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REVIEW ARTICLE

Exploring the Potential of Traditional Herbal Plants in the Management of Diabetes Mellitus: A Comprehensive Investigation

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Abstract

Diabetes Mellitus (DM) is one of the most prevalent chronic conditions bearing considerable social, health, and economic ramifications. Uncontrolled DM manifests secondary complications such as foot ulceration, retinopathy, neuropathy, nephropathy, and cardiomyopathy. The heterogeneity inherent in DM necessitates a comprehensive therapeutic strategy that is equally safe and effective against multifaceted diseases like DM. Conventionally, DM management relies on lifestyle modifications and dietary adjustments, complemented by pharmacological interventions. However, the limitations associated with oral hypoglycaemic agents prompt an exploration of alternative modalities. These days, substantial resources within healthcare are dedicated to investigating traditional systems of medicine, notably Ayurveda and traditional Chinese medicine, seeking novel interventions for DM management. This systematic review aims to evaluate the available literature of 2017-2023, focusing on identifying herbs with potential efficacy in DM management with their potent mechanism of action. By synthesizing current scientific knowledge, the review elucidates the intricate molecular-level mechanisms of action of medicinal plants in DM. This contribution enriches the scientific discourse by providing a comprehensive resource for the nuanced exploration of innovative approaches to address the complex facets of DM. As healthcare endeavours to diversify its strategies, the insights from this review may pave the way for developing novel and effective interventions for managing DM using medicinal plants.

Keywords: Diabetes, Diabetes Treatment, Epidemiology, Hypoglycemic Agent, Medicinal Plants

1. Introduction

DM has emerged as a significant global health concern, with a rapidly increasing prevalence over the past few decades. According to the International Diabetes Federation (IDF), approximately 463 million adults (20-79 years old) were living with DM in 2019. This number is expected to rise to 700 million by 2045 if current trends persist[1]. India, in particular, faces a burgeoning DM epidemic. Scientific studies highlight that India has witnessed a drastic increase in diabetes prevalence, making it the diabetes capital of the world[2]. The country is home to a substantial diabetic population, with both urban and rural areas experiencing a rise in diabetes cases[3].

The economic burden of DM is staggering, exceeding 1.3 trillion USD in 2015 and is projected to increase further[4]. This financial strain is expected to critically impact developing countries, including India, which will bear a substantial proportion of the economic burden[5,6].

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Current therapeutic strategies for managing DM primarily revolve around glycemic control through the use of oral hypoglycemic agents, insulin therapy, and lifestyle modifications. Although these interventions are safe and efficacious in mitigating hyperglycemia, they have several shortcomings that warrant scholarly attention. One notable limitation lies in the symptomatic focus of existing treatments, addressing elevated blood glucose levels without directly addressing the underlying pathophysiological factors contributing to insulin resistance or impaired insulin secretion. This symptomatic approach does not offer a definitive solution to the multidimensional nature of DM. Furthermore, certain pharmacological interventions may incur side effects such as weight gain, hypoglycemia, and gastrointestinal disturbances, posing challenges to treatment adherence and long-term patient well-being. Additionally, the current therapeutic paradigm may not sufficiently cater to the diverse and individualized needs of patients with diabetes, overlooking the potential benefits of personalized medicine in optimizing treatment outcomes. These considerations underscore the imperative for continued research and innovation to overcome these limitations and advance the precision and efficacy of diabetes management strategies.

In the pursuit of effective diabetes management, a paradigm shift towards complementary and alternative therapies has become increasingly evident. Beyond conventional treatments, there is a growing interest among patients and healthcare practitioners alike in exploring natural remedies to augment the overall quality of diabetes care[7,8].

Medicinal herbs, renowned for their rich array of bioactive compounds, hold immense potential in addressing the complexities of DM. These natural remedies have long been recognized in traditional medicine; their effectiveness interwoven into the fabric of healing practices. This deep-rooted connection between botanical remedies and metabolic disorders has impelled scientific exploration, prompting a deeper understanding of their mechanisms of action and clinical efficacy[9,10].

This review aims to explore the traditional use of medicinal plants and their therapeutic potential in addressing chronic diseases like DM. We hypothesized that the wealth of knowledge embedded in traditional medicine systems across the globe can be better and safer alternatives for Diabetes management. We systematically extract the data from various scientific databases to achieve our objectives. Our review includes scientific papers published since 2017 summarizing the latest advancements and discoveries. This timeframe provides an up-to-date synthesis of the current state of knowledge regarding the potential roles of medicinal herbs in DM treatment.

This review offers a holistic perspective on these plants' potential therapeutic benefits, fostering a more profound comprehension of their mechanisms of action and clinical relevance. Additionally, this report is a foundation for future research, guiding scientists and healthcare practitioners toward evidence-based exploration of herbal interventions. This review will also contribute to the ongoing dialogue between traditional wisdom and contemporary science by offering insights that may pave the way for innovative approaches in healthcare.

2. Methodology

The methodology employed for this comprehensive review involved a systematic search for relevant scientific literature spanning the period from 2017 to 2023. Primary databases such as PubMed, Google Scholar, and other reputable sources were methodically inquired using a combination of keywords including "medicinal plants in diabetes", "phytoconstituents and diabetes", plant-based antidiabetic activity, "antidiabetic herbals", "traditional medicine and diabetes" and "DM treatment by herbal drug". The references from previous reviews were also searched to avoid biases. The search strategy aimed to capture a broad spectrum of research articles, reviews, and preclinical and clinical studies of the English language that explored the medicinal properties of plants and their phytochemical constituents in the management of diabetes mellitus. Authors independently reviewed titles and abstracts based on the selected inclusion and exclusion criteria and accessed full-text available articles. The corresponding author performed the final assessment of the eligible studies. Boolean operators and truncation were utilised to refine the search queries, ensuring a thorough and inclusive exploration of the available literature. The inclusion criteria prioritized studies that provided insights into the therapeutic potential of medicinal plants in the context of DM management. Articles were available in other languages excluded from the study. Furthermore, articles were screened for relevance, and their references were scrutinized to identify additional pertinent publications. This rigorous methodology was employed to ensure the compilation of a comprehensive and up-to-date review, synthesizing the wealth of information available in the scientific domain regarding the role of medicinal plants in DM treatment.

3. Results

A comprehensive review of the literature from 2017 to 2023 revealed 162 studies (Table 1) that investigated the therapeutic potential of medicinal plants in the management of diabetes mellitus (DM). The findings of these studies provide compelling evidence supporting the anti-diabetic properties of a wide range of plants and their phytoconstituents. Our analysis demonstrated that various plant parts, including leaves, roots, fruits, seeds, and whole plants, have been utilized in preclinical studies exploring their anti-diabetic properties. These plant extracts have exhibited a diverse range of mechanisms of action, including an increase in insulin secretion, improving Insulin sensitivity, decreasing Oxidative stress, changes in glucose absorption and inhibiting enzymes involved in glucose metabolism. Our review also identified 23 compounds (Table 2) of interest derived from medicinal plants that have exhibited promising antidiabetic effects. These compounds belong to various chemical classes, including alkaloids, phenolics, tannins, and flavonoids, and have been shown to exert diverse mechanisms of action. The findings of this review underscore the immense potential of medicinal plants in the management of DM. Their diverse mechanisms of action and lack of adverse effects compared to conventional antidiabetic drugs make them promising candidates for further clinical development. As the review summarises the antidiabetic effect of 162 medicinal plants in different preclinical models of diabetes, there are numerous limitations including publication bias, lack of standardization and variability in study design.

