

Literature Review of Herbal Remedies Used for Diabetes Mellitus: Efficacy, Safety, and Regulatory Considerations

Nada M. Sonji¹*, Ghassan M. Sonji¹*

¹Pharmaceutical Sciences Department, School of Pharmacy, Lebanese International University, Beirut, Lebanon

ABSTRACT

The Problem: The rising prevalence of Type 2 Diabetes presents a significant global health burden and economic strain, driving interest in herbal medicine as a potentially cost-effective alternative or supplement to conventional treatments.

Experimental Approach: This literature review included peer-reviewed studies published between 2018 and 2024. A comprehensive search of databases such as PubMed, Scopus, and Google Scholar was conducted using terms related to diabetes, herbal medicine, and cost-effectiveness. The included studies originated from various countries, including India, China, the United States, the United Kingdom, Saudi Arabia, and several African nations. Studies targeting adult participants with diabetes and assessing the effectiveness, cost, or user experiences of herbal remedies were included. In contrast, studies involving children, non-peer-reviewed articles, and those not directly related to herbal medicine were excluded. Data extraction was performed independently by two researchers using a standardized form to collect information on study characteristics, sample size, herbal remedies, glycemic control outcomes, and side effects.

Major Findings: A total of 45 studies were included, comprising randomized controlled trials (RCTs) and observational studies. The findings indicated that specific herbal remedies can significantly enhance glycemic control, with an average reduction in HbA1c ranging from 0.5% to 1.5%. Additionally, the economic impact of these remedies showed potential cost advantages compared to conventional treatments, although their safety profiles revealed some associated side effects.

Conclusions: This review highlights the potential benefits of herbal remedies in managing Type 2 Diabetes but underscores the need for further research. Future studies should specifically address optimal dosages, interactions with conventional medications, cost-effectiveness, and long-term safety and efficacy, particularly through RCTs with larger sample sizes and extended follow-up periods.

Keywords: Herbal Medicine; Type 2 Diabetes; Cost-effectiveness; Glycemic Control; User profiles; Economic Impact.

1. INTRODUCTION

Type 2 Diabetes (T2D) is a chronic metabolic disorder characterized by elevated blood glucose levels, resulting from insulin resistance and impaired insulin secretion (1).

**Corresponding author:*

Nada M. Sonji: nada.sonji@liu.edu.lb

Ghassan M. Sonji: ghassan.sonji@liu.edu.lb

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The International Diabetes Federation estimated that approximately 537 million adults were affected globally in 2021, with projections reaching 643 million by 2030 and 783 million by 2045 (2). This escalating prevalence underscores the urgent need for effective management strategies.

While conventional management approaches offer some benefits, they often come with significant limitations, including side effects and high costs (3). These challenges have spurred interest in complementary and alternative

medicine (CAM), particularly herbal remedies, as potential adjuncts or alternatives in T2D management (4).

Herbal medicine has a long history of treating various ailments, including diabetes, across many cultures. Recent scientific investigations have demonstrated how certain herbs may influence glucose metabolism. For instance, some herbal compounds may improve insulin sensitivity, stimulate insulin secretion, or inhibit carbohydrate-digesting enzymes (5).

Diverse bioactive compounds found in herbal medicine may help in the management of blood sugar levels (glycemic control). For example, polyphenols in green tea and berries demonstrate antioxidant properties that may protect pancreatic β -cells from oxidative stress-induced damage (6). Terpenoids in herbs such as bitter melon (*Momordica charantia*), have improved glucose uptake in muscle and adipose tissues (7). Notable herbal remedies include berberine from *Berberis vulgaris*, which has been shown to lower blood glucose levels (8). Similarly, cinnamon (*Cinnamomum verum*) has been studied for its ability to improve insulin sensitivity (9), while bitter melon is known for its hypoglycemic properties (10). Ginseng has also exhibited hypoglycemic effects in several studies (11).

However, the use of CAM products is not without risks, and safety concerns must be carefully considered. Drug-herb interactions pose significant challenges in the management of T2D. For instance, ginseng can interact with warfarin, potentially altering its anticoagulant effects (12). Bitter melon can also interact with insulin and oral antidiabetic medications, which may lead to dangerously low blood sugar levels (13,14). Furthermore, St. John's wort can significantly affect the metabolism of various drugs, including those for diabetes, potentially leading to decreased efficacy (13). The risk of hypoglycemia is a major concern with certain herbal remedies, particularly when used alongside conventional antidiabetic medications. This highlights the importance of careful monitoring and professional guidance when incorporating

herbal remedies into diabetes management plans (13). Additionally, the lack of standardization in herbal products further complicates their safety profile. Herbal products may be contaminated with harmful substances like heavy metals or pesticides. For example, Fenugreek seeds have been found to contain contaminants that can lead to liver and kidney damage (15).

Integrating herbal medicine into mainstream T2D management faces several challenges. These include variability in herbal preparation methods, lack of standardization in dosing, potential drug-herb interactions, and limited understanding of long-term safety profiles. Moreover, the regulatory landscape for herbal products varies significantly across countries, complicating the assessment of quality and efficacy (16–18).

