

African Medicinal Plant Extracts in Diabetes Mellitus: Integrating Preclinical Evidence, Clinical Studies, and Translational Perspectives

OPADOKUN Nurudeen Abiola*

Department of Human Anatomy, Kenya Methodist University, Kenya, abiola.opadokun@kemu.ac.ke

*Correspondence

Abstract

Background: Diabetes mellitus remains a major public health challenge worldwide, with a rapidly increasing burden across Africa. Limitations associated with conventional antidiabetic therapies, including high treatment costs, adverse effects, and restricted access to healthcare, have renewed interest in medicinal plants as potential complementary therapeutic agents. African traditional medicine provides a rich source of bioactive plant species with reported antihyperglycaemic, antioxidant, and anti-inflammatory properties. **Objective:** This review synthesizes evidence on the antidiabetic potential of African medicinal plant extracts, integrating findings from preclinical investigations, available clinical studies, and translational research to evaluate their therapeutic relevance and future prospects. **Methods:** A narrative review of the literature was conducted using electronic databases including PubMed, Scopus, Web of Science, Embase, and Google Scholar. Peer-reviewed studies published in English that investigated African medicinal plants for diabetes management in experimental animal models and human subjects were considered. Evidence was synthesized according to experimental models, phytochemical composition, mechanisms of action, clinical outcomes, and translational potential. **Results:** Preclinical studies consistently demonstrate that medicinal plants including *Moringa oleifera*, *Ajuga remota*, *Uvaria chamae*, *Solanum torvum*, *Azadirachta indica*, *Vernonia amygdalina*, and *Allium sativum* improve glycaemic control, attenuate oxidative stress, modulate inflammatory pathways, preserve pancreatic islet architecture, and enhance insulin sensitivity in experimental diabetes. These biological effects are largely attributed to phytochemicals such as flavonoids, phenolic compounds, alkaloids, terpenoids, and saponins. However, clinical evidence from African populations remains limited, with considerable heterogeneity in study design, extract standardization, dosage, and outcome measures. Furthermore, uncertainties regarding pharmacokinetics, long-term safety, herb–drug interactions, and regulatory standardization continue to impede clinical translation. **Conclusion:** African medicinal plants represent promising sources of novel antidiabetic agents with substantial preclinical support. Nevertheless, well-designed randomized controlled trials, standardized phytochemical characterization, comprehensive toxicological evaluation, and harmonized regulatory frameworks are required before these botanical interventions can be integrated into evidence-based clinical practice.

Keywords: Dysmetabolism, African Medicinal Plants, Phytochemicals, Oxidative Stress, Insulin Resistance.

1. Introduction

Diabetes mellitus (DM) is one of the most prevalent non-communicable diseases worldwide and represents a major public health challenge owing to its increasing incidence, associated complications, and substantial socioeconomic burden. Characterized by chronic hyperglycaemia resulting from defects in insulin secretion, insulin action, or both, diabetes predisposes affected individuals to microvascular and macrovascular complications including retinopathy,

nephropathy, neuropathy, and cardiovascular disease [1-5]. According to recent global estimates, the prevalence of diabetes continues to rise, particularly in low- and middle-income countries where rapid urbanization, sedentary lifestyles, dietary transitions, and increasing obesity have accelerated disease progression [1, 2].

Africa is experiencing one of the fastest increases in diabetes prevalence globally. Despite this growing burden, access to effective diagnosis, treatment, and long-term disease

management remains inadequate in many parts of the continent [6, 7]. Limited healthcare infrastructure, high costs of conventional medications, poor treatment adherence, and delayed diagnosis continue to contribute to increased morbidity and mortality among affected populations [1, 6, 7]. Consequently, there has been renewed scientific and clinical interest in identifying affordable, culturally acceptable, and biologically effective therapeutic alternatives that may complement existing diabetes management strategies [3-5].

Medicinal plants have been used for centuries in African traditional medicine for the management of diabetes and numerous other chronic diseases [8]. The continent possesses an exceptionally rich biodiversity, with thousands of plant species employed by traditional healers for their perceived hypoglycaemic and health-promoting properties [4, 5, 8]. In recent decades, these ethnomedicinal claims have stimulated extensive pharmacological investigations aimed at validating the efficacy and safety of plant-derived therapies using experimental animal models and, to a lesser extent, human clinical studies [4, 5, 8, 9]. These investigations have demonstrated that many African medicinal plants possess multiple biological activities, including antihyperglycaemic, antioxidant, anti-inflammatory, hypolipidaemic, and insulin-sensitizing properties, largely attributed to their diverse phytochemical constituents such as flavonoids, phenolic compounds, alkaloids, terpenoids, and saponins [4, 5, 8, 9].

Experimental animal models remain indispensable tools for investigating the pathophysiology of diabetes and evaluating the therapeutic potential of novel interventions before clinical application. Streptozotocin (STZ)-, alloxan-, and diet induced rodent models continue to be widely employed because they reliably reproduce pancreatic β -cell injury and hyperglycaemia [10-12], thereby facilitating assessment of fasting blood glucose, insulin secretion, oxidative stress, inflammatory responses, lipid metabolism, and pancreatic histopathology following administration of plant extracts [10-15]. However, these chemically induced models primarily mimic insulin-deficient diabetes and do not fully recapitulate the complex metabolic disturbances characteristic of human type 2 diabetes, including obesity-associated insulin resistance. Increasing use of high-fat diet-induced [16, 17], and genetically modified diabetic models has therefore provided additional insight into the mechanisms through which medicinal plants may improve insulin sensitivity and metabolic homeostasis [10-17].

Although a considerable body of literature has documented the antidiabetic activities of African medicinal plants in experimental models, the available evidence remains fragmented [18-22]. Many published reviews focus predominantly on descriptive summaries of individual plant species without critically integrating phytochemical composition, mechanisms of action, quality of experimental evidence, translational relevance, or the limited but emerging clinical data available from African populations. Furthermore, challenges relating to extract standardization, pharmacokinetics, bioavailability, toxicity, herb-drug interactions, and regulatory approval continue to hinder the translation of promising preclinical findings into evidence-based clinical practice.

This review therefore provides a critical synthesis of current evidence regarding the antidiabetic potential of African medicinal plant extracts by integrating findings from experimental animal studies, available clinical investigations, and mechanistic research. Particular emphasis is placed on phytochemical constituents, proposed mechanisms of action, translational challenges, and future research priorities that may facilitate the development of safe, standardized, and clinically effective plant-derived therapies for diabetes mellitus.

2. Review Methodology

This narrative review was undertaken to critically synthesize available evidence regarding the antidiabetic potential of African medicinal plant extracts, with particular emphasis on preclinical studies, available clinical investigations, phytochemical constituents, mechanisms of action, and translational prospects. A comprehensive literature search was conducted using electronic databases including PubMed, Scopus, Web of Science, Embase, and Google Scholar to identify relevant peer-reviewed publications. The literature search employed combinations of Medical Subject Headings (MeSH) and free-text keywords, including *diabetes mellitus*, *African medicinal plants*, *plant extracts*, *antidiabetic activity*, *experimental diabetes*, *streptozotocin*, *alloxan*, *type 2 diabetes*, *oxidative stress*, *phytochemicals*, *clinical trial*, *traditional medicine*, and *Africa*. Boolean operators ("AND", "OR") were used to optimize retrieval of relevant studies.

Studies eligible for inclusion were peer-reviewed articles published in English that investigated the antidiabetic effects of medicinal plants native to or widely used in Africa. Both experimental animal studies and human clinical investigations were considered where available. Additional eligible publications included systematic reviews and meta-analyses that provided mechanistic or clinical evidence relevant to African medicinal plants. Reference lists of selected articles were also manually screened to identify additional relevant publications.

Studies were excluded if they were conference abstracts, editorials, letters to the editor, dissertations without peer review, duplicate publications, studies unrelated to diabetes mellitus, or investigations involving isolated synthetic compounds without evaluation of whole plant extracts. Publications lacking sufficient methodological information or outcome data were also excluded from the synthesis.

Data extracted from eligible studies included plant species, family, plant part investigated, extraction method, experimental model, dosage regimen, duration of treatment, principal phytochemical constituents, proposed mechanisms of action, primary metabolic outcomes, and reported adverse effects where available. Clinical studies were further evaluated according to study design, sample size, intervention characteristics, duration of follow-up, and principal efficacy and safety outcomes.

