

Review

Ethnobotany, pharmacology and phytochemistry of medicinal plants used for management of *Diabetes mellitus* in Uganda, Kenya, Tanzania and the Democratic Republic of Congo

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Abstract

Ethnopharmacological relevance For decades, patients in East Africa have used herbal medicine as an alternative and affordable therapeutic option for the treatment of diseases such as *Diabetes Mellitus* (DM). As a result, the primary objective of this research was to thoroughly investigate the plants employed for treating DM in Uganda, Tanzania, Kenya, and the Democratic Republic of Congo and gather pertinent ethnopharmacological and ethnomedicinal knowledge that could be applied in the development of therapies for DM.

Aim of the study The study is aimed at critically reviewing the phytochemistry, pharmacology, and toxicology of medicinal plants used for treating diabetes in East African countries, including Uganda, Tanzania, Kenya, and the Democratic Republic of Congo.

Method A search for relevant articles was conducted on PubMed, ISI Web of Science, Open Theses, Google Scholar, Science Direct, and Scopus, and the identified articles were evaluated for quality, relevance, and taxonomical accuracy before undergoing review.

Results The study identified 140 plant species used by local communities for the management of DM in East Africa, with decoction and infusion being the most common preparation methods. The leaves, root, and stem bark were the most frequently used parts. The in vitro and in vivo studies demonstrated the antidiabetic effect of medicinal plants such as *Kigelia Africana*, *Hagenia abyssinica* (Rosaceae), *Physalis peruviana* among other plants used for herbal treatment elicited via stimulation of insulin release, and gluconeogenesis. Phytochemicals present were mainly flavonoids, alkaloids, saponins, tannins, and glycosides.

Conclusion The local communities in Uganda, Tanzania, Kenya and the Democratic Republic of Congo use herbal medicine for managing DM, but only a fraction of these species have scientific evidence. This necessitates additional research to establish the effectiveness, safety and potentially develop novel therapeutics for the management of DM.

Article Highlights

- A study aimed to review the ethnomedicinal uses, pharmacology and phytochemistry of medicinal plants used for managing diabetes in East Africa.
- The study found 140 plant species used for this purpose.
- Decoction and infusion were the most common preparation methods.

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- Asteraceae and Fabaceae are the families with the most species of plants locally used for diabetes management.
- Phytochemicals present in these plants include flavonoids, alkaloids, saponins, tannins, and glycosides.
- Some plants were reported to have low toxicity on low and high dosage.
- Further research is needed to fully evaluate the safety and effectiveness of these plants for managing diabetes.

Keywords *Diabetes mellitus* · East Africa · Herbal medicine · Phytochemistry · Pharmacology

Abbreviations

DM	<i>Diabetes mellitus</i>
IDF	International diabetes federation
IL-1	Interleukin-1
LDL-c	Low-density lipoprotein cholesterol
LMICs	Low- to middle-income countries
NCDs	Non-communicable diseases
NF- κ B	Nuclear factor kappa-light-chain-enhancer of activated B cells
Nrf2	Nuclear factor erythroid 2-related factor 2
PI3K	Phosphoinositide 3-kinase
PKC- β	Protein kinase C β isoform
PPAR- α	Peroxisome proliferator-activated receptor alpha
PPAR- δ	Peroxisome proliferator-activated receptor gamma
PPG	Postprandial glucose
PTP1B	Protein tyrosine phosphatase 1 B
SOD	Superoxide dismutase
SSA	Sub-Saharan Africa
STZ	Streptozotocin
T2DM	Type 2 diabetes mellitus
TC	Total cholesterol
TGs	Triglycerides
TNF- α	Tumor necrosis factor- α
VLDL-c	Very low-density lipoprotein cholesterol
WHO	World health organization

1 Introduction

Traditional medicine has played a crucial role in healthcare for centuries, especially in developing regions [1]. However, much of this ancestral knowledge is at risk of disappearing as it is often passed down orally and not documented. The World Health Organization (WHO) recommends conducting ethnopharmacological studies to record this valuable folk knowledge and scientifically validate traditional medicinal claims [1]. This could lead to the development of improved medications. Around 80% of the global population depends on traditional medicine, primarily derived from plants, for their basic healthcare needs [2]. The use of medicinal plants as complementary and alternative medicines (CAM) presents opportunities in both developed and developing societies for managing various illnesses. *Diabetes Mellitus* (DM) has been a focus of research, with over 800 plant species displaying hypoglycemic activities, offering potential sources for discovering new antidiabetic molecules [3]. Recent data indicates that about 1.7 million people in the Democratic Republic of Congo (DRC) suffer from DM, ranking the country fourth in the top ten countries with diabetes cases in Africa [4]. Also, it is estimated that 478,000 people in Kenya have diabetes, with a treatment cost of USD 61 per person [5]. According to a recent STEP survey, Tanzania has the highest prevalence of DM in the East African region, with an estimated 9.1% among adults aged 25–64 years [6]. This represents a significant increase from the estimated 2.5% in 1984 [7, 8]. In East African member states of the International Diabetes Federation (IDF) in 2021 but South Sudan, there were a total of 128,048,100 adults, with a diabetes prevalence of 30.3% among them, resulting in a total of 6,850,500 cases of diabetes in adults [5] (Table 1). A study in 2022 by Sun et al. [5] reported the prevalence of diabetes among adults aged 20 to 79 over the world was estimated to reach 10.5% (536.6 million) in 2021 and 12.2% (783.2 million) in 2045. The cost of treating

Table 1 East African Member State of IDF DM Statistics 2021 (IDF, 2021)

S/No	Country	Total adult population	% Prevalence of DM in adults (%)	Total cases of DM in adults
1	Kenya	27,783,400	3	821,500
2	Uganda	20,127,600	3.6	716,000
3	Tanzania	28,027,100	10.3	2,884,000
4	Rwanda	6,631,200	4.5	297,000
5	Burundi	5,434,600	4.1	223,100
6	DRC	40,044,200	4.8	1,908,900
	TOTAL	128,048,100	30.3	6,850,500

diabetes-related illnesses worldwide was estimated at 966 billion USD in 2021 and is expected to rise to 1,054 billion USD by 2045 [5]. There are 24 million diabetics in Africa and 537 million worldwide among the 48 nations that make up the IDF African area. It is anticipated that these figures would rise even higher by 2045[5, 8].

The metabolic syndrome known as DM has several aetiologies and is characterised by persistently high blood sugar levels with a perturbation of carbohydrate, fat and protein metabolism as a result of chronic and/ or relative insulin caused by an acquired or inherited deficiency in the synthesis of insulin by the pancreas, or by the ineffectiveness of the insulin synthesised [9]. The inability of the body to produce insulin is termed as Type 1 diabetes or insulin dependent DM while Type 2 DM or insulin independent DM is characterised by non-responsiveness of cells to the insulin synthesized by the pancreas. The increased blood sugar precipitates classical symptoms including polydipsia, polyphagia and polyuria. Diabetes has resulted in severe morbidity and death due to microvascular (nephropathy, neuropathy and retinopathy) and macrovascular (stroke, peripheral vascular and heart attack) complications [10, 11]. Type 1 and Type 2 diabetes are both incurable and chronic illnesses that are still among the most feared diseases in the world today. Patients with DM in public health facilities have a severe lack of therapy options, while their private counterparts have several expensive options. Many people with DM in Africa choose to employ spiritual and alternative therapies instead of going to the doctor because they believe in them [12]. Traditional remedies are employed as the major type of basic healthcare in sub-Saharan Africa and include everyday foods and herbs. Herbal medicine is still widely used because it is affordable, easily accessible, less expensive, culturally satisfying, and available in some regions where conventional treatment is not [9].

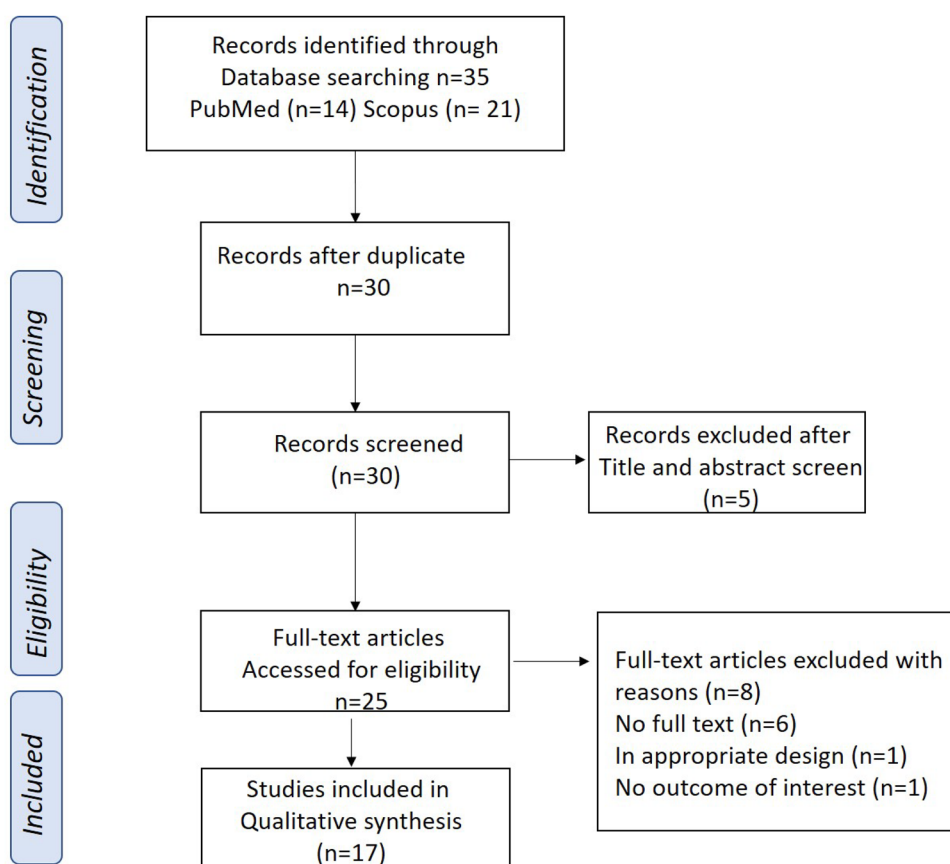
Despite the widespread use of herbal medicines, there is still a dearth of thorough documentation of these plants and other traditional treatments. The anti-diabetic properties of several plant extracts have been confirmed in numerous animal studies and randomised clinical trials across numerous nations. However, there is still need for documentation and scientific validation. As a result, there still exists a significant need to offer empirical data to legitimise local therapeutic usage. This review aims to investigate the plants utilized for the treatment and control of DM in some parts of East Africa, encompassing pertinent ethnopharmacological and ethnomedicinal data that could offer valuable insights for research on DM therapy.

2 Methods

2.1 Search strategy

From the start of the month of September until December 2022, various databases including PubMed, ISI Web of Science, Open Theses, Google Scholar, Science Direct, and Scopus were searched for relevant articles using the appropriate keywords. Several published papers that highlighted the historical use of plants to manage DM in Uganda, Kenya, Tanzania and DRC were selected for this study. These papers offer valuable insights into the traditional use of plants for treating DM. Whereas, experimental research carried out anywhere in the globe served as the foundation for the scientific evidence to support such usage. The selection of these few East African countries in Africa were selected for study given that they have rich biodiversity of a wide variety of medicinal plants with antidiabetic potentials, furthermore these regions prevalence of DM is high as compared to their counterparts with several studies suggesting so [6, 10, 13–17]. Based on the given criteria, the inclusion criteria for the study on antidiabetic plants include investigating plants traditionally used for treating diabetes, conducting various types of studies such as *ex vivo*, *in vivo*, *in vitro*, and clinical trials, and examining the antidiabetic potential of plant components and bioactive compounds with or without molecular

Fig. 1 Flow chart for selection and screening of included and excluded studies



targets. The exclusion criteria involve excluding research on phytochemicals, extracts, and fractions lacking biological activity, as well as computer simulations and thorough reviews of bioactive substances. Additionally, studies that did not examine interesting plants or those with insufficiently reported information are also excluded, along with *in vivo* studies not utilizing models of diabetes or prediabetes. Reference to Fig. 1 for the selection and screening of articles for study.

3 Results

3.1 A synopsis of the included research

Using the database, a total of 35 articles were found. These articles were checked for eligibility and evaluated for relevance according to inclusion criteria set. Hence, 17 were ultimately added (Fig. 1). The bulk of these papers (11 total) were ethnobotanical survey studies of plant usage in diabetes control. The remaining six publications dealt with *in vivo* studies on plant extracts or fractions that were antidiabetic.

