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REVIEW ARTICLE

A Quick Review on Anti-diabetic Plants and Action of Phytochemicals

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Abstract

Diabetes is an endocrinological disorder arising from insulin deficiency or due to effectiveness of the insulin produced by the body. Around 200 million people of the world are currently suffering from diabetes and the figure is projected to rise to 300 million within 2025 by the World Health Organization. The disease is caused by the inability of pancreas to produce insulin or inability of the body metabolic system to properly use the insulin produced.In Asia, India and China are the leading countries in herbal plants research, and there has been an increase in medicinal research on plants extract for diabetes treatment since 1995 in these regions. The objective of the present study was to document the medicinal plants used for thediabetes treatment, so that future work directed towards the identification of active principles from these medicinal plants may provide the opportunity for the development of a novel class of agents for the treatment of diabetes.In this review, we have attempted to compile a list of total 141 plant species belongs to 82 families, along with their type ofused extracts,botanical name, Plant part used and active principlesare includedbased on available scientific literaturesthose has been reported to be effective in diabetes. Different mechanism of action of anti-hyperglycemic phytochemicals are also shortly discussed. The information collected shows that plant leaves are about 51% more favorable for storing active ingredients, as compared to other parts of themedicinal plants.The documentation of anti-diabetic medicinal plants stimulates the researchers for further research on the potential use of medicinal plants having anti-diabetic potential.

1. Introduction

Diabetes mellitus is a common and very prevalent disease affecting the citizens of both developed and developingcountries. 6% population of human beings affected by Diabetes mellitus, which is an endocrine disorder and this will affect 5 times more people in next 10 years (WHO/Acadia, 1992; ADA, 1997). Diabetes mellitus is not disease but a syndrome with combination of hereditary and environmental causesthat results in high blood sugar levels may know as Hyperglycemia. Our body always maintain sugar level by chemicals and hormones especially beta cells of pancreas that produce insulin and defects in either insulin secretion or insulin action leads to diabetes mellitus (Tierney 2002). And this disease results in high urine production, thirst and blurred vision, lethargy and changes in energy metabolism (Patel et al.,2012).

Plants, can provide biologically active molecules and lead structures for the development of modified derivatives with enhanced activity and reduced toxicity. The small fraction of flowering plants that have so far been investigated have yielded about 120 therapeutic agents of known structure from about 90 species of plants. (Joy et al., 1998). Indigenous medicinal practices of various communities throughout the world have always proved to be an excellent route to discovery of many important modern drugs (Balick and Cox, 1996; Gilani and Rahman, 2005). In some cases, the crude extract of medicinal plants may be used as medicaments. About 121 (45 tropical and 76 subtropical) major plant drugs have been identified for which no synthetic one is currently available (Kumar et al., 1997). It has been estimated that more than 400 traditional plants or plant-derived products have been used for the management of type 2 diabetes across geographically (Bailey and Day, 1989) and about 800 plants have anti-diabetic potential (Alarcon-Aguilara et al.,1998). Plants have their chemical compounds which demonstrate alternative and safe effects on diabetes mellitus. Most of plants contain glycosides, alkaloids, terpenoids, flavonoids, carotenoids, etc., that are frequently implicated as having antidiabetic effect (Malviya et al., 2010). Galega officinalis is plant from which hypoglycemic drugs was obtained traditionally. insulin, biguanides, sulfonylurease and thiazolinediones are mordern pharmacotherapeutics , but still except glycemic control with insulin, need to look new drugs for more efficacious agents with less side effects is needed (Gover et al., 2002). Herbal medicine also known as phytomedicine, refers to usage of roots, leaves, bark, flowers, seeds and berries for medicines. Herbalism is becoming focusing point due to research on herbs and their use in treatment of diabetes and its prevention (Ang-Lee et al.,2001). The scientific study of traditional medicines, concerned medicinal plants are thus of great importance.

The anti-diabetic plant species from seventeen families have earlier been recorded by Sidhu and Sharma (2013a; 2013b). In the present review an attempt has been made to investigate the anti-diabetic medicinal plants and may be useful to the health professionals, scientists and scholars working in the field of pharmacology and therapeutics to develop anti-diabetic drugs.

2. Methodology:

The authors first carried out a computer-aided search of the literature stored in various medical data banks. In addition, relevant information was also searched on the Internet. All publications containing original data and an adequate detailed description of methodology were considered in the present review.The papers reviewed in this article are selected from the medicinal journals as tabulated in Table 1 due to reliable reputation in medicinal research on herbal plant extract. The research papers were extracted from the selected 84 journals under the key words of "Anti-diabetic activities of plants". Similar observations have also been obtained in other anti-diabetic plants review study (Chang et al., 2012). Plants which did not show any significant hypoglycemic effect were not included in the document.