Key findings are given below:

- A wide range of medicinal plants and their phytoconstituents have demonstrated antidiabetic properties.
- Plant extracts exhibit diverse mechanisms of action, including enhancing insulin secretion, improving insulin sensitivity, reducing oxidative stress, regulating glucose absorption, and inhibiting enzymes involved in glucose metabolism.
- Twenty-three compounds of interest derived from medicinal plants have shown promising antidiabetic effects.

Table 1. List of herbal plants used in diabetes mellitus, with their phytochemicals and mechanisms of action

S. No.	Plant name	Family	Part of plant	Extraction	Phytochemicals	Uses	Mode of Action	Ref rence
1	*Cynara scolymus*	Asteraceae	Leaf	Hydroalcoholic	Saponins, phenolics compounds, tannins, proteins	Anti-diabetic	Suppression of oxidative stress	11
2	*Lpomoea aquatic*	Convolv ulaceae (morning glory)	Leaf	Methanol	Flavonoid glycosides.	Hypog lycaemic	Antioxidant	12
3	*Ficus carica*	Moraceae	Leaf extract	Methanol	Notably cyanidin, chlorogenic acid, rutin, luteolin, and catechin	Hypog lycaemic	Antioxidant	13
4	*Beta vulgaris*	Amaranthaceae	Leaves	Methanol	Polyphenols, flavonoids, the polyphenolic	Antidiabetic	Antioxidant	14

Table 1. Continued...

5	*Sphaeranthus indicus*	Asteraceae.	Whole plant	Ethanol	Alkaloids, flavonoids, saponin and tannins	Antihy perglycemic	Antioxidant	15
6	*Swietenia mahagoni*	Meliaceae	Seed	Methanol	Phenolic, alkaloid, and terpene	Antidiabetic	Stimulate insulin	16
7	*Tectona grandis*	Lamiaceae	Leaves	Methanol	Phenols, flavonoids, alkaloids, terpenoids, saponins and glycosides	Antidiabetic	Increase glucose uptake assay	17
8	*Mitragyna parvifolia*	Rubiaceae	Leaves	Ethanol	Phenols, flavonoids, alkaloids, terpenoids, saponins and glycosides	Antidiabetic	Reduce elevated levels of tumour necrosis factor α (tnf-α), interleukin il-6 in the serum	18
9	*Oldenlandia corymbose*	Rubiaceae	Whole plant	Ethanol	Flavonoids, tannins, flavanols, proanth ocyanidins, and vitamin e	Antidiabetic	Antioxidant	19
10	*Crateva adansonii*	Capparaceae	Leaves	Methanol	Saponins, flavonoids, alkaloids, and phenolics	Anti-diabetic	Anti-oxidant	20
11	*Nanorrhinum ramosissimum*	Plantaginaceae	Whole plant	Methanol	D-mannitol and fatty acid	Antidiabetic	Antioxidant	21
12	*Millingtonia hortensis*	Bignoniaceae	Leaves	Ethanol	phenolic compounds, Glycosides, flavonoids, terpenoids, tannins, Steroids	Antidiabetic	Antioxidant	22
13	*Hypericum perforatum*	Hypericaceae	Whole plant	Methanol	Naphtho dianthrones, flavanol glycosides, bioflavonoids	Antid iabetic	Suppressing liver gluco neogenesis	23
14	*Fagopyrum tataricum*	Polygonaceae	Whole plant	Ethanol	Flavonoids	Hypo glycaemic	Antioxidant	24
15	*Celastrus paniculatus*	Celastraceae	Seed	Methanol	Alkaloids, coumarins, flavonoids and steroids	Hypo glycaemic	Insulin Production and release by the β-cells of the pancreas	25

Table 1. Continued...

16	*Asparagus racemosus*	Liliaceae	Leaves	Ethanol	Phenols, glycosides, Alkaloids, saponins, terpenoids, tannins, Polysaccharides, flavonoids	Hypo glycaemic	Increase insulin level	26
17	*Bauhinia forficate*	Leguminosae	Leaves and stem	Ethanol	Ascorbic acid, flavonoids, and phenolic acids, catechol, cinnamic acid, and 3-phenylpropionic acid, quercetin-3-o-glucoside	Anti-diabetic	Antioxidant	27
18	*Vigna mungo*	Leguminosae	Seed	Ethanol	Flavonoids, alkaloids, phenolic compounds, and terpenoids	Antidiabetic	Stimulate insulin	28
19	*Silybum marianum*	Asteraceae	Leaves	Ethanol	Sennoside, anthraquinone glycosides, fatty oils, flavonoids, glycosides, galactomannan, polysaccharides, and tannins	Antidiabetic	Antioxidant	29
20	*Woodfordia fruticose*	Lythraceae	Flower	Hydroalcoholic	Saponin, flavonoid, carbohydrates, alkaloids, tannin, anthraquinone, and triterpenoids	Antidiabetic	Antioxidant	30
21	*Tabern aemontana*	Apocynaceae	Lea es	Methanol	Phenols, flavonoids, alkaloids, terpenoids, saponins and glycosides	Antidiabetic	Antioxidant	31
22	*Mirabilis jalapa*	Nyctaginaceae	Root	Methanol	Flavonoids, alkaloids	Hypo glycaemic	Antioxidant	32
23	*Musa acuminate*	Musaceae	Fruit	Ethanol	Gallocatechin and anthocyanins like peonidin and malvidine	Antidiabetic	Increased glycogenesis and Reduced glyco genolysis	33
24	*Momordica dioica*	Cucurbitaceae	Fruit	Aqueous	Saponins, ferric chloride. Flavonoid, phenol, alkaloid, carbohydrates and terpenoid	Antidiabetic	Inhibit the absorption of cholesterol and promote the excretion of Cholesterol and bile acid into faces	34

Table 1. Continued...

25	*Peristrophe bicalyculat*	Acanthaceae	Leaves	Ethanol	Quercetin	Antidiabetic	Reduction of blood glucose	35
26	*Coptis teeta*	Ranunculaceae	Root	Ethanol	Saponins, flavonoids, alkaloids, and phenolics	Anti-diabetic	Stimulated insulin secretion	36
27	*Flacoutia indica*	Salicaceae	Fruit	Aqueous	Flavonoids, phenolic compounds, terpenoids, fatty acids, and steroids	Antidiabetic	Uptake of glucose By the muscle	37
28	*Lawsonia inermis*	Lythraceae	Leaves	Ethanol	Alkaloids, flavonoids, glycosides, resins, tannins, terpenoids and steroids	Antidiabetic	Increased insulin sensitivity	38
29	*Eriobotrya japonica*	Rosaceae	Leaf	Aqueous	Fatty acids, minerals, vitamins, total carbohydrate, sugar, lipid, and protein	Antidiabetic	Antioxidant	39
30	*Elaeocarpus serratus*	Elaeocarpaceae	Fruits	Ethyl acetate	Phenolic, tannin, flavonoids, alkaloids and saponins	Anti-diabetic	Reduce the blood glucose levels	40
31	*Casuarina equisetifolia*	Casuarinaceae	Leaves	Ethanol	Tannins, flavonoids, saponins, phenols, alkaloid	Hypo glycaemic	Anti-oxidan	41
32	*Adiantum incisum*	Pteridaceae	Whole plant	Aqueous	Ardiacglycosides, flavonoids, Phenolic compounds, Saponins, andfixedoils.	Anti-diabetic	Anti-oxidant	42
33	*Alium cepa*	Amaryllidaceae	Peel	Ethanol	Phenolics, total flavonoid, quercetin	Antidiabetic	Antioxidant	43
34	*Theobroma cacao*	Malvaceae	Whole plant	Aqueous	Phenols, flavonoids, alkaloids, terpenoids, saponins and glycosides	Antidiabetic	Increase glucose uptake	44
35	*Xylopia aethiopica*	Annonaceae	Fruit	Aqueous	Isoelemicin	Antidiabetic	Improved the number of Pancreatic β-cells	45

Table 1. Continued...

