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Systematic Review: The Efficacy of Coriander, Cinnamon, Fenugreek, and Flaxseed, in Regulating Blood Sugar

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Abstract

Worldwide, the incidence of type 2 diabetes in children and young adults is rising quickly, which is concerning because it is increasing the burden of childhood obesity. The illness is linked to many risk factors, some of which are hereditary and some of which are lifestyle-related. Since poorly treated diabetes can lead to the formation of related comorbidities and current drugs frequently induce undesired side effects, there is an urgent need to discover new therapies for the prevention and management of this complicated disorder. Compounds obtained from nature are becoming more popular for treating and preventing several complex diseases, such as type 2 diabetes. This systematic review paper aims to discuss the effects of four bioactive herbs, such as coriander, cinnamon, fenugreek, and flaxseed as a therapeutic for pre-diabetes and diabetes type 2 treatment. In addition, it reviews their dosage, mechanisms, and clinical efficacy in blood sugar regulation. As a result, various studies showed that using certain amounts of these herbs changed the glucose level of diabetic patients.

Keywords: blood glucose, flax seed, coriander, fenugreek, cinnamon, diabetes.

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مراجعة منهجية: فعالية الكزبرة والقرفة والحلبة وبذور الكتان في تنظيم سكر الدم

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الملخص

في جميع أنحاء العالم، يرتفع معدل الإصابة بمرض السكري من النوع 2 بين الأطفال والشباب بسرعة، وهو أمر مثير للقلق لأنه يزيد من عبء السمنة لدى الأطفال. يرتبط المرض بالعديد من عوامل الخطر، بعضها وراثي وبعضها مرتبط بأسلوب الحياة. نظرًا لأن مرض السكري الذي يتم علاجه بشكل سيئ يمكن أن يؤدي إلى تكوين أمراض مصاحبة ذات صلة وأن الأدوية الحالية تسبب في كثير من الأحيان آثارًا جانبية غير مرغوب فيها، فهناك حاجة ملحة لاكتشاف علاجات جديدة للوقاية من هذا الاضطراب المعقد وإدارته. أصبحت المركبات التي يتم الحصول عليها من الطبيعة أكثر شيوعًا لعلاج والوقاية من العديد من الأمراض المعقدة، مثل مرض السكري من النوع 2. تهدف ورقة المراجعة المنهجية هذه إلى مناقشة تأثيرات أربعة أعشاب نشطة بيولوجيًا، مثل فعالية الكزبرة والقرفة والحلبة وبذور الكتان كعلاج لمرحلة ما قبل السكري وعلاج مرض السكري من النوع 2. بالإضافة إلى ذلك، تستعرض جرعتها وآلياتها وفعاليتها السريرية في تنظيم سكر الدم. ونتيجة لذلك، أظهرت دراسات مختلفة أن استخدام كميات معينة من هذه الأعشاب يغير مستوى الجلوكوز لدى مرضى السكري.

الكلمات المفتاحية: سكر الدم، بذور الكتان، الكزبرة، الحلبة، القرفة، مرض السكري.

Introduction

Insulin resistance, reduced sensitivity to insulin, and insufficient insulin release by the pancreatic islets' β-cells are the hallmarks of type 2 diabetes mellitus (T2DM). Patients with this condition progressively raise their postprandial and fasting blood glucose levels; yet, one of the first harmful processes that starts decades before type 2 diabetes occurs is the reduction in insulin sensitivity (Roden & Shulman, 2019). An individual with prediabetes has a higher blood glucose level than usual, decreased glucose tolerance, and an increased risk of developing diabetes. On the other hand, pancreatic beta cells are destroyed by the immune system in type 1 diabetes, which results in decreased insulin generation (WHO,

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2006). There is an increased risk of developing microvascular and macrovascular problems in individuals with type 2 diabetes and prediabetes (Carris *et al.*, 2019). Metformin, sulfonylureas, thiazolidinediones, dipeptidyl peptidase-4 inhibitors, agonists of the glucagon-like peptide-1 (GLP-1) receptor, inhibitors of the sodium-glucose cotransporter-2 (SGLT2), and insulin therapy are among the drugs that are frequently administered. The main goals of these drugs are to increase insulin sensitivity, lower the amount of glucose produced by the liver, increase insulin secretion, or make it easier for peripheral tissues to absorb glucose. However, many medicines that are now administered have negative effects, cost a lot of money, lose their effectiveness over time, and can conflict with other prescriptions (Galindo *et al.*, 2023). Thus, there is a need for more effective therapies and prophylactic measures to control glucose levels.

