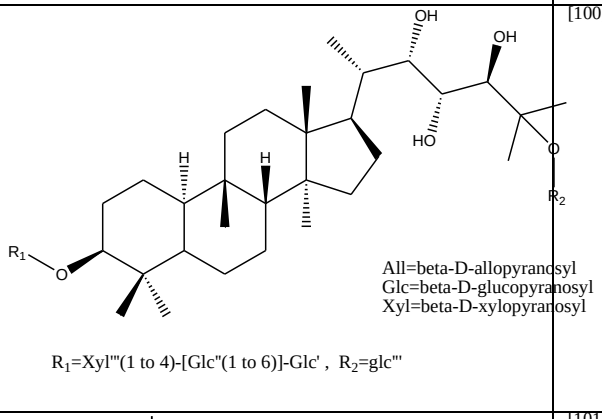
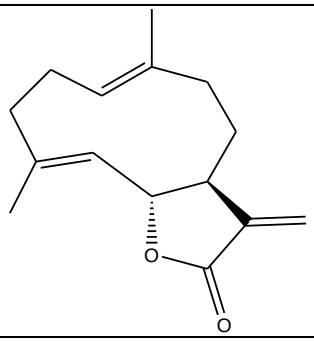
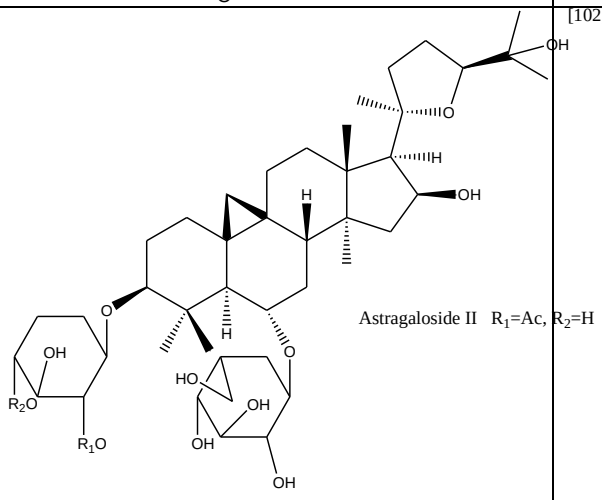
14	*Averrhoa carambola* L.	Oxalidaceae	Apigenin-6-C-(2′-*O*-α-L-rhamnopyranosyl)-β-L-fucopyranoside		[26]
15	*Averrhoacarambola* L.	Oxalidaceae	Apigenin-6-C-β-L-fucopyranoside		[90]
16	*Pongamiapinnata* (L.) Pierre	Fabaceae	Pongamol		[91]
17	*Pongamiapinnata* (L.) Pierre	Fabaceae	karanjin		[91]
18	*Euonymus alatus*	Celastraceae	Kaempferol		[92]
19	*Euonymus alatus*	Celastraceae	quercetin		[92]

