African Medicinal Plants with Antidiabetic Potentials: A Review

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Key words
- Africa
- antidiabetic effects
- diabetes mellitus
- medicinal plants
- North Africa
- East Africa
- West Africa
- Central Africa
- Southern Africa

Abstract

Diabetes mellitus is one of the major health problems in Africa. The conventional oral synthetic antidiabetic drugs available to manage the disease are costly and not readily affordable to the majority of the affected population. Interestingly, the continent is endowed with a tremendous number of medicinal plants that have been explored for their folkloric treatment of diabetes mellitus. Scientific investigations have validated the antidiabetic potentials of a number of these medicinal plants but there is no repository with information on these scientifically investigated plants as a guide for future research. In this review article, all of the *in vivo* antidiabetic studies conducted between January 2000 and July 2013 on African plants are systematically compiled with a closer look at some relevant plants from the continent's subregions. Plants of the Asteraceae and Lamiaceae families are the most investigated, and West Africa has the highest number of investigated plants. Although promising results were reported in many cases, unfortunately, only a few studies reported the partial characterization of bioactive principles and/or mechanisms of action. It is hoped that government agencies, pharmaceutical industries, and the scientific community will have a look at some of these plants for future research and, if possible, subsequent commercialization.

Introduction

Diabetes mellitus (DM) is a heterogeneous group of metabolic disorders characterized by persistent hyperglycemia [1] and derangement in the metabolism of carbohydrates, fats, and proteins as a result of defects in insulin secretion and/or insulin action [2].

Recent data from the International Diabetes Federation (IDF) indicates that DM affects over 366 million people worldwide and this is likely to increase to 552 million or even more by the year 2030 [3]. In Africa, more than 14 million people have diabetes, accounting for about 4.3 % of adults and is responsible for about 401 276 deaths in 2012 in the region [4]. West Africa recorded the highest number of DM cases with Nigeria (3.2 million diabetics) and Côte d'Ivoire (421 023 diabetics) occupying first and second positions, respectively. In Southern Africa, South Africa tops the list (2.0 million diabetics) followed by the Democratic Republic of Congo (737 000 diabetics). Kenya was listed as the fifth country in Africa and the first from the eastern region of Africa (720 730 diabetics), while Cameroon (517 860 diabetics) recorded the highest figure from the central region. North Africa had the least number of diabetics among the African subregions with no single nation in the top ten list of African countries with DM [4].

At present, different approaches are used to control DM using modern synthetic antidiabetic drugs in addition to lifestyle modification. This includes sulphonylureas (glibenclamide), glucosidase inhibitors (acarbose), and biguanide (metformin). However, these synthetic oral hypoglycemic agents have characteristic profiles of serious side effects, which include hypoglycemia, weight gain, gastrointestinal discomfort, nausea, liver and heart failure, and diarrhea [5] in addition to being rather costly and not affordable by the majority of African populations. These limitations coupled with an exponential increase in the prevalence of DM motivate researchers to scientifically validate the folkloric use of a number of antidiabetic African medicinal plants as possible alternative therapies. This is partly because herbs and natural products form an important compo-

received August 22, 2013
revised Dec. 31, 2013
accepted January 1, 2014

Bibliography
DOI http://dx.doi.org/10.1055/s-0033-1360335
Published online February 17, 2014
Planta Med 2014; 80: 354–377

ISSN 0032-0943

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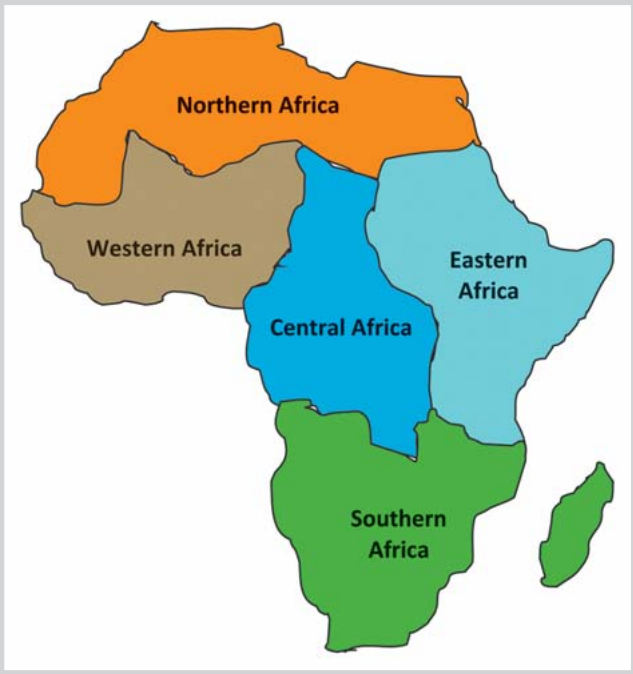

Fig. 1 Map of Africa showing the different subregions. (Color figure available online only.)

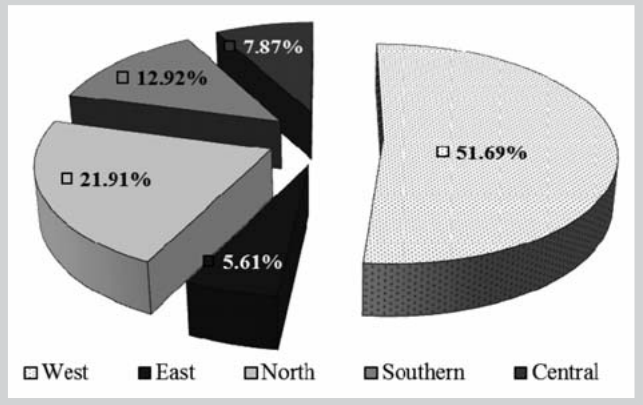

Fig. 2 Subregional distributions of investigated African medicinal plants with antidiabetic effects.

nent of the health care delivery system in African countries [6]. According to the World Health Organization (WHO) [7], 80% of the population in many African countries depend almost entirely on traditional medicines, herbal medicines in particular, for their primary health care needs [8,9]. This is attributed to the perceived effectiveness of the plant-based therapies as well as the availability of these medicinal plants because the continent accounts for about 25% of the total number of higher plants in the world where more than 5400 medicinal plants were reported to have over 16300 medicinal uses [10].

In Africa, herbal medicines are usually provided by a traditional healer, who utilizes natural products in curing many diseases. They have different local methods to diagnose DM in their patients, as they do not rely on laboratory investigations. This is achieved through identifying symptoms like frequent urination, sexual dysfunction, swollen legs, hands and stomach, obesity, fatigue, and profuse sweating during the consultation process. In some cases, they direct the patients to urinate on locally prepared formulations and return after a couple of days with the results of a diagnosis. At present, DM is among the diseases which are most extensively treated with traditional medicines using medicinal plants. This is evident by the propensity of the ethnobotanical surveys for medicinal plants used for the management of DM from different African subregions that include West [11, 12], East [13–15], North [16–18], Southern [19,20], and Central Africa [21]. Interestingly, scientific investigations have confirmed the efficacy of a number of these plant-derived formulations on DM, but presently there is no comprehensive review and/or repository that exists in the literature of these scientifically investigated African antidiabetic medicinal plants that cover the whole of Africa. In this article, we conducted an exhaustive review of all scientifically investigated African antidiabetic medicinal plants whose results have been published between January 2000 and July 2013. The scientific community, government agencies, and pharmaceutical industries may use this as a possible guide for future research.

Results and Discussion

A map of Africa indicating the subregions of the continent as used in this review is presented in **Fig. 1**. A total of 185 plants species from 75 families in Africa have been investigated for antidiabetic effects. The information obtained on these plants includes scientific and common names, families, parts of the plant used, solvent used, and whether the crude extracts or fractions were used in the course of investigation. From the results, plants from the West African subregion account for 51.69% of all the plants investigated for antidiabetic potentials in Africa over the period mentioned (**Fig. 2**). More than 90% of all documented plants from this region emanate from Nigeria, with few data from Ghana, Senegal, Benin, Togo, and Côte d'Ivoire (**Table 1**). Reports on the antidiabetic effects of North African plants account for 21.91% (**Fig. 2**) and originated from Morocco, Egypt, Algeria, Tunisia, Sudan, and Libya (**Table 3**). On the other hand, 12.92% of antidiabetic African plants were reported from Southern Africa (**Fig. 2**) with most of the studies originating from South Africa (**Table 4**). The remaining parts, East (**Table 2**) and Central (**Table 5**) Africa, recorded 7.87 and 5.61%, respectively, of African medicinal plants with antidiabetic effects. The results also indicated that plants from the Asteraceae and Lamiaceae families received a lot of attention in all parts of Africa (**Fig. 3**). On the other hand, analysis of the investigated parts of the plant indicated that the leaf was the most scientifically investigated part (**Fig. 4**).

More importantly, promising results were reported in many cases but, unfortunately, only a few studies reported detailed characterization of bioactive principles. Data available indicated that only six plants from northern and two from western regions received partial characterization of a possible active ingredient that could be responsible for their antidiabetic effects (**Table 6**). In order to provide a full view of the antidiabetic potentials of these African medicinal plants, the scientifically investigated medicinal plants are categorized into subregions (**Fig. 1**) and discussed more thoroughly. The discussions are based on the subregions and the criteria used for highlighting a plant that has potency of the reported antidiabetic activity, except in the case of

Table 1 List of scientifically investigated antidiabetic medicinal plants from West Africa.

