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The Lowering Blood Glucose Level Effects of Cinnamon Compared to Metformin in Type 2 Diabetic Patients: A Systematic Review of Randomized Controlled Trials and Observations

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Abstract

Type 2 diabetes mellitus (T2DM) is a chronic metabolic disorder with rising global prevalence and associated complications. Metformin is the standard first-line therapy, but gastrointestinal side effects have prompted interest in complementary treatments such as cinnamon (*Cinnamomum* spp.), which have been studied for glycemic and lipid-lowering properties. This systematic review aimed to evaluate whether cinnamon supplementation is as effective as metformin in lowering blood glucose levels in adults with T2DM and prediabetes. Following PRISMA 2020 Guidelines (Page et al., 2021) and the Academy of Nutrition and Dietetics Evidence Analysis Library checklist (Academy of Nutrition and Dietetics, 2022), electronic databases were searched for randomized controlled trials and observational studies published between 2020-2025. Ten studies met inclusion criteria, with interventions ranging from 500 mg to 10 g/day of cinnamon in capsule, extract, or dissolved powder form. Cinnamon consistently improved fasting blood glucose, HbA1c, and insulin sensitivity,

particularly in overweight or insulin-resistant populations. Lipid outcomes were modest and inconsistent, with some reductions in LDL and total cholesterol. Anthropometric benefits (BMI, visceral fat) were observed in select trials but not universally. Several studies were limited by small sample sizes (n<40) and short durations. Cinnamon demonstrates clinically relevant improvements in glycemic control and insulin sensitivity, though lipid and anthropometric effects are less consistent. While not a substitute for metformin, cinnamon may serve as a safe complementary therapy in T2DM management. Larger, longer-term trials are needed to confirm efficacy and inform clinical guidelines.

Keywords: cinnamon, metformin, type 2 diabetes mellitus, glycemic control, insulin sensitivity, lipid profile

1. Introduction

A chronic metabolic disorder such as diabetes mellitus is represented by elevated blood glucose levels and affects millions of individuals worldwide (American Diabetes Association, 2022). The prevalence of diabetes mellitus is increasing along with strain on the health system due to increased risk of long-term complications such as cardiovascular disease, kidney failure, and vision loss, as well as the escalating cost of managing these outcomes (Mnge et al, 2025). Diabetes mellitus includes type 1 diabetes, T2DM, gestational diabetes, hybrid forms of diabetes, and special types of diabetes (World Health Organization, 2023). Type 1 diabetes is described as an autoimmune disorder involving the destruction of pancreatic beta cells that leads to insulin deficiency (Antar et al., 2023). T2DM is due to environmental and lifestyle factors causing insulin resistance in peripheral tissues and sometimes beta cell dysfunction (Centers for Disease Control and Prevention, 2023). When left untreated chronic hyperglycemia can lead to severe complications such as nephropathy, neuropathy, retinopathy, stroke, cardiovascular disease, and peripheral vascular disease (Antar, et al 2023). Management of type 2 diabetes involves control of blood glucose levels with pharmacotherapy such as Metformin, a medication that effectively reduces hepatic glucose production and improves insulin sensitivity. Although Metformin is an affective antidiabetic, there are reported negative digestive system related side effects such as nausea, diarrhea, vomiting, and abdominal discomfort (Nabrdalik et al, 2022). Due to adverse side effects of Metformin, there is a growing interest in complimentary therapy leading to the use of more natural alternatives with potential blood glucose lowering effects.

One alternative that has sparked interest is a commonly used spice -cinnamon. Cinnamon is derived from the bark of *Cinnamomum* genus trees. According to two studies, cinnamon has shown to significantly lower glucose levels by allowing glucose to enter the cells and enhance insulin sensitivity (Naghiaee et al, 2021; Mnge et al, 2025). While there is still interest in cinnamon, clear evidence of the spice's effectiveness in controlling blood glucose for diabetic patients, particularly against established treatments like Metformin, is still lacking and varies among different studies.

The aim for this review is to determine if cinnamon is as effective as Metformin at decreasing blood glucose levels in patients with T2DM. By systematically analyzing available randomized controlled trials and observational studies, this review seeks to clarify the potential role of cinnamon as an added or alternative therapy in diabetes management and to

identify areas for future research.

2. Method

2.1 Protocol and Registration

This systematic review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) 2020 Guidelines (Page et al., 2021). A PRISMA flow diagram (Figure 1) outlines the identification, screening, eligibility assessment, and inclusion of studies. The review included randomized controlled trials, original studies, and observational studies. The protocol was registered with The International Prospective Register of Systematic Reviews (PROSPERO) ID # 1085115.

2.2 Search Strategy

Electronic databases were searched for peer-reviewed articles published between 2020 and 2025, including the National Library of Medicine (PubMed), Frontiers (PubMed), Journal of the Endocrine Society (PubMed), Sage Journals (EBSCO), Journal of Functional Foods (Science Direct), Biomedicine & Pharmacotherapy (ScienceDirect), Scientific African (ScienceDirect), and Phytomedicine Plus (University of Houston Libraries). The original search was conducted in June of 2025 and replicated in August of 2025. Medical Subject Headings (MeSH) terms were used during the search along with keywords shown in Table 1. Boolean operators (AND, OR, NOT) were used to combine search terms effectively and refine retrieval of studies relevant to the research question.