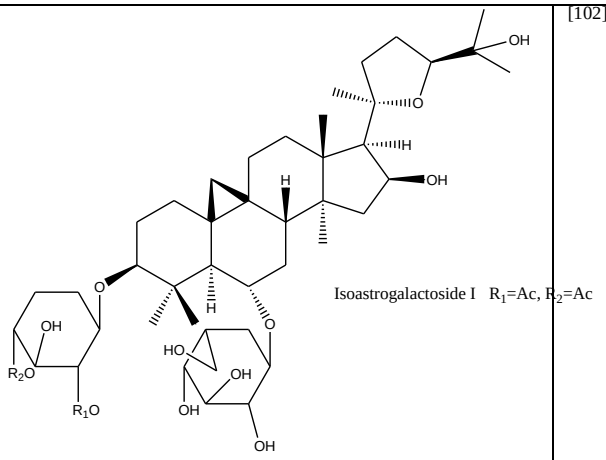
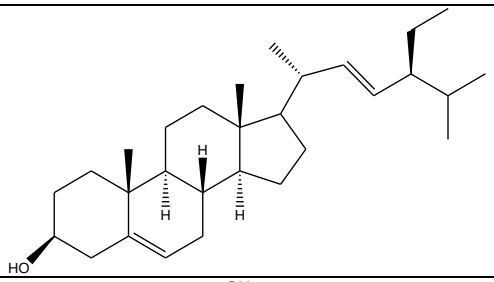
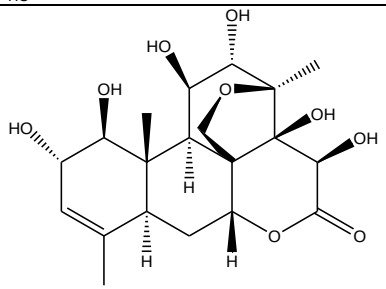
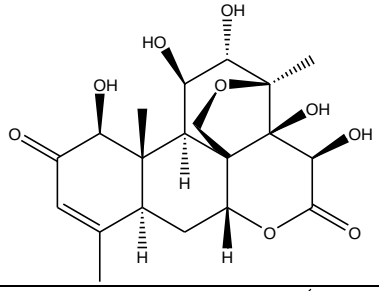
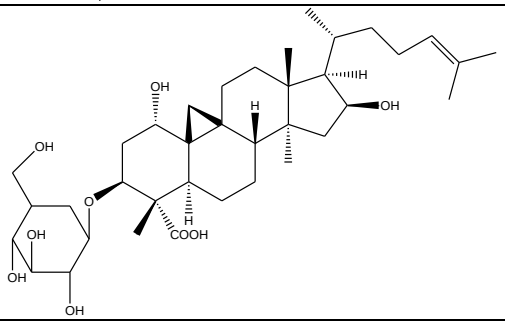
20	*Machilusphilip pinense* Merr.	Lauraceae	acylated kaempferol-3-*O*-α-L-rhamnopyranoside		[93]
21	*Machilusphilip pinense* Merr.	Lauraceae	acylated kaempferol-3-*O*-α-L-rhamnopyranoside		[93]
22	*Vacciniumvitis-idaea*	Ericaceae	quercetin 3-*O*-glycoside	 Quercetin-3-O-glucoside, R=Glucose Quercetin-3-O-galactoside, R=Galactose	[94]
23	*Vaccinium vitis-idaea*	Ericaceae	quercetin 3-*O*-galactoside	 Quercetin-3-O-glucoside, R=Glucose Quercetin-3-O-galactoside, R=Galactose	[94]
24	*Aspalathus linearis*	Fabaceae	Aspalathin		[95]
25	*Tetracera scandens*	Dilleniaceae	genistein		[96]

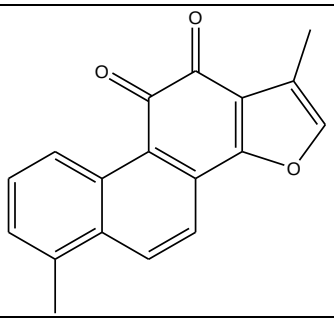
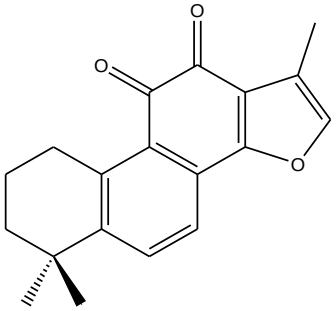
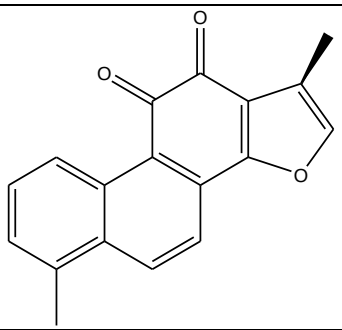
26	*Tetracera scandens*	Dilleniaceae	3′,5′-diprenylgenistein		[96]
27	*Tetracera scandens*	Dilleniaceae	6,8-diprenylgenistein		[96]
28	*Tetracera scandens*	Dilleniaceae	derrone		[96]
29	*Tetracera scandens*	Dilleniaceae	alpinumisoflavone		[96]
30	*Morus alba* L.	Moraceae	Steppogenin-4′-O-β-D-glucoside		[97]
31	*Eriobotrya japonica* LINDL	Rosaceae	CinchonainIb		[98]

32	*Withania coagulans* Dunal	Solanaceae	coagulin C		[99]
33	*Withania coagulans* Dunal	Solanaceae	17β-hydroxywithanolide K		[99]
34	*Withania coagulans* Dunal	Solanaceae	withanolide F		[99]
35	*Withania coagulans* Dunal	Solanaceae	(17*S*,20*S*,22*R*)-14α,15α,17β,20β-tetrahydroxy-1-oxowitha-2,5,24-trienolide		[99]

