REVIEW ARTICLE

Gut Microbiota and Type 2 Diabetes: Cinnamon the Promising Duo in Fighting against Diabetes- A Narrative Review

Laiba Saher[1*] and Sahar Haseeb[1]

[1]*Karachi Medical and Dental College, Karachi Metropolitan University, Karachi, Pakistan*

Abstract

This narrative review aims to investigate how gut microbiota contributes to type 2 diabetes and how cinnamon may help regulate it. It draws attention to their combined effects on metabolic health and glycemic management. Cinnamon possesses properties that enhance insulin sensitivity and lower blood glucose levels for patients suffering from type 2 diabetes, and also plays a vital role in managing gut bacteria composition. The encouraging data limits researchers' ability to make reliable judgments due to study design inconsistencies and missing standardized procedures. Although cinnamon shows promise in modulating gut microbiota and glycemic control, its therapeutic potential remains inconclusive. More comprehensive, well-designed clinical trials are essential to establish both the safety and efficacy of cinnamon supplementation in the context of Type 2 diabetes. Research into cinnamon's impact on gut bacteria may improve its application as an additional treatment option. Future diabetic treatment plans may include cinnamon as a personalized therapeutic option. Through its anti-inflammatory and anti-oxidative characteristics, cinnamon maintains gut microbiota stability and aids in type 2 diabetes management. Cinnamon influences the production of short-chain fatty acids and regulates the brain axis, which leads to homeostasis management. A more comprehensive approach is required to understand cinnamon's mechanism for the control of type 2 diabetes.

Keywords: *Diabetes Mellitus type 2, gastrointestinal microbiome, Cinnamomum zeylanicum, HBA1C levels, fasting glucose levels, metabolic health.*

INTRODUCTION

T2DM represents a complex metabolic disorder that develops due to reduced insulin sensitivity and impaired insulin secretion, leading to persistent high blood sugar levels [1]. The rapid increase in global type 2 diabetes rates demands exploration of new drug therapies to reduce its impact [2]. The pathogenesis of type 2 diabetes is associated with gut dysbiosis, as new findings in microbiome research have shown a pivotal role of gastrointestinal microbiota in glucose metabolism, insulin sensitivity, and inflammation [3]. The human gut is home to various gut microbiome flora. Numerous bodily systems are directly impacted by and interact with the diverse gut microbiome. The lifestyle and the environment play a major role in affecting this fragile microbial balance, which is so important for both disease and health. More therapeutic effects in the treatment and prevention of disease can be realized when further research is undertaken to better grasp the potential of the gut microbiome and the consequences of utilizing nutraceuticals to benefit its function [4]. Diabetes onset and progression are frequently linked to the gut microbiome. In recent years, several treatment strategies have attempted to boost health by altering the gut microbiome [5]. One of the most used spices produced from the bark of the Cinnamomum plant, cinnamon has received considerable attention owing to its potential antidiabetic activity. Packed in bioactive substances like flavonoids, polyphenols, and cinnamaldehyde, cinnamon has demonstrated potential to improve insulin sensitivity, lower oxidative stress, and alter the composition of the gut microbiota [6]. Cinnamon is also believed to be beneficial to human health, with capabilities to alleviate an extensive range of disorders, from cancer and diabetes to neurological issues. Cinnamon supplements are commonly used by diabetic patients to help return their blood glucose levels to normal [7]. According to recent research, cinnamon may have anti-diabetic benefits by altering the makeup of gut bacteria and boosting the number of good bacteria like *Bifidobacterium* and *Akkermansia muciniphila* [8]. Additionally, recent meta-analyses have demonstrated that supplementing with cinnamon significantly lowers hemoglobin A1c and fasting blood glucose levels in individuals with type 2 diabetes, confirming its use as a supplemental therapeutic agent [9]. Because cinnamon inhibits protein tyrosine phosphatase 1B and increases insulin receptor kinase activity, it improves insulin signaling and has a hypoglycemic impact [10]. Additionally, some research indicates that taking supplements of cinnamon lowers inflammatory markers and oxidative stress, two important variables in insulin resistance [11].

METHODOLOGY

The data to conduct this narrative literature review were extracted from the PubMed database, Google Scholar database, and Cochrane Library. The search for articles was done using all the concerned keywords. About 46 studies, including randomized controlled trials, meta-

*Corresponding author: *Laiba Saher, Karachi Medical and Dental College, Karachi Metropolitan University, Karachi, Pakistan, Email: saherlaiba17@gmail.com*
Received: April 23, 2025; Revised: June 30, 2025; Accepted: July 24, 2025
DOI: https://doi.org/10.37184/lnjpc.2707-3521.7.78

analyses, and systematic reviews, were selected. After full text screening to match the requirements of the study, 15 papers were selected, from which one study was neglected due to Shenlian formula usage. So a total of 14 studies were analyzed. Some studies were excluded due to the unavailability of full text, and some were rejected due to not meeting the requirement of the keywords included. The selection criteria did not specify any population, and no limitation on the year of study. The authors declare that Chat GPT was used as an AI tool for language refinement.

DISCUSSION

An Overview of Gut Microbiota and Type 2 Diabetes

The gut flora plays an important role in the pathogenesis of type 2 diabetes. But research studies show that it isn't the only factor in this condition. More than 1000 different types of bacteria reside in the human gut, where these gut bacteria are crucial for our well-being; However, when the balance is disrupted, gut health can contribute to various health complications, which is known as dysbiosis, and influence the risks and management of type 2 diabetes. A study published in 2024 suggests that restoring microbial balance can aid in the management of diabetes. Another research suggests that prebiotics and probiotics can maintain the hemostasis of the gut microbiome, which can potentially lead to the prevention and improvement of health outcomes in diabetes patients [12, 13]. Alterations in gut microbiome can act as a biomarker for early detection of T2D [14]. Emerging evidence suggests that gut bacteria are also essential for controlling bile acid metabolism, which affects glucose homeostasis *via* the Takeda G-protein receptor 5 (TGR5) and farnesoid X receptor (FXR) pathways [15]. The possibility of microbiome-targeted treatments is further supported by recent clinical trials that show that fecal microbiota transplantation (FMT) from healthy donors to diabetes patients can cause positive metabolic alterations [16].