3. Discussions

The paper presented a total of 141 plant species, have been enlistedin table 2 that have anti-diabetic properties. These plant species belongs to 82 families (Table 3). Four species belongs to each of families Combretaceae, Solanaceae and Verbenaceae. The families like Aizoaceae, Nyctaginaceae,Nymphaeaceae, Burseraceae, Cecropiaceae, Chenopodiaceae, Rosaceae, Rubiaceae, Ebenaceae, Urticaceae, Lauraceae, Liliaceae, Loganiaceae have three species each, followed by Annonaceae, Berberidaceae, Bignoniaceae, Bombacaceae, Boraginaceae, Convolvulaceae, Costaceae, Hippocrateaceae, Lythraceae, Mimosaceae, Oleaceae, Pandanaceae, Piperaceae, Polygonaceae, Portulacaceae, Ranunculaceae, Sapindaceae Sapotaceae, Scrophulariaceae, Sterculiaceae, Zingiberaceae and Zygophyllaceae credited with two species. In addition to this, one species have been reported from the families like Acoraceae, Agavaceae, Alangiaceae, Apiaceae, Araceae, Arecaceae, Araliaceae, Balanitiaceae, Basellaceae, Capparidaceae, Caricaceae, Caryophyllaceae, Moringaceae, Musaceae, Myricaceae, Onagraceae, Orchidaceae, Oxalidaceae, Palmaceae, Passifloraceae, Polypodiaceae, Primulaceae, Rhamnaceae, Crassulaceae, Elaegnaceae, Equisetaceae, Eucommiaceae, Flacourtiaceae, Fomitopsidaceae, Hericiaceae, Hypericaceae, Irvingiaceae, Juglandaceae, Melastomataceae, Melianthaceae, Salvadoraceae, Samydaceae, Sonneratiaceae, Symplocaceae, Thymelaeceae, Tiliaceae, Ulmaceae, Violaceae and Vitaceae having antidiabetic activity.

Table 1: The 84 selected journals for the study

African Journal of Traditional, Complementary and Alternative Medicines	European Journal of Scientific Research	International Journal of Phytomedicine	Journal of Diabetology
African Journal of Plant Science	Fitoterapia	International Jounal ofApplied Biology and Pharmaceutical Technology	Journal of Advanced Pharmaceutical Technology and Research
African Journal of Biotechnology	Global Journal of Biotechnology and Biochemistry	International Journal of Research in Pharmaceutical andBiomedical Sciences	Journal of Advanced Pharmacy Education andResearch
Applied Biochemistry and Biotechnology	Global Journal of Pharmacology	International Journal of Molecular Sciences	Journal ofPharmacognosy and Phytotherapy
AsianJournal of Medical Sciences	Indian Journal of Pharmacology	International Journal of Pharma Research and Development	Journal of Applied Biomedicine
Asian Journalof Pharmaceutical and Clinical Research	Indian Journal of Experimental Biology	International Journal of Applied Research in Natural Products	Journal of Endocrinology and Metabolism
Asian Pacific Journal of Tropical Medicine	Indian Journal of Pharmaceutical Science and Research	International Conferenceon Asia Agriculture and Animal	Libyan Agriculture Research Centre Journal International
Asian Pacific Journal of Tropical Biomedicine	Indian Journal of Pharmaceutical Sciences	International Journal of Phytomedicine	Methods andFindings in Experimental and Clinical Pharmacology
Biological and Pharmaceutical Bulletin	Indian Journal of Pharmaceutical Educationand Research	International Journal of Molecular Sciences	Pakistan Journal of Pharmaceutical Sciences
Biological and Pharmaceutical Bulletin	International Journalof Pharmaceutical and Biological Archives	International Journal of Applied Biology and Pharmaceutical Technology	Pacific Journal of Medical Sciences
Biology and Medicine	International Journal of Pharmacy and Pharmaceutical Sciences	International Research Journal ofPharmacy	Pharmacologyonline
Bioscience Biotechnology and Biochemistry	International Journal of Applied Research inNaturalProducts	International Journal of Pharma Sciencesand Research	Pharmacognosy Magazine
BMC Complementry and Alternative Medicine	International Journal of PharmaceuticalSciencesand Nanotechnology	International Journal of PharmTech Research	Phytotherapy Research
BMC Pharmacology	International Journal ofPharmaceutical Research and Development (IJPRD)	Iranian Journal of PharmaceuticalResearch	Pharmacy and Pharmacology Communications
British Journal of Pharmaceutical Research	Journal of Medical Sciences	Journal of Applied Pharmaceutical Science	Records of Natural Products
British Journal of Nutrition	Journal of AppliedPharmaceutical Science	Journal of Ethnopharmacology	Singapore Medical Journal
Current Science	Journal of Pharmaceutical Research andClinical Practice	Journal of Medicinal Plants Research	South African Journal of Botany

Der Pharmacia Lettre	Journal of Herbs, Spicesand Medicinal Plants	Journal of Life Sciences	The Egyptian Journal of Hospital Medicine
Diabetes Research	Journal of Chemical and Pharmaceutical Research	Journal of Pharmacy and Bio allied Sciences	
Diabetologia Croatica	Journal of Herbal Medicine and Toxicology	Journal of Pharmacognosy and Phytotherapy	
Diabetes Research and Clinical Practice	Journal of Medicinal Plants	Journal of Medicinal Food	
Drug Invention Today	Journal of Medicinal Plants	Journal of the Science ofFood and Agriculture	

