

Safety and Effectiveness of *Momordica Charantia* on Glycemic Control in Prediabetes: A Literature Review

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Abstract

Prediabetes is a metabolic condition characterized by elevated blood glucose levels that do not yet meet the diagnostic criteria for type 2 diabetes mellitus but significantly increase the risk of developing diabetes and cardiovascular disease. Early intervention is essential to delay disease progression, and herbal medicine has gained attention as a potential alternative therapy due to its accessibility and perceived safety. One promising herbal agent is *Momordica charantia* (bitter melon), which contains bioactive compounds such as charantin, polypeptide-p, and vicine that may improve glycemic control by enhancing insulin sensitivity, increasing peripheral glucose uptake, and reducing hepatic glucose production. This study aimed to systematically evaluate the effectiveness of *Momordica charantia* in improving glycemic parameters and insulin resistance among individuals with prediabetes. This literature review was conducted following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. A comprehensive search was conducted across PubMed, ScienceDirect, and OpenAlex databases for studies published between 2016 and 2026. The search strategy included keywords related to insulin resistance, prediabetes, type 2 diabetes mellitus, and *Momordica charantia*. Eligible studies included randomized controlled trials, clinical trials, and systematic reviews focusing on glycemic outcomes. Study selection, data extraction, and synthesis were performed based on predefined inclusion and exclusion criteria. The findings indicated that *Momordica charantia* may be a safe and potentially effective herbal intervention for glycemic management in individuals with prediabetes and type 2 diabetes mellitus. Regular consumption in powder or extract forms has been associated with reductions in fasting plasma glucose (FPG), improvements in insulin sensitivity as measured by the homeostatic model assessment of insulin resistance (HOMA-IR), and regulation of glucagon levels, supporting its potential role in metabolic control.

INTRODUCTION

Prediabetes is a metabolic disorder characterized by blood glucose levels that are higher than normal but do not yet meet the diagnostic criteria for type 2 diabetes mellitus (T2DM). It has become a significant global public health concern because untreated prediabetes increases the risk of progression to T2DM and the development of complications, including cardiovascular disease (International Diabetes Federation, 2021; American Diabetes Association, 2023). According to the diagnostic criteria established by the American Diabetes Association (2023), prediabetes is defined by fasting plasma glucose levels between 100–125 mg/dL or glycated hemoglobin (HbA1c) levels between 5.7% and 6.4%. Therefore, the

prediabetes stage represents an important opportunity for early intervention to prevent disease progression (Elgart et al., 2023; Hinnen et al., 2023; Merwass et al., 2024; Pellegrini et al., 2024; Zhang et al., 2023). Natural products and phytotherapy have emerged as potential approaches for the prevention and management of prediabetes. Due to their relatively lower cost, accessibility, and perceived safety compared with conventional pharmacological therapies, herbal medicines have been used as complementary therapies for metabolic disorders (Joseph & Jini, 2019; Basch et al., 2018). Among these, *Momordica charantia* (bitter melon) has been widely investigated for its potential antidiabetic effects.

The hypoglycemic bioactive compounds found in *Momordica charantia* include charantin, polypeptide-p, and vicine (Ajaghaku & Chinwuba, 2025; Kumaree & Prasansuklab, 2023; Xu et al., 2022). These compounds may contribute to glycemic regulation through mechanisms involving reduced hepatic gluconeogenesis, enhanced insulin sensitivity, and increased peripheral glucose uptake. Experimental studies have suggested that *Momordica charantia* may influence incretin signaling pathways and glucose metabolism-related hormones (Romdhoni et al., 2025). Recent clinical evidence further supports its therapeutic potential. A randomized controlled trial involving individuals with prediabetes demonstrated that 12 weeks of bitter melon extract supplementation reduced postprandial blood glucose levels and inhibited glucagon secretion, thereby improving glucose homeostasis (Kim et al., 2023). Furthermore, several smaller interventional studies have indicated that bitter melon supplementation may improve blood glucose levels and selected metabolic parameters without significant adverse effects (Peter et al., 2019).