3.2 Exploring traditional herbal remedies for diabetes

A total of 140 plants were reported to be used traditionally in the management of DM among the local communities of Uganda, Kenya, Tanzania and DRC, (Table 2). Among the reported plant 56.3% were from Kenya, 23.9% DRC, 15.49% and 4.2% from Tanzania. The 140-plant cut across fifty-five (55) different plant families, the most commonly reported family are Asteraceae and Fabaceae with 30.9% each, this was followed closely by Solanaceae 18.18%, Lamiaceae 14.54%, Apocynaceae 12.72%, Amaryllidaceae, Euphorbiaceae, Moraceae, Rutaceae and Urticaceae having 7.27% (Fig. 2).

Table 2 East African traditional medicine for treating diabetic mellitus

S/No.	English name	Family Name	Scientific name	Local name	Voucher No	Country/Region	Part Used	Preparation of fraction	Active compounds	Other uses	References
1	Rosary Pea	Fabaceae	<i>Abrus precatorius</i> subsp. <i>precatorius</i>	Kyuma Kyamditi (Kamba)	LKP 2010/028	Kenya/Eastern province	Leaf	Decoction	Alkaloids, flavonoids, tannins, phenols, saponins	fever, inflammation, and snakebites	[64]
2	Scented thorn	Fabaceae	<i>Vachellia nilotica</i> (L.)	Ngirũriti (Kikuyu)	LNM14/16	Kenya/Nyeri county	Bark, Root	Decoction	Tannins, flavonoids, alkaloids, and saponins	wounds, fever, and diarrhoea	[26]
3	Goats' Weed	Asteraceae	<i>Ageratum conyzoides</i> L	Akaddo Kanamirembe	NA	Uganda/central	Leaf	Decoctions	alkaloids, benzofurans, bioactivity, chromenes, flavonoids and terpenoids	antimicrobe, arthrosis, headache, dyspnea, pneumonia, analgesic, anti-inflammation, antispasmodic and antitussive	[23, 65]
4	Ajuga	Lamiaceae	<i>Ajuga integrifolia</i> Buch.-Ham	Wanjiru wa Rurii (Kamba)	LKP 2010/009	Kenya/Eastern province	Leaf, whole plant	Decoction	Flavonoids, phenolic acids, triterpenes, iridoids	wounds, and as a sedative	[64]
5	African albizia	Fabaceae	<i>Albizia adianthifolia</i> (Schumacher) W.Wright	Kasikeaze (Tshokwe), Kapeta nzovu (Bemba, Luba)	512	DRC/Lubumbashi	Leaf and Stem bark	Decoction	Flavonoids: kaempferol, quercetin, and rutin, Triterpenes: lupeol, betulinic acid, and oleanolic acid, Alkaloids: tryptamine, β -carboline, and serotonergic compounds	Syphilis, aphrodisiac, hiccup	[2]
6	Albizia tree	Fabaceae	<i>Albizia chinensis</i> (Osbeck) Merr	Omugavu	NA	Uganda/central	Leaf, bark and roots	Infusion, Decoction	triterpenoids, saponins, diterpenoids lignans and pyridine glycosides	rheumatism, stomach ache, cough, diarrhoea, wounds, antihelmintic etc	[23, 66]
7	Onion	Amaryllidaceae	<i>Allium Cepa</i> L	Matungu (Swahili)	NA	DRC/Oriental province	Bulb	Maceration	flavonoids (quercetin), allucin, polyphenols	coughs, colds, sore throats	[67]
8	Garlic	Amaryllidaceae	<i>Allium sativum</i> L	Kitunguua kinene	LKP 2010/014	Kenya/Eastern province	Bulb	Hot infusion of pounded bulb	Allicin, alliin, ajoene	antimicrobial, antifungal, antiviral, antiparasitic	[64]
9	Alovera	Asphodelaceae	<i>Aloe vera</i> var	Ekgigaji, Subiri (Kiswahili)	FN/011	Uganda/central, DRC/Oriental province	Leaf	whole Leaf Decoction, maceration	flavonoids, alkaloids, phenolic acids, tannins, saponin glycosides, anthraquinones, and reducing sugars	malaria, blood cleansing, stomach-ache, allergy, yellow fever, worms, fever, urinary tract infections, wasting, and scar removal	[23, 67, 68]
10	Graviola, Sour sop	Annonaceae	<i>Annona muricata</i> L	Ekitafeli	NA	Uganda/central	Fruit, bark, root and Leaf	Decoction, Fruit are eaten	annonacin, annonamine, alkaloid, litchexanthone	infections with viruses or parasites, rheumatism, arthritis, depression	[23]
11	Jack fruit	Moraceae	<i>Artocarpus heterophyllus</i> Lam	Ffene	NA	Uganda/central	Seeds, Fruit	Decoction, Fruit are eaten	Flavonoids (quercetin and kaempferol), carotenoids (beta-carotene and lutein), Saponins, Tannins, alkaloids (artocarpine and isomucronulatol)	diarrhoea, skin diseases, asthma, high blood pressure	[23]
12	Asplia	Asteraceae	<i>Asplia plurisetia</i> Schweinf. ex Engl	Muti/Wuti (Kamba)	LKP 2010/008	Kenya/Eastern province	Leaf	Decoction	Flavonoids, phenolic acids, tannins, terpenoids, saponins	fever, headache, and as an anti-inflammatory	[2, 64]

Table 2 (continued)

S/No.	English name	Family Name	Scientific name	Local name	Voucher No	Country/Region	Part Used	Preparation of fraction	Active compounds	Other uses	References
13	African star apple	Malvaceae	<i>Azanza garckeana</i> (F.Hoffm.) Exell & Hillc	Muti ya makamashi (Swahili)	180	DRC/Lubumbashi	Leaf	Decoction	Tannins: ellagitannins, gallic acid, and ellagic acid, Flavonoids: quercetin and kaempferol, Alkaloids: ammodendrine and N-methyltyramine	epilepsy, edema	[2]
14	Neem tree	Meliaceae	<i>Azadirachta indica</i> A. Juss	Mwarubaine (Kamba)	LKP 2010/012	Kenya/Eastern province	Stem bark/Leaf	Decoction	Alkaloids, flavonoids, phenolic acids, terpenoids, tannins	Malaria, fever, cough,	[64]
15	Abysinian cherry	Meliaceae	<i>Bersama abyssinica</i> Fresen	Mukilyulu (Kamba)	LKP 2010/017	Kenya/Eastern province	Root bark	Decoction	Alkaloids, flavonoids, phenolic acids, terpenoids, tannins	malaria, fever	[64]
16	African dogwood	Meliaceae	<i>Bersama abyssinica</i> var. <i>ugandensis</i> (Sprague) Verdc	Mshomoro (Swahili)	NA	Tanzania	root, stem-bark and Leaf	Decoction	phenolic acid, flavonoids and tannin	cardiovascular, cancer	[34]
17	Bidens	Asteraceae	<i>Bidens pilosa</i> var. <i>alausensis</i> (Kunth) Sherff	Kafira (Luganda), Mbaratuike (Kikuyu)	NA	Kenya/Nyamira County,	Leaf, Roots, Stem, Flowers	Infusion, Decoction and poultice	Flavonoids, Phenolic acids, Terpenoids, Carotenoids, Tannins, Steroids, Alkaloids	treat malaria, fever, diarrhoea, stomach-ache, and respiratory infections	[69]
18	Black-jack	Asteraceae	<i>Bidens pilosa</i> L	Koko i limo (Turumbu), Koko ya limo (Lokele), Mbarika (Kiswahili)	NA	DRC/Oriental province	Leaf	Decoction	flavonoids, alkaloids, and terpenoids	malaria, diarrhoea, coughs, and wounds	[67]
19	Mustard Greens	Brassicaceae	<i>Brassica juncea</i> (L)	Ndunda (Kisoko)	NA	DRC/Oriental province	Leaf	Decoction	glucosinolates, Flavonoids, alkaloids	respiratory infections and digestive disorders	[67]
20	Wild Cabbage	Brassicaceae	<i>Brassica oleracea</i> L	Shu (Kiswahili)	NA	DRC/Oriental province	Leaf	Decoction	Vitamins & Minerals, Calcium, Iron	stomach ulcers, gastrointestinal problems, eczema, psoriasis, cough	[67]
21	Cactus	Cactaceae	<i>Cactus</i> L	Matomoko (Kamba)	NA	Kenya/Eastern province	Leaf	Squeeze juice from fresh	Alkaloids, flavonoids, phenolic acids, terpenoids	constipation, wounds, and as a diuretic	[64]
22	Natal plum" or "Ama-tungulu	Apocynaceae	<i>Carissa edulis</i> Vahl	Mukawa (Kikuyu)	LNM14/24	Kenya/Nyamira County, Nyeri county, Tanzania,	Fruit, root bark	Decoction	Carissin, Quercetin, Betulinic acid, Ursolic acid	rheumatism, gonorrhoea, syphilis, rabies, herpes, malaria	[26, 69]
23	Natal Plum	Apocynaceae	<i>Carissa</i> L	Amatungulu	NA	Uganda/central	Fruit	Fruit are eaten	anthocyanins, naringenin 4'-O-glucoside, quercetin 3-O-rhamnosyl-galactoside, quercetin 3-O-rhamnosyl-glucoside and ascorbic acid	Diarrhoea, scurvy, anaemia, anxiety, constipation, heart disease	[23, 70]
24	Cassia	Fabaceae	<i>Cassia abbreviata</i> Oliv	Malandesi (Kamba)	LKP 2010/005	Kenya/Eastern province	Leaf/pods	Decoction	Antraquinones, flavonoids, phenolic acids, tannins, terpenoids	constipation, skin diseases, and as a laxative	[64]
25	Ringworm bush	Fabaceae	<i>Cassia alata</i> L	Mapalata (Lingala), Nkaya loto (Kiyombe), Muharagwe (Swahili), Mukaragwe (Kikuyu)	NA	DRC/Oriental province	Leaf	Decoction	antraquinones, saponins, tannins, and flavonoids	ringworm, eczema, fungal infections	[67]

Table 2 (continued)

S/No.	English name	Family Name	Scientific name	Local name	Voucher No	Country/Region	Part Used	Preparation of fraction	Active compounds	Other uses	References
26	coffee senna or Negro coffee	Fabaceae	<i>Cassia occidentalis</i> L	Lukunda bajanyi (Tshiluba), Mbawmbaw (Kikongo)	1098	DRC/Lubumbashi	Root or whole plant	Decoction	Antraquinones: chrysophanol, emodin, and rhein, Flavonoids: such as quercetin, kaempferol, and rutin, Alkaloids: sennosides A and B, cassioidentalin A and B, and oocystidine	treat fever, coughs, and colds	[2]
27	African cassia	Fabaceae	<i>Cassia sieberiana</i> DC	Mugunga (Hemba) Mununga ninsi (Bemba, Lamba)	172	DRC/Lubumbashi	Leaf	Decoction	Antraquinones: chrysophanol, emodin, and rhein, Flavonoids: quercetin, kaempferol, and rutin, Triterpenoids: lupeol, ursolic acid, and betulinic acid	lactation induction, verminosis	[2]
28	Rose Periwinkle	Apocynaceae	<i>Cheiridopsis minor</i> (L.Bolus) H.E.K.Hartmann	Mauwa (Kiswahili)	NA	DRC/Oriental province	Leaf	Decoction	alkaloids (vincristine and vinblastine), flavonoids, terpenoids, and phenolic acids	malaria, high blood pressure, and cancer	[67]
29	Lemon	Rutaceae	<i>Citrus limon</i> (L) Burm	Mti wa ndimu kali (Kiswahili)	NA	DRC/Oriental province	Fruit	Juice	Limonoids, flavonoids, carotenoids, coumarins	detoxification and digestion	[67]
30	Clematis	Ranunculaceae	<i>Clematis hirsuta</i> Guill. & Perr	Mugayang'undũ (Kikuyu)	LNMI14/10	Kenya/Nyeri county	Leaf, roots	Decoction	Alkaloids and flavonoids	headaches, toothaches, and joint pain	[26]
31	Blue glory bower	Lamiaceae	<i>Clerodendrum myricoides</i> R.Br. & Vatke	Muvweia/Munguya (Kamba)	LKP 2010/011	Kenya/Eastern province	Leaf	Decoction	Alkaloids, flavonoids, phenolic acids, terpenoids, saponins	fever, pain, and as an anti-inflammatory agent	[64]
32	False Indigo	Lamiaceae	<i>Rotheca myricoides</i> var. <i>discolor</i> (Klotzsch) Verdc	NA	NA	Kenya/Nyamira County,	Leaf, Roots	Decoction	alkaloids, tannins, flavonoids, saponins, and glycosides	coughs, fever, malaria, stomach ache, dysentery, and diarrhoea	[69]
33	Yellow top	Asteraceae	<i>Crassocephalum vitellinum</i> Guinea	Ekilalaakuba	NA	Uganda/central	Leaf	Decoction	Flavonoids (kaempferol and quercetin), Alkaloids (spilanthine), Steroids (stigmasterol and sitosterol), Terpenoids (β -caryophyllene and α -humulene)	Malaria, diarrhoea, vomiting, constipation, coughs, bronchitis, Wound healing	[23]
34	Ornate Crinum Lily	Amaryllidaceae	<i>Crinum ornatum</i> var. <i>speciosum</i> Herb	NA	NA	DRC/Oriental province	Leaf	Decoction	alkaloids and phenolic	fever, headache, and stomach disorders	[29]
35	Croton	Euphorbiaceae	<i>Croton macrostachyus</i> Del	Mutundu/Kitundu (Kamba)	LKP 2010/034	Kenya/Eastern province	Root bark	Decoction	Diterpenoids, flavonoids, tannins, alkaloids	skin infections, wounds, and malaria	[64]
36	African Croton	Euphorbiaceae	<i>Croton megalocarpus</i> Hutch	Muthulu/Kitulu (Kamba)	LKP 2010/018	Kenya/Eastern province	Leaf	Decoction	Diterpenes, alkaloids, flavonoids, terpenoids, phenols, tannins, saponins	malaria, wounds, and fungal infections	[64]
37	African croton or East African croton	Euphorbiaceae	<i>Croton macrostachyus</i> Hochst. ex Delile	Muvule (Luganda), Mugumo (Kikuyu), Mkonge (Swahili)	NA	Kenya/Nyamira County,	Leaf, bark, and roots	Decoction, Infusion	Alkaloids, Flavonoids, Tannins, Terpenoids, Sterols, Saponins	Malaria, Stomach problems (such as diarrhoea and dysentery), Wounds and skin infections (such as ringworm and scabies), Respiratory infections (such as coughs and bronchitis), Toothache	[69]