Table 2:Medicinal plants with anti-diabetic activeprinciples and their reported effect on experimental models

SN	Botanical Name	Family Name	Used extract	Active Principles	References
Leaves					
1	*Aegiceras corniculatum* (L.) Blanco	Primulaceae	E	Leaf extract	Gurudeeban et al., 2012
2	*Aframomum melegueta* (Rosc.)K. Schum.	Zingiberaceae	Aq.	Leaf extract	Mojekwu et al., 2011
3	*Alangium lamarckii* Thw.	Alangiaceae	Al.	Leaf extract	Kumar et al., 2011
4	*Aloe vera* (L.) Burm. Fil.	Liliaceae	Aq.	Leaf extract	Rehman et al., 2011
5	*Anabasis articulata* (Forssk) Moq.	Chenopodiaceae	Aq.	Saponins	Kambouche et al., 2009
6	*Annona squamosa* L.	Annonaceae	Aq.	Leaf extract	Gupta et al., 2005
7	*Areca catechu* L.	Palmaceae	P.E., Chlf. & M	Triterpenoids	Mondal et al., 2012
8	*Averrhoa bilimbi* L.	Oxalidaceae	E	Leaf extract	Pushparaj et al., 2000
9	*Basella rubra* L.	Basellaceae	Aq.	Leaf pulp	Nirmala et al., 2009
10	*Bersama engleriana* Gurke	Melianthaceae	Aq. & M	Leaf extract	Njike et al., 2005
11	*Boerhaavia diffusa* L.	Nyctaginaceae	Aq.	Alkaloids, sterols or triterpenoids	Koffi et al., 2011
12	*Bougainvillea glabra* L.	Nyctaginaceae	Aq.	Alkaloids, flavonoids, saponins & cardiac glycosides	Adebayo et al., 2009
13	*Bryophyllum pinnatum* (Lam.)Kurz	Crassulaceae	Aq.	Flavonoids, polyphenols, triterpenoids	Ojewole, 2005
14	*Cardiospermum halicacabum* L.	Sapindaceae	E	Leaf extract	Veeramani et al., 2008
15	*Cecropia obtusifolia* Bertol.	Cecropiaceae	Aq. & B	Flavone, isoorientin & 3-caffeoylquinic	Andrade-Cetto and Wiedenfeld (2001)
16	*Cecropia pachystachya* Mart.	Cecropiaceae	M	Leaf extract	Aragao et al., 2010
17	*Chamaerops humilis* L.	Arecaceae	Aq.	Leaf extract	Gaamoussi et al., 2010
18	*Cinnamomum tamala* Fr. Nees.	Lauraceae	Aq.	Leaf extract	Chakraborty and Das (2010)
19	*Cissus sicyoides* L.	Vitaceae	Aq.	Flavonoids & tannins	Viana et al., 2004
20	*Clerodendrum capitatum* (Willd)	Verbenaceae	Aq.	Saponins, flavonoids,	Adeneye et al., 2008

	Schumach et. Thonn.			alkaloids, tannins, glycosides	
21	*Combretum micranthum* G. Don	Combretaceae	Aq.	Leaf extract	Chika and Bello (2010)
22	*Costus afer* Ker Gawl.	Costaceae	M	Alkaloids, flavonoids, tannins, saponins	Momoh et al., 2011
23	*Dolichandrone falcata* Seem.	Bignoniaceae	Aq.	Steroidal compounds, flavonoids, tannins & sugars	Mungle et al., 2012
24	*Eucommia ulmoides* Oliv.	Eucommiaceae	Aq.	Powdered leaf extract	Lee et al., 2005
25	*Flacourtia jangomas* Raeusch.	Flacourtiaceae	M	Flavonoids, saponins, carbohydrates, steroids, tannins & phenolic compounds	Singh and Singh (2010)
26	*Gardenia taitensis* A. P. de Candolle	Rubiaceae	E	Alkaloids, phytosterols, carbohydrates & saponins	Maheswari and Gandhimathi (2011)
27	*Hedera helix* L.	Araliaceae	E	Leaf extract	Zafar et al., 2002
28	*Holoptelea integrifolia* (Roxb.)	Ulmaceae	M & P.E	Steroids & glycosides	Sharma et al., 2010
29	*Hypericum perforatum* L.	Hypericaceae	Ethl.ac.	Leaf extract	Arokiyaraj et al., 2011
30	*Juglans regia* L.	Juglandaceae	M	Leaf extract	Teimori et al., 2010
31	*Lagerstroemia speciosa* (L.) Pers.	Lythraceae	Aq.	Leaf powder or decoction	Tanquilut et al., 2009
32	*Memecylon umbellatum* Burm.F.	Melastomataceae	Al.	Leaf extract	Amalraj and Ignacimuthu (1998)
33	*Mimosa pudica* L.	Mimosaceae	E	Leaf extract	Sutar et al., 2009
34	*Mimusops elengi* L.	Sapotaceae	M	Leaf extract	Zahid et al., 2012
35	*Moringa oleifera* Lam.	Moringaceae	Aq.	Leaf extract	Manohar et al., 2012
36	*Myrcia uniflora* Barb. Rodr.	Myricaceae	Aq.	Leaf extract	Pepato et al., 1993
37	*Nauclea latifolia* Sm.	Rubiaceae	Aq.	Leaf extract	Gidado et al., 2005
38	*Nelumbo nucifera* Gaertn.	Nymphaeaceae	E	Flavonoids	Zhou et al., 2009
39	*Neolamarckia cadamba* (Roxb.) Bosser	Rubiaceae	M	Leaf extract	Ahmed et al., 2011
40	*Olea europaea* L.	Oleaceae	Al.	Leaf extract	Eidi et al., 2009
41	*Passiflora mollissima* Bailey	Passifloraceae	E	Alkaloids, tannins	Edwin et al., 2007