Bioactive substances that come from natural sources, like plants, animals, minerals, and microorganisms, are called natural compounds. Natural items have been used as traditional medicines worldwide for millennia, with more than 80% of people depending on them to heal ailments (Wangchuk, 2018). Many natural substances have demonstrated potential in treating type 2 diabetes (Terry, 2020). Several studies indicated a variety of traditional herbs elicited beneficial effects on controlling diabetes, such as flaxseeds, coriander, fenugreek, and cinnamon (Hutchins *et al.*, 2013, Ruban & Nandhini, 2020, Zargar, 1992, Zahedifar *et al.*, 2018). Therefore, concentrating on safe and efficient methods of avoiding the progression of prediabetes to diabetes could lower the burden on the health system.

Methods

This study employed an inductive qualitative methodology and published materials, including peer-reviewed journals focusing on clinical trials, systematic reviews, and meta-analyses about the efficacy of coriander, cinnamon, fenugreek, and flax seed in regulating blood sugar. Science Direct, PubMed, SCOPUS, and Google Scholar were used as sources of information that were searched up to 2024.

Results and discussion

This study includes 61 studies on diabetics varied in sample sizes, intervention durations, and measured outcomes. The primary findings for each herb are summarized below:

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Coriander

Coriander is scientifically named *Coriandrum sativum* (Velázquez *et al.,* 2023) (fig. 1), which is one of the most often used spices, it is also generally available, has therapeutic and nutritional qualities, ais mostly grown for its seeds, harvested for its essential oil and monoterpenoid, linalool (Rajeshwari & Andallu, 2011). It merits more clinical research on the use of its phytochemicals in treating illnesses since it has the potential to become a prominent plant source of therapeutic compounds. It is strongly advised to use it to achieve herbal cures for ailments and treat nutrient deficiencies because of its safe profile (Banerjee *et al.*, 2024) This herb is also well-known around the world due to its culinary, medical, and dietary applications. Numerous phytochemicals, including polyphenols, reducing sugars, terpenoids, carotenoids, glycosides, sterols, isocoumarins, flavonoids, tannins, alkaloids, fatty acids, and coumarins, can be found in it (Asghar, 2024). As a result, the consumption of coriander was found to be an effective method of maintaining the blood glucose level among pre-diabetic clients (Anjana, 2011), table (1).

Figure (1). Coriander (Yeung, & Bowra, 2011)

Over 14 days, a study tested the hypoglycemic effects of *Coriandrum sativum* (coriander) in 10 patients with type 2 diabetes who take oral hypoglycemic agents with inadequate control, and 6 control subjects were given low (2.5 g /day) and high (4.5 g /day) doses of *Coriandrum sativum* powdered part, aqueous extract, and alcoholic extract after fasting plasma and urinary glucose tests.

On the 15th day, blood and urine samples for glucose were collected. *Coriandrum sativum* has strong hypoglycemic activity at large doses and can be successfully taken with oral hypoglycemic medicines in type-2 diabetic patients who are not controlled by these