Additionally, a recent meta-analysis of randomized controlled trials demonstrated that *Momordica charantia* supplementation significantly reduced fasting blood glucose, HbA1c levels, insulin concentrations, and insulin resistance indices (HOMA-IR) among individuals with prediabetes and T2DM (Mkhize et al., 2025; Zhang et al., 2023). These findings suggest that *Momordica charantia* may contribute to glycemic regulation and improved insulin sensitivity, which are important factors in the pathophysiology of prediabetes. However, existing studies demonstrate considerable heterogeneity regarding dosage, preparation forms, and intervention durations. Therefore, a comprehensive literature review is needed to systematically evaluate the effectiveness of *Momordica charantia* in preventing the progression of prediabetes to type 2 diabetes mellitus.

Thus, this study aimed to explore the potential of *Momordica charantia* supplementation as a preventive intervention for individuals with prediabetes by evaluating its effects on glycemic parameters and insulin resistance. The findings of this research are expected to support clinicians in developing evidence-based complementary strategies for prediabetes management, assist researchers in identifying gaps for future clinical trials, inform public health policymakers in developing guidelines for integrating herbal medicine into diabetes prevention programs, and provide a reference for individuals with prediabetes seeking safe and accessible approaches for glycemic control.

METHOD

The data collection process involved reviewing written materials, recording relevant information, and collecting literature-based data from published articles and related scientific

sources. This study employed a literature review method, with data obtained from previously published research related to the study topic.

The research questions were structured using the PICO (Population, Intervention, Comparison, Outcome) framework. The population (P) consisted of individuals with prediabetes, the intervention (I) involved *Momordica charantia* supplementation, the comparison (C) included placebo or other control conditions, and the outcome (O) focused on glycemic control parameters, including fasting blood glucose (FBG), oral glucose tolerance test (OGTT), and homeostatic model assessment of insulin resistance (HOMA-IR). The literature search was conducted in April 2026 using three electronic databases: PubMed, ScienceDirect, and OpenAlex. The collected data were secondary data obtained from previous research publications. The search strategy used English-language articles with keywords related to insulin resistance, prediabetes, type 2 diabetes mellitus, and *Momordica charantia*.

The inclusion criteria were: (1) studies involving individuals with prediabetes based on recognized diagnostic criteria, such as impaired fasting glucose or impaired glucose tolerance; (2) studies investigating the effects of *Momordica charantia* in various forms, including extracts, capsules, juice, or powder, on glycemic control; (3) studies involving comparator groups, such as placebo, no intervention, or standard therapy; (4) studies reporting at least one glycemic outcome, including FBG, OGTT, or HOMA-IR; (5) interventional studies, including randomized controlled trials, non-randomized trials, quasi-experimental studies, or controlled clinical trials; (6) articles published in English; (7) studies published between 2016 and 2026; and (8) articles with accessible abstracts and full texts.

During the identification stage, 505 publications were retrieved from three databases: PubMed, ScienceDirect, and OpenAlex. Of these, 220 articles were identified from ScienceDirect, 99 from PubMed, and 186 from OpenAlex. After removing 60 duplicate records, 445 articles remained for screening. The screening stage involved reviewing article titles and abstracts to determine their relevance to the research topic. A total of 407 articles were excluded, leaving 38 articles that met the initial screening criteria. During the eligibility stage, articles consisting of scoping reviews, systematic reviews, and meta-analyses were excluded. Full-text articles evaluating the safety and effectiveness of *Momordica charantia* on glycemic control in prediabetes and published within the specified period (April 2016–April 2026) were further assessed. In the final inclusion stage, four articles met all eligibility criteria and were included in the review, while the remaining 34 articles were excluded. The article selection process is presented in the flowchart shown in Figure 1.

