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ANM Mamun-or-Rashid
PhD Research student, Graduate School of Life and Medical Sciences, Doshisha University, Japan.

Md. Shamim Hossain
Department of Biotechnology and Genetic Engineering, Faculty of Applied Science and Technology, Islamic University, Kushtia-7003, Bangladesh.

Naim Hassan
Department of Biotechnology and Genetic Engineering, Faculty of Applied Science and Technology, Islamic University, Kushtia-7003, Bangladesh.

Biplab Kumar Dash
Lecturer, Department of Genetic Engineering and Biotechnology, Jessore University of Science and Technology, Bangladesh.

Md. Ashrafuzzaman Sapon
PhD Research student, Bioscience Division, Graduate school of Science & Technology, Shizuoka University, Shizuoka, Japan.

Monokesh Kumer Sen
Department of Biotechnology and Genetic Engineering, Faculty of Applied Science and Technology, Islamic University, Kushtia-7003, Bangladesh.

Correspondence:
Md. Shamim Hossain
Department of Biotechnology and Genetic Engineering, Faculty of Applied Science and Technology, Islamic University, Kushtia-7003, Bangladesh.

A review on medicinal plants with antidiabetic activity

ANM Mamun-or-Rashid, Md. Shamim Hossain, Naim Hassan, Biplab Kumar Dash, Md. Ashrafuzzaman Sapon, Monokesh Kumer Sen

Abstract
In the last few years, there has been an exponential growth in the field of herbal medicine and gaining popularity both in developing and developed countries because of their natural origin and less side effects. A comprehensive review was conducted to pile up information about medicinal plants used for the treatment of diabetes mellitus. It is a metabolic disorder of the endocrine system and affecting nearly 10% of the population all over the world also the number of those affected is increasing day by day. The profiles presented include information about the scientific and family name, plant parts and test model used, the degree of hypoglycemic activity, and the active chemical agents. The large number of plants described in this review (108 plant species belonging to 56 families) clearly demonstrated the importance of herbal plants in the treatment of diabetes. The effects of these plants may delay the development of diabetic complications and correct the metabolic abnormalities. This work stimulates the researchers for further research on the potential use of medicinal plants having antidiabetic potential.

Keywords: Comprehensive review, medicinal plant, antidiabetic potential.

1. Introduction

Medicinal plants continue to be an important therapeutic aid for alleviating ailments of humankind. Over the last 2500 years, there have been very strong traditional systems of medicine such as Chinese, Ayurvedic, and the Unani, born and practiced, more in the eastern continent. These traditions are still flourishing, since; approximately 80% of the people in the developing countries rely on these systems of medicine for their primary health care needs [1]. These plants contain substances that can be used for therapeutic purposes, of which are precursors for the synthesis of drugs [2]. A lot of research work has been carried out on some medicinal herbs and they have been found to have definite action on the nervous, circulatory, respiratory, digestive and urinary systems; as well as the sexual organs, the skin, vision, hearing and taste [3].

Diabetes mellitus is a group of metabolic alterations characterized by hyperglycemia resulting from defects in insulin secretion, action or both. It is made up of two types: Type I and Type II. Type I diabetes often referred to as juvenile diabetes, is insulin dependent and known to affect only 5% of the diabetic population. The Type II, which is non-insulin dependent, usually develops in adults over the age of 40. It has already been established that chronic hyperglycemia of diabetes is associated with long term damage, dysfunction and eventually the failure of organs, especially the eyes, kidneys, nerves, heart and blood vessels [4]. It has an adverse effect on carbohydrate, lipid and protein metabolism resulting in chronic hyperglycemia and abnormality of lipid profile. These lead to series of secondary complications including polyurea, polyphasia, ketosis, retinopathy as well as cardiovascular disorder [5]. In spite of the introduction and extensive utilization of hypoglycemic agents, diabetes and the related complications continue to be a major health problem worldwide, which is affecting nearly 10% of the population all over the world [6] and considered as a major cause of high economic loss which can in turn impede the development of nations [7]. It is projected to become one of the world's main disablers and killers within the next 25 years. Many factors contribute to the on-set of diabetes and these are termed as predisposing or risk factors. Environmental factors such as diet, obesity and sedentary life style increase the risk of diabetes. Other important risk factors include high family aggregation, insulin resistance, nutritional status, age and lifestyle change due to urbanization [8]. The management of diabetes is a global problem until now and successful treatment is not yet discovered [9].

