ORIGINAL ARTICLE
DOI: 10.15343/0104-7809.202549e17782025I
ISSN: 1980-3990

The use of medicinal plants in the supplementary treatment of Diabetes *Mellitus*

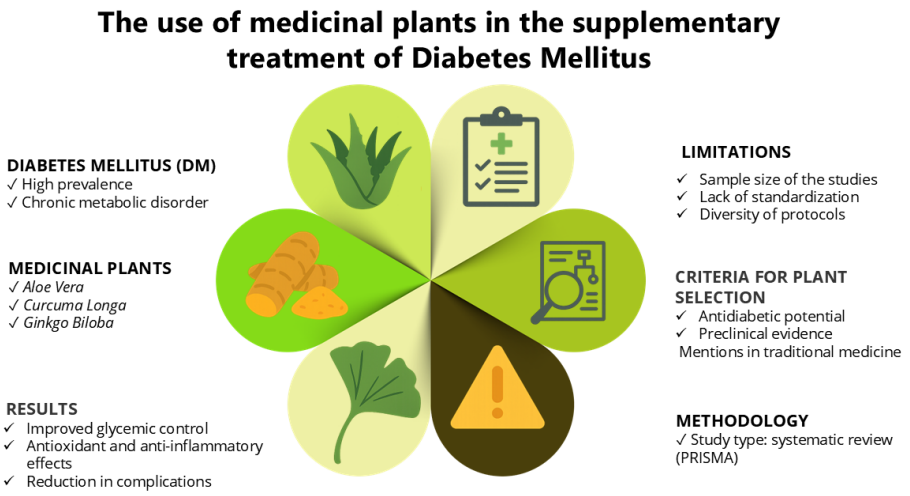
Rayssa Claudia Oliveira Duarte[1] **Guilherme Silva de Souza**[2] **Livia Cavalcante de Araújo**[3] **Sávia Denise Silva Carlotto Herrera**[2,3] **Renata Ferreira Diogo**[4] **Maykon Jhuly Martins de Paiva**[2,3]

[1]Programa de Residência Médica em Medicina de Família e Comunidade – Secretaria de Saúde de Campinas. Campinas/SP, Brasil.
[2]Curso de Medicina, Universidade de Gurupi, *Campus* Paraíso do Tocantins – UnirG. Paraíso do Tocantins/TO, Brasil.
[3]Programa de Residência Médica em Medicina de Família e Comunidade, Universidade de Gurupi, *Campus* de Gurupi – UnirG. Gurupi/TO, Brasil.
[4]Programa de Pós-Graduação em Biotecnologia, Universidade Federal do Tocantins, *Campus* de Gurupi – UFT. Gurupi/TO, Brasil.
E-mail: maykonjhulyfm@gmail.com

Highlights

- *Aloe vera, Curcuma longa, and Ginkgo biloba have been investigated for their effects on glycemic control and prevention of complications.*
- *A significant reduction in HbA1c and capillary blood glucose was observed, mainly with Aloe vera and Curcuma longa (when combined with piperine).*
- *Ginkgo biloba demonstrated potential in preventing chronic complications, such as retinopathy and nephropathy.*
- *There is a need for further standardized and controlled clinical trials to validate the clinical use of these plants as adjuvants in DM treatment.*

Graphical Abstract



Abstract

Diabetes *Mellitus* (DM) is a chronic metabolic disorder with high prevalence, and the use of medicinal plants has emerged as a promising complementary approach for the treatment of this condition. This study aimed to review the efficacy of *Aloe vera*, *Curcuma longa*, and *Ginkgo biloba* in glycemic control and in the reduction of complications associated with DM. A systematic review was conducted following the PRISMA method, using the descriptors "*Aloe vera*," "*Curcuma*," "*Ginkgo biloba*," and "*Diabetes*" in databases such as *PubMed, BVS,* and *SciELO*. Articles published between 2013 and 2024 were selected, considering only complete experimental and clinical studies that met the inclusion criteria. In total, seven studies were included in the analysis. The results showed that *Aloe vera* significantly reduced glycated hemoglobin (HbA1c) and capillary blood glucose, demonstrating efficacy as an adjuvant to metformin treatment. Curcumin combined with piperine exhibited antioxidant and anti-inflammatory properties, also contributing to the reduction of HbA1c and capillary blood glucose. *Ginkgo biloba,* in turn, presented benefits in capillary blood glucose control and in the prevention of chronic complications such as retinopathy and nephropathy. Although the analyzed herbal medicines demonstrated significant therapeutic potential, the reviewed studies presented methodological limitations, such as small sample sizes and lack of protocol standardization. Despite these limitations, *Aloe vera, Curcuma longa,* and *Ginkgo biloba* are promising alternatives for the supplementary management of DM, with potential to reduce associated complications. However, further high-quality studies are required to consolidate their clinical use within well-defined protocols.

Keyword: Phytotherapy. Diabetes *Mellitus*. Glycemic Control. *Aloe vera. Ginkgo biloba.*

Associate Editor: Edison Barbieri
Mundo Saúde. 2025,49:e17782025
O Mundo da Saúde, São Paulo, SP, Brasil.
https://revistamundodasaude.emnuvens.com.br

Received: 18 july 2025.
Accepted: 22 august 2025.
Published: 12 september 2025.

INTRODUCTION

Diabetes *Mellitus* (DM) is a chronic, slowly progressive metabolic disorder characterized by persistently elevated blood glucose levels resulting from defects in insulin secretion, insulin action, or both. The traditional classification of diabetes includes four main subtypes: Type 1 Diabetes *Mellitus* (T1DM), Type 2 Diabetes *Mellitus* (T2DM), Gestational Diabetes (GD), and other specific types[1].