36	*Prunus amygdalus*	Rosaceae	Seed	Methanol	Phenols, flavonoids, alkaloids, terpenoids, saponins and glycosides	Anti-diabetic	E promotion of insulin secretion from the b-cells, down-regulation of glucagon secretion, Enhancing masses of b-cells	[46]
37	*Phyllanthus niruri*	Euphorbiaceae	Whole plant	Ethanol	Alkaloids, flavonoids, anthraquinone, phenols, saponins, tannins, alkaloids, total phenolics, total flavonoids, carbohydrates and amino acids	Antidiabetic	Antioxidant	[47]
38	*Pongamia pinnata*	Fabaceae	Leaves	Methanol	Phenols, flavonoids, alkaloids, terpenoids, saponins and glycosides	Antidiabetic	Insulin secretion	[48]
39	*Prunus dulcis*	Rosaceae	Whole plant	Methanol	Phenols, flavonoids, alkaloids, terpenoids, saponins and glycosides	Antidiabetic	Promoting The insulin secretion	[49]
40	*Quercus infectoria*	Fagaceae	Leaves	Aqueous	Phenols, flavonoids, alkaloids, terpenoids, saponins and glycosides	Antidiabetic	Insulin secretion	[50]
41	*Rosa damascene*	Rosaceae	Flower	Ethanol	Quercetin	Antihy pertensive	Antioxidant	[51]
42	*Rubia cordifolia*	Rubiaceae	Leaves	Methanol	Alkaloids, saponins, coumarins, glycosides, tannins, phenols, reducing sugars, steroids, and triterpenoids	Antihy perglycemic	Antioxidant	[52]
43	*Operculina turpethum*	Convolvulaceae	Dried root	Methanol	Alkaloids, steroids/ triterpenoids, flavonoids, tannins, quinones, and coumarins	Antidiabetic	Decrease in glucose, cholesterol, And triglyceride level	[53]
44	*Saraca asoca*	Leguminosae	Flower	Ethanol	Polyphenolic and flavonoids	Antidiabetic	Insulin secretion	[54]

Table 1. Continued...

45	*Oryza sativa*	Poaceae	Whole plant	Ethanol	Alkaloids, steroids/ triterpenoids, flavonoids, tannins, quinones,	Antidiabetic	Increase the inhibition activity of the α-gluco sidase enzyme	55
46	*Kandelia rheedii*	Rhizophoraceae	Leaves	Methanol	Alkaloids, saponins, steroids, phenolics, tannins, flavonoids, terpenes, glycosides, proteins and carbohydrates.	Antidiabetic	Increase in uptake	56
47	*Myristica fragrans*	Myristicaceae	Seed	Methanol	Flavonoids, Alkaloids, glycoside, tannins, saponins, Phytosterols.	Antidiabetic	Increase glucose uptake	57
48	*Lagerstroemia parviflora*	Lythraceae	Leaves	Methanol	Phenols, flavonoids, alkaloids, terpenoids, saponins and glycosides	Antidiabetic	Lagers troemia parviflora	58
49	*Lycopersicon esculentum*	Solanaceae	Fruit	Water	B-carotene, lycopene	Hypo glycaemic	Reduced the fasting blood glucose level	59
50	*Helianthus tuberosus*	Asteraceae	Tuber part	Methanol	Neochlorogenic acid, chlorogenic acid, caffeic acid, 5-o-(4-coumaroyl)-quinic acid, feruloylquinic acid, caffeoylquinic acid, isoxazolidine, salicylic acid β-d-glucoside, dicaffeoylquinic acid isomers, salvianolic acid derivative isomers, and 1,4 dicaffeoylquinic acid	Antidiabetic	Enhance the glucose uptake	60
51	*Medicago sativa*	Fabaceae	Seed	Aqueous	Trigonelline	Antidiabetic	Enhancing peripheral tissue utilization of Glucose, or by decreasing the absorption of glucose by Intestine	61

Table 1. Continued...

52	*Egyptian morus alba*	Nymphaeaceae.	Leaves	Ethanol	Flavonoids, roseoside	Antidiabetic	Antioxidant	62
53	*Ficus benghalensis*	Moraceae	Bark	Ethanol	Alkaloids, steroids, terpenes and terpenoids, flavonoids	Antidiabetic	Increase uptake glucose	63
54	*Ficus lacor*	Moraceae.	Fruit	Ethanol	Alcohols, Sterols, beta sitosterol, and lanosterol	Antidiabetic	Restore the pancreatic beta-cell structure resulting In the increase in blood insulin level	64
55	*Ficus religiosa*	Moraceae	Leaf	Ethyl acetate	Phenols, flavonoids, alkaloids, steroids, terpenes and terpenoids.	Anti-diabetic	Anti-oxidant	65
56	*Barleria prionitis*	Acanthaceae	Leaves	Hydroalcoholic	Alkaloids, Flavonoids, glycosides, saponins, and phenols	Anti-diabetic	Anti-oxidant	66
57	*Lupinus albus*	Leguminacae	Seed	Hexane	Lectin γ-conglutin	Antidiabetic	Increased glucose uptake	67
58	*Hybanthus enneaspermus*	Violaceae	Stem bark	Ethanol	Phenols, flavonoids, alkaloids, terpenoids, saponins and glycosides	Antidiabetic	Antioxidant	68
59	*Cucurbita pepo*	Cucurbitaceae	Peeled	Ethanol	Proteins, peptides, polysaccharides, sterols, And vitamins	Anti-diabetic	Uptake of glucose By the muscle	69
60	*Capparis decidua*	Capparaceae	Whole plant	Water	Alkaloid, phenolic, flavonoid And terpenoid	Antidiabetic	Antioxidant	70
61	*Eucalyptus globulus*	Myrtle family (myrtaceae)	Leaf extract	Ethanol	Catechin, ergosterol, pinitol, quercetin and robinetinidol	Type-2 diabetes	Antioxidant	71
62	*Equisetum arvense*	Equisetaceae	Whole plant	Ethanol	Flavonoids, and phenolic acids	Antidiabetic	Antioxidant	72

Table 1. Continued...

63	*Senna alata*	Fabaceae	Flower	Aqueous	Chrysoeriol, kaempferol, quercetin, 5,7,4′-Trihydroflavanone, kaempferol-3-o-β-d-glucopyranoside, kaempferol-3-o-β-d-glucopyranosyl, -β-d-glucopyranoside, fatty acids, hydrotetra triacontane, n-dotriacontanol, n-triacontanol, aloe-emodin,	Anti-diabetic	Re generation of pancreatic cells for increased insulin production	73
64	*Senna occidentalis*	Leguminosae	Root	Ethanol	Sennoside, anthraquinone glycosides, fatty oils, flavonoids, glycosides, galactomannan, polysaccharides, and tannins	Antidiabetic	B-cell regenerating	74
65	*Terminalia chebula*	Combretaceae	Fruit	Ethyl acetate	Phenols, flavonoids, alkaloids, terpenoids, saponins and glycosides	Antidiabetic	Antioxidant	75
66	*Vinca rosea*	Dogbanes	Whole plant	Ethanol	Vinblastine and vincristine,	Antidiabetic	Increased Inducing the β cells.	76
67	*Areca catechu*	Arecaceae	Seed	Ethanol	Alkaloids, Flavonoids, saponins, steroids, triterpenoids, tannins, quinones, and essential oils	Anti-diabetic	Increasing the release of insulin from the pancreas	77
68	*Salacia oblonga wall*	Celastraceae	Root	Methanol	Alkaloids, phenols, flavonoids, saponins, glycosides, steroids,	Anti-diabetic	Lowering blood glucose levels Is the potentiation of β cells of pancreatic islets, leading to the secretion of insulin	78
69	*Tribulus terrestris*	Zygophyllaceae	Whole plant	Methanol	Phenols, flavonoids, alkaloids, terpenoids, saponins and glycosides	Antidiabetic	Antioxidant	79

Table 1. Continued...