This review aims to provide a comprehensive overview of the current state of research on herbal remedies used for diabetes management. We will focus on the prevalence of use, cost considerations, and safety issues associated with these interventions while identifying critical research gaps, particularly regarding safety profiles, long-term efficacy, standardization, and effective communication between healthcare providers and patients.

While some studies have shown promise for certain herbal remedies in glycemic control, many lack rigorous scientific validation (19). Therefore, this review will evaluate the efficacy, safety, and economic implications of herbal remedies in T2D management.

2. METHODS

A comprehensive search of published peer-reviewed articles was conducted using the databases PubMed, Google Scholar, Scopus, ProQuest, CINAHL, and Science Direct. Search terms included "diabetes," "herbal medicine," "traditional medicine," "natural remedies," "botanicals" "complementary and alternative medicine," "patient satisfaction," "health beliefs," "economic burden," and "cost-effectiveness" and their synonyms. Boolean operators (e.g., AND, OR) were used to refine search

results. Additional studies were identified through hand-searching reference lists.

Inclusion and Exclusion Criteria

The inclusion criteria were peer-reviewed articles published from 2018 to 2024, focusing on adult participants with diabetes and assessing aspects related to the rate of herbal remedies use, cost, or socio-demographic characteristics of herbal remedy use. Only studies published in English were included. The included studies originated from various countries, including India, China, the United States, the United Kingdom, Saudi Arabia, and some African nations. Studies were excluded if they involved children or adolescents, were not peer-reviewed, or did not specifically address herbal medicine or diabetes. The included studies were primarily cross-sectional surveys, cohort studies, and RCTs.

Data Extraction

Data extraction involved information on study characteristics, sample size, types of herbal remedies used, the prevalence of herbal remedy use, costs, and socio-demographic factors of participants (including age, gender, income, and geographical location). A standardized data extraction form was utilized, and any inconsistencies were resolved through discussions among reviewers.

Methodological Rigor Assessment

Methodological rigor was assessed using the Cochrane Collaboration's Risk of Bias tool, evaluating aspects such as randomization, allocation concealment, blinding, and selective reporting. In our review, we included 45 studies, of which only 7 were assessed for risk of bias. The selection of these 7 studies was based on their methodological rigor and the applicability of the Cochrane Collaboration's Risk of Bias tool. While this tool is primarily designed for RCTs, it can also be applied to other study designs that exhibit sufficient methodological quality. The decision to assess only these 7 studies was made to ensure a focused evaluation of bias where the tool could be most effectively utilized. We acknowledge that

the remaining studies were not assessed for bias, as they did not meet the criteria for this specific evaluation. This approach is intended to maintain the integrity of our review by concentrating on studies where a robust bias assessment was feasible.

Data Synthesis

While a meta-analysis was not conducted as part of this study, we reviewed several relevant meta-analyses in the literature. For instance, Alzahrani et al. conducted a systematic review and meta-analysis that explored the global prevalence and types of CAM use among adults with diabetes (20). Our overall findings are based on a variety of study designs, including RCTs, observational studies, and cross-sectional analyses. The goal of this narrative synthesis is to summarize the key findings and identify potential areas for future research.

3. RESULTS

Table 1 provides a comprehensive summary of various studies evaluating the effectiveness of herbal medicines for glycemic control in diabetes. It includes data from RCTs, observational studies, and cross-sectional analyses, highlighting different herbal interventions and their outcomes. For instance, Ahmad et al. conducted an RCT with 52 participants, finding significant reductions in fasting plasma glucose (FPG) and HbA1c levels with fenugreek and cinnamon, though insulin levels fell significantly only in the cinnamon group (21). Kandhare et al. reported that while fenugreek (IND-2) did not significantly reduce fasting blood sugar (FBS), there was noted improvement in HbA1c levels among 30 participants, with mild adverse events and a few discontinuations (22). Maideen reviewed a range of studies including a pilot study with 41 participants and a double-blind RCT with 250 participants, demonstrating significant improvements in fasting blood FBS and HbA1c levels with *Nigella sativa* (Black Seed) oil, showing comparable effectiveness to metformin in some cases (23). Prasopthum et al. in a cross-sectional study of 739

participants found that herbal medicines like bitter gourd, pandan leaf, and country mallow used in combination with antidiabetic agents, particularly bitter gourd, were associated with improved glycemic control (24). Chan et al. conducted RCTs on Ganopoly™, *G. lucidum*, and Lingzhi, reporting mixed results with Ganopoly™ showing reduced fasting and postprandial glucose levels and HbA1c, while the other interventions showed no significant effects (25). Adam et al. found marked improvements in glycemic control and lipid profile with *Nigella sativa* oil, supported by in vivo studies demonstrating antidiabetic effects in rats (26). Yedjou et al. highlighted positive effects of garlic, bitter melon, *Hibiscus sabdariffa*, and ginger on blood glucose levels, with notable reductions observed across the board (5).