Recognized as a global health challenge, DM significantly affects individuals' quality of life, impacting more than 463 million people worldwide in 2019, with projections indicating an increase to 700 million by 2045[2,3]. Its implications for morbidity and mortality are remarkable, being responsible for 4.2 million deaths in 2019, ranking as the ninth leading cause of death globally[2]. Furthermore, its strong association with cardiovascular complications, neuropathies, nephropathies, and other manifestations negatively affects global health[4].

T1DM is characterized by autoimmune destruction of pancreatic beta cells, resulting in total insulin deficiency. T2DM, the most common form of the disease[4], is associated with insulin resistance and progressive decline in pancreatic beta-cell insulin secretion. GD occurs during pregnancy and increases the risk of developing T2DM later in life[1,5].

In T1DM, the autoimmune response damages pancreatic beta cells, leading to complete insulin deficiency[6]. In contrast, in T2DM, insulin resistance impairs the adequate response to the hormone, while insulin production may not compensate for the demand, resulting in elevated blood glucose levels and the development of acute and chronic complications[5,7,8]. The function of incretins—gastrointestinal hormones that regulate insulin release after meals and inhibit hepatic glucose production—such as glucagon-like peptide-1 (GLP-1), is impaired in diabetic patients[9,10].

The treatment of DM involves a combination of lifestyle modifications (LSM), frequent blood glucose monitoring, and pharmacological therapies. Currently, several medications are available for DM management, including insulin and oral hypoglycemic agents. The first-line treatment for T1DM is insulin, whereas for T2DM, LSM combined with oral antidiabetic medications is recommended[1]. Among the most common oral hypoglycemics are biguanides, sulfonylureas, alpha-glucosidase inhibitors, and GLP-1 analogues[11,12].

Within this therapeutic context, phytotherapy has emerged as a promising option. Medicinal plants and their derivatives have long been recognized for their therapeutic potential in the prevention and treatment of various human diseases, contributing to the promotion and improvement of overall health[13]. These plants possess distinct chemical, organic, and inorganic properties, each with unique benefits, and are frequently used as complementary therapies, often based on traditional practices or personal recommendations[14]. The search for such natural remedies stems not only from their therapeutic efficacy but also from barriers to accessing complex healthcare services, the high costs of synthetic drugs, and cultural considerations[15].

Herbal medicines are formulated from phytochemicals extracted from various parts of plants, such as leaves, roots, stems, and flowers. They can be administered in the form of teas, capsules, juices, or oils[16,17]. The diversity in formulation and administration generates growing interest in these products, particularly among individuals seeking complementary and alternative approaches to conventional treatment.

Alternative and complementary approaches are widely used in primary care, particularly by family physicians, since this specialty seeks to understand not only the disease but also the cultural, social, and emotional contexts underlying health diagnoses. The use of medicinal plants stands out as a natural extension of this philosophy. The preventive and health-promoting focus of Family and Community Medicine (FCM) incorporates holistic therapeutic approaches that go beyond conventional disease treatment, offering patient-centered care while respecting cultures, traditions, and therapeutic preferences.

The selection of plants in this study was based on promising preclinical and clinical evidence reported in recent scientific literature, highlighting their pharmacological potential. These plants stand out for presenting standardized formulations, well-characterized bioactive compounds, and documented use in clinical studies with humans. This choice aims to strengthen the scientific basis of phytotherapy, prioritizing species with greater potential for future clinical application, while also considering the scarcity of validated herbal medicines specifically for the management of Diabetes *Mellitus*.

Therefore, this study aimed to address the central question regarding the scientific evidence related to the use of herbal medicines as complementary treatment for diabetes. Although several medicinal plants are marketed for their beneficial properties in glucose control, the safety and efficacy of these remedies remain inconsistent. Thus, diabetic patients seeking alternative treatment options face ambiguity and uncertainty.

Mundo Saúde. 2025,49:e17782025
DOI: 10.15343/0104-7809.202549e17782025I

METODOLOGY

This study is a systematic literature review conducted using the PRISMA method. Searches were performed in the PubMed, Virtual Health Library (BVS), and SciELO databases, using descriptors identified through the DeCS (Health Sciences Descriptors) platform, adapted for each database: "Curcuma," "Ginkgo," "Aloe vera," and "Diabetes," in both Portuguese and English. The research was conducted between September and October 2024. Inclusion criteria encompassed articles published between 2013 and 2024, original studies available in full text, randomized clinical trials, experimental studies, and articles from additional references. The article selection process is illustrated in Figure 1.