70	*Trigonella foenum graecum*	Fabaceae	Seed	Methanol	Polyphenols, steroids, lipids, alkaloids, saponins, flavonoids, hydrocarbons, carbohydrates, galactomannan fibre, and amino acids	Hypo glycaemic	Include β-cell renewal and insulin secretion stimulation	80
71	*Lagenaria siceraria*	Cucurbitaceae	Aerial and fruits	Petroleum ether	Sterols, oleanolic acid, triterpenoids, tannins, saponins, flavone c-glycosides, and flavonoids	Antidiabetic	Antioxidant	81
72	*Praecitrullus fistulosus*	Cucurbitaceae	Leaves	Ethanol	Polyphenols, flavonoids, ascorbic acid, tannin, alkaloid, saponin, phytosterol, diterpenes, thiamine, and carotene, proteins, carbohydrates and cardiac glycosides.	Antidiabetic	Increased release of insulin from the existing β-cells of pancreas	82
73	*Neolamarckia cadamba*	Rubiaceae	Flower	Methanol	Gallic acid	Antidiabetic	Antioxidant	83
74	*Neopicrorhiza scrophu lariiflora*	Plantaginaceae	Whole plant	Ethanol	D-mannitol, vanillic acid a	Antihyp erglycemic	Initiating the release of insulin from pancreatic b- Cells.1	84
75	*Malvastrum corom andelianum*	Malvaceae	Stem, root and leaves	Methanol	Alphaglucosidase, porcine pancreatic α-amylase, p-nitrophenyl-α-d glucopyranoside	Antidiabetic	Increased the tolerance for glucose	85
76	*Daucus carota*	Apiaceae	Carrot juice		Flavonoids, tannins, alkaloids	Antidiabetic	Reduction of blood glucose	86
77	*Mimusops elengi*	Sapotaceae	Whole plant	Ethanol	-amino acids, carbohydrates, reducing sugars, Saponins, tannins and alkaloids, lupeol, spinasterol	Antidiabetic	Improved glucose consu mption	87
78	*Hedychium coronarium*	Zingiberaceae	Rhizo mes	Ethyl acetate	Phenols, flavonoids, alkaloids, terpenoids, saponins and glycosides	Anti-diabetic	Insulin-resistant glucose uptake	88

Table 1. Continued...

79	*Hedychium spicatum*	Zingib eraceaeae	Rhizo mes	Ethanol	Oil, diarylheptanoids, starch, resin, organic acids, glycosides, Albumen and saccharide	Antidiabetic	Decrease cholesterol and Triglyceride levels can help improve lipid metabolism in Diabetics	89
80	*Hibiscus rosa-sinensis*	Malvaceae	Leaves	Ethanol	S quercetin, cyanidin, thiamine, niacin, Ascorbic acid, genistic acid, lauric acid, margaric acid, hentriacontane And calcium oxalate	Antihype rglycemic	S enhancing insulin secretion from pancreatic β-cells	90
81	*Hibiscus deflersi*	Malvaceae	Flower	Aqueous	Apigenin c-hexoside-c-pentoside, luteolin c-hexoside-c-pentoside, luteolin derivative, 4-hydroxybenzoic acid, and tyrosol and peonidin	Anti-diabetic	Antioxidant	91
82	*Gardenia gummifera*	Rubiaceae	Leaves	Methanol	Alkaloids, carbohydrates, flavonoids, glycosides, oils, fats, Polyphenols, tannins, terpens, saponins and triterpenoids	Antidiabetic	Antioxidant	92
83	*Caesalpinia sappan*	Caesalpiniaceae	Whole plant	Ethanol	Tannins, flavonoids, saponins, phenols, alkaloid	Anti-diabetic	Increases the peripheral utilization and activities of glucose metabolic enzymes	93
84	*Caesalpinia bonduc*	Febaceae	Whole plant	Hydroethanolic	Alkaloids, flavonoids, glycosides, saponins, Tannins and triterpenes	Anti-diabetic	Activation of *β* cells	94
85	*Cocos nucifera*	Arecaceae	Whole plant	Methanol	Flavonoids, alkaloids, tannins and resins	Anti-diabetic	Anti-oxidant	95

Table 1. Continued...

86	*Bridelia retusa*	Phyllanthaceae	Fruit	Methanol	Flavonoids, Alkaloids, steroids, glycosides, saponins, phenols, tannins, volatile compounds, carbohydrates, and cardiac glycosides	Anti-diabetic	Degenerate of beta cell	96
87	*Carica papaya Casearia ovata*	Caricaceae	Leaves	Distilled water	Tannins, flavonoids, saponins, phenols, alkaloid	Anti-diabetic	Protect pancreatic beta cells from damage	97
88	*Ajuga integrifolia*	Lamiaceae	Fresh root	Aqueous	Terpenoids, glycosides, tannins, flavonoids, alkaloids, steroids, phenols, and saponins	Anti-diabetic	Antioxidant	98
89	*Punica granatum*	Punicaceae family.	Leaves	Methanol	G alkaloids, Tannins, glycosides, carbohydrates, reducing sugars, saponins, steroids, flavonoids, and phytosterols	Antidiabetic	Insulin production by Stimulating the pancreatic β-cells	99
90	*Aconitum napellus*	Ranunculaceae	Whole plant	Petroleum ether	Aconitine, benzoylaconitine, mesaconitine, isoaconitine	Anti-diabetic	Anti-oxidant	100
91	*Aloevera*	Asphodelaceae	Leaves	Methanol	Flavonoids, as well as proanthocyanidins and phenolic acids , arginine	Anti-diabetic	Hypog lycaemic agent through the potent inhibition of pancreatic amylase activity.	101
92	*Aloe barbadensis*	Asphodelaceae	Leaves	Methanol	flavonoids, as well as proanthocyanidins and phenolic acid ,arginin	Antidiabetic	Inhibited the glycation reaction of proteins in the bsa/ glucose system	102
93	*Cassia alata*	Leguminosae	Leaves	Methanol	Flavones, flavonols, flavonoids glycosides, alatinon, Alanonal and β-sitosterol-β-d-glucoside	Antidiabetic	Antioxidant	103

Table 1. Continued...