Gut Microbiota's Role in Glucose Homeostasis

Gut bacteria regulate glucose metabolism by stimulating the production of short-chain fatty acids such as acetate, propionate, and butyrate, which leads to an increase in insulin efficiency [17]. Studies show that individuals suffering from type 2 diabetes possess lower microbial diversity and an altered Firmicutes to Bacteroidetes ratio, which may lead to metabolic dysregulation [18]. In addition, it maintains the balance of immunological function, reduces inflammatory responses, and helps maintain the stability of the gut barrier [19]. Persistent low-grade inflammation is caused by enhanced gram-negative bacterial production of lipopolysaccharide (LPS) due to disruption of gut bacteria (dysbiosis), resulting in insulin resistance and hyperglycemia [20]. It works by stimulating the secretion of hormones such as glucagon peptide and peptide tyrosine, which are essential for metabolizing glucose [21].

Gut Microbiota: Mechanism of Action

Gut microbiota aids in type 2 diabetes and can be a root cause of this disease. Dysbiosis (imbalance in gut flora) can cause inflammation of the intestine, which contributes to insulin resistance. It can disturb the gut hormones, which leads to glucose metabolism. Modulation of immune response, which accounts for the action against dietary antigens and pathogens, and lowers chronic inflammation. It can ferment the dietary fibers, which can improve insulin sensitivity and reduce inflammation. Insulin sensitivity and progression of T2D correlate with bile acid metabolism, which is influenced by gut microbiota. Healthy gut microbiota help maintain intestinal barrier integrity and prevent the translocation of harmful bacteria and toxins into the bloodstream, which is associated with systemic inflammation [22]. Incretin hormones, GLP-1 and PYY secretion, are modulated by gut microbiota, which helps to enhance insulin secretion. Alteration of gut microbiota increases the BCAAs (branched chain amino acids) like valine, leucine, and isoleucine [23].

Dysbiosis and T2DM

Type 2 diabetes mellitus (T2DM) is the primary outcome assessed in this research. The gut bacteria that are often related to a high risk of type 2 diabetes mellitus are Genus *Flavonifractor*, genus *Haemophilus*, family Clostridiaceae, genus *Actinomyces*, and genus *Candidatus Soleaferrea*. Alteration in gut bacteria has been correlated with high inflammation, insulin resistance, and glucose intolerance in patients with type 2 diabetes mellitus [24]. According to the research, people with type 2 diabetes mellitus have a quite different gut flora composition in contrast to people without type 2 diabetes [25]. Fig. **(1)** shows the comparison

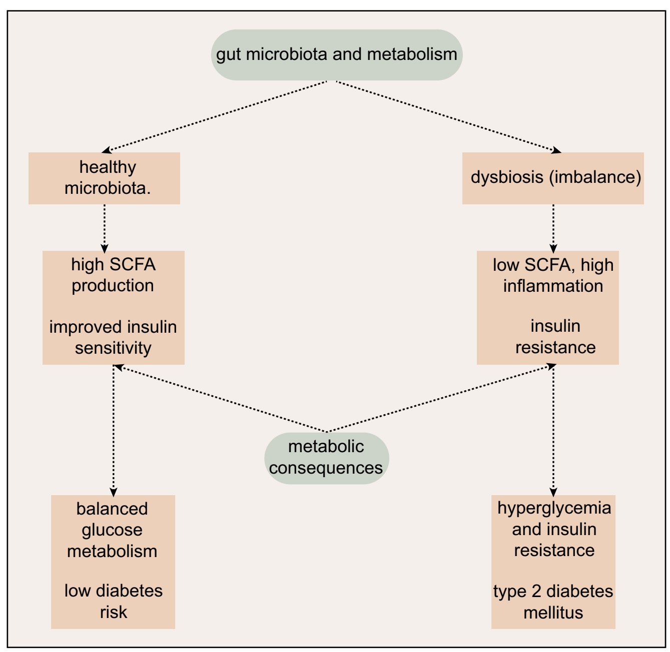

Fig. (1): The contrast between the healthy gut and dysbiosis-related gut of humans, which differs in the production of short-chain fatty acids and insulin sensitivity.

Table 1: Active compounds reflecting their effects on body glucose levels and gut microbiota[1].

Active Compounds	Mechanism of Action	Impact on Diabetes	Effect on Gut Flora
Cinnamaldehyde	upgrades the insulin sensitivity by activating the insulin	reduces the blood glucose levels by increasing the uptake of insulin	raise the levels of Lactobacillus and Bifidobacterium, which are beneficial for gut health
Cinnamic Acid	reduces oxidative stress by working as an antioxidant	improves glucose metabolism	reduces pathogenic bacteria like Proteobacteria
Polyphenols	mimics the insulin action	reduces fasting glucose levels	increase short-chain fatty acids, which improve gut health
Methylhydroxychalcone Polymer	enhances glucose transport by mimetic action	improves insulin sensitivity	elevates the levels of Firmicutes, which are beneficial
Eugenol	protect pancreatic b-cells	reduces hyperglycemia	reduces bacteria like Escherichia coli, an inflammatory bacteria

[1]Table **1** illustrates a table comprising all the active compounds in cinnamon, which are of great importance concerning diabetes type 2 management and show a positive impact on gut health by promoting the beneficial bacterial growth in the gut and reducing the bad bacteria.

of healthy *vs.* dysbiotic gut relation with insulin sensitivity. This is due to the increase in opportunistic infections (rise in bad bacteria) and fall of helpful gut bacteria like *Faecalibacterium*, *Bifidobacterium* [3, 26]. Lipopolysaccharides (LPS) are raised in blood concentration due to elevated gram-negative bacteria, which are the main cause of low-grade inflammation and lead to insulin resistance. This has been evaluated to enhance glycemic control and insulin sensitivity by restoring microbial balance through diet, prebiotics, and probiotics [27, 28].

