

REVIEW ARTICLE

A Comprehensive Review of Traditional Antidiabetic Plants Used for Diabetes Management in South Africa

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Abstract: In the wake of a global resurgence in complementary and alternative medicine, South African flora stands out for its wealth of species long employed in traditional treatments for diabetes. This review evaluates scientific advances in the anti-diabetic potential of traditional medicinal plants harvested in South Africa. Four electronic databases (Scopus, PubMed, Web of Science and African Index Medicus) were exhaustively searched up to February 2025. A total of 74 medicinal species across 21 botanical families were identified for their antidiabetic potential, notably Moraceae (23.25%), Fabaceae (16.27%) and Asteraceae (6.97%). Leaves constituted the most frequently used plant material (51.21%), followed by bark (21.95%), and extractions predominantly employed acetone (43.58%) or water (28.20%). *In vitro* assays revealed substantial inhibition of key enzymes, including yeast α -glucosidase, α -amylase, pancreatic lipase, and glucose 6-phosphatase. Meanwhile, *in vivo* studies ($n = 6$) demonstrated significant reductions in glycaemia, improvements in insulin sensitivity, attenuated protein glycation and mitigation of hepatic and renal histopathological damage. The principal mechanisms elucidated involve modulation of glucose intake, inulinomimetic enhancement, and protection and regeneration of pancreatic β cells. The most noteworthy species are *Aloe ferox*, *Artemisia afra*, *Cassia abbreviata*, *Croton gratissimus*, *Erythrina lysistemon*, *Ficus lutea*, *Garcinia livingstonei*, *Psidium x durbanensis*, *Sutherlandia frutescens* and *Terminalia sericea*.

Keywords: Diabetes Mellitus, Glycaemia, Antidiabetic Plants, Therapeutic Alternatives, South Africa

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Introduction

Type 2 Diabetes (T2D) is a chronic metabolic disease characterised by insulin resistance and fasting hyperglycaemia, leading to serious complications including cardiovascular disease, kidney damage, impaired vision, and erectile dysfunction [1, 2]. It represents a global health threat and is one of the main causes of morbidity, with almost 537 million people living with the disease worldwide, a number that is expected to rise to 783 million by 2045 [3]. This burden is particularly alarming in low- and middle-income regions, where healthcare systems often struggle to cope with the growing prevalence of non-

communicable diseases. In Africa, T2D is expanding rapidly, with a prevalence of 4.5% among adults. However, this low rate is not observed across all African countries, with as high as 11.3% (4.23 million people) of the adult population residing in some countries, such as South Africa, particularly affected [3]. This prevalence is rising quickly due to urbanisation, dietary changes and increasingly sedentary lifestyles, particularly in urban areas [4]. Consequently, the effective management of T2D has become an urgent public health priority across the continent. Current T2D management relies on lifestyle modifications and pharmacological interventions. Conventional antidiabetic agents such as metformin, sulphonylureas, SGLT2 inhibitors, and GLP-1 receptor agonists, effectively regulate blood glucose levels and reduce complication risks [5]. However, these therapies face limitations in resource-limited settings [6], including high costs and side effects that hinder treatment adherence. Consequently, many patients turn to medicinal plants, perceived as natural alternatives with fewer adverse effects. A combination of various factors such as socio-economic status, inequality of healthcare, cost of drugs, and insufficient nutritional education mitigate the challenges of managing T2D in many African countries [4]. Thus, optimal control of the disease remains a major challenge, particularly in rural areas and low-income communities, despite conventional treatments. Conventional anti-diabetic medications like metformin, sulphonylureas, SGLT2 inhibitors, and GLP-1 agonists are part of the traditional therapies for type 2 diabetes. These medications work to regulate blood sugar levels and avoid problems [5]. However, these drugs are not always accessible, particularly in rural areas of South Africa, due to their high cost. In addition, side can limit treatment adherence [7, 8]. These adverse effects fuel people's reluctance to comply with treatment, and thus, opting for medicinal plants which, according to their perception, are natural and have no side effects [9, 10].

Against this backdrop, medicinal plants have gained increasing attention for their role in the traditional management of diabetes. Numerous studies have reported that plant-based remedies can contribute meaningfully to glycaemic control [11]. Plants may be excellent blood sugar regulators due to their phytochemical composition, such as flavonoids, carotenoids, and glycosides [12]. These constituents are thought to mimic the action of insulin and, through their hepatoprotective function, promote the activation, protection, and regeneration of pancreatic β cells [13, 14]. Moreover, they stimulate insulin secretion and therefore glucose uptake into cells for energy production as well as reducing oxidative stress that destroys pancreatic β -cells [15, 16]. There is, however, a paucity of plants with anti-diabetic potential around the world, particularly in Africa.

Of particular interest is the South African flora, which includes a variety of plants commonly used in indigenous medicine to help manage or relieve diabetes. Some of these plants that have anti-diabetic effects act by lowering blood glucose, enhancing insulin sensitivity, protecting the liver, alleviating inflammation, and preventing the development of diabetic-associated complications. This review aims to evaluate scientific advances on the anti-diabetic potential of traditional medicinal plants harvested in South Africa and identify gaps that can guide future research in this area.

Materials and Methods

Literature Search

The literature search was conducted from 24 November 2024 to 6 February 2025. Web of Science, Scopus, Pubmed, and African Index Medicus literature databases were searched using the following keywords: 'medicinal plant' or "medicinal herb" or "plant extract" and "antidiabetic activity" or "antidiabetic effect" or "hypoglycaemic effect" or "antihyperglycaemic effect" or "antidiabetic potential" or "hypoglycaemic potential" or "antihyperglycaemic potential" and "type 2 diabetes" or "diabetes mellitus".

Eligible studies included *in vitro* and *in vivo* investigations focusing on medicinal plants harvested within South African territory and reporting antidiabetic activities directly related to glucose metabolism, such as effects on blood glucose levels, insulin secretion, insulin sensitivity, or glucose uptake.

Exclusion criteria comprised review articles and studies reporting only antioxidant properties without direct assessment of antidiabetic or glucose metabolism-related outcomes, since the main criterion is based on the measurable direct hypoglycaemic effect, such as reduction in blood glucose levels or improvement in insulin sensitivity.

Filters were applied to restrict the search results to studies conducted in South Africa and published in English or French, thereby ensuring geographic relevance and linguistic accessibility. The bibliographies of pertinent articles were reviewed to identify additional relevant studies, and alerts were configured in the databases to track newly published literature.

Results and Discussion

Selection of Studies

Our initial search yielded 1116 articles (Figure 1). The titles and abstracts of the remaining 885 papers were examined after 231 duplicate entries were eliminated, and as a result, 543 were disqualified. A more detailed full-text assessment of 342 articles resulted in the exclusion of 298 studies, either because the plants were sourced outside South Africa or because they focused exclusively on antioxidant activity. Ultimately, 44 full-text articles were evaluated for both their relevance and accessibility.

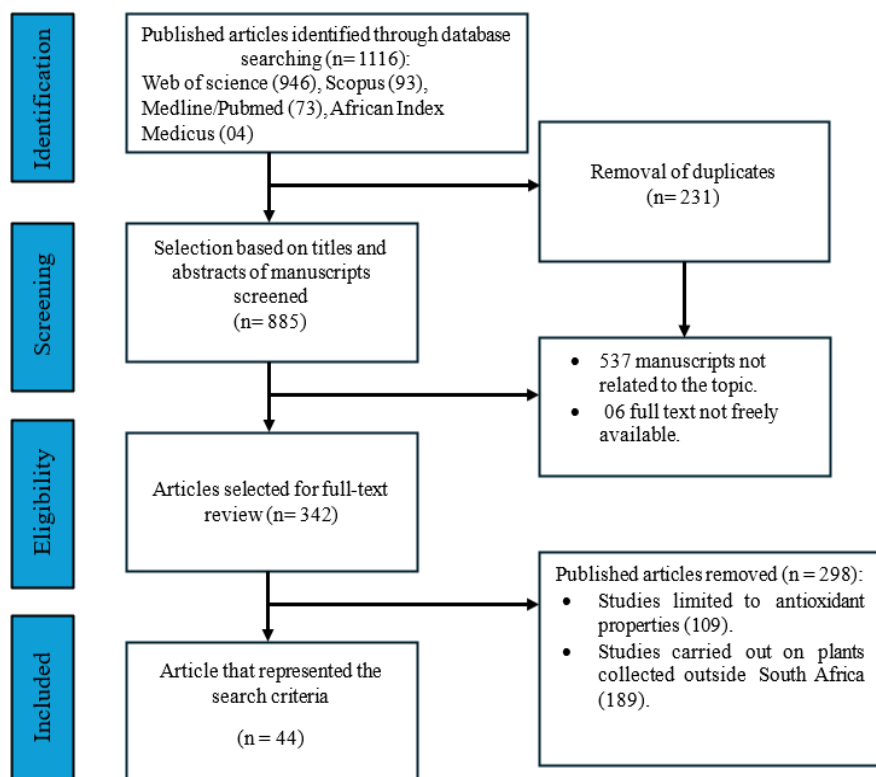


Fig. 1: Overview of the procedure used to select the articles included in this review

Taxonomic Distribution, Extraction Solvent, Plant Parts Used in Diabetes Management

Table 1 presents all the identified plants, along with their botanical families, local names, parts used, and routes of administration. Table 2 presents 74 medicinal plants from the South African pharmacopoeia that have been investigated for their antidiabetic properties. Among these, only 6 out of the 74 have been evaluated through *in vivo* studies. These medicinal plants belonged to 21 medicinal plant families, the most represented being Moraceae (23.25%), Fabaceae (16.27%) and Asteraceae (6.97%) (Figure 2). Figure 3 summarises the percentages of medicinal plant parts used in anti-diabetic studies. It shows that the parts of interest in anti-diabetic studies are leaves (51.21%) and bark (21.95%), with fewer than 10% of studies using the whole plant, stem bulb, root, aerial parts, and twigs. The plants were extracted using various solvents, in descending order of popularity among studies: acetone (43.58%), water (28.20%), ethanol (17.94%), methanol (7.69%), and ethyl acetate (2.56%) (Figure 4). Given the large number of identified plants, we focused on 10. Selection was based on anti-diabetic activities, specifically the inhibition of carbohydrate-digesting enzymes, enhancement of glucose uptake and utilisation, modulation of insulin secretion or sensitivity, and the mitigation of oxidative or glycation-related processes observed *in vitro* and within cellular or animal models. At least two of these reported activities had to be superior to or comparable with those of the reference drugs (acarbose or metformin). Furthermore, when toxicity data were available, the candidates had to show no evidence of major toxicity in the tested models. A photographic illustration of these plants is illustrated in Figure 5.

Table 1: Traditional Medicinal Plants of South Africa with Antidiabetic Uses

Scientific name	Family name	Local name	Part used	Route of administration	References
<i>Albica setosa</i> Jacq.	Hyacinthaceae	Ingwe beba	Corms	Oral	[17]
<i>Allium sativum</i> L. fam.	Alliaceae	Ikoronofile	Whole plant	Oral	[17]
<i>Aloe arborescens</i> Mill.	Asphodelaceae	Aloe, aalwyn	Leaves	Cutaneous and oral	[18]
<i>Aloe ferox</i>	Phyllanthaceae	Ikhalala-lasekoloni	Leaves	Oral	[19, 20]
<i>Aloe greatheadii</i> var. <i>davyana</i>	Asphodelaceae	Aloe	Roots	NS	[18]
<i>Anacampseros ustulata</i> E.Mey. ex Sond.	Portulacaceae	Igwele	Corms	Oral	[17]
<i>Arctopus echinatus</i> L.	Apiaceae	Platdoring	Roots	NS	[18]
<i>Aristea africana</i> (L.) Hoffmanns	Iridaceae	Sand moerbos	Leaves	NS	[18]
<i>Artemisia afra</i>	Asteraceae	Wilde als, Umhlonyane	Leaves	Oral	[21]
<i>Brachylaena discolor</i> DC.	Asteraceae	UmPhahla	Leaves	Oral	[22]
<i>Brachylaena elliptica</i> (Thunb.) DC.	Asteraceae	isiduti	Leaves	Oral	[23, 24]
<i>Brachylaena ilicifolia</i> (Lam.) E. Phillips & Schweick.	Asteraceae	Umgqeba	Leaves	Oral	[24]
<i>Bridelia micrantha</i> (Hochst.) Baill.	Phyllanthaceae	umhlalamakwaba	Stem bark	NS	[25]
<i>Bulbine abyssinica</i> A. Rich	Asphodelaceae	Uyakayakana	Whole plant	Oral	[17]
<i>Bulbine frutescens</i> L. (Willd.)	Xanthorrhoeaceae	Ibhucu	Roots	Oral	[26]
<i>Bulbine natalensis</i> Baker	Xanthorrhoeaceae	Ibhucu	Roots	Oral	[17]
<i>Bulbine latifolia</i> (L.f.) Spreng. var. <i>latifolia</i>	Asphodelaceae	Red carrot, rooiwortel	Roots	NS	[18]
<i>Cadaba aphylla</i> (Thunb.) Wild	Capparaceae	Swartstorm	Stem and leaves	Oral	[21]
<i>Cannabis sativa</i> L.	Cannabaceae	Umya	Whole plant	NS	[22]
<i>Carpobrotus edulis</i> (L.) N.E.Br.	Aizoaceae	Suurvyehotnotsveye	Leaves, sap and fruits	Oral	[21]
<i>Catharanthus roseus</i> (L.) G. Don.	Apocynaceae	Isisushlungu	Leaves	Oral	[26]
<i>Catha edulis</i> (Vahl) Forrsk. ex Endl.	Celastraceae	Iqgwaka	Leaves	Oral	[27]
<i>Chilianthus olearaceus</i> Burch.	Buddlejaceae	Umgeba	Leaves and twigs	Oral	[26]
<i>Chironia baccifera</i> L.	Gentianaceae	NS	Rhizomes	Oral	[28]
<i>Croton gratissimus</i> var. <i>gratissimus</i>	Euphorbiaceae	Ihubeshane-elikhulu or Rekstokbos Bitterbos	Leaves	Oral	[29-31]
<i>Chrysocoma ciliata</i> L.	Asteraceae	Bitterbos	Leaves and roots	Oral	[21]
<i>Cissampelos capensis</i>	Menispermaceae	Dawidjiewortel, Umayisake	Rhizomes, roots, stem, leaves	Oral	[17, 28, 32]
<i>Convolvulus capensis</i> Burm. f.	Convolvulaceae	Bitterpatat	Bulb	Oral	[21]
<i>Conyza scabrida</i> DC.	Asteraceae	Isavu	Leaves	Oral	[17]
<i>Crassula muscosa</i> L.	Crassulaceae	Akkedisbos	Leaves, stems, roots and flowers	Oral	[21]
<i>Dianthus thunbergia</i> Hooper	Caryophyllaceae	Ungcana	Roots	Oral	[17]
<i>Dicrothamnus rhinocerotis</i> (L.f.) Koek.	Asteraceae	Ranosterbos	Leaves and stem	Oral	[21]
<i>Erythrina lysistemon</i> Hutch. abates	Fabaceae	Coral tree	Bark	Oral	[33]
<i>Euclea natalensis</i> A.DC.	Ebenaceae	Umkhasa	Roots	Oral	[34]
<i>Euclea undulata</i> Thunb.	Ebenaceae	Umgwali	Roots, bark	Oral	[35]
<i>Euryops abrotanifolius</i> (L.) DC.	Asteraceae	Harpuisbos	Stem and leaves	NS	[18]