94	*Trigonella Foenum Graecum*	Fabaceae	Seed	Aqueous	Polyphenols, steroids, lipids, alkaloids, saponins, flavonoids, hydrocarbons, carbohydrates, galactomannan fiber, and amino acids	Antidiabetic	Fenugreek increased glucose uptake in hepg2 cells is due to the overex pression of the glucose transporter	104
95	*Terminelia Arjuna*	Combertaceae	Whole plant	Ethanol	Tannins, polyphenols And triterpenoids	Antidiabetic	Enhan cement of insulin Secretion	105
96	*Terminalia Catappa*	Combretaceae	Leaves (crude ex tract)	Water	B-carotene, phenol, flavonoids, and tannins	Antidiabetic	Impro vement in pancreatic beta cells in Stimulating insulin release	106
97	*Ricinus communis*	Euphorbiaceae	Leaves	Ethanol and aqueous	Alkaloids, flavonoids and saponins	Anti-diabetic	Stimulant for the release of insulin	107
98	*Sonneratia apetala*	Lythraceae	Leaves	Methanol	Phenols, flavonoids, alkaloids, terpenoids, saponins and glycosides	Antidiabetic	Increase glucose uptake assay	108
99	*Solena amplexicaulis*	Cucurbitaceae	Leaves	Methanol	Phenols, flavonoids, alkaloids, terpenoids, saponins and glycosides	Antidiabetic	Stimulus to release insulin	109
100	*Momordica cymbalaria*	Cucurbitaceae	Seed	Ethanol	Saponins, triterpenoids, polysaccharides, sterols, polypeptides, essential oils, flavonoids and alkaloids	Hypog lycaemic	, improving glucose uptake and utilization	110
101	*Salacia chinensis*	Celastraceae	Stem	Distilled water	Flavonoids, glycosides, alkaloid, and steroids	Antidiabetic	Stimulation of glucose intake in to cells	111
102	*Satureja thymbra*	Lamiaceae	Arieal part	Methanol	Γ-terpinene, carvacrol, p-cymene, and B-caryophyllene	Antidiabetic	inhibit the activity of α-glucosidase	112

Table 1. Continued...

103	*Securigera securidaca*	Fabaceae	Seed	Aqueous	Flavonoids, Steroids, saponins, and tannins	Antidiabetic	Reduces serum ldl and triglyceride levels	113
104	*Olea europaea*	Oleaceae	Leaves	Ethanol	Oleuropein, verbascoside, rutin, tyrosol And hydroxytyrosol	Antidiabetic	Antioxidant	114
105	*Leucaena leucocephala*	Fabaceae	Seed	Aqueous	Alkaloid, flavonoid, saponin, tannin, and phenolic compounds;	Antidiabetic	antioxidant	115
106	*Magnolia champaca*	Magnoliaceae	Bark	Ethanol	Phenolics, flavonoids, flavanol	Antidiabetic	Antioxidant	116
107	*Clerodendrum indicum*	Verbenaceae	Leaves	Ethanol	Flavonoids, alkaloids, tannins, triterpenes, and saponins	Anti-diabetic	increasing the size and number of pancreatic Islets	117
108	*Asparagus gonoclados*	Liliaceae	Root	Ethanol	Paragines, apigenin, kaempferol, rutin, chalcone glycosides, Anthocyanins	Anti-diabetic	increase insulin secreta gogue activity from pancreatic B-cells	118
109	*Ferula asafoetida*	Umbelliferae	Gum-resin	Ethanol	ferulic acid, umbelliferone, and quercetin	Antidiabetic	Stimulation of insulin release	119
110	*Lepidium sativum*	Brassicaceae	Seeds	Methanol	Benzoic, gallic, dihydroxy benzoic, vanillic, chlorogenic, 4-hydroxycoumaric and salycilic acids, pyrogallol, catechol, catechin, caffeine, isoleucine	Hypo glycaemic	Antioxidant	120
111	*Bombax ceiba*	Malvaceae	Root	Ethanol	Alkaloids, Glycosides, flavonoids, steroids, saponins, phytosterols and Triterpenoids (lupeol and beta-sitosterol), phenolic compounds And tannins	Antidiabetic	Increasing the production of insulin	121
112	*Sarcop oterium spinosum*	Rosaceae	Root	Aqueous	Phenols, flavonoids, alkaloids, Saponins, steroids, and terpenoids	Anti-diabetic	Reduced insulin resistance	122

Table 1. Continued...

113	*Senna auriculata*	Fabaceae	Bud and flower	Ethanol	Flavonoids, phenolics	Anti-diabetic	Anti-oxidant	123
114	*Senna surattensis*	Caesalpiniaceae	Leaves	Ethanol	Flavanol glycosides, chrysophanol, ,kaempferide, and Quercetin	Antidiabetic	Antioxidant	124
115	*Zanthoxylum armatum*	Rutaceae	Leaves	Aqueous	Phenols, flavonoids, alkaloids, terpenoids, saponins and glycosides	Antihype rtensive	Inhibition of a-amylase and Glucosidase enzymes	125
116	*Senna sophera*	Fabaceae	Leaves and root	Methanol	Phenols, flavonoids, alkaloids, terpenoids, saponins and glycosides	Antidiabetic	Increased insulin secretion by β-cells	126
117	*Phyllanthus emblica*	Euphorbiaceae	Fruit	Ethanol	Ellagic acid, gallic acid, Corilagin, furosin, flavonoids, glycosides and tannins	Antidiabetic	Antioxidant	127
118	*Polyalthia longifolia*	Annonaceae	Leaves	Aqueous	Phenols, flavonoids, alkaloids, terpenoids, saponins and glycosides	Antidiabetic	Slowing down of glucose absorption	128
119	*Premna corymbose*	Lamiaceae	Root	Ethanol	Alkaloids, tannin', flavonoid'	Antidiabetic	Insulin is a hormone produced by the pancreas	129
120	*Sansevieria trifasciata*	Asparagaceae	Leaves	Ethanol	Flavonoids, glycosides, alkaloid, and steroids	Antidiabetic	secret pancreatic β cell function	130
121	*Oroxylum indicum*	Bignoniaceae	Seed	Ethanol	Baicalein-7-o-diglucoside (oroxylin b), baicalein-7-o-glucoside, chrysin, apegenin, Prunetin, sitosterol, oroxindin, biochanin-a, ellagic acid, baicalein and its 6- and 7- Glucuronides, scutellarein, tetuin, antraquinone and aloe-emodin	Hypog lycaemic	Stimulate insulin secretion from pancreatic b-cell	131

Table 1. Continued...

122	*Ichnocarpus frutescens*	Apocynaceae	Leaves, stem and flower	Methanol	, flavonoids, coumarins, sterols, and pentacyclic triterpenoids, i.e., δ12-dehydrolupanyl-3 β-palmitate, δ12-dehydrolupeol, 5-hydroxy octacosan-25-one, lupeol acetate, friedelin, oleanolic acid, friedelinol, nonane, sitosterol dotriacontanoic acid	Antidiabetic	Decrease in blood glucose level	132
123	*Indigofera tinctoria*	Lamiaceae	Whole plant	Ethanol	Tannins, Alkaloids, saponins, flavonoids, terpenoids and phenols	Hypo glycaemic	Reduced glucose conc entration	133
124	*Leucas cephalotes*	Lamiaceae	Whole plant	Alcohol	Triterpenes/ steroids, flavonoids, saponins	Antidiabetic	Reduced blood glucose level	134
125	*Litsea glutinosa*	Lauraceae	Bark	Ethanol	Alkaloids, lignans, and flavones	Antihype rglycemic	Increased insulin sensitivity	135
126	*Luffa echinata*	Cucurbitaceae	Fruit	Pet ether	Flavonoids, steroids, terpenoids and saponins	Antidiabetic	Stimulatory Effect on insulin secretion	136
127	*Marsilea minuta*	Marsileaceae	Leaf and stem	Methanol	Steroids, saponins, flavonoids, tannins, and alkaloids	Hypo glycaemic	Stimulation of glucose Uptake	137
128	*Marsilea quadrifolia*	Marsileaceae	Leaf and stem	Methanol	Saponins, flavonoids, alkaloids, and phenolics	Antidiabetic	Secretion of insulin from the beta cells and increase the utilization of glucose	138
129	*Garcinia indica*	Guttiferae	Seed	Methanol	Carbohydrates, xanthones as C-glycosides, tannins, and citric acid	Anti-diabetic	Reduction in Blood glucose	139
130	*Chenopodium album*	Amaranthaceae	Root	Methanol	Carbohydrates, alkaloids, Glycosides, steroids, saponins, and tannins.	Anti-diabetic	Decrease cholesterol and triglyceride	140
131	*Actiniopteris dichotoma*	Pteridaceae.	Whole plant	Ethyle acetate	Terpenoids, phenyl propanoids, Steroids, and flavonoids	Anti-diabetic	Anti-oxidant	141

Table 1. Continued...