Scientific name	Common name	Family	Part(s) used	Dosage (orally/day)/ Extract/Fraction	Type of effects	Type of DM/ Model used	Country	References
Acacia albida Del.	Ana Tree	Mimosaceae	Root	200 mg/kg bw Methanol extract	Antihyperglycemic	Type 1/Animal	Nigeria	[139]
Acalypha wilkesiana Müll. Arg.	Copperleaf	Euphorbiaceae	Leaf	100, 200, and 300 mg/kg bw Aqueous extract	Antihyperglycemic and antihyperlipidemic	Type 1/Animal	Nigeria	[140]
Adansonia digitata L.	Baobab	Bombacaceae	Stem bark	100, 200, and 400 mg/kg bw Aqueous extract	Antihyperglycemic	Type 1/Animal	Nigeria	[141]
Afzelia Africana Smith.	Counter wood	Fabaceae	Root	62.5, 125, 250, 500, and 1000 mg/kg bw Aqueous extract	Antihyperglycemic	Type 1/Animal	Nigeria	[142]
Ageratum conyzoides L.	Billygoat weed	Asteraceae	Seed	100, 200, 400 and, 500 mg/kg bw Ethanol extract	Antihyperglycemic	Type 1/Animal	Nigeria	[143, 144]
Alchornea cordifolia Müll. Arg.			Leaf	200, 400, and 800 mg/kg bw Butanol fraction	Antihyperglycemic	Type 1/Animal	Nigeria	[145]
Allium cepa L.	Onion	Liliaceae	Bulb	200, 250, and 300 mg/kg bw Aqueous extract	Antihyperglycemic	Type 1/Animal	Nigeria	[85, 146–150]
Allium sativum L.	Garlic	Liliaceae	Bulb	200, 250, and 300 mg/kg bw Aqueous extract	Antihyperglycemic	Type 1/Animal	Nigeria	[85, 150]
Aloe perryi Baker.		Liliaceae	Leaf	2 mg/kg bw Ethanol extract	Antihyperglycemic	Type 1/Animal	Nigeria	[34]
Anacardium occidentale L.	Cashew	Anacardiaceae	Leaf	34, 200, 300, and 400 mg/kg bw Aqueous extract	Antihyperglycemic	Type 1 and 2/Animal	Nigeria	[22–25, 151]
Anisopus mannii N. E. Br.	–	Asclepiadaceae	Stem	100, 200, 300, and 400 mg/kg bw Aqueous extract	Antihyperglycemic	Type 1/Animal	Nigeria	[152, 153]
Anthocleista djalonensis A. Chev.	Cabbage tree	Loganiaceae	Leaf/Stem/ Root	1 g/kg bw Methanol extract and its fractions	Antihyperglycemic	Type 1/Animal	Nigeria	[154]
Axonopus compressus P. Beauv.	Blanket grass	Fabaceae	Leaf	250, 500, and 1000 mg/kg bw Methanol extract	Antihyperglycemic	Type 1/Animal	Nigeria	[155]
Azadirachta indica A. Juss.	Neem	Meliaceae	Leaf	70 and 400 mg/kg bw Ethanol extract	Antihyperglycemic and antihyperlipidemic	Type 1/Animal	Nigeria/ Ghana	[26–31]
Bauhinia rufescens Lam.	–	Caesalpiniaceae	Leaf	200, 300, and 400 mg/kg bw Methanol extract	Antihyperglycemic and antihyperlipidemic	Type 1/Animal	Nigeria	[156, 157]
Bridelia ferruginea Benth.	–	Euphorbiaceae	Root bark	250 mg/kg bw Methanol extract	Antihyperglycemic and hypoglycemic	Type 1/Animal	Nigeria	[158]
Carica papaya L.	Pawpaw	Caricaceae	Seed	100, 200, 300, and 400 mg/kg bw Aqueous extract	Antihyperglycemic and hypolipidemic	Type 1/Animal	Nigeria	[159, 160]
Carum carvi L.	Caraway	Apiaceae	Fruit	5, 10, 20, 40, and 80 mg/kg bw Aqueous extract	Antihyperglycemic	Type 1/Animal	Nigeria	[161–164]
Cassia italic Mill.	Italian senna	Caesalpiniaceae	Leaf	200 mg/kg bw Aqueous/ethanol extract	Antihyperglycemic and antioxidative	Type 1/Animal	Nigeria	[165, 166]
Catharantus roseus L.	Madagascar periwinkle	Apocynaceae	Leaf	Ethanol extract	Antihyperglycemic	Type 1/Animal	Nigeria	[77, 167]
Ceiba pentandra L. Gaertn.	Silk-cotton tree	Bombacaceae	Stem bark	250, 400, 800, and 1500 mg/kg bw Aqueous extract	Antihyperglycemic	Type 1/Animal	Nigeria	[168]
Chrysophyllum cainito L.	Star apple	Anacardiaceae	Leaf	10, 20, and 30 g/l Aqueous extract in drinking water	Antihyperglycemic	Type 1/Animal	Côte d'Ivoire	[169]
Cinchona calisaya Wedd.	–	Rubiaceae	Stem bark	50 and 100 mg/kg bw Aqueous extract	Antihyperglycemic	Type 1/Animal	Nigeria	[170]

continued

Table 1 *Continued*

Scientific name	Common name	Family	Part(s) used	Dosage (orally/day)/ Extract/Fraction	Type of effects	Type of DM/ Model used	Country	References
Cissampelos mucronata A. Rich.	Heart-leaved vine	Menispermaceae	Leaf	200, 400, and 800 mg/kg bw Ethanol extract	Antihyperglycemic	Type 1/Animal	Nigeria	[171]
Cissampelos owariensis P. Beauv.	Velvet leaf	Menispermaceae	Leaf	100 and 200 mg/kg bw Ethanol extract	Antihyperglycemic	Type 1/Animal	Nigeria	[172]
Citrus aurantium L.	Bitter orange	Rutaceae	Fruit	400 and 800 mg/kg bw Aqueous extract	Antihyperglycemic	Type 1/Animal	Nigeria	[173]
Citrus paradise Macfad.	Grapefruit	Rutaceae	Seed	100, 300, and 600 mg/kg bw Aqueous extract	Antihyperglycemia	Type 1/Animal	Nigeria	[174]
Clausena lansium Lour. Skeels.	Wampee	Rutaceae	Stem bark	100 mg/kg bw Methanol and dichloro methane extract	Antihyperglycemic and insulinotropic	Type 1/Animal	Nigeria	[175]
Cnestis ferruginea D. C.	–	Connaracea	Leaf	250 mg/kg bw Methanol and ethyl acetate extract	Antihyperglycemic and antihyperlipidemic	Type 1/Animal	Nigeria	[176]
Combretum micranthum G. Don.	–	Combretaceae	Leaf	100, 200, and 400 mg/kg bw Aqueous extract	Antihyperglycemic	Type 1/Animal	Nigeria	[177]
Commelina Africana L.	–		Leaf	500 mg/kg bw Aqueous extract	Antihyperglycemic	Type 1/Animal	Nigeria	[144]
Curcumin longa L.	Curcuma	Zingiberaceae	Root	250 mg/kg bw Methanol extract	Antihyperglycemic	Type 1/Animal	Nigeria	[178]
Daniella oliveri Bull. Misc.	Daniellia	Caesalpiniaceae	Root	250 mg/kg bw Aqueous extract	Antihyperglycemic and inhibition of glycolytic enzymes	Type 1/Animal	Nigeria	[179, 180]
Detarium microcarpum Guill. & Perr.	Sweet detar	Caesalpiniaceae		Aqueous extract	Antihyperglycemic	Type 1/Animal	Nigeria	[153]
Ficus asperifolia L.	Sand paper tree	Moraceae	Stem	400, 800, and 1200 mg/kg bw Aqueous extract	Antihyperglycemic	Type 1/Animal	Nigeria	[181]
Ficus exasperate Vahl.	White fig tree	Moraceae	Leaf	100, 200, and 300 mg/kg bw Aqueous extract	Antihyperglycemic and insulinotropic	Type 1/Animal	Nigeria	[182, 183]
Ganoderma lucidum Curtis. P. Karst.	Hemlock varnish shelf	Ganodermataceae	Fruit	50 mg/kg bw Ethyl acetate and butanol fractions	Antihyperglycemic	Type 1/Animal	Nigeria	[184]
Gongronema latifolium Benth.	Amaranth globe	Asclepiadaceae	Leaf	2, 25, 75, 100, 200, and 400 mg/kg bw Aqueous extract	Antihyperglycemic, antihyperlipidemic and insulinotropic	Type 1/Animal	Nigeria	[32–39, 147]
Hibiscus sabdariffa L.	Red sorrel	Malvaceae	Calyces	0.5 mg/ml Aqueous and ethanol extract	Antihyperglycemic and antihyperlipidemic	Type 1/Animal	Nigeria	[40–42]
Holarrhena floribunda G. Don.	False rubber tree	Apocynaceae	Leaf	100, 250 and 500 mg/kg bw Ethanol extract and its solvent fractions	Antihyperglycemic	Type 1/Animal	Côte d'Ivoire	[185]
Homalium letestui Pellegr.	–	Flacourtiaceae	Root	500, 750, and 1000 mg/kg bw Ethanol extract	Antihyperglycemic	Type 1/Animal	Nigeria	[186]
Hunteria umbellate K. Schum. Hallier f.	Flantueh	Apocynaceae	Stem	50, 100, and 200 mg/kg bw Ethanol extract	Antihyperglycemic and insulinotropic	Type 1/Animal	Nigeria	[187]
Hymenocardia acida Tul.	Red-heart	Phyllanthaceae	Leaf	250, 500, 1000, and 2000 mg/kg bw Methanol extract	Antihyperglycemic and antihyperlipimic	Type 1/Animal	Nigeria	[188]
Hyptis suaveolens Poit.	Mint weed	Lamiaceae	Leaf	750 mg/kg bw Methanol extract	Antihyperglycemic	Type 1/Animal	Nigeria	[189]
Indigofera pulchra L.	Indigofera	Papilionaceae	Leaf	50, 100, 200, 250, 500 and 1000 mg/kg bw Butanol fraction	Antihyperglycemic and hypoglycemic	Type 1/Animal	Nigeria	[43–46]
Irvinga gabonensis Aubry-Lecomte ex O'Rorke. Baill.	Wild mango	Asteraceae	Stem bark	200 mg/kg bw Aqueous extract	Antihyperglycemic	Type 1/Animal	Nigeria	[190]

continued

Table 1 *Continued*

Scientific name	Common name	Family	Part(s) used	Dosage (orally/day)/ Extract/Fraction	Type of effects	Type of DM/ Model used	Country	References
Khaya senegalensisis Desr. A. Juss.	African mahogany	Meliaceae	Stem	50, 100, and 150 mg/kg bw Aqueous extract/oil	Antihyperglycemic	Type 1/Animal	Nigeria	[191, 192]
Leptedenia hastate Pers.	–	Leguminosae	Leaf	300 mg/kg bw Ethanol extract	Antihyperglycemic and antihyperlipidemic	Type 1/Animal	Nigeria	[153, 193]
Loranthus micranthus L.	Mistletoe	Loranthaceae	Leaf	250 and 400 mg/kg bw Methanol extract and its fractions	Antihyperglycemic	Type 1/Animal	Nigeria	[194, 195]
Mangifera indica L.	Mango	Anacardiaceae	Leaf	0.5 and 1.0 g/kg bw Methanol extract	Antihyperglycemic	Type 1/Animal	Nigeria	[196]
Mammea africana Sabine.	African apple	Guttiferae	Stem bark	30, 60, and 90 mg/kg bw Ethanol extract	Antihyperglycemic	Type 1/Animal	Nigeria	[197]
Melanthera scandens Schumach. Roberty.	–	Asteraceae	Leaf	37, 74, and 111 mg/kg bw Ethanol extract and its fractions	Antihyperglycemic and antihyperlipidemic	Type 1/Animal	Nigeria	[198]
Mimosa invisa Mart.	Sleeping plant	Fabaceae	Leaf	Aqueous extract	Antihyperglycemic	Type 1/Animal	Nigeria	[153]
Momordica charantia L.	Bitter melon	Cucurbitaceae	Leaf	250, 400, and 500 mg/kg bw Methanol extract	Antihyperglycemic	Type 1/Animal	Nigeria	[199, 200]
Morinda lucida Benth.	Brimstone tree	Rubiaceae	Stem bark	50, 100, 200, and 240 mg/kg bw Aqueous extract	Antihyperglycemic	Type 1/Animal	Nigeria	[201, 202]
Moringa oleifera Lam.	Horseradish	Moringaceae	Leaf	100, 200, and 300 mg/kg bw Aqueous Extract	Antihyperglycemic	Type 1/Animal	Nigeria	[203]
Musa sapientum L var. paradisiacal. Sucker.	Banana	Musaceae		5, 10, 250, and 500 mg/kg bw Methanol extract	Antihyperglycemic and GIT transit time	Type 1/Animal	Nigeria	[204, 205]
Musanga cecropioides R.Br. & Tedlie.	Umbrella tree	Cecropiaceae	Stem bark	250, 500, and 1000 mg/kg bw Aqueous and ethanol extract	Antihyperglycemic	Type 1/Animal	Nigeria	[206]
Nauclea latifolia S. M.	Bishop's head	Rubiaceae	Root/Stem/ Leaf	200, 400, and 1000 mg/kg bw Ethanol and hexane extracts	Antihyperglycemic and sucrose and maltase inhibitions	Type 1/Animal	Benin/Nigeria	[47–51]
Newbouldia laevis P. Beauv.	African Border Tree	Bignoniaceae	Leaf	100, 200, and 400 mg/kg bw Ethanol extract	Antihyperglycemic	Type 1/Animal	Nigeria	[207]
Ocimum gratissimum L.	African/Clove basil	Lamiaceae	Leaf	250, 400, 500, 600, 800, 1000, and 1500 mg/kg bw Methanol extract	Antihyperglycemic and antihyperlipidemic	Type 1/Animal	Nigeria	[53–60]
Ocimum suave Wild.	Hoary basil	Lamiaceae	Leaf	800 mg/kg bw Aqueous extract	Antihyperglycemic	Type 1/Animal	Nigeria	[208]
Oxytenanthera abyssinica A. Rich Munro.	Bindura bamboo	Gramineae	Leaf	25 mg/kg bw Ethanol extract	Antihyperglycemic	Type 1/Animal	Benin	[50]
Parimari microphylla	Boxleaf azara	Chrysobalanaceae	Seed	500 mg/kg bw Ethanol extract	Antihyperglycemic and antihyperlipidemic	Type 1/Animal	Nigeria	[209]
Parinari excels (Guinea Plum)			Bark	100 and 300 mg/kg bw Aqueous extract	Antihyperglycemic	Type 1/Animal	Senegal	[210]
Parkia biglobosa Jacq.	African locust bean	Fabaceae	Seed	6 g/kg bw Aqueous extract	Antihyperglycemic and antihyperlipidemic	Type 1/Animal	Nigeria	[211]
Parquetina nigrescens Afzel. Bullock.		Asclepiadaceae	Leaf	1000 mg/kg bw Aqueous extract	Antihyperglycemic	Type 1/Animal	Nigeria	[212]
Persea Americana Mill.	Avocado	Lauraceae	Seed	450 and 900 mg/kg bw Ethanol extract	Antihyperglycemic	Type 1/Animal	Nigeria	[213]
Phyllanthus amarus L.	Stone breaker	Euphorbiaceae	Whole plant	150, 300, 500, 600, and 1000 mg/kg bw Aqueous/hydroalcoholic extract	Antihyperglycemic and insulinotropic	Type 1/Animal	Nigeria/ Togo	[61–64]

