ISSN: 2230-9926

Available online at http://www.journalijdr.com

IJDR

International Journal of Development Research
Vol. 15, Issue, 09, pp. 68970-68973, September, 2025
https://doi.org/10.37118/ijdr.29993.09.2025

RESEARCH ARTICLE OPEN ACCESS

PHARMACOLOGICAL PERSPECTIVES ON CAMELLIA SINENSIS IN THE MANAGEMENT OF DIABETES

***[1]Lalit Verma and [2]Amit Rathore**

[1]Department of Pharmacy: Bhagwant Global University Kotdwar Uttrakhand
[2]Department of Pharmaceutical Science: Gurukul Kangri Vishwavidyalaya Uttrakhand

ARTICLE INFO

Article History:
Received 11th June, 2025
Received in revised form
17th July, 2025
Accepted 27th August, 2025
Published online 30th September, 2025

Key Words:
Camellia sinensis; Green tea; Diabetes mellitus; Catechins; Epigallocatechin gallate (EGCG); Antidiabetic pharmacology.

****Corresponding author: Lalit Verma,***

ABSTRACT

Diabetes mellitus is a complex and progressive metabolic disorder that continues to pose a significant global health challenge. Current therapeutic strategies, although effective, are often accompanied by side effects, reduced patient compliance, and economic burden, which has fueled the search for safer and more sustainable alternatives. Among various medicinal plants, *Camellia sinensis* (green tea) has received particular attention due to its rich content of bioactive catechins, especially epigallocatechin gallate (EGCG). These polyphenolic compounds exert multifaceted pharmacological actions relevant to glycaemic regulation, including enhancement of insulin sensitivity, modulation of glucose uptake, inhibition of digestive enzymes such as α-amylase and α-glucosidase, and protection of pancreatic β-cells from oxidative damage. In addition, antioxidant and anti-inflammatory activities of green tea contribute to its potential in reducing the risk of diabetes-associated complications such as cardiovascular dysfunction, nephropathy, and neuropathy. Evidence from experimental studies strongly supports its antidiabetic activity, while clinical trials provide suggestive but variable outcomes, primarily due to differences in dosage forms, standardization, and study design. Despite these limitations, *Camellia sinensis* remains a promising candidate for integrative diabetes management. A deeper understanding of its pharmacological mechanisms, supported by rigorous clinical validation, may pave the way for its development as an adjunct or complementary therapy in the management of diabetes mellitus.

Citation: Lalit Verma and Amit Rathore. 2025. "Pharmacological Perspectives on camellia sinensis in the Management of Diabetes". *International Journal of Development Research*, 15, (09), 68970-68973.

INTRODUCTION

Diabetes mellitus is one of the most prevalent non-communicable diseases worldwide, characterized by chronic hyperglycaemia arising from defects in insulin secretion, insulin action, or both. According to the International Diabetes Federation, the global diabetic population is projected to rise significantly in the coming decades, posing not only a medical but also a socioeconomic burden. Conventional antidiabetic therapies, including oral hypoglycaemic agents and insulin, have proven effective in controlling blood glucose levels; however, their long-term use is often limited by side effects, high costs, and reduced patient adherence. These limitations have generated considerable interest in natural remedies and plant-based interventions as complementary approaches for diabetes management. *Camellia sinensis* (green tea), a widely consumed beverage across Asia and increasingly popular worldwide, has been extensively studied for its potential health benefits. Its pharmacological relevance in diabetes is attributed to the presence of polyphenolic compounds, particularly catechins such as epigallocatechin gallate (EGCG), epigallocatechin, and epicatechin gallate. These bioactive constituents exert diverse biological actions, including antioxidant, anti-inflammatory, and metabolic regulatory effects, which may contribute to the prevention and management of diabetes and its complications. Recent experimental and clinical evidence suggests that green tea influences glucose homeostasis by enhancing insulin sensitivity, modulating carbohydrate metabolism, and protecting pancreatic β-cells from oxidative damage. Despite encouraging findings, inconsistencies in clinical outcomes highlight the need for systematic evaluation and standardization. This paper focuses on the pharmacological perspectives of *Camellia sinensis* in the management of diabetes mellitus, aiming to bridge mechanistic insights with therapeutic potential.