Because of substantial heterogeneity in experimental designs, animal models, extract preparation methods, outcome measures, and reporting standards, quantitative meta-analysis was not considered appropriate. Instead, findings were synthesized narratively, with emphasis on the strength of

available evidence, biological plausibility, methodological quality, translational relevance, and existing knowledge gaps requiring future investigation.

3. Experimental Models for Investigating the Antidiabetic Effects of Medicinal Plants

Experimental animal models remain indispensable tools for investigating the pathophysiology of diabetes mellitus and evaluating the efficacy and safety of novel therapeutic agents before clinical application [10-15]. These models [Table 1] provide controlled experimental environments for assessing glycaemic regulation, insulin secretion, insulin sensitivity, lipid metabolism, oxidative stress, inflammatory responses, and tissue-specific pathological changes following administration of medicinal plant extracts [10-17]. Furthermore, they facilitate mechanistic investigations that would be difficult or ethically impossible to conduct in humans.

Selection of an appropriate experimental model is crucial because no single animal model fully reproduces the complex metabolic, genetic, and environmental interactions underlying human diabetes mellitus. Consequently, different experimental models have been developed to mimic specific aspects of the disease, each possessing distinct strengths and inherent limitations.

3.1 Chemically Induced Models

Streptozotocin (STZ) and alloxan remain the most widely employed diabetogenic agents in preclinical evaluation of medicinal plants. Both compounds selectively damage pancreatic β -cells through oxidative stress-mediated mechanisms, resulting in reduced insulin secretion and persistent hyperglycaemia [23-26]. These models have become the standard platforms for screening antihyperglycaemic agents because they are relatively inexpensive, reproducible, and capable of producing stable diabetic phenotypes within a short period.

STZ preferentially enters pancreatic β -cells through the GLUT2 transporter, where it induces DNA alkylation, mitochondrial dysfunction, and excessive generation of reactive oxygen species, ultimately leading to β -cell death and insulin deficiency. Alloxan similarly induces selective β -cell toxicity through the production of reactive oxygen species and intracellular calcium dysregulation [23-26]. These models are particularly valuable for evaluating compounds that preserve pancreatic islet morphology, reduce oxidative injury, or improve residual insulin secretory capacity.

Although chemically induced models have substantially advanced understanding of plant-derived antidiabetic agents, they predominantly mimic insulin-deficient diabetes rather than the progressive insulin resistance characteristic of most patients with type 2 diabetes mellitus. Consequently, extrapolation of findings from STZ- and alloxan-induced models to clinical populations should be undertaken cautiously.

3.2 Diet-Induced Models of Type 2 Diabetes

High-fat diet (HFD)-induced models more closely resemble the metabolic abnormalities observed in human type 2 diabetes. Prolonged consumption of energy-dense diets results in obesity, chronic low-grade inflammation, dyslipidaemia, impaired glucose tolerance, and progressive insulin resistance, thereby

reproducing many clinical features of metabolic syndrome [27-29]. Administration of medicinal plant extracts in HFD models allows investigators to evaluate their ability to improve insulin sensitivity, regulate lipid metabolism, reduce adipose tissue inflammation, and enhance whole-body glucose homeostasis. Several investigators have combined HFD feeding with low-dose STZ administration to generate experimental models that exhibit both insulin resistance and partial β -cell dysfunction. These combination models better approximate the pathophysiological progression of human type 2 diabetes and have become increasingly valuable for assessing the translational potential of novel phytotherapeutic interventions [30, 31].

3.3 Genetic Models of Diabetes

Genetically diabetic animals provide additional insight into mechanisms underlying obesity-associated diabetes. The ob/ob (Obese) mouse, which lacks functional leptin, develops severe obesity, hyperphagia, hyperinsulinaemia, and insulin resistance, whereas the db/db (Diabetes) mouse possesses mutations in the leptin receptor that result in progressive obesity, insulin resistance, and eventual β -cell dysfunction [32-34]. These models are particularly useful for evaluating medicinal plants that influence appetite regulation, energy metabolism, adipokine signalling, and insulin sensitivity. Unlike chemically induced models, genetic models permit long-term investigation of chronic metabolic disturbances and diabetic complications [32-34]. However, their relatively high cost, specialized breeding requirements, and species-specific genetic alterations may limit their routine use in many research settings, particularly in resource-constrained environments.

3.4 Strengths and Limitations of Experimental Models

Animal models continue to provide invaluable information regarding the pharmacological activities of medicinal plants, including their effects on glucose homeostasis, oxidative stress, inflammation, pancreatic morphology, hepatic metabolism, and diabetic complications. They also permit comprehensive evaluation of dose-response relationships, toxicity profiles, and potential mechanisms of action under highly controlled experimental conditions [35, 36].

Nevertheless, several important limitations should be acknowledged. Significant interspecies differences exist in drug absorption, metabolism, immune responses, and endocrine regulation, which may influence therapeutic outcomes. Moreover, experimental diabetes is typically induced rapidly, whereas human diabetes develops gradually through complex interactions among genetic susceptibility, environmental factors, obesity, ageing, and lifestyle. Variations in extraction methods, phytochemical composition, treatment duration, and experimental protocols further complicate comparison between studies and may reduce reproducibility [35, 36].

Accordingly, findings from animal studies should be interpreted as important preclinical evidence rather than definitive proof of clinical efficacy. Confirmation through well-designed human clinical trials remains essential before medicinal plant extracts can be recommended for routine management of diabetes mellitus.

4. African Medicinal Plants with Demonstrated Antidiabetic Activity

Africa possesses one of the world's richest reservoirs of medicinal plant biodiversity, with numerous species traditionally employed in the management of diabetes mellitus [Table 2]. Increasing scientific interest in these ethnomedicinal resources has resulted in extensive preclinical investigations evaluating their antihyperglycaemic efficacy, mechanisms of action, and safety profiles [18, 19]. Although the quality of evidence varies considerably among plant species, several medicinal plants have consistently demonstrated beneficial effects in experimental diabetes models. These effects are largely attributed to their ability to improve glycaemic control, reduce oxidative stress, modulate inflammatory pathways, preserve pancreatic islet architecture, improve insulin sensitivity, and correct diabetes-associated dyslipidaemia [18, 19].

4.1 *Ajuga remota* Benth.

Ajuga remota is widely used in East African traditional medicine for the treatment of diabetes and other metabolic disorders. Experimental studies using alloxan-induced diabetic mice have demonstrated that aqueous and hydroethanolic leaf extracts significantly reduce fasting blood glucose concentrations following repeated oral administration [37]. The antihyperglycaemic activity has been associated with the abundance of flavonoids, phenolic compounds, tannins, and other antioxidant phytochemicals capable of reducing oxidative stress and limiting pancreatic cellular injury [37].

Beyond improvements in glycaemic control, treated animals exhibited partial preservation of pancreatic histological architecture, suggesting protection against oxidative β -cell damage rather than complete regeneration. Although these findings provide encouraging preclinical evidence, the available studies remain limited by relatively small sample sizes and the absence of detailed pharmacokinetic and toxicological evaluations. Consequently, additional investigations employing standardized extracts and clinically relevant experimental models are required before therapeutic translation can be considered [37].

4.2 *Uvaria chamae* P. Beauv.

Uvaria chamae is indigenous to West Africa and has long been utilized in traditional medicine for diabetes management. Ethanolic root extracts have demonstrated significant dose-dependent reductions in blood glucose levels in streptozotocin-induced diabetic rodents while simultaneously improving serum lipid profiles through reductions in total cholesterol and triglycerides and increases in high-density lipoprotein concentrations [38, 39].

The observed metabolic improvements have been attributed to the presence of flavonoids, alkaloids, saponins, and polyphenolic constituents, which are proposed to enhance insulin secretion, reduce oxidative stress, and improve peripheral glucose utilization [38-40]. However, mechanistic evidence remains largely indirect, and the molecular pathways responsible for these biological effects have not yet been comprehensively elucidated. Furthermore, evidence supporting long-term safety and efficacy remains scarce, highlighting the

need for further pharmacological and toxicological investigations.

4.3 *Solanum torvum* Swartz

Solanum torvum has received considerable scientific attention because of its consistent antidiabetic activity across several experimental studies. Administration of ethanolic fruit extracts to streptozotocin-induced diabetic rats has been associated with significant reductions in fasting blood glucose, improvement of serum lipid profiles, attenuation of hepatic enzyme abnormalities, and preservation of pancreatic tissue morphology [41, 42]. The therapeutic effects of *S. torvum* are believed to result primarily from its rich phenolic and flavonoid composition, which contributes to antioxidant activity, reduction of lipid peroxidation, and protection against oxidative pancreatic injury [41, 42]. Experimental studies also suggest improvements in endogenous antioxidant enzyme activity and attenuation of inflammatory responses. Nevertheless, current evidence should be interpreted cautiously because most mechanistic conclusions are inferred from biochemical observations rather than direct molecular investigations. Among the medicinal plants reviewed, *S. torvum* possesses one of the more comprehensive preclinical evidence bases, making it an attractive candidate for future translational and clinical research.