While detailed cost information was not consistently reported across studies, systematic reviews have highlighted the potential of herbal remedies; however, comprehensive cost-effectiveness analyses specifically

focusing on these interventions are still lacking (27,28). This review acknowledges the inconsistencies in cost reporting and aims to provide a clearer analysis of cost considerations in future work. Overall, the findings indicate that certain herbal remedies may be effective in managing glycemic levels, but uncertainties regarding their cost-effectiveness remain. More rigorous cost analyses are necessary to fully understand their economic implications in diabetes management.

The safety profiles for herbal remedies were generally favorable, with only minor adverse effects reported in a few instances (5,23,24). For example, in the studies reviewed, most participants experienced mild adverse events with fenugreek and IND-2, while no major adverse effects were noted for *Nigella sativa*, which reported long-term safety during trials (23). Specific adverse effects, such as gastrointestinal disturbances and allergic reactions, were documented but were typically mild and manageable. The detailed findings are summarized in Table 1.

Table 1. Summary of the studies that assess effectiveness, cost considerations and safety issues associated with herbal medications in DM.

Reference	Type of Study, No. of Participants	Intervention	Outcome	Result	Cost Study	Safety Study
(21)	Randomized Controlled Trial (RCT); 52 participants (26 in each group)	Fenugreek (20g/day) and Cinnamon (4g/day)	Fasting Plasma Glucose (FPG), HbA1c, Insulin levels	Significant reduction in FPG and HbA1c in both groups; Insulin level fell significantly only in Cinnamon group	NA	NA
(22)	Prospective, single arm, uncontrolled, multicenter 30 participants	IND-2 (700 mg Fenugreek, thrice daily)	HbA1c levels, FBS, PPBS, insulin requirement	No significant reduction in FBS; HbA1c improvement noted	NA	Majority of adverse events were mild; 4 discontinuations due to AEs

Reference	Type of Study, No. of Participants	Intervention	Outcome	Result	Cost Study	Safety Study
(23)	Prospective observational study - 60 participants Pilot study - 41 participants Prospective cohort study - 94 participants Pilot study - 80 participants Randomized, double-blind, placebo-controlled clinical trial - 70 participants Participant-blinded, placebo-controlled clinical trial - 114 participants Double-blind, randomized controlled trial - 250 participants Single-blind, randomized controlled trial - 99 participants Non-randomized clinical trial - 114 participants Randomized clinical trial - 117 participants	<i>Nigella sativa</i> (Black Seed) oil - Doses ranging from 2 g/day to 1350 mg/day. Combination therapy with metformin. Placebo control in various trials. Oral <i>N. sativa</i> oil - 2.5 mL/day for chronic kidney disease patients. Powdered <i>N. sativa</i> - 2 g/day for 1 year. <i>N. sativa</i> oil - 1.5 mL and 3 mL daily for metabolic syndrome patients.	FBS and HbA1c levels.	Significant improvement in metabolic parameters such as HbA1c and FBG. Comparable effectiveness to metformin in some studies. Protective effects on cardiac function in diabetic patients. Statistically significant reductions in cholesterol levels. Significant reduction of insulin resistance and inflammatory markers.	NA	No major adverse effects reported in the studies. Safety observed in long-term administration (up to 1 year). Monitoring of metabolic parameters ensured participant safety throughout the trials.

Reference	Type of Study, No. of Participants	Intervention	Outcome	Result	Cost Study	Safety Study
(24)	Cross-sectional- 739 participants	Herbal medicine use in combination with antidiabetic agents 1.Pandan leaf (<i>Pandanus amaryllifolius</i>) - 23.1% 2.Bitter gourd (<i>Momordica charantia</i>) - 19.2% 3.Country mallow (<i>Abutilon indicum</i>) - 10.8% 4.Yanang leaf (<i>Tiliacora triandra</i>) - 6.2% 5.Lingzhi mushroom (<i>Ganoderma lucidum</i>) - 6.2%	Glycemic control (HbA1c levels)	These plants were used in combination with prescribed antidiabetic drugs, and the study highlighted that bitter gourd, in particular, was associated with good glycemic control when used alongside 500 mg/day of metformin	NA	NA

Reference	Type of Study, No. of Participants	Intervention	Outcome	Result	Cost Study	Safety Study
(25)	Randomized controlled trial- 62 participants	GanopolyTM (1800 mg three times daily for 12 weeks)	Fasting and postprandial plasma glucose levels, HbA1c	Reduced	NA	NA
	Randomized controlled trial- 84 participants	G. lucidum (3 g/day) or G. lucidum plus Cordyceps sinensis capsules for 16 weeks	Hyperglycemia and cardiovascular risk factors	No significant effects	NA	NA
	Randomized, double-blind, placebo- controlled study-26 participants	Lingzhi (1.44 g extract/d for 12 weeks)	insulin and HOMA-IR (homeostasis model assessment– insulin resistance)	Reduced	NA	NA
(26)	Clinical (e.g., Trial 50- 100)	<i>Nigella sativa</i> oil	Glycemic control (FBG, HbA1c, insulin levels)	Marked improvement in glycemic control and lipid profile after 8 weeks of treatment	NA	NA
	In Vivo Study- Not specified	Aqueous extract of <i>Nigella</i> <i>sativa</i>	Antidiabetic effect	Demonstrated antidiabetic effects in diabetic rats	NA	In vivo toxicity assessed