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medications (Akbar & Munir, 2006). Furthermore, a clinical trial indicated that coriander seed intake (1000 mg/day) lowered Fasting Blood Sugar (FBS) from 156.15 mg/dl to 130.30 mg/dl, serum insulin (17.72±0.47 to 17.12±0.76), Homeostasis Model Assessment of Insulin Resistance (HOMA-IR) (6.82±0.95 to 5.52±0.99) after six weeks (Zamany *et al.*, 2022). A study found that coriandrum sativum L. oil has antioxidant activity as well as the ability to improve kidney and pancreatic pathological abnormalities caused by diabetes (El-Soud *et al.*, 2012). A research evaluated coriander seed powder's efficiency in lowering blood sugar levels among pre-diabetic individuals, and found a significant decrease from a pretest mean of 119.65 to a post-test mean of 111.92, with a paired'test value of 10.950. (Ruban, 2020). Another study found that all subjects had a mean (FBS) of 189.4 ± 51.05 mg/dl and an average (HbA1C) of 9.2 ± 1.42 percent. There was no significant difference between the coriander and placebo groups (Zahmatkesh & Khodashenas, 2013). Therefore, coriander has considerable hypoglycemic efficacy at lower doses and antioxidant characteristics, however, its effects on (HbA1c) require additional investigation, table (5, 6).

Table (1) Effects of bioactive components of coriander on blood sugar and metabolic markers

Author & Year	Bioactive components	Effects
(Iqbal *et al.*, 2019) (Dhakshayani & Priya, 2022) (Asghar, 2024)	phenols and flavonoids	-It has antioxidant capabilities to minimize oxidative stress and enhance glucose metabolism. - It enhances α-amylase enzyme inhibition, contributing to their antidiabetic potential.
(Zambelli, 2024) (Rajeshwari & Andallu, 2011) (Iqbal *et al.*, 2019).	Linalool and petroselinic acid	- They have been connected to anti-inflammatory properties, which help blood sugar management.
(Iqbal *et al.*, 2019)	lipid and essential oil content	- It has significant hypoglycemia.

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Cinnamon

The bio name of cinnamon is *Cinnamomum verum* (or *Cinnamomum zeylanicum*) (Velázquez *et al.*, 2023) (fig. 2), which is conventional herbs and spices frequently used to regulate blood sugar, with cinnamon having the most impact. Cinnamon has been found in studies to help reduce blood sugar levels that have similar effects on insulin action (Hlebowicz *et al.*, 2007)Numerous investigations have been carried out to validate the impact of cinnamon on lowering blood glucose levels in individuals with diabetes (Gheibi *et al.*, 2024). According to in vitro research, cinnamon extract exhibits insulin-like qualities by enhancing the phosphorylation activity of insulin receptors and lowering tyrosine phosphatase activity (Olefsky, 2000). According to certain research, cinnamon suppresses the action of glycogen synthase just the way insulin hormone does (Jarvill-Taylor *et al.*, 2001). Hence, using cinnamon for type II diabetes patients can be recommended, table (2).

Figure (2). Cinnamon (Newerli-Guz, & Śmiechowska, 2022)

A study showed diabetic patients who took cinnamon for four weeks, their mean fasting blood glucose level fell to 126.67 mg/dl, triglycerides (150 mg/dl). The drop in mean fasting blood glucose level was significant ($P < 0.001$) (Al Jamal, 2009). Moreover, cinnamon at 250 mg twice a day decreased blood glucose with mean difference (MD) = -0.25 (95% Confidence Interval (CI) = - 0.36 to -0.14; $p<0.00001$), while 2 g three times a day had MD = -5.60 (95%CI = -6.98 to -4.22; $p<0.00001$). (Antônio *et al.*, 2021). Cinnamon supplementation (5 g/day for eight weeks) demonstrated significant health advantages both in vitro and in vivo, suggesting its potential as a natural herbal medicine (Aldaye, 2016). Meta-analysis of 28 Randomized Controlled Trials (RCTs) with durations ranging from 30 to 120 days with a total enrollment of 3054 DM2 patients. Participants consuming cinnamon showed a significant