Nutritional Therapy to Control Gut Microbiota in Diabetes

There are a number of nutritional interventions suggested to improve metabolic results and ensure microbial equilibrium, considering the association between gut microbiota and T2DM. Recent research has proven that the use of probiotics, prebiotics, and dietary fibers can significantly favor the progress of favorable bacteria, increasing insulin sensitivity and reducing inflammation [29]. Dietary fibers do so by altering the metabolism of glucose and reducing intestinal permeability through the formation of short-chain fatty acids (SSCFA) [30]. Bioactive compounds like Polyphenols and flavonoids, natural constituents of fruits, vegetables, and spices like cinnamon, also have proven to have a role in boosting the expansion of beneficial bacteria while preventing harmful ones [31].

Cinnamon as a Natural Remedy for Diabetes

A popular functional food, cinnamon is rich in powerful bioactive compounds like cinnamaldehyde, flavonoids, polyphenols, cyanide, eugenol, cinnamic acid, and catechins. These substances support its anti-inflammatory, antioxidant, and antidiabetic effects [32]. Cinnamon also reduces post-meal blood glucose rises by suppressing the enzymes α-glucosidase and α-amylase. It has also been established that cinnamon decreases oxidative stress, a primary cause of insulin resistance and β-cell dysfunction [33]. Cinnamon possesses a prebiotic effect; it may assist in the growth of friendly gut bacteria and improve gastrointestinal health. It may modulate gut bacteria and affect metabolic health [34]. Cinnamon enhances gut health by facilitating the proliferation of good bacteria and minimizing the harmful ones. It also boosts insulin sensitivity and, by activating insulin signaling, helps cells to absorb glucose [35]. Phosphoenolpyruvate carboxykinase inhibition blocks hepatic gluconeogenesis, reducing glucose production in the liver. Flavonoids enhance endothelial function, which decreases vascular hazards. Cinnamic acid inhibits the proinflammatory cytokines and also inhibits lipid peroxidation. Eugenol helps in protection against AGE (advanced glycation end product), which further helps in fighting diabetes complications. Cinnamon works by enhancing insulin sensitivity and lowering fasting glucose levels. It mimics insulin, having methylhydroxychalcone polymer and procyanidin oligomer compounds. These compounds may activate insulin receptor (IR) kinase activity and enhance glucose uptake by cells, leading to improved glucose utilization in tissues. It also appears to enhance glycogen synthesis, which further contributes to the decrement of glucose level [9]. A component of cinnamon, Cinnamtannin B1, can stimulate the phosphorylation of the insulin receptor, which enhances insulin sensitivity [36]. A significant decrease in insulin levels was observed in a meta-analysis published in 2024 [37]. By inhibiting protein tyrosine phosphatase 1B, the body's response to insulin can be improved, as this protein negatively regulates cinnamon [38].

Table **1** depicts all the active compounds in cinnamon and their effect on glucose levels and gut flora.

Cinnamon: A Strong Ally in the Fight against Type 2 Diabetes

Cinnamon can be an adjunct therapy for glycemic control. It has been proven by the molecular structure of cinnamon that it has a positive effect on the plasma glucose concentration. A randomized controlled trial published in 2006 involved 79 type 2 diabetes patients. This double-blinded trial revealed that patients using cinnamon extract had lower plasma glucose levels than those using the placebo. This research suggests that patients with higher plasma glucose can benefit from cinnamon consumption. After a 4-month intervention, the cinnamon group indicated a substantial drop in fasting plasma glucose levels from a reference point of 9.26 ± 2.26 mmol/L to 8.15 ± 1.65 mmol/L with a mean absolute difference of 1.11 ± 1.59 mmol/L. In contrast, the placebo group had a baseline level of fasting plasma glucose of 8.66 ± 1.47 mmol/L, which reduced to 8.31 ± 1.62 mmol/L post-intervention, with a mean

Table 2: Impact of cinnamon on key metabolic pathways in T2DM.

Metabolic Pathway	Effect of Cinnamon	Key Mechanism	Outcome
Insulin Signaling	Increase sensitivity	Enhances GLUT4 translocation	Improved glucose uptake
Lipid Metabolism	Decrease lipogenesis	AMPK activation	Lower cholesterol and triglycerides
Inflammation	Decrease proinflammatory cytokines	Inhibits NF-kb pathway	Reduce systemic inflammation
Oxidative Stress	Increase antioxidant enzymes	Enhances Nrf2 pathway	Protects pancreatic beta cells