<i>Gnidia deserticola</i> Gilg	Thymelaeaceae	Koorsbos	Leaves, stems and roots	Oral	[21]
<i>Helichrysum gymnocomum</i>	Asteraceae	Impepho	Leaves	Oral	[17]
<i>Helichrysum nudifolium</i> (L.) Less.	Asteraceae	Ichocholo	Leaves and roots	Oral	[26]
<i>Helichrysum odoratissimum</i> L.	Asteraceae	Imphepho	Whole plant	Oral	[26]
<i>Heliichrysum petiolare</i> Hilliard & B.L.	Asteraceae	Imphepho	Whole plant	Oral	[26]
<i>Heteromorpha arborescens</i> (Spreng.) Cham.	Apiaceae	Umbangandlala	Leaves and roots	Oral	[26]
<i>Hoodia gordonii</i> (Masson) Sweet ex Decne	Apocynaceae	Bitterghaap	Inner stem	Oral	[21]
<i>Hypoxis argentea</i> Harv Ex Baker	Hypoxidaceae	Ixalanxa	Corms	Oral	[17]
<i>Hypoxis colchicifolia</i> Bak.	Hypoxidaceae	Inongwe	Corms	Oral	[26]
<i>Hypoxis hemerocallidea</i> Fisch. and C. A	Hypoxidaceae	Inongwe	Corms	Oral	[26]
<i>Kedrostis nana</i> (Lam.) Cogn. var. <i>nana</i>	Cucurbitaceae	Bitter patat	Tuber	NS	[18]
<i>Lauridia tetragonia</i> (L.f.) R.H. Archer	Celastraceae	Umdlavuzza	Bark	Oral	[17]
<i>Leonotis leonorus</i> (L.) R.Br.	Lamiaceae	Unfincafincane	Whole plant	Oral	[17]
<i>Lichtensteinia lacera</i> Cham. & Schtdl.	Apiaceae	Kaalmoes	Stem and leaves	Oral	[21]
<i>Mentha longifolia</i> (L.) L.	Lamiaceae	Ballerja	Stem and leaves	Oral	[21]
<i>Momordica balsamina</i>	Cucurbitaceae	Bitter melon	Leaves, fruits, stem and flowers	Oral	[24, 28, 36]
<i>Momordica foetida</i> Schumach.	Cucurbitaceae	NS	Whole plant	NS	[22]
<i>Ornithogalum longibracteatum</i> (Jacq)	Hyacinthaceae	Ingwe beba	Bulb	Oral	[22]
<i>Pelargonium antidysentericum</i> (Eckl. & Zeyh.) Kostel.	Geraniaceae	Rooistorm	Roots	Oral	[21]
<i>Pentanisia prunelloides</i> (Klotzsch ex. Eckl. & Zeyh.) Walp. Subsp.	Rubiaceae	Iscimamlilo	Roots	NS	[18]
<i>Prunelloides</i>					
<i>Ruta graveolens</i> L.	Rutaceae	Iyeza lomoya	Leaves	Oral	[37]
<i>Salvia africana-lutea</i> L.	Lamiaceae	Red sage	Leaves	NS	[18]
<i>Searsia burchellii</i> (Sond. Ex Engl.) Moffett.	Anacardiaceae	Taibos	Leaves, stem and roots	Oral	[21]
<i>Solanum aculeastrum</i> Dunal subsp. <i>Aculeastrum</i>	Solanaceae	Umthuma, Itunga	Roots	Oral	[17]
<i>Strychnos henningsii</i> Gilg	Loganiaceae	Umnonono	Bark	Oral	[17]
<i>Sutherlandia frutescens</i>	Fabaceae	Umnwele	Leaves and stems	Oral	[38]
<i>Tagetes minuta</i> L.	Asteraceae	Koebiebos	Leaves	Oral	[21]
<i>Tarchonanthus camphoratus</i> L.	Asteraceae	Umgqemba	Leaves	Oral	[17]
<i>Thesium lineatum</i> L.f.	Santalaceae	Black storm, sawrtstrom	Roots	NS	[18]
<i>Trichogyne repens</i> (L.) Anderb.	Asteraceae	Moerbos	Leaves	NS	[18]
<i>Tulbaghia alliacea</i> L.	Alliaceae	Umwelela	Roots	Oral	[39]
<i>Tulbaghia capensis</i> L.	Alliaceae	Wild garlic, wilde knoffel	Bulb	NS	[21]
<i>Tulbaghia violacea</i> Harv.	Alliaceae	Wilde knoffel, Utswelane	Leaves and roots	Cutaneous and oral	[21]
<i>Tylecodon paniculatus</i> (L.f.) Toelken	Crassulaceae	Bees se bal	Leaves and stem	Cutaneous and anal	[21]
<i>Vernonia amygdalina</i> DeL.	Asteraceae	Umhlunguhlungu	Leaves	Oral	[26]
<i>Vernonia oligocephala</i> Sch. Bip.	Asteraceae	Umhlunguhlungu	Leaves, roots or twigs	Oral	[26]

Vinca major L.	Apocynaceae	Iflawa	Leaves, roots, NS	[37]
Ziziphus mucronata Wild.	Rhamnaceae	wag-'n-bietjie tree	Leaves and stem bark	[24]

Table 2: Summary of anti-diabetic activities of South African medicinal plants

Species (Family)	Plant crude Extracts/ fractions used (part used)	Models used		Dose(s)/ Concentration(s)	Standard drug used	Phytochemical constituents	Effects	References
		<i>In vitro</i>	<i>In vivo</i>					
Aloe ferox (Asphodelaceae)	Aqueous and ethanolic extract (Leaves)	Chromogenic DNSA and α -Glucosidase, pancreatic lipase	/	15, 30, 60, 120, 240 μ g/mL	Acarbose	Aloin B, Chlorogenic acid, 5-Hydroxyaloin A, Aloeresin, Benzoic acid, 4-nitrophenyl ester, 4-isothiocyanato-2,4,5-Trifluoro-3-ethoxybenzoic acid, aloe emodin and coumarine	At 120 μ g/mL, glucose uptake in yeast cells was greater with the ethanolic extract than with the aqueous extract. Inhibition by aqueous extract of pancreatic α -amylase, α -glucosidase and lipase (IC_{50} of 96.24 $\pm$ 0.1, 663.2 $\pm$ 0.3 and 122.01 $\pm$ 5.9 μ g/mL respectively). Inhibition by ethanolic extract of α -amylase, α -glucosidase and pancreatic lipase (IC_{50} of 5.73 $\pm$ 2.5, 79.8 $\pm$ 2.9 and 65.89 $\pm$ 0.03 μ g/mL respectively).	[40]
Amaranthus cruentus L. (Amaranthaceae)	Methanolic extract (Leaves)	Chromogenic DNSA and α -Glucosidase	/	0.062, 0.125, 0.25, 0.5, 1 and 2 mg/mL	Acarbose	α -Spinasterol, Pheophorbide A-methyl ester and Palmitic acid	$\downarrow$ of α -amylase and α -glucosidase activity by 87.13 $\pm$ 0.18 and 39.63 $\pm$ 0.05 % respectively at 0.25 mg/mL	[41]
	Aqueous extract	/	Oral Glucose	50, 100, and	Glibenclamide (600	/	significant $\downarrow$ (p < 0.05) in	[42]

Artemisia afra Jacq. ex Willd. (Asteraceae)	(Leaves and stems)		Tolerance Test (OGTT), Fasting Blood Glucose (FBG), STZ- induced diabetic rats	200 mg/kg of BW	$\mu\text{g/kg}$ body weight/day)		blood glucose levels; diabetic rats had normal blood glucose levels after 15 days. Restoration of glucose tolerance manifested by a $\downarrow$ of blood glucose ($p < 0.05$) at 60 and 90 min.	
	Acetone extract (Leaves)	Chromog enic DNSA and α - Glucosid ase	/	0.2 mg/mL	Acarbose		$\downarrow$ of α - amylase and α - glucosidase activity of 90.1 $\pm$ 0.01 and 62.7 $\pm$ 0.19% respectively	[43]
Brachylaena elliptica (Asteraceae)							$\uparrow$ significant ($p < 0.05$) glucose uptake by HepG2 cells compared to control and promotes optimal glucose utilisation ($\geq 100\%$). Does not stimulate glucose metabolism. At 25 $\mu\text{g/ml}$ the extract induces $\uparrow$ significant ($p < 0.05$) in INS-1 cells.	
	Aqueous extract (Leaves)	Chromog enic DNSA and α - Glucosid ase MTT assay	/	12.5, 25, 50 and 100 $\mu\text{g/ml}$	Metformin, insulin and Acarbose	/	$\downarrow$ of α - glucosidase activity from 32.6% to 200 $\mu\text{g/ml}$ extract, weak inhibition of lipase (5.9%) and but significant inhibition of α -amylase dipeptidyl peptidase IV.	[44]

							Low antiglycation activity (8.2%). Low toxicity, 5% HepG2 cell death at 100 µg/ml and no toxicity on myoblast L6 cells.	
Bulbine frutescens Whole (Asphodelaceae)	Aqueous and ethanolic extract (Whole plant)	glucose uptake et MTT assay	/	0.5 and 50 µg/ml	Insulin	/	Both extracts induce a ↑ of glucose uptake with both extracts. ↓ in the viability of C2C12 muscle cells and Chang's liver cells.	[38]
Carica papaya (Caricaceae)	Aqueous extract (Leaves and roots)	Chromogenic DNSA, MTT assay	/	500 and 1000 µg/mL	Metformin	/	Stimulates ↑ glucose uptake. At 500 µg/mL in HepG2 cells with root extract at 500 µg/mL. Very low cytotoxicity of root extract (≥ 97% of HepG2 cells and ≈ 100% of Hek293 cells).	[45]
Cassia Abbreviate (Fabaceae)	Acetone extract (Stem bark)	Mammalian α-glucosidase, Yeast α-glucosidase	/	0.04, 0.08, 0.16, 0.3156, 0.625, 1.25, 2.5 mg/mL	Acarbose	/	Inhibition (p < 0.05) of yeast α-glucosidase (IC ₅₀ = 10 µg/ml) clearly superior to that of rat intestinal α-glucosidase (> 2500 µg/ml).	[46]
	Acetone extract	Chromogenic DNSA and α-Glucosidase	/	34 to 88 mg/mL	Acarbose	/	↓ amylase activity of ≈ 27.14% and α-glucosidase (IC ₅₀ = 600 µg/ml).	[47]
Cissampelos capensis L.f (Menispermaceae)	Methanolic extract, (Leaf, stem, rhizome)	Chromogenic DNSA and α-Glucosidase	/	31.25, 62.5, 125, 250 and 500 µg/mL	Acarbose	lauroschoitzine, pronuciferine, Glaziovine, salutaridine, cycleanine, insularine, 8,14-	Approximately 49.73 and 83.64±0.90 % of α-amylase, α-glucosidase	[48]

						dihydromorphinan dienone, cissamaline, 12- O-methylcurine, reticuline, insulanoline, cissamanine and issamidine	inhibition, respectively with the methanolic extract of rhizomes; The methanolic extract of leaves has the highest viability ↑ (≈ 93.58 of Caco-2 cells).	
Croton gratissimus Burch. (Euphorbiac eae)	Aqueous extract	Chromog enic DNSA, α- Glucosid ase, lipase, MTT assay	/	15, 30, 60, 120 and 240 µg/mL	Metformin, Aminoguan idine, Acarbose, orlistat	Gallic acid, quercetin, caffeic acid and catechin	At all concentratio ns, the aqueous extract exhibited glucose uptake > than metfomin Inhibition of α-amylase, α- glucosidase and pancreatic lipase with respected IC ₅₀ of 35.67±0.07, 60.56±2.78 and 50.27±1.51 µg/mL. Inhibition (p ≥ 0.05) of glycation at 120 µg/mL extract and aminoguanid ine. No toxicity (≈ 100% of 3T3 -fibroblast cell).	[37]
Dianthus asuticus (Caryophylla ceae)	Aqueous, ethanolic and hydro- ethanolic (50:50) extract (whole plant)	Chromog enic DNSA, α- Glucosid ase maltase and sucrase	/	3.13, 6.25, 12.5, 25, 50 and 100 mg/mL	Acarbose	/	↓ of α- amylase and α-glucoside, maltase and saccharolyti c activity respectively of IC ₅₀ 8.5×10 ⁴ ±2.43 , 1.29×10 ⁴ ±2.5 1, 4.6×10 ⁴ ±2.2 9 and 3.4×10 ⁴ ±0.96 µg/mL.	[49]
<i>Erythrina lysistemon</i>	Ethyl acetate	/	Chromog enic	150 and 300 mg/kg	Metformin	Cedr-8-ene, β- Caryophyllene,	↑glucose tolerance.	[50]