continued

Table 1 *Continued*

Scientific name	Common name	Family	Part(s) used	Dosage (orally/day)/ Extract/Fraction	Type of effects	Type of DM/ Model used	Country	References
Phyllanthus niruri L.	Gulf leaf flower	Euphorbiaceae	Whole plant	240 mg/kg bw Aqueous extract	Antihyperglycemic	Type 1/Animal	Nigeria	[214]
Picralima nitida Stapf.	Picralima	Apocynaceae	Pulp/Seed	250 and 648 mg/kg bw Ethanol and aqueous extract	Antihyperglycemic and hypoglycemic	Type 1/Animal	Nigeria/ Benin	[65, 66]
Raphia hookeri G.Mann & H.Wendl.	Wine palm	Palmaceae	Stem	50, 100, and 200 mg/kg bw Aqueous extract	Antihyperglycemic and hypolipidemic	Type 1/Animal	Nigeria	[215]
Rauvolfia vomitoria Afzel.	Swizzle stick	Apocynaceae	Fruit	400 and 800 mg/kg bw Aqueous extract	Antihyperglycemic	Type 1/Animal	Nigeria	[173]
Sansevieria senegambica Baker.	African flax	Agavaceae	Root	100, 200, and 300 mg/kg bw Aqueous extract	Antihyperglycemic and antihyperlipidemic	Type 1/Animal	Nigeria	[216]
Sarcocephalus latifolius Sm. E. A. Bruce.	African peach	Rubiaceae	Root	250 mg/kg bw Aqueous extract	Antihyperglycemic and inhibition of glycolytic enzymes	Type 1/Animal	Nigeria	[179, 180]
Senna occidentalis L.	Stink weed	Caesalpiniaceae	Leaf	200, 300, and 450 mg/kg bw Methanol extract	Antihyperglycemic	Type 1/Animal	Nigeria	[217]
Senna alata L. Roxb.	Candle bush	Leguminosae	Leaf	250 mg/kg bw Methanol extract	Antihyperglycemic and hypoglycemia	Type 1/Animal	Nigeria	[158]
Senna siamea Lam.	Thailand shower	Caesalpiniaceae	Leaf/Stem bark	250, 500, 1000, 2000, and 3000 mg/kg bw Methanol extract	Antihyperglycemic	Type 1/Animal	Nigeria	[218, 219]
Setaria megaphylla Steud. Dur. & Schinz.	Ribbon grass	Phyllanthaceae	Root	200, 400, and 600 mg/kg bw Ethanol extract	Antihyperglycemic	Type 1/Animal	Nigeria	[220]
Sida acuta Burm. f.	Wire weed	Malvaceae	Leaf	200 and 400 mg/kg bw Ethanol and methanol extract	Antihyperglycemic	Type 1/Animal	Nigeria	[221]
Sphagneticola trilobata L. Pruski.	Creeping oxeye	Asteraceae	Leaf	50 mg/kg bw Aqueous extract	Antihyperglycemic and antioxidative	Type 1/Animal	Nigeria	[222]
Sphenocentrum jollyanum Pierre.	Sorghum bicolor	Menispermaceae	Root	50, 100, and 200 mg/kg bw Aqueous extract	Antihyperglycemic	Type 1/Animal	Nigeria	[223]
Stachytarpheta angustifolia Mill. Vahl.	Devil's coach whip	Verbenaceae	Whole part	250, 500, 750, and 1000 mg/kg bw Aqueous extract	Antihyperglycemic	Type 1/Animal	Nigeria	[224]
Telfairia occidentalis Hook. f.	Fluted pumpkin	Cucurbitaceae	Seed	2, 100, and 250 mg/kg bw Ethanol extract	Antihyperglycemic	Type 1/Animal	Nigeria	[225, 226]
Terminalia catappa L.	Bengal almond	Combretaceae		0.6 ml/20 kg bw Aqueous extract	Antihyperglycemic	Type 1/Animal	Côte d'Ivoire	[227]
Treculia Africana Decne.	African bread-fruit	Moraceae	Root	200 mg/kg bw Aqueous extract	Antihyperglycemic and antihyperlipidemic	Type 1/Animal	Nigeria	[228]
Triplochiton scleroxylon K. Schum.	African white wood	Sterculiaceae	Stem bark	Aqueous extract	Antihyperglycemic	Type 1/Animal	Nigeria	[229]
Vernonia amygdalina Del.	Bitter leaf	Compositae	Leaf	50, 100, 200, 250, 400, and 500 mg/kg bw Hexane and ethylacetate extract	Antihyperglycemic, insulinotropic, and antioxidant	Type 1/Animal	Nigeria	[67–82]
Vernonia colorata Schreb.	Star-flowered bitter-tea	Compositae	Leaf	100 and 300 mg/kg bw Aqueous extract	Antihyperglycemic	Type 1/Animal	Senegal	[230]
Vitex doniana Wild.	African black plum sweet	Verbenaceae	Stem bark	100 mg/kg bw Aqueous extract	Antihyperglycemic	Type 1/Animal	Nigeria	[62]
Viscum album L.	Mistletoe	Loranthaceae	Whole plant	2, 50, and 100 mg/kg bw Methanol extract	Antihyperglycemic	Type 1/Animal	Nigeria	[34, 231]
Zingiber officinale L. Roscoe.	Ginger	Zingiberaceae	Rhizome	200, 250, and 300 mg/kg bw Aqueous extract	Antihyperglycemic and α-amylase inhibition	Type 1/Animal	Nigeria	[83–89]

Table 2 List of scientifically investigated antidiabetic medicinal plants from East Africa.

Scientific name	Common name	Family	Part(s) used	Dosage (orally/day)/ Extract/Fraction	Type of effects	Type of DM/ Model used	Country	Reference
Aspilia pluriseta Schweinf.	Dwarf aspilia	Asteraceae	Root	50, 100, and 200 mg/kg bw Aqueous extract	Antihyperglycemic	Type 1/Animal	Kenya	[232]
Bidens pilosa L.	Spanish needle	Asteraceae	Leaf	50, 100, and 200 mg/kg bw Aqueous extract	Antihyperglycemic	Type 1/Animal	Kenya	[232]
Caylusea abyssinica Fresen. Fisch. & Mey.	–	Resedaceae	Leaf	100, 200, and 300 mg/kg bw Methanol extract	Antihyperglycemic	Type 1/Animal	Ethiopia	[133]
Catha edulis Vahl.	Bushman's tea	Celastraceae	Root	50, 100, and 200 mg/kg bw Aqueous extract	Antihyperglycemic	Type 1/Animal	Kenya	[232]
Erythrina abyssinica Lam.	Red-hot-poker	Fabaceae	Stem bark	50, 100, and 200 mg/kg bw Aqueous extract	Antihyperglycemic	Type 1/Animal	Kenya	[232]
Ficus sycomorus L.	Fig-mulberry	Moraceae	Stem bark	50, 100, and 150 mg/kg bw Aqueous extract	Antihyperglycemic	Type 1/Animal	Kenya	[233]
Moringa stenopetala Baker f.	Cabbage tree	Moringaceae	Leaf	500 mg/kg bw Butanol fraction	Antihyperglycemic and hypoglycemic	Type 1/Animal	Ethiopia	[137]
Pappea capensis Eckl. & Zeyh.	Jacket plum	Sapindaceae	Leaf/ Stem bark	100 and 200 mg/kg bw Aqueous and ethylacetate extract	Antihyperglycemic	Type 1/Animal	Kenya	[234]
Pentas schimperiana A. Rich.	–	Rubiaceae	Leaf	500 and 1000 mg/kg bw Aqueous extract	Antihyperglycemic	Type 1/Animal	Ethiopia	[235]
Strychnos henningsii Gilg.	Red bitter berry	Loganiaceae	Leaf	50, 100, and 200 mg/kg bw Aqueous extract	Antihyperglycemic	Type 1/Animal	Kenya	[232]

West Africa where citations were used as a criteria in addition to the potency of the results.

West Africa

Anacardium occidentale L. (Anacardiaceae), or cashew, is perhaps one of the most cited plants from West Africa. The antidiabetic activity of a stem-bark methanol extract was investigated in a fructose-fed type 2 diabetes (T2D) model of rats [22]. Treatment with 200 mg/kg body weight (bw)/day of the extract given orally significantly ameliorated the changes in plasma glucose, lipid profile, malonyldialdehyde, urea, and creatinine induced by an enriched fructose diet, but showed no effect on plasma alkaline phosphatase levels. Extract treatment reduced plasma glucose levels by almost 40% in fructose-fed type 2 diabetic rats. In another study, oral administration of an ethanolic extract of inner bark and fractions at various doses administered caused a significant decrease in blood glucose levels in a type 1 diabetes (T1D) model of rats [23]. The crude extract decreased blood glucose by 36.8% at 700 mg/kg bw when different fractions at 300, 30, and 200 mg/kg bw/day indicated a glycemic decrease of 18.4%, 15.6%, and 17.3%, respectively. Furthermore, bioactivity-guided fractionation of the ethanolic extract led to fractions that displayed diverse polyphenolic compounds, which are known for their hypoglycemic effect. The methanolic leaf extract, orally administered at 400 mg/kg bw/day, decreased the blood glucose levels of alloxanized rats by 20.8% after 4 hours of treatment compared to 47.63% for tolbutamide, a standard antidiabetic drug [24]. More recently, Ukwenya et al. [25] reported that administration of a methanolic leaf extract at a dose of 300 mg/kg bw recovered the beta cell damage in a T1D model of rats. Although an extensive antidiabetic study on this plant is yet to be done, the preliminary data indicates that the stem bark contains more therapeutically active antidiabetic phytochemicals than the other parts of the plant.

