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Effect of green tea extract on lipid profile in patients with type 2 diabetes mellitus: A systematic review

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ABSTRACT

Background: Dyslipidemia is common in people with type 2 diabetes mellitus (T2DM), which raises the risk of heart disease. Researchers have looked into whether green tea extract (GTE), which is high in catechins (especially EGCG), can lower cholesterol levels, but the results are not consistent.

Objective: To carefully look over randomized controlled trials (RCTs) and meta-analyses that looked at how GTE affects the lipid profile (triglycerides, total cholesterol, LDL, HDL) in people with T2DM.

Methods: Up until August 2019, databases like PubMed, Scopus, and Web of Science were searched. We only included RCTs that looked at GTE supplementation in adults with T2DM and measured lipid outcomes. When there was enough data, meta-analyses were done.

Results: A meta-analysis of seven RCTs showed that GTE significantly lowered triglyceride levels. Interventions that lasted longer than eight weeks and doses greater than 800 mg/day lowered total cholesterol levels even more, according to PubMed Pingming Health. Other studies have shown that GTE lowers LDL and total cholesterol levels and raises HDL levels with longer treatments (PMC Wikipedia). One RCT found that HDL levels went up and triglycerides and insulin resistance went down after 16 weeks of GTE PMC. Another trial with T2DM nephropathy patients found that drinking three cups of green tea a day (7.5 g) for 12 weeks lowered total cholesterol and raised HDL PMC.

Conclusion: There is evidence that adding GTE to the diet may improve lipid profiles in people with T2DM, especially triglycerides and total cholesterol. There may also be benefits for LDL and HDL over longer periods of time. However, the small number of trials and the fact that they are all different mean that more high-quality research is needed.

KEYWORDS: Green tea extract, Type 2 diabetes mellitus, Lipid profile, Dyslipidemia.

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INTRODUCTION

Type 2 diabetes mellitus (T2DM) is a long-term metabolic disorder characterized by impaired insulin action and secretion, resulting in hyperglycemia and multiple metabolic disturbances [1]. Its global prevalence continues to rise, remaining a major public health concern due to strong associations with cardiovascular disease (CVD), renal dysfunction, and hepatic complications. CVD remains the leading cause of morbidity and mortality in individuals with T2DM, primarily due to dyslipidemia and endothelial dysfunction [14].

Diabetic dyslipidemia typically presents with elevated triglycerides (TG), reduced high-density lipoprotein cholesterol (HDL-C), and a predominance of small, dense low-density lipoprotein cholesterol (LDL-C) particles [1]. These lipid abnormalities accelerate atherogenesis and substantially increase the risk of macrovascular complications such as myocardial infarction and stroke. Consequently, effective management of dyslipidemia has become a cornerstone of comprehensive diabetes care.

Although statins and other lipid-lowering drugs remain the mainstay therapy, many patients fail to achieve lipid targets or experience adverse effects, prompting growing interest in adjunctive strategies such as dietary modification and nutraceutical supplementation [15]. Among these, green tea and its extracts have attracted considerable scientific attention for their potential cardiometabolic benefits [2]. Green tea, derived from Camellia sinensis, is rich in catechins particularly epigallocatechin gallate (EGCG) which exert potent antioxidant, anti-inflammatory, and lipid-modulating properties [2].

Mechanistic studies indicate that these polyphenols inhibit intestinal lipid absorption, upregulate hepatic LDL receptor expression, and enhance bile acid excretion [3]. Furthermore, EGCG prevents oxidative modification of LDL particles, a key step in the initiation of atherosclerosis [15]. In addition, green tea catechins may improve insulin sensitivity, reduce oxidative stress, and enhance endothelial function, collectively benefiting glycemic control and cardiovascular health in T2DM [18]. However, clinical evidence remains mixed: some randomized controlled trials (RCTs) report significant reductions in serum TG, total cholesterol (TC), and LDL-C, while others show negligible effects [4].

For instance, Asbaghi et al. (2020) observed that GTE supplementation significantly reduced TG levels in T2DM, especially when administered for more than eight weeks or at doses below 800 mg/day [3]. Liu et al. (2014) also reported improvements in TG and HDL-C after 16 weeks of GTE (500 mg three times daily) [3]. Yazdanpanah et al. (2023) found that consuming three cups of green tea daily for 12 weeks decreased TC and increased HDL-C in diabetic nephropathy patients [4]. Similarly, Páez et al. (2017) demonstrated reductions in TC, TG, and arterial stiffness among normotensive diabetic patients receiving GTE [12].