Currently available therapy for diabetes includes insulin and various oral hypoglycemic agents such as sulfonylureas, metformin, glucosidase inhibitors, troglitazone, etc. But these are reported to produce serious adverse side effects such as liver problems, lactic acidosis and diarrhea [10]. It is currently affecting around 143 million people [11] and the number of those affected is increasing day by day, by 2030 it is predicted to reach 366 million population worldwide [12]. About 800 plant species have been reported to possess antidiabetic properties. Several plant species have been used for prevention or management of diabetes by the Native Americans, Chinese, South Americans and Asian Indians [11].

The study showed that Asian and African continents have 56% and 17% share of the worldwide distribution of therapeutic herbal plants, respectively [13]. Biological actions of the plants are related to chemical composition that are rich in phenolics, alkaloids, flavonoids, terpenoids, coumarins, and glycosides usually show positive effects. On the other hand, many conventional drugs for treatment of diabetes, such as metformin are secretagogues which have a plant origin [14].

The conventional drugs are used to treat diabetes by improving insulin sensitivity, increasing insulin production and decreasing the amount of glucose in blood. The adverse effect of drug treatment are not always satisfactory in maintaining normal levels of blood glucose and this view many medicinal plants have been provided a potential source of antidiabetic principle which are widely used for the treatment of diabetes mellitus in various traditional system of medicine worldwide and many of them are known to be effective against diabetes. The hypoglycemic effect of pharmacologically active component of plant decrease the effect on α-amylase and various direct and indirect effects of different blood parameters responsible for development of diabetes [15]. A large number of antidiabetic medicines are available in the pharmaceutical market for diabetes and its related complications; however, currently no effective therapy is available to cure the disease. However, due to unwanted side effects the efficacies of these compounds are debatable and there is a demand for new compounds for the treatment of diabetes [16, 17]. In the last few years, there has been a growing interest in the herbal medicine in care and management of diabetes both in developing and developed countries, due to their natural origin and less side effects [18, 19, 20].

In this review article, an attempt has been made to compile the reported hypoglycemic plants available in different scientific journals and may be useful to the health professionals, scientists and scholars working in the field of pharmacology and therapeutics to develop evidence based alternative medicine to cure different kinds of diabetes in man and animals. This review shows the importance and the interest placed on medicinal plants in the drive to demonstrate their antidiabetic effects and the responsible bioactive agents. This review also covers the common name of a plant, the parts that are commonly used as a remedy sources, extracts, doses, and a test model.

Table 1: Analysis of remedies obtained from different plant parts for diabetes mellitus

Family	Botanical name	Common name	Parts used	Extracts	Active chemical constituents	Dose mg/kg	Test model	Result	References
Fabaceae	*Acacia arabica*	Indian gum arabic	Seed, Bark	-	Polyphenol, Tannin	-	-	-	[21,22, 23,24, 25,26]
	Cassia auriculata	Tanner's cassia	Flower	-	Sterol, Triterpenoid, Flavonoid, Tannin	-	-	-	
	Glycine max	Soya beans	Seed	-	3-O-methyl-D-chiro-inositol	-	-	-	
	Tamarindus indica	Tatul tree	Seed, Fruit	Methanolic	Flavonoid, Polysaccharide	200	STZ rat	-	
	Xanthocercis zambesiaca	Nyala tree	Leaf	-	Fagomine, 4-O-beta-D-glucopyranosylfagomine, Castanospermine	-	-	-	
	Retama raetam	-	whole plant	Aqueous	-	i.v., AT	STZ rat	↓Glucose	
	Butea monosperma	Bastard teak	Fruit	Aqueous	Butein, Palasonin, Stigmasterol-3 β-D-glucopyranoside	1 or 2g	Type II diabetic patient	-	
Rutaceae	*Aegle marmelos*	Golden apple	Leaf, Seed, Fruit	Ethanolic, Aqueous	Aegeline 2, Coumarin, Flavonoid, Alkaloid	I.p., 14d; p.o., 14d; 1.0 g/kg	STZ rat	↓Glucose, ↓glycosylated Hemoglobin, ↑C-peptide, ↑glucose Tolerance, ↑glycogen,	[27, 28,29, 30, 31,32, 25,26]