absolute difference of only 0.35 ± 1.29 mmol/L. Thus, the current research indicated that the patients with poorer glycemic control noted a greater reduction in fasting glucose level [39]. Another randomized placebo-controlled trial demonstrated a statistically significant diminution in fasting plasma glucose. This research, released in December 2003, consisted of 60 subjects who consumed cinnamon in various amounts (1, 3, or 6 grams per day) or a placebo for 40 days, with a subsequent 20-day washout period. Subjects exhibited a significant reduction in fasting serum glucose by 18-29% which indicated that cinnamon consumption resulted in a noteworthy reduction in fasting glucose level, even the low cinnamon amount seemed to be helpful in type 2 diabetes patients [40]. The 2019 meta-analysis that included the Randomized controlled trials (RCTs) between 2000 and 2018 revealed the same findings as above, Cinnamon supplementation significantly lowered fasting blood glucose by a mean of -19.26 mg/dL *versus* placebo (95% CI: -28.08, -10.45; I^2: 96.5%; p=0.0001) [36]. Yet another systematic review and meta-analysis indicates a promising intervention of cinnamon for type 2 diabetes patients through the reduction of the fasting glucose level. This study specifically mentioned cinnamon zeylanicum (true cinnamon), which can assist in maintaining and managing the metabolic parameters of insulin [41]. However, in contrast to these studies, another meta-analysis of 15 RCTs published in 2023 showed negative results. There was no remarkable decline reported in fasting sugar levels; however, this study showed a great impact on lipid profile in type 2 diabetes patients [42]. Another meta-analysis published in 2024 examined eleven studies to test the potential of cinnamon in managing type 2 diabetes. The results show a major dip of about 18.67 mg/dl in fasting glucose level. However, heterogeneity in dosage and duration was accounted for, which can influence the outcomes. Despite heterogeneity, the cinnamon dosage range is 360 to 3000mg; the most commonly preferred is 1000mg [43]. A double-blinded Randomized controlled trial in the Chinese population displays the same results as other research shows, a decrease in fasting glucose level. In low dosage, an average reduction of 1.01 mmol/L and a high dosage decline of 1.62mmol/L is shown [38]. Another meta-analysis shows the positive results of the consumption of cinnamon. The statistically highlighted decline in fasting plasma glucose levels by approximately -24.59 mg/dL (95% CI, -40.52 to -8.67 mg/dL) across the studies was analyzed [9]. A meta-analysis of eight randomized controlled placebo trials shed light on fasting glucose levels and determined the effectiveness of cinnamon. The comparison of cinnamon extract consumption with metformin and results showed a decline of -5.8% with cinnamon consumption compared to -4.5% for metformin. And overall decrease in FBG attributed to cinnamon intake was about -8.7 mg/dL (approximately -0.48 mmol/L), which was statistically significant (P < .008) [35]. A systematic review published in 2012 shows no notable enhancement in fasting glucose levels [43]. While cinnamon supplementation has shown a reduction in fasting blood glucose levels in some trials, the magnitude of this effect—approximately 18-29 mg/dL—may be modest in clinical terms. Additionally, heterogeneity in study design, participant characteristics, and intervention protocols limits the generalizability of these findings. As such, cinnamon may offer supportive benefits when used alongside conventional treatment, but should not be viewed as a replacement for established diabetic therapies. Table **2** outlines the cinnamon impact on metabolic pathways in type 2 diabetes, along with the mechanism and outcome.

Interaction of Cinnamon and HbA1c Levels

Evidence regarding cinnamon's impact on HbA1c, a key marker of long-term glycemic control, remains inconsistent. While a few randomized controlled trials and meta-analyses report a slight reduction in HbA1c, many others demonstrate no statistically or clinically significant changes. For instance, one meta-analysis (2023) showed a negligible mean difference of -0.02% with a p-value of 0.801, indicating a lack of efficacy in lowering HbA1c. These findings suggest that, despite biochemical plausibility, cinnamon's real-world effect on long-term glucose regulation remains uncertain and warrants further investigation. Most of the studies display no notable impact on HbA1c levels. The RCT published in 2006 indicated no notable decrease in HbA1c levels in patients with diabetes taking cinnamon extract [39].

The meta-analysis published in 2019, which included the RCTs from 2000 to 2018, finds a slight reduction in HbA1c levels by -0.24%. As pooled weighted mean difference (WMD) for HbA1c showed a non-significant reduction in the cinnamon group compared to the placebo group, with a WMD of -0.24% (95% CI: -0.48, -0.01). This gives an idea that cinnamon supplementation did not have a clinically notable influence on HbA1c levels [36]. One meta-analysis and systematic review dealing specifically with cinnamon zeylanicum shows a reduction in HbA1c levels, which marks the long-term glycemic control, but it included animal models [41]. This study is different from the others due to the animal model included in it, which can be present differently in human clinical trials. Moreover, a meta-analysis published in 2023 also showed the same results, indicating that cinnamon does not significantly influence HbA1c levels. In a study analyzing 11 trials with 12 effect sizes, the results showed that cinnamon intervention produced a mean difference of -0.02 in HbA1c levels, with a 95% confidence interval of -0.14 to 0.11 and a p-value of 0.801. This suggests no statistically significant impact on HbA1c from cinnamon supplementation. Additionally, in nonlinear dose-response analyses, no discernible effect of cinnamon on HbA1c levels was found (p-nonlinearity = 0.159) [42]. RCT published in 2009 shows a significant decrease in HbA1c levels. This study involves 89 patients who completed the study. Among the patients who completed the treatment, 91% (42 out of 46) reported taking more than 75% of their cinnamon capsules, demonstrating high adherence to the prescribed regimen. This study dives into insulin sensitivity analysis, which helps in better utilization of glucose and reduces HbA1c levels. Particularly, this contrast with other studies may be due to poorly controlled diabetes, sample size, and absence of a placebo [44]. Another meta-analysis examining 11 research articles from which six papers show a significant decrease in HbA1c levels [37]. A double-blinded Randomized controlled trial in the Chinese population reflects a substantial drop in HbA1c levels. The low dosage group manifested a 0.67% reduction, and the high dosage group revealed a 0.92% decline in HbA1c levels, particularly when baseline levels are high. The heterogeneity in this research is lower because baseline levels for all patients were high, and all were on the same antidiabetic medication. One month was chosen to evaluate the glycemic results. This paper particularly shows the HbA1c results, which contrast with previous studies [39]. Another meta-analysis published in 2013 shows no significant impact on HbA1c levels despite showing alteration in other glycemic parameters [9]. A systematic review published in 2012 shows no improvement in Glycosylated Hemoglobin A1c (HbA1c) [43]. Healthy gut microbiota helps maintain intestinal barrier integrity and prevent the translocation of harmful bacteria and toxins into the bloodstream, which is associated with systemic inflammation. However, most of the studies suggest adverse outcomes, showing no significant decrease in HbA1c levels by cinnamon usage.