				& flavonoids	
42	*Piper betle* L.	Piperaceae	Aq. & E	Leaf extract	Arambewela et al., 2005
43	*Pisonia alba* Span.	Nyctaginaceae	E	Vitamin A, alkaloids, proteins & fats	Sunil et al., 2009
44	*Premna corymbosa* (Burm. F.) Rottl	Verbenaceae	E & Aq.	Alkaloids, flavonoids, glycosides, saponins, terpenes & steroids	Thiruvenkatasubramaniam and Jayakar (2010)
45	*Salacia fruticosa* Heyne exLawson	Hippocrateaceae	M	Alkaloids, carbohydrates, phytosterols, glycosides, saponins & phenolic compounds	Venkateshwarlu et al., 2009
46	*Salacia reticulata* Wight	Hippocrateaceae	Aq.	Leaf extract	Yoshino et al., 2009
47	*Solanum nigrum* L.	Solanaceae	Aq. & hydro-alcoholic	Alkaloids, flavonoids, phenolics	Meonah et al., 2012
48	*Solanum trilobatum* L.	Solanaceae	Aq.	Leaf extract	Doss et al., 2009
49	*Sonneratia alba* Sm.	Sonneratiaceae	M	Leaf extract	Morada et al., 2011
50	*Spinacia oleracea* L.	Chenopodiaceae	E	Leaf extract	Kumar and Loganathan (2010)
51	*Symplocos cochinchinensis* (Lour.) S. Moore.	Symplocaceae	H	Leaf extract	Sunil et al., 2011
52	*Talinum portulacifolium* Forssk.	Portulacaceae	M	Steroids, triterpenoids & flavonoids	Rao et al., 2007
53	*Urtica dioica* L.	Urticaceae	Aq.	Leaf extract	Das et al., 2011
54	*Urtica parviflora* roxb.	Urticaceae	Aq.	Alkaloids, reducing sugars, polysaccharides, tannins, saponins, glycosides & flavonoids	Sah et al., 2010
55	*Withania somnifera* (L.) Dunal	Solanaceae	E	Flavonoids	Udayakumar et al., 2009
56	*Zizyphus sativa* Gaertn.	Rhamnaceae	Al.	Leaf extract	Anand et al., 1989

Barks

57	*Adansonia digitata* L.	Bombacaceae	M	Tannins, carbohydrates, terpenes, saponins, flavonoids & alkaloids	Tanko et al., 2008
58	*Albizia odoratissima* Benth.	Mimosaceae	M	Bark extract	Kumar et al., 2011
59	*Cinnamomum* verum J. S. Presl	Lauraceae	Aq.	Bark extract	El-Desoky et al., 2012
60	*Commiphora africana* (A.Rich.) Engl.	Burseraceae	Aq. & E	Alkaloids, tannins, flavonoids, steroids & saponins	Goji et al., 2009
61	*Crataeva nurvala* Buch. Ham.	Capparidaceae	P.E, Aq., Chlf. & Al.	Triterpenoids & flavonoids	Sikarwar and Patil (2010)
62	*Diospyros melanoxylon* Roxb.	Ebenaceae	E	Triterpenoids, steroids, alkaloids, flavonoids & tannins	Gupta et al., 2009
63	*Helicteres isora* L.	Sterculiaceae	Aq.	Bark extract	Kumar et al., 2009
64	*Madhuca indica* J. F. Gmel.	Sapotaceae	M	Bark extract	Choudhary et al., 2011
65	*Musanga cecropioides* R. Br. Ex Bennet	Cecropiaceae	E & Aq.	Bark extract	Adeneye et al., 2007
66	*Parinari excela* Sougue	Rosaceae	Aq.	Bark extract	Ndiaye et al., 2008
67	*Polyalthia longifolia* var. angustifolia Thw.	Annonaceae	M	Alkaloids, triterpenoids, flavonoids, steroids, saponins, glycosides & tannins	Gosh et al., 2010
68	*Strychnos henningsii* Gilg.	Loganiaceae	Aq.	Flavonoids, tannins & saponins	Oyedemi et al., 2012
69	*Triplochiton scleroxylon* Schumann	Sterculiaceae	Aq.	Bark extract	Prohp and Onoagbe (2011)
Roots					
70	*Anthocleista djalonensis* A. Chev	Loganiaceae	E	Flavonoids, saponins, tannins, cardiac glycosides & anthraquinones	Okokon et al., 2012
71	*Asparagus racemosus* Willd.	Liliaceae	E	Root extract	Hannan et al., 2012
72	*Berberis lyceum* Royle	Berberidaceae	E & Aq.	Root extract	Gulfraz et al., 2007
73	*Casearia esculenta* Roxb.	Samydaceae	E	Alkaloids, glycosides, saponins, phytosterols, tannins & amino acids	Arul et al., 2006
74	*Costus speciosus* (Koenex.Retz.)	Costaceae	E	Root extract	Bavarva et al., 2008