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reduction in (FBG) Weighted Mean Difference (WMD: -15.26 mg/dL; 95% CI: -22.23 to -8.30; I2 = 88%), postprandial glucose (WMD: -39.22 mg/dL; (Confidence Interval) 95% CI: -63.90 to -14.55; I2 = 100%), Hemoglobin A1c (HbA1c) (WMD: -0.56 mg/dL; 95% CI: -0.99 to -0.13; I2 = 94%), and HOMA-IR (WMD = -0.76, 95% CI: -1.13 to -0.39; I2 = 22%) compared with the control group. An intervention of cinnamon in capsule form reduced (FBG) (WMD:-18.43 mg/dL, 95% CI: -26.32 to -10.53; I2 = 89%), postprandial glucose (WMD: -44.83 mg/dL, 95% CI: -70.67 to -18.99; I2 = 100%), (HbA1c) (WMD: -0.56 mg/dL, 95% CI: -1.02 to -0.09; I2 = 94%), Both doses (≤ 2 g/day and >2 g/day) decreased fasting blood glucose and postprandial glucose. (De Moura, 2024). Thus, cinnamon significantly reduces FBS, (HbA1c), and postprandial glucose. It also improves insulin sensitivity markers, making it a strong candidate for glycemic control, table (5, 6).

Table (2) Effects of bioactive components of cinnamon on blood sugar and metabolic markers

Author	Year	Bioactive Compounds
(Olefsky, 2000) (Rachid, *et al.*, 2022) (Xie *et al.*, 2023)	Polyphenols (glucuronides and proanthocyanidins)	- It enhances the phosphorylation activity of insulin receptors and lowers tyrosine phosphatase activity. - It improves glucose absorption and glycogen production.
(Stockert *et al.*, 2022)	Sirtuin	-It is important for maintaining glucose homeostasis.

Fenugreek

Scientific Name of fenugreek is *Trigonella foenum-graecum* L (Velázquez *et al.*, 2023) (fig. 3), it is frequently used as an herbal medicine for the management of diabetes. Its effectiveness in the diabetes population is explained by a number of reasons. The soluble fibers in fenugreek, such as glucomannan fiber, slow down the intestinal absorption of carbohydrates that are consumed. Additionally, alkaloids, such as fenugrecin and trigonelline, have been shown to have hypoglycemic properties, while the amino acid 4-hydroxyisoleucine (4-OH Ile) stimulates the pancreas to release insulin (Ranade & Mudgalkar, 2017).Therefore, supporting the idea that low-glycemic diets with high soluble fiber levels lower blood glucose levels in diabetic patients by confirming an inverse

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relationship between fenugreek seed consumption and glucose resistance (Phadnis *et al.*, 2011), table (3).

Figure (3). Fenugreek (Dhakad *et al.*, 2023)

Hadi *et al.*, (2020) reported on an 8-week controlled clinical research involving 50 patients with type 2 diabetes who were treated with anti-diabetic medications. Patients were given either 5 g of fenugreek seed powder three times daily or served as control patients. Compared to control patients, treated patients exhibited a significant decrease in fasting plasma glucose ($p = 0.024$). The exposed group was given 10 g of powdered fenugreek seeds steeped in water every day for 60 days, while the control group received no test diet. Patients' blood glucose levels were strongly linked with fenugreek supplementation ($p < 0.001$) and type of therapy ($p < 0.05$), even after controlling for demographics, physical conditions, and medical history.

The exposed group's fasting and postprandial blood glucose levels were 2.38 mmol/L (95% CI:-3.45,-1.32, $p < 0.001$) and 4.18 mmol/L (95% CI:-5.41,-2.95, $p < 0.001$, respectively), considerably lower than the control group. The decrease of blood glucose levels in the exposed group occurred gradually over time, whereas significant alterations were noticed after 30 days of supplements (Khatun *et al.*, 2023). After 12 weeks of fenugreek treatment, fasting and postprandial serum glucose levels had lowered by 38 and 44%, respectively. Simultaneously, a significant 34.7% drop in glycated hemoglobin was observed (Gupta *et al.*, 2024), table (5, 6). Hence, Fenugreek reduces (FBS), postprandial glucose, and (HbA1c) levels

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substantially, with the benefits becoming greater with extended intake.