Table 1. Example search MeSH/key terms used during database searches

PICO Element	**MeSH/Key terms**	**MeSH/ Key terms combined with Boolean operators**
Population	"Diabetes, glucose intolerant, high blood sugar, non-insulin dependent, insulin resistant"	"Diabetes AND cinnamon AND metformin", "Diabetes AND cinnamon AND decreased blood glucose", "insulin resistant AND cinnamon"
Intervention	"Cinnamon, Metformin, Complimentary therapy, diet supplements"	"Metformin and cinnamon OR complimentary supplements"
Comparison	"Metformin, Cinnamon"	"Cinnamon compared to Metformin"
Outcome	"Glucose levels, Decreased blood sugar, efficacy, glycemic index, HbA1c"	"Glycemic index and cinnamon OR Metformin", "Glucose levels AND cinnamon OR Metformin"

2.3 Eligibility Criteria

Studies were chosen according to the population, health status, interventions, outcomes, study design preferences, size of study groups, language, publication year range, and human studies

as eligibility (see Table 2). The population of interest included are male and female participants over the age of 18 diagnosed with pre-diabetes or T2DM. Interventions only included cinnamon or Metformin while other glucose lowering drugs or supplements were excluded. The study design preferences included original studies, randomized control trials, and observations with study groups of no less than ten individuals. Only articles published in English within the last five years were included to provide the most current information. Only human studies were included due to testing efficacy.

Table 2. Inclusion and exclusion criteria

Criteria	Inclusion	Exclusion
Population	Men and women over the age of 18	Children under 18
Health status	Diagnosed with T2DM (type 2 diabetes mellitus), prediabetes	Participants without a diagnosis of prediabetes or T2DM
Interventions	Cinnamon, Metformin	Other glucose lowering drugs or supplements
Outcomes	Hypoglycemia, hyperglycemia, no change in blood glucose, similar levels	Non glycemic metabolic markers
Study Design Preferences	Original studies, Randomized control trials, Observational studies	Systematic reviews, literature reviews
Size of Study Groups	At least 10 in each group	Less than 10
Language	English	Non-English
Publication Year	Within the last 5 years (2020-2025)	Publications before 2020
Population	Humans	Animals, non-humans

2.4 Data Extraction and Quality Assessment

Data extraction was performed using an adapted standard structured summary table (Table 3). For each included study, details such as citation, study purpose, population/sample characteristics, design and method, key findings, and risk of bias were systematically recorded. This approach ensures consistency and transparency across studies and allows direct comparison of outcomes related to glycemic control, lipid parameters, anthropometric measures, and insulin levels. To establish a process of quality assessment and risk of bias, the Academy of Nutrition and Dietetics EAL checklist was utilized (Academy of Nutrition and Dietetics, 2022). The purpose of the EAL checklist is to create the best available research evidence on important dietetic practice questions. This checklist was used to evaluate the methodology quality of each study and determine if bias is present. Questions were then answered about the articles such as strengths, limitations, and major findings that were then given an evidence grade. A positive rating suggests that the article has clearly addressed criteria of inclusion/exclusion, bias, generalizability, and data collection and analysis. A

negative rating suggests that these criteria have not been clearly addressed. A neutral rating suggests that an article is neither strong nor weak. The Academy of Nutrition and Dietetics EAL checklist ensures that nutrition recommendations are based on the best quality and most reliable scientific evidence available.