Hutch. Abates (Fabaceae)	(bark)	DNSA, OGTT α -amylase, pancreatic lipase, STZ-induced diabetic rats, histopathology of the liver				Tetrahydroionol, α -Muurolene, β -Bisabolene, Caryophyllene oxide, Asarone, β -Sitosterol, Dihydrodiethylstilbestrol, Phytol acetate, Epiglobulol, Isoaromadendrene epoxide, 2',4'-Dihydroxychalcone and Aromadendrene oxide-(2) α -Bisabolol	Insulinemia and glycation of treated diabetic rats is similar to that of untreated normoglycemic rats. $\downarrow$ activity of pancreatic lipase and glucose-6-phosphatase (p < 0.05). Regeneration of β -cells.	
Euclea natalensis A.DC (Ebenaceae)	Acetone extract (Root bark)	Chromogenic DNSA, and α -Glucosidase	/	0.2 mg/mL	Acarbose	/	$\downarrow$ of α -glucosidase and α -amylase activity by 92.6 $\pm$ 0.04 and 74.5 $\pm$ 0.04% respectively.	[43]
Ficus capreifolia Delile (Moraceae)	Acetone extract (Leaves)	Chromogenic DNSA, and α -Glucosidase	/	1 mg/ml	Acarbose	Phenols	$\downarrow$ of α -glucosidase and α -amylase activity with IC ₅₀ of >1000 and >100 μ g/ml, respectively.	[51]
Ficus cordata Thunb. (Moraceae)	Acetone extract (Leaves)	Chromogenic DNSA, and α -Glucosidase	/	1 mg/ml	Acarbose	Phenols	$\downarrow$ of α -glucosidase and α -amylase activity with IC ₅₀ of >1000 and >100 μ g/ml, respectively.	[51]
Ficus raterostoma Mildbr. (Moraceae)	Acetone extract (Leaves)	Chromogenic DNSA, and α -Glucosidase	/	1 mg/ml	Acarbose	Phenols	$\downarrow$ of α -glucosidase and α -amylase activity with respective IC ₅₀ > 1000 and 11.41 $\pm$ 4.68 μ g/ml.	[51]
Ficus glumosa Delile (Moraceae)	Acetone extract (Leaves)	Chromogenic DNSA, and α -Glucosidase	/	1 mg/ml	Acarbose	Phenols	$\downarrow$ of α -glucosidase and α -amylase activity with IC ₅₀ of >1000 and >100 μ g/ml, respectively.	[51]
Ficus lutea Vahl. (Moraceae)	Acetone extract (Leaves)	Chromogenic DNSA, and α -	/	1 mg/ml	Acarbose	Phenols	$\downarrow$ of α -glucosidase and α -amylase	[51]

	Glucosidase					activity with IC_{50} of 290 ± 111 and 9.42 ± 2.01 $\mu\text{g/ml}$, respectively.	
				Acarbose, Insulin, Glibenclamide		Stimulate glucose uptake in H-4-II-E cells and C2C12 muscle cells > to insulin at 250 $\mu\text{g/ml}$. RIN-m5F pancreatic cells treated with the ethyl acetate fraction induced insulin secretion (10.88 ± 0.55 $\mu\text{g/L}$ at 250 $\mu\text{g/ml}$). This fraction inhibits α -amylase ($IC_{50} = 39.53 \pm 7.10$ $\mu\text{g/ml}$) and α -glucosidase ($IC_{50} = 126.78 \pm 30.62$ $\mu\text{g/ml}$) activity. Low toxicity to H-4-II-E liver cells ($LD_{50} = 562.9 \pm 4.9$ $\mu\text{g/ml}$).	
Ethyl acetate	Chromogenic DNSA, and α -Glucosidase, MTT assay	OGTT, fat diet induced obese rats	Dose: 1 mg/kg Concentrations: 500, 250, 125, 63, 31, 15 $\mu\text{g/ml}$		Polyphenols		[52]
Hexane (Leaves)	Chromogenic DNSA, and α -Glucosidase	/	500, 250, 125, 63, 31, 15 $\mu\text{g/ml}$	Acarbose, Insulin, Glibenclamide	Polyphenols	Very low α -glucosidase and α -amylase activity ($IC_{50} > 1000$). Low toxicity to C2C12 muscle cells ($LD_{50} > 1000$ $\mu\text{g/ml}$).	[52]
Chloroform (Leaves)	Chromogenic DNSA, and α -Glucosidase	/	500, 250, 125, 63, 31, 15 $\mu\text{g/ml}$	Acarbose, Insulin, Glibenclamide	Polyphenols	Very low α -glucosidase and α -amylase activity ($IC_{50} > 1000$)	[52]
Dichloromethane (Leaves)	Chromogenic DNSA, and α -	/	500, 250, 125, 63, 31, 15 $\mu\text{g/ml}$	Acarbose, Insulin, Glibenclamide	Polyphenols	Very low α -glucosidase and α -amylase activity (IC_{50}	[52]

		Glucosidase				= 854.51±56.92 and > 1000 µg/ml respectively)	
	n-Butanol (Leaves)	Chromogenic DNSA, and α-Glucosidase	/	500, 250, 125, 63, 31, 15 µg/ml	Acarbose, Insulin, Glibenclamide	Polyphenols	Glucose uptake > than insulin in C2C12 muscle cells and H-4-II-E cells at 500 µg/ml). Good α-amylase activity (IC ₅₀ > 26.50±1.22 µg/ml) and low α-glucosidase activity (IC ₅₀ = 195.17±63.60 µg/ml). High toxicity for C2C12 muscle (LD ₅₀ = 53.3±6.2 µg/ml) and H-4-II-E liver (LD ₅₀ = 148.9±2.5 µg/ml) cells. [52]
	Water (Leaves)	Chromogenic DNSA, and α-Glucosidase	/	500, 250, 125, 63, 31, 15 µg/ml	Acarbose, Insulin, Glibenclamide	Polyphenols	Very low α-amylase activity ((IC ₅₀ > 1000 µg/ml) and α-glucosidic IC ₅₀ = 558.40±51.67 µg/ml). [52]
Ficus natalensis Hochst. (Moraceae)	Acetone extract (Leaves)	Chromogenic DNSA, and α-Glucosidase	/	1 mg/ml	Acarbose	Phenols	↓ of α-glucosidase and α-amylase activity with respective IC ₅₀ > 1000 of and 17.85±4.42 µg/ml. [51]
Ficus polita Vahl. (Moraceae)	Acetone extract (Leaves)	Chromogenic DNSA, and α-Glucosidase	/	1 mg/ml	Acarbose	Phenols	↓ of α-glucosidase and α-amylase activity with IC ₅₀ > 1000 of and >100 µg/ml respectively. [51]
Ficus religiosa L. (Moraceae)	Acetone extract (Leaves)	Chromogenic DNSA, and α-	/	1 mg/ml	Acarbose	Phenols	↓ of α-glucosidase and α-amylase [51]

		Glucosidase					activity with IC ₅₀ of >1000 and 100µg/ml, respectively.	
Ficus sycomorus L. (Moraceae)	Acetone extract (Leaves)	Chromogenic DNSA, and α-Glucosidase	/	1 mg/ml	Acarbose	Phenols	↓ of α-glucosidase and α-amylase activity with IC ₅₀ > 217±69 of and >100 µg/ml respectively.	[51]
Ficus thonningii Blume (Moraceae)	Acetone extract (Leaves)	Chromogenic DNSA, and α-Glucosidase	/	1 mg/ml	Acarbose	Phenols	↓ of α-glucosidase and α-amylase activity with IC ₅₀ of > 1000 and >100 µg/ml respectively	[51]
<i>Garcinia livingstonei</i> (Clusiaceae)	Aqueous extract (Leaves)	Chromogenic DNSA and α-Glucosidase, lipase pancréatique	/	15.625, 31.25, 62.5, 125, 250 and 500 µg/mL	Acarbose	Hydroxycinnamic Acids, Benzophenones, Flavan-3-Ols, Flavonols, Flavone	Glucose uptake by hepatic C3A control cells was statistically identical (p ≥ 0.05) to that of cells treated with 125 µg/mL. At this concentration, glucose utilisation was >60%. At all concentrations pancreatic lipase inhibition is < 5% and α-glucosidase inhibition ≈96.47% at 0.3 mg/mL. No cytotoxicity observed.	[53]
Gymnosporia buxifolia (Celastraceae)	Acetone extract	Chromogenic DNSA and α-Glucosidase	/	0.2 mg/mL	Acarbose	/	↓ amylase activity of ≈ 26.62% and α-glucosidase (IC ₅₀ = 2400 µg/ml).	[47]
Leonotis leonurus L. (Lamiaceae)	Aqueous extract (Leaves)	/	FBG, STZ-induced diabetic rats	125, 250 and 500 mg/kg	Glibenclamide	Phenols, flavonoids and proanthocyanidins	Induced ↓ in blood glucose by 18 units after 15 days, i.e. from	[17]

							33.30±0.16 to 15.23±0.00 mmol/L respectively in the diabetic control group and the diabetic group treated with 250 mg/kg.	
<i>Manilkara mochisia</i> (Sapotaceae)	Acetone extract (Stem bark)	Mammalian α -glucosidase, Yeast α -glucosidase	/	0.04, 0.08, 0.16, 0.3156, 0.625, 1.25, 2.5 mg/ml	Acarbose	/	Inhibition de l' α -glucosidase de levure et de l' α -glucosidase de mammifère IC ₅₀ 50 et 40 µg/ml respectivement.	[46]
<i>Mormodica balsamina</i> (Cucurbitaceae)	Acetone extract	Chromogenic DNSA and α -Glucosidase	/	34 to 88 mg/mL	Acarbose	/	↓ amylase activity of ≈ 28.82% and α -glucosidase (IC ₅₀ = 2100 µg/ml).	[47]
<i>Ornithogalum Longibracteatum</i> (Hyacinthaceae)	Aqueous and ethanolic extract (Bulb)	Absorption du glucose et MTT assay	/	0.5 and 50 µg/ml	Insulin	/	↑ of glucose uptake in muscle C2C12 and liver Chang cells 0.5 µg/mL	[39]
<i>Ozoroa cf. albicans</i> (Anacardiaceae)	Acetone extract (Stem bark)	Mammalian α -glucosidase, Yeast α -glucosidase	/	0.04, 0.08, 0.16, 0.3156, 0.625, 1.25, 2.5 mg/ml	Acarbose	/	Inhibition of Yeast α -glucosidase and Mammalian α -glucosidase IC ₅₀ 50 and 40 µg/ml respectively	[46]
<i>Peltophorum africanum</i> (Fabaceae)	Acetone extract (Leaves)	Mammalian α -glucosidase, Yeast α -glucosidase	/	0.04, 0.08, 0.16, 0.3156, 0.625, 1.25, 2.5 mg/ml	Acarbose	/	Inhibition of α -glucosidase (IC ₅₀ = 40 µg/ml)	[46]
<i>Psidium x durbanensis</i> Baijnath & Ramcharun ined. (Myrtaceae)	Hydro-methanolic extracts (Leaves)	/	FBG, fasting plasma insulin (FPI), Acute, Histological analysis, toxicity, STZ-induced	400 mg/kg of BW	Insulin	1-(4-Methylphenyl)-2-(pyrrolidin-2-one-1-yl)-1, 2,3-dihydro-3,5-dihydroxy-6-4H-Pyran-4-one, 1,2,3-Benzenetriol, 4-Methyl-dodecane, 2,3-Dimethyldodecan	↑ of glucose tolerance, insulin secretion, GLUT4 and IRS-1 gene expression. ↓ hepatic histomorphological damage and islet cell	[13]