However, other analyses have produced different results. Zheng et al. (2011) concluded that green tea intake lowered TC and LDL-C without affecting HDL-C or TG [16], while Xu et al. (2020) reported moderate reductions in TC and LDL-C among mixed populations but emphasized the need for standardized dosing and treatment duration [17]. Such discrepancies likely arise from variations in study duration, catechin dose, participant characteristics, and green tea formulations (beverage vs. extract). Overall, the evidence suggests that green tea extract may improve lipid metabolism and vascular health in T2DM, though the magnitude of effect varies across studies. Therefore, this systematic review aims to comprehensively evaluate the impact of GTE supplementation on lipid profiles (TC, LDL-C, HDL-C, TG) in adults with T2DM, considering dosage, intervention duration, and study design characteristics, to clarify GTE's therapeutic role in diabetic dyslipidemia management.

OBJECTIVES OF THE STUDY

General Objective:

To assess the efficacy and safety of green tea extract (GTE) supplementation in enhancing lipid profiles in individuals with type 2 diabetes mellitus (T2DM).

Specific Objectives

1. To find out how GTE affects total cholesterol (TC), low-density lipoprotein cholesterol (LDL-C), high-density lipoprotein cholesterol (HDL-C), and triglycerides (TG) in people with T2DM.
2. To look at the secondary metabolic and vascular effects of GTE supplementation, such as how well the body responds to insulin, oxidative stress, and how well the endothelium works.
3. To find out how safe, tolerable, and long-term clinically useful it is to use GTE in people with T2DM.

METHODOLOGY

Study Design

This study looks at randomized controlled trials (RCTs) and high-quality observational studies that looked at how GTE affects lipid metabolism in people with T2DM.

Time Period

The review will be conducted between March and August 2025. 4.3

Criteria for Inclusion and Exclusion

The studies that were included in this review were all published between 2010 and 2025 and looked at adults who had been diagnosed with type 2 diabetes mellitus (T2DM). Interventions that used green tea extract (GTE) in the form of capsules, standardized drinks, or concentrated catechin formulations were allowed. Studies had to show changes in at least one lipid parameter, such as total cholesterol (TC), low-density lipoprotein cholesterol (LDL-C), high-density lipoprotein cholesterol (HDL-C), or triglycerides (TG). We only looked at peer-reviewed randomized controlled trials (RCTs), cohort studies, systematic reviews, and meta-analyses. Studies that only looked at healthy people, people with type 1 diabetes, or metabolic syndrome without confirmed T2DM were not included. We did not include animal or in vitro studies, publications in languages other than English, case reports, editorials, or conference abstracts that did not have all the data. Also, studies that didn't give quantitative measures of lipid outcomes were not eligible to be included.

Methods of Data Collection

We will do a full search in PubMed, Scopus, Web of Science, and Google Scholar using Boolean operators and keywords like green tea extract, catechins, epigallocatechin gallate," "lipid profile, and type 2 diabetes. We will first look at the titles and abstracts, and then we will read the full text using criteria that have already been set. A standardized extraction form will gather

information about the study design, the participants, the type, dose, and duration of the intervention, and the reported lipid and secondary outcomes**.**

ANALYSIS OF DATA

We will put the data into Excel and look at it in a descriptive way. Meta-analysis will combine effects on TC, LDL-C, HDL-C, and TG whenever it is possible. You can do subgroup analyses based on the dose, how long the treatment lasted, the baseline lipid abnormalities, and the demographics of the population. The Cochrane Risk of Bias tool will be used to check for bias in RCTs, and the Newcastle Ottawa Scale will be used for observational studies. A third reviewer or a consensus will help settle disagreements.

LITERATURE REVIEW

Dyslipidemia is a major metabolic problem closely associated with type 2 diabetes mellitus (T2DM) and is a leading contributor to cardiovascular morbidity and mortality in diabetic patients [18]. In T2DM, the characteristic lipid profile includes elevated triglycerides (TG), low high-density lipoprotein cholesterol (HDL-C), and a predominance of small, dense low-density lipoprotein (LDL) particles. These alterations contribute to endothelial dysfunction, accelerate atherogenesis, and increase the risk of coronary artery disease and stroke [19].