RESULTS AND DISCUSSION

Table 1. Safety and Effectiveness of *Momordica charantia* on Glycemic Control in Prediabetes

No	Author & Title	Aim & Study Design	Population & Key Results	Conclusion
1	Krawinkel et al. (2018). <i>Bitter gourd reduces elevated</i>	To evaluate the antidiabetic effects of daily consumption	61 eligible participants were randomized, with 52 participants finishing the study and 44 complete data sets used for the final primary outcome analysis. A	Consumption of 2.5 g of dry bitter gourd (equivalent to roughly 50 g of fresh fruit) is an effective dietary

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	<i>fasting plasma glucose levels in an intervention study among prediabetics in Tanzania</i>	of 2.5 g bitter gourd powder over an eight-week period in individuals with prediabetes; Randomized Controlled Trial (RCT), 8 weeks	significant difference in the change of fasting plasma glucose (FPG) of 0.31 mmol/L (5.6 mg/dL) was observed between the bitter gourd and placebo groups (p=0.031). The study was powered at 0.82 to detect a medium-to-large effect size (Cohen's d =.62). The glucose-lowering effect was also more apparent in those with higher starting blood glucose levels. There were no major changes in BMI, blood lipids or blood pressure and there were no serious adverse events reported Safety: They reported mild side effects such as loose stools, diarrhea, flatulence, nausea, or vomiting. no significant effects of bitter melon supplementation on the participants' liver or renal functions, and confirmed that no participants experienced hypoglycemia during the study	approach for lowering elevated blood glucose in prediabetic individuals. The researchers concluded that because the effect is baseline-dependent, the benefits would likely be even more significant for patients with manifest diabetes who have higher glucose levels. Furthermore, bitter gourd serves as a safe and viable option for dietary self-management, particularly in regions where access to professional medical care and pharmacological treatments is limited.
2	Boone et al. (2017). <i>Acute effects of a beverage containing bitter melon extract (CARELA) on postprandial glycemia among prediabetic adults</i>	To examine the acute effects of a beverage containing bitter melon extract on blood glucose regulation during an oral glucose tolerance test (OGTT) among prediabetic adults; Acute intervention study	10 adults with prediabetes. Exactly 50% of the participants (n=5) were identified as "responders" who experienced significant improvements in glucose regulation. For this group, the bitter melon beverage resulted in a 13.2% reduction in glucose AUC, a 12.2% reduction in mean glucose, and a 10.6% reduction in peak glucose. Plasma glucose concentrations were significantly reduced at 30, 60, and 90 minutes post-ingestion. These glycemic improvements occurred independently of any change in the insulin response, suggesting extra-pancreatic mechanisms. The beverage's effectiveness was seemingly uninfluenced by the subjects' baseline glucose tolerance level	Acute ingestion of bitter melon extract can enhance glucose tolerance in some prediabetic individuals , likely through extra-pancreatic mechanisms rather than by increasing insulin secretion. These mechanisms may include increased activity of glucose transporters (GLUT4) or enhanced glucose uptake in the liver and skeletal muscles. The researchers concluded that while effective for half the group, further molecular-level research is needed to understand the individual variation in response and fully elucidate the extract's impact on glucose regulation.