Table 1: Characteristics and Advantages of Experimental Animal Models Used in Antidiabetic Plant Research

Experimental Model	Mechanism	Represents	Major Advantages
STZ-induced rodents [23-27]	β -cell cytotoxicity	Type 1-like diabetes	Highly reproducible; widely used
Alloxan-induced rodents [23-27]	Oxidative injury	β -cell Type 1-like diabetes	Simple and inexpensive
High-fat diet [28, 29]	Diet-induced insulin resistance	Type 2 diabetes	Closely resembles metabolic syndrome
HFD + Low-dose STZ [30, 31]	Insulin resistance with partial β -cell dysfunction	Advanced Type 2 diabetes	Mimics clinical disease progression
ob/ob mice [32-34]	Leptin deficiency	Obesity-associated diabetes	Useful for obesity studies
db/db mice [33, 34]	Leptin receptor mutation	Severe Type 2 diabetes	Progressive metabolic disease

4.4 *Moringa oleifera* Lam.

Moringa oleifera is perhaps the most extensively investigated African medicinal plant for diabetes management. Numerous experimental studies have demonstrated that aqueous, ethanolic, and methanolic leaf extracts significantly improve glycaemic control, enhance insulin sensitivity, reduce oxidative

stress, normalize serum lipid profiles, and preserve pancreatic morphology in experimental diabetes models [43, 44]. These biological activities are attributed largely to bioactive phytochemicals including quercetin, kaempferol, chlorogenic acid, isothiocyanates, and other polyphenolic compounds possessing potent antioxidant and anti-inflammatory properties. Several investigators have proposed that *M. oleifera* may influence AMP-activated protein kinase (AMPK) signalling and glucose transporter (GLUT4) activity, thereby improving peripheral glucose uptake. However, these mechanisms remain incompletely characterized, and direct molecular confirmation is still limited [43-46]. Compared with many other medicinal plants, *M. oleifera* has the strongest translational potential because it has been evaluated in both experimental animals and a limited number of human studies. Nevertheless, differences in extract preparation, dosage, study populations, and treatment duration continue to limit direct comparison among investigations.

4.5 *Azadirachta indica* A. Juss.

Azadirachta indica (Neem) is widely recognized for its diverse pharmacological activities, including antidiabetic, antioxidant, anti-inflammatory, and immunomodulatory effects. Experimental studies have demonstrated significant improvements in fasting blood glucose concentrations, preservation of pancreatic tissue architecture, and amelioration of oxidative stress following administration of neem leaf extracts in chemically induced diabetic models [47-49]. The antidiabetic effects have been associated with limonoids, flavonoids, and other phytochemicals that may enhance insulin sensitivity and reduce oxidative injury [47-49]. However, considerable variability exists among published studies regarding extraction procedures, dosage regimens, and experimental protocols, making direct comparison difficult. Standardization of extract preparation remains an important prerequisite for future clinical translation.

4.6 *Allium sativum* L.

Allium sativum (garlic) has been extensively employed in traditional medicine because of its hypoglycaemic, antioxidant, lipid-lowering, and cardioprotective properties. Experimental studies indicate that garlic extracts improve glucose homeostasis while reducing oxidative stress and inflammatory responses associated with diabetes [50]. The principal bioactive constituents, including allicin and related organosulfur compounds, are believed to enhance insulin sensitivity, improve endothelial function, and reduce lipid peroxidation [50]. Although several experimental investigations support these beneficial effects, relatively few well-designed clinical studies have evaluated standardized garlic preparations in African populations. Consequently, further randomized controlled trials are required to establish their therapeutic value in routine diabetes management.

4.7 *Vernonia amygdalina* Delile (Bitter Leaf)

Vernonia amygdalina is one of the most widely utilized medicinal plants in sub-Saharan Africa and has long been employed in traditional medicine for the management of

diabetes mellitus and other metabolic disorders [51-53]. Preclinical studies have consistently demonstrated that aqueous and ethanolic leaf extracts of *V. amygdalina* significantly reduce fasting blood glucose concentrations, improve glucose tolerance, and ameliorate diabetes-associated dyslipidaemia in chemically induced diabetic animal models [51-53]. These beneficial effects have been accompanied by reductions in oxidative stress markers and improvements in endogenous antioxidant enzyme activities, suggesting that the plant exerts both antihyperglycaemic and antioxidant actions. The antidiabetic activity of *V. amygdalina* has been attributed to its rich phytochemical composition, including flavonoids, sesquiterpene lactones, saponins, alkaloids, tannins, and phenolic compounds. These bioactive constituents are proposed to improve glucose homeostasis through multiple complementary mechanisms, including enhancement of insulin secretion, preservation of pancreatic β -cell integrity, attenuation of oxidative stress, inhibition of inflammatory pathways, and modulation of carbohydrate metabolism [51-53]. In addition, experimental studies have reported improvements in serum lipid profiles, indicating potential cardiometabolic benefits beyond glycaemic control [53].

Despite these promising preclinical findings, the precise molecular mechanisms underlying the antidiabetic effects of *V. amygdalina* remain incompletely understood, and robust clinical evidence supporting its efficacy in humans is limited. Furthermore, variability in extraction methods, phytochemical composition, dosage regimens, and study designs has hindered direct comparison among published investigations. Future research should therefore focus on standardized phytochemical characterization, mechanistic studies, pharmacokinetic evaluation, and well-designed randomized controlled clinical trials to establish the therapeutic potential and safety of *V. amygdalina* in the management of diabetes mellitus.

5. Mechanisms Underlying the Antidiabetic Effects of African Medicinal Plant Extracts

The antidiabetic activities of medicinal plant extracts are multifactorial and involve numerous complementary biological mechanisms rather than a single pharmacological pathway. Experimental evidence suggests that many African medicinal plants [Table 3] improve glucose homeostasis through simultaneous modulation of insulin secretion, insulin sensitivity, carbohydrate metabolism, oxidative stress, inflammatory responses, and cellular signalling pathways [54, 55]. The diversity of phytochemical constituents present in medicinal plants enables them to target multiple metabolic abnormalities associated with diabetes mellitus [54, 55], thereby offering potential advantages over therapies directed at a single molecular target.

5.1 Modulation of Insulin Secretion and Preservation of Pancreatic β -Cell Function

Loss of functional pancreatic β -cell mass is a defining feature of diabetes mellitus, particularly in insulin-deficient states. Several African medicinal plant extracts have demonstrated the ability to preserve pancreatic islet architecture and improve circulating insulin concentrations in experimental diabetes models [10, 54, 55]. Rather than inducing true β -cell regeneration, current evidence suggests that these extracts primarily reduce oxidative injury, attenuate apoptosis, and preserve residual β -cell function.

Plant species including *Moringa oleifera*, *Solanum torvum*, *Ajuga remota*, *Vernonia amygdalina*, and *Azadirachta indica* have consistently demonstrated improvements in pancreatic histological appearance following administration in streptozotocin- and alloxan-induced diabetic animals [47-53]. These findings are generally accompanied by reductions in hyperglycaemia and improvements in endogenous insulin secretion. However, most available studies rely on histopathological observations and biochemical markers, and direct evidence of β -cell proliferation or neogenesis remains limited. Consequently, the term "preservation of pancreatic β -cell integrity" is scientifically more appropriate than " β -cell regeneration" in the absence of molecular confirmation.