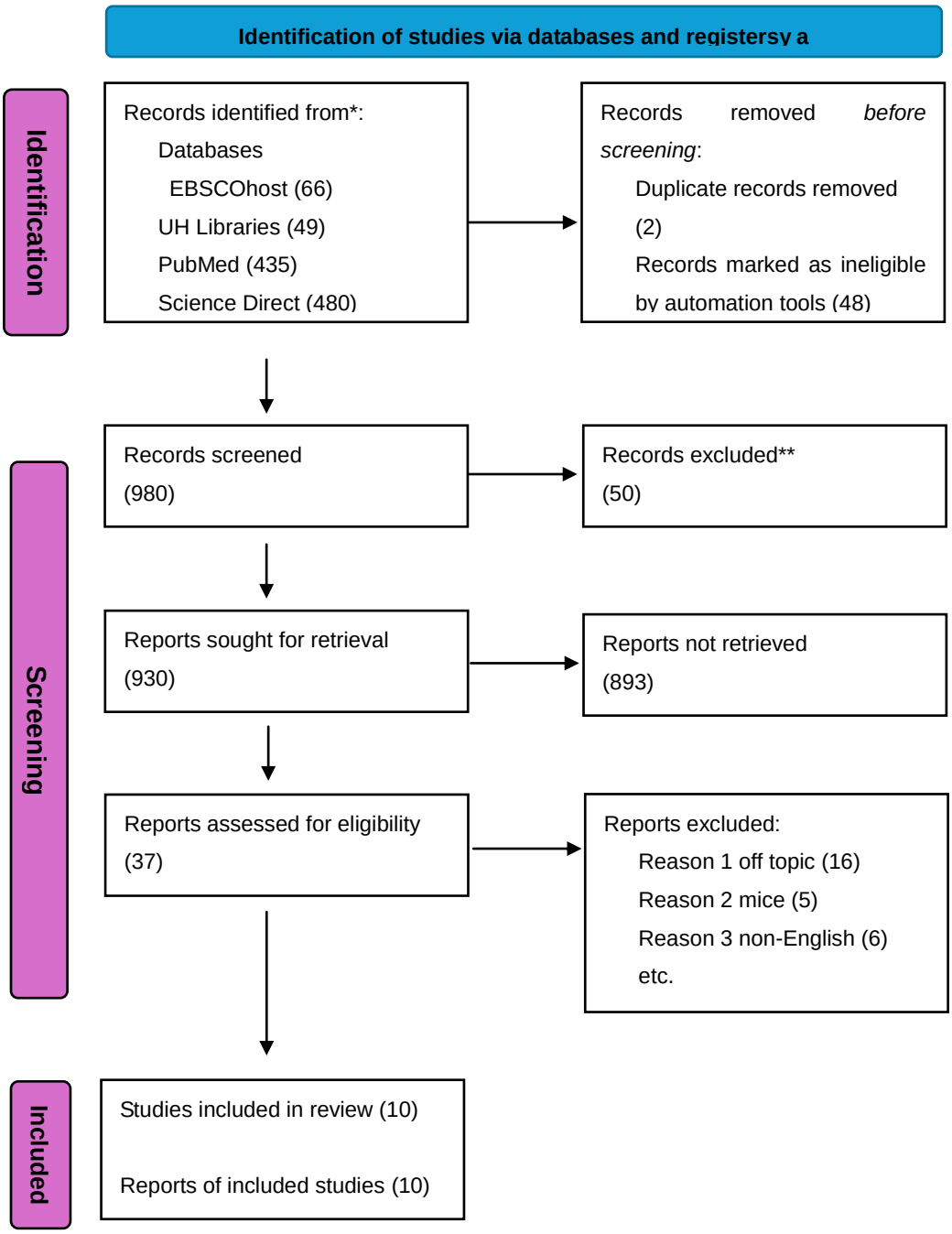

Figure 1. PRISMA 2020 flowchart of the literature search and filtering results for a systematic review of Cinnamon's effect of lowering blood glucose compared to Metformin

3. Results

A total of 980 articles were initially identified in the literature review based on the

inclusion/exclusion criteria. From the 980 articles screened, 943 articles were excluded for not meeting pre-established criteria. The remaining 37 articles underwent further review, which resulted in the removal of 16 articles for lack of topic relevance, five for including or being conducted on animals, and six for being non-English literature. Ultimately, ten articles met all inclusion criteria (see Table 3). Additional studies included in Table 3- Neto et al. (2020) and Romero et al. (2020)- were reviewed for contextual relevance but were not incorporated into the primary synthesis due to differences in study design and population characteristics. Included were, randomized controlled trials (RCTs) evaluating the effects of cinnamon supplementation on glycemic control, lipid profile, insulin sensitivity, and anthropometric outcomes in adults with T2DM, prediabetes, or metabolic syndrome. Cinnamon doses ranged from 500 mg to 3000 mg/day, administered over durations from a single oral glucose tolerance test (OGTT) to 12 weeks. Cinnamon was administered in a variety of formats, including encapsulated bark powder, standardized aqueous extracts, brewed decoctions and dry powder dissolved in water. Most studies used oral capsules containing either crude cinnamon powder (Zare et al., 2019; Zelicha et al., 2024) or standardized extracts rich in polyphenols (Anderson et al., 2016; Muthukuda et al., 2025). Others employed aqueous preparations, such as cinnamon tea or decoctions consumed immediately after carbohydrate ingestion (Rachid et al., 2022; Agustia et al., 2025), while Moriera et al. (2025) directly compared dissolved powder versus encapsulated cinnamon, demonstrative superior glycemic effects with the solubilized form. Most trials employed double -blind, placebo-controlled designs and measured outcomes such as fasting blood glucose (FBG), HbA1c, insulin resistance (HOMA-IR), lipid parameters, and body composition.

3.1 Glycemic Control

Glycemic outcomes were consistently improved in trials using cinnamon extract or powder. Anderson et al. (2016) conducted a double-blind RCT in 137 Chinese adults with elevated serum glucose, administering 500 mg/day of CinSulin® (*Cinnamomum cassia*) for eight weeks. Fasting blood sugar (FBS) decreased significantly *(p<0.001)* from 8.85 ± 0.36 to 8.19 ± 0.29 mmol/L, with improvements also observed in 2-hour postprandial glucose, fasting insulin, and Homeostatic Model Assessment of Insulin Resistance (HOMA-IR). Similarly, Zare et al. (2019) found 1g/day of cinnamon bark powder over 12 weeks significantly (p<0.001) reduced FBS (-13.1 ± 1.7 mg/dL), HbA1c (-0.36 ± 0.1 %), and insulin resistance, with effects more pronounced in patients with BMI ≥ 27 kg/m². In a crossover trial using continuous glucose monitoring, Zelicha and team (2024) reported lower 24-hr glucose trajectories, reduced net area under the curve (AUC), and smaller glucose peaks in prediabetic adults consuming 4g/day of cinnamon compared to placebo (p<0.001). The results collectively demonstrate cinnamon supplementation, across varied doses and delivery formats, yields consistent improvements in fasting and postprandial glycemic markers in both diabetic and prediabetic populations.