								↑insulin	
	Citrus reticulate	Mandarin	Fruit	Essential oil	Essential oil	500-2000	Alloxan rat	-	
	Feronia elephantum	Wood apple	Fruit	Aqueous	Bioflavonoid, Triterpenoid, Stigma sterol, Bergapten	500	Alloxan rat	-	
	Murraya koenigii	Curry-leaf tree	Leaf, Fruit	Fruit juice	Carbazole, Alkaloid	2.5-5.0 ml/kg	Alloxan mice	-	
	Limonia acidissima	Wood apple	Fruit	Methanolic	Polysaccharide	200-400	Alloxan rat		
Alliaceae	*Allium cepa*	Onion	Bulb		Allyl propyl disulphide, S- methyl cysteine sulphoxide	-	Alloxan rat	-	[34,35, 36,37, 38, 39,26]
	Allium sativum	Garlic	Root	Ethanolic	Diallyl disulphide oxide, Ajoene, Allyl propyl disulfide, S-allyl cysteine, S-allyl mercaptocysteine	P.o., 14d, 21-112 d	STZ rat	↓Glucose, ↓Lipid, ↑Insulin, ↓Oxidative stress	
Asphodelaceae	*Aloe barbadensis*	Barbados aloe	Leaf	-	Lophenol, 24-methyl-lophenol, 24-ethyllophenol	-	-	-	[40, 26]
Meliaceae	*Azadirachta indica*	Neem	Leaf, Seed	-	Nimbidin	-	-	-	[41,25, 26]
	Melia dubia	African mahogany	-	Alcoholic	Liminoid	300	STZ rat	-	
Chenopodiaceae	*Beta vulgaris*	Beetroot	Whole Plant	-	Sugar beet pectin, Polydextrose	-	-	-	[42, 26]
Oxalidaceae	*Biophytum. Sensitivum*	Sikerpud	Whole Plant	-	Not known	-	-	-	[43,32,26]
	Averrhoa bilimbi	-	Leaf	Aqueous	-	P.o., 14d	STZ rat	↓Glucose, ↓Lipid	
Brassicaceae	*Brassica juncea*	Mustard	Seed, Leaf	-	Isorhamnetin diglucoside	-	-	-	[44, 45, 46, 26]
	Lepidium sativum	-	Leaf	Aqueous	-	p.o., AT, p.o.,15d	STZ rat	↓Glucose	
	Raphanus sativus	-	Whole plant	Aqueous	-	p.o., 21d	STZ rat	↓Glucose, ↓Lipid, ↓Insulin	
Leguminosae	*Cajanus cajan*	Pigeon pea	Seed	-	(7R*,9as*)-7-phenyl-octahydroquinolizin-2-one	-	-	-	[47, 26]
Solanaceae	*Withania somnifera*	Winter cherry	Leaf	-	Withanolide, Alkaloid	-	-	-	[48,49, 50,25, 26]
	Lycium barbarum	Chirchita	Fruit	Crude polysaccharide extract	Polysaccharide	p.o., 21-26d; 10-250 mg/kg	STZ rat, Alloxan rabbit	↓Glucose, ↓Oxidative stress, ↑GLUT4, ↑Insulin	
	Withania coagulans	Vegetable rennet	Fruit	Ethanolic	Milk-coagulating enzyme, Esterase, Fatty oil, Essential oil, Alkaloid	750	STZ rat	-	
	Physalis alkekengi	Strawberry tomato	-	Aqueous	Polysaccharide	50-100	Alloxan mice	-	
	Capsicum frutescens	Chilli	-	-	Capsaicin	-	-	-	
Apocynaceae	*Catharanthus roseus*	Red periwinkle	Whole Plant	-	Vinculin, Alkaloid	-	-	-	[26]
Lauraceae	*Cinnamomum zeylanicum*	Cinnamon	Leaf, Bark	-	Cinnamaldehyde	-	-	-	[51,25, 26]