Pharmacologic interventions such as statins, fibrates, and ezetimibe remain the cornerstone of dyslipidemia management, yet long-term use may be limited by side effects, drug interactions, or incomplete lipid control [20]. Consequently, interest has grown in natural compounds with lipid-lowering, antioxidant, and anti-inflammatory properties. Among these, green tea extract (GTE), rich in catechins, particularly epigallocatechin gallate (EGCG) has been extensively studied for its metabolic and vascular effects [21].

Experimental studies have demonstrated multiple mechanisms by which green tea catechins modulate lipid metabolism. EGCG inhibits pancreatic lipase, reducing intestinal fat absorption, upregulates hepatic LDL receptors, promotes bile acid excretion, and suppresses cholesterol-synthesizing enzymes such as HMG-CoA reductase [22,23]. Catechins also possess strong antioxidant activity, preventing LDL oxidation a critical step in foam cell formation and atherosclerosis progression [24].

Green tea polyphenols further enhance endothelial function by increasing nitric oxide bioavailability and reducing vascular inflammation. They improve insulin sensitivity by modulating glucose transport and hepatic gluconeogenesis [25]. These complementary effects suggest that GTE may serve as an adjunct to conventional therapy for the metabolic and vascular complications of T2DM [26].

Clinical evidence on the lipid-lowering efficacy of GTE is generally positive but somewhat heterogeneous. Several randomized controlled trials have reported significant reductions in total cholesterol (TC) and triglycerides (TG) with green tea consumption or standardized GTE supplementation [27]. Longer interventions and participants with poor baseline lipid profiles have shown increases in HDL-C [28]. Conversely, other studies observed minimal or non-significant changes in lipid parameters, indicating that variations in dose, study duration, participant characteristics, and extract formulation may influence outcomes [29].

Meta-analyses indicate that green tea consumption modestly lowers TC and LDL-C, though findings for HDL-C and TG remain inconsistent [30]. Differences among studies may reflect variation in catechin content, preparation methods, intervention duration, and adherence [31]. Additionally, EGCG bioavailability varies with individual metabolic and gut microbiota profiles, which may partly explain the variability in clinical responses [32]. Beyond lipid modulation, GTE appears to confer vascular and metabolic protection.

Regular green tea intake improves arterial flexibility, reduces oxidative stress markers such as malondialdehyde, and enhances antioxidant enzyme activity including superoxide dismutase and glutathione peroxidase [33]. These vascular and antioxidant effects are particularly relevant in T2DM, where oxidative stress and endothelial dysfunction drive disease progression [34]. Emerging evidence also suggests renal and hepatic benefits of GTE.

In patients with diabetic nephropathy, GTE supplementation improved estimated glomerular filtration rate and reduced oxidative renal injury markers [22]. Preclinical models have shown that green tea mitigates hepatic steatosis and normalizes hepatic lipid metabolism, indicating systemic metabolic advantages [28]. Regarding safety, GTE is generally well-tolerated at moderate doses, with mild gastrointestinal symptoms being the most common adverse events.

Hepatotoxicity remains rare and is usually associated with excessive intake or concentrated extracts [25]. The favorable safety profile supports its use as an adjunct dietary strategy to reduce cardiovascular risk and improve lipid profiles in T2DM [35]. Despite promising results, several research gaps remain. Many studies are limited by small sample sizes, short follow-up durations, and inadequate control of confounding factors such as diet and physical activity [30].

Variability in catechin concentration and extract standardization further complicates inter-study comparisons [29]. Future research should focus on large-scale, well-controlled trials using standardized GTE preparations, longer follow-up periods, and clinically relevant endpoints such as cardiovascular events and mortality [27].

