

HERBAL-BASED SUPPLEMENTS OF PHYTOTHERAPEUTIC POTENTIAL IN THE PREVENTION AND MANAGEMENT OF PREDIABETES

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REVIEW ARTICLE

Abstract

This synthesis paper aims to address the biomedical significance of relevant medicinal plants through their hypoglycemic properties, promising for the prevention and management of diabetes, the efficacy of phytotherapeutic supplements, available studies, mechanisms of action and biochemical aspects, and comparative analysis of supplements. This article aims to provide an in-depth look at the potential of phytotherapeutic supplements, combining data obtained from preclinical and clinical studies with the analysis of the molecular mechanisms involved. The results presented in this review contribute to substantiating the knowledge needed to integrate herbal treatments into modern medical practice, thus supporting the adoption of complementary therapeutic strategies in the face of the increasing incidence of diabetes. The main findings include efficacy (most herbal supplements have demonstrated the ability to lower HbA1c levels and fasting blood glucose), active mechanisms that include stimulating insulin secretion, increasing insulin sensitivity, and reducing inflammation. It is necessary to adopt standardized methods of extraction and administration to ensure the consistency of the results. Future studies should target larger populations and a robust methodological design to clearly establish clinical benefits and possible adverse effects. By clarifying the beneficial effects, mechanisms of action and current limitations, future research will be able to develop standardized treatment protocols that maximize the benefits of phytotherapy and minimize the associated risks. The integration of these treatments into current medical systems can represent a viable solution for patients facing the chronic form of diabetes, helping to improve the quality of life and reduce treatment costs in the long term.

Keywords: antioxidant, anti-inflammatory, glycemic control, bioavailability, extraction.

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INTRODUCTION

Diabetes is one of the most widespread metabolic diseases, affecting millions of people globally (Alhar et al., 2025). This chronic condition, characterized by hyperglycemia and insulin metabolism disorders, leads to severe complications such as cardiovascular disease, kidney failure, retinopathy, and neuropathy (Kumar et al., 2021). Prediabetes is defined as an intermediate state, in which glycemic levels are higher than normal, but do not reach the

diagnostic threshold of type 2 diabetes. Identifying preventive strategies and complementary treatments thus becomes essential for managing and, in the long term, reducing the incidence of diabetes (Mostafa et al., 2021; Mtshali and Sookan-Kassie, 2024).

Phytotherapeutic supplements, derived from medicinal plants, have increasingly captured the interest of the scientific community and specialists in the medical and pharmaceutical fields (Chattopadhyay et al., 2022). Recent studies suggest that certain plant extracts such as *Aloe vera*, *Psyllium fiber*, *Fenugreek seeds*, *Nigella sativa*, *Astragalus membranaceus*, *Allium sativum* (Garlic),

Momordica charantia (Bitter Melon), *Hibiscus sabdariffa* L. (Roselle), *Curcuma longa* (Turmeric), *Zingiber officinale* (Ginger) have been investigated in the context of improving glycemic control and reducing the risk of complications associated with diabetes (Jamrozik et al., 2022; Tabatabaei-Malazy et al., 2025). These plants can act by secreting and increasing insulin sensitivity, reducing oxidative stress and modulating inflammation, essential aspects in the pathogenesis of type 2 diabetes (Firdous et al., 2025).

Currently, the literature provides evidence that highlights the benefits of these phytotherapeutic supplements (Al-Makhmari et al., 2025). For example, the results of some meta-analyses showed that *Aloe vera*, Psyllium fiber and fenugreek seeds can significantly reduce HbA1c (glycated hemoglobin) and glycemic levels compared to conventional treatments, and clinical trials conducted in different countries show comparable efficacy with allopathic treatments (Willcox et al., 2021). At the same time, traditional sources of knowledge, such as traditional Chinese medicine and Ayurvedic medicine, have used these plants for centuries, and the transfer of these practices to modern science offers a bridge between tradition and technology (Sriraman et al., 2023).

The role of evidence-based information is essential in this branch of investigation. The prevalence of preclinical studies, while promising, raises questions about the replication of results in clinical trials and the optimization of doses and forms of administration (Adam et al., 2022; Al-Makhmari et al., 2025). In addition, the lack of knowledge of many health professionals about the existing evidence limits open communication with patients seeking complementary treatments (Sriraman et al., 2023). Thus, the aim of this paper is to evaluate, through a systematic review, the phytotherapeutic potential of herbal supplements for the prevention and management of prediabetes and diabetes, presenting a synthesis of the available results.

In the global context of increasing incidence of diabetes, the prevalence of prediabetes and associated complications requires the adoption of interdisciplinary strategies, where herbal supplements could have a significant complementary role. This information is particularly relevant both for researchers in the field of biochemistry and pharmacology, as well as for clinical specialists looking for alternative and complementary options for the treatment of patients (Chattopadhyay et al., 2023; Heinrich et al., 2022).

MATERIAL AND METHOD

To carry out this review, scientific databases such as PubMed, ScienceDirect, Wiley Online Library, MEDLINE and Google Scholar were analyzed. The searches were carried out using keywords such as "diabetes", "prediabetes", "plant-based therapy", "phytotherapeutic supplements", along with specific terms extracted from the available studies.