Cinnamon's Impact on Gut Brain Health and Gene Regulation in Protection against T2DM

Type 2 diabetes mellitus (T2DM) is largely determined by the gut-brain axis. The gut bacteria affect brain signaling through vagus nerve stimulation, neurotransmitter synthesis, and inflammatory processes [45]. Being rich in polyphenols and aldehydes, cinnamon has been demonstrated to modify the makeup of gut microbes, increasing the synthesis of serotonin and gamma-aminobutyric acid (GABA), two chemicals involved in controlling hunger, insulin sensitivity, and stress reactions [46]. An increasing amount of data indicates that some dietary elements may cause epigenetic modifications that affect the gene expression entangled in metabolism. Changes in histone acetylation, DNA methylation, and microRNA regulation—all linked to inflammation and insulin resistance—have been linked to cinnamon's bioactive components [47]. Cinnamaldehyde, for instance, has been shown to increase the pancreatic release of insulin by inhibiting miR-29, a microRNA linked to β-cell failure [48].

Comparing Species of Cinnamon

Cinnamon Ceylon and cassia, with their antidiabetic properties, are more commonly studied species of cinnamon. Indonesian cinnamon and Saigon cinnamon are also species with similar uses. Ceylon cinnamon is preferred over cassia cinnamon because of the risk factors associated with cassia cinnamon. Cassia cinnamon has a high quantity of coumarin, which is toxic to our health and can be dangerous in high doses of cassia cinnamon. It has up to 63 times more coumarin than Ceylon cinnamon and can end up damaging the liver [49]. However, Ceylon cinnamon has a milder effect on fasting glucose levels than cassia cinnamon, but for long-term usage, the Ceylon species is more favorable due to low toxicity [50]. More importantly, the antioxidant activity should be taken into account. Cinnamon Ceylon has a higher activity of antioxidants than cassia cinnamon. For the management of diabetes, cassia cinnamon is more potent, but it has higher risk factors. While Ceylon cinnamon is safer to use, it is not recommended for daily users. Cassia species is taken in less than 1g/day, while Ceylon is recommended to be taken in higher quantities, such as 1 to 3g/day. In general, Ceylon cinnamon is more reliable due to high polyphenol and low coumarin levels. Indonesian cinnamon Saigon contains high coumarin content. Indonesian cinnamon has an active compound similar to cassia cinnamon with a milder, slightly sweeter taste, and Saigon has a high amount of cinnamaldehyde with a strong taste. Cassia and Saigon cinnamon are best for rapid glucose reduction and short-term usage. While overdosing should be avoided because of the toxicity of coumarin.

Recommendation of Dosage of Cinnamon

The dose of Cinnamon varies along the lines of various research studies, but most of them recommend a dosage between 500mg and 6g per day. One of the studies published in 2003 reflected the usage of 1g, 3g, and 6g of cinnamon for 40 days, resulting in a reduction of fasting glucose levels. However, 1g and 3 g showed optimal reduction [40]. Another study published in 2006 foreshadowed 500mg of cinnamon extract twice a day and showed a significant and favorable decrement in fasting glucose levels [51]. Results from 2010 research demonstrate that 2g of cinnamon for 12 days reduces the HbA1c levels, as well as the fasting glucose levels, which were amplified [52]. In 2013, another publication showed 120mg to 6g/day, the favorable dosage to diminish the fasting glucose levels [9]. So based on the evidence

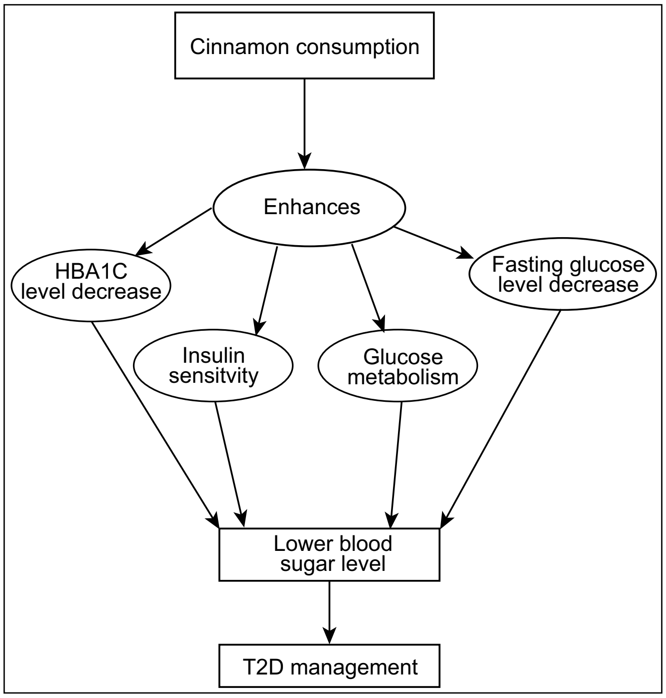

Fig. (2): Effects of cinnamon on factors such as HBA1C level, insulin sensitivity, glucose metabolism, and fasting glucose levels.

collected, the mild effects of 500mg to 1g/day. Moderate effects are exhibited by 2g/day. And higher dosage like 3-6g/day shows great effects, but no more than 3g/day shows any additional effects. The flow chart given in Fig. **(2)** shows cinnamon consumption enhances the i. HBA1C level II. Improves insulin sensitivity iii. Glucose metabolism IV. Fasting glucose level decreases. These factors contribute to lowering the blood sugar level and help in the management of type 2 diabetes.