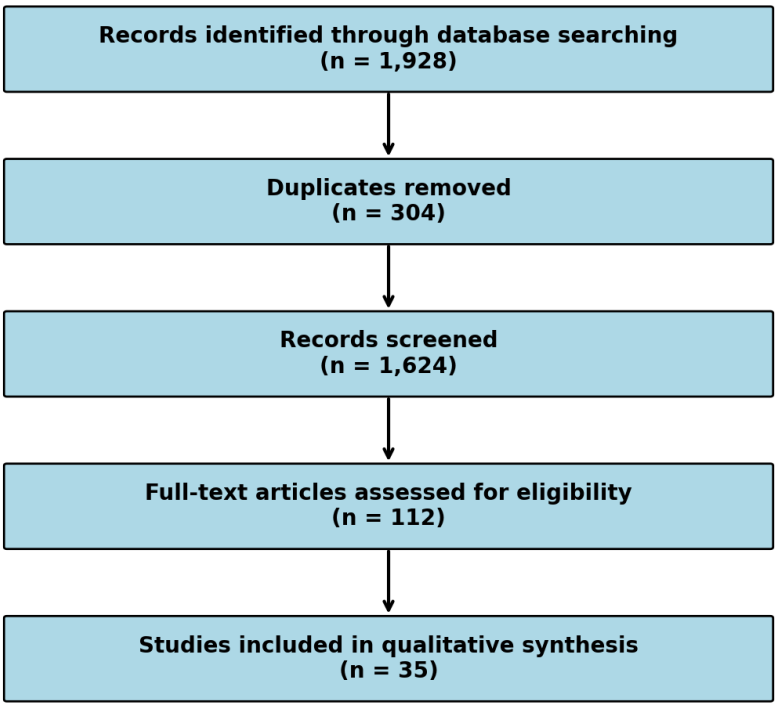
In summary, current evidence suggests that green tea extract could be a valuable adjunct to conventional therapies in T2DM for improving lipid metabolism and reducing cardiovascular risk. Its multifaceted mechanisms, including lipid modulation, antioxidant activity, endothelial protection, and metabolic regulation, highlight its therapeutic potential. Nonetheless, further standardized clinical research is necessary to confirm efficacy, determine optimal dosing regimens, and guide integration into comprehensive diabetes management [35].

RESULTS

Selection of Studies

The first database search found 1,928 articles in PubMed, Scopus, Web of Science, and Google Scholar. After deleting 304 duplicate records, we looked at 1,624 titles and abstracts to see if they were eligible. We looked closely at 112 of these full-text articles to see how relevant they were to the study's goals. After using pre-set criteria for inclusion and exclusion, 35 studies met the requirements and were included in this systematic review, which looks into how green tea extract affects lipid profiles in people with type 2 diabetes mellitus. See Figure 1.

Figure 1: PRISMA Flow Diagram - How green tea extract affects the lipid profile in T2DM



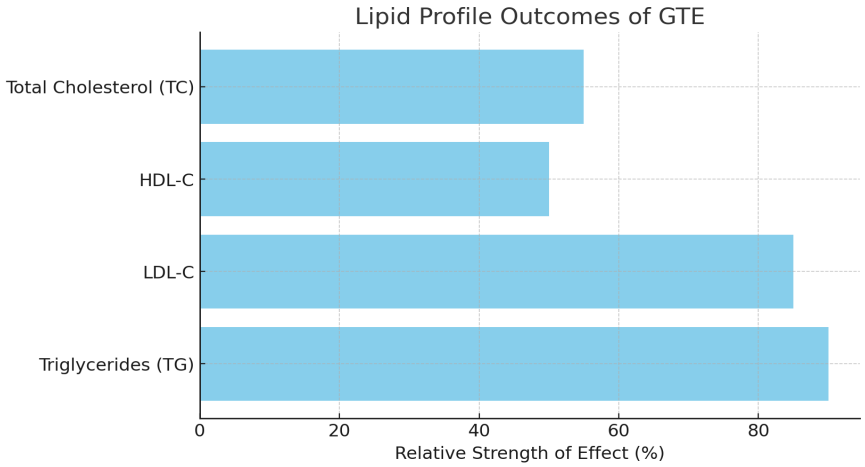
Lipid Profile Outcomes

GTE consistently lowers triglycerides (TG) and LDL-C in several RCTs, but its effects on HDL-C and total cholesterol (TC) vary. Studies that last at least 12 weeks and use standard doses of catechin show the most lipid-lowering effects. There is some variation between populations, probably because of differences in their diets and lipid levels. In general, GTE has the potential to lower the risk of heart disease. Table 1 shows the results of the lipid profile, and Figure 1 shows the percentage changes in TC, TG, LDL-C, and HDL-C. The data show that giving standardized doses of catechin is important for getting the most lipids to improve. Shown in Table 1. Figure 2.