Another highly cited antidiabetic plant is *Azadirachta indica* A. Juss. (Meliaceae), which is commonly referred to as neem tree. The hypoglycemic and antihyperglycemic effects of the leaves in a T1D model of rats have been investigated [26,27]. Oral treatment of the aqueous extract at 400 mg/kg bw/day was found to decrease fasting blood glucose by 54% compared to the control. Further studies were conducted by Akinlola et al. [28], who reported that the ethanolic extract orally administered at 500 mg/kg bw/day prevented intestinal lesions and decreased hyperglycemia (87.5%) in an STZ-induced T1D model of rats. Moreover, in 2010, Akinlola et al. [29] evaluated the chronic treatment of diabetic rats with an *A. indica* leaf ethanolic extract at 500 mg/kg bw/day orally on blood glucose, pancreatic islet histopathology, and oxidative status of the pancreas. The results obtained were quite promising, the fasting blood glucose of the extract-treated group dropped to 50%, the number of β-cells was improved and, similarly, islet histology showed a marked improvement with a significant decrease in oxidative stress. In 2011, this research group also indicated that the oral administration of *A. indica* leaf extract at 500 mg/kg bw/day ameliorated the renal damage in an STZ-induced T1D model of rats [30]. In another study, an orally administered ethanolic leaf extract at 400 mg/kg bw/day was reported to decrease fasting blood glucose by 50% and further prevented the alterations posed by DM on immunological and hematological parameters [31] which have clinical significance in the control of atherosclerosis and other diabetes-associated vascular complications.

Gongronema latifolium Benth. (Asclepiadaceae) is another plant that received much attention as a hypoglycemic and antihyperglycemic agent in Africa. Almost all of its parts are claimed to have an antidiabetic effect. Treatment with the aqueous leaf extract at various dosages was found to decrease the fasting blood glucose in an STZ-induced T1D model of rats [32–35]. Fasting blood glucose dropped by 30.4% compared to untreated diabetic animals. Akah et al. [36] reported that treatment with both aque-

Table 3 List of scientifically investigated antidiabetic medicinal plants from North Africa.

Scientific name	Common name	Family	Part(s) used	Dosage (orally/day)/ Extract/Fraction	Type of effects	Type of DM/Model used	Country	Reference
Ajuga iva L.	Herb ivy	Labiatae	Whole part	10 mg/kg bw Aqueous extract	Antihyperglycemic and antihyperlipidemic	Type 1/Animal	Morocco/ Tunisia	[89–93]
Allium cepa L.	Onion	Liliaceae	Bulb	100 and 400 mg/kg bw Aqueous extract	Antihyperglycemic, antihyperlipidemic, and antioxidative	Type 1and 2/Animal and DM patients	Sudan	[94–96]
Anabasis articulate Forssk. Moq.	Jointed anabis	Chenopodiaceae	Leaf	400 mg/kg bw Methanol extract	Antihyperglycemic and hypoglycemic	Type 1/Animal	Algeria	[236]
Artemisia herba-alba Asso.	White wormwood	Lamiaceae	Aerial part	2 g/kg bw Hydroalcoholic extract	Antihyperglycemic	Type 2/Animal	Algeria	[237]
Balanites aegyptiaca L.	Desert date/Hegleg	Balanitaceae	Fruit	80 mg/kg bw Ethanol and aqueous extracts	Antihyperglycemic, hypoglycemic, and α-amylase inhibition	Type 1/Animal	Egypt	[97, 98]
Capparis spinosa L.	Flinders rose	Capparidaceae	Fruit	20 and 1500 mg/kg bw Aqueous extract	Antihyperglycemic and antihyperlipidemic	Type 2/Animal	Morocco	[103, 238]
Carum carvi L.	Caraway	Apiaceae	Fruit/Oil	2 ml and 20 mg/kg bw Oil and aqueous extract	Antihyperglycemic and antihyperlipidemic	Type 1/Animal	Morocco/ Egypt	[99–102]
Centaurium erythraea Rafn.	Bitter herb	Gentianaceae	Aerial part/Leaf	200 mg/kg bw Aqueous extract	Antihyperglycemic and antioxidative	Type 1 and 2/Animal	Algeria/ Morocco	[239]
Chamaemelum nobile L.	Chamomile	Asteraceae	Aerial part	20 mg/kg bw Aqueous extract	Antihyperglycemic, repress gluconeogenesis, and improve insulin sensitivity	Type 2/Animal	Morocco	[104]
Cinnamomi cassia Nees & T.Nees. J.Presl.	Cinnamon twigs	Lauraceae	Stem bark	200 mg/kg bw Aqueous extract	Antihyperglycemic	Type 1/Animal	Egypt	[240]
Cleome droserifolia Delile. Forsk.	Cleome herb	Capparaceae	Leaf	0.31 g/kg bw Ethanol extract	Antihyperglycemic	Type 1/Animal	Egypt	[241]
Cuminum cyminum L.	Cumin	Apiaceae	Oil	2 ml/kg bw	Antihyperglycemic and antihyperlipidemic	Type 1/Animal	Egypt	[102]
Curcumin longa L.	Curcuma	Zingiberaceae	Root	300 mg/kg bw Methanol extract	Antihyperglycemic	Type 1/Animal	Egypt	[110]
Cynara cornigera L.	Wild artichoke	Asteraceae	Root	1.5 g/kg bw Aqueous extract	Antihyperglycemic	Type 1/Animal	Libya	[242]
Eucalyptus globulus Labill.	Waxy bloom	Myrtaceae	Leaf	200 and 400 mg/kg bw Ethanol extract	Antihyperglycemic	Type 1/Animal	Algeria	[243]
Trigonella foenum graecum L.	Fenugreek	Leguminosae	Seed	1.5 g/kg bw Methanol extract	Antihyperglycemic and α-amylase inhibition	Type 1/Animal	Egypt	[98]
Globularia alypum L.	Black thorn	Globulariaceae	Leaf	20 mg/kg bw Aqueous extract	Antihyperglycemic	Type 1/Animal	Morocco	[244]
Guiera senegalensis J. F. Gmel.	Moshi medicine	Combretaceae	Leaf	200 and 400 mg/kg bw Ethanol extract	Antihyperglycemic	Type 1/Animal	Sudan	[243]
Inula viscosa L.	False yellow head	Asteraceae	Aerial part	20 mg/kg bw Aqueous extract	Antihyperglycemic and antihyperlipidemic	Type 1/Animal	Morocco	[245]
Lepidium sativum L.	Pepper grass	Cruciferae	Stem	20 mg/kg bw Aqueous extract	Antihyperglycemic and hypoglycemic	Type 1/Animal	Morocco	[246]
Magnifera indica L.	Mango	Anacardiaceae	Leaf	250 mg/kg bw Aqueous extract	Antihyperglycemic	Type 1/Animal	Egypt	[247]
Morus alba L.	White mulberry	Moraceae	Leaf/Root bark	200 and 400 mg/kg bw Ethanol extract	Antihyperglycemic, antihyperlipidemic, and antioxidative	Type 1/Animal	Egypt	[105–107]

continued

Table 3 List of scientifically investigated antidiabetic medicinal plants from North Africa.

Scientific name	Common name	Family	Part(s) used	Dosage (orally/day)/ Extract/Fraction	Type of effects	Type of DM/Model used	Country	Reference
Nigella sativa L.	Black seed	Ranunculaceae	Seed	2 g and 300 mg/kg bw Petroleum ether extract	Antihyperglycemic and enhancement of GLUT4 expression	Type 1 and 2/Animal	Egypt	[108–111]
Ocimum basilicum L.	Sweet basil	Lamiaceae	Leaf	20 mg/kg bw Aqueous extract	Antihyperglycemic and antihyperlipidemic	Type 1/Animal	Morocco/ Egypt	[102, 248]
Panax ginseng L.	Korean ginseng	Araliaceae	Root	22.5 mg/rat	Antihyperglycemic, anti-oxidative, and insulinotropic	Type 1/Animal	Egypt	[249]
Psidium guajava L.	Guava	Myrtaceae	Leaf	250 mg/kg bw Aqueous extract	Antihyperglycemic	Type 1/Animal	Egypt	[247]
Rubus fructicosis L.	Blackberry	Rosaceae	Leaf	100 mg/kg bw Aqueous extract	Antihyperglycemic and hypoglycemic	Type 1/Animal	Egypt	[244]
Salvia officinalis L.	Garden sage	Lamiaceae	Leaf	200 and 400 mg/kg bw Ethanol extract	Antihyperglycemic	Type 1/Animal	Algeria	[243]
Spergularia purpurea Pers. G. Don.	Purple sand spurry	Caryophyllaceae	Whole plant	10 mg/kg bw Aqueous extract	Antihyperglycemic and antihyperlipidemic	Type 1/Animal	Morocco	[250, 251]
Suaeda fruticosa L. Forrssk.	Shrubby seablite	Chenopodiaceae	Aerial part	0.8 mg/kg bw/min Aqueous extract	Antihyperglycemic and hypoglycemic	Type 1/Animal	Morocco	[252]
Thymelaea hirsute L. Endl.	Spur flax	Thymelaceae	Aerial part	3 mg/kg bw Aqueous extract	Antihyperglycemic and hypoglycemic	Type 1/Animal	Morocco	[253]
Thymus vulgaris L.	Thyme	Lamiaceae	Oil	2 ml/kg bw	Antihyperglycemic and hypoglycemic	Type 1/Animal	Egypt	[102]
Trigonella foenum graecum	Fenugreek	Leguminosae	Seed	1.5 g/kg bw Methanol extract	Antihyperglycemic, hypo-glycemic, and α-amylase inhibition	Type 1/Animal	Egypt	[98]
Triticum repens L.	Couch grass	Gramineae	Root	20 mg/kg bw Aqueous extract	Antihyperglycemic	Type 1/Animal	Morocco	[254]
Zingiber officinale L. Roscoe	Ginger	Zingiberaceae	Rhizome	4 ml/kg bw Aqueous extract	Antihyperglycemic and antihyperlipidemic	Type 1/Animal	Egypt	[255]
Ziziphus spina-christi L.	Christ's Thorn Jujube	Rhamnaceae	Leaf	100 and 450 mg/kg bw Butanol fraction	Antihyperglycemic, insulino-tropic, and α-amylase in-hibition	Type 1 and 2/Animal	Egypt	[112–114]

Table 4 List of scientifically investigated antidiabetic medicinal plants from Southern Africa.