The inclusion criteria consisted of the publication of studies presenting clinical or preclinical data on the efficacy of herbal supplements in reducing glycemic levels and preventing complications associated with diabetes. Studies that did not include complete data or were not validated by rigorous statistical methods were excluded.

Relevant data were extracted from the selected articles, including information on: the type of study, duration of treatment and doses administered, reported outcomes such as changes in HbA1c, fasting blood glucose, cholesterol levels and other metabolic parameters. For a clear and structured interpretation of the results, we have made the following table (Table 1) and a diagram illustrating the mechanistic flow from the administration of a phytotherapeutic supplement to the final impact on glucose metabolism and glycemic control (Figure 1).

Table 1

Comparison of phytotherapeutic supplements used in studies

Medicinal plant	Active compounds	Mechanism of action	Reported efficacy	Bibliographic references
<i>Aloe vera</i>	Polyphenols, enzymes, amino acids	Improving insulin secretion, anti-	Significant reduction in HbA1c	(Chattopadhyay et al., 2022; Firdous et al., 2025; Unuofin

		inflammatory properties		and Lebelo, 2020)
Psyllium fiber	Soluble Fiber	Slowing down carbohydrate absorption	Reduction averages of HbA1c	(Shen et al., 2025; Wang et al., 2025; Willcox et al., 2021)
Fenugreek seeds	Alkaloids, saponins, fiber	Increased insulin sensitivity	About 0.85% HbA1c reduction	(Ali et al., 2025; Deshpande et al., 2025; Muluye et al., 2024; Willcox et al., 2021)
<i>Nigella sativa</i>	Thymoquinone, fatty acids, carvacrol, terpinene	Anti-inflammatory and antioxidant activity	Clinically significant reduction in blood glucose and HbA1c	(Adam et al., 2022; Karimi et al., 2025; Morar (Romoccea) et al., 2025)
<i>Astragalus membranaceus</i>	Polysaccharides, Flavonoids	Modulation of glucose metabolism	Moderate effect on blood sugar	(Willcox et al., 2021)
<i>Allium sativum</i>	Allicin, sulfur compounds	Improving glycemic control, antioxidant	Effect comparable to conventional treatments	(Firdous et al., 2025; Kumar et al., 2021; Yedjou et al., 2023)
<i>Momordica charantia</i>	Flavonoids, glycosides, phytosterols	Increased glucose absorption, activation of the glucose transporter 4 (GLUT 4)	Hypoglycemic effects, increased insulin secretion	(Chattopadhyay et al., 2022; Firdous et al., 2025; Guarneiri et al., 2025; Yedjou et al., 2023)
<i>Hibiscus sabdariffa</i> L.	Anthocyanins, polyphenols, flavonoids (hibiscetine)	Improved insulin sensitivity, antioxidant properties	Significant reduction in blood sugar in prediabetes	(Mistry et al., 2025; Tabatabaei-Malazy et al., 2025; Yedjou et al., 2023)
<i>Curcuma longa</i>	Curcuminoids, tumerone	Antioxidant, Anti-inflammatory	Reduction of hyperglycemia and pancreatic protection	(Alhar et al., 2025; Chattopadhyay et al., 2022; Unuofin and Lebelo, 2020)
<i>Zingiber officinale</i>	Gingerols, shogaols, zingiberene	Stimulation of insulin secretion	Beneficial effect on glycemic control	(Chattopadhyay et al., 2022; Firdous et al., 2025)