			diabetic rats			e, Caryophyllene oxide, 2,3,4,4a,5,6,7,8-Octahydro-2-naphthalenemethanol, Cubenol, Quinic acid, α - Cadinol, 3-ethyl-3-hydroxy-, (5. α)-androstan-17-one, Octatriacontyl pentafluoropropionate, Epiglobulol, n-Tetradecyl ester heptafluorobutyric acid, 4,4,8-Trimethyltricyclo [6.3.1.0(1,5)] dodecane-2,9-diol, 2,6-Dihexadecanoate L-(+)-ascorbic acid, (Z)-9-Octadecen-1-ol, n-Nonadecanol-1-Phytol, (Z)-9-Octadecenamide	regeneration .	
<i>Psidium guajava</i> L. (Myrtaceae)	Acetone extract (Leaves)	Chromogenic DNSA and α -Glucosidase	/	0.2 mg/mL	Acarbose	/	$\downarrow$ of α -glucosidase and α -amylase activity of 62.7 $\pm$ 0.19 and 90.1 $\pm$ 0.01 % respectively.	[43]
<i>Ruta graveolens</i> (Rutaceae)	Aqueous and ethanolic extract (Aerial parts)	Absorption du glucose, MTT assay	/	0.5 and 50 μ g/ml	Insulin	/	$\uparrow$ of glucose uptake in C2C12 muscle and liver Chang cells 0.5 μ g/mL. Aqueous extracts stimulated the growth of liver Chang cells at 62.5 μ g/mL.	[39]
<i>Senna italica</i> (Fabaceae)	Acetone extract	Chromogenic DNSA and α -Glucosidase	/	34 to 88 mg/ml	Acarbose	/	$\downarrow$ amylase activity of $\approx$ 29.59% and α -glucosidase (IC ₅₀ = 1800 μ g/ml).	[47]
<i>Sclerocarya birrea</i> (A.Richi.) Hochst. subsp. Caffra (Anacardiaceae)	Acetone extract (Stem bark)	Chromogenic DNSA and α -Glucosidase	/	0.2 mg/mL	Acarbose	/	$\downarrow$ of α -glucosidase and α -amylase activity of 94.9 $\pm$ 0.01 and 97.4 $\pm$ 0.04% respectively.	[43]

<i>Sutherlandia frutescens</i> (Fabaceae)	Aqueous extract (Leaves)	/	Chromogenic DNSA, OGTT, FPI, FBG, STZ-induced diabetic rats	0.01 ml/g	Metformin	/	Blood glucose levels in untreated rats returned to normal. ↓ intestinal glucose absorption after 30 min ($p < 0.01$), 50 min ($p < 0.001$). ↓ ($p < 0.001$) insulin levels. Causes ↓ ($p < 0.001$) of hepatic glycogen.	[52]
<i>Tarchonanthus Camphoratus</i> (Asteraceae)	Aqueous and ethanolic extract (Leaves / soft twigs)	Absorption du glucose, MTT assay	/	0.5 and 50 µg/ml	Insulin	/	↑ of glucose uptake. Stimulation of C2C12 and Chang cell growth.	[39]
<i>Terminalia sericea</i> Burch. ex DC (Combretaceae)	Acetone extract (Stem bark)	Chromogenic DNSA and α-Glucosidase	/	0.2 mg/mL	Acarbose	β-sitosterol, β-sitosterol-acetate, Lupeol, Stigma-4-ene-3-one, Catechin & epicatechin, Gallocatechin and epigallocatechin	↓ of α-glucosidase and α-amylase activity of 97.4 ± 0.03 and 91.9 ± 0.10 % respectively	[43]
<i>Tinospora fragosa</i> (Menispermaceae)	Acetone extract	Chromogenic DNSA and α-Glucosidase	/	34 to 88 mg/ml	Acarbose	/	↓ amylase activity of $\approx 26.75\%$ and α-glucosidase ($IC_{50} = 2800$ µg/ml).	[47]
<i>Tulbaghia violacea</i> (Amaryllidaceae)	Aqueous and ethanolic extract (Whole plant)	Absorption du glucose, MTT assay	/	0.5, 50 and 62.5 µg/ml	Insulin	/	↑ of glucose uptake. Inhibition of liver Chang cells at 62.5 µg/ml extract.	[39]
<i>Waltheria indica</i> (Malvaceae)	Acetone extract	Chromogenic DNSA and α-Glucosidase	/	34 to 88 mg/ml	Acarbose	/	↓ amylase activity of $\approx 24.55\%$ and α-glucosidase ($IC_{50} = 2100$ µg/ml).	[47]
<i>Warbugia salutaris</i> Bertol.f.) Chiov. (Canellaceae)	Acetone extract (Stem bark)	Chromogenic DNSA and α-Glucosidase	/	0.2 mg/mL	Acarbose	/	↓ of α-glucosidase and α-amylase activity of 71.8 ± 0.27 and $89.2 \pm 0.06\%$ respectively.	[43]
<i>Xanthocercis zambesiaca</i>	Acetone extract (Stem bark)	Mammalian α-	/	0.04, 0.08, 0.16, 0.3156,	Acarbose	/	Inhibition of Mammalian α-	[46]

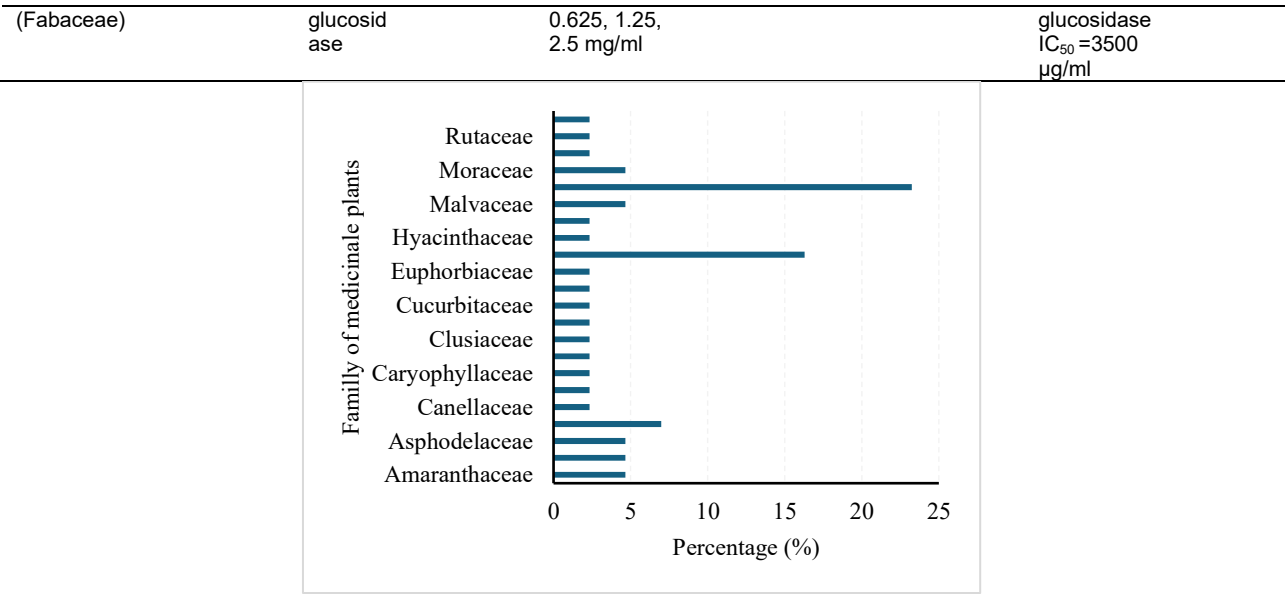


Fig. 2: Anti-diabetic medicinal plants studied in South Africa according to plant families

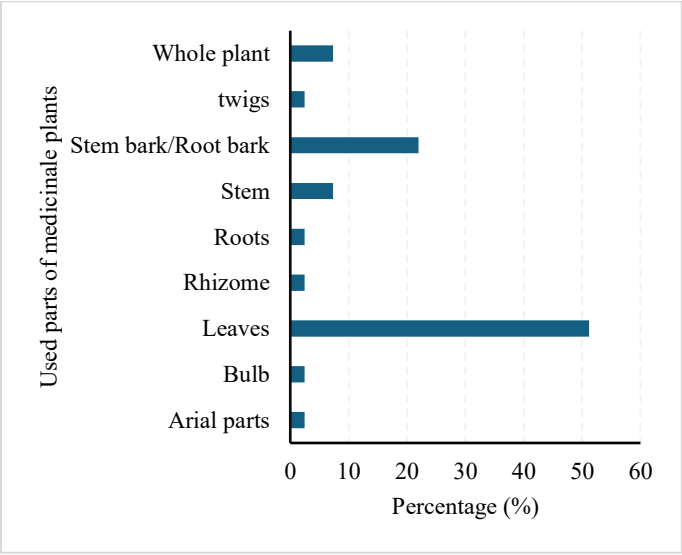


Fig. 3: Commonly used parts of anti-diabetic medicinal plants

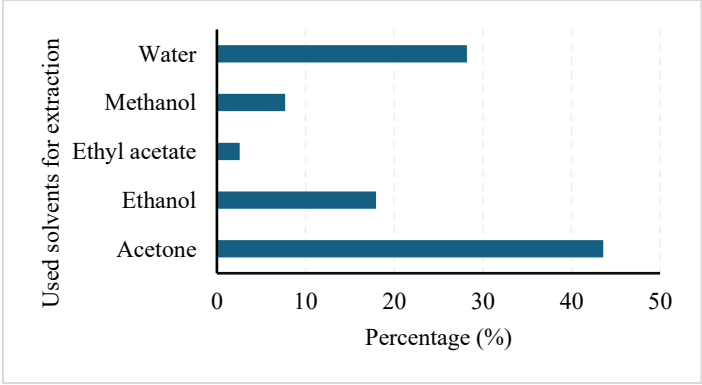


Fig. 4: Solvents commonly used for the extraction/fractionation of anti-diabetic medicinal

Anti-Diabetic Properties of Some of the Most Promising South African Plants

Family Asphodelaceaes

Aloe Ferox

Commonly referred to as Ikhala-lasekoloni, *Aloe ferox* is a plant that belongs to the Asphodelaceae family and is utilised in traditional medicine for several reasons, most notably its ability to prevent diabetes. Several studies have highlighted the plant's potential for reducing blood glucose levels and the associated biochemical mechanisms. Diabetes is characterised in patients by a deficit in the absorption of glucose into the cells, sometimes due to an inadequate secretion of insulin, resulting in hyperglycemia [54]. Aqueous ($IC_{50} = 308.01 \pm 0.7 \mu\text{g/mL}$) and ethanolic ($IC_{50} = 338.79 \pm 7.05 \mu\text{g/mL}$) extracts have been reported to enhance glucose uptake in yeast cells. Interestingly, the aqueous extract demonstrated more potent inhibition of essential enzymes responsible for carbohydrate digestion, namely α -glucosidase, α -amylase, and pancreatic lipase, with IC_{50} values of 96.24 ± 0.1 , 663.2 ± 0.3 , and $122.01 \pm 5.9 \mu\text{g/mL}$, respectively. Furthermore, at a concentration of $120 \mu\text{g/mL}$, its effect was statistically comparable ($p \geq 0.05$) to that of metformin [40]. In another study conducted in obese rats (a risk factor for diabetes), a diet containing 11.8% *A. ferox* leaf powder resulted in a remarkable reduction in food intake between the 2nd and 7th week [55]. These effects are linked to the plant's bioactive compounds, which are typically extracted using water and/or ethanol-based solvents. The main compounds that support these activities are steroids, phenols, flavonoids [56], tannins, saponins, diterpenoids and glycosides [57, 58].

Most enzyme inhibition studies relied on non-human models, and the translation of these findings to human intestinal α -glucosidase remains uncertain. Moreover, while short-term toxicity appears low, long-term safety data are still lacking.

Family Asteraceaes

Artemisia Afra

Endowed with curative properties, this plant reached peak popularity during the COVID-19 pandemic. *A. afra* belongs to the Asteraceae family and is of interest for the treatment of infections and metabolic disorders such as diabetes mellitus. [43] demonstrated that the acetone extract of *A. afra* (0.2 mg/mL) inhibited α -glucosidase and α -amylase by 90.1 ± 0.01 and $62.7 \pm 0.19\%$ respectively. According to [42], the aqueous extract of this medicinal plant, administered at a dose of 200 mg/kg , demonstrated significant *in vivo* efficacy by reducing fasting blood glucose levels ($p < 0.05$) after 15 days of treatment.

According to the findings of [42], administering 200 mg/kg of the plant's aqueous extract resulted in a notable reduction ($p < 0.05$) in fasting blood glucose levels after 15 days of *in vivo* treatment. The glucose tolerance test revealed that diabetic rats receiving *A. afra* extract at a dose of 200 mg/kg (comparable to glibenclamide treatment) exhibited a return to normal blood glucose levels ($5.07 \pm 0.36 \text{ mmol/L}$) within 60 minutes [42]. Encouraging outcomes were observed in a preclinical study where alloxan-induced diabetic rats treated with 750 mg/kg of *A. afra* aqueous extract experienced a 56.9% decrease in blood glucose levels after 5 h. No signs of toxicity were reported at this dosage [59].

Nevertheless, the majority of studies remain preclinical, and dose standardisation is inconsistent across reports. In addition, mechanistic insights at the molecular level remain limited, particularly regarding insulin signalling pathways.