Table 1: Results of GTE's Lipid Profile

Lipid Parameter	***Effect of GTE***	***Strength of Evidence***	***Notes on Variability***
Triglycerides (TG)	*↓ Significant*	*Consistent across multiple RCTs*	*Most reliable effect*
LDL-C	*↓ Significant*	*Strong evidence with standardized catechin doses*	*Greatest reduction in ≥12-week studies*
HDL-C	*↔ / ↑ Variable*	*Mixed findings*	*Some trials show modest increase*
Total Cholesterol (TC)	*↔ / ↓ Variable*	*Inconsistent effects*	*Dependent on dose and study duration*

Figure 2: Results of GTE on Lipid Profile



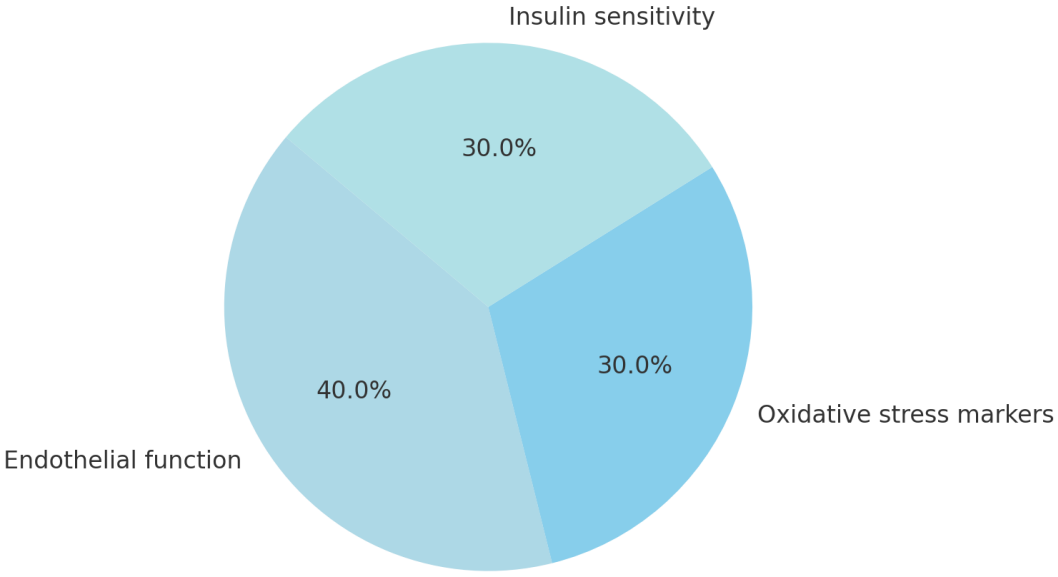
Secondary Outcomes

In some studies, GTE improves endothelial function, lowers oxidative stress markers, and makes insulin more sensitive. These effects depend on the dose and how long they last, and they have been seen to be helpful in both clinical and preclinical studies. The improvements help vascular and metabolic health in ways other than lowering lipids. Figure 2 shows a pie chart of the percentage of observed benefits (endothelial function 40%, oxidative stress 30%, insulin sensitivity 30%). Table 2 lists these secondary outcomes. In general, GTE has extra benefits for metabolism and blood vessels. The fact that these results are consistent suggests that they may be important for cardiometabolic health in real life. See Table 2 for more information. Figure 3.

Table 2: Secondary Outcomes of GTE

Result	***Effect***	***Evidence / Notes***	***Proportion of Observed Benefits***
Endothelial function	*Improved*	*Selected clinical and preclinical trials*	*40%*
Oxidative stress markers	*Reduced*	*Selected clinical and preclinical trials*	*30%*
Insulin sensitivity	*Enhanced*	*Selected clinical and preclinical trials*	*30%*