Scientific name	Common name	Family	Part(s) used	Dosage (orally/day) Extract/Fraction	Type of effects	Type of DM/ Model used	Country	Reference
Afzelia africana SM. ex Pers.	Counter wood	Fabaceae	Root	100 and 200 mg/kg bw Aqueous extract	Antihyperglycemic	Type 1/Animal	South Africa	[256]
Allium cepa L.	Onion	Liliaceae	Bulb	0.5 and 2.0% Aqueous extract	Antihyperglycemic	Type 1/Animal	South Africa	[257]
Aloe excels Berger.	–	Aloaceae	–	–	Antihyperglycemic	Type 1/Animal	Zimbabwe	[258]
Aloe ferox Mill.	Bitter aloe	Xanthorrhoeaceae	Leaf	300 mg/kg bw Ethanol extract	Antihyperglycemic	Type 1/Animal	South Africa	[259]
Aloe greatheadii var. davyana	Spotted aloe	Asphodelaceae	Leaf	300 mg/kg bw Ethanol extract	Antihyperglycemic	Type 1/Animal	South Africa	[259]
Artemisia afra Jacq.	African wormwood	Asteraceae	Leaf	50 and 100 mg/kg bw Aqueous extract	Antihyperglycemic, antioxidative, and insulinotropic	Type 1/Animal	South Africa	[115, 116]
Brachylaena discolor D. C.	Coast silver oak	Asteraceae	Leaf	50 and 150 mg/kg bw Methanol extract	Antihyperglycemic	Type 1/Animal	South Africa	[260]
Bryophyllum pinnatum Lam.	Life plant	Crassulaceae	Leaf	400 mg/kg bw Aqueous extract	Antihyperglycemic	Type 1/Animal	South Africa	[117]
Camellia sinensis L.	White tea	Theaceae		0.5 g/100 ml Aqueous extract	Antihyperglycemic	Type 1/Animal	South Africa	[261]
Clausena anisata Wild.	Horse wood	Rutaceae	Leaf/Root	100, 200, 400, and 800 mg/kg bw Methanol extract	Antihyperglycemic	Type 1/Animal	South Africa	[262]
Catharantus roseus L. G. Don.	Madagascar periwinkle	Apocynaceae	Leaf	500 mg/kg bw Methanol extract	Antihyperglycemic and hypoglycemic	Type 1/Animal	South Africa	[263]
Euclea undulata Thunb. var. *myrtina*	Fire fighter's blessing	Ebenaceae	Root	25 and 50 mg/kg bw Acetone extract	Antihyperglycemic	Type 1/Animal	South Africa	[264]
Hypoxis hemerocallidea Fisch. & C. A. Mey.	African potato	Hypoxidaceae	Corm	50, 100, 200, 400, and 800 mg/kg bw Aqueous extract	Antihyperglycemic	Type 1/Animal	South Africa	[265, 266]
Leonotis leonurus L. R. Br.	Throw-hort	Lamiaceae	Leaf	125 250, and 500 mg/kg bw Aqueous extract	Antihyperglycemic	Type 1/Animal	South Africa	[267]
Momordica charantia L.	Bitter melon	Cucurbitaceae	Whole plant	50, 100, 200, 400, and 800 mg/kg bw Aqueous extract	Antihyperglycemic	Type 1/Animal	South Africa	[268, 277]
Prosopis glandulosa Torr.	Honey mesquite	Fabaceae	Pods	100 mg/kg bw Aqueous extract	Antihyperglycemic and antihyperlipidemic	Type 1 and 2/Animal	South Africa	[269]
Psidium guajava L.	Guava	Myrtaceae	Leaf	Aqueous extract	Antihyperglycemic	Type 1/Animal	South Africa	[270]
Raphia gentiliana De Wild.		Arecaceae	Fruit	0.2 g/kg bw Aqueous extract	Antihyperglycemic	Type 1/Animal	DR Congo	[118]
Rhus chirindensis Baker F.	Red currant	Anacardiaceae	Stem bark	50, 100, 200, 400, and 800 mg/kg bw Aqueous extract	Anti-hyperglycemic	Type 1/Animal	South Africa	[271]
Sclerocarya birrea A. Rich. Hochst.	Jelly plum	Anacardiaceae	Stem bark	100, 200, 400, and 800 mg/kg bw Methanol and dichloromethane extract	Anti-hyperglycemic	Type 1/Animal	South Africa	[119–122]
Strychnos henningsii Gilg.	Red bitter berry	Loganiaceae	Stem bark	125, 250, and 500 mg/kg bw Aqueous extract	Antihyperglycemic, antioxidative, and hypoglycemic	Type 2/Animal	South Africa	[272]
Sutherlandia frutescens R.BR. var. incana E. MEY.	Cancer brush	Fabaceae	Leaf	2.5 g/100 ml Aqueous extract	Antihyperglycemic, antihyperlipidemic, and prevention of insulin resistance	Type 1/Animal	South Africa	[123–125]

Table 5 List of scientifically investigated antidiabetic medicinal plants from Central Africa.

Scientific name	Common name	Family	Part(s) used	Dosage (orally/day)/ Extract/Fraction	Type of effects	Type of DM/ Model used	Country	Reference
Anacardium occidentale L.	Cashew	Anacardiaceae	Leaf	35, 175, and 250 mg/kg bw Methanol and its solvent fractions	Antihyperglycemic	Type 1/Animal	Cameroon	[273]
Bersama engleriana Gurke.	Winged-bersama	Melianthaceae	Leaf	300 and 600 mg/kg bw Aqueous extract	Antihyperglycemic and antihyperlipidemic	Type 2/Animal	Cameroon	[126, 127]
Canarium schweinfurthii Engl.	Bush candle tree	Burseraceae	Stem bark	150 and 300 mg/kg bw Methanol and dichloromethane extract	Antihyperglycemic	Type 1/Animal	Cameroon	[274]
Ceiba pentandra L. Gaertn.	Silk-cotton tree	Bombacaceae	Stem bark	40 and 75 mg/kg/bw Methylene chloride/methanol extracts	Antihyperglycemic	Type 2/Animal	Cameroon	[268]
Citrullus lanatus Thunb.	Watermelon	Cucurbitaceae	Seed	50 mg/kg bw Ethanol extract	Antihyperglycemic	Type 1/Animal	Cameroon	[226]
Cucumeropsis mannii Naudin.	White seed melon	Cucurbitaceae	Seed	50 mg/kg bw Ethanol extract	Antihyperglycemic	Type 1/Animal	Cameroon	[226]
Cucurbita moschata Duchesne ex Poir.	Butternut squash	Leguminosae	Pods	50 mg/kg bw Aqueous extract	Antihyperglycemic	Type 1/Animal	Cameroon	[226]
Dichrostachys glomerata Chiov.	Chinese lantern	Cucurbitaceae	Seed	400 mg Ethanol extract	Antihyperglycemic and antihyperlipidemic	Type 2/DM Patients	Cameroon	[125]
Dracena arborea Wild.	Dragon tree	Dracaenaceae	Root	500 Aqueous and 100 mg/kg bw Ethanol extract	Antihyperglycemic	Type 1/Animal	Cameroon	[130]
Kalanchoe crenata Andr. Haw.	Never ride	Crassulaceae	Whole plant	50 and 68 mg/kg bw Methanol extract	Antihyperglycemic, antihyperlipidemic, and antioxidative	Type 1/Animal	Cameroon	[131]
Lagenaria siceraria L.	Bottle gourd	Cucurbitaceae	Seed	50 mg/kg bw Ethanol extract	Anti-hyperglycemic	Type 1/Animal	Cameroon	[226]
Sclerocarya birrea A. Rich. Hochst.	Jelly plum	Anacardiaceae	Stem bark	150 and 300 mg/kg bw Methanol and dichloromethane extract	Antihyperglycemic and insulinotropic	Type 1 and 2/Animal	Cameroon	[275, 276]
Telfairia occidentalis Hook. f.	Fluted pumpkin	Cucurbitaceae	Seed	50 mg/kg bw Ethanol extract	Antihyperglycemic	Type 1/Animal	Cameroon	[259]
Terminalia superba Engl. & Diels	Ofram tree	Combretaceae	Stembark	150 and 300 mg/kg bw Methanol and dichloromethane extract	Antihyperglycemic	Type 1/Animal	Cameroon	[274]

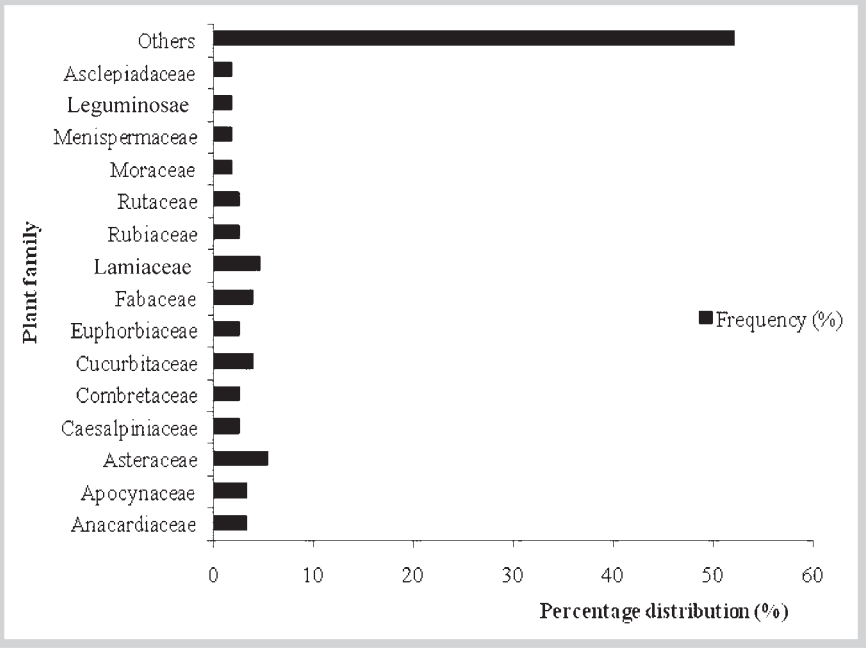

Fig. 3 Percentage of distributions in families of African medicinal plants with antidiabetic effects.

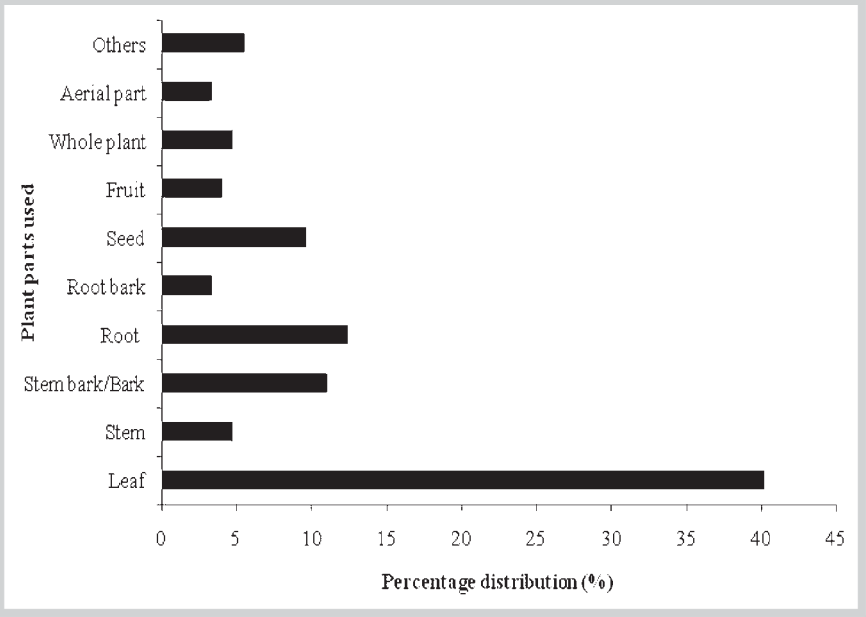

Fig. 4 Frequency of plant part used in anti diabetic studies.

ous and methanolic extracts and fractions at 800 mg/kg bw showed a significant antihyperglycemic effect in an experimentally-induced T1D model of rats. The highest glycemic reduction recorded was 43% at 32 h post-treatment of the crude aqueous extract compared to 35% for the methanolic extract. The methanolic fraction showed the highest decrease in glycemia (30%) at 400 mg/kg bw after 32 hours of treatment. Furthermore, these extracts showed a protective effect on the activity of some cardiac enzymes, which are crucial in the management of DM, in the same model of diabetic rats [37]. In an attempt to investigate the possible mechanism of action, Adebajo et al. [38] reported the insulinotropic and glucose lowering effects of the combined root and stem bark methanolic extracts (1 : 1) and various fractions when administered orally at a dose of 100 mg/kg bw/day. It was observed that the effect of the combined extracts was far better than the individual actions of the fractions. Both the extract and fractions caused an insulin release and lowered the blood glucose levels better than glibenclimide in glucose-loaded rats and INS-1 cell lines. In another study, oral administration of ethanolic roots and twig extracts at 200 and 400 mg/kg bw/day showed a protective effect against alterations on the markers of kidney functions in a T1D model of rats [39]. Fasting blood glucose dropped by more than 60% for a single twig administered via orogastric intubation compared to 43% for the root ethanolic extracts.