Family Fabaceaes

Cassia Abbreviate

Numerous investigations have demonstrated the antidiabetic potential of *C. abbreviata* (Fabaceae), supporting its traditional application in diabetes management [60]. This plant particularly caught the attention of [46], who demonstrated that acetone extraction was active on α -amylase ($\approx 27.14\%$) and α -glucosidase ($IC_{50} = 600 \mu\text{g/mL}$). Furthermore, a comparative study assessing the effects of extracts and acetone fractions from four medicinal plants (*Peltophorum africanum*, *Ozoroa cf. albicans*, *Manilkara mochisia*, and *Cassia abbreviata*) initially identified the husk of *C. abbreviata* as having the strongest α -glucosidase inhibitory activity ($IC_{50} = 10 \mu\text{g/mL}$), significantly surpassing the other plants and even outperforming acarbose ($IC_{50} = 1500 \mu\text{g/mL}$). A comparison between yeast and mammalian α -glucosidase shows that the yeast enzyme is more effectively inhibited, with an IC_{50} of $10 \mu\text{g/mL}$, whereas the mammalian counterpart requires over $2500 \mu\text{g/mL}$ to achieve similar inhibition [47]. From the above, we note a disparity between the activity of the acetone extract of *C. abbreviate* respectively of $IC_{50} = 600 \mu\text{g/mL}$ [46] and $IC_{50} > 2500 \mu\text{g/mL}$ [47]. This disparity is thought to be due to a difference in enzyme concentration (unspecified in both cases). This finding aligns with various other reports indicating that methanolic extracts from plants exhibit greater activity against yeast α -glucosidase compared to those targeting the mammalian enzyme. For

instance, the aqueous extract of *Capsicum annum*, a species from the pepper family, demonstrated a stronger inhibitory effect against yeast α -glucosidase (57%) than against the mammalian enzyme (48%) [61]. The effect of these extracts on yeast α -glucosidase, although interesting, could not be extrapolated to humans; it would therefore be of great interest to include studies on human intestinal α -glucosidase in future studies.

This observation, which has also been reported for other species, suggests that results obtained using non-human enzymes should be interpreted cautiously. Furthermore, toxicological and *in vivo* data remain extremely limited, which undermines any reliable clinical extrapolation.

Erythrina Lysistemon

E. lysistemon is a tree commonly known as the 'Coral tree' which produces dark orange flowers and belongs to the Fabaceae family. Limited research has been conducted on the anti-diabetic potential of *E. lysistemon*. The ethyl acetate extract from the bark of this tree presents a promising alternative for anti-diabetic treatment. When administered to streptozotocin-induced diabetic rats at a dose of 150 mg/kg, the *E. lysistemon* extract significantly reduced blood glucose levels ($p < 0.05$) during the oral glucose tolerance test, with notable decreases observed after 60 min. Furthermore, the rate of glycation in diabetic rats given the extract (150 and 300 mg/kg) was similar ($p < 0.05$) to that in untreated normoglycemic rats. It significantly reduced ($p < 0.05$) glucose-6-phosphatase and pancreatic lipase activity and protected and/or regenerated β -cells. Ethyl-acetate extract of *E. lysistemon* abounds in a panoply of bioactive molecules such as β -Sitosterol, which Docking's simulation shows to be potentially active on α -amylase, pancreatic lipase and superoxide dismutase [50]. Administering β -Sitosterol (20 mg/kg) to streptozotocin-induced diabetic rats resulted in the regulation of both glycaemia and insulinemia, with no rats developing diabetes after 21 days. In contrast, 11.11% of rats in the glibenclamide (0.3 mg/kg) group developed diabetes [62]. The above would therefore support the anti-diabetic potential of *E. lysistemon* which requires further studies on its toxicity.

Bioactive compounds like β -sitosterol, which has been independently confirmed to have anti-diabetic effects, make the observed effects seem biologically plausible. Still, there aren't many studies on this, and the toxicological data is still not enough.

Sutherlandia Frutescens

Better known as Umnwele, *S. frutescens* is recognised for its notable medicinal properties and is used for curative purposes in the treatment and alleviation of several diseases [32]. Scientific evidence supports its potential as a promising treatment for diabetes. Administration of the aqueous extract of *Sutherlandia frutescens* subsp. *microphylla* (0.01 ml/g) led to a reduction in blood glucose levels in pre-diabetic rats (obese and insulin-resistant), with levels returning to normal after eight weeks of treatment. Additionally, it significantly ($p < 0.001$) decreased insulin levels in these rats, showing no significant difference when compared to the levels in untreated normal rats [64]. This suggests that *S. frutescens* extract does not affect insulin secretion while effectively regulating blood glucose levels. This finding is further supported by the observation that the aqueous extract of *S. frutescens* significantly reduced ($p < 0.01$) intestinal glucose absorption (< 4 mmol/L) after 30 minutes, a level notably lower than the blood glucose levels observed in rats treated with metformin (> 4 mmol/L) [64]. Numerous studies have highlighted the potential of *S. frutescens* in the prevention and treatment of type 2 diabetes. In addition to reducing insulin levels, the extract of *S. frutescens* (50 mg/kg) improves the lipid profile and supports weight loss in insulin-resistant rats on a high-fat diet [65]. [63] demonstrated that Chang liver cells pre-treated for 48 h with aqueous extract of *S. frutescens* positively influenced 2-[3 H]-DOG glucose intake than metformin, and also maintained glucose levels similar to control. It also reduces lipid accumulation and targets 27 genes encoding various cellular components such as receptors, vesicle transporters, metabolic enzymes and transcription factors.

In light of the above, *S. frutescens* appears to be one of the best candidates for diabetes prevention, particularly due to its insulin-sensitising action.

Family Euphorbiaceae

Croton Gratissimus

Widely utilised across various regions of Africa and commonly known as Rekstokbos in South Africa, *C. gratissimus* is traditionally employed to manage metabolic conditions such as diabetes, hypertension, and arthritis, as well as infections including gonorrhoea and malaria [66]. At all tested concentrations (15, 30, 60, 120, and 240 μ g/mL), the aqueous extract of

C. gratissimus significantly enhanced glucose uptake in yeast cells ($p < 0.05$), surpassing the effect observed with metformin at each corresponding dose. The extract exhibited inhibitory activity against α -glucosidase, α -amylase, and pancreatic lipase, with IC_{50} values of 60.56 ± 2.78 , 35.67 ± 0.07 , and 50.27 ± 1.51 $\mu\text{g/mL}$, respectively. Additionally, the aqueous extract of *C. gratissimus* at a concentration of 120 $\mu\text{g/mL}$ inhibited glycation reactions by approximately 50%, relatively close ($p \geq 0.05$) to that of aminoguanidine (10 mM). However, at 240 $\mu\text{g/mL}$, the anti-glycation activity is higher ($p < 0.05$) than that of aminoguanidine [31]. The MTT assay, however, showed no cytotoxicity on 3T3-fibroblast cells, suggesting that *C. gratissimus* could be a promising and safe candidate for the development of antidiabetic phytotherapeutic agents. Nevertheless, it will be necessary to extend the toxicity tests to other sensitive organs in the body, such as the brain and heart, and to monitor adverse effects following small-scale clinical trials. The anti-diabetic effects can be attributed to the presence of bioactive compounds, including gallic acid, catechin, caffeic acid, and quercetin [31]. Indeed, catechin [68] and quercetin [68] have been implicated in the inhibition of α -glucosidase and α -amylase enzymes, the reduction of blood glucose levels and the protection and/or regeneration of β -pancreatic cells. According to a study by [69] (+)-catechin inhibits yeast α -glucosidase preferentially, at the expense of mammalian α -glucosidase.

Although this plant combines good digestive enzyme inhibition activity with low toxicity, enhancing its pharmacological interest, the lack of *in vivo* evaluations and long-term toxicity data remains to be explored in order to glimpse its potential clinical effects.

Family Moraceae

Ficus Lutea

Belonging to the Moraceae family, *F. lutea* is a plant used in many traditional treatment systems. It contains bioactive compounds such as lupeol, stigmasterol, α -myrin acetate, epicatechin, and epiafzelechin, all of which have demonstrated anti-diabetic properties [52]. Acetone extract of *F. lutea* leaves (0.2 mg/mL) has been shown *in vitro* to inhibit amylase and α -glucosidase activity, respectively (IC_{50} , 9.42 ± 2.01 and 290 ± 111 $\mu\text{g/mL}$ respectively) significantly lower than that of arcabose (0.04 ± 0.03 and 3.4 ± 0.5 $\mu\text{g/mL}$ respectively) [51]. However, in-depth evaluation of the (previously cited) chemical constituents isolated and tested by [52] showed low anti- α -glucosidase activity (epicatechin 5.72 ± 2.7 $\mu\text{g/mL}$, epiafzelechin 7.64 ± 37.5 $\mu\text{g/mL}$ and > 1000 $\mu\text{g/mL}$ for the others) compared with the reference molecule arcabose ($IC_{50} = 1.52 \pm 0.05$ $\mu\text{g/mL}$). In another study, the ethyl acetate fraction of the leaves exhibited the greatest potential compared to dichloromethane, n-butanol, chloroform, hexane, and water. At 250 $\mu\text{g/mL}$, it enhanced glucose uptake in C2C12 muscle cells and H-4-II-E cells more effectively than insulin. Similarly, RIN-m5F pancreatic cells treated with the ethyl acetate fraction induced insulin secretion (10.88 ± 0.55 $\mu\text{g/L}$ at 250 $\mu\text{g/mL}$) in the same way as glibenclamide at 1 $\mu\text{g/mL}$. It also exhibits α -glucosidase ($IC_{50} = 126.78 \pm 30.62$ $\mu\text{g/mL}$) and α -amylase ($IC_{50} = 39.53 \pm 7.10$ $\mu\text{g/mL}$) enzyme inhibitory activity and low toxicity towards H-4-II-E liver cells ($LD_{50} = 562.9 \pm 4.9$ $\mu\text{g/mL}$) [70]. It is important to note that the variation in the effectiveness of the extracts on α -glucosidase and α -amylase is closely associated with their chemical composition, with this particular extract having a higher concentration of polyphenols (100.51 ± 1.60 mg GAE/g of dry weight) [70]. The nature of the enzyme can also be indexed, as it has been shown that mammalian α -glucosidase is less susceptible to the effect of medicinal plant extracts; [70] used rat α -glucosidase while [51] used yeast α -glucosidase.

Family Clusiaceae

Garcinia Livingstonei

Particularly in Africa, *G. livingstonei* (Clusiaceae) is generally used to alleviate numerous pathologies (diabetes, parasitic and bacterial infections, respiratory and skin diseases, etc.) [71-74]. It is generally found in the Limpopo region (South Africa), and is known as Mupimbi. This medicinal plant has attracted the curiosity of numerous researchers, who have highlighted the anti-diabetic potential of its leaves, bark and root in regulating blood sugar levels [71, 53]. CA3 cells previously treated for 24 h with the aqueous extract of *G. livingstonei* leaves (125 $\mu\text{g/mL}$), favoured glucose uptake ($\approx 5.58\%$) and utilisation ($> 60\%$) as did ($p \geq 0.05$) that of the positive control. Through its effect on α -glucosidase and pancreatic lipase, enzymatic activity at 0.3 mg/mL extract was reduced by $\approx 96.47\%$ and less than 5%, respectively. No toxicity was observed with this extract of *G. livingstonei* [53]. This plant has an exceptional activity because it reduces to almost zero the activity of α -glucosidase, an enzyme whose catalysis releases glucose molecules in the intestine, thus indicating that this plant has a good potential for maintaining post-prandial glycaemia at normal levels. However, studies should be carried out on human α -glucosidase to clarify and extrapolate its action in humans or, more objectively, to administer it in humans and explore the different organs and its impact on diabetes. The aqueous extract of *G. livingstonei* leaves contains various phytochemicals, including

hydroxycinnamic acid, benzophenones, flavan-3-ols, flavonols, and flavones [53], all of which are known to be effective in managing diabetic complications [75]. Hydroxycinnamic acids are recognized for their ability to stimulate adiponectin secretion in response to inflammation, neutralize free radicals by enhancing antioxidant enzyme activity, and decrease lipid peroxidation [76, 77]. Benzophenones, common in the *Garcinia* genus, reduce dyslipidaemia and promote weight loss and glucose utilisation by cells, which are effects sought in the management of T2D, and a cardioprotective effect due to its flavonoid content [78].

Family Myrtaceae

Psidium x Durbanensis

Commonly known as Durban guava, *Psidium x durbanensis* is an endemic plant of South Africa that is abundant in the KwaZulu-Natal province [79]. This species was studied mainly in the hydromethanolic and acetone fractions. The acetone extract of the leaves inhibited α -amylase and α -glucosidase activity by $90.1 \pm 0.01\%$ and $62.7 \pm 0.19\%$, respectively [43]. Additionally, in STZ-induced diabetic rats treated with the hydromethanolic extract of *Psidium x durbanensis* leaves, glucose tolerance improved (with no significant difference compared to insulin-treated diabetic rats), and insulin secretion was notably higher ($p > 0.05$) compared to the untreated diabetic group. This effect was further supported by the upregulation of GLUT4 and IRS-1 genes, which are involved in glucose transport in muscle and fat cells and insulin secretion, respectively [13, 80]. *Psidium x durbanensis* extract also reduces hepatic histomorphological damage and regenerates islet cells [13]. Several studies have shown a significant decrease in blood glucose levels and an improvement in glucose tolerance in diabetic rats treated with *P. guajava* leaf extract, indicating that the extract likely contains bioactive compounds that mimic the action of insulin [81, 82]. Furthermore, the *P. guajava* leaf extract does not promote insulin secretion compared to the non-diabetic control group, implying that the extract or its chemical components act as insulin sensitisers. Flavonoids such as strictin, isostrictin, and pedunculagin, found in *P. guajava* leaf extracts, help reduce blood sugar levels by enhancing glucose uptake into cells and improving insulin sensitivity [81, 83].