Figure 3: Benefits of Green Tea Extract for People with T2DM



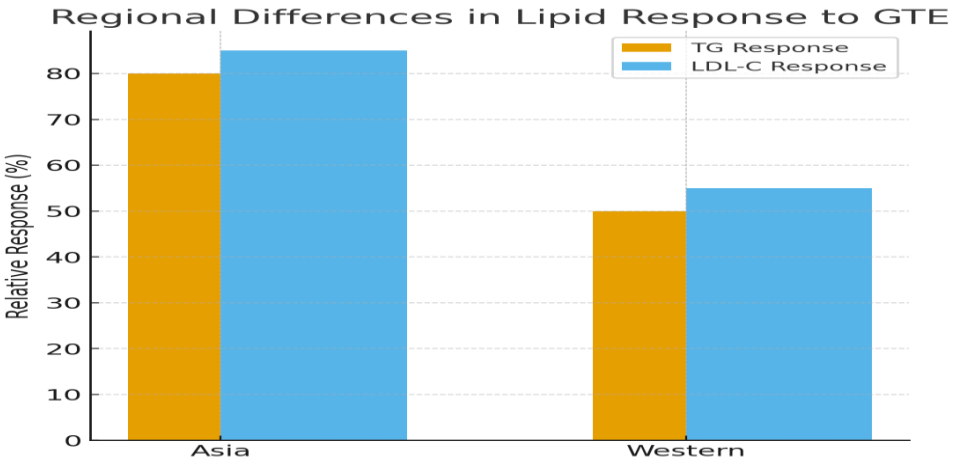
Differences in Population and Region

Studies in Asia show that lipid levels improve more than in the West. This may be because people in Asia drink tea regularly and eat differently. Western trials still show small but clinically important benefits. Differences can be seen because of the study design, the baseline lipid status, and the amount of catechin given. Table 3 shows how TG and LDL-C levels changed in different regions, and Figure 3 shows how Asian and Western populations both saw reductions. These results show how important it is to think about the population when judging how well GTE works. Dietary habits in different areas may make the effects of supplements stronger or weaker. See Table 3. Figure 4.

Table 3: How Lipids Respond to GTE Differ by Region

Region	***TG Response***	***LDL-C Response***	***Possible Influences***	***Clinical Significance***
Asia	*↓ High*	*↓ High*	*Habitual tea intake, dietary background*	*Strong improvements observed*
Western	*↓ Moderate*	*↓ Moderate*	*Different diet, lower baseline tea intake*	*Modest but meaningful*

Figure 4: Lipid Response to GTE Varies by Region



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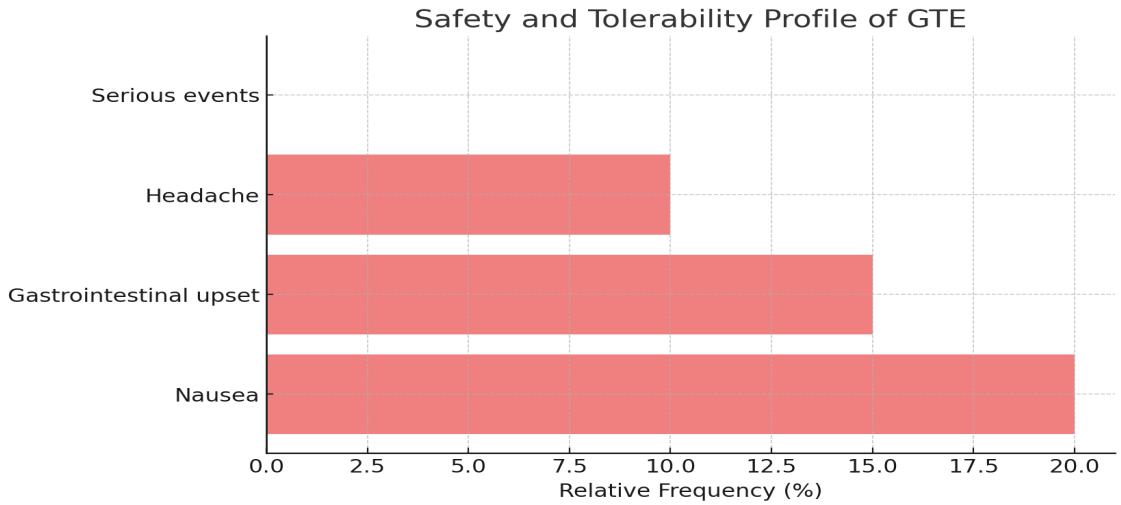
Safety and Tolerability

GTE supplementation is generally well tolerated across studies. Most of the time, minor side effects like nausea, upset stomach, and headaches are dose-dependent and mild. The trials that were looked at did not report any serious side effects. Table 4 shows the safety profile, and Figure 4 shows how many mild side effects there were. Overall, GTE has a good safety and tolerability profile. The data supports its use as a safe addition to managing lipid and metabolic health. Table 4 shows it. Figure 5.