The hypoglycemic and hypolipidemic effects of *Hibiscus sabdariffa* L. (Malaceae) calyces have been reported [40]. The authors showed that the oral administration of the aqueous extract at 0.5 mg/ml/day alleviated the oxidative stress in a T1D model of rats [41], which is comparable to vitamin C and glibenclimide. The extract decreased fasting blood glucose by almost 70%,

Table 6 Scientifically investigated African antidiabetic medicinal plants with identified possible bioactive compounds.

Scientific name	Common name	Family	Part(s) used	Possible compound(s) present/isolated	Country	Reference
Anacardium occidentale	Cashew	Anacardiaceae	Leaf/n-hexane/ diethylether fractions	Polyphenols, terpenoids, alkaloids, and flavonoids	Nigeria	[23]
Balanites aegyptiaca	Desert date/ Hegleg	Balanitaceae	Fruit/chloroform : methanol : water	Diosgenin	Egypt	[97,98]
Carum carvi	Caraway	Apiaceae	Fruit oil	D-limonene, benzyl alcohol, O-cresol, isomenthone, methyl chavicol, D-carvone, perillaldehyde, and β-patchoullene	Morocco/ Egypt	[99–102]
Gongronema latifolium	Amaranth globe	Asclepiadaceae	Root stem/methanol extract	α and β-amyrin cinnamates, lupenyl cinnamates, lupenyl acetate, and two other unknown triterpenoids Y and Z	Nigeria	[38]
Morus alba	White mulberry	Moraceae	Root bark/water-methanol fractions	Morusin, cyclomorusin, neocyclomorusin, kuwanon E, 2-arylbenzo furan, moracin M, betulinic acid and methyl ursolate, and two other triterpenes, betulinic acid and methyl ursolate, mulberroside A, 5,7,2′-trihydroxy flavonone-4′-O-β-D-glucoside, and albanols A and B	Egypt	[105–107]
Trigonella foenum graecum	Fenugreek	Leguminosae	Seed/chloroform : methanol : water fractions	Diosgenin	Egypt	[98]
Ziziphus spina-christi	Christ's Thorn Jujube	Rhamnaceae	Leaf/butanol fraction	Chritinin-A	Egypt	[112–114]

which is comparable to ascorbic acid and glibenclimide. To investigate the possible mode of action, Adedayo and Ganiyu [42] revealed that the extract inhibited the activities of the two key enzymes involved in carbohydrate digestion, alpha glucosidase and alpha amylase, which are very crucial in the management of T2D mellitus.

Using an alloxan-induced T1D rat model, Tanko et al. [43,44] demonstrated the glucose lowering effect of the hydromethanolic extract of the *Indigofera pulchra* L. (Papilionaceae) leaf when administered orally at 250, 500, and 1000 mg/kg bw/day. Surprisingly, the lower dosage that was administered decreased the glucose levels by 50% after 8 hours post-treatment. The daily intraperitoneal administration of ethyl acetate and *n*-butanol fractions of this extract also showed a hypoglycemic effect [45, 46] and was able to restore the DM-induced hematological alterations.

Nauclea latifolia S.M. (Rubiaceae) is among the most widely used traditional plants in the management of DM in the different parts of Nigeria. In an attempt to investigate this claim by traditional herbalists, Gidado et al. [47] showed that the oral treatment of the aqueous leaf extract of *N. latifolia* at 200 mg/kg bw/day significantly decreased blood glucose levels in a T1D model of rats, which was 45% within a 4-hour period of treatment. Further studies by this group indicated that both the aqueous and ethanolic leaf extracts at 100, 200, and 400 mg/kg bw/day significantly decreased the blood glucose levels in a dose-dependent manner when administered orally. At 400 mg/kg bw, aqueous and ethanolic leaf extracts lowered fasting blood glucose by 31.7% and 36.1%, respectively, [48] and were able to inhibit maltase and sucrase activities *in vitro* but not *in vivo* [49]. Other researchers reported that stem and root ethanolic extracts administered intraperitoneally at 25 mg/kg bw/day have potent immunosuppressive effects on T cell proliferation in an STZ-induced T1D model of rats [50] and could improve the antioxidant status and hormonal changes in another diabetes rat model [51].

Ocimum gratissimum L. (Lamiaceae) is used widely as a condiment or spice in different cultural settings in Africa. It is traditionally used for the management of DM [52]. Intraperitoneal administration of 400 mg/kg bw/day of *O. gratissimum* methanolic leaf extract significantly decreased the blood glucose level in both normal and T1D models of rats by 56% and 69%, respectively [53, 54]. Oral treatments at 500, 1000, and 1500 mg/kg bw/day of the aqueous leaf extract dropped the fasting blood glucose by more than 50% [55]. Mohammed et al. [56] also showed that the administration of 500 mg/kg bw of this extract caused a reduction in blood glucose by 81.3% 24 hours after administration. Moreover, the *O. gratissimum* leaf ethanolic extract treated at 200 mg/kg bw/day prevented the alteration of germinal epithelium, distortion of seminiferous tubules, as well as vacuolation of seminiferous tubules in an STZ-induced T1D model of rats [57,58]. More recently, Oguanobi et al. [59] reported that oral administration of the *O. gratissimum* leaf extract at 100, 200, and 300 mg/kg bw/day had a blood glucose lowering effect and the ability to alleviate derangements in serum and biliary bilirubin, cholesterol, and electrolytes in a neonatal STZ-induced T2D rat model [60].

Phyllanthus amarus L. (Euphorbiaceae) (stone breaker or gulf flower) is another highly cited antidiabetic plant from West Africa. The hypoglycemic potential of the aqueous leaf extract of *P. amarus* was investigated in an alloxan-induced T1D rat model. The extract at a dose of 260 mg/kg bw produced a significant ($p < 0.05$) reduction in blood glucose level by 112%, 61%, and 31% at 24 hours, 7 days, and 14 days of oral administration, respectively. Furthermore, the reduction was dose-dependent and dropped by 82%, 41%, and 16% after 24 hours, 7 days, and 14 days of oral administration, respectively [61]. Owolabi et al. [62] reported that oral treatment of the aqueous extract at 100 mg/kg bw/day decreased fasting blood glucose by 46.53% compared to 66.6% for insulin treatment in a T1D model of rats. In another study from Togo, Povi et al. [63] indicated that *P. amarus* whole plant aqueous and hydroalcoholic extracts at 500 and 1000 mg/kg bw/day had both hypoglycemic and hypolipidemic effects

after 15 days of oral administration. Aqueous leaf and seed extracts at 150, 300, and 600 mg/kg bw/day were also shown to have antihyperglycemic, antihyperlipidemic, and cardioprotective effects as well as an insulin sensitizing effect in a T2D model of rats [64].

The hypoglycemic effect of the seed aqueous extract of *Picralima nitida* Stapf. (Apocynaceae) has been investigated in a T1D model of rats [65]. The extract at 648 mg/kg bw decreased the fasting blood glucose by about 19.46% and 75.5% in normoglycemic and alloxanized rats within 3 and 6 hours, respectively. However, a contradictory finding was reported by Igboasoiyi et al. [66] where the seed (250 mg/kg bw/day), but not fruit pulp, extract showed no hypoglycemic effect.

The folkloric use of *Vernonia amygdalina* Del. (Compositae) (bitter leaf) in the management of DM is widely documented and this corroborates with the propensity of antidiabetic studies conducted in both type 1 and type 2 animal models of diabetes [67–74] and human subjects [75]. In all studies reported, *V. amygdalina* was found to significantly reduce the hyperglycemia in T1D models of rats. The alterations on the markers of kidney functions were prevented by the leaf ethanolic extract administered at 400 mg/kg bw/day by gastric intubation and the fasting blood glucose was decreased by more than 80% [76]. Oral administration of this extract was also reported to prevent the macrovascular complications associated with DM [77]. In an attempt to further investigate the hypoglycemic effect of this plant, Akah et al. [78] reported that the hexane/ethyl acetate fraction obtained from the leaf methanolic extract possessed an antidiabetic effect when treated orally at 80, 160, and 320 mg/kg bw/day. The histological and hematological results showed no alterations on the full tissue architecture and other parameters analyzed. It was also reported that *V. amygdalina* leaf ethanolic extract at 100 mg/kg bw/day prevented the alteration of germinal epithelium, distortion of seminiferous tubules, as well as vacuolation of seminiferous tubules in an STZ-induced T1D model of rats [58]. The synergistic or antagonistic effects of this plant with other traditionally claimed antidiabetic plants have also been documented in numerous studies [79–82].

Another plant that has received much attention from researchers and has been used in the management of DM is *Zingiber officinale* L. (Zingiberaceae) (ginger). Its hypoglycemic effect has been reported in STZ and glucose-induced diabetic rat models [83–85]. The glucose-lowering effect began after 30 minutes of intraperitoneal administration of a rhizome aqueous extract at 2, 4, and 8 mg/kg bw. At 200, 250, and 300 mg/kg bw, the decreases in the blood glucose levels were recorded as 51.4%, 56.9%, and 56.7%, respectively. In another study, Iranloye et al. [86] investigated the antihyperglycemic and antioxidant effects of an orally administered aqueous extract of *Z. officinale* at 500 mg/kg bw/day in both type 1 and fructose-fed T2D models of rats. The extracts decreased blood glucose by 48.23% in type 1, and 83.5% in T2D models of rats. The extract also showed the high radical scavenging ability and improvement of insulin biosynthesis in this experiment. It has also been reported that *Z. officinale* at doses of 250 and 500 mg/kg bw/day could inhibit oxidative stress and inflammation by enhancing antioxidant enzymes and TNF-α activity in an STZ-induced T1D model of rats [87]. Arikawe et al. [88], in their studies, indicated that this extract could prevent the diabetes and insulin resistant-associated effects on spermatogenesis in an experimentally induced diabetes rat model.