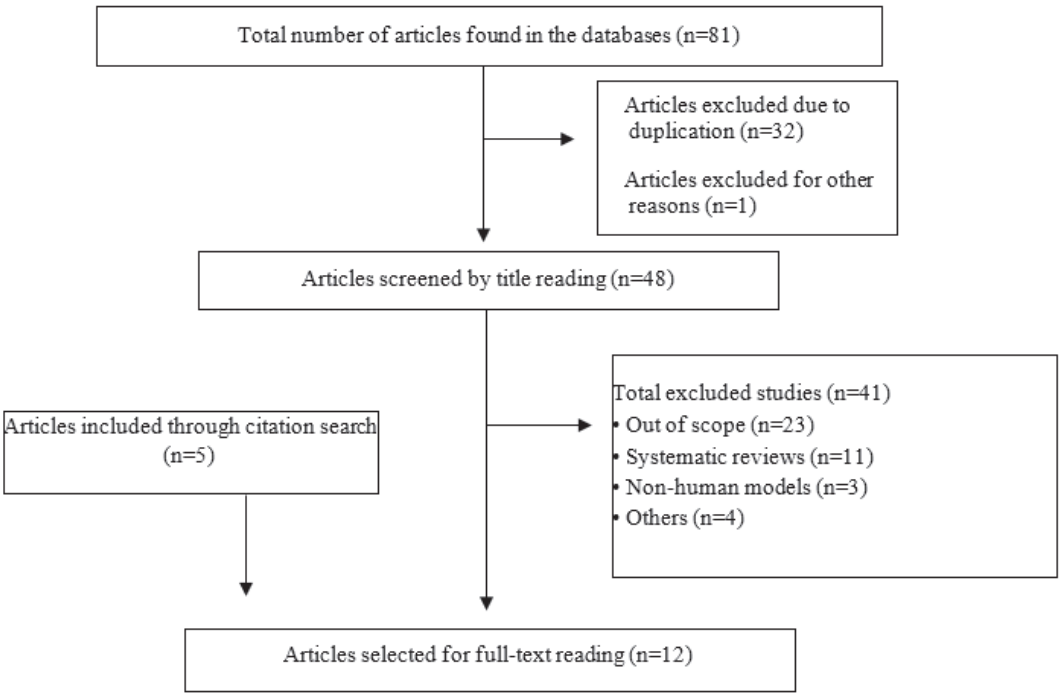


Figure 1 - Flowchart of the article selection methodology.

RESULTS

The database search yielded a total of 81 articles, distributed as follows: 23 from PubMed, four from *SciELO*, and 54 from BVS. However, after subsequent stages of screening and exclusion (Figure 1), only seven articles were included in the final review, with an additional five articles identified through citation searching.

The selected studies are presented in Table 1, categorized according to the plants investigated—*Curcuma longa* L. (*Zingiberaceae*), *Ginkgo biloba* L. (*Ginkgoaceae)*, and *Aloe vera* (L.) *Burm.f.* (*Asphodelaceae*)—and the main findings of each study. This structure provides a clear overview of the results, highlighting the most relevant scientific evidence on the use of these plants in the management of Diabetes *Mellitus*.

This rigorous selection process ensures that only high-quality studies aligned with the objectives of this review are included, thus strengthening the robustness of the conclusions presented. A detailed analysis of the results is discussed below, with emphasis on the clinical and methodological implications of the findings.

Table 1 - Distribution of articles selected for the systematic review.

Reference	Author and Year	Study Type	Sample	Dosage	Results
			Ginkgo biloba		
[18]	Aziz *et al.* (2018)	Randomized, double-blind, placebo-controlled	40 individuals with metabolic syndrome and uncontrolled glycemia	Group 1: Metformin + *Ginkgo biloba* dry extract 120 mg/day; Group 2: Metformin only. For 90 days.	HbA1c ↓0.6 (p=0.001); Capillary blood glucose ↓18 (p=0.002); Insulin ↓9.4 (p<0.001)
[19]	Zhao *et al.* (2016)	Randomized, double-blind, simulated, placebo-controlled, clinical	140 individuals with type 2 diabetes, aged 50–75 years	Liuwei Dihuang 62.5 mg, 8 tablets 3×/day + *Ginkgo biloba* 4 mg, 2 tablets 3×/day. For 36 months.	HbA1c ↓0.1 (p>0.05); Capillary blood glucose ↓5.4 (p>0.05). No significant difference between treatment and placebo groups.
[20]	Aziz *et al.* (2018)	Randomized, double-blind, placebo-controlled, multicenter clinical	47 individuals with uncontrolled type 2 diabetes	Metformin (500 or 850 mg) + powdered *Ginkgo biloba* extract 120 mg, 1 tablet/day. For 90 days.	HbA1c ↓0.7 (p<0.001); Capillary blood glucose ↓40 (p<0.001); Insulin ↓5.1 (p=0.006). Insulin results similar to placebo.
			Aloe Vera		
[21]	Devaraj *et al.* (2013)	Double-blind, placebo-controlled	45 pre-diabetic individuals with metabolic syndrome	(1) *Aloe vera* UP780 500 mg, 1 capsule 2×/day; (2) Aloe vera AC952 500 mg, 1 capsule 2×/day. For 8 weeks..	(1) UP780: HbA1c ↓0.3 (p<0.02); Capillary blood glucose ↓8 (p<0.02). (2) AC952: HbA1c ↓0.1 (p<0.05); Capillary blood glucose ↓6 (p<0.05). Effective for diabetes, with UP780 more significant.
[22]	Choi *et al.* (2013)	Randomized, double-blind	122 pre-diabetic individuals and patients with early-stage DM	*Aloe* QDM 700 mg (Aloe vera gel 147 mg + aloesin powder 3 mg + yeast chromone 125 mg), 2 capsules after breakfast and 2 after dinner. For 8 weeks.	Week 4: Capillary blood glucose ↓7 (p<0.01); Week 8: ↓3 (p=0.02). Low significance vs. placebo, but improvement in insulin resistance and fat mass.
[23]	Alinejad-Mofrad *et al.* (2015)	Randomized, double-blind	70 pre-diabetic individuals aged 35–65	(1) *Aloe vera* 300 mg (AL300), 1 capsule/day; (2) Aloe vera 500 mg (AL500), 1 capsule/day. For 8 weeks.	(1) AL300: HbA1c ↓0.2 (p=0.042); Capillary blood glucose ↓4 (p=0.002). (2) AL500: HbA1c ↓0.4 (p=0.011); Capillary blood glucose ↓7 (p<0.001). Effective for diabetes.
			Curcuma		
[24]	Rahim*i et al.* (2016)	Randomized, double-blind	70 type 2 diabetic individuals	Herbal drug: *Nano-curcumin* 80 mg, 1 capsule 3×/day. For 3 months.	HbA1c ↓0.28 (p<0.001); Capillary blood glucose ↓15 (p<0.049). Effective adjuvant effect.
[25]	Adab *et al.* (2019)	Randomized, double-blind	75 non–insulin-dependent type 2 diabetic individuals	Turmeric powder 700 mg, 1 capsule 3×/day. For 8 weeks.	HbA1c ↓0.2 (p=0.90); Capillary blood glucose ↓2 (p=0.57). Not significant.
[26]	Sukandar *et al.* (2014)	Randomized, double-blind, parallel	29 type 2 diabetic individuals, never used hypoglycemics	Dry turmeric extract 200 mg + garlic extract 200 mg, 3 capsules after meals. Control: Glibenclamide 5 mg, 1 capsule/day. For 14 weeks.	HbA1c ↓2.33 (p=0.000); Capillary blood glucose ↓51 (p<0.028).
[27]	Panahi *et al.* (2018)	Randomized, double-blind, parallel	100 type 2 diabetic individuals	Dry turmeric powder extract 500 mg + Piperine 5 mg, 1 capsule/day. For 3 months.	HbA1c ↓0.9 (p<0.001); Capillary blood glucose ↓9 (p<0.001).