Table 2. Comparative Summary of African Medicinal Plants with Reported Antidiabetic Activity in Experimental Models

Plant	Major Phytochemicals	Experimental Model	Principal Findings
<i>Moringa oleifera</i> [43-46]	Quercetin, kaempferol, chlorogenic acid	STZ, HFD	↓ Blood glucose, ↑ insulin sensitivity
<i>Solanum torvum</i> [41, 42]	Phenolics, flavonoids	STZ	↓ Hyperglycaemia, hepatoprotection
<i>Ajuga remota</i> [37]	Flavonoids, tannins	Alloxan	↓ Blood glucose, pancreatic protection
<i>Uvaria chamae</i> [38-40]	Alkaloids, flavonoids, saponins	STZ	Improved glycaemia and lipid profile
<i>Azadirachta indica</i> [47-49]	Limonoids, flavonoids	Alloxan	Improved glycaemia, reduced oxidative stress
<i>Allium sativum</i> [50]	Allicin, organosulfur compounds	STZ	Improved glucose metabolism, antioxidant effects
<i>Vernonia amygdalina</i> [51-53]	flavonoids, sesquiterpene lactones, saponins	STZ/Alloxan	Improved glycaemia, metabolism, antioxidant effects

5.2 Improvement of Insulin Sensitivity

Insulin resistance is the principal metabolic abnormality underlying type 2 diabetes mellitus. Experimental evidence indicates that several medicinal plant extracts improve peripheral insulin responsiveness by enhancing glucose uptake in skeletal muscle and adipose tissue while reducing hepatic glucose production [56, 57]. These effects have been associated with activation of intracellular signalling pathways involved in glucose metabolism, including AMP-activated protein kinase (AMPK), phosphatidylinositol 3-kinase (PI3K)/Akt signalling, and increased translocation of glucose transporter-4 (GLUT4) to the plasma membrane [58]. Although these mechanisms have been proposed for several medicinal plants, direct molecular evidence remains available for only a limited number of species. Therefore, improvements in insulin sensitivity reported in many studies should be interpreted as biologically plausible rather than definitively established.

5.3 Inhibition of Intestinal Carbohydrate Digestion and Hepatic Glucose Production

Another important mechanism through which medicinal plants may improve glycaemic control involves reduction of postprandial glucose excursions. Numerous plant-derived polyphenols, flavonoids, and tannins have demonstrated inhibitory activity against intestinal α -amylase and α -glucosidase enzymes, thereby delaying carbohydrate digestion and glucose absorption [59]. Some plant extracts have also been reported to suppress hepatic gluconeogenesis through modulation of key enzymes involved in glucose production, including glucose-6-phosphatase and phosphoenolpyruvate carboxykinase [59]. Although these observations have been reported primarily in experimental models, they provide a mechanistic basis for reductions in fasting and postprandial blood glucose concentrations following plant extract administration.

5.4 Antioxidant Mechanisms

Oxidative stress plays a central role in the development and progression of diabetes mellitus by promoting pancreatic β -cell dysfunction, insulin resistance, endothelial injury, and chronic diabetic complications. Persistent hyperglycaemia increases production of reactive oxygen species while simultaneously reducing endogenous antioxidant defense mechanisms [51-53]. Many African medicinal plants are particularly rich in flavonoids, phenolic acids, terpenoids, and other antioxidant phytochemicals capable of scavenging free radicals and enhancing endogenous antioxidant enzyme activity [22, 23, 37-53]. Experimental studies have consistently demonstrated reductions in malondialdehyde concentrations together with increased activities of superoxide dismutase, catalase, glutathione peroxidase, and reduced glutathione following administration of plant extracts [22, 23]. These antioxidant

effects are believed to contribute substantially to preservation of pancreatic tissue and improvement of metabolic homeostasis.

5.5 Modulation of Inflammatory Responses

Chronic low-grade inflammation is increasingly recognized as an important contributor to insulin resistance and progressive β -cell dysfunction [22, 23]. Elevated circulating concentrations of tumour necrosis factor- α (TNF- α), interleukin-1 β (IL-1 β), and interleukin-6 (IL-6) impair insulin signalling and promote further metabolic dysfunction. Experimental investigations indicate that several African medicinal plants reduce the expression of pro-inflammatory cytokines while enhancing anti-inflammatory mediators [22, 23]. Although the precise molecular mechanisms remain incompletely understood, inhibition of nuclear factor-kappa B (NF- κ B) signalling and modulation of inflammatory transcription factors have been proposed as potential mechanisms underlying these observations [59]. These anti-inflammatory effects may complement antioxidant activity in preserving pancreatic function and improving insulin responsiveness.

5.6 Regulation of Lipid Metabolism

Dyslipidaemia commonly accompanies diabetes mellitus and contributes significantly to cardiovascular morbidity. Numerous experimental studies have reported that medicinal plant extracts improve serum lipid profiles through reductions in total cholesterol, triglycerides, and low-density lipoprotein cholesterol while increasing high-density lipoprotein cholesterol [15-19]. Improved lipid metabolism may result from enhanced insulin sensitivity, reduced hepatic lipogenesis, increased fatty acid oxidation, and antioxidant protection against lipid peroxidation. Such effects are particularly relevant because correction of dyslipidaemia may reduce the long-term cardiovascular complications associated with diabetes.

5.7 Emerging Molecular Targets

Recent advances in molecular pharmacology suggest that several medicinal plant phytochemicals may influence multiple intracellular signalling pathways involved in glucose metabolism. Proposed molecular targets include, AMP-activated protein kinase (AMPK), Phosphatidylinositol 3-kinase (PI3K)/Akt signalling, Peroxisome proliferator-activated receptors (PPAR- α and PPAR- γ), Nuclear factor erythroid 2-related factor 2 (Nrf2), Nuclear factor-kappa B (NF- κ B) and Glucose transporter-4 (GLUT4) [59-61]. Activation or modulation of these pathways may contribute to improved glucose uptake, enhanced insulin signalling, reduced oxidative stress, and suppression of inflammatory responses [59-61]. Nevertheless, for many African medicinal plants, evidence supporting these molecular mechanisms remains preliminary, and additional studies employing genomic, proteomic, and metabolomic approaches are required to confirm these observations.

Table 3. Summary of Possible Mechanisms Underlying the Antidiabetic Effects of Medicinal Plant Extracts

Mechanism	Representative Phytochemicals	Biological Effect
Preservation of β -cell integrity	Flavonoids, phenolics	Reduced oxidative injury and apoptosis
Improved insulin sensitivity	Quercetin, kaempferol, limonoids	Enhanced glucose uptake
α -Amylase/ α -glucosidase inhibition	Polyphenols, tannins	Reduced carbohydrate absorption
Antioxidant activity	Flavonoids, phenolic acids	Reduced ROS, increased antioxidant enzymes
Anti-inflammatory activity	Polyphenols, terpenoids	Reduced TNF- α , IL-1 β , NF- κ B activity
Lipid regulation	Organosulfur compounds, flavonoids	Improved lipid profile

6. Basis of the Antidiabetic Activity of African Medicinal Plants

The therapeutic effects of African medicinal plants in diabetes mellitus are largely attributed to their diverse phytochemical constituents, many of which possess multiple complementary biological activities [37-53]. Unlike synthetic antidiabetic agents that often target a single molecular pathway, plant extracts contain complex mixtures of bioactive compounds capable of simultaneously modulating oxidative stress, inflammation, glucose metabolism, insulin signalling, lipid homeostasis, and cellular survival pathways [17-19]. The synergistic interactions among these phytochemicals may partly explain the broad pharmacological activities observed in experimental studies.

Despite the growing body of evidence supporting the antidiabetic properties of medicinal plants, considerable variability exists in phytochemical composition owing to differences in plant species, geographical origin, cultivation conditions, harvesting time, extraction methods, and storage conditions. Consequently, comprehensive phytochemical characterization has become an essential prerequisite for reproducible preclinical research and successful clinical translation.

6.1 Flavonoids and Phenolic Compounds

Flavonoids represent one of the most abundant classes of phytochemicals identified in African medicinal plants. Compounds such as quercetin, kaempferol, rutin, catechin, and luteolin have demonstrated significant antioxidant, anti-

inflammatory, and antihyperglycaemic activities in experimental diabetes models [20-23]. These compounds may improve glucose homeostasis through several complementary mechanisms, including scavenging reactive oxygen species, enhancing endogenous antioxidant enzyme activity, improving insulin sensitivity, suppressing inflammatory signalling, and promoting glucose uptake by peripheral tissues [23]. Flavonoids have also been proposed to activate intracellular signalling pathways such as AMP-activated protein kinase (AMPK) and phosphatidylinositol 3-kinase (PI3K)/Akt, although direct molecular evidence remains limited for many African medicinal plants [59]. The abundance of flavonoids in *Moringa oleifera*, *Ajuga remota*, *Solanum torvum*, and *Uvaria chamae* is considered an important contributor to their reported antidiabetic activities [20-23, 62].

Phenolic acids and related polyphenolic compounds contribute substantially to the antioxidant capacity of medicinal plants. Chlorogenic acid, gallic acid, caffeic acid, and ferulic acid have been associated with improved glucose metabolism through inhibition of oxidative stress, preservation of pancreatic cellular integrity, and modulation of carbohydrate metabolism [63]. Experimental studies suggest that phenolic compounds may reduce intestinal glucose absorption by inhibiting α -amylase and α -glucosidase while simultaneously suppressing hepatic gluconeogenesis [63]. Their ability to reduce lipid peroxidation may also contribute to preservation of pancreatic tissue and improvement of insulin responsiveness.