Formulation and delivery method of cinnamon-whether as aqueous extract, encapsulated powder, or dissolved spice- appears to play a critical role in its glycemic efficacy. Anderson and team (2016) used a spray-dried water extract of Cinnamomum cassia (CinSulin®) in

capsule form, delivering 500 mg twice daily; fasting blood glucose (FBG) decreased significantly (p<0.001). Moriera et al. (2024), demonstrated cinnamon powder dissolved in water significantly (p<0.01) suppressed postprandial hyperglycemia, while encapsulated cinnamon had no effect (p=0.78), despite identical dosing. In contrast, Rachid et al. (2022) noted aqueous cinnamon extract (6 g/100 mL) administered immediately after OGTT did not significantly (p=0.834) alter postprandial glucose response in adults with T2DM. Timing of administration and delivery method may therefore be critical factors influencing the metabolic outcomes of cinnamon supplementation.

3.2 Lipid Profile

In a Sri Lankan RCT, Muthukuda and colleagues (2025) administered 1000 mg/day of Ceylon cinnamon extract for 12 weeks to adults with LDL-C between 100-190 mg/dL. While LDL-C reductions were modest and not statistically significant (-6.05 mg/dL, p=0.161), FBS decreased significantly (-8.59 mg/dL, p=0.036), with the greatest effect observed in participants with T2DM (-78.6 mg/dL, p=0.002) after seven days of 10 g/day cinnamon extract in Indonesian adults with T2DM.

Lipid outcomes varied across studies. Al Dhaheri et al. (2024) conducted a 12-week RCT in 97 adults with or at risk of metabolic syndrome, comparing 3 g/day of cinnamon, ginger, black seed, or placebo. Cinnamon reduced HbA1c by 0.596% (p≤0.001). Although LDL-C (p=0.03) and LDL-C (p=0.01) changes reached statistical significance, the magnitude of effect was small and unlikely to be clinically meaningful. Thus, cinnamon demonstrated limited impact on lipid parameters compared with black seed and ginger. In contrast, black seed and ginger significantly reduced total cholesterol (-13.05 and -11.49 mg/dL, p=0.031 respectively) and LDL-C (-2.14 and -5.31 mg/dL, (p≤0.001) respectively), while cinnamon showed no lipid lowering effect. Zare et al. (2019) and Anderson et al. (2016) reported modest reductions in LDL-C (-10 and -15 mg/dL) and total cholesterol, particularly overweight populations, though effects on HDL and triglycerides were inconsistent. Overall, while cinnamon demonstrated modest and inconsistent effects on lipid parameters, black seed and ginger produced statistically significant (p≤0.001) reductions in total and LDL cholesterol, suggesting formulation and botanical choice may critically influence lipid outcomes in metabolic populations.

3.3 Insulin Sensitivity

Several trials assessed cinnamon's impact on insulin sensitivity using surrogate markers such as fasting insulin and HOMA-IR. Anderson and researchers (2016) revealed significant reductions in both fasting insulin and HOMA-IR (p<0.001) following twelve weeks of supplementation with 500 mg/day of spray-dried cinnamon extract (CInSulin), suggesting improved insulin signaling. Similarly, Zare et al. (2019) noted a significant decrease in HOMA-IR (p<0.001) with 1 g/day of encapsulated C. Verum powder, indicating enhanced insulin sensitivity in overweight adults with type 2 diabetes. Zelicha and associates (2024) used continuous glucose monitoring to evaluate glycemic dynamics and observed significant reductions in 24-hour glucose AUC (p=0.01) and peak glucose excursions (p=0.027) with 4 g/day of encapsulated *C. burmannii*, reflecting improved postprandial insulin action.

Although direct measures such as clamp studies were not employed, consistent improvements in surrogate indices suggest that cinnamon may enhance insulin sensitivity, particularly when delivered in bioavailable formats and standardized doses.

3.4 Anthropometric Outcomes

Anthropometric changes were modest but favorable. Zare and associates (2019) administered 1 g/day of encapsulated Cinnamomum verum powder for eight weeks and found significant (p<0.001, respectively) reductions in BMI (-0.63 ± 0.06 kg/m²), body fat percentage (-1.92 ± 0.26 %), and visceral fat (-0.69 ± 0.13%) in the cinnamon group, with greater effects in participants with higher baseline BMI. In contrast, Al Dhaheri and colleagues (2024) provided 3 g/day of dry ground Cinnamomum spp. powder in sachets dissolved in hot water for 12 weeks and reported no significant changes in weight (-1.5 ± 2.3 kg, p=0.12) or waist circumference (-1.05 cm, p=0.09) in the cinnamon group. Notably, ginger and black seed groups in the same trial showed greater and statistically significant effects on lipid parameters and anthropometric indices (p<0.05), suggesting cinnamon's impact may be formulation-dependent and less potent in this context.