Table 2 (continued)

S/No.	English name	Family Name	Scientific name	Local name	Voucher No	Country/Region	Part Used	Preparation of fraction	Active compounds	Other uses	References
38	Pumpkin	Cucurbitaceae	<i>Cucurbita maxima</i> Lam	Ensujju	NA	Uganda/central	Fruit	Boil and eaten	carotenoids, polyphenols (flavonols and phenolic acids), tocopherols, vitamins (C, B1, folates), minerals (K, Ca, Mg, Na, Fe, Zn, Cu, Mn)	Constipation, arthritis, prostatic hyperplasia	[23]
39	Lemon-grass	Poaceae	<i>Cymbopogon citratus</i> (DC.) Stapf	Mchaichai, Majani tshai (Kiswahili)	NA	Tanzania/Kilimanjaro Region, DRC/Oriental province	Leaf, Stem, Oil extract	Decoction	terpenes, alcohols, ketones, aldehyde, flavonoids, phenols, citral, geraniol, limonene and phenolic compounds	antipyretic/anti-malarial, stimulant, anti-spasmodic, jaundice	[67]
40	Yellow yam	Dioscoreaceae	<i>Dioscorea praehensilis</i> Benth	Amasoma	MJM 3246	Tanzania/Kagera Region	Tubers	The tubers are eaten as food	Alkaloids, saponins, tannins, terpenoids	malaria, rheumatism	[32]
41	Steudner's Dragon Tree	Asparagaceae	<i>Dracaena steudneri</i> Engl	Ithare (Kikuyu)	LNMI4/11	Kenya/Nyeri county	Bark, Root	Decoction	Steroids, alkaloids, phenolics, terpenoids	malaria	[26]
42	Abys-sinian coral	Fabaceae	<i>Erythrina abyssinica</i> Lam	NA	NA	Uganda/Mpigi Region	Stem bark	Decoction	Alkaloids, flavonoids, phenolic acids, saponins, terpenoids	anaemia, birth control, brain disorders, dehydration	[71]
43	Ethiopian coral tree	Fabaceae	<i>Erythrina abyssinica</i> Lam	Kinsungu (Tabwa), Isungwa (Hemba), Katshiyit-shiyi (Luba)	174	DRC/Lubumbashi	Root bark	Decoction	Alkaloids: erythrahyssin II, erythrahyssin IV, and erythrahyssin N; Flavonoids: quercetin, kaempferol, and myricetin, Triterpenoids: oleanolic acid and betulinic acid	hernia, sinusitis	[2]
44	Eucalyptus	Myrtaceae	<i>Eucalyptus tereticornis</i> subsp. <i>tereticornis</i>	Musanduku (Kamba)	NA	Kenya/Eastern province	Stem bark	Decoction	Flavonoids, phenolic acids, tannins, terpenoids, saponins	respiratory infections, fever, and as an analgesic	[64]
45	Diviner's elder	Ebenaceae	<i>Euclea divinorum</i> Hiern	Kikuthi/Mukinyei (Kamba)	LKP 2010/001	Kenya/Eastern province	Root bark	Decoction	Alkaloids, flavonoids, phenolic acids, tannins, terpenoids	cough, respiratory infections, and as an antiseptic	[64]
46	Natal Ebony	Ebenaceae	<i>Euclea natalensis</i> A. DC	Mukinyei (Kamba)	LKP 2010/029	Kenya/Eastern province	Whole root	Decoction	Saponins, flavonoids, alkaloids, tannins, phenols	fever, malaria, and toothache	[64]
47	Bush Guarri	Ebenaceae	<i>Euclea racemosa</i> Murr	Mukinyei (Kamba)	LKP 2010/030	Kenya/Eastern province	Leaf/stem bark/ root bark	Decoction	Saponins, tannins, alkaloids, flavonoids	coughs, fever, and stomach pains	[64]
48	Natal fig	Moraceae	<i>Ficus natalensis</i> Hochst	Muomono/Kiumo (Kamba)	LKP 2010/015	Kenya/Eastern province	Fruit	Cold infusion	Flavonoids, phenolic acids, tannins, terpenoids	diarrhoea, respiratory infections, and as a general tonic	[64]
49	Sandpaper Tree	Moraceae	<i>Ficus exasperata</i> Vahl	Lukenga (Bangu) (Bangu)	NA	DRC/Oriental province	Leaf	Decoction	quercetin, kaempferol, rutin, flavonoids, tannins, and saponins	fever, diarrhoea, and respiratory tract infections	[67]
50	Saussure fig	Moraceae	<i>Ficus saussureana</i> DC	DC	NA	Uganda/Mpigi Region	Stem bark, Leaf	Decoction	Flavonoids, tannins, phenolic acids, terpenoids	fallopian tube blockage, HIV/AIDS, infertility in men, STIs	[71]
51	African Furstia	Meliaceae	<i>Fuerstia africana</i> T.C.E.Fr	Kalaku (Kamba)	LKP 2010/007	Kenya/Eastern province	Aerial parts	Decoction	Alkaloids, flavonoids, phenolic acids, terpenoids	malaria, fever, and as a general tonic	[64]

Table 2 (continued)

S/No.	English name	Family Name	Scientific name	Local name	Voucher No	Country/Region	Part Used	Preparation of fraction	Active compounds	Other uses	References
52	Galinsoga	Asteraceae	<i>Galinsoga Ruiz & Pav</i>	Müng'ei (Kikuyu)	LNM14/08	Kenya/Nyeri county	Leaf, Roots	Decoction	Alkaloids, flavonoids, terpenoids, steroids	fever and malaria	[26]
53	African Mango-steen	Clusiaceae	<i>Garcinia burchananii</i> Bak	Mukanga (Kamba)	LKP 2010/032	Kenya/Eastern province	stem bark	Decoction	Xanthones, benzophenones, flavonoids	skin infections, diarrhoea, and coughs	[64]
54	Klatt's gladiolus	Iridaceae	<i>Gladiolus klattianus</i> Hutch	Kitala (Bemba), Kitokatoka (Luba)	306	DRC/Lubumbashi	Bulb	Decoction	Saponins, Flavonoids, Alkaloids, Triterpenoids	gonorrhea	[2]
55	African Mistle-toe	Gnetaceae	<i>Gnetum africanum</i> Welw	Fumbwa (Lingala)	NA	DRC/Oriental province	Leaf	Decoction	flavonoids, phenols, and tannins	high blood pressure, and stomach problems	[67]
56	Milkweed	Apocynaceae	<i>Gomphocarpus fruticosus</i> L	Mukangarithi (Kikuyu)	LNM14/14	Kenya/Nyeri county	seeds, roots	Decoction	Cardiac glycosides, triterpenoids, flavonoids	cancer	[26]
57	Grewia	Tiliaceae	<i>Grewia similis</i> K.Schum	Mütheregendu (Kikuyu)	LNM14/21	Kenya/Nyeri county	Leaf	Decoction	Flavonoids, tannins, saponins	diarrhoea, coughs, and fever	[26]
58	African red-wood; East African rose-wood	Rosaceae	<i>Hagenia abyssinica</i> (Bruce) J.F.Gmel	Enjani engashe (Maasai)	NA	Tanzania/Kilimanjaro Region	Flower and Leaf extracts	Decoction	kosin (aphloroglucinol), & quercetin glucuronides	Helminthic infections, Typhoid fever, wound healing, epilepsy, sexually transmitted diseases, and symptomatic ailments	[67]
59	Okra	Malvaceae	<i>Hibiscus esculentus</i> L	Dongodongo (Lingala)	NA	DRC/Oriental province	Fruit	Decoction	flavonoids, tannins, and saponins	urinary tract infections, syphilis, and gastrointestinal disorders	[67]
60	Hydnora	Hydnoraceae	<i>Hydnora abyssinica</i> A	Muthigira (Kikuyu)	LNM14/17	Kenya/Nyeri county	stem	Decoction	Tannins, alkaloids, and phenolic compounds	asthma, epilepsy, and infertility	[26]
61	Star flower or African potato	Hypoxidaceae	<i>Hypoxis obtuse</i> Burch. ex Ker Gawl	Kifumbi	NA	Tanzania/Kagera	Corn	Raw corn is crushed, boiled and given patients	flavonoids, alkaloids, tannins, and saponins	urinary tract infections, stomach disorders, and respiratory infections	
62	Natal Indigo	Fabaceae	<i>Indigofera arrecta</i> Benth. ex Harv	Akabamba	NA	Uganda/central	Leaf	Decoctions	phenols, tannins, flavonoids, terpenoids, carbohydrates and proteins	gum infections, snake-bites, gonorrhoea, epilepsy and jaundice	[23]
63	none	Convolvulaceae	<i>Ipomoea mauritiana</i> Jacq	Mivinje (Swahili), Mugwabulu (Kikuyu)	NA	DRC/Oriental province	Tubercule	Decoction	flavonoids, alkaloids, and saponins	fever, headache, dysentery, diarrhoea	[67]
64	Barbados nut	Euphorbiaceae	<i>Jatropha curcas</i> L	Asangi (Bangubangu), Mpuluka (Kikongo), Mbarimbari (Swahili)	NA	DRC/Oriental province	Bark	Decoction	curcin, phorbol esters, diterpenes alkaloids, flavonoids, and terpenoids	skin infections, purgative or laxative, skin injuries	[67]
65	Sausage tree	Bignoniaceae	<i>Kigelia africana</i> (Lam.)	Mkuyu (Swahili)	NA	Kenya, Embu	Leaf	Decoction	Vitamin C, Vitamin B1, Vitamin B3, Alkaloids, Total phenols, Tannins, Saponins, Flavonoids	ungal infections, boils, psoriasis and eczema, leprosy, syphilis, and cancer	[72]

Table 2 (continued)