6.2 Alkaloids, Terpenoids and Limonoids

Alkaloids comprise another important class of naturally occurring bioactive compounds with reported antidiabetic activity. Several alkaloids have demonstrated insulinotropic effects, enhancement of peripheral glucose utilization, and modulation of hepatic glucose metabolism [64]. Although alkaloids have been identified in several African medicinal plants, including *Uvaria chamae*, relatively few studies have isolated individual compounds responsible for these biological effects [37]. Consequently, further phytochemical investigations are required to determine the contribution of specific alkaloids to diabetes management.

Terpenoids constitute one of the largest groups of plant secondary metabolites and possess diverse pharmacological activities. Limonoids, abundant in *Azadirachta indica*, have demonstrated antioxidant, anti-inflammatory, and insulin-sensitizing properties in experimental diabetes models [65]. These compounds may contribute to improved glucose homeostasis by reducing oxidative injury, preserving pancreatic cellular integrity, and modulating intracellular signalling pathways involved in glucose metabolism [65]. However, mechanistic evidence remains largely preclinical, and additional molecular investigations are necessary to confirm these observations.

6.3 Saponins and Organosulfur Compounds

Saponins are widely distributed among medicinal plants and have been associated with hypoglycaemic, hypolipidaemic, and antioxidant activities [41-45]. Experimental evidence suggests that these compounds may improve insulin secretion, reduce intestinal glucose absorption, and enhance peripheral glucose utilization. Several African medicinal plants contain appreciable concentrations of saponins, although their individual contributions to the overall therapeutic response remain incompletely understood because of the complexity of crude plant extracts [37-53].

Garlic (*Allium sativum*) contains numerous organosulfur compounds, including allicin, ajoene, diallyl sulphides, and S-allyl cysteine, which have demonstrated antioxidant and antihyperglycaemic properties [50]. These compounds are proposed to improve insulin sensitivity, reduce oxidative stress, inhibit lipid peroxidation, and improve endothelial function [50]. Their combined antioxidant and cardioprotective properties may provide additional benefits for diabetic patients at increased cardiovascular risk.

6.4 Synergistic Interactions Among Phytochemicals

The pharmacological efficacy of medicinal plant extracts is unlikely to result from a single bioactive compound. Instead, interactions among multiple phytochemical classes may produce additive or synergistic therapeutic effects [62-64]. For example, flavonoids may reduce oxidative stress while alkaloids enhance insulin secretion and phenolic compounds inhibit carbohydrate digestion. Such complementary mechanisms could collectively produce greater antihyperglycaemic activity than any individual constituent acting alone.

However, these synergistic interactions also complicate standardization because variations in phytochemical composition may significantly alter biological activity. Consequently, modern phytochemical investigations increasingly combine chromatographic techniques such as high-performance liquid chromatography (HPLC), gas chromatography-mass spectrometry (GC-MS), liquid chromatography-mass spectrometry (LC-MS/MS), and nuclear magnetic resonance (NMR) spectroscopy to identify, quantify, and standardize bioactive constituents before biological evaluation [66, 67].

6.5 Importance of Phytochemical Standardization

One of the major obstacles limiting clinical translation of African medicinal plants is the absence of standardized extract preparation and phytochemical characterization. Many published studies report only crude aqueous or organic extracts without identifying the concentrations of active constituents responsible for the observed pharmacological effects [65-67]. Future investigations should therefore incorporate comprehensive phytochemical profiling, identification of

marker compounds, quantitative standardization of bioactive constituents, and quality control procedures to improve reproducibility across laboratories. Such approaches will facilitate comparison among studies, strengthen regulatory acceptance, and enhance the development of evidence-based phytopharmaceuticals for diabetes management.

7. Clinical Evidence on African Medicinal Plants for Diabetes Mellitus

Although extensive preclinical investigations have demonstrated the antidiabetic potential of numerous African medicinal plants, translation of these findings into clinical practice remains limited [68]. Compared with experimental animal studies, relatively few well-designed clinical trials have evaluated the efficacy and safety of standardized plant extracts in individuals with diabetes mellitus. Consequently, the available clinical evidence is insufficient to support widespread therapeutic recommendations, despite encouraging findings from experimental models.

Most published human studies have evaluated medicinal plants as complementary therapies alongside conventional antidiabetic medications rather than as stand-alone interventions [Table 4]. Furthermore, many investigations have been characterized by relatively small sample sizes, short treatment durations, heterogeneous study populations, inadequate blinding, inconsistent extract standardization, and variable outcome measures, making direct comparison among studies difficult [68, 69].

7.1 Clinical Studies of *Moringa oleifera*

Among African medicinal plants, *Moringa oleifera* has received the greatest attention in human clinical research. Several small clinical studies have reported modest improvements in fasting blood glucose, postprandial glucose concentrations, glycated haemoglobin (HbA1c), and lipid profiles following supplementation with *M. oleifera* leaf preparations [69,70].

The beneficial effects have been attributed to its high concentrations of flavonoids, phenolic compounds, vitamins, minerals, and isothiocyanates, which may improve insulin sensitivity, reduce oxidative stress, and modulate inflammatory pathways. Nevertheless, substantial heterogeneity exists among published studies regarding dosage, formulation, treatment duration, and participant characteristics. Consequently, current evidence remains insufficient to establish standardized therapeutic recommendations.

Compared with *Moringa oleifera*, clinical evidence supporting other African medicinal plants remains extremely limited [71]. While experimental studies have demonstrated promising antihyperglycaemic effects for *Solanum torvum*, *Ajuga remota*, *Uvaria chamae*, and *Azadirachta indica*, few randomized

controlled trials have evaluated these plants in African populations.

Existing human studies are predominantly observational, exploratory, or pilot investigations with limited statistical power [71]. Furthermore, differences in extract preparation, phytochemical composition, dosage regimens, and study endpoints reduce the ability to compare outcomes across studies or perform meaningful evidence synthesis. Consequently, although these medicinal plants demonstrate considerable therapeutic promise in experimental models, robust clinical validation remains lacking.

Table 4. Summary of Available Clinical Evidence for Selected African Medicinal Plants in Diabetes Mellitus

Plant Species	Clinical Evidence		Reported Clinical Outcomes	Major Limitations	
<i>Moringa oleifera</i>	Small trials	clinical	Improved fasting glucose, HbA1c, lipid profile	Small sample size; variable preparations	
<i>Allium sativum</i>	Clinical and observational studies	and	Improved glycaemic control and lipid metabolism	Heterogeneous formulations	
<i>Azadirachta indica</i>	Limited studies	pilot	Possible reduction in blood glucose	Limited randomized trials	
<i>Solanum torvum</i>	Very limited clinical evidence		Clinical efficacy not yet established	Insufficient human data	
<i>Ajuga remota</i>	No clinical trials	robust	Evidence restricted to preclinical studies	Lack of human studies	
<i>Uvaria chamae</i>	No clinical trials	robust	Evidence restricted to animal studies	Lack of human studies	

7.2 Challenges Limiting Clinical Translation

Several important factors continue to impede successful translation of preclinical findings into routine clinical practice [72]. First, considerable variability exists in the phytochemical composition of medicinal plant extracts owing to differences in geographical origin, cultivation practices, harvesting conditions, extraction procedures, and storage methods. Such variability complicates standardization and reproducibility

between studies [71, 72]. Second, pharmacokinetic properties including absorption, distribution, metabolism, bioavailability, and elimination remain poorly characterized for most African medicinal plants. Without these data, determination of optimal therapeutic dosing remains difficult [72].

Furthermore, many published clinical studies have enrolled relatively small numbers of participants and lacked adequate randomization, placebo controls, or long-term follow-up. Consequently, the strength of current clinical evidence remains substantially lower than that of the preclinical literature. Finally, regulatory frameworks governing herbal medicines vary considerably among African countries, creating additional challenges for quality assurance, product standardization, and clinical implementation.

7.3 Future Directions for Clinical Research

Future clinical investigations should prioritize multicentre randomized controlled trials employing standardized phytochemical preparations and internationally accepted reporting guidelines. Adequately powered studies with longer treatment durations are required to evaluate sustained glycaemic control, diabetes-related complications, quality of life, and long-term safety. Integration of pharmacokinetic studies, biomarker analyses, metabolomics, and pharmacogenomic approaches may further improve understanding of individual variability in therapeutic responses. In addition, establishment of harmonized regulatory standards for botanical medicines across Africa would facilitate commercialization of safe, effective, and evidence-based phytopharmaceutical products.