3.5 Results of Risk and Quality Assessment

The Academy of Nutrition and Dietetics EAL checklist was utilized to conduct the quality assessment of the literature (Academy of Nutrition and Dietetics, 2022). Four of the ten articles produced a positive rating, which suggests criteria of inclusion/exclusion, bias, generalizability, data collection and analysis were clearly addressed. The other six articles produced a neutral rating due to issues such as limited sample size and duration, limited generalizability, single-center recruitment, and lack of placebo and blinding. There were no negative studies presented. In conclusion, the studies presented a low to moderate risk of bias and a strong quality assessment of this review.

Table 3. Characteristics of Studies Reviewed

Citation	**Study Purpose**	**Population/ Sample**	**Design & Method**	**Key Findings**	**Risk of Bias**
Anderson et al, (2015).	To evaluate the effects of cinnamon extract on glucose, insulin, and cholesterol in hyperglycemic adults	**Initial:** 173 adults **Final:** 65 men 72 females Mean Age: 61 years; BMI 25.3; fasting glucose> 6.1mmol/L Or 2-h glucose> 7.7 mmol/L	Double blind, placebo- controlled RCT; 250mg cinnamon extract (CinSulin) vs placebo, Twice a day for 2 months	**Cinnamon extract supplement group**: Reduced fasting glucose: 8.85 to 8.19mmol/L (p< 0.001). Fasting insulin & HOMA-IR reduced, Total & LDL cholesterol decreased **Placebo group**: 8.57 to 8.44 (p=0.45). HDL in both groups decreased	Quality Rating: + Low risk: RCT design with good compliance, but some attrition and regional specificity
Agustia et	To determine	30 patients with	Randomized	Pre-treatment blood sugar:	Quality rating: ø

al, (2025)	whether a higher dose of cinnamon extract can significantly reduce blood sugar levels in patients with type 2 diabetes mellitus.	type 2 diabetes mellitus, randomly assigned to intervention (n=15) and control (n=15) groups.	controlled trial conducted at Medan Denai Health Center (Nov-Dec 2023). Intervention group received 10 mg/day cinnamon extract; control group received no treatment. Blood sugar measured pre- and post-intervention	**Intervention:** 238.80 mg/dL vs. **Control:** 225.33 mg/dL Post treatment: **Intervention:** 127.73 mg/dL vs. **Control**: 222.20 mg/dL **Reduction in intervention group:** -111.07 mg/dL P< 0.001, indicating statistically significant improvement.	Moderate risk: randomization used, but lack of placebo and blinding may introduce bias.
Al Dhaheri et al, (2024).	To evaluate the effects of ginger, cinnamon, and black seed supplementation on cardiometabolic parameters in individuals with or at risk of metabolic syndrome.	120 adults aged 18-50 in the UAE with 2 or more metabolic syndrome risk factors; randomized into 4 groups (ginger, cinnamon, black seed, placebo)	12- week double-blind, placebo-controlled randomized clinical trial; participants consumed 3g day of assigned spice or placebo.	**Fasting Blood Glucose**: Significant reduction in all spice groups vs. placebo (p<0.001) **HbA1c**: Cinnamon group showed greatest reduction (-0.5%, p=0.002) **Total cholesterol**: Ginger (-15.2mg/dL, p=0.01), black seed (-18.7mg/dL, p=0.004) **LDL cholesterol**: Ginger (-12.4mg/dL, p=0.03), black seed (-14.9mg/dL, p=0.01) No significant changes in BMI or waist circumference across groups.	Quality rating: + Low risk: due to randomized, placebo-controlled design; minor bias possible from single-blind setup and adherence tracking.
Moreira, F.D. et al. (2024).	To evaluate whether the form of cinnamon administration (powder vs. capsule) affects its ability to suppress postprandial hypoglycemia in type 2 diabetes	19 fasting adults with type 2 diabetes; crossover design with five test conditions	Randomized crossover trial: participants consumed a standardized meal alone or after ingesting 3g or 6g of raw cinnamon either in capsule form or dissolved in water; blood glucose measured at multiple	Cinnamon dissolved in water significantly reduced postprandial glucose spikes and glycemic curve area (1 hr glycemia: 79mg/dL, p=0.002; peak rise: 87 mg/dL, p=0.001); capsule showed diminished or no effect	Quality rating: ø Moderate risk: well controlled crossover design, but limited by sample size and short duration