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3	Mes et al. (2025). <i>Bitter gourd (Momordica charantia L.) supplementation for twelve weeks improves biomarkers of glucose homeostasis in a prediabetic population</i>	To assess the efficacy of Momordica charantia (bitter gourd) supplementation on markers of glucose homeostasis in a prediabetic population through two separate clinical trials; Study 1: crossover (4 weeks), Study 2: randomized controlled trial (12 weeks)	Study 1 involved 30 subjects (4-week cross-over design): no significant overall differences between the bitter gourd and placebo groups, though a reduction in FPG was observed in subjects who had higher baseline values. Study 2 involved 38 subjects (12-week parallel design, with 36 subjects analyzed per protocol): significant reductions in FPG (p=0.014), fasting insulin (p=0.007), and HOMA-IR (p=0.003) within the bitter gourd group. Between-treatment analysis further showed significant effects on FPG (p=0.026) and HOMA-IR (p=0.045) compared to the control. On average, the intervention reduced FPG by approximately 0.05 mmol/L per week, while FPG remained unchanged in the placebo group. Both studies indicated the supplement was safe and well-tolerated Safety: They recorded various complaints such as bloating, headache, and diarrhea, but concluded that the frequency of these events was small and not significantly different between the bitter gourd group and the control (cucumber) group. They also monitored liver enzymes (ALAT/ASAT) and kidney function (eGFR) no significant effects of bitter melon supplementation on the participants' liver or renal functions.	Supplementation with bitter gourd fruit has positive effects on fasting glucose and insulin levels , but these effects are highly dependent on the duration of the intervention , requiring consistent intake for at least 12 weeks . The researchers concluded that although the effects are smaller than those of traditional T2DM medications like metformin, bitter gourd-based products are safe, effective complements to lifestyle interventions for reversing early glucose dysregulation. The improvement in HOMA-IR values specifically indicates that long-term consumption helps enhance insulin sensitivity in prediabetic populations.
4	Kim et al. (2022). <i>Momordica charantia (bitter melon) efficacy and safety on glucose metabolism in Korean</i>	To investigate the effects of bitter melon extract (BME) on glucose metabolism, insulin resistance, and various metabolic	76 participants were randomized, with 65 participants included in the final analysis (33 in the BME group and 32 in the placebo group). Blood glucose levels during an OGTT decreased in the BME group after 12 weeks, with a significant reduction specifically at the 30-minute mark post-glucose ingestion (p < 0.05).	Bitter melon exhibits its glucose-lowering effects primarily through the suppression of glucagon levels , which are typically not sufficiently suppressed in the prediabetic state. The study concluded that BME could provide a

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	<i>prediabetes participants: a 12-week, randomized clinical study</i>	parameters in Korean prediabetic participants; Randomized clinical trial, 12 weeks	Additionally, glucagon levels significantly decreased 120 minutes after the OGTT ($p < 0.05$) and showed a significant reduction in maximum concentration (C_{max} , $p=0.039$). C-peptide levels at the 30-minute interval were also significantly reduced ($p < 0.01$), indicating a lowered insulin requirement due to the lower blood glucose. However, the study found no significant differences in insulin secretion or resistance (measured by HOMA-IR and HOMA- β) or lipid profiles Safety: side effects such as fatigue, dizziness, and pruritus (itching) . These occurrences were recorded in detail in a " Safety events " table and compared with the placebo group to statistically observe any differences. The researchers concluded that no critical side effects were reported during the 12-week study period.	prophylactic (preventative) effect against the progression to full diabetes. Furthermore, the study confirmed that 12 weeks of extract consumption is clinically safe , showing no critical adverse effects on liver or renal function markers in this healthy prediabetic population.

Source: Author's Literature Review (2026)

Mechanism Of Momordica Charantia Lowers Blood Glucose Levels

A. Inhibition of Intestinal Glucose Absorption

Momordica charantia (bitter melon) reduces glucose absorption in the small intestine. The specific mechanisms include:

1. **Enzyme Inhibition.** A bioactive compound such as trehalose-like molecules in bittermelon exerts genism of inhibition to carbohydrate-digesting enzymes, especially toward α -glucosidase and α -amylase (Khatib et al, 2017; Mes et al, 2025).
2. **Respons to Postprandial Glucose Peaks:** These enzymes are inhibited, leading to delaying of the breakdown of complex carbohydrates into simple sugars; hence reducing postprandial glucose spikes.

B. Insulin-Mimetic Effects

One of the active components of bitter melon is polypeptide-p (also known as p-insulin or v-insulin), a plant-derived insulin-like peptide with hypoglycemic properties (Oliveira et al., 2018; Boone et al., 2017). Its mechanisms include:

1. **Improved Glucose Utilization:** Bitter melon has been found to promote glucose uptake by peripheral tissues including skeletal muscle and liver (Habicht et al., 2014; Boone et al., 2017).