75	*Lantana aculeata* L.	Verbenaceae	E	Root extract	Kumar et al., 2010
76	*Merremia tridentata* (L.) Hall. f.	Convolvulaceae	Aq.	Root extract	Arunachalam and Parimelazhagan (2012)
77	*Nyctanthes arbor-tristis* L.	Oleaceae	M	Root extract	Sharma et al., 2011
78	*Pandanus fascicularis* Lam.	Pandanaceae	Aq & E	Carbohydrates, proteins, amino acids, saponins, tannins, phenolic compounds, alkaloids & flavonoids	Rajeswari et al., 2012
79	*Pandanus odorus* RIDL.	Pandanaceae	Aq.	Root extract	Peunqvicha
80	*Potentilla fulgens* L.	Rosaceae	CM	Root extract	Syiem et al., 2002
81	*Tectona grandis* L.	Verbenaceae	M	Root extract	Pooja et al., 2011
82	*Withania somnifera* (L.) Dunal	Solanaceae	E	Flavonoids	Udayakumar et al., 2009
83	*Zaleya decandra* L. N. Burm. f.	Aizoaceae	E	Root extract	Meenakshi et al., 2010
Fruits					
84	*Balanites aegyptiaca* (L.) Delile	Balanitiaceae	Aq. & E	Fruit flesh extract	Zaahkouk et al., 2003
85	*Diospyros lotus* L.	Ebenaceae	Aq.	Fruit extract	Azadbakhta et al., 2010
86	*Fomitopsis pinicola* (Swartz. Fries) Karst.	Fomitopsidaceae	Aq. & Alkali	Fruit body extract	Lee et al., 2008
87	*Hericium erinaceus* (Bull.) Pers.	Hericiaceae	M	Fruiting bodies extract	Wang et al., 2005
88	*Musa paradisiaca* L.	Musaceae	M	Fruit extract	Ojewole and Adewunmi (2003)
89	*Phaleria macrocarpa* (Scheff.) Boerl (Pm)	Thymelaeaceae	M	Flavonoids, terpenoids & tannins	Ali et al., 2012
90	*Rosa canina* L.	Rosaceae	E	Fruit extract	Orhan et al., 2009
91	*Solanum nigrum* L.	Solanaceae	Aq.& hydro alcoholic	Alkaloids, flavonoids, phenolics & micronutrients	Meonah et al., 2012
92	*Terminalia belerica* Roxb.	Combretaceae	M	Triterpenoids-arjungenin, bellericagenins & belleric acid	Sabu and Kuttan (2009)
93	*Terminalia pallida* Brandis	Combretaceae	E	Flavonoids, phenolic acids, sterols/	Kameswara et al., 2003

				triterpenoid, alkaloids, tannins & anthocyanins	
94	*Trapa natans* L.	Lythraceae	M	Fruit peel extract	Das et al., 2011
Seeds					
95	*Brassica juncea* L.	Brassicaceae	Aq.	Seed extract	Thirumalai et al., 2011
96	*Carica papaya* L.	Caricaceae	Aq.	Alkaloids, flavonoids, saponins, tannins, anthraquinones, anthocyanosides & reducing sugars	Adeneye and Olagunju (2009)
97	*Carum carvi* L.	Apiaceae	E	Carvone, limonene, carveol, dihydrocarveol & thymol	Eidi et al., 2010
98	*Hippophae rhamnoides* L.	Elaegnaceae	Aq.	Seed extract	Zhang et al., 2010
99	*Irvingia gabonensis* (Aubry-Lecomte) Baill.	Irvingiaceae	Aq.	Seed extract	Ozolua et al., 2006
100	*Lepidium sativum* L.	Brassicaceae	Aq.	Seed extract	Eddouks et al., 2005
101	*Nigella sativa* L.	Ranunculaceae	Aq.	Essential oils, proteins, alkaloids & saponins	Mathur et al., 2011
102	*Persea americana* Mill.	Lauraceae	E	Seed extract	Edem (2009)
103	*Spergularia purpurea* (Pers.) G.Don. Fil	Caryophyllaceae	Aq.	Saponins & flavonoids	Jouad et al., 2000
104	*Strychnus potatorum* L.	Loganiaceae	E & Aq.	Seed extract	Raghu et al., 2011
105	*Terminalia chebula* Retz.	Combretaceae	Chlf.	Seed extract	Rao et al., 2006
Aerial Parts					
106	*Bacopa monnieri* L.	Scrophulariaceae	E	Aerial parts extract	Ghosh et al., 2008
107	*Equisetum myriochaetum* Schlecht and Cham	Equisetaceae	Aq. & B	Flavonol glycosides & one Caffeoylglycoside	Choudhary et al., 2011
108	*Laportea ovalifolia* Schamand Thonn.	Urticaceae	Aq.	Aerial part extract	Momo et al., 2006
109	*Lycium shawii* Roem and Schult	Solanaceae	E	Aerial part extract	Sher et al., 2011
110	*Salvadora oleoides* Decne	Salvadoraceae	E	Aerial part extract	Yadav et al., 2008
111	*Scoparia dulcis* L.	Scrophulariaceae	E	Alkaloids, carbohydrates, glycosides, flavonoids &	Zulfiker et al., 2010