Reference	Type of Study, No. of Participants	Intervention	Outcome	Result	Cost Study	Safety Study
(5)	Clinical Study Not specified	<i>Allium sativum</i> (Garlic)	Blood sugar levels	Significant reduction in blood sugar levels observed	NA	Yes
	Clinical Study Not specified	<i>Momordica charantia</i> (Bitter Melon)	Blood sugar levels	Notable improvement in glycemic control	NA	Yes
	Clinical Study Not specified	<i>Hibiscus sabdariffa</i> L. (roselle)	Blood pressure and blood sugar	Positive effects on both blood pressure and blood sugar levels	NA	Yes
	Clinical Study Not specified	<i>Zingiber officinale</i> Rosc. (Ginger)	Blood sugar levels	Reduction in fasting blood glucose levels	NA	Yes

RCT = Randomized Controlled Trial; FPG = Fasting Plasma Glucose; HbA1c = Hemoglobin A1c; FBS = Fasting Blood Sugar; PPBS = Postprandial Blood Sugar; HOMA-IR = Homeostasis Model Assessment of Insulin Resistance; NA = Not Available.

Table 2 provides a comprehensive overview of the cultural, societal, professional, and regulatory factors that influence the use of herbal remedies in diabetes management. Key findings highlight the diverse motivations for using herbal remedies, including dissatisfaction with conventional treatments, cultural

beliefs, and economic factors. Furthermore, the table explores the role of perceptions, communication, and obstacles in the adoption and utilization of herbal medicine. These factors collectively shape the complex landscape of herbal remedy usage in diabetes care.

Table 2. Cultural, Societal, Professional, and Regulatory Factors Affecting the Use of Herbal Remedies in Diabetes Management

Topic	Key Findings	References
Motivations	- Dissatisfaction with conventional treatments, preference for holistic approaches, cultural beliefs - Perceptions of herbal medicine as more natural or safer than pharmaceuticals - Economic factors, including cost of conventional treatments and perceived affordability of herbal alternatives - Access and availability of herbal practitioners and products - Enhancing quality of life and gaining a sense of control over health	(29,30)
Perceptions	- Cultural and ethnic factors influence acceptance and integration of herbal remedies - Regulation and professionalization of herbal medicine impact trust and usage - Evidence-based research and psychological factors (e.g., stress management, placebo effect) influence perceptions	(31,32)
Communication	- Many herbal medicine users do not disclose use to healthcare providers due to concerns about judgment, lack of support, and fears of negative reactions - Healthcare providers often do not routinely inquire about herbal medicine use, contributing to communication gaps - Patients often seek information on herbal remedies from sources other than healthcare providers	(33,34)
Obstacles	- Lack of standardized practices and consensus on efficacy and safety of herbal treatments - Inadequate provider education and training on herbal medicine, leading to skepticism and reluctance to recommend - Structural barriers in healthcare systems, including cost and time constraints, and lack of insurance coverage for herbal remedies - Cultural and societal factors influencing acceptance and use of herbal medicine - Regulatory challenges due to inconsistent standards, affecting product quality and efficacy	(35,36)

Using the Cochrane Collaboration's Risk of Bias tool, we assessed the methodological rigor of the studies. This evaluation focused on randomization, allocation concealment, blinding, and selective reporting to assess

the reliability and validity of the findings. Table 3 summarizes these quality assessments, providing a clearer picture of the literature's methodological strength.

Table 3. Assessment of Bias Risks in Included Studies on Herbal Remedies for Diabetes Management

Reference	Study Type	Selection Bias	Performance Bias	Detection Bias	Attrition Bias	Reporting Bias	Overall Bias Risk
(21)	RCT	Low	Low	Low	Low	Low	Low
(22)	Uncontrolled	High	High	High	High	Medium	High
(23)	Observational	High	N/A	N/A	Unknown	Medium	Medium
(24)	Cross-sectional	High	N/A	N/A	N/A	High	High
(25)	RCT	Low	Low	Low	Low	Low	Low
(26)	Clinical Trial	Unknown	N/A	N/A	N/A	Unknown	Unknown
(5)	Clinical Study	Unknown	N/A	N/A	N/A	Unknown	Unknown

- N/A: Not Apply

4. DISCUSSION

4.1. Trends in Herbal Medicine Use for Diabetes

Our review of the literature reveals several key trends in the use of herbal medicine for diabetes management:

4.1.1. Motivations and Perceptions Regarding the Use of Herbal Medicine

A significant trend observed across studies is the multifaceted motivation behind herbal medicine use. Individuals often turn to herbal remedies due to dissatisfaction with conventional treatments, a preference for holistic approaches, or deeply rooted cultural beliefs. The perception of herbal medicines as “more natural” or safer than pharmaceutical options significantly influences its use (Table 2) (37,38).

4.1.1.1. Economic Factors

Multiple studies highlight the role of economic considerations in driving individuals towards herbal alternatives. The high cost of conventional diabetes treatments appears to be a significant factor influencing this trend, especially in low- and middle-income countries. This shift is especially evident when conventional treatments are not covered by insurance (37,39). These economic motivations are further reflected in the key findings of Table 2.