Conclusion

African medicinal plants show considerable promise as complementary therapies for diabetes mellitus, with preclinical studies demonstrating significant antihyperglycaemic, antioxidant, and anti-inflammatory activities. However, limited clinical evidence, inadequate standardization, and insufficient safety data currently restrict their clinical application. Future research should focus on standardized phytochemical characterization and well-designed clinical trials to support the development of safe, effective, and evidence-based phytopharmaceuticals.

Acknowledgement

I acknowledge the valuable support of Mrs. Adeoye Fatima from the Department of Anatomy, Federal University of Medicine and Medical Sciences, for her careful review, constructive input, and necessary corrections, which contributed to improving the quality of this manuscript and ensuring that it meets the expected standards of a review study.

Funding

This review did not receive any grants from funding agencies in the public, commercial or not-for-profit sectors.

Availability of data and materials

Not Applicable

Competing interests

Author of this paper declares that there is no conflict of interest related to the content of this manuscript.

Received June 19th, 2026, Revised July 13th, 2026; Accepted: 31st July, 2026, **Published online:25/08/2026**

References

1. World Health Organization (WHO). **Diabetes**. Geneva: World Health Organization; 2025. Available from: <https://www.who.int/news-room/fact-sheets/detail/diabetes>
2. Hossain MJ, Al-Mamun M, Islam MR. Diabetes mellitus, the fastest growing global public health concern: Early detection should be focused. *Health Sci Rep*. 2024 Mar 22;7(3):e2004. doi: 10.1002/hsr.2.2004.
3. Pan C, Cao B, Fang H, Liu Y, Zhang S, Luo W, Wu Y. Global burden of diabetes mellitus 1990-2021: epidemiological trends, geospatial disparities, and risk factor dynamics. *Front Endocrinol (Lausanne)*. 2025 Jul 1;16:1596127. doi: 10.3389/fendo.2025.1596127.
4. Onaolapo AY, Onaolapo OJ. Nutraceuticals and Diet-based Phytochemicals in Type 2 Diabetes Mellitus: From Whole Food to Components with Defined Roles and Mechanisms. *Curr Diabetes Rev*. 2019;16(1):12-25. doi: 10.2174/1573399814666181031103930.
5. Onaolapo AY, Ojo FO, Adeleye OO, Falade J, Onaolapo OJ. Diabetes Mellitus and Energy Dysmetabolism in Alzheimer's Disease: Understanding the Relationships and Potential Therapeutic Targets. *Curr Diabetes Rev*. 2023;19(8):e020123212333.
6. Wang QY, Mensah E, Li ZC, Wang DG, Zhang CW, Baako BM, Zha L, Kong X. African regional and national burden of diabetes mellitus and its attributable risk factors from 1990 to 2021: results from the global burden of disease study 2021. *Front Endocrinol (Lausanne)*. 2025 Aug 28;16:1643999. doi: 10.3389/fendo.2025.1643999.
7. World Health Organization (WHO) African region tops world in undiagnosed diabetes: WHO analysis Geneva: World Health Organization; 2025. Available from: <https://www.afro.who.int/news/african-region-tops-world-undiagnosed-diabetes-who-analysis>
8. Onaolapo AY, Onaolapo OJ. African Plants with Antidiabetic Potentials: Beyond Glycaemic Control to Central Nervous System Benefits. *Curr Diabetes Rev*. 2020;16(5):419-437. doi: 10.2174/1573399815666191106104941.
9. Hasan MM, Ahmed QU, Soad SZM, Tunna TS, et al. Animal models and natural products to investigate in vivo and in vitro antidiabetic activity. *Biomed Pharmacother*. 2018;101:833-841.
10. Singh R, Gholipourmalekabadi M, Shafikhani SH. Animal models for type 1 and type 2 diabetes: Advantages and limitations. *Front Endocrinol (Lausanne)*. 2024;15:1359685. doi:10.3389/fendo.2024.1359685.