DISCUSSION

Aloe vera, popularly known as "babosa," is a plant native to desert regions, well adapted to the Brazilian cerrado. It is a succulent plant belonging to the *Asphodelaceae* family, with numerous medicinal properties, including the treatment of scars, burns, laxative effects, and hair care[28].

The chemical composition of *Aloe vera* includes polysaccharides, amino acids, enzymes, vitamins, and minerals, which confer anti-inflammatory, antioxidant, and immunomodulatory properties[29]. In vitro and animal model studies indicate that the bioactive compounds of *Aloe vera*, such as lectins and

polysaccharides, may influence insulin secretion and improve insulin sensitivity, producing beneficial effects in reducing blood glucose levels[28]. Furthermore, evidence suggests antioxidant properties capable of mitigating the oxidative stress caused by Diabetes *Mellitus* (DM), a factor that contributes to the prevention of long-term complications[29,30,31].

The main active components of *Aloe vera* have been shown to exert direct effects on various health parameters, including the reduction of fasting blood glucose, adipose tissue, triglycerides, and glycated hemoglobin (HbA1c), as well as an increase in lean muscle mass[31]. The plant is described as having moderate hypoglycemic properties and the ability to potentiate the effects of drugs with this purpose, suggesting a potential impact on glucose levels[32]. Despite these scientifically demonstrated benefits, some studies have failed to show significant improvement in the hyperglycemic state of diabetic patients.

Regarding HbA1c reduction, a study conducted with 70 pre-diabetic patients with metabolic syndrome demonstrated the greatest reduction (0.4 ± 0.33, p=0.04) with a daily dose of 500 mg of *Aloe vera* extract powder[23]. This formulation is obtained from fresh leaf gel through cold drying or spray drying[33]. The results for capillary glucose (CG) are consistent with other studies, showing a reduction of 7 ± 4.2 (p=0.001). The formulation with a daily dose of 300 mg also demonstrated efficacy, though with less pronounced results.

One study compared specific *Aloe vera* powder formulations at different dosages, including UP780, enriched with chromone and 2% aloesin (1000 mg/day), and AC952, without chromone (1000 mg/day)[25]. The UP780 formulation showed a significant reduction in capillary glucose (CG) of 8 ± 16 (p<0.02) and HbA1c of 0.3 ± 0.6 (p<0.02). The AC952 formulation presented less pronounced reductions, with a decrease in CG of 6 ± 12 (p<0.05) and HbA1c of 0.1 ± 0.5 (p<0.05). Positive results for UP780 were also observed in studies conducted with alloxan-induced diabetic rats[34,35].

The largest clinical trial involved 122 pre-diabetic individuals or patients with early-stage Diabetes *Mellitus* (DM)[22]. The study employed comparative analysis at four and eight weeks, allowing the evaluation of progressive results. Participants received Aloe QDM (700 mg, including *Aloe vera* gel, aloesin, and chromone), with two capsules administered after breakfast and dinner. The results revealed a significant reduction in capillary glucose (CG) of 7 ± 2.0 (p<0.01) at the fourth week and 3 ± 1.5 (p=0.02) at the eighth week. Although these reductions were statistically significant, the study considered the results clinically modest, since values in the placebo group were similar. However, improvements in insulin resistance and fat mass reduction were observed, contributing to the decrease in CG. Hypoglycemic and hypolipidemic effects were also reported in studies with rats[36,37,38], suggesting possible variations in outcomes between human and animal studies.

A study evaluated 60 diabetic individuals treated with metformin and a daily dose of 450 mg of *Aloe vera* twice daily[39]. The study provided significant insights into the therapeutic potential of *Aloe vera* as complementary therapy for Diabetes *Mellitus* (DM). The proposed methodology compared oral antihyperglycemic treatment alone with treatment combined with herbal therapy. The results demonstrated a substantial reduction in capillary glucose (CG) of 13.94 ± 11.52 (p=0.001) in the herbal therapy group, compared to a reduction of 0.2 ± 0.18 (p=0.001) in the placebo group. Despite reports of gastrointestinal side effects, likely attributable to metformin[39,40,41,42], the study concluded that *Aloe vera* is safe and effective as an adjuvant treatment.

Curcuma longa L. (*Zingiberaceae*), commonly known as turmeric in Brazil, is one of many functional foods with therapeutic health benefits. *Curcumin*, the yellow-orange pigment present in turmeric, is responsible for its anti-inflammatory and antioxidant effects[43].

Turmeric (*Curcuma longa L.*) has been used for centuries, with origins tracing back to approximately 4000 BC in India, the 7th century in China, the 10th century in Arab countries, and its introduction into Europe in the 13th century. Initially valued for its nutritional similarities to ginger, turmeric later gained recognition for its numerous ethnomedicinal properties, including hepatoprotective, gastroprotective, anti-inflammatory, antimicrobial, anti-HIV, hypolipidemic, hypoglycemic, antiplatelet, dermatological, ophthalmological, antioxidant, and potential oncological benefits, as well as therapeutic effects on the respiratory, reproductive, digestive, and central nervous systems[44,45].