2. Activation of GLUT4: Compounds in bitter melon stimulate the movement of GLUT4 transporters into the membrane allowing glucose to move from blood into cells for use as energy (Boone et al., 2017).

C. Regulation of Glucagon and GLP-1 Hormones

Bitter melon regulates glucose homeostasis hormones beyond insulin, according to recent research :

- a. Bitter melon suppresses glucagon, notably after oral carbohydrate consumption or postprandially (Kim et al., 2023). Glucagon boosts blood glucose, hence reducing it helps glycemics.
- b. Bitter melon boosts intestinal GLP-1 synthesis, which delays stomach emptying, suppresses glucagon, and promotes insulin secretion (Mes et al., 2025).

D. Modulation of Cellular Metabolic Pathways

Bitter melon influences intracellular metabolic pathways to improve energy utilization:

- a. Activation of AMPK and SIRT1: Bitter melon extract has demonstrated stimulation of key metabolic regulators such as AMPK and SIRT1 which are associated with increasing cellular glucose uptake (Yoon et al., 2017) and promoting metabolic efficiency (Tan et al., 2008).
- b. Bitter melon inhibits key gluconeogenic enzymes in liver, which results in reduction of endogenous glucose production (Habicht et al. 2014; Singh et al. 2011).

E. Enhancement of Insulin Secretion and Sensitivity

Although findings across studies vary, bitter melon is generally reported to:

- a. Increase insulin secretion from pancreatic β -cells (Habicht et al., 2014; Boone et al., 2017).
- b. Improve insulin sensitivity, as evidenced by reductions in HOMA-IR, which is particularly beneficial in individuals with insulin resistance or prediabetes (Mes et al., 2025).

Side Effects *Momordica Charantia*

1) Gastrointestinal Side Effects

The most frequently reported adverse events are related to the gastrointestinal system (Krawinkel et al., 2018; Mes et al., 2025). These symptoms include:

Diarrhea or loose stools

- a. Flatulence (gas), abdominal rumbling, and bloating
- b. Nausea and vomiting: In some studies, these symptoms were severe enough to cause participants (particularly some female subjects) to withdraw from the study
- c. Abdominal pain or cramps (Krawinkel et al., 2018; Mes et al., 2025)

2) Neurological and Physical Symptoms

In addition to gastrointestinal effects, other reported side effects include (Kim et al., 2023):

- a. Headache and dizziness: Dizziness was specifically reported more frequently in the group consuming bitter melon extract compared to the placebo group.
- b. Fatigue or general tiredness.
- c. Pruritus (itching sensation).

3) Effects on Organ Function

Current evidence suggests that bitter melon does not have a negative impact on liver or kidney function (Krawinkel et al 2018; Mes et al 2025). Several clinical markers, including liver enzyme (ALT and AST) as well as renal function (eGFR), are mostly normal and healthy

following supplementation up to 12 weeks' timeframe (Krawinkel et al., 2018; Mes et al., 2025).

CONCLUSION

Momordica charantia (bitter melon) may serve as an effective and safe herbal adjunctive therapy for glycemic management in individuals with prediabetes and may help reduce the risk of progression to type 2 diabetes mellitus. Clinical evidence indicates that regular consumption of bitter melon in powder or extract forms is associated with reductions in fasting plasma glucose (FPG) levels and improvements in glucose homeostasis markers, including insulin sensitivity measured by the homeostatic model assessment of insulin resistance (HOMA-IR) and glucagon regulation. Future research should prioritize large-scale, long-term randomized controlled trials with standardized dosages and formulations to strengthen the evidence base and establish clearer clinical recommendations. Clinicians may consider bitter melon as a complementary therapy in prediabetes management while emphasizing that it should be used alongside lifestyle interventions and appropriate medical monitoring. Public health policymakers should consider incorporating evidence-based herbal medicine approaches into diabetes prevention programs, particularly in resource-limited settings.

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