	Persea americana	Avocado	Fruit	Aqueous	Fat, Protein, Vitamin, Mineral	450-900	Alloxan rat	-	
Apiaceae	*Coriandrum sativum*	Coriander	Leaf	-	Alanine	-	-	-	[52, 26]
	Cuminum cyminum	Cumin seed	Seed	-	Aldehyde	-	-	-	
Zingiberaceae	*Curcuma longa*	Turmeric	Root	-	Curcuminoid	-	-	-	[53,54, 26]
	Zingiber officinale	Ginger	Bulb	-	Gingerol, Ethanol	-	-	-	
Myrtaceae	*Eucalyptus globules*	Blue gum	Leaf	-	Calytoside	-	-	-	[55,56, 57,58, 25,26]
	Psidium guajava	Guava	Leaf, Fruit	Aqueous, Methanolic	Terpen, Flavonoid, Strictinin, Isostrictinin, Pedunculagin, Polysaccharide	P.o., AT; 100-400 mg/kg	STZ rat	↓Glucose	
	Baccharis trimera	-	Leaf	Aqueous	-	P.o., 7d	STZ mice	↓Glucose	
	Syzygium cordatum	-	Leaf	Aqueous	-	p.o., 28d	STZ rat	↓Glucose, ↑Hepatic glycogen	
	Syzygium jambolanum	Jambolan	Fruit	Methanolic	Anthocyanin, Citric, Malic, Gallic acid	100 ng ml-1	-	-	
Moraceae	*Ficus bengalensis*	Banyan tree	Bark	-	Leucopelargonidin	-	-	-	[59,60, 61,62, 63,25, 26]
	Ficus carica	Anjir	Leaf, Fruit	-	Invert sugar		-	-	
	Egyptian Morus alba		Stem bark	Alcoholic	-	p.o., 10d	STZ rat	↓Glucose, ↓Lipid peroxidation, ↑Insulin	
	Artocarpus heterophyllus	Jackfruit	Fruit	Aqueous	Sapogenin	250-500	Alloxan rat	-	
Asclepiadaceae	*Gymnema sylvestre*	Sugar destroyer	Leaf	-	Gymnemic acid, Gymnema, Saponin	-	-	-	[64, 26]
Poaceae	*Hordeum vulgare*	Barley	Seed	-	Beta-glucan	-	-	-	[65,66, 26]
	Triticum vulgare	Wheat	Whole plant	-	Albumin	-	-	-	
Acanthaceae	*Hygrophila auriculata*	Talmakhana	Whole plant	-	Unknown	-	-	-	[67, 26]
	Strobilanthes crispus		Leaf	Aqueous	-	p.o., 21d	STZ rat	↓Glucose	
Cucurbitaceae	*Ibervillea sonorae*	Huereque	Root	-	Monoglyceride (MG), Fatty acid	-	-	-	[68, 69,70, 71,72, 73,74, 75,76, 25,26]
	Momordica charantia	Bitter melon	Whole plant	methanolic, Aqueous, chloroformic	Charantin, Momordicin, Galactose-binding lectin Non-bitter, Diosgenin, Cholesterol, lanosterol, β-sitosterol, Cucurbitacin glycoside	p.o., 27-30d; 10-20 mg/kg	SZT mice	↓Glucose, ↓Glycosylated hemoglobin, ↓Oxidative stress, ↑Glycogen, ↓Lipid peroxidation	
	Coccinia indica	Ivy-gourd	Fruit	Alcoholic	B-amyrin, Lupeol, Cucurbitacin B	150	Alloxan rat	-	
	Cucumis metuliferus	Jelly melon	Fruit	Fruit extract	B-carotene, Fatty acid	1000-1500	Alloxan rat	-	
	Momordica	Kaarali-kanda	Fruit	Aqueous	Steroidal glycoside or phenolics	0.5g/kg	STZ rat	-	