LIMITATIONS AND FUTURE FINDINGS

Although cinnamon demonstrates encouraging biological activity in improving insulin sensitivity and modulating gut flora, the current body of research lacks conclusive evidence to support its clinical application. Existing studies show inconsistency in outcomes, are often underpowered, and vary widely in methodology. Future research must focus on high-quality, randomized controlled trials with adequate sample sizes, standardized dosages, and long-term follow-up. These studies are necessary to confirm the safety, reproducibility, and therapeutic relevance of cinnamon in managing Type 2 Diabetes. The particular mechanism through which cinnamon acts, the dosage, and the long-term effects of cinnamon are still not clear. More comprehensive Randomized controlled trials with a huge population size are required to analyze the effectiveness and safety of cinnamon extract for diabetic patients. By filling up these gaps, future studies can offer validated and evidence-based studies that will be more authentic to provide advice for diabetic patients. The major focus of the future research will be to rectify the particular aspects of gut bacteria that are modulated by cinnamon supplementation.

CONCLUSION

This review highlights cinnamon's potential as a supportive agent in the regulation of type 2 Diabetes Mellitus (T2DM), particularly through its influence on gut microbiota, inflammation, and glucose metabolism. However, the existing evidence is preliminary and varies across studies. Most clinical trials to date suffer from limitations in sample size, duration, and heterogeneity in cinnamon dosage and formulation. Therefore, while the findings are promising, cinnamon should be considered an adjunct rather than a substitute for standard antidiabetic therapies. Rigorous, large-scale randomized controlled trials are urgently needed to validate its long-term safety and effectiveness.

Overall, cinnamon may serve as a complementary dietary intervention, particularly for individuals seeking natural supplements alongside standard care. However, its glucose-lowering and HbA1c-modifying effects are modest and inconsistent, reinforcing the importance of medical oversight and the use of cinnamon only as a supportive adjunct, not a primary treatment.

FUNDING

None.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

ACKNOWLEDGEMENTS

Declare none.

AUTHORS' CONTRIBUTION

L.S: conceptualization, drafting, data extraction, writing

S.H.: Data extraction, writing manuscript, reviewing

REFERENCES

1. ElSayed NA, Aleppo G, Aroda VR, Bannuru RR, Brown FM, Bruemmer D, *et al.* on behalf of the American Diabetes Association. 2. Classification and diagnosis of diabetes: Standards of care in diabetes-2023. Diabetes Care 2023; 46(Suppl 1): S19-S40. DOI: https://doi.org/10.2337/dc23-S002 Erratum in: Diabetes Care 2023; 46(5): 1106.
2. Fan Y, Pedersen O. Gut microbiota in human metabolic health and disease. Nat Rev Microbiol 2021; 19(1): 55-71. DOI: https://doi.org/10.1038/s41579-020-0433-9
3. Gurung M, Li Z, You H, Rodrigues R, Jump DB, Morgun A, Shulzhenko N. Role of gut microbiota in type 2 diabetes pathophysiology. EBioMedicine 2020; 51: 102590. DOI: https://doi.org/10.1016/j.ebiom.2019.11.051
4. Kacena C. Effects of the curcuminoid and non-curcuminoid compounds of turmeric on the gut microbiome and inflammation: Potential use in the treatment and prevention of disease. Nutr Rev 2025; nuae221. DOI: https://doi.org/10.1093/nutrit/nuae221
5. Burcelin R, Serino M, Chabo C, Blasco-Baque V, Amar J. Gut microbiota and diabetes: From pathogenesis to therapeutic perspective. Acta Diabetol 2011; 48(4): 257-73. DOI: https://doi.org/10.1007/s00592-011-0333-6
6. Sun H, Saeedi P, Karuranga S, Pinkepank M, Ogurtsova K, Duncan BB, *et al.* IDF Diabetes Atlas: Global, regional and country-level diabetes prevalence estimates for 2021 and projections for 2045. Diabetes Res Clin Pract 2022; 183: 109119.

DOI: https://doi.org/10.1016/j.diabres.2021.109119
Erratum in: Diabetes Res Clin Pract. 2023 Oct; 204: 110945.
DOI: https://doi.org/10.1016/j.diabres.2023.110945