			time points post meal		
Muthukuda et al, (2025).	To evaluate the effect of Ceylon cinnamon extract on LDL cholesterol, glucose levels, and safety outcomes in adults	150 adults (mean age 50.4 years; 66% female) with LDL-C 100-190 mg/dL	Randomized, double blind, placebo-controlled trial; 1000 mg/ day cinnamon extract vs placebo for 12 weeks; ANCOVA used for analysis	Cinnamon extract significantly reduced fasting blood sugar (FBS) (8.59mg/dL p=0.036) FBS in T2DM subgroup: -78.6mg/dL vs -11.2 mg/dL p= 0.002); LDL-C reduced 6.05 mg/dL	Quality rating: ø Moderate risk: strong design and safety profile, but limited by duration and scope
Neto et al, (2020).	To evaluate the efficacy of Cinnamomum verum (true cinnamon) supplementation on glycemic. Lipid, anthropometric, and lifestyle outcomes in patients with type 2 diabetes.	130 adult patients with type 2 diabetes (HbA1c≥6.5%) recruited from primary care centers in Brazil.	Randomized, double-blind, placebo-controlled Phase II trial; participants received 3 g/day cinnamon capsules or placebo for 90 days. Outcomes measured pre- and post-intervention included HbA1c, fasting glucose, lipid profile, and waist circumference.	**HbA1c** decreased: (-0.67%, p=0.01) **Fasting glucose** dropped: (-18.8% mg/dL, p<0.05) **LDL-C** reduced: (-12.3 mg/dL, p=0.03) **Triglycerides** decreased: (-21.6 mg/dL, p=0.04) **Waist circumference** improved: (-1.8 cm, p=0.04)	Quality rating: ø Moderate risk: randomization and blinding were clearly described; possible selection bias due to single-center recruitment; No data on compliance or drop-out rate included.
Rachid et al, (2022).	To assess the effect of aqueous cinnamon extract on postprandial glycemia in adults with type 2 diabetes	36 adults Intervention group: M:3 F:15 Control group: 18 with T2DM. Intervention: 18 Control: 18 Aged 35-77	Randomized controlled trial; OGTT (oral glucose tolerance test) followed by 6g/100mL cinnamon extract vs OGTT alone; glucose measured at 0, 30, 60, 90, and 120 minutes	No significant difference in AUCi (p=0.834), Cmax (p=0.527), or Cmax (p=0.873); extract had high antioxidant activity (DPPH: 5125 umol Trolox/L; FRAP; 3658.8 umol Trolox/L)	Quality rating: ø Moderate risk: RCT design but limited generalizability and short intervention on period
Romero, G.R., Lee, J., Mulla, C.M, et al. (2020).	To evaluate whether cinnamon supplementation improves glucose homeostasis in	54 adults with prediabetes (27 per group), recruited from two academic	Double-blind, placebo-controlled RCT; 500mg cinnamic or placebo 3x a day for 12	Cinnamon group showed stable FPG vs. increase in placebo group (mean difference: 5 mg/dL) p< 0.5; significant reduction (p<0.001) in 2-hour	Quality rating: ø Moderate risk: well-designed RCT, but limited by sample size and

	individuals with prediabetes.	centers in the US and Korea	weeks: primary outcome; fasting plasma glucose; secondary: OGTT results	OGTT glucose and AUC glucose with cinnamon	duration
Zare et al, (2019)	To assess the effect of cinnamon supplementation on anthropometric, glycemic, and lipid parameters in patients with type II diabetes mellitus, stratified by BMI.	140 patients with type II diabetes mellitus, divided into 4 groups: Cinnamon (BMI≥ 27 and< 27) and placebo (BMI≥ 27 and <27)	Triple blind, placebo controlled randomized clinical trial. Cinnamon bark powder (500 mg) twice daily for 3 months.2	Significant reduction in **BMI**: -0.7 ±0.2 kg/m ² (p<0.001) **Body fat**: -1.2 ± 0.3% (p< 0.001) **Visceral fat**: -0.5 ±0.1 (p<0.001) **FPG**: -13.1± 1.7 mg/dL (p<0.001) **Fasting insulin**: -1.8 ± 0.3 IU/mL (p<0.001) **HOMA-IR**: -0.6 ± 0.1 (p< 0.001) **Total Cholesterol**: -12.4 ±2.1 mg/dL (p<0.001) **LDL-c:** -9.8 ± 1.7 mg/dL (p<0.001) **HDL-c**: + 3.2 ±0.9 mg/dL (p<0.01) **Triglycerides:** No significant change.	Quality rating: + Low risk: due to randomization and blinding. Minor bias possible from self-reported adherence and single-site recruitment.
Zelicha et al, (2024)	To evaluate whether daily cinnamon spice supplementation affects 24-hour glucose concentrations and glycemic variability in adults with obesity-related prediabetes.	18 adults (mean age 51.1 years) 72% female with obesity and prediabetes.	Double blind randomized controlled crossover trial. Participants received 4 g/day cinnamon or placebo for 4 weeks, separated by a 2-week washout. Continuous glucose monitoring (CGM) and oral glucose tolerance (OGTT) test were used.	24-hour glucose concentrations significantly lower with cinnamon (effect size [ES] = 0.96; 95% Cl: -2.9, -1.5; p<0.001) **Net-AUC for glucose** reduced (ES= -0.66; 95% Cl: 2501.7-5412.1; p = 0.01) **Glucose peak reduced:** 9.56± 9.1 mg/dL vs. 11.73± 8.0 mg/dL. (P=0.027) **GIP levels** increased: (p=0.04). **Triglycerides** decreased (p=0.02)	Quality rating: + Low risk: due to crossover design and blinding. High adherence (97.6%) and no serious adverse events reported.