	cymbalaria								
	Momordica balsamina	Balsam apple	Fruit	Methanolic	Momordicin, Vitamin C, Resin acid, Fixed oil, Carotene, Aromatic volatile oil, Alkaloid, Cucurbitacin, Saponin	250-500	STZ rat	-	
Euphorbiaceae	*Jatropha curcas*	Barbados nut	Whole plant	-	Diterpene	-	-	-	[77,25,26]
	Phyllanthus emblica; P. Acidus	Indian gooseberry	Fruit	Aqueous	Tannin	350	Alloxan rat	-	
	Emblica officinalis	Amla	Fruit	-	Tannoid	-	-	-	
Anacardiaceae	*Mangifera indica*	Mango tree	Leaf, Stem Bark, Fruit	Aqueous, Alcoholic	Mangiferin, Phenolics, Flavonoid	i.p., AT; 100-200 mg/kg	STZ rat, Alloxan rat	↓Glucose	[78,79, 25,26]
	Rhus coriaria	Sicilian Sumac	Fruit	Ethanolic	Limonene, Nonanal, Dec-2 (Z)-enal	400	Alloxan wistar rat	-	
Lamiaceae	*Mentha piperita*	Peppermint	Leaf	-	Essential oil, Terpen, Flavonoid. Vanadium, Zinc, Chromium, Copper, Iron, Potassium, Sodium, Nickel	-	-	-	[80,81, 82, 26]
	Ocimum sanctum	Holy basil	Leaf	-	Eugenol (1-hydroxy-2-methoxy-4-allylbenzene)	-	-	-	
	Leonotis leonurus	-	Leaf	Aqueous	-	p.o., AT	STZ mice	↓Glucose	
	Salvia officinalis	-	Leaf	Aqueous	-	p.o., 14d	STZ rat	↓Glucose ↓Gluconeogenesis	
Moringaceae	*Moringa oleifera*	Moringa	Whole plant	-	Not known	-	-	-	[26]
Musaceae	*Musa sapientum*	Sweet banana	Flower	-	Flavonoid, Steroid, Glycoside	-	-	-	[83,25, 26]
	Musa paradisiaca	Banana	Fruit	Methanolic	Dietary fibre, Pectin	100-800	STZ rat		
Nymphaeaceae	*Nelumbo nucifera*	Sacred lotus	Flower	-	Tolbutamide	-	-	-	[84, 26]
Ranunculaceae	*Nigella sativa*	Roman coriander	Whole plant	-	Thymoquinone	-	-	-	[85, 26]
Turneraceae	*Turnera diffusa*	Damiana	Leaf	-	Flavonoid, Terpen	-	-	-	[26]
Utricaceae	*Urtica dioica*	Nettles	Leaf	-	Flavonoid, Coumarin, Lectin	-	-		[26]
Ericaceae	*Vaccinium myrtillus*	Bilberry	Leaf, Fruit	-	Anthocyanoside	-	-	-	[86,25, 26]
	Vaccinium angustifolium	Wild blueberry	Fruit	Ethanolic	Phenolic	12.5 mg/ml	-	-	
Liliaceae	*Aloe vera*	Barbados aloe	Leaf	Ethanolic	Pseudoprototinosaponin, Prototinosaponin	P.o., 28d	Db/db mice	↓Glycosylated hemoglobin	[40,62, 32]
Amaranthaceae	*Amaranthus esculentus*	-	Whole plant	Oil fraction	-	P.o., 21d	STZ rat	↓Gluose, ↑Insulin	[87, 32]
Annonaceae	*Annona squamosa*	-	Leaf, Fruit-Pulp	Aqueous, Ethanolic	-	P.o., 10-30d; p.o., 10-15d	STZ rat, Alloxan rabbit	↓Glucose, ↓Lipid, ↓Lipid peroxidation	[88,89, 90,91, 32]