S/No.	English name	Family Name	Scientific name	Local name	Voucher No	Country/Region	Part Used	Preparation of fraction	Active compounds	Other uses	References
66	Smooth lettuce	Asteraceae	<i>Lactuca inermis</i> Forssk	Mũthũnga (Kikuyu)	LNMI14/01	Kenya/Nyeri county	Leaf	Chew the Leaf or boil the whole plant	Lactucin, lactucopicrin, flavonoids, phenolics	fever and insomnia	[26]
67	Wild lettuce	Asteraceae	<i>Launaea cornuta</i> Hochst	NA	BKM2010/005	Kenya	Whole plant	Decoction	flavonoids, terpenoids, and alkaloids	liver and digestive disorders	[29]
68	Horned Goat's beard	Asteraceae	<i>Protea gaguedi</i> subsp. <i>laetans</i> (L.E.Davidson) Beard	Mũthũnga (Kikuyu)	LNMI14/03	Kenya/Nyeri county	Leaf	Chew the Leaf or boil the whole plant	Sesquiterpene lactones, flavonoids, phenolics	fever and malaria	[26]
69	Lion's ear	Lamiaceae	<i>Leonatis mollisima</i>	Ekifumufumu	NA	Uganda/central	Leaf	Decoctions	Sederin, hydroxylucidenic acid	Malaria, anti snake venom	[23]
70	Harms/wild liana	Fabaceae	<i>Lonchocarpus erio-calyx</i> Harms	Mkindu (Swahili)	BKM2010/002	Kenya/Tanzania	Stem bark	Decoction	flavonoids and alkaloids	Malaria, Fever	[29]
71	Maerua	Capparidaceae	<i>Maerua decumbens</i> (Brongn.) DeWolf	Munatha (Kamba)	M.UH/MD/0021/17	Kenya/Marakwet	Roots	Decoction	alkaloids, glycosides, flavonoids, phenolic compounds, saponins, steroids, tannins and terpenoids	malaria, fever, and coughs	[73]
72	Mango	Anacardiaceae	<i>Magnifera indica</i> L	Mti wa hembe (Kiswahili) Nzete ya manga (Lingala)	BKM2010/001	Kenya/Nyamira County, DRC/Oriental province	Shoot, Root bark	Decoction	Mangiferin, Gallic acid, Quercetin, Beta-carotene, Lutein, Vitamin C, Kaempferol, Chlorogenic acid, Caffeic acid, Ellagic acid, Myricetin, Rutin, Catechins, Epicatechins	high blood pressure, diarrhoea	[29, 67, 69]
73	Bitter melon	Cucurbitaceae	<i>Momordica foetida</i> Schumacher	Iphunzu (Kamba)	LKP 2010/002	Kenya/Eastern province	Leaf	Decoction	Alkaloids, flavonoids, phenolic acids, saponins, terpenoids	malaria, fever	[64]
74	Bitter Melon or Gourd	Cucurbitaceae	<i>Momordica breteri</i> H.Schaefer	Iphunzu (Kamba)	NA	Kenya/Eastern province	Leaf	Decoction	Alkaloids, flavonoids, tannins	malaria	[64]
75	bitter gourd	Cucurbitaceae	<i>Momordica charantia</i> L	mara kwamara (Swahili), dooda (Luganda), entula (Runyankole)	NA	Uganda/Tanzania/Moshi	Fruit	tea, juice, or in cooking	alkaloids, flavonoids, and saponins	malaria, constipation, and skin infections	[74]
76	White's ginger or African ginger	Apocynaceae	<i>Mondia whytei</i>	Omulondo	NA	Uganda/central	Roots	Decoction	2-hydroxy-4-methoxybenzaldehyde, isovanillin, steroids and terpenes	male infertility, aphrodisiac, gonorrhea, constipation, bilharziasis, stress and tension	[23, 75]
77	Brimstone Tree	Rubiaceae	<i>Morinda lucida</i> Benth	Bokakate (Turumbu) Mulambu (Bangubangu et Tshiluba)	NA	DRC/Oriental province	Leaf, bark and roots	Maceration, Decoction	Alkaloids, iridoids, triterpenoids	fever and malaria	[67]
78	Morinda	Rubiaceae	<i>Morinda morindoides</i> (Baker) Milne-Redh	Kongobololo (Kinyanzi) Mesokhama (Kikongo)	NA	DRC/Oriental province	Leaf	Decoction	Antraquinones, iridoids, triterpenoids	No information available	[67]

Table 2 (continued)

S/No.	English name	Family Name	Scientific name	Local name	Voucher No	Country/Region	Part Used	Preparation of fraction	Active compounds	Other uses	References
79	Moringa; Drumstick tree	Moringaceae	<i>Moringa oleifera</i> Lam	Mlonge	NA	Tanzania/Kilimanjaro Region, Kenya/Nyeri county	Flowers Pods/ seeds Roots Leaf	Commonly grounded into powder for mixing, chewing seeds	Salicylic and ferulic acids, Flavonoids (quercetin, kaempferol), alkaloids (moringine), Phenolic acids (gallic acid, chlorogenic acid), terpenoids (β -caryophyllene and α -humulene) flavonoids, phenolic acids, glucosinolates and isothiocyanates, tannins and saponins	hypertension, HIV/AIDS-related symptoms, stimulates breastmilk production	[26]
80	African box-wood	Primulaceae	<i>Myrsine africana</i> L	Mūgaita (Kikuyu)	LNMI14/26	Kenya/Nyeri county	Fruit	Decoction	Tannins, flavonoids, alkaloids, and saponins	coughs, stomachaches, and skin conditions	[26]
81	Sweet Basil	Lamiaceae	<i>Ocimum basilicum</i> L	Mutaa (Kamba)	LKP 2010/021	Kenya/Eastern province	Whole plant/ Leaf	Pounded Leaf cold infusion/ Decoction	Phenols, flavonoids, tannins, terpenoids	gastrointestinal disorders, inflammation, and stress	[64]
82	Olive	Oleaceae	<i>Olea europaea</i> L	Molialundi (Kamba)	LKP 2010/033	Kenya/Eastern province	stem bark/ Whole root	Decoction	Polyphenols, flavonoids, triterpenoids	high blood pressure, inflammation, and digestive disorders	[64]
83	African olive	Oleaceae	<i>Olea africana</i> Mill	Mūtero (Kikuyu)	LNMI14/27	Kenya/Nyeri county	Leaf, root	Decoction	Oleuropein, hydroxytyrosol, and flavonoids	malaria, fever, and respiratory problems	[26]
84	Ormosia	Fabaceae	<i>Ormocarpum kirkii</i> S. Moore	Muthii (Kamba)	LKP 2010/024	Kenya/Eastern province	Leaf	Decoction	Saponins, flavonoids, tannins, alkaloids	malaria, diarrhoea, and fever	[64]
85	Narrow-Leafed Star of Bethlehem	Asparagaceae	<i>Ornithogalum tenuifolium</i> F	Mūgwace (Kikuyu)	LNMI14/22	Kenya/Nyeri county	Rhizome	Decoction	Anthocyanins, saponins, flavonoids, alkaloids, glycosides, tannins	skin diseases, inflammation, fever, diarrhoea, snakebites	[26]
86	Oxygonum	Oxalidaceae	<i>Oxygonium sinuatum</i> (Meisn.)	Songé (Kamba)	LKP 2010/020	Kenya/Eastern province	Whole plant	Cold infusion of pounded whole plant	Alkaloids, flavonoids, tannins, phenols, saponins	gastrointestinal disorders, fever, and inflammation	[64]
87	Panda Berry	Pandaceae	<i>Panda oleosa</i> Pierre	Okali (Lingala)	NA	DRC/Oriental province	Bark	Decoction	No information available		[67]
88	Passion flower	Passifloraceae	<i>Passiflora oaxacana</i> (Killip) H.T.Svoboda	Makundi (Kamba)	NA	Kenya/Eastern province	Leaf	Decoction	Alkaloids, flavonoids, phenolic acids, terpenoids	anxiety, insomnia, and as a sedative	[64]
89	Passion Flower	Passifloraceae	<i>Passiflora subpeltata</i>	Makundi (Kamba)	LKP 2010/025	Kenya/Eastern province	Leaf	Decoction	Alkaloids, flavonoids, tannins, phenols, saponins	anxiety, insomnia, and gastrointestinal disorders	[64]
90	Fruit red	Menispermaceae	<i>Penicanthus longifolius</i> Miers	NA	NA	DRC/Oriental province	Bark	Maceration	alkaloids and flavonoids	malaria, fever, stomach problems	[67]
91	Periploca	Apocynaceae	<i>Periploca linearifolia</i> Quart.-Dill. & A.Rich	Mwembaiguru (Kikuyu)	LNMI14/0	Kenya/Nyeri county	Leaf, Stem	Decoction	Cardiac glycosides, triterpenoids, flavonoids	snake bites and malaria	[26]

Table 2 (continued)

S/No.	English name	Family Name	Scientific name	Local name	Voucher No	Country/Region	Part Used	Preparation of fraction	Active compounds	Other uses	References
92	Avacado	Lauraceae	<i>Persea americana</i> Mill	Okakedo, Avocado (Swahili)	NA	Uganda/central, DRC/Oriental province	seeds, Fruit and Leaf	Fruit are eaten, Decoction, avocado paste	Carotenoids, Polyphenols, Fatty acids, vitamin C, vitamin E, vitamin K, potassium, magnesium, and copper	eczema, psoriasis, and wounds	[23]
93	Wild Date Palm	Arecaceae	<i>Phoenix reclinata</i> Jacq	Empirivuma	NA	Uganda/central	seeds	Edible	tannins, flavonoids and saponins	backpain, stomach ache, toothache, headache, arthritis, pain of but-tocks, piles, nervous debility	[23]
94	Coleus forskohlii	Lamiaceae	<i>Plectranthus barbatus</i> var. <i>barbatus</i>	NA	NA	Kenya/Nyamira County,	Leaf	consumed as a tea, Decoction	forskolin, rosmarinic acid, and flavonoids	respiratory disorders, digestive problems, and skin conditions	[69]
95	Red stink-wood	Rosaceae	<i>Prunus africana</i> Hook.f	Mūiri (Kikuyu)	LNMI14/20	Kenya/Nyeri county	Leaf, bark	Decoction	Phytosterols, triterpenes, and flavonoids	prostate problems and fever	[26]
96	Quinine tree	Apocynaceae	<i>Rauvolfia caffra</i> Sond	Mutalala (Bemba)	6046	DRC/Lubumbashi	Leaf and stem	Infusions, Decoctions and poultice	Alkaloids: reserpine, yohimbine, and ajmalicine, Tannins, Flavonoids	malaria, tuberculosis, antibacterial	[2]
97	Swahili Snake Root	Apocynaceae	<i>Rauvolfia vomitoria</i> Afzel Mubilizi (Kiswahili)	Isumbubulu (Bangubangu), Mubilizi (Kiswahili)	NA	DRC/Oriental province	Root bark	Decoction	alkaloids (reserpine, rescinamine, and ajmaline), flavonoids, terpenoids, and phenolic acids	fever, high blood pressure, anxiety, and gastrointestinal disorders	[67]
98	Buckthorn	Rhamnaceae	<i>Rhamnus prinoides</i> L'Hér	Mukarakinga (Kikuyu)	LNMI14/18	Kenya/Nyeri county	Roots, bark	Decoction	Antraquinones, tannins, and flavonoids	constipation, stomach-aches, and skin conditions	[26]
99	Bush violet	Lamiaceae	<i>Rotheca myricoides</i> (Hochst.) Steane & Mabb	Munjugairia	LNMI14/09	Kenya/Nyeri county	Leaf, roots, Bark	Decoction	Alkaloids, flavonoids, phenolic acids, terpenoids, saponins	Athritus, typhoid, cough, rheumatism, gonorrhea,	[26, 76]
100	Curious weed	Asteraceae	<i>Schkuhria pinnata</i> (Lam.) Cabrera	NA	BKM2010/004	Kenya	Whole plant	Decoction	flavonoids, terpenoids, and sesquiterpene lactones	fever, inflammation, and respiratory infections	[29]
101	Cabbage Tree	Oleaceae	<i>Schrebera alata</i> (Hochst.) Welw	Mutoma (Kamba)	LKP 2010/031	Kenya/Eastern province	Stem bark/ Root/ Leaf	Cold infusion	Alkaloids, flavonoids, tannins, saponins	malaria, stomach aches, and snake bites	[64]
102	African Senna	Fabaceae	<i>Senna didymobotrya</i> (Fres.)	Muthaa/thaa (Kamba)	LKP 2010/019	Kenya/Eastern province	Leaf	Hot infusion	Antraquinones, saponins, flavonoids, tannins	laxative and to treat snake-bites and gastrointestinal disorders	[64]
103	Senna	Fabaceae	<i>Senna singuana</i> (Del.) Lock	Mukengeka (Kamba)	LKP 2010/013	Kenya/Eastern province	Leaf	Decoction	Antraquinones, saponins, flavonoids, tannins	Laxative, treatment of skin diseases and fever	[64]
104	bitter apple	Solanaceae	<i>Solanum incanum</i> L	Mukondur/Mutungu (Kamba)	LKP 2010/022	Kenya/Eastern province	Leaf	Decoction	Solanine, solasonine, Alkaloids, flavonoids, saponins, phenols, tannins	fever, rheumatism, and cough	[64]
105	Rensch's Nightshade	Solanaceae	<i>Solanum renschii</i> Vatke	Mukonda Kondu (Kamba)	LKP 2010/027	Kenya/Eastern province	Whole root/ Leaf	Decoction	Alkaloids, flavonoids, tannins, phenols, saponins	gastrointestinal disorders and inflammation	[64]