4.1.1.2. Prevalence and Cost of Herbal Medicine Use

Research shows that many individuals turn to herbal alternatives for diabetes management, particularly in low

and middle-income countries where financial barriers limit access to conventional treatments (40,41). Americans spend over \$34 billion annually out-of-pocket on Complementary and Alternative Medicine (CAM) therapies, reflecting a widespread perception that the perceived benefits of these treatments outweigh their costs (42). A comprehensive review by Alzahrani et al. revealed significant global variation in the use of CAM, with a prevalence rate of 51% and substantial heterogeneity. The most commonly used herbs include cinnamon, fenugreek, garlic, aloe vera, and black seed (20). In Thailand, 37.5% of patients used herbal medicine alongside their prescribed antidiabetic drugs, with tea being the most common form (24). In Africa, the use of traditional medicine ranges from 12.4% to 77.1%, with a median of 50% (43).

Despite the high prevalence, the financial and practical implications of herbal medicine use are complex. Initially, herbal remedies may appear cost-effective compared to conventional treatments (44,45). However, the true cost-effectiveness of these remedies involves more than just immediate out-of-pocket expenses. Herbal medicines often lack the comprehensive evidence and long-term effectiveness provided by conventional medicines. This can lead to potential costs down the line if the remedies prove less effective in managing chronic conditions like diabetes (46,47).

Literature reviews on the cost-effectiveness of herbal

medicine in diabetes management are notably scarce, reflecting a significant gap in our understanding of the economic implications of these interventions. While cost-effectiveness analyses (CEAs) have been conducted for herbal treatments in various other health conditions, comprehensive studies specifically addressing diabetes remain limited. This scarcity is particularly concerning given the global prevalence of diabetes and the potential role of herbal medicines in its management (45).

To contextualize this gap, it is instructive to consider examples from other therapeutic areas where CEAs of herbal medicines have been conducted. For instance, Lin et al. evaluated the long-term economic impact of combining traditional Chinese medicine (Gastroma Guteng Yin) with conventional western medicine for hypertension management. Their study revealed improved health outcomes but at significantly higher costs, underscoring the complexity of economic evaluations in herbal medicine (48). In the realm of mental health, St. John's wort has been shown to be as effective as conventional antidepressants but at a lower cost, demonstrating the potential for cost-effective herbal interventions (49). Similarly, in chronic pain management, acupuncture, often involving herbal remedies, has been found to be more cost-effective than conventional treatments for chronic low back pain (50). These examples highlight the feasibility and importance of conducting rigorous CEAs in herbal medicine.

However, the paucity of such studies in diabetes management represents a critical research gap (45). The multi-component nature of herbal products complicates toxicity assessments and efficacy evaluations, presenting unique challenges in conducting comprehensive CEAs (51). Furthermore, the heterogeneity of outcomes within herbal medicine research and the importance of considering local economic contexts add layers of complexity to these analyses (52). As diabetes imposes a significant economic burden on healthcare systems worldwide, there is an urgent need for well-designed, long-

term studies that evaluate not only the clinical efficacy but also the cost-effectiveness of herbal interventions in diabetes management. Such research would provide valuable insights for policymakers, healthcare providers, and patients, potentially leading to more informed decision-making and resource allocation in diabetes care.

4.1.1.3. Access and Psychological Aspects

Multiple studies also highlight the importance of access and availability in the use of herbal medicine. In regions where herbal practitioners and products are more accessible, usage tends to be higher, with geographic and socioeconomic factors affecting access to both conventional and alternative therapies. Additionally, many patients use herbal medicine to enhance their quality of life and gain a sense of control over their health, finding empowerment in actively participating in their care (38,53). Psychological factors, including stress management and the placebo effect, contribute to the perceived benefits of herbal medicine, as these remedies can offer psychological comfort that positively affects health outcomes (54,55).

4.1.1.4. Cultural and Ethnic Influences

The literature consistently points to the strong influence of cultural and ethnic factors on herbal medicine use. Some communities have a long history of using herbal medicine, deeply rooted in cultural traditions (56,57). Additionally, some individuals combine herbal remedies with conventional treatments to enhance their overall health regimen, highlighting the role of herbal medicine in comprehensive patient care strategies (29).

4.2. Research Gaps and Methodological Challenges

Our review has identified several critical gaps in the current research landscape:

4.2.1. Safety Profiles of Herbal Medicines Used for Diabetes

There is a notable lack of rigorous scientific validation for the safety profiles of many herbal remedies used in diabetes management. This gap is particularly concerning given the potential for drug-herb interactions and liver

toxicity. The lack of rigorous scientific validation for the safety profiles of many herbal remedies is compounded by the bias risks present in the studies reviewed. Table 3 summarizes the assessment of bias risks, indicating that many studies, particularly observational ones, face significant limitations in their design and execution. The safety of herbal medicines used for diabetes management is a critical concern, particularly since many patients do not disclose their use of CAM to their healthcare providers (58). While the widespread use of herbal remedies among individuals with diabetes indicates a perceived safety and efficacy, specific details on their safety profiles are often not well-documented (59). This risk is further amplified in patients on polypharmacy, where the complexity of drug regimens increases the likelihood of harmful interactions, as demonstrated in national diabetes programs such as PROLANIS in Indonesia (60).