	Malmea depressa	-	Root	Aqueous, Ethanolic, *n*-butanol fraction	-	p.o., AT	STZ rat	↓Glucose	
Crassulaceae	*Bryophyllum pinnatum*	-	Leaf	Alcoholic	-	p.o./i.p., AT	STZ rat	↓Glucose	[92]
Burseraceae	*Canarium schweinfurthi*	-	Stem bark	Methanolic, Methylene chloride	-	p.o.,14d	STZ rat	↓Glucose	[93]
Asteraceae	*Chamaemelum nobile*	-	Leaf	Aqueous	-	p.o., 15d	STZ rat	↓Glucose	[94,95, 96,97, 25, 26]
	Eugenia jambolana	-	Fruit pulp, Seed	Aqueous, Ethanolic	Pandanus odorus	p.o., AT	STZ rabbit	↓Glucose, ↓Lipid, ↑Glucose tolerance	
	Artemisia sphaerocephala	Worm wood	Fruit	Aqueous	Polysaccharide	200	Alloxan rat	-	
	Taraxacum officinale	Dandelion	Fruit	-	Terpen	-	-	-	
Menispermaceae	*Coscinium fenestratum*	-	Stem bark	Alcoholic	-	p.o., 12d	STZ rat	↓Glucose, ↓Glycosylated hemoglobin, ↓Glycogen, ↓Lipid, ↓Oxidative stress	[98]
Rubiaceae	*Hintonia standleyana*	-	Stem bark	methanolic	-	p.o., AT	STZ rat	↓Glucose	[99,100,25]
	Morinda citrifolia	Indian mulberry	Fruit	Fruit juice	Saponin, Triterpene, Steroid, Flavonoid	2 ml/kg	STZ rat	-	
Hypoxidaceae	*Hypoxis hemerocallidea*	-	Fruit	Aqueous	-	p.o., AT	STZ mice	↓Glucose	[101]
Piperaceae	*Piper betle*	Pan	Leaf	Aqueous	-	p.o., 30 d	STZ rat	↓Glucose, ↓Glycosylated hemoglobin	[102, 103]
Scrophulariaceae	*Scoparia dulcis*	-	Whole plant	Aqueous	-	p.o., 21-42 d	STZ rat	↓Glucose, ↓Lipid, ↓oxidative stress, ↑Insulin	[104, 105]
Combretaceae	*Terminalia chebula*	Chebulic myrobalan	Seed, Fruit	chloroform, Aqueous	Shikimic, Gallic, Triacontanoic, Palmitic acid, β-sitosterol, Daucosterol	p.o., AT; 200 mg/kg	STZ rat	↓Glucose	[93,106,107,25]
	Terminalia superba	-	Stem bark	methanolic, methylene chloride	-	p.o., 14 d	STZ rat	↓Glucose	
	Terminalia catappa	Indian almond	Fruit	Petroleum ether, Methanolic, Aqueous	Phenolics	68, 40, 42	Alloxan rat	-	
	Tremella mesenterica	-	Fruit	Isolated compound	-	p.o., 14 d	STZ rat	↓Glucose	
Rhamnaceae	*Ziziphus spina-christi*	Christ thorn	Leaf	*n*-butanol fraction, Hydroalcoholic	Christinin-A, Fatty acid	p.o., AT; 500 mg/kg	STZ rat, Alloxan dog	↓Glucose	[108, 25]
Caricaceae	*Carica papaya*	Papaya	Fruit	Aqueous	Saponin, Tannin, Alkaloid, Flavonoid,	100-400	Wistar rat	-	[25]