132	*Abroma augusta*	Malvaceae	Root	Benzene	Octacosanol, taraxerol, β-sitosterol acetate, lupeol, an aliphatic alcohol	Antihype rglycemic	Promoting glucose uptake and metabolizing	142
133	*Anoectochilus roxburghii*	(orchidaceae)	Whole plant	Methanol	Mannose, Glucose and galactose	Anti-diabetic	Anti-oxidant	143
134	*Ipomoea batata*	Convol vulaceae.	Root	Methanol	Glycoprotein, anthocyanins, alkaloids, and flavonoids	Antidiabetic	Decreased blood glucose level, protein glycation level, total cholesterol, triglycerides, and ldl-cholesterol.	144
135	*Camellia sinensis*	Theaceae	Leaves	Ethanol	Polyphenols, flavonoids, and catechins	Antidiabetic	Increase insulin sensitivity and reduce oxidative Stress	145
136	*Bougainvillea spectabilis*	Nyctaginacea	Leaves	Methanol	Flavonoids, Alkaloids, steroids, glycosides, saponins, phenols, tannins, volatile compounds, carbohydrates, and cardiac glycosides	Hypog lycaemic	Improve beta cell	146
137	*Dioscorea alata*	Dioscoreacea	Whole plant	Ethanol	Alkaloids, glycosides, tannins, polyphenols, Flavonoids and terpenoids	Antidiabetic	Anti-oxidant	147
138	*Cucumis melo*	Cucurbitaceae	Leaves	Ethanol	Phenols and Flavonoids	Anti-diabetic	Stimulate insulin secretion from remnant Pancreatic â-cells	148
139	*Gynandropsis gynandra*	Capparidaceae	Root	Aqueous	Sterols, glycosides, saponins, Carbohydrates, alkaloids, flavonoids, tannins, proteins And phenolic steroids.	Hypo glycaemic	Reduction of Blood glucose levels	149

Table 1. Continued...

140	*Senna alexandrina*	Leguminosae	Seed	Ether	Alkaloids, steroids, terpenes, flavonoids, saponins, glycosides, Tannins, resins, lactones, quinines, and volatile oils	Anti-diabetic	Antioxidant	150
141	*Boerhavia diffusa*	Nyctaginaceae	Root	Methanol	Flavonoids, steroid, and phenolics	Anti-diabetic	Insulin secretion from Remnant or rejuvenated pancreatic β-cells	151
142	*Tinospora sinensis*	Menis permaceae	Stem	Ethanol	Phenols, flavonoids, alkaloids, terpenoids, saponins and glycosides	Antidiabetic	Stimulation of Endogenous insulin secretion	152
143	*Picrorhiza kurroa*	Scroph ulariaceae	Rhiz ome	Hydroalcoholic	Mino acids/ organic acids/ cucurbitacins, sugars/polyols and phenolics/iridoids/ flavonoids	Antidiabetic	Insulin secretion	153
144	*Rubus ulmifolius*	Rosacea	Fruit	Ethyl acetate	Flavonoids, cyanogenic glycosides, phytoestrogens and phenolic	Hypog lycaemic	Antioxidant	154
145	*Mukia mader aspatana*	Cucurbitaceae	Whole plant	Petroleum ether	Flavonoid and terpenoid	Antidiabetic	Inhibit glucone ogenesis in the rat liver and increase glucose uptake	155
146	*Murraya paniculata*	Rutaceae	Leaves	Water	Acetonitrile, phosphoric acid, gallic acid, ellagic acid, Chlorogenic acid	Antidiabetic	increased insulin secretion	156
147	*Nymphaea alba*	Nymphaeaceae	Leaves	Ethanol	Quercetin, apigenin, kaempferol and ellagic Acid	Antidiabetic	Secretion and production of insulin	157
148	*Ocimum basilicum*	Lamiaceae	Leaves	Aqueous	Polyphenols, flavonoids, Alkaloids, terpenoids, steroids, and glycosides	Antidiabetic	Secretion and production of insulin	158

Table 1. Continued...

149	*Ocimum gratissimum*	Lamiaceae	Leaves	Methanol	Phenols, flavonoids, alkaloids, terpenoids, saponins and glycosides	Antidiabetic	Decrease in blood glucose	159
150	*Gossypium herbaceum*	Malvaceae	Seed	Ethanol	Phenols, flavonoids, alkaloids, terpenoids, saponins and glycosides	Antidiabetic	Reduced normo glycemia, serum cholesterol, triglyceride, and urea	160
151	*Ludwigia octovalvis*	Onagraceae	Whole plant	Methanol	B-sitosterol	Antidiabetic	Regulate systemic glucose metabolism	161
152	*Melochia corchorifolia*	Meliaceae	Leaves	Aqueous	Phenols, flavonoids, alkaloids, terpenoids, saponins and glycosides	Antihype glycemic	Reducing insulin resistance	162
153	*Mentha spicata*	Lamiaceae.	Leaves	Aqueous	Carvone, limonene, menthone, menthol, pulegone, dihydrocarvone, and s-carveol	Hypo glycaemic	Reduction of total cholesterol, triglyceride and LDL-cholesterol	163
154	*Mimosa pudica*	Fabaceae.	Whole parts	Ethanol	Steroids, tannins, flavonoids And phenolic compounds kaempferol and stigmasterol	Hypog lycaemic	Stimulates the insulin secretion	164
155	*Garcinia pedunculata*	Clusiaceae	Fruit	Methanol	Alkaloids, carbohydrates, flavonoids, glycosides, oils, fats, Polyphenols, tannins, terpenes, saponins and triterpenoids	Antihy perglycemic	Antioxidant	165
156	*Chonemorpha fragrans*	Apocynaceae	Leaf	Ethanol	Alkaloids, glycosides, carbohydrates, flavonoids, tannins, saponins, sterols, Phenols and proteins	Antidiabetic	Reduction in blood glucose level	166
157	*Chrysan themum morifolium*	Asteraceae	Flower	Methanol	Alkaloids, flavonoids, Tannins, sterols, carbohydrates and glycoside	Antidiabetic	Anti-oxidant	167

Table 1. Continued...

158	*Abrus precatorius*	Fabaceae	Seed	Aqueous	Saponins, phenolics compounds, tannins, proteins and	Hypo glycaemic	Altered lipid profiles and liver glycogen	168
159	*Cassia fistula*	Fabaceae	Fresh pod	Hydro alcoholic	Catechin, epiafzelechin, epicatechin, procyanidin b-2,25 rhein; 1,8-dihydroxy-3-anthraquinone carboxylic,26 fistulic Acid,27 3-formyl-1-hydroxy-8-methoxy anthraquinone,28 diterpene	Hypo glycaemic	Enhanced insulin secretion from the Beta cells, improved glucose utilization and transport	169
160	*Swertia Chirata*	Gentinaceae	Root	Ethanol	Amarogentin, mangiferin and swertia Merin	Antihy perglycemic	Blood glucose Lowering property and also decreases lipid levels.	170
161	*Aegle marmelose*	Rutaceae	Fruits	Alcohol	Alkaloids, Carbohydrates, glycosides, flavonoids, tannins, coumarins, sterols and triterpenoids	Antidiabetic	Antioxidant	171
162	*Citrullus colocynthis*	Cucurbitaceae	Seed	Aqueous	Saponins, total alkaloids and glycosidic isosaponarin; isovitexin and isoorientin 3	Antihy perglycemic	Lower effect on blood glucose levels	172