Numerous herbal remedies show promise in glycemic control, their safety profiles often lack rigorous scientific validation. For example, Teschke et al. highlighted the potential liver toxicity associated with certain Chinese herbal medicines used for diabetes (61). Fenugreek has been reported to cause hypoglycemia when used concurrently with insulin or sulfonylureas (62), while bitter melon may interact with P-glycoprotein and CYP3A4 substrate drugs, potentially altering their effectiveness (63). Ginseng has been associated with side effects such as headaches, insomnia, and hypertension (64).

Recent studies have found that, although some herbal medicines demonstrate hypoglycemic effects, they may also cause liver, kidney, and lung damage, highlighting the need for caution in their long-term use (65,66). The American Diabetes Association (ADA) emphasizes the importance of patient-provider communication regarding herbal supplement use, as failure to disclose such information can lead to dangerous drug-herb interactions (67). Quality control of herbal products is also a pressing issue, with studies revealing inconsistencies in active ingredient concentrations and occasional contamination

with heavy metals or pharmaceutical agents (68). These concerns underscore the necessity for standardized manufacturing processes, comprehensive safety evaluations, and improved regulatory oversight in the herbal medicine industry.

Healthcare professionals often express reluctance to recommend herbal treatments due to concerns about interactions with conventional medications and insufficient knowledge about their safety profiles (69). While herbal remedies can be gentler than synthetic drugs, they are also prone to issues such as plant misidentification, incorrect preparation, and improper administration by inadequately trained practitioners. In contrast, synthetic drugs, though newer to Western medicine, are generally trusted more due to their standardized production and well-documented effects. Therefore, ongoing research and careful monitoring are essential to address safety concerns and improve patient outcomes with herbal medicine (70).

4.2.2. Long-term efficacy studies

There is a scarcity of long-term, large-scale clinical trials to conclusively establish herbal medicine efficacy in diabetes management (45,71). This poses significant challenges to establishing the efficacy and safety of these treatments. Current research is limited by small sample sizes, short durations, and varying methodologies, making it difficult to draw definitive conclusions about the effectiveness of herbal remedies (51). This lack of robust evidence is a major barrier to the integration of herbal medicine into mainstream diabetes care, as healthcare providers and policymakers require high-quality data to make informed decisions. The absence of comprehensive clinical trials limits the understanding of how herbal medicines interact with conventional diabetes treatments, particularly given the complex nature of diabetes management. Large-scale studies could provide valuable insights into the synergistic effects of combining herbal and conventional therapies, potentially leading to more effective and personalized treatment strategies (72).

Addressing these research gaps is crucial for advancing the field and ensuring patients have access to safe and effective treatment options.

4.2.3. Standardization and Quality Control

The literature highlights significant challenges in the standardization and quality control of herbal products, which complicates the assessment of their safety and efficacy. Herbal medicines frequently face issues with standardization and quality. The variability in effectiveness and safety due to lack of standardization can impact their overall cost-effectiveness (73). Many countries lack stringent regulations for herbal drugs, leading to issues like adulteration and spurious products, which compromise safety and efficacy (74). In contrast, conventional medicines undergo rigorous testing and standardization processes to ensure consistency and reliability (75).

4.2.4. Communication with Healthcare Providers Regarding Herbal Medicine Use

A recurring theme in the literature is the communication gap between patients and healthcare providers regarding herbal medicine use. Effective communication between herbal medicine users and healthcare providers is crucial for ensuring safe and coordinated care. The review reveals that many individuals using herbal remedies do not disclose this information to their healthcare providers, primarily due to concerns about judgment, perceived lack of support, and fears of negative reactions (30,32,76). This reluctance complicates diabetes management because nondisclosure can lead to risks such as adverse drug interactions and hampers the integration of herbal remedies into conventional treatment plans (33). Notably, this pattern of nondisclosure and self-medication is not limited to herbal remedies; it extends to other medications, as demonstrated by a recent study in Lebanon showing that caregivers frequently administer antibiotic suspensions to children without consulting healthcare professionals (77). This suggests a deeply rooted culture of self-medication that underscores the need for targeted

education and improved patient-provider dialogue.

The review also highlights that a significant number of healthcare providers do not routinely inquire about herbal medicine use, which contributes to this communication gap (45). Furthermore, only a small percentage of herbal users seek information from conventional practitioners, indicating that healthcare providers are not the primary source of information on herbal remedies (78).

Addressing these communication gaps is essential for improving patient safety and the effectiveness of treatment plans. The World Health Organization emphasizes the need for enhanced dialogue and collaboration between patients and healthcare providers to ensure the informed and safe use of herbal medicine (36). Initiatives that empower pharmacy students as health educators—such as training them to help patients interpret food labels and make informed decisions—demonstrate a successful model for building health literacy in Lebanon (79). This educational approach can be expanded to include counseling on herbal remedies, equipping future pharmacists to bridge the information gap and support safe, evidence-based self-management.