7. Nuffer W, Tall Bull S, Bakhach H, Nuffer M. Sweetly Improving Sugars? Reviewing Cinnamon's Effects on Blood Glucose. J Med Food 2023; 26(1): 68-73.
DOI: https://doi.org/10.1089/jmf.2022.0073
8. Byndloss M, Devkota S, Duca F, Niess JH, Nieuwdorp M, Orho-Melander M, *et al.* The gut microbiota and diabetes: Research, translation, and clinical applications - 2023 Diabetes, Diabetes Care, and Diabetologia Expert Forum. Diabetologia 2024; 67(9): 1760-82.
DOI: https://doi.org/10.1007/s00125-024-06198-1
9. Allen RW, Schwartzman E, Baker WL, Coleman CI, Phung OJ. Cinnamon use in type 2 diabetes: An updated systematic review and meta-analysis. Ann Fam Med 2013; 11(5): 452-9.
DOI: https://doi.org/10.1370/afm.1517
10. Shen J, Obin MS, Zhao L. The gut microbiota, obesity and insulin resistance. Mol Aspects Med 2013; 34(1): 39-58.
DOI: https://doi.org/10.1016/j.mam.2012.11.001
11. Bandopadhyay P, Ganguly D. Gut dysbiosis and metabolic diseases. Prog Mol Biol Transl Sci 2022; 191(1): 153-74.
DOI: https://doi.org/10.1016/bs.pmbts.2022.06.031
12. Chong S, Lin M, Chong D, Jensen S, Lau NS. A systematic review on gut microbiota in type 2 diabetes mellitus. Front Endocrinol (Lausanne) 2025; 15: 1486793.
DOI: https://doi.org/10.3389/fendo.2024.1486793
13. Zeppa SD, Gervasi M, Bartolacci A, Di Renzo L, De Lorenzo A, Stocchi V, *et al.* Targeting the gut microbiota for prevention and management of type 2 diabetes. Nutrients 2024; 16(22): 3951.
DOI: https://doi.org/10.3390/nu16223951
14. Kumari H, Prakash S, Kumar A. Dysbiosis and regulation of gut microbiota in type 2 diabetes mellitus. Curr Pharm Biotechnol 2024; 26(14): 2288-309.
DOI: https://doi.org/10.2174/0113892010318580240910061534
15. Liu P, Jin M, Hu P, Sun W, Tang Y, Wu J, *et al.* Gut microbiota and bile acids: Metabolic interactions and impacts on diabetic kidney disease. Curr Res Microb Sci 2024; 7: 100315.
DOI: https://doi.org/10.1016/j.crmicr.2024.100315
16. Saha S, Schnabl B. Modulating the microbiome in chronic liver diseases - current evidence on the role of fecal microbiota transplantation. Expert Rev Gastroenterol Hepatol 2025; 19(1): 53-64.
DOI: https://doi.org/10.1080/17474124.2025.2450707
17. Canfora EE, Meex RCR, Venema K, Blaak EE. Gut microbial metabolites in obesity, NAFLD and T2DM. Nat Rev Endocrinol 2019; 15(5): 261-73.
DOI: https://doi.org/10.1038/s41574-019-0156-z
18. Karlsson FH, Tremaroli V, Nookaew I, Bergström G, Behre CJ, Fagerberg B, *et al.* Gut metagenome in European women with normal, impaired and diabetic glucose control. Nature 2013; 498(7452): 99-103.
DOI: https://doi.org/10.1038/nature12198
19. Tremaroli V, Bäckhed F. Functional interactions between the gut microbiota and host metabolism. Nature 2012; 489(7415): 242-9.
DOI: https://doi.org/10.1038/nature11552
20. Cani PD, Amar J, Iglesias MA, Poggi M, Knauf C, Bastelica D, *et al.* Metabolic endotoxemia initiates obesity and insulin resistance. Diabetes 2007; 56(7): 1761-72.
DOI: https://doi.org/10.2337/db06-1491
21. Ye J, Wu Z, Zhao Y, Zhang S, Liu W, Su Y. Role of gut microbiota in the pathogenesis and treatment of diabetes mellitus: Advanced research-based review. Front Microbiol 2022; 13: 1029890.
DOI: https://doi.org/10.3389/fmicb.2022.1029890
22. Gu Y, Wang X, Li J, Luo P, Zhang Y, Zhu J, *et al.* Analyses of gut microbiota and plasma bile acids enable stratification of patients for antidiabetic treatments. Nat Commun 2017; 8: 1785.
DOI: https://doi.org/10.1038/s41467-017-01682-2
23. Pedersen HK, Gudmundsdottir V, Nielsen HB, Hyotylainen T, Nielsen T, Jensen BA, *et al.* Human gut microbes impact host serum metabolome and insulin sensitivity. Nature 2016; 535(7612): 376-81.
DOI: https://doi.org/10.1038/nature18646
24. Sun K, Liu D, Zhang R, Wang C, Li Y, Zhao H, *et al.* The causal relationship between gut microbiota and type 2 diabetes: A two-sample Mendelian randomized study. Front Public Health 2023; 11: 1255059.
DOI: https://doi.org/10.3389/fpubh.2023.1255059
25. Qin J, Li Y, Cai Z, Li S, Zhu J, Zhang F, *et al.* A metagenome-wide association study of gut microbiota in type 2 diabetes. Nature 2012; 490(7418): 55-60.
DOI: https://doi.org/10.1038/nature11450
26. Larsen N, Vogensen FK, van den Berg FW, Nielsen DS, Andreasen AS, Pedersen BK, *et al.* Gut microbiota in human adults with type 2 diabetes differs from non-diabetic adults. PLoS One 2010; 5(2): e9085.
DOI: https://doi.org/10.1371/journal.pone.0009085
27. Amar J, Chabo C, Waget A, Klopp P, Vachoux C, Bermúdez-Humarán LG, *et al.* Intestinal mucosal adherence and translocation of commensal bacteria at the early onset of type 2 diabetes: molecular mechanisms and probiotic treatment. EMBO Mol Med 2011; 3(9): 559-72.
DOI: https://doi.org/10.1002/emmm.201100159
28. Kocsis T, Molnár B, Németh D, Hegyi P, Szakács Z, Bálint A, *et al.* Probiotics have beneficial metabolic effects in patients with type 2 diabetes mellitus: a meta-analysis of randomized clinical trials. Sci Rep 2020; 10(1): 11787.
DOI: https://doi.org/10.1038/s41598-020-68440-1
29. Singh RK, Chang HW, Yan D, Lee KM, Ucmak D, Wong K, *et al.* Influence of diet on the gut microbiome and implications for human health. J Transl Med 2017; 15(1): 73.
DOI: https://doi.org/10.1186/s12967-017-1175-y
30. Mazhar M, Zhu Y, Qin L. The interplay of dietary fibers and intestinal microbiota affects type 2 diabetes by generating short-chain fatty acids. Foods 2023; 12(5): 1023.
DOI: https://doi.org/10.3390/foods12051023
31. Pasinetti GM, Singh R, Westfall S, Herman F, Faith J, Ho L. The role of the gut microbiota in the metabolism of polyphenols as characterized by gnotobiotic mice. J Alzheimers Dis 2018; 63(2): 409-21.
DOI: https://doi.org/10.3233/JAD-171151
32. Deyno S, Eneyew K, Seyfe S, Tuyiringire N, Peter EL, Muluye RA, *et al.* Efficacy and safety of cinnamon in type 2 diabetes mellitus and pre-diabetes patients: A meta-analysis and meta-regression. Diabetes Res Clin Pract 2019; 156: 107815.
DOI: https://doi.org/10.1016/j.diabres.2019.107815
33. Qin B, Dawson HD, Schoene NW, Polansky MM, Anderson RA. Cinnamon polyphenols regulate multiple metabolic pathways involved in insulin signaling and intestinal lipoprotein metabolism of small intestinal enterocytes. Nutrition 2012; 28(11-12): 1172-9.
DOI: https://doi.org/10.1016/j.nut.2012.03.020
34. Lu QY, Summanen PH, Lee RP, Huang J, Henning SM, Heber D, Finegold SM, Li Z. Prebiotic potential and chemical composition of seven culinary spice extracts. J Food Sci 2017; 82(8): 1807-1813.
DOI: https://doi.org/10.1111/1750-3841.13792
35. Davis PA, Yokoyama W. Cinnamon intake lowers fasting blood glucose: Meta-analysis. J Med Food. 2011; 14(9): 884-9.
DOI: https://doi.org/10.1089/jmf.2010.0180
36. Namazi N, Esfanjani AT, Heshmati J, Bahrami A. The impact of cinnamon on anthropometric indices and glycemic status in patients with type 2 diabetes: A systematic review and meta-analysis of clinical trials. Complement Ther Med 2019; 43: 92-101.
DOI: https://doi.org/10.1016/j.ctim.2019.01.002
37. Garza MC, Pérez-Calahorra S, Rodrigo-Carbó C, Sánchez-Calavera MA, Jarauta E, Mateo-Gallego R, *et al.*Effect of aromatic herbs and spices present in the Mediterranean diet on the glycemic profile in type 2 diabetes subjects: A systematic review and meta-analysis. Nutrients 2024; 16(6): 756.
DOI: https://doi.org/10.3390/nu16060756