Table (3) Effects of bioactive components of fenugreek on blood sugar and metabolic markers

Author & Year	Bioactive components	Effects
(Ranade & Mudgalkar, 2017) (Al Mosawi, 2021)	glucomannan fiber	-It slows down the intestinal absorption of carbohydrates that are consumed.
(Singh, *et al*., 2023)(Sarker *et al*., 2024) (Asghar, 2024)	fenugrecin and trigonelline	- They have hypoglycemic properties.
(Tak *et al*., 2024) (Sarker *et al*., 2024)	Diosgenin	- It promotes glucose transporter type-4 (GLUT4) translocation, hence boosting glucose absorption in cells.
(Ranade & Mudgalkar, 2017) (Al Mosawi, 2021) (Singh, *et al*., 2023). (Luo *et al*., 2023).	4-Hydroxyisoleucine	-It stimulates the pancreas to release insulin. - It increases insulin secretion and improves insulin sensitivity. - It has anti-inflammatory and antioxidant effects, which protect pancreatic β-cells from harm.

Flaxseed

The botanical name of flaxseed (fig. 4) is *Linum usitatissimum* L (Shim *et al.*, 2014) and there is not much research that shows how supplementing with flaxseed can help diabetes patients' oxidative stress, glycemic status, and inflammation (Pan *et al.*, 2007) In research including individuals with insulin resistance, flaxseed considerably improved glycemic control (Rhee *et al.*, 2011) Because of its abundance in lignans, dietary fiber, alpha-linolenic acid (ALA), and other compounds that may be healthful, flaxseed

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has gained interest as a functional food (Ursoniu *et al*., 2016), table (4).

Figure (4). Flaxseed (Batool *et al.*, 2024)

A study showed in the flaxseed group, the peak glucose increase and 2-hour AUC glycemic response decreased by 17% ($p = 0.001$) and 24% ($p < 0.001$), respectively. The glucose peak time, palatability, and taste parameters were the same between the two groups. Conclusions: Consuming 15 g of ground raw golden flaxseed before breakfast reduces the 2-hour postprandial glycemic response in males with T2DM (Moreira *et al.*, 2021). In another study, flaxseed supplementation significantly reduced (FBS) Standardized the Difference of Mean between groups (SMD: -0.66; 95% CI: -0.96, -0.35), (HOMA-IR) and Quantitative Insulin Sensitivity Check Index (QUICKI scores) (SMD: -0.64; 95% CI: -1.02, -0.26), and insulin (SMD: -0.49; 95% CI: -0.80, -0.17), according to findings from 4725 randomized clinical studies (RCTs). Moreover, QUICKI increased significantly (SMD: 1.64; 95% CI: 1.13, 2.14) following flaxseed supplementation. Flaxseed had no significant effect on (HbA1c) levels (SMD: -0.47; 95% CI: -0.97, 0.04) (Kavyani *et al.*, 2023). However, (Andrea *et al.*, 2022) reported that flaxseed significantly decreased (HbA1c) levels. A total of 25 (RCs) (30 treatment arms) were considered. Meta-analysis suggested a significant association between flaxseed supplementation and a reduction in blood glucose [WMD], −2.94 mg/dL; 95%CI, −5.31 to − 0.56; P = 0.015), insulin levels (WMD, −7.32 pmol/L; 95%CI, −11.66 to −2.97; P = 0.001), and HOMA-IR index (WMD, −0.49; 95%CI,: −0.78 to − 0.20;

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P = 0.001) and an increase in QUIKI index (WMD, 0.019; 95%CI, 0.008-0.031; P = 0.001). There was no significant effect on (HbA1c) levels (WMD, -0.045%; 95%CI, -0.16 to -0.07; P=0.468). As aresult, flaxseed lowers (FBS) and improves insulin sensitivity but has mixed results on (HbA1c), with whole flaxseed with a larger dose being more effective than flaxseed extracts, table (5, 6).

Table (4) Effects of bioactive components of flaxseed on blood sugar and metabolic markers

Author & Year	Bioactive components	Effects
(Pan *et al.*, 2009)(Ursoniu et al 2016) (Nowak & Jeziorek, 2023)(Mishra, 2021)	Alpha-Linolenic Acid (ALA)	-It Lowers insulin sensitivity via regulating hormone secretion, enhancing insulin signaling, and encouraging β cells to produce insulin. -Its omega-3 fatty acid has anti-inflammatory characteristics, which can increase insulin sensitivity and reduce fasting glucose levels.
(Maurya, 2024) (Mishra, 2021).	Lignans and α-linolenic acid	- It may help in decreasing blood sugar levels due to its antioxidant effects.
(Wioletta *et al.*, 2023) (Nowak & Jeziorek, 2023)(Mishra, 2021).	Dietary Fiber	-Its high fiber content leads to slower glucose absorption, resulting in more stable blood sugar levels.