				tannins	
112	*Suaeda fruticosa* Forssk. ex J. F. Gmel.	Chenopodiaceae	Aq.	Aerial part extract	Benwahhoud et al., 2001
113	*Zygophyllum gaetulum* Emb. and Maire	Zygophyllaceae	Aq.	Aerial part extract	Jaouhari et al., 2000
114	*Zygophyllum geslini* Coss.	Zygophyllaceae	Aq.	Aerial parts extract	Medjdoub et al., 2012
Flower					
115	*Antigonon leptopus* Hook & Arn.	Polygonaceae	M	Flower extract	Sujatha et al., 2012
116	*Kigelia pinnata* Jacq.	Bignoniaceae	M	Flower extract	Kumar et al., 2012
117	*Mimusops elengi* L.	Sapotaceae	M	Flower extract	Sidhu et al., 2013
118	*Nymphaea stellata* Willd.	Nymphaeaceae	E	Flower extract	Rajagopal and Sasikala (2008)
Whole Plant					
119	*Heliotropium zeylanicum* (Burm.F) Lamk	Boraginaceae	M	Plant extract	Murugesh et al., 2006
120	*Hemionitis arifolia* (Burm.) Moore.	Polypodiaceae	Aq.	Plant extract	Nair et al., 2006
121	*Hybanthus enneaspermus* (L.) F. Muell	Violaceae	E	Flavonoids, terpenes, phenols, anthraquinones, glycosides, polyoses, alkaloids, saponins & tannins	Patel et al., 2011
122	*Jussiaea suffruticosa* L.	Onagraceae	M	Plant extract	Murugesan et al., 2000
123	*Merremia emarginata* Burm. F.	Convolvulaceae	M	Plant extract	Gandhi and Sasikumar (2012)
124	*Mollugo nudicaulis* Lam.	Aizoaceae	E	Plant extract	Sindhu et al., 2010
125	*Piper sarmentosum* Roxb.	Piperaceae	Aq.	Plant extract	Peunqvicha et al., 1998
126	*Polygala javana* DC.	Polygalaceae	E	Alkaloids, catechism, tannins, saponins, steroids, flavonoids, phenols, sugar, glycosides & xanthoprotein	Alagammal et al., 2012
127	*Portulaca oleracea* L.	Portulacaceae	Chlf, M	Plant extract	Syiem et al., 2002
128	*Trianthema portulacastrum* L.	Aizoaceae	M	Alkaloids, flavonoids, saponins, phenolic compounds & terpenoids	Sunder et al., 2009

129	*Triumfetta pilosa* Roth	Tiliaceae	E	Plant extract	Ramakrishna et al., 2011
Rhizome					
130	*Acorus calamus* L.	Acoraceae	M	Rhizome extract	Prisilla et al., 2012
131	*Alpinia galanga* Willd.	Zingiberaceae	M & Aq.	Rhizome extract	Akhtar et al., 2002
132	*Sansevieria roxburghiana* Schult. and Schult. f.	Agavaceae	Aq. & E	Alkaloids, triterpenes, steroids, flavonoids & saponins	Haldar et al., 2010
Root bark					
133	*Blighia sapida* K. Kong	Sapindaceae	Aq.	Terpenoids, phenol, alkaloids, tannins	Saidu et al., 2012
134	*Ceiba pentandra* (L.) Gaertner	Bombacaceae	Mthl. Cl. & M	Root bark extract	Djomeni et al., 2006
135	*Euclea undulata* Thunb. var myrtina	Ebenaceae	Act.	Root bark extract	Deutschlander et al., 2012
Stem					
136	*Berberis aristata* DC.	Berberidaceae	M	Alkaloids, glycosides, carbohydrates, bitter principles & saponins	Upwar et al., 2010
137	*Flacourtia jangomas* Raeusch.	Flacourtiaceae	M	Flavonoids, saponins, carbohydrates, steroids, tannins & phenolic compounds	Singh and Singh 2010
138	*Nervilia plicata* (Andrews)Schltr.	Orchidaceae	Al.	Stem extract	Kumar and Janardhana (2011)
139	*Tournefortia hirsutissima* L.	Boraginaceae	Aq. & B	Stem extract	Andrade-Cetto et al., 2007
Tubers					
140	*Anaphyllum wightii* Schott.	Araceae	E	Tuber extract	Mathew et al., 2013
141	*Nymphaea pubescens* Willd.	Nymphaeaceae	E	Alkaloids, flavonoids, glycosides, terpenoids, tannins,phenols, saponins &steroids	Shajeela et al., 2012