The functional characteristics of *Curcuma longa* have made it the focus of numerous investigations regarding its antioxidant and anti-inflammatory effects. Curcumin, the main phenolic compound in turmeric, is key to these effects. In addition to its ability to neutralize reactive oxygen species (ROS), curcumin enhances the activity of antioxidant enzymes such as glutathione (GSH), superoxide dismutase (SOD), and catalase (CAT) through supplementation[43,46,47].

Curcumin, derived from *Curcuma longa L.*, is a bioactive compound with documented use in the management of diabetes and its associated complications. Its molecular formula is $C_{21}H_{20}O_6$, and its molecular weight is 368.37 g/mol[48]. Turmeric, a spice native to Southeast Asia, is not only a flavor enhancer but also a source of curcumin, an antioxidant, antimicrobial, and coloring agent with potential applications in the cosmetics, textile, pharmaceutical, and food industries[47].

The studies by Hodaei *et al.* (2019)[49] and Adab *et al.* (2019)[25] employed turmeric powder at dosages of 1500 mg and 2100 mg, respectively. The first study, involving adult patients with type 2 diabetes (non–insulin-dependent) diagnosed between 1 and 10 years earlier, lasted 10 weeks. During this period, patients were instructed not to alter their usual dietary and physical activity habits, and statistical analyses confirmed no significant differences between groups in these factors. It reported an average change in HbA1c of −0.3 ± 0.4 (p=0.65) and a mean reduction in fasting blood sugar (FBS) of −7 ± 2 mg/dl (p=0.02) in the curcumin group. The second study, conducted over eight weeks without dietary or exercise standardization, reported reductions of 0.2 ± 0.98 in HbA1c (p<0.90) and 2 ± 28.33 in fasting glucose (p<0.57). Despite numerical improvements, both studies concluded that there was no statistically significant difference between treatment and placebo in HbA1c reduction. However, Hodaei *et al.* (2019)[49] demonstrated significant improvements in fasting glucose compared with placebo, whereas Adab *et al.*[25] did not report such significance. Divergent findings were observed in other studies. For example, a dosage of 300 mg/day of curcumin for three months in diabetic and obese patients resulted in significant reductions in glycemic markers and insulin resistance[50]. Similarly, a dosage of 1500 mg/day for three months also showed reductions in insulin resistance[51]. In animal models, curcumin reduced hyperglycemia and insulin resistance in obese rats fed high-fat diets[52] and in diabetic rat models[53]. These discrepancies highlight the need for standardized protocols to better elucidate the effects of curcumin.

When combined with other substances, curcumin's efficacy was comparable to other treatments. Sukandar *et al.* (2014)[26] studied the combination of 200 mg of curcumin extract with 200 mg of garlic extract in 29 individuals with type 2 diabetes, aged over 35 years, who were not using hypoglycemic drugs or insulin. The combination resulted in reductions of 2.33 ± 0.47 in HbA1c (p=0.000) and 51 ± 9.67 in fasting glucose (p<0.028). The HbA1c reduction was comparable to the effect of 5 mg of glibenclamide used as control, indicating similar glycemic control between the herbal combination and the drug. Panahi *et al.* (2018)[27] evaluated the combination of 500 mg of powdered curcumin extract and 5 mg of piperine, an alkaloid from black pepper with anti-inflammatory and antioxidant properties. In a study involving 100 patients with type 2 diabetes over three months, significant reductions were observed in HbA1c (0.9 ± 1.0, p<0.001) and fasting glucose (9 ± 34, p<0.001).

These findings were significant compared with placebo and demonstrated curcumin's efficacy in improving glycemic control when combined with piperine. Rahimi *et al.* (2016)[24] investigated nano-curcumin, a nanoparticulate formulation with greater bioavailability and antitumor properties. Over three months, participants consumed 80 mg of nano-curcumin daily, resulting in reductions in HbA1c (0.28 ± 1.54, p<0.001) and fasting glucose (15 ± 38.01, p<0.049), highlighting its potential as an adjuvant therapy for diabetes. *Ginkgo biloba*, an ancient plant native to China, is renowned for its resilience and medicinal applications. *Ginkgo biloba extract* (EGB) contains flavonoid glycosides and terpene trilactones, providing antioxidant, circulatory, and neuroprotective benefits[54,55]. Flavonoids in EGB contribute to its antioxidant properties, while terpenes act as antagonists of platelet-activating factor (PAF), implicated in insulin resistance and diabetic complications such as neuropathy, retinopathy, and vascular disorders[56,57,58].

Aziz *et al.* (2018)[18] compared the adjuvant use of EGB with metformin in 40 patients with metabolic syndrome and impaired fasting glucose. Combined therapy reduced HbA1c by 0.6 ± 0.7 (p=0.001) and fasting glucose by 18 ± 16.1 (p<0.002), outperforming metformin alone. Another study with type 2 diabetic patients using metformin and EGB also demonstrated significant improvements, including reductions in HbA1c (0.7 ± 1.2, p<0.001) and fasting glucose (40 ± 36.1, p<0.001)[20]. These findings are consistent with earlier animal studies showing similar protective effects against hyperglycemia and insulin resistance[59,60].

Zhao *et al.* (2016)[19] examined the combination of 24 mg of Ginkgo biloba with 1.5 g of Liuwei in type 2 diabetic patients, reporting reductions of 0.1 ± 1.1 in HbA1c (p>0.05) and 5.4 ± 25.2 in fasting glucose (p>0.05). Although these results did not reach statistical significance, the study observed a significantly lower prevalence of diabetic retinopathy and nephropathy in the treatment group, with relative risk reductions of 66% and 44%, respectively, over three years.

This review faced limitations, including a restricted number of studies, variability in sample sizes, dosage regimens, and study designs. These factors hinder robust comparisons and contribute

to inconsistencies in the results. Establishing standardized protocols for future research is essential to clarify the therapeutic potential of curcumin and *Ginkgo biloba* in diabetes management.