11. Qamar F, Sultana S, Sharma M. Animal models for induction of diabetes and its complications. *J Diabetes Metab Disord*. 2023 Aug 29;22(2):1021-1028. doi: 10.1007/s40200-023-01277-3.
12. Onaolapo AY, Onaolapo OJ, Adewole SO. Ocimum Gratissimum Linn Worsens Streptozotocin-Induced Nephrotoxicity in Diabetic Wistar Rats. *Maced J Med Sci*. 2012 Dec;5(4):382-8.
13. Tafesse TB, Hymete A, Mekonnen Y, Tadesse M. Antidiabetic activity and phytochemical screening of extracts of the leaves of *Ajuga remota* Benth on alloxan-induced diabetic mice. *BMC Complement Altern Med*. 2017;17:243.
14. Emordi JE, Agbaje EO, Oreagba IA, Iribhogbe OI. Antidiabetic effects of the ethanolic root extract of *Uvaria chamae* P. Beauv. (Annonaceae) in alloxan-induced diabetic rats. *Adv Pharmacol Pharm Sci*. 2018;2018:1314941.
15. Gandhi GR, Ignacimuthu S, Paulraj MG. *Solanum torvum* Swartz fruit containing phenolic compounds shows antidiabetic and antioxidant effects in streptozotocin-induced diabetic rats. *Food Chem Toxicol*. 2011;49(11):2725–2733.
16. Olofinnade AT, Alawode A, Onaolapo AY, Onaolapo OJ. Lepidium meyenii supplemented diet modulates neurobehavioral and biochemical parameters in mice fed high-fat high-sugar diet. *Endocrine, Metabolic & Immune Disorders-Drug Targets (Formerly Current Drug Targets-Immune, Endocrine & Metabolic Disorders)*. 2021 Jul 1;21(7):1333-43.
17. Onaolapo AY, Adebisi EO, Adeleye AE, Olofinnade AT, Onaolapo OJ. Dietary Melatonin Protects Against Behavioural, Metabolic, Oxidative, and Organ Morphological Changes in Mice that are Fed High-Fat, High- Sugar Diet. *Endocr Metab Immune Disord Drug Targets*. 2020;20(4):570-583. doi: 10.2174/1871530319666191009161228.
18. Frimpong EK, Thembane N, Hlatshwayo S, Ngcobo M, Gqaleni N. Indigenous medicinal plants used in the management of diabetes in Africa: Five years (2019–2024) in perspective. *Plants (Basel)*. 2024;13(14):1898.
19. Afolayan AJ, Sunmonu TO. In vivo studies on antidiabetic plants used in South African herbal medicine. *J Clin Biochem Nutr*. 2010;47(2):98–106.
20. Infante-García C, García-Alloza M. Review of the effect of natural compounds and extracts on neurodegeneration in animal models of diabetes mellitus. *Int J Mol Sci*. 2019;20(10):2533.
21. Rasineni K, Bellamkonda R, Singareddy SR, Desireddy S. Antihyperglycemic activity of *Catharanthus roseus* leaf powder in streptozotocin-induced diabetic rats. *Pharmacogn Res*. 2011;3(3):195–200.
22. Fakhrozi NF, Jofrry SM, Long CM, Choo CY. Mechanisms of antidiabetic effects of medicinal plants: A systematic review. *Curr Tradit Med*. 2026;12(1). doi:10.2174/0122150838239961240815102258.
23. Mîndruț S-G, Pop C, Mârza S-M, Hoța A-T, Tăbăran F-A, Sall IM, Uifălean A, Mogoșan E-L, Voștinaru O, Mogoșan C-I. Comparative Analysis of Streptozotocin, Streptozotocin–Nicotinamide and Alloxan-Based Diabetes Models in Female Wistar Rats. *Methods and Protocols*. 2026; 9(3):72. https://doi.org/10.3390/mps9030072
24. Szkudelski T. The mechanism of alloxan and streptozotocin action in B cells of the rat pancreas. *Physiol Res*. 2001;50(6):537-46. PMID: 11829314.
25. Lenzen S. The mechanisms of alloxan- and streptozotocin-induced diabetes. *Diabetologia*. 2008 Feb;51(2):216-26. doi: 10.1007/s00125-007-0886-7.
26. Athmuri DN, Shiekh PA. Experimental diabetic animal models to study diabetes and diabetic complications. *MethodsX*. 2023 Nov 4;11:102474. doi: 10.1016/j.mex.2023.102474.
27. Preguiça I, Alves A, Nunes S, Fernandes R, Gomes P, Viana SD, Reis F. Diet-induced rodent models of obesity-related metabolic disorders-A guide to a translational perspective. *Obes Rev*. 2020 Dec;21(12):e13081. doi: 10.1111/obr.13081.
28. Banerjee D, Mani A. Obesity's systemic impact: exploring molecular and physiological links to diabetes, cardiovascular disease, and heart failure. *Front Endocrinol (Lausanne)*. 2025 Nov 7;16:1681766. doi: 10.3389/fendo.2025.1681766.
29. Mo Q, Deng X, Zhou Z, Yin L. High-Fat Diet and Metabolic Diseases: A Comparative Analysis of Sex-Dependent Responses and Mechanisms. *Int J Mol Sci*. 2025 May 16;26(10):4777. doi: 10.3390/ijms26104777.
30. Brito AKDS, Mendes AVDS, Timah Acha B, Santos Oliveira ASDS, Lopes Macedo J, Suzuki Cruzio A, Prianti MDG, Abreu RR, Lucarini M, Durazzo A, do Carmo de Carvalho E Martins M, Arcanjo DDR. Experimental Models of Type 2 Diabetes Mellitus Induced by Combining Hyperlipidemic Diet (HFD) and Streptozotocin Administration in Rats: An Integrative Review. *Biomedicines*. 2025 May 9;13(5):1158. doi: 10.3390/biomedicines13051158.
31. Zhang M, Lv XY, Li J, Xu ZG, Chen L. The characterization of high-fat diet and multiple low-dose streptozotocin induced type 2 diabetes rat model. *Exp Diabetes Res*. 2008;2008:704045. doi: 10.1155/2008/704045.
32. Wang B, Chandrasekera PC, Pippin JJ. Leptin- and leptin receptor-deficient rodent models: relevance for human type 2 diabetes. *Curr Diabetes Rev*. 2014 Mar;10(2):131-45. doi: 10.2174/1573399810666140508121012.
33. Nilsson C, Raun K, Yan FF, Larsen MO, Tang-Christensen M. Laboratory animals as surrogate models of human obesity. *Acta Pharmacol Sin*. 2012 Feb;33(2):173-81. doi: 10.1038/aps.2011.203.
34. Pandey S, Dvorakova MC. Future Perspective of Diabetic Animal Models. *Endocr Metab Immune Disord Drug Targets*. 2020;20(1):25-38. doi: 10.2174/1871530319666190626143832.
35. Chahrouh JA, Abdel Baki Z, El Badan D, Nasser G, Maresca M, Hijazi A. Herbal Medicines in the Management of Diabetes Mellitus: Plants, Bioactive Compounds, and Mechanisms of Action. *Biomolecules*. 2025; 15(12):1674. https://doi.org/10.3390/biom15121674
36. Clemente-Suárez VJ, Martín-Rodríguez A, Beltrán-Velasco AI, Rubio-Zarapuz A, Martínez-Guardado I, Valcárcel-Martín R, Tornero-Aguilera JF. Functional and Therapeutic Roles of Plant-Derived Antioxidants in Type 2 Diabetes Mellitus: Mechanisms, Challenges, and Considerations for Special Populations. *Antioxidants*. 2025; 14(6):725. https://doi.org/10.3390/antiox14060725
37. Tafesse TB, Hymete A, Mekonnen Y, Tadesse M. Antidiabetic activity and phytochemical screening of extracts of the leaves of *Ajuga remota* Benth on alloxan-induced diabetic mice. *BMC Complement Altern Med*. 2017 May 2;17(1):243. doi: 10.1186/s12906-017-1757-5.
38. Emordi JE, Agbaje EO, Oreagba IA, Iribhogbe OI. Antidiabetic and hypolipidemic activities of hydroethanolic root extract of *Uvaria chamae* in streptozotocin induced diabetic albino rats. *BMC Complement Altern Med*. 2016 Nov 15;16(1):468. doi: 10.1186/s12906-016-1450-0.
39. Emordi JE, Agbaje EO, Oreagba IA, Iribhogbe OI. Antidiabetic Effects of the Ethanolic Root Extract of *Uvaria chamae* P. Beauv (Annonaceae) in Alloxan-Induced Diabetic Rats: A Potential Alternative Treatment for Diabetes Mellitus. *Adv Pharmacol Sci*. 2018 Nov 8;2018:1314941. doi: 10.1155/2018/1314941.
40. Agbebi EA, Omotuyi OI, Oyinloye BE, Okeke UB, Apanisile I, Okor B, Adefabijo D. Ethnomedicine, phytochemistry, and pharmacological activities of *Uvaria chamae* P. Beauv.: A comprehensive review. *Naunyn Schmiedebergs Arch Pharmacol*. 2024 Aug;397(8):5421-5436. doi: 10.1007/s00210-024-03018-6.