38. Lu T, Sheng H, Wu J, Cheng Y, Zhu J, Chen Y. Cinnamon extract improves fasting blood glucose and glycosylated hemoglobin level in Chinese patients with type 2 diabetes. Nutr Res 2012; 32(6): 408-12.
DOI: https://doi.org/10.1016/j.nutres.2012.05.003

39. Mang B, Wolters M, Schmitt B, Kelb K, Lichtinghagen R, Stichtenoth DO, *et al.* Effects of a cinnamon extract on plasma glucose, HbA, and serum lipids in diabetes mellitus type 2. Eur J Clin Invest 2006; 36(5): 340-4.
DOI: https://doi.org/10.1111/j.1365-2362.2006.01629.x

40. Khan A, Safdar M, Ali Khan MM, Khattak KN, Anderson RA. Cinnamon improves glucose and lipids of people with type 2 diabetes. Diabetes Care 2003; 26(12): 3215-8.
DOI: https://doi.org/10.2337/diacare.26.12.3215

41. Ranasinghe P, Pigera S, Premakumara GA, Galappaththy P, Constantine GR, Katulanda P. Efficacy and safety of 'true' cinnamon (Cinnamomum zeylanicum) as a pharmaceutical agent in diabetes: A systematic review and meta-analysis. Diabet Med 2012; 29(12): 1480-92.
DOI: https://doi.org/10.1111/j.1464-5491.2012.03718.x

42. Yu T, Lu K, Cao X, Xia H, Wang S, Sun G, *et al.* The effect of cinnamon on glycolipid metabolism: A dose-response meta-analysis of randomized controlled trials. Nutrients 2023; 15(13): 2983.
DOI: https://doi.org/10.3390/nu15132983

43. Leach MJ, Kumar S. Cinnamon for diabetes mellitus. Cochrane Database Syst Rev 2012; 9: CD007170.
DOI: https://doi.org/10.1002/14651858.CD007170.pub2

44. Crawford P. Effectiveness of cinnamon for lowering hemoglobin A1C in patients with type 2 diabetes: A randomized, controlled trial. J Am Board Fam Med 2009; 22(5): 507-12.
DOI: https://doi.org/10.3122/jabfm.2009.05.080093

45. Suganya K, Koo BS. Gut-brain axis: Role of gut microbiota on neurological disorders and how probiotics/prebiotics beneficially modulate microbial and immune pathways to improve brain functions. Int J Mol Sci 2020; 21(20): 7551.
DOI: https://doi.org/10.3390/ijms21207551

46. Filosa S, Di Meo F, Crispi S. Polyphenols-gut microbiota interplay and brain neuromodulation. Neural Regen Res 2018; 13(12): 2055-9. PMID:
DOI: https://doi.org/10.4103/1673-5374.241429

47. Akilen R, Tsiami A, Devendra D, Robinson N. Cinnamon in glycaemic control: Systematic review and meta-analysis. Clin Nutr 2012; 31(5): 609-15.
DOI: https://doi.org/10.1016/j.clnu.2012.04.003

48. Latreille M, Hausser J, Stützer I, Zhang Q, Hastoy B, Gargani S, *et al.* MicroRNA-7a regulates pancreatic β cell function. J Clin Invest 2014; 124(6): 2722-35.
DOI: https://doi.org/10.1172/JCI73066

49. Donnerer J, Liebmann I. Dorsal root ganglion neurons respond with prolonged extracellular signal-regulated protein kinase phosphorylation following noxious heat and cold stimulation. Neurosci Lett 2010; 472(2): 109-13.
DOI: https://doi.org/10.1016/j.neulet.2010.01.064

50. Nakamura YK, Omaye ST. Metabolic diseases and pro- and prebiotics: Mechanistic insights. Nutr Metab (Lond) 2012; 9(1): 60.
DOI: https://doi.org/10.1186/1743-7075-9-60

51. Ziegenfuss TN, Hofheins JE, Mendel RW, Landis J, Anderson RA. Effects of a water-soluble cinnamon extract on body composition and features of the metabolic syndrome in pre-diabetic men and women. J Int Soc Sports Nutr 2006; 3(2): 45-53.
DOI: https://doi.org/10.1186/1550-2783-3-2-45

52. Akilen R, Tsiami A, Devendra D, Robinson N. The effect of cinnamon on glucose control in type 2 diabetes mellitus: A pilot study. Diabet Med 2010; 27(10): 1159-67.
DOI: https://doi.org/10.1111/j.1464-5491.2010.03079.x