4. Discussion

This systematic synthesis of randomized controlled trials evaluating cinnamon supplementation in adults with T2DM, prediabetes, and metabolic syndrome revealed consistent glycemic benefits, modest lipid improvements, and favorable effects on insulin sensitivity, particularly when cinnamon is delivered in aqueous or food-integrated formats. While many studies reported statistically significant improvements in fasting glucose, HbA1c, and HOMA-IR, the consistency of the effects appeared to hinge in formulation, dose, and delivery method. Aqueous preparations and solubilized formats such as brewed decoctions or dissolved powders were notably more effective than encapsulated bark powder, likely due to enhanced bioavailability and gastric interaction. Across studies, cinnamon reduced FBG and HbA1c with statistical significance ($p<0.001$) in most trials, including Anderson and associates (2016) and Zare and team (2019), both of which used encapsulated extracts or powders. Notably, Moriera et al. (2024) demonstrated cinnamon powder dissolved in water significantly suppressed postprandial hyperglycemia ($p<0.01$), whereas the same dose in encapsulated form had no effect (p=0.78). This underscores the importance of solubility and gastric exposure in bio-efficacy.

Insulin sensitivity outcomes were similarly favorable. Anderson et al. (2016) and Zare et al. (2019) both revealed significant reductions in HOMA-IR ($p<0.001$), while Zelicha and researchers (2024) observed improved 24-hour glucose dynamics using continuous glucose monitoring (AUC $p=0.01$; peak glucose $p= 0.027$). The findings suggest cinnamon may enhance insulin signaling and reduce glycemic variability, particularly in individuals with elevated baseline glucose or BMI.

Proposed mechanisms include enhancing insulin receptor phosphorylation and downstream signaling, as well as increased translocation of GLUT4 transporters to the cell membrane, which facilitates glucose uptake in skeletal m-1uscle and adipose tissue. Polyphenolic compounds in cinnamon, such as cinnamaldehyde, may also modulate insulin receptor activity and improve cellular glucose utilization.

Emerging evidence suggests that cinnamons metabolic effects may be partially mediated through activation of Sirtuin-1 (SIRT1), a NAD+-dependent deacetylase involved in glucose homeostasis, mitochondrial function, and insulin sensitivity. SIRT1 activation enhances insulin receptor signaling, promotes GLUT4 translocation, and improves hepatic glucose regulation (Canto & Auwerz, 2012; Bordone & Guarente, 2005). Polyphenolic compounds in cinnamon-particularly cinnamaldehyde-have been shown in experimental models to upregulate SIRT1 expression and downstream targets such as PGC-1α, thereby improving cellular energy metabolism and reducing oxidative stress (Kitada & Koya, 2013; Shay et al., 2012). Although human trials included in this review did not directly measure SIRT1 activity, the observed improvements in HOMA-IR, fasting glucose, and postprandial glycemia are consistent with metabolic pathways influenced by SIRT1 activation. Future clinical studies should incorporate SIRT1-related biomarkers to clarify cinnamon's mechanistic role in metabolic regulation.

Lipid outcomes were more variable and generally modest. While Zare and colleagues (2019) and Anderson and team (2016) observed significant reductions in total cholesterol and

LDL-C (p<0.001), other studies such as Al Dhaheri and researchers (2024) found the cinnamon group showed a change of -0.308 mg/dL, with no significant p value reported for this group individually, despite comparable dosing. This inconsistency may reflect differences in cinnamon species, extract standardization, or study duration. In contrast, black seed and ginger produced significant reductions in both total cholesterol and LDL-C (p≤=0.031), Cinnamon's lipid-modulating effects may be formulation-dependent or less potent than other botanicals.

Anthropometric changes were similarly mixed. Although reductions in BMI, body fat, and waist circumference were observed in select trials such as Zare and team (2019), the effects were not uniformly significant and may be secondary to improved glycemic control rather than direct modulation of adipose tissue. The diversity in study design-particularly regarding intervention duration and participant characteristics, limits the ability to draw firm conclusions about cinnamon's role in weight management.

Despite promising findings in select trials, cinnamon is not currently endorsed by major professional organizations such as the American Diabetes Association (ADA), which explicitly notes insufficient evidence to support its use for glycemic management (American Diabetes Association, 2023). The American Medical Association (AMA), the Academy of Nutrition and Dietetics (AND) and the American College of Obstetricians and Gynecologists (ACOG) do not provide guidance on cinnamon use, and their silence reflects a broader lack of consensus in evidence-based practice. In clinical guideline development, omission can be as meaningful as inclusion-signaling; despite promising preliminary data, cinnamon has not met the evidentiary threshold for formal recommendation. Until larger, longer-duration trials with standardized extracts demonstrate reproducible benefits, cinnamon remains a complementary option rather than a formally recognized intervention.

From a methodological perspective, the overall quality of the included studies was moderate. The Academy of Nutrition and Dietetics EAL checklist was utilized to conduct the quality assessment of the literature (Academy of Nutrition and Dietetics, 2022). Four of the ten articles produced a positive rating, which suggested criteria of inclusion/exclusion, bias, generalizability, data collection and analysis were clearly addressed. The other six articles produced a neutral rating due to issues such as limited sample size and duration, limited generalizability, single-center recruitment, and lack of placebo and blinding. There were no negative studies presented. The studies presented a low to moderate risk of bias and a strong quality assessment of this review.

In summary, cinnamon appears to be a promising adjunctive intervention for glycemic regulation and insulin sensitivity, with formulation and baseline metabolic status serving as key moderators of efficacy. Lipid and anthropometric effects are less consistent, and may depend on dose, species, and delivery format. Future trials should prioritize standardized extracts, longer durations, and stratified analyses to better elucidate cinnamon's therapeutic potential across diverse metabolic profiles.