CONCLUSION

The plants studied stand out as promising herbal species and bioactive agents for complementary diabetes management, demonstrating benefits in glycemic control and mitigation of associated complications. However, the undeniable need for well-designed study protocols remains in order to standardize and improve the quality of research outcomes. Such efforts are essential to establish clear guidelines on dosage and administration, facilitating the integration of phytotherapy into diabetes treatment. This would ensure safe and effective therapeutic options while optimizing strategies for diabetes management.

CRediT author statement

Conceptualization: Duarte, RCO; Paiva, MJM. Methodology: Duarte, RCO; Souza, GS. Validation: Paiva, MJM. Statistical analysis: Paiva, MJM. Formal analysis: Herrera, SDSC. Investigation: Duarte, RCO; Diogo, RF. Resources: Diogo, RF. Original draft: Duarte, RCO. Writing-review and editing: Souza, GS; Paiva, MJM, Araújo, LC. Visualization: Herrera, SDSC. Supervision: Paiva, MJM. Project administration: Duarte, RCO.

All authors have read and agreed to the published version of the manuscript.

Funding

The authors did not receive funding for the development of the present research.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the workreported in this paper.

REFERENCES

1. American Diabetes Association. Classification and Diagnosis of Diabetes: Standards of Medical Care in Diabetes-2021. Diabetes Care. 2021 Jan;44(Suppl 1):S15–33. https://doi.org/10.2337/dc21-S002
2. Saeedi P, Petersohn I, Salpea P, Malanda B, Karuranga S, Unwin N, et al. Global and regional diabetes prevalence estimates for 2019 and projections for 2030 and 2045: Results from the International Diabetes Federation Diabetes Atlas, 9th edition. Diabetes Res Clin Pract. 2019 Nov 1;157:107843. https://doi.org/10.1016/j.diabres.2019.107843
3. Pan American Health Organization. Panorama of Diabetes in the Americas [Internet]. 2022 [cited 2023 Nov 20]. Available from: https://iris.paho.org/handle/10665.2/56643
4. Engelgau MM, Geiss LS, Saaddine JB, Boyle JP, Benjamin SM, Gregg EW, et al. The evolving diabetes burden in the United States. Ann Intern Med. 2004 Jun 1;140(11):945–50. https://doi.org/10.7326/0003-4819-140-11-200406010-0003
5. Robertson RP. Antagonist: diabetes and insulin resistance--philosophy, science, and the multiplier hypothesis. J Lab Clin Med. 1995 May;125(5):560–4; discussion 565.
6. Lucier J, Weinstock RS. Type 1 Diabetes. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2023 [cited 2023 Nov 20]. Available from: http://www.ncbi.nlm.nih.gov/books/NBK507713/
7. Westermark P, Johnson KH, O'Brien TD, Betsholtz C. Islet amyloid polypeptide--a novel controversy in diabetes research. Diabetologia. 1992 Apr;35(4):297–303.
8. Li Y, Xu W, Liao Z, Yao B, Chen X, Huang Z, et al. Induction of long-term glycemic control in newly diagnosed type 2 diabetic patients is associated with improvement of beta-cell function. Diabetes Care. 2004 Nov;27(11):2597–602. https://doi.org/10.2337/diacare.27.11.2597
9. Calanna S, Christensen M, Holst JJ, Laferrère B, Gluud LL, Vilsbøll T, et al. Secretion of glucagon-like peptide-1 in patients with type 2 diabetes mellitus: systematic review and meta-analyses of clinical studies. Diabetologia. 2013 May;56(5):965–72. https://doi.org/10.1007/s00125-013-2841-0
10. Vilsbøll T, Krarup T, Deacon CF, Madsbad S, Holst JJ. Reduced postprandial concentrations of intact biologically active glucagon-like peptide 1 in type 2 diabetic patients. Diabetes. 2001 Mar;50(3):609–13. https://doi.org/10.2337/diabetes.50.3.609
11. Effect of intensive blood-glucose control with metformin on complications in overweight patients with type 2 diabetes (UKPDS 34). The Lancet. 1998 Sep 12;352(9131):854–65. PMID: 9742977
12. Inzucchi SE, Bergenstal RM, Buse JB, Diamant M, Ferrannini E, Nauck M, et al. Management of hyperglycemia in type 2 diabetes: a patient-centered approach: position statement of the American Diabetes Association (ADA) and the European Association for the Study of Diabetes (EASD). Diabetes Care. 2012 Jun;35(6):1364–79. https://doi.org/10.2337/dc12-0413
13. De Carvalho AC, Oliveira AADS, Siqueira LDP. Medicinal plants used in the treatment of Diabetes Mellitus: A review. Braz J Health Rev. 2021 Jun 11;4(3):12873–94. https://doi.org/10.34119/bjhrv4n3-247
14. Pedroso RDS, Andrade G, Pires RH. Medicinal plants: a perspective on safe and rational use. Physis Rev Saúde Coletiva. 2021;31(2):e310218. https://doi.org/10.1590/S0103-73312021310218
15. Guimarães BM, Ramos KA, Souza MCD, Franco ML, Alves CCDS, Carli ADP, et al. Therapeutic practices with medicinal plants for the treatment of Diabetes Mellitus. Res Soc Dev. 2021 Aug 16;10(10):e474101018874. https://doi.org/10.33448/rsd-v10i10.18874
16. Kalluf L de JH. Functional phytotherapy: from active principles to phytotherapic prescriptions. In: Functional phytotherapy [Internet]. 2008 [cited 2023 Nov 26]. p. 304–304. Available from: https://pesquisa.bvsalud.org/portal/resource/pt/lil-558217