Table 2. Chemical list including chemical names and chemical structures

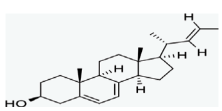
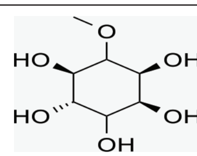
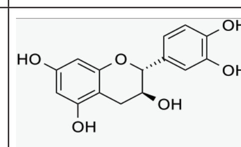
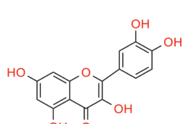
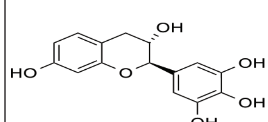
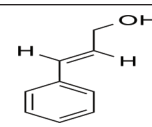
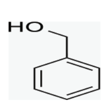
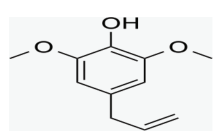
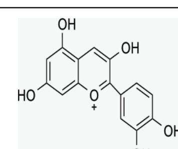
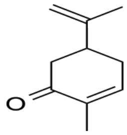
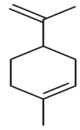
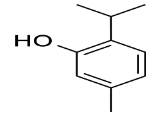
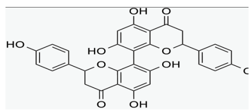
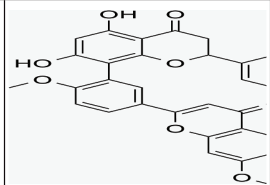
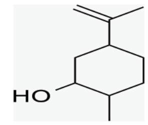
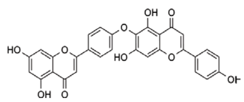
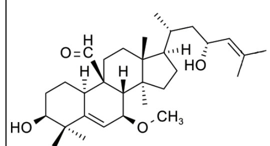
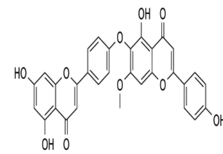
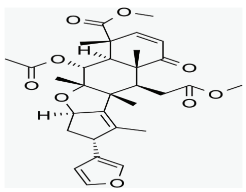
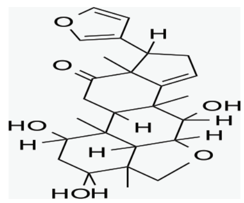
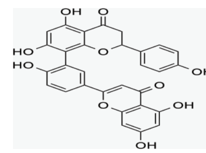
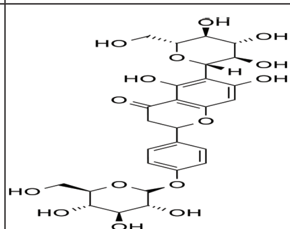
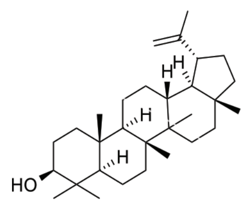
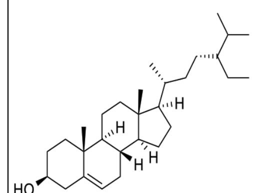
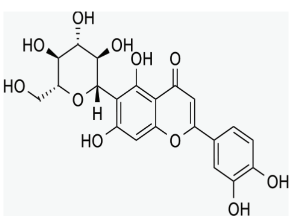
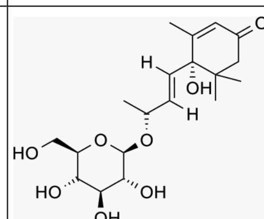
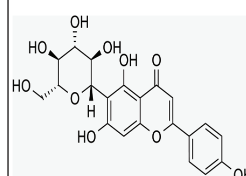
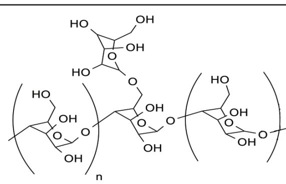
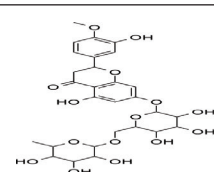
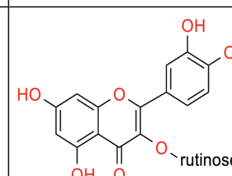
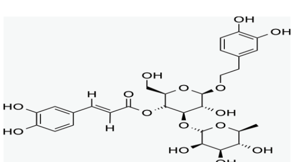
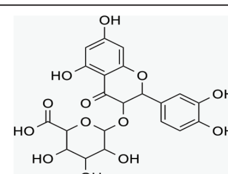
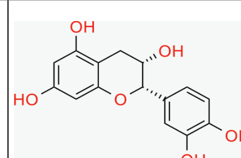
Chemical name	Structure	Chemical name	Structure	Chemical name	Structure
Ergosterol		Pinitol,		Catechin	
Quercetin		Robinetinidol		Cinnamyl alcohol	
Benzyl alcohol		4-allyl-2,6-dimetho xyphenol		Cyanidin	

Table 2. Continued...

Carvone		Limonene		Thymol	
Cupress uflavone		Sciadopitysin		Dihydro carveol,	
Hinokiflavone		Charantin		Isoc yptomerin	
Nimbin		Nimbidin		Amen toflavone	
Isosaponarin		Lupeol		Beta-sitosterol	
Isoorientin 3		Roseoside		Isovitexin	
Galactomannan fiber		Hesperetin 7- rham noglucoside,		Rutin,	
Verbascoside		Quercetin-3-glucuronide		Epicatechin-(epi) gallo catechin dimer	