Table 2 (continued)

S/No.	English name	Family Name	Scientific name	Local name	Voucher No	Country/Region	Part Used	Preparation of fraction	Active compounds	Other uses	References
106	Bitter tomato	Solanaceae	<i>Solanum aethiopicum</i> L	Entula	NA	Uganda/central	Fruit	Decoctions	Alkaloids (solanine, solasonine, and solamargine), Flavonoids (kaempferol, quercetin, and rutin), sterols (stigmasterol and beta-sitosterol) triterpenoids (solamargine, solasonine, and solasodine) and glycoalkaloids (solanine, solasonine, and solamargine)	Fever, constipation, diarrhoea, stomach ache, cough, asthma, bronchitis, acne, eczema, and psoriasis	[23]
107	Gilo	Solanaceae	<i>Solanum gilo</i> Raddi	Nyanya (Kiswahili)	NA	DRC/Oriental province	Root	Decoction	Steroidal alkaloids, flavonoids, saponins		[67]
108	Bitter Berries	Solanaceae	<i>Solanum indicum</i> Roxb	Katunkuma	NA	Uganda/central	Fruit	Decoction		skin problems, ulcers, difficulties breathing, stomach aches, coughing, and dyspepsia	[23]
109	Brihati or Indian night-shade	Solanaceae	<i>Solanum indicum</i> L	Mnavu (Swahili)	NA	Kenya/Nyamira County,	Leaf, roots and Fruit	Decoction, Fruit are eaten	alkaloids, flavonoids, glycosides, tannins, and saponins	Respiratory ailments, Digestive issues, Joint pain, Skin infections	[69]
110	Maué night-shade	Solanaceae	<i>Solanum mauense</i> Bitter	NA	NA	Kenya/Nyamira County,	Leaf, stems, roots, and flowers	Decoction	Not available		[69]
111	Egg plant	Solanaceae	<i>Solanum melongena</i> L	Bilinganya	NA	Uganda/central	Fruit and Leaf	Decoction, Fruit are eaten	N-trans-Feruloyl tyramine, N-trans-p-Coumaroyl tyramine, N-cis-p-Coumaroyl tyramine, Ferul aldehyde, 6,7-Dimethoxycoumarin, Ficusal, Acarbose, 1-Deoxynojirimycin	rheumatism, beriberi, itching, toothache, bleeding, asthma, bronchitis, cholera, neuralgia and hemorrhoids	[23, 40]
112	Black Night-shade	Solanaceae	<i>Solanum nigrum</i> L	Makeke (Kiswahili)	NA	DRC/Oriental province	Fruit	Decoction	Alkaloids, flavonoids, phenolics, steroids	skin diseases	[67]
113	Prickly Sowthistle	Asteraceae	<i>Sonchus asper</i> L	Muthunga (Kikuyu)	LNM14/05	Kenya/Nyeri county	Leaf	Chew the Leaf or boil the whole plant	Sesquiterpene lactones, flavonoids, phenolics	treat inflammation	[26]
114	Mediterranean sowthistle	Asteraceae	<i>Sonchus luxurians</i>	Muthunga (Kikuyu)	LNM14/04	Kenya/Nyeri county	Leaf	Chew the Leaf or boil the whole plant	Sesquiterpene lactones, flavonoids, phenolics		[26]
115	Sowthistle	Asteraceae	<i>Sonchus oleraceus</i> L	Muthunga (Kikuyu)	LNM14/02	Kenya/Nyeri county	Leaf	Chew the Leaf or boil the whole plant	Sesquiterpene lactones, flavonoids, phenolics	liver ailments	[26]
116	Toothache Plant	Asteraceae	<i>Spilanthes mauritiana</i> (A.Rich. ex Pers.)	Gathariaita (Kikuyu)	LNM14/30	Kenya/Nyeri county	Whole plant	Decoction	Sesquiterpene lactones, flavonoids, phenolics	malaria and fever	[26]

Table 2 (continued)

S/No.	English name	Family Name	Scientific name	Local name	Voucher No	Country/Region	Part Used	Preparation of fraction	Active compounds	Other uses	References
117	Ethiopian Carrot	Apiaceae	<i>Steganotaenia araliacea</i> Hoch	Muvuvui (Kamba)	LKP 2010/023	Kenya/Eastern province	Leaf	Decoction	Alkaloids, flavonoids, tannins, saponins	respiratory ailments, malaria, and fever	[64]
118	Heming's strychnos	Loganiaceae	<i>Strychnos henningssii</i> Gilg	Muteta (Kamba)	LKP 2010/004	Kenya/Eastern province	Leaf	Decoction	Alkaloids, flavonoids, phenolic acids, terpenoids, saponins	malaria, fever	[64]
119	spiny-fruit strychnos	Loganiaceae	<i>Strychnos spinosa</i> Lam	Sansa (Bemba), Kison-gole (Luba)	519	DRC/Lubumbashi	Root bark	Decoction	quinones, iridoids, triterpenoids, alkaloids, flavonoids, tannins, and phenolic	Abdominal pain, dysentery, gonorrhea	[2]
120	Java plum	Myrtaceae	<i>Syzygium cumini</i> (L.) Skeels	Jambula	NA	Uganda/central	seeds and Fruit	Infusions and Decoctions	anthocyanins, glucoside, ellagic acid, isoquercetin, kaemferol and myrecetin	sore throat, bronchitis, asthma, thirst, biliousness, dysentery and ulcers	[23, 77]
121	Malabar plum	Myrtaceae	<i>Syzygium cumini</i> (L.) Telezia (Kiswahili)	Telezia (Kiswahili)	NA	DRC/Oriental province	Fruit	Decoction	Eugenol, tannins, flavonoids, triterpenoids		[67]
122	Tamarind	Fabaceae	<i>Tamarindus indica</i> Linn	Kithumula (Kamba)	LKP 2010/003	Kenya/Eastern province	Root bark, fruit	Decoction	Flavonoids, phenolic acids, tannins, terpenoids, alkaloids	constipation, diarrhoea, fever	[64]
123	Teclea	Rutaceae	<i>Teclea simplicifolia</i> L'Verd	Munderendu (Kikuyu)	LNMI14/25	Kenya/Nyeri county	Leaf	Decoction	Alkaloids, flavonoids, and terpenoids	malaria, fever, and skin conditions	[26]
124	Brown's Terminalia	Combretaceae	<i>Terminalia brownie</i> Fres	Muuuku/Kiuku (Kamba)	LKP 2010/016	Kenya/Eastern province	Stem bark	Decoction	Triterpenoids, flavonoids	diarrhoea, wounds, and fever	[64]
125	Tropical almond tree	Combretaceae	<i>Terminalia catappa</i> L	Madame' (Lingala), Kalanga ya Wazungu (Kiswahili), Mung'ano (Kikuyu)	NA	DRC/Oriental province	Leaf	Decoction	tannins, flavonoids, and alkaloids	treat diarrhoea, dysentery, digestive disorders, wounds, rashes, and burns	[67]
126	none	Dilleniaceae	<i>Tetracera poggei</i> Gilg	NA	NA	DRC/Oriental province	Leaf	Decoction	poggein, triterpenoids, flavonoids, and alkaloids	fever, headache, diarrhoea and dysentery	[67]
127	Forest Bells	Acanthaceae	<i>Thomandersia hensii</i> De wild	Ikoka (Turumbu), Liowa (Topoke), Mugandagana (Swahili)	NA	DRC/Oriental province	Leaf	Decoction	alkaloids, flavonoids, and terpenoids	fever, malaria, and respiratory infections	[29]
128	African wild orange	Rutaceae	<i>Toddalia asiatica</i> (L.) Lam	NA	NA	Uganda/Mpigi Region	Leaf, bark	Decoction	Alkaloids, flavonoids, phenolic acids, terpenoids, coumarins	anaemia, aphrodisiac, brain disorders, diarrhoea, HIV/AIDS, hypertension, menstrual cramps, NA typhoid fever, snake bite	[71]
129	Typha	Typhaceae	<i>Typha domingensis</i> Pers	Ndoothua (Kikuyu)	LNMI14/15	Kenya/Nyeri county	Rhizome	Decoction	Flavonoids, phenols, tannins, terpenoids, alkaloids	dysentery, diarrhoea, and inflammation	[26]
130	Stinging nettle	Urticaceae	<i>Urtica dioica</i> L	Muthakwa (Kikuyu), Musawo (Luganda)	NA	Kenya/Nyamira County,	Leaf, roots, and seeds	tea or tincture	Flavonoids, Lectins, Lignans, Triterpenoids, Sterols, Phenolic acids	allergies, arthritis, and urinary tract infections	[69]
131	Massaica nettle	Urticaceae	<i>Urtica massaica</i> Mildbr	Kinyelelya (Kamba)	LKP 2010/010	Kenya/Eastern province	Leaf	Decoction of pounded Leaf	Flavonoids, phenolic acids, sterols, triterpenes, tannins	anaemia, hypertension, and as a diuretic	[64]

Table 2 (continued)

S/No.	English name	Family Name	Scientific name	Local name	Voucher No	Country/Region	Part Used	Preparation of fraction	Active compounds	Other uses	References
132	Small-fruited Bridelia	Euphorbiaceae	<i>Bridelia micrantha</i> (Hochst.) Baill	Mshamako	MJM 3166	Tanzania/Kenya	Root	Roots are boiled with water to make decoction which is drunk	Flavonoids, phenolic acids, sterols, triterpenes, tannins	yellow fever, malaria, amenorrhea and dysmenorrhea	[26]
133	Natalie	Asteraceae	<i>Melanthera scandens</i> subsp. <i>scandens</i>	Ekarwe	GH18-017	Kenya/Uganda	shrub	shade dry, grind into powder and drink in porridge/tea	flavonoids, alkaloids, and terpenes	arthritis, asthma, and other respiratory conditions	[29]
134	Bitter Leaf	Asteraceae	<i>Vernonia amygdalina</i> Del	Omululuza, Kilulukunju (Kiswahili)	NA	Uganda/central, DRC/Oriental province	Leaf	Decoction	Vernoniosides, Steroidal saponins, Sesquiterpene lactones, Flavonoids	anti-helminth, anti-malarial, laxative, digestive tonic, appetizer, febrifuge and for the topical treatment of wounds	[23, 67]
135	Ethiopian iron-weed	Asteraceae	<i>Vernonia auriculifera</i> Hiern	omubilizi (Luganda)	NA	Kenya/Nyamira County, Uganda, Tanzania	Leaf, roots, and stem bark	Decoctions	sesquiterpene lactones, flavonoids, alkaloids, phenolic acids, chlorogenic acid, rutin, and quercetin	dysentery and stomach ache	[69]
136	Ironweed	Asteraceae	<i>Vernonia lasiopus</i> O.Hoffm	Muchatha (Kikuyu)	LN14/23	Kenya/Nyeri county	Leaf	Decoction	Sesquiterpene lactones, flavonoids, phenolics	malaria and fever	[26]
137	African lilac	Lamiaceae	<i>Vitex madensis</i> Oliv	Mufutu (Luba), Mufute Kinka (Bemba)	1247	DRC/Lubumbashi	Leaf, roots	infusion, Decoction, or tincture	iridoids, flavonoids, terpenoids, agnuside and essential oils	asthma, anaemia, diarrhoea, premenstrual syndrome, malaria	[2]
138	East African green-heart, pepper bark tree, and Ugandan green-heart	Canelaceae	<i>Warburgia ugandensis</i> subsp. <i>ugandensis</i>	Abasi	NA	Kenya/Uganda	bark and roots	Decoction	essential oils, flavonoids, alkaloids, tannins, and coumarins	pneumonia, asthma, malaria, candidiasis, skin infections, human immunodeficiency virus opportunistic infections, diarrhoea, and measles	[69, 78]
139	Ashwagandha	Solanaceae	<i>Withania somnifera</i> (L.) Dunal	Mwianzo (Kamba)	LKP 2010/026	Kenya/Eastern province	Whole root	Cold infusion	Alkaloids, steroidal lactones, flavonoids	adaptogen, anti-inflammatory, and to boost immune function	[64]
140	Ironwood	Rutaceae	<i>Zanthoxylum chalybeum</i> Engl	Mukenea (Kamba)	LKP 2010/006	Kenya/Eastern province	Stem bark	Decoction/hot infusion	Alkaloids, flavonoids, phenolic acids, terpenoids	fever, pain, and as an anti-inflammatory agent	[64]