North Africa

Ajuga iva L. (Labiatae) is among the most frequently investigated antidiabetic plants from northern Africa, especially Morocco and Algeria. The hypoglycemic and hypolipidemic effects of the aqueous extract of *A. iva* have been investigated in a number of T1D models of rats [89–91]. Oral administration of the extract at 10 mg/kg bw/day reduced the plasma glucose levels by 69.73% after a 6-hour post-treatment period and 87.3% in a subchronic dosing of 28 days in diabetic rats compared to 21.4% and 18.4% in normoglycemic rats, respectively. Furthermore, the *in vivo* antioxidant effects of this plant's extracts have also been reported in an STZ-induced T1D model of rats [92]. The 4-week supplementation of 0.5% aqueous extract of *A. iva* prevented oxidative damages by decreasing lipid peroxidation, and improved the activities of plasma and tissue antioxidant enzymes in experimentally induced diabetic rats. Hamden et al. [93] reported that the phytoecdysteroids rich extract of *A. iva* prevented the diabetes-associated microvascular complications in alloxan-induced diabetic rats when administered orally for fifteen days.

Allium cepa L. (Liliaceae) (onion) is widely distributed throughout the African region and is among the most cited plants from West and North Africa. The antidiabetic effect of *A. cepa* was evaluated in both animal models and human subjects [94]. Fresh crude slices (100 g) of *A. cepa* were given to type 1 and 2 diabetic human subjects. In type 1 diabetic subjects, a 50% reduction in the blood glucose level was observed at 4 hours post-treatment compared to insulin-treated (70.8%) patients. In type 2 diabetic subjects, about 20% reduction was observed compared to 37.5% in insulin-injected subjects [94]. It was also reported by El-Demerdash et al. [95] that *A. cepa* at a dose of 1 mL or 0.4 g/100 g bw restored the biochemical and antioxidant status altered by alloxan injection in a T1D model of rats. The concentration of thiobarbituric acid reactive substances and the activity of glutathione S-transferase in plasma, liver, testes, brain, and kidneys were significantly increased in alloxan diabetic rats. These increases were completely prevented in *A. cepa*-treated rats. Various compounds were isolated and correlated positively as being responsible for the hypoglycemic effect of *A. cepa*. Phenolics and sulphur compounds, such as cysteine and allyl propyldisulphide, have been associated with this effect [94]. Some studies linked the observed hypoglycemic effects of this plant to the essential oils [96].

In Egyptian traditional medicine, *Balanites aegyptiaca* L. (Balanitaceae) is popularly used as an oral hypoglycemic agent. The protective effect of orally treated aqueous and ethanolic extracts at 80 mg/kg bw/day against liver damage, and hypoglycemic and hypolipidemic effects in alloxan-induced type 1 diabetic rats were investigated [97]. Liver glycogen, serum insulin, leptin, and testosterone levels were increased in treated rats while glucagon, total lipids, total cholesterol, triglyceride level, and transaminase activities were significantly decreased. In another study, oral administration of *B. aegyptiaca* fruit aqueous extract at 1500 mg/kg bw/day decreased fasting blood glucose by 24% compared to the diabetic control. The dose-dependent inhibition of alpha amylase and glucose-6-phosphatase activities with an increase in glucose-6-phosphate dehydrogenase and phospho-fructokinase activities were reported [98]. The TLC and HPLC fingerprints of this extract led to the identification of a marker compound, diosgenin [98].

It has been reported that *Carum carvi* L. (Apiaceae) has been used for medicinal purposes since ancient times [99]. Hypoglycemic and hypolipidemic effects of the aqueous fruit extract orally administered at 20 mg/kg bw/day have been evaluated in an STZ-in-

duced T1D model of rats [100, 101]. The extract significantly decreased the blood glucose levels by more than 50% compared to nondiabetic rats within two weeks of administration but did not increase the insulin levels of normal rats. Moreover, treatment with the extract significantly decreased the serum lipid profile levels. *C. carvi* has been classified as a good hypoglycemic agent with high radical scavenging activity [102]. Some of the active compounds isolated from this plant include d-limonene, benzyl alcohol, o-cresol, isomenthone, methyl chavicol, d-carvone, perillaldehyde, and *β*-patchoullene [102].

In Morocco, *Chamaemelum nobile* L. (Asteraceae) is used locally for the treatment of DM and its complications. The antihyperglycemic effect of the aqueous fruit extract administered at 20 mg/kg bw/day has been reported in an obese T2D model of mice [103]. The postprandial hyperglycemia dropped significantly by more than 80%, and the increase in body weight was completely prevented in mice treated with this extract. In another study, Lemhadri et al. [104] reported that the extract-treated animals demonstrated a decrease in endogenous glucose production compared to the diabetic control group. It also improved insulin sensitivity in peripheral tissues, which was confirmed by an increased glucose utilization in an STZ-induced diabetic model of mice [104].

Morus alba L. (Moraceae) (white mulberry) is another important plant used in the management of DM in northern Africa. The hypoglycemic effect of root bark flavonoid-rich fractions has been investigated [105]. The blood glucose levels of treated animals at 600 mg/kg bw for ten days dropped by about 50% compared to that of the diabetic control group. Insulin levels were significantly increased, while the peroxide levels were significantly decreased in this study. Morusin, cyclomorusin, neocyclomorusin, kuwanon E, 2-arylbenzofuran, moracinM, betulinic acid, and methylursolate were the compounds isolated from *M. alba*. El-Sayyad et al. [106] investigated the effect of the *M. alba* leaf extract on both micro- and macrovascular complications associated with DM. In their study, treatment with the extract at 100 mg/kg bw/day prevented the increase in maternal serum glucose, alterations in lipid profiles, and creatine phosphokinase activity, as well as retinal neurotransmitters including acetylcholine, adrenaline, noradrenaline, serotonin, histamine, dopamine, and gamma amino butyric acid. Furthermore, cataract and retinopathy were also prevented in the treated groups. In another study, mulberroside A, 5,7,2′-trihydroxyflavonone-4≠O-*β*-D-glucoside, and albanols A and B were also isolated from fractions derived from the ethanolic root bark of *M. alba* [107]. The authors also indicated that oral administration of these fractions at 500 mg/kg bw/day significantly prevented the oxidative damage induced by hyperlipidemia in rats.

Nigella sativa L. (Ranunculaceae), popularly used as a spice, has also been reported to be used traditionally in the treatment of diabetes and was investigated in a number of studies [108]. The hypoglycemic potentials of *N. sativa* oil from the seed have been reported [109]. The oil significantly reduced the blood glucose levels in an STZ-induced T1D model of rats within six weeks of oral administration. It was reported by the authors that the blood glucose lowering effect might be stimulated by extra hepatic tissues rather than by insulin release. In another study, *N. sativa* seed extract decreased the blood glucose levels by almost 81% and normalized fructosamine, hemoglobin, and albumin levels in experimentally induced diabetic animals within 30 days of oral administration of 300 mg/kg bw [110]. The extract was able to ameliorate the diabetes-associated oxidative damages in the same study. The regulation of hepatic glycolytic and gluconeogenic enzyme activities were considered as a possible mode of action in this study. Benhaddou-Andaloussi et al. [111] have recently demonstrated the antidiabetic effect of *N. sativa* seed ethanolic extract when administered at 2 g/kg bw/day, and which is mediated through an insulin-sensitizing action by enhancing acetyl-CoA carboxylase phosphorylation, a major component of the insulin-independent AMPK signaling pathway, and by enhancing muscle GLUT4 expression.

The antidiabetic effect of the butanol leaf extract and christinin A (a major saponin glycoside) of *Ziziphus spina-christi* L. (Rhamnaceae) has been investigated in both type 1 and type 2 diabetic models of rats [112, 113]. In type 2 but not in the T1D model, pretreatment of both the extract and the isolated compound at 100 mg/kg bw/day indicated a clear improvement in the oral glucose tolerance test and mediated glucose-induced insulin release. Both the extract and christin A caused a significant decrease in blood glucose levels by 24% and 22%, respectively, after 60 minutes, and increased serum insulin levels in a T2D model of rats. The extract was also reported to cause no damage to the kidneys, liver, or hematological parameters after 30 days of oral administration. Michel et al. [114] have also demonstrated the hypoglycemic effect of *Z. spina-christi* leaf ethanolic extract when fed orally at 200 mg/kg bw/day. A significant increase in serum insulin and C-peptide levels were observed in extract-treated animals. The extract also ameliorated the oxidative damages and prevented the protein glycosylation induced by diabetes. The activities of liver glucose-6-phosphatase and alpha amylase (IC_{50} of 0.3 mg/mL) were inhibited by this extract, but significantly increased the activity of glucose 6-phosphate dehydrogenase. HPLC and spectrophotometric determination revealed a flavonoid as a marker compound named christinin A in this plant.

Southern Africa

Artemisia afra Jacq. (Asteraceae) is mostly identified by its aromatic odor. It is widely available and is being used to treat DM. In 2011, Afolayan and Sunmonu [115] reported that the orally administered aqueous leaf extract at 50 and 100 mg/kg bw/day significantly decreased the blood glucose levels by more than 50% compared to the diabetic control, with a concomitant increase in insulin levels. The extract also showed a high antioxidant effect by increasing the levels of antioxidant enzymes and decreasing lipid peroxidation. Similar effects of the extract on antioxidant defense systems in the liver and kidneys were also observed within three weeks of oral administration at the same doses in diabetic animals [116].

Bryophyllum pinnatum Lam. (Crassulaceae), popularly known as "good luck" or "life plant" is widely used in the management of DM by the majority of the African populace. Ojewole [117] has reported the antidiabetic, antinociceptive, and anti-inflammatory effects of *B. pinnatum* in rats using fresh egg albumin-induced pedal (paw) edema, and in an STZ-induced T1D model of rats. *B. pinnatum* leaf aqueous extract treated orally at 400 mg/kg bw significantly and dose-dependently decreased fasting blood glucose in diabetic rats by almost 50% within 8 hours. A similar effect was observed in albumin-induced acute inflammation of the rat hind paw.

Raphia gentiliana De Wild. (Arecaceae) is one of the most popular plants used in the treatment of several disease ailments in the Democratic Republic of Congo. Its fruits are commonly consumed as food. The hypoglycemic effect of the aqueous fruit extract has been investigated in normoglycemic human subjects and glu-

cose-induced hyperglycemic animals [118]. After one and two hours post-treatment at 200 mg/kg bw, the fasting blood glucose dropped by 27% and 56%, respectively, in diabetic mice. In human subjects, the glycemic index (signifying glucose absorbed into the blood after a meal) and load index (total glucose content in normal subjects) recorded were − 3.60% and − 1.36%, respectively, which are within the recommended range. The results indicate the preventive role of *R. gentiliana* fruit in glucose absorption, which could be associated with the active principles present in the fruit extract.

The stem bark, roots, and leaves of *Sclerocarya birrea* A. Rich. Hochst. (Anacardiaceae) are widely used in South Africa and African countries as folk medicine in the treatment DM. The hypoglycemic effect of the stem bark aqueous extract has been investigated in normal and STZ-induced diabetic rats [119, 120]. *S. birrea* stem bark aqueous extract at 800 mg/kg bw significantly and dose-dependently decreased the fasting blood glucose in both normal and diabetic-treated rats, with a maximum reduction capacity of 50.16%, which was comparable with that of chlorpropamide (62.44%) after 8 hours post-oral treatment. Furthermore, Musabayane et al. [121] previously established the beneficial effect of the *S. birrea* stem bark aqueous extract treated orally at various doses (60, 120, and 240 mg/kg bw) on markers of kidney and cardiovascular functions in diabetic rats. It significantly decreased the blood glucose levels and the levels of Na^+ and K^+ ion excretion rates, which were not altered by short-term or prolonged exposure to the extract. The same research group reported that the ethanolic stem bark extract at the same dosages improved blood glucose, the glomerular filtration rate, and mean arterial blood pressure in an STZ-induced T1D model of rats [122].