Substantially, we note that extracts of *P. x durbanensis* significantly improve glucose tolerance, stimulate GLUT4 translocation and regenerate pancreatic islets in diabetic rats. These effects, similar to those observed with *P. guajava*, are closely related to an insulin-sensitising mechanism.

Family Combretaceae

Terminalia Sericea

The anti-diabetic effects of *Terminalia sericea* are primarily linked to the acetone and methanol extracts of its bark. *In vitro*, the acetone extract demonstrated a strong inhibitory effect on α -amylase and α -glucosidase, with inhibition rates of $91.9 \pm 0.10\%$ and $97.4 \pm 0.03\%$, respectively [43]. When tested at different doses, the methanol extract of the bark (100 and 200 mg/kg) exhibited significant efficacy in reducing blood glucose levels and improving the lipid profile in diabetic rats after 30 days of treatment. The acetone extract contains active compounds such as β -sitosterol and lupeol, which showed strong inhibitory effects on α -amylase (IC₅₀ of 60.0 and 28.37 μ g/mL, respectively) and α -glucosidase (IC₅₀ of 89.5 and 22.6 μ g/mL, respectively) [43].

A limited number of studies have investigated the anti-diabetic potential of this plant, highlighting the need to refine the extraction solvents, conduct *in vivo* experiments, and assess its toxicity in order to draw more conclusive and relevant findings.

Biochemical and Mechanistic Basis of the Limitations of Yeast α -Glucosidase in Antidiabetic Screening

The divergence in sensitivity between yeast and mammalian α -glucosidases has a clear biochemical basis [84]. Yeast α -glucosidase is a monofunctional homotetramer (~150 kDa) with a relatively hydrophobic and highly accessible active site, specialised in the rapid hydrolysis of α -1,4-linked oligosaccharides such as maltose and maltodextrins. This structural configuration confers a high substrate affinity, reflected by low K_m values (0.1-1 mM [85]). In contrast, mammalian α -glucosidases, particularly the human sucrase-isomaltase complex (~520 kDa), are multifunctional heterodimers composed of multiple catalytic domains. They hydrolyse a broader spectrum of dietary starch-derived oligosaccharides, including both α -1,4 and α -1,6 linkages, and display lower substrate affinity (K_m 5-10 mM), together with allosteric regulation by digestion products [86, 87]. Consequently, many plant-derived inhibitors act predominantly through non-competitive or weak mixed-type mechanisms on mammalian enzymes, leading to markedly reduced inhibitory efficacy compared with yeast systems.



Fig. 5: Image showing a selection of plants with potential anti-diabetic properties. a: *Aloe ferox*, b: *Artemisia afra*, c: *Cassia abbreviata*, d: *Croton gratissimus*, e: *Erythrina lysistemon*, f: *Ficus lutea*, g: *Garcinia livingstonei*, h: *Psidium x durbanensis*, i: *Sutherlandia frutescens*, j: *Terminalia sericea*

These fundamental biochemical differences translate into marked discrepancies in inhibitory potency. For instance, *Cassia abbreviata* exhibits an IC_{50} of approximately 10 $\mu\text{g/mL}$ against yeast α -glucosidase, compared with values exceeding 2,500 $\mu\text{g/mL}$ when tested on the rat enzyme. Similar trends are observed for *Ficus lutea* ($IC_{50} \approx 290 \mu\text{g/mL}$ for yeast versus 126.78 $\mu\text{g/mL}$ for rat α -glucosidase) and *Croton gratissimus* ($IC_{50} \approx 60.56 \mu\text{g/mL}$ against the yeast enzyme) [88]. These findings indicate that inhibition observed in yeast models often reflects favourable enzyme accessibility rather than true physiological potency. Collectively, the literature supports the preferential use of recombinant human α -glucosidase, or closely related mammalian homologues such as the porcine enzyme, to better capture clinically relevant inhibitory mechanisms and avoid overestimation of antidiabetic potential [89-91]. While these mechanistic observations provide valuable insights into the potential antidiabetic actions of these plants, translating such effects from controlled experimental models to whole-organism physiology remains a key challenge.

Taken together, the different biological activities reported for these medicinal plants can be interpreted within an integrated antidiabetic framework. Rapid increases in blood glucose levels may be prevented by inhibiting digestive enzymes like α -amylase and α -glucosidase [92, 93], which may decrease postprandial glucose absorption. Several plant extracts have also been demonstrated to improve insulin sensitivity in peripheral tissues and increase glucose uptake at the cellular level, which leads to more effective glucose utilisation [92]. Simultaneously, these plants include cytoprotective and antioxidant substances that may assist maintain pancreatic β -cell function by lowering inflammation and oxidative stress [94].

Limitations and Perspectives

Although this review highlights the considerable antidiabetic potential of South African medicinal flora, several limitations must be acknowledged in order to properly contextualise the findings and guide future research efforts.

First, only a small proportion of the identified plants, six out of seventy four, have been evaluated *in vivo*, and even fewer have progressed to clinical investigation. The majority of the available evidence is derived from *in vitro* studies, particularly enzyme inhibition assays targeting α -glucosidase and α -amylase. These assays frequently employ enzymes of non-human

origin, such as yeast or rodent enzymes. It is, however, well recognised that human α -glucosidase is less sensitive to plant extracts, which substantially limits the direct extrapolation of these results to clinical settings.

Second, considerable heterogeneity exists with respect to the plant parts used, extraction solvents, tested concentrations and experimental models. This methodological variability hampers meaningful comparisons across studies and prevents the robust identification of specific plants or standardised extracts with clear therapeutic superiority.

Finally, although several extracts demonstrated low cytotoxicity *in vitro*, data on acute, subchronic and chronic toxicity remain scarce. The lack of comprehensive toxicological assessments, particularly involving sensitive organs such as the liver, kidneys, heart and brain, represents a major barrier to the development of safe and regulated phytotherapeutic agents.

In light of these limitations, future research should prioritise the use of human enzymes and physiologically relevant cellular models, the implementation of well-designed *in vivo* studies using standardised protocols, and systematic evaluations of toxicity and pharmacokinetic profiles for the most promising extracts. Such efforts will contribute to a more rigorous scientific validation of ethnomedicinal knowledge and facilitate its integration into evidence-based therapeutic strategies.

Conclusion

The rich diversity of South African flora presents promising anti-diabetic potential, with some species demonstrating efficacy that exceeds that of established reference molecules. Given the low proportion of medicinal plants whose antidiabetic properties have been experimentally investigated, a large number of species remain to be scientifically explored. This review highlights that several traditional medicinal plants, including *A. ferox*, *A. afra*, *C. abbreviata*, *C. gratissimus*, *E. lysistemon*, *F. lutea*, *G. livingstonei*, *P. x durbanensis*, *S. frutescens* and *T. sericea* exhibit relevant biological activities such as the inhibition of α -amylase and α -glucosidase, stimulating the uptake of glucose into cells, and regulating insulin levels. From a clinical perspective, these findings suggest that some South African medicinal plants could represent promising complementary therapeutic options for the prevention and management of diabetes, particularly in regions where access to conventional antidiabetic drugs remains limited. The results also highlight the importance of strengthening research and innovation policies aimed at the scientific validation and sustainable use of indigenous medicinal plants. Among the species reviewed, *S. frutescens* and *A. ferox* appear particularly promising for diabetes prevention and management. Future work should include mammalian α -glucosidase, which appears to be less susceptible to plant extracts. It would be wise to evaluate the long-term toxicity of plant extracts that have shown no or very low toxicity, such as *C. gratissimus*, *F. lutea* and *G. livingstonei*, to assess the benefits and potential clinical risks.

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Author's Contributions

Laverdure Tchamani Piame: Conceptualisation, writing original draft preparation.

Yandiswa Yolanda Yako: Conceptualisation, writing original draft preparation, supervision.

Constance Rusike: Supervision.

Ethics

This article is original and contains unpublished material. The corresponding author confirms that all of the other authors have read and approved the manuscript and no ethical issues involved.

References

1. Ekoru, K., Doumatey, A., Bentley, A. R., Chen, G., Zhou, J., Shriner, D., Fasanmade, O., Okafor, G., Eghan, B., Agyenim-Boateng, K., Adeleye, J., Balogun, W., Amoah, A., Acheampong, J., Johnson, T., Oli, J., Adebamowo, C., Collins, F., Dunston, G., ... Rotimi, C. (2019). Type 2 diabetes complications and comorbidity in Sub-Saharan Africans. In *EClinicalMedicine* (Vol. 16, pp. 30–41). <https://doi.org/10.1016/j.eclim.2019.09.001>
2. Vijan, S. (2010). Type 2 Diabetes. *Annals of Internal Medicine*, 152(5), ITC3-1. <https://doi.org/10.7326/0003-4819-152-5-201003020-01003>
3. Aschner, P., Karuranga, S., James, S., Simmons, D., Basit, A., Shaw, J. E., Wild, S. H., Ogurtsova, K., & Saeedi, P. (2021). The International Diabetes Federation's guide for diabetes epidemiological studies. *Diabetes Research and Clinical Practice*, 172, 108630. <https://doi.org/10.1016/j.diabres.2020.108630>
4. Grundlingh, N., Zewotir, T. T., Roberts, D. J., & Manda, S. (2022). Assessment of prevalence and risk factors of diabetes and pre-diabetes in South Africa. In *Journal of Health, Population and Nutrition* (Vol. 41, Issue 1, p. 7). <https://doi.org/10.1186/s41043-022-00281-2>
5. DeMarsilis, A., Reddy, N., Boutari, C., Filippaios, A., Sternthal, E., Katsiki, N., & Mantzoros, C. (2022). Pharmacotherapy of type 2 diabetes: An update and future directions. In *Metabolism* (Vol. 137, p. 155332). <https://doi.org/10.1016/j.metabol.2022.155332>
6. Butt, J. H., Shen, L., Inzucchi, S. E., Docherty, K. F., Jhund, P. S., Martinez, F. A., Sabatine, M. S., Vaduganathan, M., Solomon, S. D., & McMurray, J. J. V. (2024). Dapagliflozin in Heart Failure, Type 2 Diabetes, and Neuropathy. *JACC: Heart Failure*, 12(11), 1946–1948. <https://doi.org/10.1016/j.jchf.2024.07.017>
7. Akiyode, O. F., & Adesoye, A. A. (2017). Adverse Effects Associated With Newer Diabetes Therapies. *Journal of Pharmacy Practice*, 30(2), 238–244. <https://doi.org/10.1177/0897190015594732>
8. Ghatage, T., Jarag, R., Jadhav, S., & Raut, R. (2017). A review on adverse drug reactions of antidiabetic drugs. *Int. J. Allied Med. Sci. Clin. Res.*
9. Frimpong, E., & Nlooto, M. (2019) Management of diabetes and hypertension among Zulu traditional health practitioners: A study of focus group interviews. *Ethiopian Journal of Health Development*, 33(4), 219–228.
10. Frimpong, E., & Nlooto, M. (2020). Management of diabetes and hypertension among Zulu traditional health practitioners: A study of focus group interviews. In *African Journal of Biomedical Research* (Vol. 23, Issue 2, pp. 135–146). <https://doi.org/10.11604/pamj.2019.34.93.19112>
11. Yakubu, M. T., Nurudeen, Q. O., Salimon, S. S., Yakubu, M. O., Jimoh, R. O., Nafiu, M. O., Akanji, M. A., Oladiji, A. T., & Williams, F. E. (2015). Antidiarrhoeal Activity of *Musa paradisiaca* Sap in Wistar Rats. *Evidence-Based Complementary and Alternative Medicine*, 2015, 1–9. <https://doi.org/10.1155/2015/683726>
12. Govindappa, M. (2015). A review on role of plant (s) extracts and its phytochemicals for the management of diabetes. *Journal of Diabetes & Metabolism*, 6(7), 10–38. <https://doi.org/10.4172/2155-6156.1000565>
13. Mbara, K. C., Rambharose, S., Baijnath, H., Nlooto, M., & Owira, P. M. O. (2022). Antidiabetic effects of *Psidium x durbanensis* Baijnath & Ramcharun ined. (Myrtaceae) leaf extract on streptozotocin-induced diabetes in rats. *Journal of Ethnopharmacology*, 297, 115542. <https://doi.org/10.1016/j.jep.2022.115542>
14. Olofinisan, K., Salau, V., Erukainure, O., & Islam, Md. S. (2024). *Erythrina lysistemon* Hutch. abates deranged metabolic indices linked with diabetic complications in experimental rat model. *Scientific African*, 26, e02478. <https://doi.org/10.1016/j.sciaf.2024.e02478>
15. Kifle, Z. D., Yesuf, J. S., & Atnafie, S. A. (2020). Evaluation of *in vitro* and *in vivo* Anti-Diabetic, Anti-Hyperlipidemic and Anti-Oxidant Activity of Flower Crude Extract and Solvent Fractions of *Hagenia abyssinica* (Rosaceae). *Journal of Experimental Pharmacology*, Volume 12, 151–167. <https://doi.org/10.2147/jep.s249964>
16. Upadhyay, S., & Dixit, M. (2015). Role of Polyphenols and Other Phytochemicals on Molecular Signaling. *Oxidative Medicine and Cellular Longevity*, 2015, 1–15. <https://doi.org/10.1155/2015/504253>
17. Oyedemi, S. O., Bradley, G., & Afolayan, A. J. (2009). Ethnobotanical survey of medicinal plants used for the management of diabetes mellitus in the Nkonkobe municipality of South Africa. *Pharmacognosy Journal*, 3(12), 1040–1044.
18. Philander, L. A., (2011). An ethnobotany of Western Cape Rasta bush medicine. *Journal of Ethnopharmacology*, 138(2), 578–594. <https://doi.org/10.1016/j.jep.2011.10.004>
19. Comas-Serra, F., Martínez-García, J. J., Pérez-Alba, A., Sáenz-Esqueda, M. de los Á., Candelas-Cadillo, M. G., Femenia, A., & Minjares-Fuentes, R. (2023). A New Functional Food Ingredient Obtained from *Aloe ferox* by Spray Drying. *Foods*, 12(4), 850. <https://doi.org/10.3390/foods12040850>
20. Loots, D. T., Pieters, M., Islam, M. S., & Botes, L. (2011). Antidiabetic effects of *Aloe ferox* and *Aloe greatheadii* var. *davyana* leaf gel extracts in a low-dose streptozotocin diabetes rat model. *South African Journal of Science*, 107(7/8), 1–8. <https://doi.org/10.4102/sajs.v107i7/8.532>
21. Davids, D., Gibson, D., & Johnson, Q. (2016). Ethnobotanical survey of medicinal plants used to manage High Blood Pressure and Type 2 Diabetes Mellitus in Bitterfontein, Western Cape Province, South Africa. *Journal of Ethnopharmacology*, 194, 755–766. <https://doi.org/10.1016/j.jep.2016.10.063>
22. Naidoo, C. M., Naidoo, Y., Dewir, Y. H., Singh, M., Daniels, A. N., & El-Ramady, H. (2022). *In Vitro* Investigation of the Antioxidant and Cytotoxic Potential of *Tabernaemontana ventricosa* Hochst. ex A. DC. Leaf, Stem, and Latex Extracts. *Horticulturae*, 8(2), 91. <https://doi.org/10.3390/horticulturae8020091>
23. Coates P., K. (2002). *Trees of Southern Africa* (Struik).
24. Deutschländer, M. S., van de Venter, M., Roux, S., Louw, J., & Lall, N. (2009). Hypoglycaemic activity of four plant extracts traditionally used in South Africa for diabetes. *Journal of Ethnopharmacology*, 124(3), 619–624. <https://doi.org/10.1016/j.jep.2009.04.052>
25. Riaz, Naheed, Feroze, Kanwal, Saleem, M., Musaddiq, S., Ashraf, M., & Alam, U. (2013). Oligocephlate, a new alpha-Glucosidase inhibitory Neohopane Triterpene from *Vernonia oligocephala*. *Journal of the Chemical Society of Pakistan*, 35(3), 823–826.