NA not available

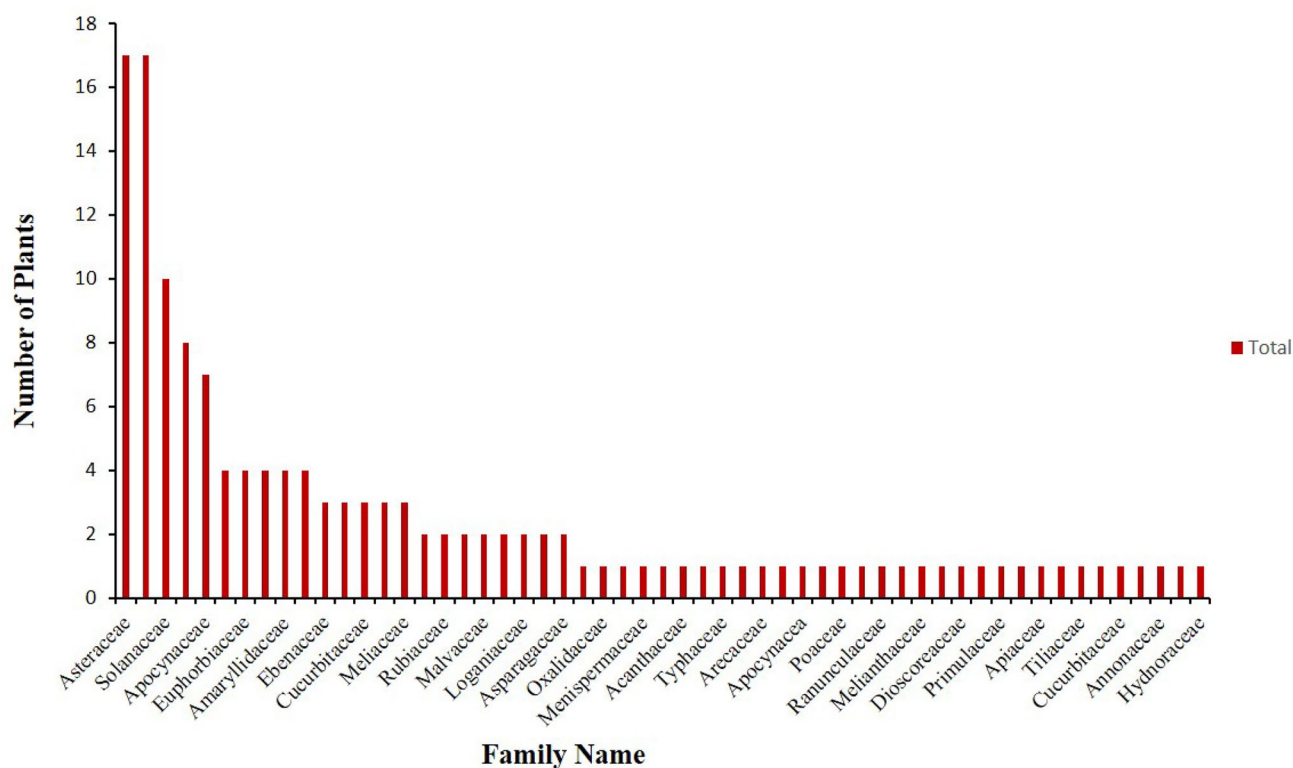


Fig. 2 Families of plant species investigated

3.2.1 Plants utilized for managing *Diabetes mellitus* in Uganda

Uganda's rich cultural heritage has a long-standing tradition of using medicinal plants to treat a range of health issues, including DM. Among the 22 plants reported for DM management in Uganda from this study, notable species include *Ageratum conyzoides*, *Albizia chinensis*, *Aloe vera* var, and *Vernonia amygdalina* [15, 18, 22, 23], among others (see Table 2). These indigenous plants have a well-established reputation for their efficacy in DM treatment, with deep roots in Ugandan folklore and traditional healing practices. Traditional medicine in Uganda makes use of specific parts of these plants, primarily focusing on the fruits, leaves, and roots [18]. Fruits are central to the traditional methods of managing DM remedies in Uganda. Bitter melon, scientifically known as *Momordica charantia*, is famed for its bitter fruits, attributed to their potential blood sugar-lowering properties, it is consumed as tea, juice or in cooking. Some individuals in Uganda juice bitter melon and consume it as a beverage, they usually combine it with other fruits or adding a bit of lemon to help mask the bitterness [15, 19]. Many parts of Uganda serve it with a groundnut (peanut) sauce, which adds a creamy and nutty flavour to the dish serve alongside staples like posho (maize meal) or rice [19]. *Anona muricata*, is another standout, with its fruits being a key component of DM remedies. The fresh soursop fruit is commonly consumed by either scooping out the sweet, pleasantly flavoured flesh or by juicing it. *Anona muricata* leaf tea is another popular approach, with dried leaves steeped in hot water to create herbal tea believed to offer antidiabetic benefits when consumed regularly [20, 21]. Some individuals opt for soursop leaf extracts or tinctures, which provide a more concentrated form of the active compounds and can be diluted in water for controlled consumption. Additionally, *Anona muricata* is incorporated into various traditional recipes, including smoothies, desserts, stews, and curries, as part of the local approach to utilizing soursop for its potential antidiabetic properties [22]. Leaves are another vital plant part utilised in traditional medicine. *Aloe vera* var, known for its succulent leaves, is processed into a gel for a variety of therapeutic applications, including potential DM management, many Ugandans use it as dietary supplement, and its gel, extracted from the inner leaf, is consumed in various ways, such as mixing it with water or other beverages [22]. *Ageratum conyzoides*, referred to locally as "billy goat weed," is also prized for its leaves with anti-diabetic potential. People in Uganda often used to create herbal infusions or teas by drying the leaves and steeping them in hot water, with the belief that this herbal tea possesses medicinal properties for managing diabetes [22]. Additionally, the leaves are processed to extract compounds that are thought to help regulate blood sugar levels, and these extracts are consumed in controlled amounts.

Furthermore, *Ageratum conyzoides* leaves are incorporated into traditional recipes, such as soups and stews, aiming to introduce their potential health benefits into the local diet [23]. *Vernonia amygdalina*, known as “bitter leaf” is commonly integrated into local cuisine and traditional remedies among the locals of Uganda. They frequently employed it in the preparation of vegetable soups and stews, where the leaves are meticulously washed, finely chopped, and included in these dishes, contributing to their flavour and nutritional content. Additionally, some locals dried the leaves to produce bitter leaf tea, an herbal infusion believed to offer potential health advantages, including potential antidiabetic effects. Some individuals opt for bitter leaf extracts, derived from the leaves, which can be consumed in controlled quantities due to the belief in their ability to help regulate blood sugar levels. Bitter leaf’s versatility also extends to its incorporation into various traditional recipes, often combined with other locally available vegetables and ingredients, as an integral component of local dishes [23, 24]. Additionally, the roots of *Ficus saussureana* are incorporated into traditional formulations, attributed to their anti-diabetic effects [18, 22]. In Uganda, medicinal herbs are traditionally prepared using two primary methods decoction and infusion [25]. These plants offer a diverse array of options for those seeking alternative remedies for diabetes. The choice of specific plant parts and traditional preparation methods reflects the accumulated knowledge and experience of Ugandan traditional healers over generations. The integration of this traditional knowledge with modern scientific research holds promise for advancing diabetes treatment options, offering the potential for effective, evidence-based therapies.

3.2.2 Plants utilized for managing *Diabetes mellitus* in Kenya

In Kenya, a substantial repertoire of seventy-nine (79) locally employed plant species has been documented for the treatment of DM Table 2. These plants are sourced for their fruits, roots, leaves, and stems, signifying a diverse range of plant parts utilised in traditional remedies. Some notable species include *Acacia nilotica*, *Allium sativum* (Garlic), *Azadirachta indica* (Neem), and *Bidens pilosa*, among others. In various regions of Kenya, *Acacia nilotica*, is traditionally utilized as a potential antidiabetic remedy. Its various parts, including the bark, leaves, and pods, are employed in distinct ways. The bark is dried and steeped in hot water to create herbal infusions or teas, believed to have antidiabetic properties [14, 26]. The leaves are dried, crushed, and used in the preparation of teas or extracts for potential medicinal benefits. Additionally, the pods are processed and consumed in various forms, such as boiling, grinding into powder, or integration into traditional recipes, all depending on local customs and practices. *Allium sativum*, is a versatile and widely used plant with both culinary and potential medicinal applications. As a staple ingredient in Kenyan cuisine, garlic adds flavour and enhances the taste of a diverse array of dishes, spanning from soups and stews to vegetable and meat-based meals [27]. Beyond its culinary role, garlic features prominently in traditional herbal remedies, where it is believed to offer potential antidiabetic and cardiovascular benefits [28]. In these remedies, some individuals either consume garlic cloves directly or incorporate it into herbal preparations. Furthermore, garlic is used to create garlic-infused oils or vinegars, which not only enhance culinary creations but are also consumed as health tonics. *Azadirachta indica* is employed for potential antidiabetic purposes through various methods in Kenya. Neem leaves are widely used in Kenyan traditional remedies and are either chewed or prepared as a tea or infusion, with neem leaf tea believed to possess antidiabetic properties and often consumed regularly [16, 27]. Neem extracts, encompassing neem leaf extracts and neem oil, are harnessed for their potential medicinal benefits and consumed in controlled amounts. Neem bark and twigs find application in some traditional practices, notably for dental hygiene, a significant consideration given the impact of diabetes on oral health. In Kenya, *Bidens pilosa*, is employed in various forms for potential antidiabetic purposes. Herbal infusions serve as the most common method of preparation which are commonly made by drying the leaves and steeping them in hot water to create an herbal tea, believed to offer potential antidiabetic benefits and consumed regularly [14, 29]. Most of the herbal preparations include the leaves, stems, or the entire plant often in the form of decoctions or tinctures, are consumed. Additionally, *Bidens pilosa* is incorporated into traditional Kenyan recipes and local dishes example Sukuma wiki, where it is cooked and forms part of the traditional diet. The comprehensive list also encompasses plant species like *Kigelia africana*, *Olea europaea* and *Prunus africana*, illustrating the varied plant-based approaches to DM treatment in Kenyan traditional medicine [14]. In Kenya, the traditional use of medicinal plants for managing DM is deeply ingrained in the country’s cultural heritage. The extensive variety of plant species and plant parts employed for DM treatment reflects the rich indigenous knowledge of the local communities. The use of decoction and infusion as primary preparation methods underlines the versatility and adaptability of traditional remedies to suit the unique characteristics of each plant species [30]. As modern medicine explores the potential benefits of these plants, their integration with scientific research offers a promising avenue for advancing DM treatment options, harnessing the power of nature to tackle a growing global health concern.

3.2.3 Plants utilized for managing *Diabetes mellitus* in Tanzania

Tanzania, like its East African counterparts, has a rich tradition of utilising medicinal plants for various health applications, including the management of DM. A selection of plant species has garnered significant attention and study in the realm of traditional medicine, with some of them being extensively researched. In this study 10 of these plants were mentioned notable among these are *Bersama abyssinica*, *Dioscorea praehensilis* Benth, *Hagenia abyssinica*, *Hypoxis obtusa*, and *Moringa oleifera* Table 2. In Tanzania, *Dioscorea praehensilis*, particularly its roots and tubers, is esteemed for its potential antidiabetic properties and is incorporated into Tanzanian culinary and traditional practices in various ways. The tubers of *Dioscorea praehensilis* are commonly cooked or boiled and integrated into Tanzanian meals, offering a delicious and nutritious addition while being believed to possess potential antidiabetic benefits [31]. Furthermore, herbal infusions or teas are crafted from tubers or other parts of the plant, esteemed for their perceived medicinal properties and their consumption for potential antidiabetic effects. Moreover, *Dioscorea praehensilis* finds its place in traditional Tanzanian recipes, where it becomes an integral ingredient in soups, stews, or side dishes, often harmoniously combined with other components to form a “Mboga na Mtori wa Boga” a local Tanzanian dish. These practices reflect local beliefs in the antidiabetic potential of *Dioscorea praehensilis* [6, 17]. In traditional Tanzanian antidiabetic management, *Moringa oleifera*, often referred to as the drumstick tree or horseradish tree, plays a significant role through various preparations and administration methods. Moringa leaf powder, derived from drying and finely grinding the leaves, is frequently used as a dietary supplement and is incorporated into a variety of dishes, such as soups, stews, and smoothies [32]. It is esteemed for its nutritional support and potential in regulating blood sugar levels. Herbal infusions made from dried Moringa leaves are another common practice, where steeping these leaves in hot water yields an herbal tea believed to possess antidiabetic properties. Additionally, Moringa oil, typically recognized for its skincare benefits, is occasionally utilized in culinary preparations or as part of the diet, contributing to overall health. Moringa seeds are consumed directly or included in recipes, believed to offer potential health advantages, including their role in diabetes management [33]. Similarly, in Tanzanian traditional medicine, various parts of *Bersama abyssinica*, including the bark and leaves, have been utilized for their potential antidiabetic properties [34]. Preparations are done by making herbal infusions or teas this is achieved through drying the bark and steeping it in hot water, resulting in an herbal tea believed to possess antidiabetic benefits and consumed regularly. Additionally, the leaves of the tree are prepared by decoctions or tinctures and consumed in controlled amounts in management of DM [17, 32]. Moreover, *Bersama abyssinica* may be integrated into various recipes and preparations, often combined with other locally available herbs and plants, as part of traditional practices aimed at managing DM. These plants, among others, have been explored for their potential anti-diabetic properties. In recent years, there has been a growing interest in the scientific validation of the antidiabetic properties of these traditional remedies. A study conducted by Zekeya et al. [34] provided confirmation of the antidiabetic properties of *Bersama abyssinica*. This research adds a layer of credibility to the traditional knowledge held by Tanzanian communities. It underscores the potential of traditional herbs to contribute to the management of diabetes and highlights the importance of integrating traditional practices with modern scientific research. Decoction and infusion have established themselves as the most commonly employed methods among Tanzanian communities.