Abbreviations: Aq.- Aqueous,Acetone- Act., Al.- Alcohol, B- Buthanol, E- Ethanol, H- Hexane, M.- Methanol, Chlf.- Chloroform, CM- Crude Methanol, Ethl.ac.-Ethyl acetate, Methl. Cl.- Methyl Chloride, PE- Petroleum Ether.

Table 3: Number of plant species in different families

Acoraceae	1	Eucommiaceae	1	Piperaceae	2
Agavaceae	1	Flacourtiaceae	1	Polygonaceae	2
Aizoaceae	3	Fomitopsidaceae	1	Polypodiaceae	1
Alangiaceae	1	Hericiaceae	1	Portulacaceae	2
Annonaceae	2	Hippocrateaceae	2	Ranunculaceae	1
Apiaceae	1	Hypericaceae	1	Rhamnaceae	1
Araceae	1	Irvingiaceae	1	Rosaceae	3
Araliaceae	1	Juglandaceae	1	Rubiaceae	3
Arecaceae	1	Lauraceae	3	Salvadoraceae	1
Balanitiaceae	1	Liliaceae	2	Samydaceae	1
Basellaceae	1	Loganiaceae	3	Sapindaceae	2
Berberidaceae	2	Lythraceae	2	Sapotaceae	2
Bignoniaceae	2	Melastomataceae	1	Scrophulariaceae	2
Bombacaceae	2	Melianthaceae	1	Solanaceae	4
Boraginaceae	2	Mimosaceae	2	Sonneratiaceae	1
Burseraceae	3	Moringaceae	1	Sterculiaceae	2
Capparidaceae	1	Musaceae	1	Symplocaceae	1
Caricaceae	1	Myricaceae	1	Thymelaeceae	1
Caryophyllaceae	1	Nyctaginaceae	3	Tiliaceae	1
Cecropiaceae	3	Nymphaeaceae	3	Ulmaceae	1
Chenopodiaceae	3	Oleaceae	2	Urticaceae	3
Combretaceae	4	Onagraceae	1	Verbenaceae	4
Convolvulaceae	2	Orchidaceae	1	Violaceae	1
Costaceae	2	Oxalidaceae	1	Vitaceae	1
Crassulaceae	1	Palmaceae	1	Zingiberaceae	2
Ebenaceae	3	Pandanaceae	2	Zygophyllaceae	2
Elaegnaceae	1	Passifloraceae	1		
Equisetaceae	1	Primulaceae	1		

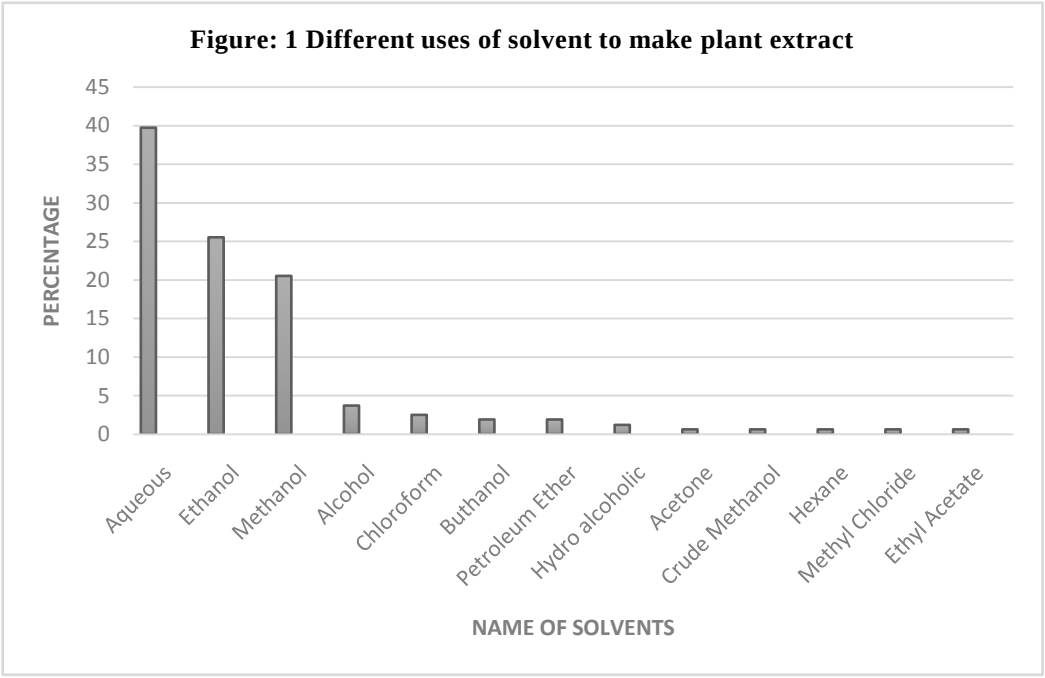
Plants have also been categorized on the basis of plant part used (Table 4). Leaves were found to be the most frequently used plant part (56) in the management of diabetes, followed by roots (14), bark (13), fruits (11), seeds (11), whole plants (11), and aerial parts (9) have shown activity against diabetes. Rhizome (3), flower (4), root bark (3), stem (4), tubers (2) also possess anti-diabetic activity.