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Table (5) the comparative optimal dose and efficacy of four herbs in reducing blood sugar levels in diabetic patients

Herb	Author & Year	The optimal dose	Outcome
Coriander	(Zamany *et al., 2022*). (Rajeshwari, 2011). (Akbar & Munir, 2006).	1g/day Not reported 4.5 g/day	-(FBS) from 156.15 to 130.30 mg/dL -This trial also reported changes in insulin levels and other metabolic markers. - Its effective hypoglycemic activity when combined with oral hypoglycemic agents.
Cinnamon	(Aldayel, 2016). (Moura et al., 2024). (Antônio *et al.*, 2021).	5 g/day 2 g/day 2 g/day	- There were no significant variations in glucose responses. - In comparison to larger doses, it dramatically reduces fasting blood glucose, postprandial glucose, HbA1c. - A considerable drop in fasting plasma glucose levels.
Fenugreek	(Al Mosawi, 2021). (Khatun *et al.*, 2023). (Gupta *et al.*, 2024).	15g/day 10 g/day 1g/day	-It significantly reduced HbA1C and postprandial glucose levels. - It provides significant benefits in glycemic control at these dosages. - Reductions in fasting blood glucose (FBG) and postprandial blood glucose (PBG). - It successfully regulates blood sugar levels in individuals.

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Flaxseed	Yari *et al*,, (2019) (Almehmadi *et al*., 2021). (Andrea, *et al*., 2022). (Kavyani *et al*., 2023). (Mohammadi-Sartang *et al*., 2018).	30 g/day	- Consuming flaxseed in split amounts was proven to reduce and stabilize blood glucose responses over 24 hours compared to control groups. - Whole flaxseed outperformed flaxseed oil or lignan extracts in terms of improving glycemic markers

Table (6) the comparative of four herbs in reducing blood sugar levels in diabetics

Herb	Fasting Blood Glucose (FBG)	Postprandial Glucose (PPG)	HbA1c (%)	Insulin Sensitivity/Resistance (HOMA-IR, QUICKI)
Coriander	↓ 156.15 to 130.30 mg/dL (seeds).	Not reported	No significant change.	↓ HOMA-IR (6.82 to 5.52), serum insulin (17.72 to 17.12)
Cinnamon	↓ 126.67 mg/dL (mean drop significant); MD: -18.43 mg/dL	↓ 39.22 mg/dL	↓ 0.56%	↓ HOMA-IR (MD: -0.76)
Fenugreek	↓ 38-44% FBG	↓ 44%	↓ 34.7%	↑Improves insulin resistance
Flaxseed	↓ 2.94 mg/dL; SMD: -0.66	↓ 24%	↓ 0.045%	↑ QUICKI (SMD: 1.64); ↓ HOMA-IR (SMD: -0.49)

Conclusion

An extensive study has demonstrated the possibility of using traditional herbs and spices to control blood glucose. These could be attributed to the synergistic action of its bioactive compounds. However, the efficiency of these natural remedies differs based on form, dosage, study design, and patient characteristics. Herbs, such as coriander, cinnamon, fenugreek, and flaxseed have shown

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significant potential, but the degree of improvement in markers, including HbA1c and postprandial glucose requires further investigation. The study findings indicated coriander has the strongest overall effect on blood sugar reduction with the least dose whereas flaxseed has the least impact with the highest dose on blood sugar reduction among herbs under investigation additionally, variations in study designs, sample sizes, and methodologies limit the generalizability of findings. According to published findings, medical plants are more inexpensive, have fewer side effects than synthetic medications, and are more successful in treating diabetes mellitus. Nonetheless, more extensive research with superior designs and a long study is required to validate negligible and/or unclear results.

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