3.2.4 Plants utilized for managing *Diabetes mellitus* in DRC

The Democratic Republic of the Congo (DRC) is home to a diverse array of medicinal plants with potential antidiabetic properties. In this study 38 of these plants were mentioned, these plants, including *Allium cepa* L. (Onion), *Azanza garckeana*, *Bidens pilosa* L., *Brassica juncea* (L) and *Cassia occidentalis* L. (Table 2), represent a rich pharmacopoeia deeply rooted in the traditional healing practices of the region [2, 10]. Alongside these, species like *Bersama abyssinica* (Meliaceae), *Ficus exasperata* Vahl, and *Vernonia amygdalina* [34–36] have been explored for their antidiabetic potential. While the study by Zekeya et al. [34] supports the antidiabetic properties of *Bersama abyssinica*, further scientific research is needed to fully comprehend the efficacy and safety of these plants in diabetes management. The preparation of remedies commonly involves traditional methods such as decoction and infusion, which play a vital role in extracting bioactive compounds from plant parts, making these plants valuable assets in the fight against diabetes in DRC. For example, in DRC, traditional practices involving *Allium cepa* L. as a potential antidiabetic remedy take various forms. Raw onion consumption is a common method, with raw onions frequently featured in salads and various dishes, as it is believed to contribute to the regulation of blood sugar levels [13]. Additionally, onion tea, created by steeping slices or small pieces of onion in hot water, is a popular choice. This aromatic infusion is enjoyed as a beverage and is thought to harbour potential antidiabetic effects. Furthermore, herbal extracts are crafted from onions through the process of maceration

or crushing of fresh onion pieces, followed by soaking them in a solvent, usually water. These herbal extracts are administered in controlled amounts and are believed to harness antidiabetic properties, reflecting the rich tradition of using natural remedies like onions in the management of diabetes in the region [2]. Furthermore, in DRC, *Azanza garckeana*, known as the “African Ordeal Tree” or “Mbugu,” is traditionally administered in various ways to harness its potential antidiabetic benefits. One method involves the consumption of *Azanza garckeana* fruit, which is incorporated into dishes in raw form or as an ingredient. This practice is rooted in the belief in the fruit’s potential to aid in diabetes management [10]. Additionally, *Azanza garckeana* leaves and other plant parts are used to create herbal infusions and teas, achieved by drying the plant material and steeping it in hot water. The resulting tea is enjoyed as a beverage, with the hope of delivering antidiabetic effects. Herbal extracts from *Azanza garckeana* are also crafted by macerating or crushing plant material and soaking it in water, offering a controlled means of consumption and further reinforcing the plant’s reputation for its perceived antidiabetic properties [2].

Different plant parts were reported to be used in the preparation of herbal extract with leaf forming (50.7%) as the most commonly used part, followed by roots (9.15%) and stem bark (7.74%). The other plant parts used are fruits, whole plants, seeds, tubers, tubules, corm, aerial parts, bulbs and cloves. The decoction was the most desired conventional dosage form, based on the information that was provided. The basic method of preparing the dose was hot water maceration or decoction. For the duration of therapy, a quantity of medicine necessary for a daily dose is typically made each day. Other methods of preparation include eating the whole plant part, infusion, tea or tincture, grinding into powder form and poultice (Table 2). It’s interesting to note that plants used to treat traditional methods of managing DM have also been found to be effective in treating other health issues, including erectile dysfunction, allergies, yellow fever, worms, infertility, urinary tract infections, hypertension, stomach-aches, ulcers, malaria, blood purification, stroke, and eye problems [6, 15, 30]. There are several complications of DM that also include many of these illnesses.

3.3 Authentication

3.3.1 In vivo studies of medicinal plants

Of the 17 articles retrieved from data base 8 articles reported in vivo investigation using animal models. Analysis indicated high-fat diet and low-dose streptozotocin (STZ) was the most preferred substance for induction of DM in animals. Different routes of administration and doses were used. Other models used include Alloxan monohydrate, glucose-loaded, STZ-nicotinamide [37]. Investigations showed that the plant extract has distinct mechanisms of action for managing DM and reducing blood glucose levels. Some of these mechanisms include, but are not limited to: decreasing total cholesterol (TC), triglycerides (TG), low density lipoprotein cholesterol (LDL-c) and very-low density lipoprotein cholesterol (VLDL-c), stimulating glycogenesis in the liver and/or inhibition of glucagon secretion, promoting the regeneration of b-cells of the islets of Langerhans, ameliorating oxidative stress, and facilitating glucose-induced insulin release [9, 13, 38]. Furthermore, different extracts were used for the preparation of doses of which ethanolic extract was the most used, other extract used include ethyl acetate, methanolic extract, aqueous and crude extract. All the plants investigated had a glucose-lowering effect at different doses of extracts and fractions. The eight (8) plant species traditionally used for DM in Uganda, Kenya, Tanzania and DRC as per this study are; *Kigelia africana*, *Hagenia abyssinica* (Rosaceae), *Physalis peruviana*, *Chenopodium ambrosioides*, *Mangifera indica* L. *Lonchocarpus eriocalyx*, *Urtica massaica* Mildr. *Schkuhria pinnata*, *Launaea cornuta*, *Rotheca myricoides* (Hochst.), *Maerua decumbens* (Brongn.) [1, 38–40, 44, 52] which have been reported to have in vivo antidiabetic effect (Table 3). For instance, *Kigelia africana* fruit extract caused significant improvements in blood glucose levels, haematological parameters, and kidney and liver health, suggesting its potential protective effect against diabetes-related complications [1]. Similarly, *Hagenia abyssinica* leaf extract induced hypoglycaemic, antihyperglycemic, and anti-dyslipidaemic effects in Streptozotocin-Induced Diabetic mice, contributing to the lowering of blood glucose levels and improvement of dyslipidaemia [38]. Additionally, the leaf extract of *Physalis peruviana* L. effectively lowered blood glucose levels without causing toxicity in mice [39]. *Chenopodium ambrosioides*, on the other hand, exhibited a significant hypoglycaemic effect in mice [40]. *Lonchocarpus eriocalyx* extracts displayed significant anti-inflammatory, antinociceptive, and antioxidant effects without acute oral toxicity, highlighting their potential as safe and effective natural alternatives for treating inflammatory and oxidative stress-related diseases [41]. The ethyl acetate extract of *Launaea cornuta* showed hypoglycaemic efficacy in diabetic mice, while the aqueous extract had adverse effects on body weight and haematological parameters, indicating the potential of the ethyl acetate extract as a safe and effective option for managing diabetes [42]. Freeze-dried extracts of *Rotheca myricoides* exhibited hypoglycaemic, hypolipidemic, and hypoinsulinemic effects in a rat model of type 2 diabetes, suggesting the potential as a natural treatment for diabetes and

Table 3 Phytotherapeutic potentials of plants commonly utilized in East Africa for managing diabetes in vivo

Scientific name	Model /Sample size	Mechanism of action	Extract/Fraction	Reference
<i>Kigelia africana</i>	Alloxan (186.9 mg/kg) i.p: Male Swissalbino mice n = 5	Inhibition of intestinal absorption of glucose, Facilitation of glucose-induced insulin release, Enhancement of peripheral glucose uptake, Promotion of the regeneration of b-cell of islets of Langerhans and amelioration of oxidative stress	Aqueous and ethyl acetate leaves extract; doses 1.25, 2.5, 5, and 7 mg/kg (i.p/p.o) and insulin 1 IU/kg i.p or glibenclamide 3 mg/kg p.o once	[58, 72]
<i>Hagenia abyssinica</i> (Rosaceae)	STZ (50 mg/kg, i.p) Male Swiss albino mice n = 6	stimulating insulin release from pancreatic β -cells inhibiting glucose absorption in the gut stimulating glycogenesis in the liver and/or increasing glucose utilization inhibition of glucagon secretion decrease TC, TG, LDL, and VLDL	Crude extract, aqueous, ethyl acetate and chloroform leaves extract; doses 100, 200 and 400 mg/kg (p.o) glibenclamide 5 mg/kg p.o once	[38]
<i>Physalis peruviana</i>	glucose-loaded i.p n = 5 Wistar rats	stimulation of the residual pancreatic, increased peripheral utilization of glucose, converted glucose to glycogen, and promoted glycogen storage in the liver and skeletal muscles	Aqueous and methanolic leaves extract; doses 100, 200 and 400 mg/kg (o.p) glibenclamide 5 mg/kg p.o	[48]
<i>Chenopodium ambrosioides</i>	glucose-loaded n = 5 i.p Wistar rats	stimulation of the residual pancreatic, increased peripheral utilization of glucose, converted glucose to glycogen, and promoted glycogen storage in the liver and skeletal muscles	Aqueous and methanolic leaves extract; doses 100, 200 and 400 mg/kg (o.p) glibenclamide 5 mg/kg p.o	[29]
<i>Mangifera indica</i> L	high-fat and high-fructose diet Wistar rats	Reduce TG	Aqueous and ethanolic shoot extract; dose 100 g/kg o.p	[29]
<i>Lonchocarpus eriocalyx</i>	high-fat and high-fructose diet Wistar rats	Reduce TG	Aqueous and Ethanolic bark extract; dose 100 g/kg o.p	[29]
<i>Urtica massaica Mildr</i>	high-fat and high-fructose diet Wistar rats	Reduce TG	Aqueous and Ethanolic extract leaf & stalk; dose 100 g/kg o.p	[29]
<i>Schkuhria pinnata</i>	high-fat and high-fructose diet Wistar rats	Reduce TG	Aqueous and ethanolic whole plant extract; dose 100 g/kg o.p	[29]
<i>Launaea cornuta</i>	high-fat and high-fructose diet Wistar rats	Reduce TG	Aqueous and Ethanolic whole plant extract; dose 100 g/kg o.p	[29]
<i>Rothea myricoides</i> (Hochst.)	High fat- high fructose diet and STZ (30 mg/kg) i.p	enhanced glucose uptake by adipose tissue upregulation of GLUT-4 transporters expression inhibition of hepatic glucose production and increased insulin secretion	freeze- dried extracts 50 mg/kg RME 100 mg/kg RME Pioglitazone 20 mg/kg o.p	[73]
<i>Maerua decumbens</i> (Brongn.)	STZ = 50 mg	stimulating insulin release from pancreatic β -cells	Methanolic root extract; 100 mg/kg and 400 mg/kg	[73]

STZ Streptozotocin, TG Triglycerides, TC total cholesterol, LDL low-density lipoprotein, VLDL very low-density lipoprotein, i.p intraperitoneal, o.p oral administration

Table 4 Some GC–MS Compounds from Selected Plants with antidiabetic Potentials

S/No	Plants	Phytochemicals (GC–MS)	References
1	<i>Kigelia africana</i>	Heptadecane-2,6,10,15-tetramethyl- Decane-2,4,6-trimethyl- Benzene-1,2,3,5-tetramethyl- Oxalic acid-4-chlorophenyl nonyl ester Decane-2,3,5,8-tetramethyl- 1-Iodo-2-methylundecane Heptane-2,4-dimethyl- Naphthalene-2-methyl- Tetradecane Phenol-2,4-bis(1,1-dimethylethyl)- Benzene propanoic acid-3,5-bis(1,1-dimethylethyl)- 4-hydroxymethylester 1-Hentetracontanol	[1]
2	<i>Physalis peruviana</i>	- (E)-2-Decenal - (Z)-8-Methyl-9-tetradecenoic acid - 1-Hexadecyn-3-ol, 3,7,11,15-tetramethyl- - 2-Hexadecanol - 2-Undecanone, 6,10-dimethyl- - Dihydroactinidiolide - Phytol - Tetradecanoic acid, 5,9,13-trimethyl-, methyl ester	[39]
3	<i>Mangifera indica</i>	Fatty acids and ester -Hexadecanoic acid, methyl ester -Dibutyl phthalate -Di-2-ethylhexyl phthalate (DEHP) -N-2,5 dimethoxy-phenyl, Fumaric acid heptyl ester Alkaloids 1-(4-Methyl-6-methoxy-2-quinoyl)- 3,3'-dimethyl-(4,5-bipyrazol)-5-ol N-(2,7-Dipropoxy-fluoren-9-ylidene)- N-(4-nitro-phenyl)-hydrazine 5,6-Dihydro-2-(p-nitrobenzylidene-amino ,4H-benzo(3,4)cyclohepta(2,1)thiazole Propanedinitrile,2-4-[bis-4-methylphenyl]amino] phenyl, methylene	[79]
4	<i>Dysphania ambrosioides</i> L	-phytol -4, 8, 12,16-tetramethyl-heptadecan-4-olide -phytol, acetate	[80]

the ability to modulate peroxisome proliferator-activated gamma receptor and reduce hepatic triglycerides [43]. *Maerua decumbens* methanolic root extract demonstrated antidiabetic activity without signs of toxicity, including decreased fasting blood glucose levels, reduced liver malondialdehyde levels, and cytoprotective effects on the liver and pancreas in diabetic rats [9]. The assessment of *Mangifera indica* leaves extract, both alone and in combination with gliclazide, in diabetic rats showed significant reductions in fasting blood glucose levels [44]. The collective findings of these studies highlight the promising effects of various plant extracts on different aspects of diabetes, including blood glucose levels and associated complications.