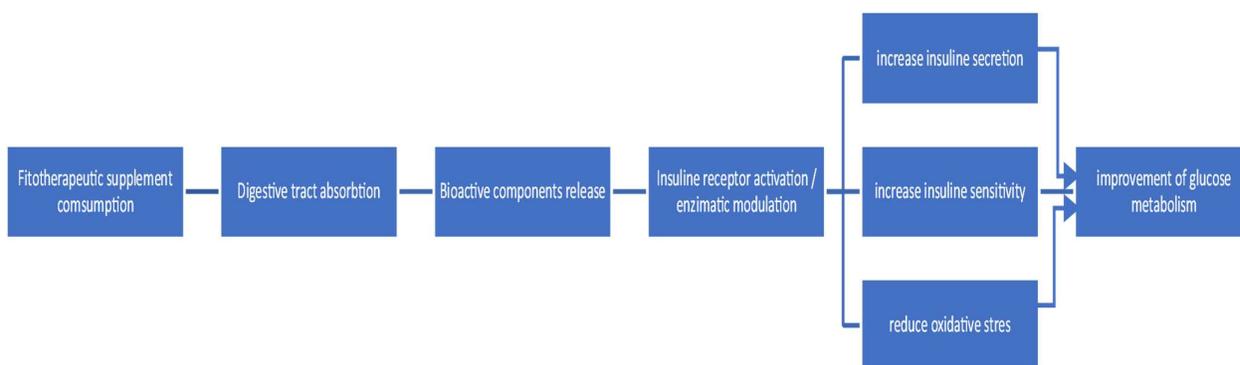


Figure 1 The mechanism of biological action of phytotherapeutic supplements

RESULTS AND DISCUSSIONS

The results obtained from studies indicate that many of the plants used are based on bioactive compounds that can reduce blood sugar levels, improve insulin sensitivity and alleviate oxidative stress (Hannan et al., 2021). Recent meta-analyses have highlighted that extracts of *Aloe vera*, Psyllium fiber and Fenugreek seeds are among the most effective in reducing HbA1c values, with significant effects comparable to conventional treatments (Sriraman et al., 2023; Willcox et al., 2021). Studies have also focused on how it is administered – in the form of capsules or liquid extract – highlighting that the form of administration can influence the bioavailability of the active compounds.

Studies on *Hibiscus sabdariffa* L. have suggested anti-inflammatory and hypoglycemic effects through the action of bioactive compounds, such as flavonoids, anthocyanins, phenolic acids. One animal study reported that administration of 72 mg/200 g body weight and 288 mg/200 g body weight for 21 days decreased the glycemic profile in diabetic rats (Yedjou et al., 2023).

Studies with *Curcuma longa*, often administered in combination with *Allium sativum*, have reported a significant decrease in fasting and postprandial blood glucose, due to the synergy between curcuminoids and sulfur compounds (Alhar et al., 2025; Chattopadhyay et al., 2022; Unuofin and Lebelo, 2020).

Most clinical trials focus on capsule administration, with varying treatment periods (from 14 days to 12 weeks). In animal models, herbal extracts have suggested overwhelming evidence of the regenerative ability of pancreatic beta cells, reduced oxidative stress, and improved glucose metabolism (Unuofin and

Lebelo, 2020). For example, administering bitter melon extract to diabetic rats resulted in decreased glycemic levels and protection of pancreatic tissues, although the results were not always replicable in clinical trials in humans (Yedjou et al., 2023). These differences can be attributed to variability in the chemical composition of the extracts, dosage differences, and specific experimental conditions (Chattopadhyay et al., 2022).

The mechanisms by which herbal supplements influence glucose metabolism are multiple and complex. Among the major mechanisms are: modulation of insulin secretion and sensitivity (many plants, such as bitter melon and turmeric, contain compounds that can stimulate insulin secretion and improve sensitivity to it – for example, bitter melon contains peptides with an insulin mimetic effect that can activate glucose transporters on target cells); antioxidant and anti-inflammatory action (plants such as garlic, turmeric and ginger are rich in compounds with strong antioxidant and anti-inflammatory properties, helping to reduce oxidative stress, which is a major cause of cell damage in diabetes); slowing down the absorption of carbohydrates (the soluble fiber in Psyllium reduces the rate of carbohydrate absorption, thus improving the postprandial glycemic response). These mechanisms have been visualized in the mechanistic flow diagram presented above, which highlights how taking supplements leads to a series of biochemical reactions that culminate in the regulation of glucose metabolism (Firdous et al., 2025; Unuofin and Lebelo, 2020).

This comparative analysis suggests that although the benefits of each herb may vary depending on the dose administered and the form of preparation, there is a consensus on the ability of these supplements to complement

conventional therapies in the management of diabetes.

Another important aspect is the variability and bioavailability of the active compounds. For example, bitter melon extract has demonstrated contrasting results between preclinical and clinical studies, which can be attributed to regional differences in the chemical composition of the plant and preparation methodologies (Yedjou et al., 2023). In contrast, the combination of turmeric and garlic has been a topic of interest due to the synergistic effects reported in clinical trials comparable to standardized treatments.

CONCLUSIONS

The systematic review of the literature on herbal supplements for the prevention and management of prediabetes and diabetes highlights some conclusions.

Studies reveal that extracts from *Aloe vera*, Psyllium, *Hibiscus sabdariffa* L., Fenugreek seeds, garlic, turmeric and ginger have the potential to reduce blood sugar levels, thus improving diabetes control and decreasing the risk of associated complications.

Supplements act through multiple biochemical pathways: increased insulin secretion and sensitivity, reduced carbohydrate absorption, protection against oxidative stress, and anti-inflammatory activity, highlighting complementary mechanisms.

There is variability in outcomes depending on the form of administration, doses and extraction methodologies, which underscores the need for standardization of the treatment protocol to ensure the reproducibility of clinical results.

Although preclinical results and some clinical trials are promising, better evaluation through large studies and randomized controlled trials is needed to validate the long-term efficacy and safety of these herbal supplements.

In summary, phytotherapeutic supplements are shown to be a promising strategy in the prevention and management of diabetes, offering an alternative or complement to conventional treatments. The implementation of these supplements, however, requires standardization in terms of dosage, extraction method and administration, in addition to a continuous evaluation of the risks and benefits for each subgroup of patients.

This paper provides a synthesis of the literature on phytotherapeutic supplements in the context of prediabetes and diabetes, emphasizing the importance of multidisciplinary and collaborative studies in the development of future prevention and treatment strategies.

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