17. Katiyar C, Gupta A, Kanjilal S, Katiyar S. Drug discovery from plant sources: An integrated approach. Ayu. 2012;33(1):10–9. https://doi.org/10.4103/0974-8520.100295
18. Aziz TA, Hussain SA, Mahwi TO, Ahmed ZA. Efficacy and safety of Ginkgo biloba extract as an "add-on" treatment to metformin for patients with metabolic syndrome: a pilot clinical study. Ther Clin Risk Manag. 2018;1219–26.
19. Zhao Y, Yu J, Liu J, An X. The Role of Liuwei Dihuang Pills and Ginkgo Leaf Tablets in Treating Diabetic Complications. Evid Based Complement Altern Med. 2016;7931314–7931314.
20. Aziz TA, Hussain SA, Mahwi TO, Ahmed ZA, Rahman HS, Rasedee A. The efficacy and safety of Ginkgo biloba extract as an adjuvant in type 2 diabetes mellitus patients ineffectively managed with metformin: a double-blind, randomized, placebo-controlled trial. Drug Des Devel Ther. 2018;12:735–42.
21. Devaraj S, Yimam M, Brownell LA, Jialal I, Singh S, Jia Q. Effects of Aloe vera supplementation in subjects with prediabetes/metabolic syndrome. Metab Syndr Relat Disord. 2013;35–40. https://doi.org/10.1089/met.2012.0066
22. Choi HC, Kim SJ, Son KY, Oh BJ, Cho BL. Metabolic effects of aloe vera gel complex in obese prediabetes and early untreated diabetic patients: randomized controlled trial. Nutrition. 2013;1110–4. https://doi.org/10.1016/j.nut.2013.02.015
23. Alinejad-Mofrad S, Foadoddini M, Saadatjoo SA, Shayesteh M. Improvement of glucose and lipid profile status with Aloe vera in pre-diabetic subjects: a randomized controlled-trial. J Diabetes Metab Disord. 2015;22–22. https://doi.org/10.1186/s40200-015-0137-2
24. Rahimi HR, Mohammadpour AH, Dastani M, Jaafari MR, Abnous K, Ghayour Mobarhan M, et al. The effect of nano-curcumin on HbA1c, fasting blood glucose, and lipid profile in diabetic subjects: a randomized clinical trial. Avicenna J Phytomedicine. 2016;6(5):567–77.
25. Adab Z, Eghtesadi S, Vafa M, Heydari I, Shojaii A, Haqqani H, et al. Effect of turmeric on glycemic status, lipid profile, hs-CRP, and total antioxidant capacity in hyperlipidemic type 2 diabetes mellitus patients. Phytother Res. 2019 Apr;33(4):1173–81.
26. Sukandar EY, Sudjana P, Adnyana IK, Setiawan AS, Yuniarni U. Recent Study of Turmeric in Combination with Garlic as Antidiabetic Agent. Procedia Chem. 2014;13:44–56.
27. Panahi Y, Khalili N, Sahebi E, Namazi S, Simental-Mendía L, Majeed M, et al. Effects of Curcuminoids Plus Piperine on Glycemic, Hepatic and Inflammatory Biomarkers in Patients with Type 2 Diabetes Mellitus: A Randomized Double-Blind Placebo-Controlled Trial. Drug Res. 2018 Jul;68(7):403–9.
28. Fleming T, editor. PDR for herbal medicines. 2nd ed. Montvale, NJ: Medical Economics Co; 2000. https://naturalingredient.org/wp/wp-content/uploads/Pdr_for_Herbal_Medicines.pdf
29. Eshun K, He Q. Aloe vera: a valuable ingredient for the food, pharmaceutical and cosmetic industries--a review. Crit Rev Food Sci Nutr. 2004;44(2):91–6. https://doi.org/10.1080/10408690490424694
30. PubChem. CID 369012 [Internet]. [cited 2024 Jan 4]. Available from: https://pubchem.ncbi.nlm.nih.gov/compound/369012
31. Yongchaiyudha S, Rungpitarangsi V, Bunyapraphatsara N, Chokechaijaroenporn O. Antidiabetic activity of Aloe vera L. juice. I. Clinical trial in new cases of diabetes mellitus. Phytomedicine Int J Phytother Phytopharm. 1996 Nov;3(3):241–3.
32. Pejuçara Aloe Use - RS | Journal of Health Sciences [Internet]. [cited 2023 Dec 2]. Available from: https://journalhealthscience.pgsskroton.com.br/article/view/301
33. Queiroga V de P. Aloe vera (babosa): commercial scale planting technologies for the semi-arid region and utilization. Arepb; 2018. https://www.infoteca.cnptia.embrapa.br/infoteca/handle/doc/1120076
34. Tseng-Crank J, Do SG, Corneliusen B, Hertel C, Homan J, Yimam M, et al. UP780, a Chromone-Enriched Aloe Composition, Enhances Adipose Insulin Receptor Signaling and Decreases Liver Lipid Biosynthesis. Open J Genet. 2013 Jul 21;3(2):9. https://doi.org/10.4236/
35.Yimam M, Zhao J, Corneliusen B, Pantier M, Brownell L, Jia Q. Blood glucose-lowering activity of aloe-based composition, UP780, in alloxan-induced insulin-dependent mouse diabetes model. Diabetol Metab Syndr. 2014 May 24;6:61. https://doi.org/10.1186/1758-5996-6-61
36.Shin S, Kim S, Oh HE, Kong H, Shin E, Do SG, et al. Dietary Aloe QDM Complex Reduces Obesity-Induced Insulin Resistance and Adipogenesis in Obese Mice Fed a High-Fat Diet. Immune Netw. 2012 Jun;12(3):96–103. https://doi.org/10.4110/in.2012.12.3.96
37.Lee Y, Kim J, An J, Lee H, Kong H, Song Y, et al. Aloe QDM complex enhances specific cytotoxic T lymphocyte killing in vivo in metabolic disease mice. Biosci Biotechnol Biochem. 2017 Mar 4;81(3):595–603. https://doi.org/10.1080/09168451.2016.1258986
38.Shin E, Shin S, Kong H, Lee S, Do SG, Jo TH, et al. Dietary Aloe Reduces Adipogenesis via the Activation of AMPK and Suppresses Obesity-related Inflammation in Obese Mice. Immune Netw. 2011;11(2):107.
39.G PTF, A EMRu, M TS, R GA. The effectiveness and safety of Aloe vera as an adjunct treatment to metformin in diabetic patients seen at the QCGH family medicine outpatient department. Filip Fam Physician. 2015;25–35.
40.Borg MJ, Rayner CK, Jones KL, Horowitz M, Xie C, Wu T. Gastrointestinal Mechanisms Underlying the Cardiovascular Effect of Metformin. Pharmaceuticals. 2020 Nov 22;13(11):410.
41.McCreight LJ, Bailey CJ, Pearson ER. Metformin and the gastrointestinal tract. Diabetologia. 2016 Mar;59(3):426–35.
42.Raju B, Resta C, Tibaldi JT. Metformin and late gastrointestinal complications. Am J Med. 2000 Aug;109(3):260–1. doi:10.1016/S0002-9343(00)00522-2
43.Seliprandy Peres A, Garonci Alves Vargas E, Rocha Simonin De Souza V. Functional Properties of Turmeric in Nutritional Supplementation. REINPEC. 2015 Dec 10;1(2):218–29.
44.Alonso J. Tratado de fitofármacos e nutracêuticos. AC Farmacêutica; 2013.
45.Avci G, Kadioglu H, Sehirli AO, Bozkurt S, Guclu O, Arslan E, et al. Curcumin protects against ischemia/reperfusion injury in rat skeletal muscle. J Surg Res. 2012 Jan;172(1):e39–46.
46.Sabir SM, Zeb A, Mahmood M, Abbas SR, Ahmad Z, Iqbal N. Phytochemical analysis and biological activities of ethanolic extract of Curcuma longa rhizome. Braz J Biol. 2020 Sep 21;81:737–40.
47.Silva JM da, Silva VG da, Araujo RR da S, Araujo MCC de, Constant PBL, Fanchiotti FE. Properties of Curcuma longa L. in type 2 diabetes mellitus: Integrative review. RBONE - Rev Bras Obesidade Nutr E Emagrecimento. 2020;14(90):1180–91.
48.Priyadarsini KI. The Chemistry of Curcumin: From Extraction to Therapeutic Agent. Molecules. 2014 Dec 1;19(12):20091–112.
49.Hodaei H, Adibian M, Nikpayam O, Hedayati M, Sohrab G. The effect of curcumin supplementation on anthropometric indices, insulin resistance and oxidative stress in patients with type 2 diabetes: a randomized, double-blind clinical trial. Diabetol Metab Syndr. 2019 Dec;11(1):41.
50.Na LX, Li Y, Pan HZ, Zhou XL, Sun DJ, Meng M, et al. Curcuminoids exert glucose-lowering effect in type 2 diabetes by decreasing serum free fatty acids: a double-blind, placebo-controlled trial. Mol Nutr Food Res. 2013 Sep;57(9):1569–77.
51.Chuengsamarn S, Rattanamongkolgul S, Phonrat B, Tungtrongchitr R, Jirawatnotai S. Reduction of atherogenic risk in patients with type 2 diabetes by curcuminoid extract: a randomized controlled trial. J Nutr Biochem. 2014 Feb;25(2):144–50.
52.Jang EM, Choi MS, Jung UJ, Kim MJ, Kim HJ, Jeon SM, et al. Beneficial effects of curcumin on hyperlipidemia and insulin resistance in high-fat-fed hamsters. Metabolism. 2008 Nov;57(11):1576–83.
53.Weisberg SP, Leibel R, Tortoriello DV. Dietary curcumin significantly improves obesity-associated inflammation and diabetes in mouse models of diabesity. Endocrinology. 2008 Jul;149(7):3549–58.
54.Biernacka P, Adamska I, Felisiak K. The Potential of Ginkgo biloba as a Source of Biologically Active Compounds—A Review of the Recent Literature and Patents. Molecules. 2023 May 9;28(10):3993.
55.Drieu K. Preparation and Definition of Ginkgo biloba Extract. In: Fünfgeld EW, editor. Rökan. Berlin, Heidelberg: Springer; 1988. p. 32–6.
56.Cheng D, Liang B, Li Y. Antihyperglycemic Effect of Ginkgo biloba Extract in Streptozotocin-Induced Diabetes in Rats. BioMed Res Int.