26. Erasto, P. (2006). Phytomedical Investigation of *Veronia Amygdalina*: A Medicinal Plant Used for the Treatment of Diabetes. *Journal of Ethnopharmacology*, 106(1), 117–120.
27. Debecho, D. A., Kinfe, Y. A., Dugul, T. T., & Melka, D. S. (2018). Effect of fresh juice of Khat (*Catha edulis*) on blood glucose levels of normoglycemic and streptozocin-induced diabetic rats. *International Journal of Pharmaceutical Sciences and Research*, 9(2), 784–789.
28. van Wyk, B.-E., & Gericke, N. (2000). People's plants: A guide to useful plants of Southern Africa.
29. Erhabor, J. O., Oyenih, O. R., Erukainure, O. L., & Matsabisa, M. G. (842). *Croton gratissimus* Burch. (Lavender croton): A Review of the Traditional Uses, Phytochemistry, Nutritional Constituents and Pharmacological Activities. *Tropical Journal of Natural Product Research*, 6(6), 855. <https://doi.org/10.3390/plants12162915>
30. Moremi, M. P., Kamatou, G. P., Viljoen, A. M., & Tankeu, S. Y. (2021). *Croton gratissimus* - essential oil composition and chemometric analysis of an ethnomedicinally important tree from South Africa. *South African Journal of Botany*, 138(3), 141–147. <https://doi.org/10.1016/j.sajb.2020.12.015>
31. Salau, V. F., Olofinisan, K. A., Mishra, A. P., Odewole, O. A., Ngameko, C. R., & Matsabisa, M. G. (2024). *Croton gratissimus* Burch Herbal Tea Exhibits Anti-Hyperglycemic and Anti-Lipidemic Properties via Inhibition of Glycation and Digestive Enzyme Activities. *Plants*, 13(14), 1952. <https://doi.org/10.3390/plants13141952>
32. De Wet, H., & Van Wyk, B. E. (2008). An ethnobotanical survey of southern African Menispermaceae. *South African Journal of Botany*, 74(1), 2–9. <https://doi.org/10.1016/j.sajb.2007.07.001>
33. Bilanda, D. C., Bidingha, R. à G., Djomeni Dzeufiet, P. D., Fouda, Y. B., Ngapout, R. F., Tcheutchoua, Y., Owona, P. E., Njonte Wouamba, S. C., Tanfack Tatchou, L., Dimo, T., & Kamtchouing, P. (2020). Antihypertensive and antidiabetic activities of *Erythrina senegalensis* DC (Fabaceae) stem bark aqueous extract on diabetic hypertensive rats. *Journal of Ethnopharmacology*, 246, 112200. <https://doi.org/10.1016/j.jep.2019.112200>
34. Maroyi, A. (2017a). *Euclea undulata* Thunb.: Review of its botany, ethnomedicinal uses, phytochemistry and biological activities. *Asian Pacific Journal of Tropical Medicine*, 10(11), 1030–1036. <https://doi.org/10.1016/j.apjtm.2017.10.005>
35. Maroyi, A. (2017b). Review of Ethnomedicinal Uses, Phytochemistry and Pharmacological Properties of *Euclea natalensis* A.DC. *Molecules*, 22(12), 2128. <https://doi.org/10.3390/molecules22122128>
36. Khumalo, B., Siboto, A., Akinnuga, A. M., Sibiya, N., Khathi, A., & Ngubane, P. S. (2023). *Momordica balsamina* improves glucose handling in a diet-induced prediabetic rat model. *Plos One*, 18(12), e0295498. <https://doi.org/10.1371/journal.pone.0295498>
37. van de Venter, M., Roux, S., Bungu, L. C., Louw, J., Crouch, N. R., Grace, O. M., Maharaj, V., Pillay, P., Sewnarian, P., Bhagwandin, N., & Folb, P. (2008). Antidiabetic screening and scoring of 11 plants traditionally used in South Africa. *Journal of Ethnopharmacology*, 119(1), 81–86. <https://doi.org/10.1016/j.jep.2008.05.031>
38. Van Wyk, B.-E., de Wet, H. de, & Van Heerden, F. R. (2008). An ethnobotanical survey of medicinal plants in the southeastern Karoo, South Africa. *South African Journal of Botany*, 74(4), 696–704. <https://doi.org/10.1016/j.sajb.2008.05.001>
39. Van Huyssteen, Van de Venter, M., Milne, P. J., & Campbell, E. E. (2011). Antidiabetic and cytotoxicity screening of five medicinal plants used by traditional African health practitioners in the Nelson Mandela Metropole, South Africa. *African Journal of Traditional, Complementary and Alternative Medicines*, 8(2), 165–175. <https://doi.org/10.4314/ajtcam.v8i2.63202>
40. Ismail, H., Mohamed, A. I., & Islam, Md. S. (2024). *Aloe ferox* leaf gel extracts attenuate redox imbalance in oxidative renal injury and stimulates glucose uptake, whilst inhibiting key enzymes linked to diabetes and obesity. *Scientific African*, 26, e02425. <https://doi.org/10.1016/j.sciaf.2024.e02425>
41. Nkobile, N., Bodede, O., Hussein, A. A., & Prinsloo, G. (2021). *In vitro* α -Glucosidase and α -Amylase Activities of Wild and Cultivated *Amaranthus* spp. and Isolated Compounds. *Pharmacognosy Journal*, 13(6s), 1614–1620. <https://doi.org/10.5530/pj.2021.13.208>
42. Sunmonu, T. O., & Afolayan, A. J. (2013). Evaluation of Antidiabetic Activity and Associated Toxicity of *Artemisia afra* Aqueous Extract in Wistar Rats. *Evidence-Based Complementary and Alternative Medicine*, 2013, 1–8. <https://doi.org/10.1155/2013/929074>
43. Nkobile, N., Houghton, P. J., Hussein, A., & Lall, N. (2011). Antidiabetic activity of *Terminalia sericea* constituents. *Natural Product Communications*, 6(11), 1585–1588. <https://doi.org/10.1177/1934578x1100601106>
44. Sagbo, I. J., van de Venter, M., Koekemoer, T., & Bradley, G. (2018). *In Vitro* Antidiabetic Activity and Mechanism of Action of *Brachylaena elliptica* (Thunb.) DC. *Evidence-Based Complementary and Alternative Medicine*, 2018(1), 4170372. <https://doi.org/10.1155/2018/4170372>
45. Nxumalo, M. B., Ntanz, N., Kumalo, H. M., & Khan, R. B. (2024). Mitigating Hyperglycaemic Oxidative Stress in HepG2 Cells: The Role of *Carica papaya* Leaf and Root Extracts in Promoting Glucose Uptake and Antioxidant Defence. *Nutrients*, 16(20), 3496. <https://doi.org/10.3390/nu16203496>
46. Shai, L. J., Magano, S. R., Lebelo, S. L., & Mogale, A. M. (2011). Inhibitory effects of five medicinal plants on rat alpha-glucosidase: Comparison with their effects on yeast alpha-glucosidase. *Journal of Medicinal Plants Research*, 5(13), 2863–2867.
47. Shai, L. J., Masoko, P., Mokgotho, M. P., Magano, S. R., Mogale, A. M., Boaduo, N., & Eloff, J. N. (2010). Yeast alpha glucosidase inhibitory and antioxidant activities of six medicinal plants collected in Phalaborwa, South Africa. *South African Journal of Botany*, 76(3), 465–470. <https://doi.org/10.1016/j.sajb.2010.03.002>
48. Latolla, N., Reddy, S., Venter, M. van de, & Hlangothi, B. (2023). Phytochemical composition and antidiabetic potential of the leaf, stem, and rhizome extracts of *Cissampelos capensis* L.f. *South African Journal of Botany*, 163, 468–477. <https://doi.org/10.1016/j.sajb.2023.11.003>
49. Kazeem, M. I., & Ashafa, A. O. T. (2015). In-vitro antioxidant and antidiabetic potentials of *Dianthus basuticus* Burt Davy whole plant extracts. *Journal of Herbal Medicine*, 5(3), 158–164. <https://doi.org/10.1016/j.hermed.2015.06.003>
50. Olofinisan, K., Salau, V., Erukainure, O., & Islam, Md. S. (2024). *Erythrina lysistemon* Hutch. abates deranged metabolic indices linked with diabetic complications in experimental rat model. *Scientific African*, 26, e02478. <https://doi.org/10.1016/j.sciaf.2024.e02478>