Sutherlandia frutescens R. BR., variety incana E. MEY., (Fabaceae) is among the most common and widely used plants in the southern part of Africa for the treatment of DM and its associated complications. The hypoglycemic effect of *S. frutescens* has been investigated [123]. The shoots aqueous extract significantly prevented the STZ-induced hyperglycemic condition in mice when administered orally at various dosages (50–800 mg/kg bw). In another study, Chadwick et al. [124] reported that *S. frutescens* is a potential agent in the management of DM, especially type 2 DM. The aqueous leaf extract-treated rats showed an increase in glucose uptake and utilization by peripheral tissues with a decrease in intestinal glucose absorption. Glucose uptake was carried out using [^{3}H] deoxy-glucose. The [^{3}H] deoxy-glucose count increased significantly in muscle and epididymal fat tissues when treated with the *S. frutescens* shoot aqueous extract in a diet-induced T2D model of rats, and the results were comparable with metformin-treated rats. In a different study, *S. frutescens* prevented insulin resistance and showed a hypolipidemic effect in diabetic rats [125]. The plasma free fatty acid dropped significantly. Similarly, the homeostatic model assessment (HOMA-IR) and quantitative insulin sensitivity check index (QUICKI) demonstrated that oral treatment of the extract at 50 mg/kg bw prevented the development of insulin resistance in a high-fat diet-fed insulin-resistance model of rats.

Central Africa

Bersama engleriana (Melianthaceae) is commonly available in almost all African regions and has been traditionally used in the management of DM. To evaluate such a claim, preliminary hypoglycemic effects of both aqueous and methanolic leaf extracts at 300 and 600 mg/kg bw/day were reported in normoglycemic rats [126]. At the 600 mg dose, blood glucose levels dropped by 37.7% and 49.11% for aqueous and methanolic extracts, respectively. To expand upon this study, Watcho et al. [127] investigated the effect of this plant on STZ/nicotinamide T2D models of rats. The leaf aqueous and methanolic extracts treated orally at 400 and 600 mg/kg bw/day significantly and dose-dependently decreased the blood glucose levels and lipid profile with an increase in HDL cholesterol levels. At the 600 mg dose, the ethanolic extract demonstrated a higher reduction of blood glucose levels (80.31%) compared to the aqueous extract (67.74%). The decrease in organ weight recorded in diabetic-untreated rats was completely prevented in the extract-treated groups.

Dichrostachys glomerata Chiov. (Cucurbitaceae) is a spice used in the management of DM and its associated complications. Because of its strong antioxidant action, the effect of *D. glomerata* on various cardiovascular disease risk factors in obese normoglycemic and obese type 2 diabetic human subjects has been reported [128]. Dried pods were supplied daily in the form of capsules containing 400 mg *D. glomerata* 30–60 minutes before lunch and dinner. The results of the study indicated a decrease in body weight by 7.91% in obese normoglycemic and 5.97% in obese type 2 diabetic subjects. Similarly, the reduction of BMI, waist and hip circumference, body fat, blood pressure, blood cholesterol, triglycerides, glucose, and glycosylated hemoglobin was higher in the normoglycemic subjects compared to the obese type 2 diabetic subjects. The results confirmed the traditional claims that *D. glomerata* could ameliorate the complications associated with DM and other related cardiovascular diseases.

Although rarely investigated, an important complication associated with DM in men is infertility or erectile dysfunction [129]. As a result, Wankeu-Nya et al. [130] investigated the possible antidiabetic effect of aqueous and ethanolic root bark extracts of *Dracena arborea* Wild. (Dracaenaceae), which has been widely acclaimed for its aphrodisiac action in Cameroonian traditional medicine. The antihyperglycemic effect was observed in an STZ-induced T1D model of rats, with no such effect on normoglycemic rats. Oral treatment at 500 mg/kg bw of aqueous extract and 100 mg/kg bw of ethanolic extract for three weeks ameliorated the severe damages of the testes morphology and spermatogenesis, as observed in the diabetic-untreated rats. Although an increase in blood glucose was observed in both the aqueous (15.39%) and ethanolic extract (19.04%) -treated animals, this increase was lower than that of the untreated animals (> 60.34%). Flavonoids, sterols, and saponins were some of the compounds qualitatively determined to be present in both extracts.

Kalanchoe crenata Andr. Haw. (Crassulaceae) is among the most widely used plants in Cameroon and other central African countries for therapeutic purposes. Kamgang et al. [131] have reported that the aqueous-ethanol extract significantly, but not dose-dependently, decreased the blood glucose levels of diet-induced type 2 diabetic rats within six hours and four weeks of oral treatment at 200 mg/kg bw/day. The percentage of decrease recorded after four weeks was 52%. The diabetic-treated rats also showed an improvement in insulin sensitivity, a decrease in body weight, and reduced water intake. In another study, Fondjo et al. [132] investigated the antidyslipidemic and antioxidant effects of *K. crenata* whole plant methanolic extract in an STZ-induced T1D model of rats. The extract treated orally at 50 and 68 mg/kg bw/day showed a decrease in serum, liver, and kidney malondialdehyde levels, with an increase in activities of antioxidant enzymes. The glycemic reduction in treated animals was 35% and 44% for 50 and 68 mg/kg bw, respectively, after the 6-week post-treat-

ment period. All diabetic-treated animals showed a decrease in lipid parameters, with an increase in HDL cholesterol levels and an overall reduction of the atherogenic index by 31%.

East Africa

Caylusea abyssinica Fresen. Fisch. & Mey. (Resedaceae) is popularly used in different East African countries for the management of DM, especially in Ethiopian folklore medicine. Tamiru et al. [133] reported the hypoglycemic effect of the methanolic leaf extract of *C. abyssinica* in a normal, glucose-loaded, and STZ-induced T1D model of rats when administered orally at 100, 200, and 300 mg/kg bw. In an oral glucose tolerance test, the extract-treated rats indicated a better glucose handling ability than the diabetic controls. A reduction of 52.2%, 62.3%, and 52.8% in glycemia was achieved at the fourth hour of treatment at 100, 200, and 300 mg/kg bw, respectively.

The hypoglycemic effect of five Kenyan medicinal plants in alloxanized mice has been reported [134]. These plants include *Strychnos henningsii* Gilg. (Loganiaceae), *Erythrina abyssinica* Lam. (Fabaceae), *Aspilia pluriseta* Schweinf. (Asteraceae), *Bidens pilosa* L. (Asteraceae), and *Catha edulis* (Vahl) Forssk. ex Endl. (Celastraceae). All the extracts showed a significant and dose-dependent blood glucose lowering activity within the 4-h post-treatment period at 50, 100, and 150 mg/kg bw. The hypoglycemic effect of *C. edulis* was much better compared to others when given at a dose of 150 mg/kg bw and was as effective as insulin. Polyphenols were the major active components detected in the various parts of the plants under this study. Based on the toxicity study conducted for various parts of these plants, at higher dosages, aqueous extracts from the stem bark of *E. abyssinica,* the root bark of *C. edulis*, and *B. pilosa* leaves were nephrotoxic as well as hepatotoxic. *S. henningsii* leaves were moderately toxic while *A. pluriseta* root bark was reported as safe during these studies.

Momordica charantia L. (Cucurbitaceae) is one of the plants commonly used as food and in therapeutic purposes by both diabetic and healthy people, and has been known in traditional medicine for its glucose-lowering action worldwide [135]. Its fruit has a distinguished bitter taste, which is more pronounced as it ripens; hence, it is named bitter melon. A study reported by Matheka et al. [136] demonstrated that the oral administration of fresh fruit juice extract of *M. charantia* by gastric gavage at 10 ml/kg bw decreased blood glucose levels significantly by about 30 and 10% after 30 and 90 minutes, respectively, in a T1D model of rats.

Moringa stenopetala Baker f. (Moringaceae) is acclaimed for its glucose-lowering ability in Ethiopian traditional medicine. Nardos et al. [137] reported the antidiabetic effect of the leaf extracts and fractions of *M. stenopetala* in an alloxan-induced T1D model of rats. The extracts and fractions intraperitoneally administered at 300 mg/kg bw decreased blood glucose levels significantly by nearly 20% after an 8-day post-treatment period. The ethanolic extract was safe up to 5 g/kg bw. Furthermore, Toma et al. [138] demonstrated both antihyperglycemic and antihyperlipidemic effects with a daily oral administration of butanol fraction from the leaf ethanolic extract of *M. stenopetala* for four weeks in an alloxan-induced T1D rat model.

Conclusion

Apart from the folkloric claims, it is evident from the above reviewed studies that Africa is blessed with an abundance of antidiabetic plants resources based on scientific findings. However, due to the variations in the scientific investigations in terms of analyzed antidiabetic parameters, doses, and durations used, it is difficult to precisely identify the plant(s) with the best reported activity, but our close analysis of the reports seem to suggest that *O. gratissimum, A. occidentale, V. amygdalina, G. latifolium, A. indica, C. carvi, M. alba*, and *A. iva* are the most active because they received much attention as is evident by numerous studies and, thus, possibly contain the most bioactive antidiabetic phytochemicals among all the plants. The methods mostly utilized for the extractions of various parts via organic solvent extractions include maceration/cold extraction, soxhlet, distillation, percolation, and sequential extraction. Moreover, it is evident that very few studies were reported to involve human subjects. Most studies used either T1D or T2D animal models. Unfortunately, perhaps due to limited research resources, most of the studies are preliminary in nature (though with promising results) and do not include detailed isolation and characterization of the bioactive compounds and/or the mechanisms of antidiabetic actions. Government agencies and/or pharmaceutical industries should support more research activities in this area in order to commercially utilize these antidiabetic medicinal plants for a solution to the continent's myriad of economic problems.

Methodology

Relevant literatures were collected by searching the major scientific databases including Pubmed, ScienceDirect, Medline, and Google Scholar for medicinal plants of African origin that have been studied and investigated for their antidiabetic therapeutic potentials *in vivo*. Some articles were found through tracking citations from other publications or by directly accessing the journals' website. They were considered on the basis of the geographical region of their origin. The literature considered were those available covering the period January 2000 to July 2013. The keyword combinations for the search were antidiabetic, antihyperglycemia, hypoglycemia, medicinal plant, and Africa. Supplementary information was obtained by using another keyword combination such as plant, hypoglycemia, and Africa. A total of 313 articles were retrieved in this review, out of which 256 research articles that reported *in vivo*, and not *in vitro*, activity were selected and presented in this review. Following the search, the plants were categorized and presented based on their regional origins.

Acknowledgements

This study was supported by the Competitive Research Grant from the Research Office, University of KwaZulu-Natal (UKZN), Durban, an Incentive Grant for Rated Researchers, and Grant Support for Women and Young Researchers from the National Research Foundation (NRF), Pretoria, South Africa. The first author was awarded a PhD study scholarship by the Education Trust Fund desk office, Ahmadu Bello University, Zaria, Nigeria.

Conflict of Interest

There is no conflict of interest within this article.

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