2013;2013:162724.
57.Kudolo GB, Bressler P, DeFronzo RA. Plasma PAF acetylhydrolase in non-insulin dependent diabetes mellitus and obesity: effect of hyperinsulinemia and lovastatin treatment. J Lipid Mediat Cell Signal. 1997 Nov;17(2):97–113.
58.Robertson RP, Tanaka Y, Takahashi H, Tran POT, Harmon JS. Prevention of oxidative stress by adenoviral overexpression of glutathione-related enzymes in pancreatic islets. Ann N Y Acad Sci. 2005 Jun;1043:513–20.
59.Ajabnoor MA. Effect of aloes on blood glucose levels in normal and alloxan diabetic mice. J Ethnopharmacol. 1990 Feb;28(2):215–20.
60.Kudolo GB. The effect of 3-month ingestion of Ginkgo biloba extract (EGb 761) on pancreatic beta-cell function in response to glucose loading in individuals with non-insulin-dependent diabetes mellitus. J Clin Pharmacol. 2001 Jun;41(6):600–11.

How to cite this article: Duarte, R.C.O., Souza, G.S., Araújo, L.C., Herrera, S.D.S.C., Diogo, R.F., Paiva, M.J.M. (2025). The use of medicinal plants in the supplementary treatment of Diabetes *Mellitus*. *O Mundo Da Saúde*, 49. https://doi.org/10.15343/0104-7809.202549e17782025I. Mundo Saúde. 2025,49:e17782025.