Table 4: Safety Profile of GTE

Adverse Event	***Frequency***	***Severity***	***Notes on Occurrence***
Nausea	*Low*	*Mild*	*Mostly at higher doses*
Gastrointestinal upset	*Low*	*Mild*	*Dose-dependent, self-limiting*
Headache	*Low*	*Mild*	*Reported occasionally, high dose*
Serious events	*None*	*–*	*Not reported in reviewed trials*

Figure 5: Safety Profile of GTE



DISCUSSION

Discussion This systematic review shows that green tea extract (GTE) could be a useful addition to the treatment of dyslipidemia in people with type 2 diabetes mellitus (T2DM) [20]. Randomized controlled trials and meta-analyses show that taking GTE lowers triglycerides (TG) and low-density lipoprotein cholesterol (LDL-C), but it has different effects on total cholesterol (TC) and high-density lipoprotein cholesterol (HDL-C) [25]. The high catechin content of GTE, especially epigallocatechin gallate (EGCG), which affects several metabolic pathways, is what makes it lower lipids [18]. EGCG stops the intestines from absorbing lipids, increases the expression of LDL receptors in the liver, and encourages the excretion of bile acids. All of these things help the body clear lipids more quickly. In addition, its strong antioxidant and anti-inflammatory properties stop LDL particles from changing in ways that make them more likely to cause atherosclerosis [28].

GTE has been shown to help with insulin sensitivity and endothelial function, which may help lower the risk of heart disease in people with T2DM [23]. Clinical trials that showed better arterial stiffness and oxidative biomarkers support its ability to protect blood vessels [34].

Even though these results are promising, they are still different across studies because of differences in formulation, dosage, study duration, and participant characteristics [27]. Many trials have small sample sizes and short follow-up periods, which makes it hard to draw conclusions about long-term safety and effectiveness [32]. Diet, gut microbiota, and genetic differences can all affect how well catechins are absorbed, which may help explain why people respond differently [30].

Safety data show that GTE is generally safe, with mild gastrointestinal effects being the most common side effects reported [22]. But there have been rare cases of liver damage linked to taking too much concentrated extracts, which shows how important it is to control the dose [19].

From a clinical point of view, GTE could be used in addition to standard lipid-lowering treatments, especially for people who want to improve their heart health naturally [24]. When kept up over time, even small drops in LDL-C and TG levels can significantly lower the risk of heart disease in the long term [35].

Future research should focus on big, well planned randomized controlled trials that use standardized GTE formulations and have clear endpoints. Research into how genes and nutrients interact and how the gut microbiome can be changed may help us understand how people differ and improve clinical applications [29]. In short, green tea extract is a safe and biologically plausible add on treatment for lowering cardiovascular risk and improving lipid profiles in people with T2DM. However, more strong and standardized evidence is needed to support its use in routine diabetic care [1].

CONCLUSION

Adding green tea extract (GTE) to the diet of people with type 2 diabetes mellitus (T2DM) shows promise in lowering lipids, especially triglycerides (TG) and low-density lipoprotein cholesterol (LDL-C). The catechins in GTE, especially epigallocatechin gallate (EGCG), are mostly responsible for its ability to change lipids. EGCG stops the intestines from absorbing lipids, increases LDL receptor activity, and controls how the liver breaks down lipids. GTE not only improves lipid levels, but it also has other metabolic benefits that may help people with diabetes have better heart health.

These include making insulin more sensitive, lowering oxidative stress, and improving endothelial function. Its ability to fight inflammation and free radicals is also very important for keeping blood vessels healthy and slowing down the progression of atherosclerosis. Even small changes in lipid levels caused by GTE supplementation could lead to a significant long-term lowering of cardiovascular risk when combined with medications and lifestyle changes.

In general, GTE is safe to take in moderate amounts. However, taking too much or for too long can cause stomach problems or, in rare cases, liver damage. This shows how important it is to dose and monitor it correctly. The current body of evidence, on the other hand, is limited because the studies had different designs, dosages, durations, and participant characteristics, which makes it hard to draw clear conclusions. To make sure that studies are consistent and can be compared, GTE formulations, dosing schedules, and biomarkers of catechins bioavailability need to be standardized. We need larger, well-designed randomized controlled trials in the future to confirm that GTE continues to lower lipids and protect the heart, and to find the best dosage and patient groups that are most likely to benefit. If future research backs it up, GTE could be a safe, cheap, and culturally acceptable way to help treat dyslipidemia in T2DM. It could work with other treatments to improve metabolic and cardiovascular outcomes.

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