51. Olaokun, O. O., McGaw, L. J., Eloff, J. N., & Naidoo, V. (2013). Evaluation of the inhibition of carbohydrate hydrolysing enzymes, antioxidant activity and polyphenolic content of extracts of ten African *Ficus* species (Moraceae) used traditionally to treat diabetes. *BMC Complementary and Alternative Medicine*, 13(1), 94. <https://doi.org/10.1186/1472-6882-13-94>
52. Olaokun, O. O., & Zubair, M. S. (2023). Antidiabetic Activity, Molecular Docking, and ADMET Properties of Compounds Isolated from Bioactive Ethyl Acetate Fraction of *Ficus lutea* Leaf Extract. *Molecules*, 28(23), 7717. <https://doi.org/10.3390/molecules28237717>
53. Nethengwe, M., Okaiyeto, K., Opuwari, C. S., & Oguntibeju, O. O. (2025). The effect of *Garcinia livingstonei* aqueous leaf extract on hyperglycaemic-induced human sperm cell: An in-vitro study. *Phytomedicine Plus*, 5(1), 100750. <https://doi.org/10.1016/j.phyplu.2025.100750>
54. Mohamed, A. M., Aljabal, H., Alalawi, A. S., & Al-Nooh, N. (2024). The Impact of Bariatric Surgery on Type 2 Diabetes Mellitus Remission: A Systematic Review. *Cureus*, 16(11), e74755. <https://doi.org/10.7759/cureus.74755>
55. Mokhele, M. S., Tswaledi, D., Aboyade, O., Shai, J., & Katerere, D. (2020). Investigation of *Aloe ferox* leaf powder on anti-diabetes activity. *South African Journal of Botany*, 128, 174–181. <https://doi.org/10.1016/j.sajb.2019.10.012>
56. Heo, S.-J., Hwang, J.-Y., Choi, J.-I., Han, J.-S., Kim, H.-J., & Jeon, Y.-J. (2009). Diphlorethohydroxycarmalol isolated from *Ishige okamurae*, a brown algae, a potent α -glucosidase and α -amylase inhibitor, alleviates postprandial hyperglycemia in diabetic mice. In *European Journal of Pharmacology* (Vol. 615, Issues 1–3, pp. 252–256). <https://doi.org/10.1016/j.ejphar.2009.05.017>
57. Assefa, F., Daniel, S., & Eyasu, M. (2017). Antihyperglycemic and antihyperlipidemic activities of ethanol extract of *Ajuga remota* Benth (Harmegusa) leaves in streptozotocin induced diabetic rats. *African Journal of Pharmacy and Pharmacology*, 11(2), 17–24. <https://doi.org/10.5897/ajpp2014.4699>
58. Bekele, T. T., Hymete, A., Mekonnen, Y., & Tadesse, M. (2008). Antidiabetic activity and phytochemical screening of extracts of the leaves of *Ajuga remota* Benth on alloxan-induced diabetic mice. *BMC Complementary and Alternative Medicine*, 17, 243. <https://doi.org/https://doi.org/10.1186/s12906-017-1757-5>
59. Issa, I. A., & Hussien Bule, M. (2015). Hypoglycemic Effect of Aqueous and Methanolic Extract of *Artemisia afra* on Alloxan Induced Diabetic Swiss Albino Mice. *Evidence-Based Complementary and Alternative Medicine*, 1, 752486. <https://doi.org/10.1155/2015/752486>
60. Abesundara, K. J. M., Matsui, T., & Matsumoto, K. (2004). α -Glucosidase Inhibitory Activity of Some Sri Lanka Plant Extracts, One of Which, *Cassia auriculata*, Exerts a Strong Antihyperglycemic Effect in Rats Comparable to the Therapeutic Drug Acarbose. *Journal of Agricultural and Food Chemistry*, 52(9), 2541–2545. <https://doi.org/10.1021/jf035330s>
61. Kwon, Y.-I., Apostolidis, E., & Shetty, K. (2007). Evaluation of pepper for management of diabetes and hypertension. *Journal of Food Biochemistry*, 31(3), 370–385. <https://doi.org/10.1111/j.1745-4514.2007.00120.x>
62. Gupta, R. K., Kumar, D., Chaudhary, A. K., Maithani, M., & Singh, R. (2012). Antidiabetic activity of *Passiflora incarnata* Linn. in streptozotocin-induced diabetes in mice. In *Journal of Ethnopharmacology* (Vol. 139, Issue 3, pp. 801–806). <https://doi.org/10.1016/j.jep.2011.12.021>
63. Williams, S., Roux, S., Koekemoer, T., van de Venter, M., & Dealtry, G. (2013). *Sutherlandia frutescens* prevents changes in diabetes-related gene expression in a fructose-induced insulin resistant cell model. *Journal of Ethnopharmacology*, 146(2), 482–489. <https://doi.org/10.1016/j.jep.2013.01.008>
64. Chadwick, W. A., Roux, S., van de Venter, M., Louw, J., & Oelofsen, W. (2007). Anti-diabetic effects of *Sutherlandia frutescens* in Wistar rats fed a diabetogenic diet. In *Journal of Ethnopharmacology* (Vol. 109, Issue 1, pp. 121–127). <https://doi.org/10.1016/j.jep.2006.07.012>
65. MacKenzie, J., Koekemoer, T. C., Roux, S., van de Venter, M., & Dealtry, G. B. (2012). Effect of *Sutherlandia frutescens* on the Lipid Metabolism in an Insulin Resistant Rat Model and 3T3-L1 Adipocytes. *Phytotherapy Research*, 26(12), 1830–1837. <https://doi.org/10.1002/ptr.4653>
66. Moremi, M. P., Kamatou, G. P., Viljoen, A. M., & Tankeu, S. Y. (2021). *Croton gratissimus* - essential oil composition and chemometric analysis of an ethnomedicinally important tree from South Africa. *South African Journal of Botany*, 138(3), 141–147. <https://doi.org/10.1016/j.sajb.2020.12.015>
67. Liu, J., Lu, J., Kan, J., Wen, X., & Jin, C. (2014). Synthesis, characterization and *in vitro* anti-diabetic activity of catechin grafted inulin. *International Journal of Biological Macromolecules*, 64, 76–83. <https://doi.org/10.1016/j.ijbiomac.2013.11.028>
68. Tadera, K., Minami, Y., Takamatsu, K., & Matsuoka, T. (2006). Inhibition of α -Glucosidase and α -Amylase by Flavonoids. In *Journal of Nutritional Science and Vitaminology* (Vol. 52, Issue 2, pp. 149–153). <https://doi.org/10.3177/jnsv.52.149>
69. Oki, T., Matsui, T., & Osajima, Y. (1999). Inhibitory Effect of α -Glucosidase Inhibitors Varies According to Its Origin. *Journal of Agricultural and Food Chemistry*, 47(2), 550–553. <https://doi.org/10.1021/jf980788t>
70. Olaokun, O. O., McGaw, L. J., Janse van Rensburg, I., Eloff, J. N., & Naidoo, V. (2016). Antidiabetic activity of the ethyl acetate fraction of *Ficus lutea* (Moraceae) leaf extract: comparison of an *in vitro* assay with an *in vivo* obese mouse model. *BMC Complementary and Alternative Medicine*, 16(1), 110. <https://doi.org/10.1186/s12906-016-1087-z>
71. Mudau, T. E., Olowoyo, J. O., & Amoo, S. O. (2022). Ethnobotanical assessment of medicinal plants used traditionally for treating diabetes in Vhembe district, Limpopo Province, South Africa. *South African Journal of Botany*, 146, 304–324. <https://doi.org/10.1016/j.sajb.2021.10.016>
72. Mulholland, D. A., Mwangi, E. M., Dlova, N. C., Plant, N., Crouch, N. R., & Coombes, P. H. (2013). Non-toxic melanin production inhibitors from *Garcinia livingstonei* (Clusiaceae). *Journal of Ethnopharmacology*, 149(2), 570–575. <https://doi.org/10.1016/j.jep.2013.07.023>
73. Nciki, S., Vuuren, S., van Eyk, A., & de Wet, H. (2016). Plants used to treat skin diseases in northern Maputaland, South Africa: antimicrobial activity and *in vitro* permeability studies. *Pharmaceutical Biology*, 54(11), 2420–2436. <https://doi.org/10.3109/13880209.2016.1158287>
74. Szuster-Ciesielska, A., Plewka, K., Daniluk, J., & Kandefer-Szerszeń, M. (2011). Betulin and betulinic acid attenuate ethanol-induced liver stellate cell activation by inhibiting reactive oxygen species (ROS), cytokine (TNF- α , TGF- β) production and by influencing intracellular signaling. *Toxicology*, 280(3), 152–163. <https://doi.org/10.1016/j.tox.2010.12.006>
75. Joseph, L., & George, M. (2016). Anti-bacterial and *in vitro* Anti-diabetic Potential of Novel Isoxazole Derivatives. *British Journal of Pharmaceutical Research*, 9(4), 1–7. <https://doi.org/10.9734/bjpr/2016/21926>

76. Alam, M. A., Subhan, N., Hossain, H., Hossain, M., Reza, H. M., Rahman, M. M., & Ullah, M. O. (2016). Hydroxycinnamic acid derivatives: a potential class of natural compounds for the management of lipid metabolism and obesity. *Nutrition & Metabolism*, 13(1), 27. <https://doi.org/10.1186/s12986-016-0080-3>
77. Ambika, S., Saravanan, R., & Thirumavalavan, K. (2013). Antidiabetic and antihyperlipidemic effect of p-hydroxycinnamic acid on streptozotocin-induced diabetic Wistar rats. *Biomedicine & Aging Pathology*, 3(4), 253–257. <https://doi.org/10.1016/j.biomag.2013.09.004>
78. Zhang, Y., Zhang, L., Gu, E., Zhu, B., Zhao, X., & Chen, J. (2016). Long-term insulin treatment restores cardioprotection induced by sufentanil postconditioning in diabetic rat heart. *Experimental Biology and Medicine*, 241(6), 650–657. <https://doi.org/10.1177/1535370215622706>
79. Msomi, E. T. (2008). The potential impact of the Cara legislation (for guava as an invader species) on selected disadvantaged communities in KwaZulu-Nata.
80. Stockli, J., Fazakerley, D. J., & James, D. E. (2011). GLUT4 exocytosis. *Journal of Cell Science*, 124(24), 4147–4159. <https://doi.org/10.1242/jcs.097063>
81. Shen, S., Cheng, F., & Wu, N. (2008). Effect of guava (*Psidium guajava* Linn.) leaf soluble solids on glucose metabolism in type 2 diabetic rats. *Phytotherapy Research*, 22(11), 1458–1464. <https://doi.org/10.1002/ptr.2476>
82. Zhu, X., Ouyang, W., Lan, Y., Xiao, H., Tang, L., Liu, G., Feng, K., Zhang, L., Song, M., & Cao, Y. (2020). Anti-hyperglycemic and liver protective effects of flavonoids from *Psidium guajava* L. (guava) leaf in diabetic mice. *Food Bioscience*, 35, 100574. <https://doi.org/10.1016/j.fbio.2020.100574>
83. Patel, D. K., Prasad, S. K., Kumar, R. K., & Hemalatha, S. (2012). An overview on antidiabetic medicinal plants having insulin mimetic property. *Asian Pacific Journal of Tropical Biomedicine*, 2(4), 320–330. [https://doi.org/10.1016/s2221-1691\(12\)60032-x](https://doi.org/10.1016/s2221-1691(12)60032-x)
84. Naim, H. Y., Niermann, T., Kleinhans, U., Hollenberg, C. P., & Strasser, A. W. M. (1991). Striking structural and functional similarities suggest that intestinal sucrase-isomaltase, human lysosomal α -glucosidase and *Schwanniomyces occidentalis* glucoamylase are derived from a common ancestral gene. *FEBS Letters*, 294(1–2), 109–112. [https://doi.org/10.1016/0014-5793\(91\)81353-a](https://doi.org/10.1016/0014-5793(91)81353-a)
85. Nguyen, D. V., Hengphasatporn, K., Danova, A., Suroengrit, A., Boonyasuppayakorn, S., Fujiki, R., Shigeta, Y., Rungrotmongkol, T., & Chavasiri, W. (2023). Structure–yeast α -glucosidase inhibitory activity relationship of 9-O-berberrubine carboxylates. *Scientific Reports*, 13(1), 18865. <https://doi.org/10.1038/s41598-023-45116-0>
86. Faridmoayer, A., & Scaman, C. H. (2005). Binding residues and catalytic domain of soluble *Saccharomyces cerevisiae* processing α -glucosidase I. In *Glycobiology* (Vol. 15, Issue 12, pp. 1341–1348). <https://doi.org/10.1093/glycob/cwj009>
87. Yonekura, L., Hisada, H., & Intravichakul, J. (2024). Human α -glucosidase inhibition and phytochemical profile of natural and shinzuke treated olives: implications from the processing method. *Food Production, Processing and Nutrition*, 6(1), 46. <https://doi.org/10.1186/s43014-024-00227-7>
88. Farazi, M., Houghton, M. J., Murray, M., & Williamson, G. (2023). A systematic review of the inhibitory effect of extracts from edible parts of nuts on α -glucosidase activity. In *Food & Function* (Vol. 14, Issue 13, pp. 5962–5976). <https://doi.org/10.1039/d3fo00328k>
89. Dirir, A. M., Daou, M., Yousef, A. F., & Yousef, L. F. (2022). A review of α -glucosidase inhibitors from plants as potential candidates for the treatment of type-2 diabetes. In *Phytochemistry Reviews* (Vol. 21, Issue 4, pp. 1049–1079). <https://doi.org/10.1007/s11101-021-09773-1>
90. Kumar, V., Prakash, O., Kumar, S., & Narwal, S. (2011). α -glucosidase inhibitors from plants: A natural approach to treat diabetes. *Pharmacognosy Reviews*, 5(9), 19. <https://doi.org/10.4103/0973-7847.79096>
91. Miller, N., & Joubert, E. (2022). Critical Assessment of *In Vitro* Screening of α -Glucosidase Inhibitors from Plants with Acarbose as a Reference Standard. *Planta Medica*, 88(12), 1078–1091. <https://doi.org/10.1055/a-1557-7379>
92. Kan, J., Velliquette, R. A., Grann, K., Burns, C. R., Scholten, J., Tian, F., Zhang, Q., & Gui, M. (2017). A novel botanical formula prevents diabetes by improving insulin resistance. *BMC Complementary and Alternative Medicine*, 17(1), 352. <https://doi.org/10.1186/s12906-017-1848-3>
93. Telagari, M., & Hullatti, K. (2015). In-vitro α -amylase and α -glucosidase inhibitory activity of *Adiantum caudatum* Linn. and *Celosia argentea* Linn. extracts and fractions. *Indian Journal of Pharmacology*, 47(4), 425. <https://doi.org/10.4103/0253-7613.161270>
94. Moens, C., Muller, C. J. F., & Bouwens, L. (2022). *In vitro* comparison of various antioxidants and flavonoids from Rooibos as beta cell protectants against lipotoxicity and oxidative stress-induced cell death. *PLOS ONE*, 17(5), e0268551. <https://doi.org/10.1371/journal.pone.0268551>