					Anthraquinone, Glycoside, Reducing sugar				
Malvaceae	*Thespesia populnea*	Portia tree	Fruit	Alcoholic	Populnetin, Herbacetin, Populneol, Quercetin	100-300	Alloxan rat	-	[25]
	Abelmoschus esculentus	Gumbo	Fruit	Ethanolic	Carbohydrate, Gum, Mucilage, Protein, Phytosterol, Flavonoid, Tannin, Phenolics, Volatile oil	300	Alloxan mice	-	
Ebenaceae	*Diospyros peregrine*	Gaub persimmon	Fruit	Aqueous	Lupeol, Betulin, Gallic acid, Betulinic acid, Hexacosane, Hexacosanol, Sitosterol	50-100	STZ rat	-	[25]
	Diospyros lotus	Date plum	Fruit	Aqueous	Phenolics	150-1000	STZ rat	-	
Ganodermataceae	*Ganoderma lucidum*	Reishi mushroom	Fruit	Polysaccharide fraction	Polysaccharide	25-100	STZ rat	-	[25]
Meripilaceae	*Grifola frondosa*	Maitake	Fruit	Diethyl ether, Ethyl alcohol	Disaccharide	20% Maitake Extract	Glucose tolerance mice	-	[25]
Sterculiaceae	*Helicteres isora*	East Indian screw tree	Fruit	Aqueous	Steroid, Terpenoid, Alkaloid, Carbohydrate, Phenolics	500µg/ml	Glucose tolerance rat	-	[25]
Palmae	*Lodoicea sechellarum*	Sea coconut	Fruit	Fruit extract	Carbohydrate	2-4g	Type II diabetic patient	-	[25]
Punicaceae	*Punica granatum*	Pomegranate	Fruit	Ethanolic	Tannin	200	Alloxan mice	-	[25]
Araliaceae	*Panax ginseng*	Ginseng	Fruit	Berry extract	Saponin	150	Glucose tolerance mice	-	[25]
Cactaceae	*Opuntia dillenii*	Prickly pear	Fruit	Polysaccharide extract	Polysaccharide	100, 200, 400	STZ rat	-	[25]
Lyophyllaceae	*Lyophyllum decastes*	Fried chicken mushroom	Fruit	Aqueous	Polysaccharide	500	KK-Ay diabetic mice	-	[25]
Caprifoliaceae	*Viburnum opulus*	Cranberry bush	Fruit	Aqueous	Tannin	100	Alloxan mice	-	[25]
Papilionaceae	*Butea monosperma*	Flame of the forest	Fruit	Aqueous	Flavonoid	3g	Type II diabetic patient	-	[25]

AT: Acute treatment, GLUT-4: Glucose transporter, Hex: Hexane fraction, i.p.: Intraperitoneal route, p.o.: oral route and STZ: Streptozotocin

2. Discussion

Diabetes mellitus is spreading in an alarming way throughout the world and three fourth of the world populations and considered as a major cause of high economic loss which can in turn impede the development of nations. Moreover, uncontrolled diabetes leads to many chronic complications such as blindness, heart disease, and renal failure, etc. For this, therapies developed along the principles of western medicine (allopathic) are often limited in efficacy, carry the risk of adverse effects, and are often too costly, especially for the developing world. Therefore, treating diabetes mellitus with plant derived compounds which are accessible and do not require laborious pharmaceutical synthesis seems highly attractive.

The study revealed that 108 plant species belonging to 56 families were generally used for treatment of diabetes. The majority of the experiments confirmed the benefits of medicinal plants with hypoglycemic effects in the management of diabetes mellitus. Among the plants used for the diabetes, Annona squamosa, Momordica charantia, Egyptian Morus alba, Lycium barbarum, Allium sativum, and Aegle marmelose seems to be most common plants used to treat diabetes and are available everywhere. The detailed natural plants not only used for the treatment of diabetes, but also treated for other ailments also. The fruits were most commonly used plant parts and other parts (leaf, root, stem, bark, flower, and whole plant) were also useful for curing. However, the diabetic model that was most commonly used was the streptozotocin and alloxan-induced diabetic mouse or rat as diabetic models. In this study, most commonly used animal model was STZ rat. In some cases alloxan mice, glucose tolerance mice, KK-Ay diabetic mice, and diabetic patient were used as a model. Some authors have used hereditary diabetic mice e.g. KK Ay mice as a model of type II diabetes with hyperinsulinemia.109

The most commonly involved active constituents are Flavonoid, Tannin, Phenolics, and Alkaloid. Numerous mechanisms of actions have been proposed for these plant extracts. Some hypotheses relate to their effects on the activity of pancreatic ß cells (synthesis, release) or the increase of the insulin sensitivity or the insulin-like activity of the plant extracts. All of these actions may be responsible for the reduction or abolition of diabetic complications.

3. Conclusion

The present review has presented comprehensive details of antidiabetic plants used in the treatment of diabetes mellitus. Some of these plant derived medicines, however, offer potential for cost effective management of diabetes through dietary interventions, nutrient supplementation, and combination therapies with synthetic drugs in the short term, and as the sole medication from natural sources over the long term. The presences of bioactive chemicals are mainly responsible for this antidiabetic action. However, many other active agents obtained from plants have not been well characterized. More investigations must be carried out to evaluate the mechanism of action of medicinal plants with antidiabetic effect.

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