4.3. Integrating Findings: A Narrative Synthesis

Synthesizing the available literature reveals several key themes:

4.3.1. Efficacy of Specific Herbal Remedies

The effectiveness and safety of herbal medicines for diabetes management vary widely. Salleh et al. evaluated the impact of specific herbal remedies including turmeric, garlic, bitter melon, and roselle (*Hibiscus sabdariffa*) on blood glucose levels. Their findings revealed that a combination of turmeric and garlic significantly reduced fasting blood glucose levels and HbA1C, without adverse effects on blood pressure, liver, or kidney function. In contrast, bitter melon did not show significant effects on blood glucose or other health markers, which might be attributed to variations in bioactive compounds based on regional differences (80).

Zhang et al. reviewed Chinese Herbal Medicine (CHM)

for diabetic kidney disease, focusing on herbs such as Astragali Radix, Rehmanniae Radix, and Rhei Radix et Rhizoma. CHM was found to be beneficial as an adjunct therapy with renin-angiotensin system inhibitors, leading to reduced albuminuria and improved estimated glomerular filtration rate. However, the studies had limitations, including high heterogeneity and small sample sizes, which warrant cautious interpretation of the results (81).

Table 1 summarizes various studies on the use of medicinal plants in diabetes management. Ahmad et al. found that both fenugreek and cinnamon significantly reduced fasting plasma glucose and HbA1c, with cinnamon also lowering insulin levels (21). Kandhare et al. reported improvements in HbA1c with fenugreek but noted mild adverse events and no significant reduction in fasting blood sugar (22). Maideen showed that *Nigella sativa* oil improved metabolic parameters and was comparable to metformin, with no major adverse effects (23). Prasopthum et al. highlighted that bitter melon, when used with metformin, improved glycemic control (24). Chan et al. observed mixed results with *Ganoderma lucidum*, including reduced glucose levels in some trials (25). Adam et al. demonstrated significant glycemic and lipid profile improvements with *Nigella sativa* (26), while Yedjou et al. noted positive effects on blood sugar levels and safety for garlic, bitter melon, roselle, and ginger (5). Overall, the studies suggest that these herbs can positively impact diabetes management, although safety and cost evaluations vary. However, most of these studies focus exclusively on biochemical and clinical markers, with little to no assessment of patient-reported outcomes such as health-related quality of life (HRQoL). A recent study in Quetta, Pakistan, demonstrated the value of using the EQ-5D-3L instrument to evaluate HRQoL in patients with Type 2 Diabetes, revealing significant impacts of the disease on daily functioning and well-being (82). Future research on herbal remedies should incorporate such validated tools to provide a more comprehensive understanding of their true impact on patients' lives.

4.3.2. Regulatory Challenges

The review reveals a global challenge in regulating herbal medicines, with significant variations in regulatory frameworks across different countries. This inconsistency impacts the quality, safety, and efficacy of herbal products available to diabetes patients. In countries where herbal medicine is regulated and practitioners are licensed, there is often higher trust and usage of these remedies. In India, the AYUSH system regulates nearly 8000 herbal medications, fostering trust in their safety and effectiveness (83). Regulatory challenges pose significant barriers as well. Herbal medicine manufacturers and practitioners often face difficulties due to inconsistent regulatory standards, resulting in variability in product quality and efficacy. This lack of uniform regulation complicates efforts to integrate herbal medicine into established healthcare frameworks (35,84,85).

Case studies provide valuable insights into these challenges. For example, a study in India highlighted how regulatory inconsistencies led to the prevalence of low-quality herbal products, affecting patient safety and treatment outcomes (35). Conversely, in Germany, well-regulated herbal medicine practices within the healthcare system have demonstrated successful integration, showcasing how standardized approaches can enhance both safety and efficacy (86).

Comparative analysis reveals different approaches taken by other countries. In China, herbal medicine is widely integrated into the healthcare system, supported by robust regulatory frameworks and research initiatives (87). Similarly, in South Korea, the integration of traditional medicine into conventional healthcare has been facilitated by government support and standardized practices, providing a model for other regions (88).

4.3.3. Socioeconomic and Cultural Determinants

The literature consistently points to the significant role of socioeconomic factors and cultural beliefs in shaping patients' choices regarding herbal medicine use. Cultural beliefs and societal attitudes can strongly impact

individuals' preferences for herbal remedies over conventional treatments. For example, in many communities, herbal medicine is deeply ingrained in tradition and is considered a trusted component of healthcare (36,89). *Vinca rosea*, also known as *Catharanthus roseus*, is a traditional medicine in Jordan that is used to manage diabetes. Research has shown that leaf extracts from this plant have antidiabetic properties (90). Local herbalists prescribe remedies based on symptoms rather than a comprehensive understanding of the underlying conditions. The Northern Badia region, known for its diverse medicinal plants, stands out for its unique herbal practices (41). This highlights the need for culturally sensitive and economically considerate approaches in diabetes care.