4.1 Strengths and Limitations

This review offers notable strengths. First, the review employed a rigorous methodological appraisal using the PRISMA Guidelines and the Academy of Nutrition and Dietetics Evidence Analysis Library (EAL) checklist, ensuring consistent evaluation of bias, generalizability, and analytic transparency across studies (Page et al., 2021; Academy of Nutrition and Dietetics, 2022). Second, the review focuses on adult populations with T2DM or metabolic syndrome, enhancing clinical relevance and applicability to practitioner decision-making. Outcomes such as fasting glucose, HbA1c, HOMA-IR, LDL-C, and waist circumference are directly aligned with therapeutic targets in metabolic care. Additionally, the review provides formulation-specific insight by comparing aqueous, encapsulated, and food-integrated cinnamon formats, highlighting the importance of delivery methods in therapeutic efficacy. Finally, the inclusion of RCTs further strengthens the reviews methodological rigor. RCTs are considered the gold standard for evaluating intervention efficacy, as they minimize selection bias through random allocation and allow for casual inference between cinnamon supplementation and metabolic outcomes. Many of the included studies employed double-or triple-blinding and placebo controls, enhancing internal validity and reducing performance and detection bias. The use of standardized outcome measures-such as fasting glucose, HbA1c, HOMA-IR, LDL-C, and anthropometric indices-across diverse populations supports the reliability and reproducibility of findings.

However, the review is not without limitations. The included studies varied widely in cinnamon species such as *C. cassia, C. verum*, and *C. burnannii*, dosage ranging from 500 mg to 10 g/day, and delivery format, which limits direct comparability and precludes quantitative meta-analysis. Many trials were short duration (≤ twelve weeks) and involved small sample sized (n<40), reducing statistical power and limiting conclusions about long-term efficacy and safety. Six studies received neutral EAL ratings due to methodological concerns such as lack of placebo control, single-center recruitment, and absence of blinding, which may introduce bias. Furthermore, few studies systematically reported adverse events, making it difficult to assess tolerability across formulations and populations.

4.2 Practical Implications for Practitioner

The findings suggest cinnamon supplementation may serve as a clinically useful adjunct for improving glycemic control and insulin sensitivity in adults with T2DM or metabolic syndrome. Evidence indicated formulation plays a critical role in efficacy, with aqueous or food-integrated formats- such as dissolved powders, brewed decoctions, or standardized extracts like CinSulin®- demonstrating greater metabolic benefits that encapsulated bark powder. Delivery methods likely enhance bioavailability and gastric interaction, which may be essential for therapeutic action. Cinnamon's effects were most pronounced in individuals with elevated baseline glucose or BMI, suggesting cinnamon supplementation may be particularly beneficial for patients with early-stage insulin resistance or poorly controlled T2DM. Effective doses ranged 1 to 4 g/day, with higher doses (≥3 g/day) and longer durations (≥ twelve weeks) associated with stronger outcomes. While lipid and anthropometric changes were less consistent, some studies reported modest reductions in LDL-C and waist circumference, indicating potential secondary benefits. Safety profiles were favorable across trials, though long-term data remain limited. Practitioners should monitor

liver enzymes when using *C. cassia* due to its coumarin content and educate patients on evidence-based formats, emphasizing cinnamon as an adjunct-not a replacement for pharmacologic therapy such as Metformin.

4.3 Conclusion

In conclusion, this systematic review demonstrated cinnamon supplementation, particularly in aqueous or food-integrated formats, can significantly improve glycemic control and insulin sensitivity in adults with T2DM and metabolic syndrome, with effects most pronounced in individuals with elevated baseline glucose or BMI. While lipid and anthropometric outcomes were less consistent, select studies reported modest benefits, especially when higher doses and longer durations were employed. Compared to Metformin, cinnamon's effects are more modest and variable, with average reductions in fasting glucose and HbA1c falling below those typically achieved by pharmacologic therapy. However, cinnamon may offer complementary benefits, particularly in insulin-resistant individuals, and could serve as a food-based adjunct to conventional treatment. Importantly, formulation and bioavailability appear to influence efficacy, with solubilized or extract-based preparations producing stronger glycemic and insulin-related outcomes than encapsulated bark powder. Comparative data also suggest that botanical choice may shape lipid outcomes, as black seed and ginger demonstrated more consistent cholesterol-lowering effects than cinnamon. The variability in cinnamon species, formulation, and study design highlights the need for standardized protocols in future research. Overall, the evidence supports cinnamon as a potential effective adjunctive intervention in metabolic care, especially when tailored to the right patients and delivered in the right form.

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Authors' contributions

Lacy Powell and Kevin Haubrick were responsible for the study conceptualization, design, and revising. Lacy Powell was responsible for data collection and drafting the manuscript. Lacy Powell and Kevin Haubrick revised the various drafts. Both authors read and approved the final manuscript.

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AI Disclosure

The author used digital tools to assist with minor editing and formatting during preparation of the manuscript. All analysis, interpretation, and final content were developed and verified by the author, who assumes full responsibility for the accuracy and integrity of the final manuscript.

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Obtained.

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