Table 4: Various plant parts used & number of their plant species

Plant Parts Used	Number of Species
Leaf	56
Root	14
Bark	13
Fruit	11
Seed	11
Whole plant	11
Aerial Part	9
Flower	4
Steam	4
Rhizome	3
Root bark	3
Tuber	2

Extraction is the first crucial step in preparation of plant formulations. Considerable effort has been made by researchers to find efficient extraction methods in order to get high efficiency and efficacy. It should be noted that choice of appropriate solvent is of essential importance along with application of a compatible extraction method (Gupta et al. 2012). In this review of 141 anti-diabetic plants, the most popular used solvent to make plant extract was aqueous solvent 39.7% among the 141 species, after then ethanol 25.5%, methanol 20.5%, alcohol 3.7%, and chloroform 2.5%. The rest of the used solvents were buthanol, petroleum ether 1.9% each, hydro alcoholic 1.2% and acetone, crude methanol, hexane, methyl chloride & ethyl acetate 0.62 % respectively (fig 1).

Figure: 1 Different uses of solvent to make plant extract



4. Hypoglycemic Constituents and Mechanisms of Actionof Phytochemicals

It has been studied that bioactive plant, secondary metabolites are important in chemical defense mechanisms (Ehrlich and Raven 1964; Berenbaum 1983). Glucose is metabolic energy source and this undergoes storage and

mobilization under hormonal control. Plant growth regulators such as indole-3-acetic acid and similarly indole-3-butyric acid, L-tryptophan, indole-3-propionic acid and p-chlorophenoxyacetic acid, inhibits insulinase in vitro and are hypoglycemic in vivo (Mirsky et al. 1956). In the same way, insulinase and potentiate administered insulin with the help of anthranilic and nicotinic acid. An efficient hypoglycemic activity was observed when an inhibitor of indole-3-acetic acid oxidase from Phaseolus vulgaris (fruit exocarps) was applied for diabetic treatment, similarly hypoglycemic alkaloid trigonelline from Trigonella foenum-graecum, is a growth inhibitor helps in hypoglycemic activity. In the same way, another plant growth inhibitor is ''Salicylic Acid'' (Oliver- Bever and Zahnd, 1979). So plant metabolism regulating constituents can also be anti-diabetic, animal metabolism-regulatory agents.

Cinnamaldehyde, a phytoconstituent extracts have been reported to exhibit significant antihyperglycemic effect resulting in the lowering of both total cholesterol and triglyceride levels and, at the same time, increasing HDL-cholesterol in STZ-induced diabetic rats. This investigation reveals the potential of cinnamaldehyde for use as a natural oral agent, with both hypoglycemic and hypolipidemic effects. Recent reports indicate that Cinnamonextract and polyphenols with procyanidin type-A polymers exhibit the potential to increase the amount of TTP (Thrombotic Thrombocytopenic Purpura), IR (Insulin Resistance), and GLUT4 (Glucose Transporter-4) in 3T3-L1 Adipocytes. It was suggested that the mechanism of Cinnamon's insulin-like activity may be in part due to increase in the amounts of TTP, IR (Insulin Resistance), and GLUT4 and that Cinnamon polyphenols may have additional roles as anti-inflammatory and/or anti-angiogenesis agents (Jakhetia et al.,2010).

Summary

In Present world, the word ''Diabetes'' has got striking significance because this disease with its causes and effects in different ages. One of the important thing is impediment in the cure of this syndrome, which provides chief importance and critical analysis of it, to provide vital treatments of diabetes so that this disease will not affect succeeding generations. For a long time, remedy of it has been under surveillance, and for this medicinal plants played their vital role, as nature has sovereignty in a particular way to overcome harmful effects of diabetes. So this document is an endeavor to assemble those patent medicinal plants that are with benevolent use in cure of syndrome diabetes. As 141 plant species with all their particulars and data are being mentioned in this review article, especially with their action of mechanism to help in apprehension role of anti-diabetic plants. All contents of this paper, especially ''tables'' with their brief information about anti-diabetic medicinal plants are cognition source with systemize details. This review paper with all its particulars is compile work to elevate importance of plants in treatment of threatening syndrome diabetes so that we might be able of secure world from its vulnerable risks in near future.

Conflict of interest statement

We declare that we have no conflict of interest.

Authors' contribution

The authors are thankful to Beauty Akter Rupa for her gracious contribution in this work. All the authors edited the paper, read and approved the final paper.

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