3.3.2 Phytochemicals identified

A number of phytochemicals were identified to be present in all the plants reported to possess antidiabetic activities. The most commonly reported phytochemicals from this review include; tannins, flavonoids, saponin glycosides, phenolic acids, alkaloids, anthraquinones, alkaloids sterols triterpenoids and glycoalkaloids (Table 2). Fagbohon et al. [1] reported some phytochemicals (Table 4) from the n-hexane fruit extract of *K. africana* to possess antidiabetic potentials, they identified phytochemicals were docked against AMP-activated protein kinase (AMPK) and mitochondrial glycerophosphate dehydrogenase (mGPDH) with metformin a reference standard. Benzene-1,2,3,5-tetramethyl- was reported to have a higher binding affinity of – 6.4 kcal/mol and can activate mitochondrial glycerophosphate dehydrogenase better than

metformin with binding affinity of -6.3 kcal/mol. Several studies have shown that certain phytochemicals can help in the management of diabetes by improving insulin sensitivity, reducing inflammation, and lowering blood glucose levels [3, 45–48]. For example, flavonoids, such as quercetin and kaempferol, have been shown to improve insulin sensitivity and reduce inflammation, which can help in the management of diabetes [49]. Other phytochemicals, such as resveratrol and curcumin, have been shown to improve glucose metabolism and reduce blood glucose levels [50]. GC–MS analysis of some selected plants reveal some compounds having antidiabetic potentials (Table 4).

3.3.3 In vitro studies

Several studies conducted on extracts derived from *Kigelia africana*, *Hagenia abyssinica*, *Physalis peruviana*, *Chenopodium ambrosioides*, *Mangifera indica* L., *Lonchocarpus eriocalyx*, *Urtica massaica* Mildr., *Schkuhria pinnata*, *Launaea cornuta*, *Rothea myricoides* (Hochst.), and *Maerua decumbens* (Brongn.) have provided further evidence supporting their efficacy in managing diabetes [38, 39, 51]. For instance, Fagbohun et al., [1] identified new compounds in fruit extracts of *Kigelia africana* and found that the hexane and ethyl acetate fractions showed the highest antioxidant activities. The hexane fraction also exhibited the lowest IC_{50} value against α -amylase. The methanol extract and its fractions of *Chenopodium ambrosioides* showed moderate inhibitory activity on α -glucosidase, an enzyme involved in carbohydrate digestion [52, 53]. *Mangifera Indica* leaf (MIL) extract demonstrated an inhibitory effect on alpha-amylase activity, reducing it by 51.4% at a concentration of 200 μ g/mL. This suggests the extract can potentially slow down the breakdown of complex carbohydrates by inhibiting amylase, leading to a slower release of glucose [54]. The antioxidant activity of the aqueous root extract of *Launaea cornuta* using the ferric-reducing antioxidant power (FRAP) and 2,2-diphenyl-2-picrylhydrazyl (DPPH) radical scavenging test methods demonstrated significant antioxidant effects, as evidenced by its ability to scavenge DPPH radicals and its FRAP activity [55]. This suggests that the extract has the potential to protect cells from oxidative damage caused by free radicals, which are known to contribute to various health conditions, including DM, inflammation and other chronic diseases. The findings of these studies suggest that the identified plant extracts possess various mechanisms of action that contribute to their antidiabetic properties. One such mechanism involves the inhibition of alpha-amylase and alpha-glucosidase enzymes. Alpha-amylase is an enzyme responsible for the breakdown of complex carbohydrates into simpler sugars, while alpha-glucosidase aids in the final digestion of carbohydrates by breaking down disaccharides into absorbable monosaccharides. Inhibiting the activity of these enzymes can help reduce the rate of carbohydrate breakdown and subsequent glucose absorption, leading to improved glycemic control [56]. Moreover, the investigated plant extracts have demonstrated the ability to stimulate insulin secretion. Insulin plays a crucial role in regulating blood glucose levels by facilitating the uptake of glucose into cells and promoting its storage as glycogen [40]. The stimulation of insulin secretion by these extracts suggests a potential therapeutic benefit in individuals with impaired insulin production or function.

Furthermore, the studies have revealed that the examined plant extracts exhibit the capacity to reduce blood glucose levels. Hyperglycaemia, or high blood glucose levels, is a hallmark characteristic of diabetes and is associated with various complications [57]. The ability of these extracts to lower blood glucose levels indicates their potential in managing this metabolic disorder. It is important to note that these in vitro studies provide valuable preliminary evidence of the antidiabetic effects of the identified plant extracts. However, further research is necessary to validate these findings and elucidate the underlying mechanisms in in vivo models and, eventually, human trials. The in vitro studies conducted on the extracts have demonstrated promising antidiabetic effects. The inhibition of alpha-amylase and alpha-glucosidase enzymes, stimulation of insulin secretion, and reduction of blood glucose levels suggest the potential of these plant extracts in managing diabetes. Further research is warranted to validate these findings, explore the underlying mechanisms, and identify the bioactive components responsible for these beneficial effects.

3.3.4 Toxicological studies

Toxicological studies on the listed plants have been limited, and most of the available studies have focused on acute toxicity in animal models. These studies have generally shown that these plants have low toxicity and are relatively safe when consumed in moderate doses. However, it is essential to note that these findings may not necessarily translate to human consumption and further toxicological studies, including chronic toxicity and genotoxicity, are needed.

For instance, in a study on *Kigelia africana*, the aqueous and methanol extracts were found to have no observable toxic effects in rats at doses of up to 5000 mg/kg [58]. Kasali et al. [39] investigated the acute and subchronic toxicities of *Kigelia africana* bark extract in rats. The study reported that the extract did not induce significant acute toxicity or adverse effects

in the treated animals. However, more comprehensive toxicological studies are necessary to evaluate its chronic toxicity and long-term effects. Similarly, a study on *Hagenia abyssinica* showed no significant acute toxicity in mice at doses up to 5000 mg/kg [38]. In another study on *Mangifera indica*, the ethanol extract was found to be safe in rats at doses of up to 2000 mg/kg [59]. Similarly, Kifle et al. [38] examined the acute and subchronic toxicities of *Hagenia abyssinica* leaf extracts in mice did not show toxicity at a dose of 2 g/kg in mice. Therefore, the LD₅₀ of the extract is greater than 2 g/kg. The findings revealed no signs of acute toxicity, but the subchronic toxicity study indicated mild haematological alterations in the treated animals. Regarding *Physalis peruviana*, Kasali et al., [39] conducted an acute oral toxicity study on the methanol extract of the plant's leaves with an LD₅₀ of 2000 mg/kg. The results suggested that the extract had a high safety margin, as no mortality or significant adverse effects were observed in the treated animals.

In contrast, some studies have reported potential toxicity concerns with some of these plants. For instance, a study on *Chenopodium ambrosioides* found that the essential oil from this plant had acute toxic effects on mice at doses higher than 2000 mg/kg [52]. Similarly, a study on *Lonchocarpus eriocalyx* found that the aqueous extract had toxic effects on rats at doses of 4000 mg/kg and above [41]. While some of the listed plants have shown low toxicity in animal studies, further toxicological studies are needed to determine their safety profile, particularly with long-term exposure and in human consumption.

4 Discussion

In the pursuit of alternative remedies for managing diabetes mellitus, traditional medicinal plants have exhibited promise. Our research findings unveil that local communities in Uganda, Kenya, DRC, and Tanzania employ a minimum of 140 different plant species to handle DM. While some of these species have undergone extensive investigation of their phytochemicals for DM management with encouraging results, other species necessitate additional scientific validation. This revelation may open avenues for discovering valuable drug lead compounds by concentrating research efforts on traditionally utilized plant species.

In vitro studies demonstrate that the investigated species exert their effects on multiple cellular and molecular targets in the liver, skeletal muscles, gastrointestinal tract, pancreas, and adipocytes. These plants inhibit enzymes such as α -amylase, α -glucosidase, sucrase, and maltase, regenerate pancreatic β -cells, and diminish fat accumulation in adipocytes by activating signalling pathways like PPAR- α and PPAR- δ [60]. Additional molecular actions involve inhibiting the nuclear inflammatory signalling pathway through the modulation of nuclear factor-erythroid 2-related factor Nrf2/NF κ B signalling and suppressing pro-inflammatory cytokines such as IL-1 α , IL-1 β , and tumour necrosis factor (TNF)- α [33, 61, 62].

In recent years, it has been acknowledged that the pathophysiology of DM involves multiple cellular and molecular abnormalities. Consequently, drugs with the potential to target multiple sites have become the focal point for effective DM management [46]. Nevertheless, while in vitro studies on plant preparations have reported dose ranges up to 1000 μ g/mL and much higher doses up to 1500 mg/kg, there is no standardized cut-off dose for either extract in either in vitro or in vivo studies [3, 47]. Recognizing that the tested dose should be sufficient to yield a meaningful pharmacological response and realistically convertible to a clinical dose, the large doses tested may pose challenges in translating them to human equivalent doses.

For the pharmacological assessment of herbal products, Heinrich et al. [63] proposed a plant extract dosage ranging from 100 to 200 mg/kg, significantly lower for its pure constituent. Despite the potential benefits of these traditional medicinal herbs, numerous methodological flaws have been identified in research analyses. Notably, certain studies documented considerable variation in effect size between standard medication and test substances. Methodological issues such as insufficient dosage optimization, improper preparation techniques, and inadequate ethnomedical data, including a lack of a comprehensive description of the identification process and voucher specimen, have been noted. Our study underscores the substantial potential of traditional medicinal herbs as complementary treatments for DM management. However, to sufficiently affirm the safety and efficacy of these plants, additional scientific evidence is imperative.

5 Conclusion

In conclusion, the traditional use of 140 plant species by local communities in Uganda, Kenya, DRC, and Tanzania for the management of DM is a valuable source of knowledge that deserves further exploration. While some of these plant species have been investigated scientifically, many have not, highlighting the need for additional research in this area.

Despite the lack of scientific evidence for some of these plants, toxicological studies have shown that many of them are safe for human consumption at both low and high doses. Therefore, it is essential to conduct more in vitro, in vivo, and phytochemical investigations to fully understand the therapeutic potential of these plant species for DM management. Such research could help identify novel and effective plant-derived therapies that could be incorporated into existing diabetes management strategies. Furthermore, engaging with local communities to better understand their traditional knowledge could help in the discovery of new plant species with promising anti-diabetic properties.

Overall, bridging the gap between traditional knowledge and modern scientific investigation is crucial to improving diabetes management in these regions and beyond. The potential of these plant species as a source of new anti-diabetic drugs cannot be overstated, and future research in this area should be a priority.

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Data availability The data that support the findings of this study are available from the corresponding author, RSD, upon reasonable request.

Declarations

Ethics approval and consent to participate Ethical approval is not required for the work.

Competing interest No conflict of interest from the authors.

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