41. Satyanarayana N, Chinni SV, Gobinath R, Sunitha P, Uma Sankar A, Muthuvenkatachalam BS. Antidiabetic activity of *Solanum torvum* fruit extract in streptozotocin-induced diabetic rats. *Front Nutr*. 2022 Oct 28;9:987552. doi: 10.3389/fnut.2022.987552
42. Gandhi GR, Ignacimuthu S, Paulraj MG. *Solanum torvum* Swartz. fruit containing phenolic compounds shows antidiabetic and antioxidant effects in streptozotocin induced diabetic rats. *Food Chem Toxicol*. 2011 Nov;49(11):2725-33. doi: 10.1016/j.fct.2011.08.005
43. Mthiyane FT, Dlodla PV, Ziqubu K, Mthembu SXH, Muvhulawa N, Hlengwa N, Nkambule BB, Mazibuko-Mbeje SE. A Review on the Antidiabetic Properties of *Moringa oleifera* Extracts: Focusing on Oxidative Stress and Inflammation as Main Therapeutic Targets. *Front Pharmacol*. 2022 Jul 11;13:940572. doi: 10.3389/fphar.2022.940572. Erratum in: *Front Pharmacol*. 2023 Jan 24;14:1142410. doi: 10.3389/fphar.2023.1142410.
44. Saini RK, Sivanesan I, Keum YS. Phytochemicals of *Moringa oleifera*: a review of their nutritional, therapeutic and industrial significance. *3 Biotech*. 2016 Dec;6(2):203. doi: 10.1007/s13205-016-0526-3.
45. Saini RK, Sivanesan I, Keum YS. Phytochemicals of *Moringa oleifera*: a review of their nutritional, therapeutic and industrial significance. *3 Biotech*. 2016 Dec;6(2):203. doi: 10.1007/s13205-016-0526-3.
46. Sannu SA, Regmi P, Sapana. Effectiveness of *Moringa oleifera* extract in type 2 diabetes: A comprehensive literature review. *Medtigo J Pharmacol*. 2024;1(2):1–15.
47. Yarmohammadi F, Mehri S, Najafi N, Salar Amoli S, Hosseinzadeh H. The protective effect of *Azadirachta indica* (neem) against metabolic syndrome: A review. *Iran J Basic Med Sci*. 2021 Mar;24(3):280-292. doi: 10.22038/ijbms.2021.48965.11218.
48. Makena, Wusa, Nwankwo, Monday, Idris, Aisha, Dangoji, D avid Philip, Ogbe, Alex, Umoren, Elizabeth Bassey, Aja, Patrick Maduabuchi, Terkimbi, Swase Dominic, Fasogbon, Ilemobayo Victor, Antidiabetic Efficacy and Mechanistic Insights of *Azadirachta indica*: A Systematic Review and Meta-Analysis of Preclinical Evidence With Nutraceutical Applications, *Journal of Food Biochemistry*, 2026, 8618936, 29 pages, 2026. <https://doi.org/10.1155/jfbc/8618936>
49. Khosla P, Bhanwra S, Singh J, Seth S, Srivastava RK. A study of hypoglycaemic effects of *Azadirachta indica* in normal and alloxan diabetic rabbits. *Indian J Physiol Pharmacol*. 2000;44(1):69–74.
50. Singh A, Pandey R, Sarvottam K, Tripathi A. Hypoglycemic, Hypolipidemic, and Antioxidant Effect of *Allium sativum* in Daily Consumable Dosage in High-fat Diet and Streptozotocin-induced Type 2 Diabetic Model of Rats. *Int J Appl Basic Med Res*. 2026 Jan-Mar;16(1):43-50. doi: 10.4103/ijabmr.ijabmr_318_25.
51. Asante DB, Effah-Yeboah E, Barnes P, Abban HA, Ameyaw EO, Boampong JN, Ofori EG, Dadzie JB. Antidiabetic Effect of Young and Old Ethanolic Leaf Extracts of *Vernonia amygdalina*: A Comparative Study. *J Diabetes Res*. 2016;2016:8252741. doi: 10.1155/2016/8252741. Epub 2016 May 16. Erratum in: *J Diabetes Res*. 2017;2017:5618548. doi: 10.1155/2017/5618548.
52. Adekemi, F.E., Folake, J.K. & Omowumi, F.P. Antidiabetic effects of aqueous leaf extract of *Vernonia amygdalina* on serum liver markers in streptozotocin-induced diabetic albino Rats: a new data to support its Anti-diabetic effect. *Clin Phytosci* **10**, 13 (2024). <https://doi.org/10.1186/s40816-024-00376-9>
53. Nwanjo HU. Efficacy of aqueous leaf extract of *Vernonia amygdalina* on plasma lipoprotein and oxidative status in diabetic rat models. *Niger J Physiol Sci*. 2005;20(1–2):39–42.
54. Salehi B, Ata A, V Anil Kumar N, Sharopov F, Ramírez-Alarcón K, Ruiz-Ortega A, Abdulmajid Ayatollahi S, Tsouh Fokou PV, Kobarfard F, Amiruddin Zakaria Z, Iriti M, Taheri Y, Martorell M, Sureda A, Setzer WN, Durazzo A, Lucarini M, Santini A, Capasso R, Ostrander EA; Atta-ur-Rahman; Choudhary MI, Cho WC, Sharifi-Rad J. Antidiabetic Potential of Medicinal Plants and Their Active Components. *Biomolecules*. 2019 Sep 30;9(10):551. doi: 10.3390/biom9100551.
55. Chahrour JA, Abdel Baki Z, El Badan D, Nasser G, Maresca M, Hijazi A. Herbal Medicines in the Management of Diabetes Mellitus: Plants, Bioactive Compounds, and Mechanisms of Action. *Biomolecules*. 2025; 15(12):1674. <https://doi.org/10.3390/biom15121674>
56. Ansari P, Khan JT, Chowdhury S, Reberio AD, Kumar S, Seidel V, Abdel-Wahab YHA, Flatt PR. Plant-Based Diets and Phytochemicals in the Management of Diabetes Mellitus and Prevention of Its Complications: A Review. *Nutrients*. 2024; 16(21):3709. <https://doi.org/10.3390/nu16213709>
57. Lee J, Noh S, Lim S, Kim B. Plant Extracts for Type 2 Diabetes: From Traditional Medicine to Modern Drug Discovery. *Antioxidants (Basel)*. 2021 Jan 9;10(1):81. doi: 10.3390/antiox10010081
58. Tang W, Liu H, Li X, Deng S, Gao C. Influence and treatment of insulin receptor substrate/PI3K/Akt-mediated insulin resistance in diabetes mellitus (Review). *Mol Med Rep*. 2026 Feb;33(2):63. doi: 10.3892/mmr.2025.13773.
59. Mohanta YK, Mishra AK, Nongbet A, Chakrabartty I, Mahanta S, Sarma B, Panda J, Panda SK. Potential use of the Asteraceae family as a cure for diabetes: A review of ethnopharmacology to modern day drug and nutraceuticals developments. *Front Pharmacol*. 2023 Aug 3;14:1153600. doi: 10.3389/fphar.2023.1153600.
60. Prakash G, Chaudhary AA, Tanu R, Ali MAM, Boufahja F, Sharma PK, Lakhawat SS, Yadav T, Upadhyay NK, Kumar V. Harnessing Phytochemicals and Nanotechnology Synergy for Molecular, Epigenetic, and Microbiota-Driven Regulation in Type 2 Diabetes Mellitus. *Pharmaceutics*. 2026 Jan 15;18(1):113. doi: 10.3390/pharmaceutics18010113.
61. Li M, Ding L, Cao L, Zhang Z, Li X, Li Z, Xia Q, Yin K, Song S, Wang Z, Du H, Zhao D, Li X, Wang Z. Natural products targeting AMPK signaling pathway therapy, diabetes mellitus and its complications. *Front Pharmacol*. 2025 Feb 3;16:1534634. doi: 10.3389/fphar.2025.1534634. Erratum in: *Front Pharmacol*. 2025 Apr 14;16:1604573. doi: 10.3389/fphar.2025.1604573.
62. Setyani W, Murwanti R, Sulaiman TNS, Hertiani T. Flavonoid from *Moringa oleifera* leaves revisited: A review article on *in vitro*, *in vivo*, and *in silico* studies of antidiabetic insulin-resistant activity. *J Adv Pharm Technol Res*. 2023 Oct-Dec;14(4):283-288. doi: 10.4103/JAPTR.JAPTR_290_23.
63. Sun M, Zhang Z, Xie J, Yu J, Xiong S, Xiang F, Ma X, Yang C, Lin L. Research Progress on the Mechanism for Improving Glucose and Lipid Metabolism Disorders Using Phenolic Acid Components from Medicinal and Edible Homologous Plants. *Molecules*. 2024 Oct 10;29(20):4790. doi: 10.3390/molecules29204790.
64. Behl T, Gupta A, Albratty M, Najmi A, Meraya AM, Alhazmi HA, Anwer MK, Bhatia S, Bungau SG. Alkaloidal

- Phytoconstituents for Diabetes Management: Exploring the Unrevealed Potential. *Molecules*. 2022 Sep 9;27(18):5851. doi: 10.3390/molecules27185851.
65. Tufail T, Bader Ul Ain H, Ijaz A, Nasir MA, Ikram A, Noreen S, Arshad MT, Abdullahi MA. Neem (*Azadirachta indica*): A Miracle Herb; Panacea for All Ailments. *Food Sci Nutr*. 2025 Sep 1;13(9):e70820. doi: 10.1002/fsn3.70820.
 66. Misra RC, Thimmappa R, Bonfill M. Editorial: Advances in discoveries of plant phytochemicals. *Front Plant Sci*. 2024 Apr 30;15:1414150. doi: 10.3389/fpls.2024.1414150.
 67. Sharma B, Yadav DK. Metabolomics and Network Pharmacology in the Exploration of the Multi-Targeted Therapeutic Approach of Traditional Medicinal Plants. *Plants (Basel)*. 2022 Nov 25;11(23):3243. doi: 10.3390/plants11233243.
 68. Mohammed A, Ibrahim MA, Islam MS. African medicinal plants with antidiabetic potentials: a review. *Planta Med*. 2014 Mar;80(5):354-77. doi: 10.1055/s-0033-1360335.
 69. Crişan D, Gavrilăş L, Păltinean R, Frumuzachi O, Mocan A, Crişan G. Effects of *Moringa oleifera* Lam. Supplementation on Cardiometabolic Outcomes: A Meta-Analysis of Randomized Controlled Trials with GRADE Assessment. *Nutrients*. 2025; 17(22):3501. <https://doi.org/10.3390/nu17223501>
 70. Mthiyane FT, Dlodla PV, Ziqubu K, Mthembu SXH, Muvhulawa N, Hlengwa N, Nkambule BB, Mazibuko-Mbeje SE. A Review on the Antidiabetic Properties of *Moringa oleifera* Extracts: Focusing on Oxidative Stress and Inflammation as Main Therapeutic Targets. *Front Pharmacol*. 2022 Jul 11;13:940572. doi: 10.3389/fphar.2022.940572. Erratum in: *Front Pharmacol*. 2023 Jan 24;14:1142410. doi: 10.3389/fphar.2023.1142410.
 71. Oguntibeju OO. Hypoglycaemic and anti-diabetic activity of selected African medicinal plants. *Int J Physiol Pathophysiol Pharmacol*. 2019 Dec 15;11(6):224-237.
 72. Palit, P., Mandal, S.C. (2021). Climate Change, Geographical Location, and Other Allied Triggering Factors Modulate the Standardization and Characterization of Traditional Medicinal Plants: A Challenge and Prospect for Phyto-drug Development. In: Mandal, S.C., Chakraborty, R., Sen, S. (eds) *Evidence Based Validation of Traditional Medicines*. Springer, Singapore. https://doi.org/10.1007/978-981-15-8127-4_18

Cite as: Opadokun NA. African Medicinal Plant Extracts in Diabetes Mellitus: Integrating Preclinical Evidence, Clinical Studies, and Translational Perspectives. *Acta Bioscientia* 2026:2(5);516-528. <https://doi.org/10.71181/actabioscientia12660>