4.3.4. Obstacles to Integrating Herbal Medicine into the Healthcare System

Integrating herbal medicine into the healthcare system encounters several notable obstacles. A key challenge is the lack of standardized practices and consensus on the efficacy and safety of various herbal treatments (73). Many healthcare providers are inadequately trained to discuss herbal medicine with their patients, leading to missed opportunities for addressing potential drug-herb interactions and ensuring patient safety. This training gap, along with limited clinical data and research specifically on herbal medicine, contributes to provider skepticism and reluctance to recommend these therapies (34,91). The absence of insurance coverage for herbal remedies and therapies further complicates integration efforts (92).

Future directions for overcoming obstacles in herbal medicine promotion include enhancing provider education, improving regulatory standards, and increasing clinical research to build a stronger evidence base, as

suggested in the literature (93). In summary, while the integration of herbal medicine into the healthcare system faces significant challenges—such as skepticism, inadequate provider education, regulatory issues, and cultural factors—there are also promising avenues for improvement (94). By learning from successful international models and addressing these obstacles proactively, the potential benefits of herbal medicine can be better realized and incorporated into mainstream healthcare (36).

5. CONCLUSION

The use of medicinal plants like cinnamon, aloe vera, bitter melon, turmeric, garlic, and roselle flower in diabetes treatments can enhance glucose control and overall health. However, it is crucial to educate healthcare providers and patients about potential interactions between herbal remedies and prescribed anti-diabetic medications. These efforts require updating diabetes management practices based on scientific evidence, involving patients and caregivers, and integrating herbal medicine into national health systems. Further research on herbal medicine is important for establishing safety profiles and promoting evidence-based guidelines. Encouraging lifestyle modifications and a whole food plant-based diet can also help manage diabetes and prevent complications.

6. Conflicts of Interests

The authors declare that there are no conflicts of interest.

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مراجعة أدبية للعلاجات العشبية المستخدمة في داء السكري: الفعالية، السلامة، والاعتبارات التنظيمية

ندى م. صونجي^{1*}، غسان م. صونجي^{1*}

¹قسم العلوم الصيدلانية، كلية الصيدلة، الجامعة الدولية اللبنانية، بيروت، لبنان

ملخص

المشكلة: إن الانتشار المتزايد لداء السكري من النوع الثاني يشكل عبئاً صحياً واقتصادياً كبيراً على مستوى العالم، مما أدى إلى تنامي الاهتمام بالطب العشبي كخيار بديل أو مكمل منخفض التكلفة للعلاجات التقليدية. **المنهج التجريبي:** شملت هذه المراجعة الأدبية دراسات مُحكَّمة نُشرت بين عامي 2018 و2024. تم إجراء بحث شامل في قواعد بيانات مثل PubMed وScopus وGoogle Scholar باستخدام مصطلحات مرتبطة بالسكري، والطب العشبي، والجدوى الاقتصادية. وقد شملت الدراسات المضمَّنة بلداناً متعددة منها الهند، الصين، الولايات المتحدة، المملكة المتحدة، السعودية، وعدد من الدول الإفريقية. تم تضمين الدراسات التي استهدفت البالغين المصابين بالسكري وقيمت فعالية العلاجات العشبية أو تكلفتها أو تجارب المستخدمين. واستُبعدت الدراسات التي شملت أطفالاً، أو لم تكن مُحكَّمة، أو لم تكن مرتبطة بشكل مباشر بالطب العشبي. وقد أجرى باحثان عملية استخلاص البيانات بشكل مستقل باستخدام نموذج موحد لجمع معلومات حول خصائص الدراسة، وحجم العينة، والعلاجات العشبية، ونتائج التحكم في نسبة السكر في الدم، والآثار الجانبية.

النتائج الرئيسية: بلغ عدد الدراسات المشمولة 45 دراسة، تضمنت تجارب سريرية عشوائية ودراسات رصدية. أشارت النتائج إلى أن بعض العلاجات العشبية يمكن أن تحسن التحكم في نسبة السكر في الدم بشكل ملحوظ، مع متوسط انخفاض في HbA1c يتراوح بين 0.5% و1.5%. كما أظهرت التأثيرات الاقتصادية لهذه العلاجات مزايا محتملة من حيث التكلفة مقارنة بالعلاجات التقليدية، على الرغم من أن ملفات السلامة أظهرت بعض الآثار الجانبية المصاحبة. **الاستنتاجات:** تُبرز هذه المراجعة الفوائد المحتملة للعلاجات العشبية في إدارة داء السكري من النوع الثاني، لكنها تؤكد في الوقت نفسه على الحاجة إلى مزيد من البحث. وينبغي أن تركز الدراسات المستقبلية على الجرعات المثلى، والتفاعلات مع الأدوية التقليدية، والجدوى الاقتصادية، وسلامة وفعالية الاستخدام على المدى الطويل، وخاصة من خلال التجارب السريرية العشوائية ذات الأحجام الكبيرة وفترات المتابعة الممتدة.

الكلمات الدالة: الطب العشبي؛ داء السكري من النوع الثاني؛ الجدوى الاقتصادية؛ التحكم في نسبة السكر في الدم؛ ملفات المستخدمين؛ التأثير الاقتصادي.

*المؤلف المراسل:

ندى م. صونجي: nada.sonji@liu.edu.lb

غسان م. صونجي: ghassan.sonji@liu.edu.lb

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