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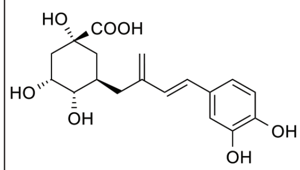
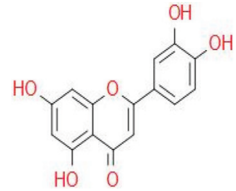
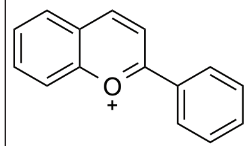
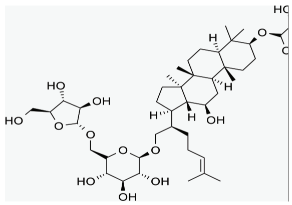
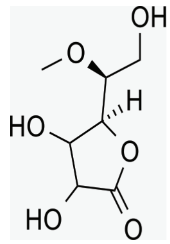
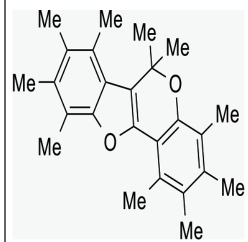
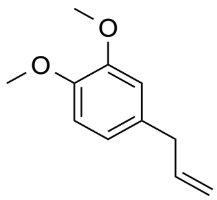
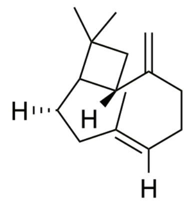
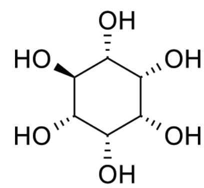
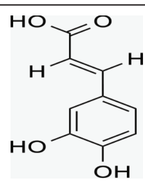
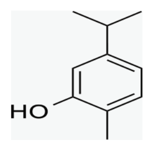
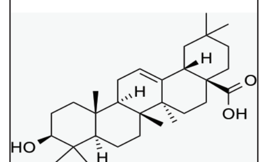
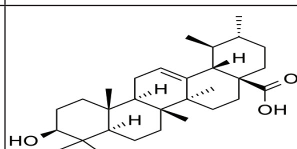
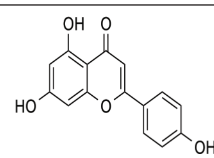
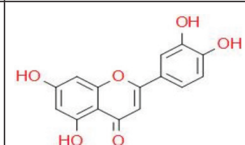
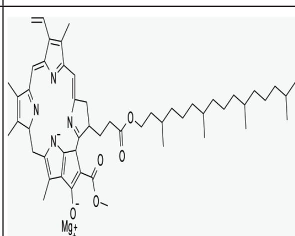
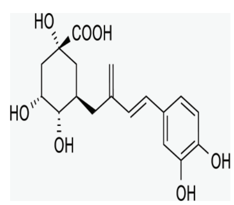
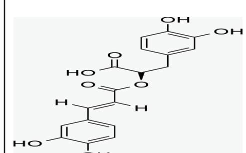
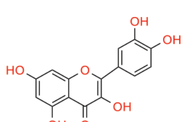
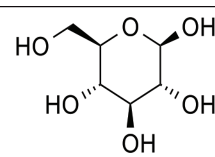
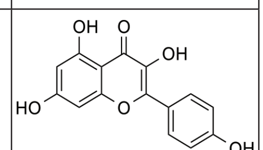
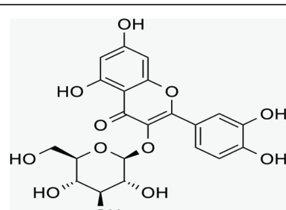
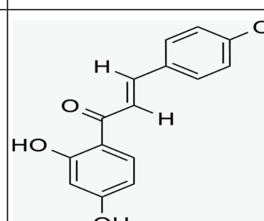
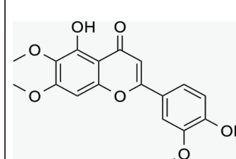
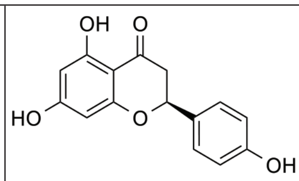
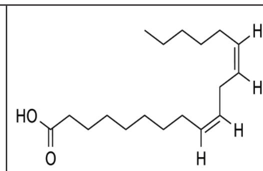
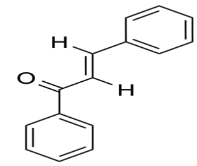
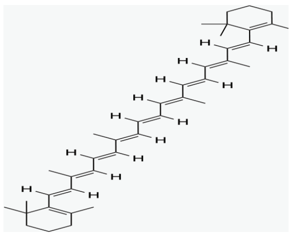
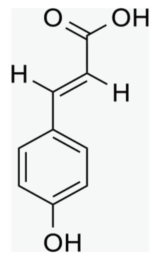
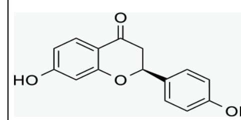
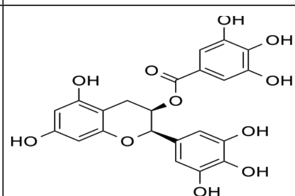
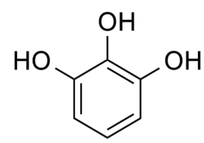
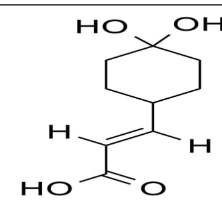
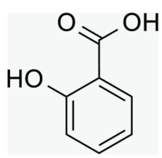
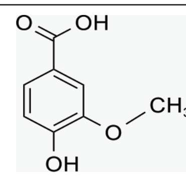
Chlorogenic acid		Luteolin		Anthocyanin	
Triterpenes		Ascorbic acid,		Coumestans	
Eugenol methyl Ether		Caryo phyllene		D-chiro-inositol	
Caffeic acid		Carvacrol		Oleanolic acid	
Ursolic acid (triterpenoid		Apigenin		Luteolin,	
Chlorophyll		Chlorogenic		Rosmarinic acid	
Quercetin		Glucoside		Rosmarinic acid (Phenylpro panoid	
Isoquercitrin		Isoliquir itigenin		Kaempferol	

Table 2. Continued...

Naringenin		Linoleate		Cirsilineol	
ß-carotene		P-coumaric acid		Chalcone	
Dihydroxy benzoic		Pyrogallol		Liquirit igenin	
Salicylic acid		Vanillic		4- hydrox ycoumaric	

4. Discussion

DM is a chronic metabolic disorder characterised by elevated blood glucose levels. It is a major global health concern, affecting approximately 463 million adults worldwide. The prevalence of DM is projected to increase further, reaching 700 million by 2045[173]. Uncontrolled DM can lead to various complications, including cardiovascular disease, diabetic nephropathy, and diabetic retinopathy. Conventional treatments for DM, such as insulin therapy and oral hypoglycemic agents, often have side effects and can be expensive. Therefore, exploring alternative treatment options, particularly from natural sources, is crucial[174].

This comprehensive review provides compelling evidence supporting the antidiabetic properties of a wide range of medicinal plants and their phytoconstituents. The findings of 162 studies published between 2017 and 2023 highlight the diverse mechanisms of action and promising therapeutic potential of these plant extracts. These findings involved the major mechanism of action to overcome the diabetes mellitus.

The intricate interplay between medicinal plants and their potential as therapeutic agents for DM revolves around their capacity to modulate various aspects of glucose metabolism. A basic mechanism through which these plants exert their antidiabetic effects is the enhancement of insulin secretion from pancreatic beta cells. The wealth of bioactive compounds harboured by medicinal plants presents a rich tapestry of potential interventions across various facets of diabetes management. The multifaceted mechanisms encompassing insulin secretion enhancement, insulin sensitivity improvement, oxidative stress reduction, regulation of glucose absorption, and enzyme inhibition collectively underscore the promising role of medicinal plants in the intricate landscape of diabetes mellitus therapeutics.

These diverse mechanisms highlight the potential of medicinal plants in inhibiting enzymes involved in glucose metabolism and improving glycemic control in diabetes management. Further research is warranted to fully elucidate the molecular mechanisms involved and to establish the efficacy and safety of these plant-based approaches in clinical settings.

The findings of this comprehensive review underscore the immense potential of medicinal plants in the management of DM. Their diverse mechanisms of action, lack of adverse effects compared to conventional antidiabetic drugs, and widespread availability make them promising candidates for further clinical development.

5. Future Directions

- **Standardization of plant extracts:** Further research is warranted to standardize the extraction, formulation, and dosage of plant extracts to ensure their consistent efficacy and safety.
- **Clinical trials:** Well-designed clinical trials are needed to evaluate the efficacy and safety of plant extracts in human populations with DM.
- **Mechanism of action of studies:** More in-depth studies are required to fully elucidate the molecular mechanisms of action of plant extracts and their interactions with conventional antidiabetic drugs.
- **Integration into DM management:** Comprehensive DM management strategies should consider the integration of medicinal plants alongside conventional therapies to provide a more personalised and holistic approach to patient care.

6. Conclusion

Medicinal plants offer a promising alternative or adjunct to conventional antidiabetic therapies. Plants have displayed antidiabetic properties via numerous mechanisms of action including antioxidative properties and anti-inflammatory activity, increasing insulin sensitivity and glucose uptake, increasing glyconeogenesis and regulating insulin-induced signalling in different tissues.

Their diverse mechanisms of action, lack of adverse effects, and widespread availability make them attractive candidates for further clinical development. Integrating medicinal plants into comprehensive DM management strategies could provide a more holistic and personalised approach to patient care. Therefore, this review provides a direction for research scientists to further explore the potential mechanism of action of these medicinal plants in the management of diabetes mellitus in patients.

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