36	*Withania coagulans* Dunal	Solanaceae	coagulin L		[99]
37	*Momordicacharantia*	Cucurbitaceae	Karaviloside XI (cucurbitane glycoside)	 R_1=All' , R_2=H All=beta-D-allopyranosyl Glc=beta-D-glucopyranosyl Xyl=beta-D-xylopyranosyl	[100]
38	*Momordicacharantia*	Cucurbitaceae	momordicosides Q (cucurbitane glycoside)	 R_1=glc' , R_2=H All=beta-D-allopyranosyl Glc=beta-D-glucopyranosyl Xyl=beta-D-xylopyranosyl	[100]
39	*Momordicacharantia*	Cucurbitaceae	momordicosides R (cucurbitane glycoside)	 R_1=All' , R_2=glc" All=beta-D-allopyranosyl Glc=beta-D-glucopyranosyl Xyl=beta-D-xylopyranosyl	[100]

40	*Momordica charantia*	Cucurbitaceae	momordicosides S (cucurbitane glycoside)		[100]
41	*Momordica charantia*	Cucurbitaceae	momordicosides T (cucurbitane glycoside)		[100]
42	*Costus speciosus*	Cheilocostus	Costunolide		[101]
43	*Astragalu spropinquus* Schischkin	Fabaceae	Astragaloside II		[102]

44	*Astragalus propinquus* Schischkin	Fabaceae	isoastragalosi de I	 Isoastrogalactoside I R_1=Ac, R_2=Ac	[102]
45	*Butea monosperma* (Lam.) Kuntze	Fabaceae	Stigmasterol		[103]
46	*Brucea javanica* (L.) Merr	Simaroubacea e	bruceines E		[104]
47	*Brucea javanica* (L.) Merr	Simaroubacea e	bruceines D		[104]
48	*Combretum molle* (R. Br. ex G. Don) Engl. & Diels	Combretacea e	1α-hydroxycyclo artenoid (Mollic acid glucoside)		[105]

49	*Salvia miltiorrhiza* Bunge	Labiatae	tanshinone I		[106]
50	*Salvia miltiorrhiza* Bunge	Labiatae	tanshinone IIA		[106]
51	*Salvia miltiorrhiza* Bunge	Labiatae	15,16-dihydrotanshinone I		[106]

Conclusion

Diabetes is mainly a lifestyle disease which is observed with increased serum glucose levels and it is also associated with many other complication like glaucoma, cardio-vascular disorders, renal insufficiency and sometimes amputations has also been observed in many patients due to decrease in wound healing properties ultimately leading to gangrene. Many medicinal plants are useful in wound healing as well as controlling diabetes mellitus. Medicinal plants themselves provide a number of biologically active compounds and they also provide leads to other therapeutically useful compounds and therefore it becomes crucial to scan more number of natural resources in order to treat diabetes mellitus. The combination of modern knowledge and traditional knowledge can provide better drugs for diabetes mellitus with fewer side effects.

A total number of 150 plant species belonging to numerous families are presented in this review which is useful in the treatment of diabetes mellitus. Article also contains more than fifty medicinal compounds recently updated in literature.

The most important families in present review are Fabaceae and Cucurbitaceae. The plants from these families are found to be of high therapeutic value to treat diabetes mellitus however families like Musaceae, Punicaceae and Aloaceae have been found to contain least number of effective plant species. The plant parts contributing mostly active compounds are leaves, fruit & seeds.

It is pertinent to mention here that while selecting the dose regimen, the physician must avoid a combination of traditional and synthetic medicine which can cause hypoglycaemia in patients.

It is important that the combination of these medicinal plants should be used for glucose management and the rejuvenation of dying tissues. Overall aim is to develop a better healthcare system using traditional knowledge of medicine in order to create conducive environment for patients as well as much needed research in Phytochemistry.

Allopathic doctors are misguided about folk medicinal practices as they find it based on superstition or just a placebo effect. The fact is that medicinal plants are the ultimate source of novel and efficacious drugs and it is highly recommended to carry out further research so that we can harness the healing power of Mother Nature.

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Conflict of Interests

The author has not declared any conflict of interests.

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