Phytochemistry of *Camellia sinensis:* The pharmacological potential of *Camellia sinensis* (green tea) is largely attributed to its diverse phytoconstituents, among which polyphenols, alkaloids, amino acids, and volatile compounds are most prominent. The leaves contain approximately 30–40% polyphenolic compounds by dry weight, predominantly flavan-3-ols, commonly referred to as catechins. These

include epigallocatechin gallate (EGCG), epigallocatechin (EGC), epicatechin gallate (ECG), and epicatechin (EC), which are considered the primary bioactive agents responsible for the antidiabetic and antioxidant properties of green tea.

Fig. 1. ***Camellia sinensis***

In addition to catechins, green tea contains caffeine, theobromine, and theophylline, which contribute to its central nervous system stimulation and lipid metabolism effects. The amino acid L-theanine imparts neuroprotective and relaxing properties, while volatile oils are responsible for its characteristic aroma. Furthermore, green tea leaves contain vitamins (C, E, and B complex), minerals (zinc, manganese, selenium, chromium), and saponins, which together enhance its therapeutic value. The synergistic actions of these phytoconstituents enable green tea to influence multiple molecular pathways associated with glucose homeostasis, insulin signaling, and oxidative stress, thereby underscoring its pharmacological relevance in diabetes management.

Inhibition of Carbohydrate-Digesting Enzymes: EGCG and related compounds inhibit intestinal α-amylase and α-glucosidase enzymes, thereby reducing postprandial glucose spikes by delaying carbohydrate digestion and absorption.

Protection of Pancreatic β-Cells: Antioxidant properties of catechins neutralize reactive oxygen species (ROS) and reduce oxidative stress, thus preserving pancreatic β-cell integrity and insulin secretory capacity.

Regulation of Hepatic Glucose Metabolism: Green tea polyphenols suppress hepatic gluconeogenesis by downregulating key enzymes such as phosphoenolpyruvate carboxykinase (PEPCK) and glucose-6-phosphatase, while simultaneously promoting glycogen synthesis.

Anti-Inflammatory Actions: Catechins inhibit pro-inflammatory mediators like TNF-α and IL-6, which are implicated in insulin resistance, thereby supporting improved glycaemic control.

Improvement of Lipid Metabolism: Green tea consumption has been linked to reductions in serum triglycerides and LDL cholesterol, contributing to decreased risk of diabetic dyslipidemia and cardiovascular complications.

Pharmacological Evidence

Preclinical Evidence (In-vitro and In-vivo): A substantial body of preclinical work supports the antidiabetic potential of *Camellia sinensis*, particularly its catechin-rich fractions.

In-vitro findings: Green tea catechins—most notably EGCG—consistently demonstrate (i) inhibition of α-amylase and α-glucosidase, (ii) enhancement of insulin signaling (PI3K/Akt) with downstream GLUT4 translocation in myocytes and adipocytes, and (iii) attenuation of oxidative and inflammatory stress in pancreatic β-cells and hepatocytes.

Table 1. Major Phytoconstituents of *Camellia sinensis* and Their Biological Significance

Phytochemical Class	Representative Compounds	Biological Significance
Catechins (Polyphenols)	Epigallocatechin gallate (EGCG), Epigallocatechin (EGC), Epicatechin gallate (ECG), Epicatechin (EC)	Antioxidant, antihyperglycaemic, inhibition of α-amylase and α-glucosidase, improvement of insulin sensitivity
Alkaloids	Caffeine, Theobromine, Theophylline	CNS stimulation, lipolysis, mild thermogenic effect
Amino Acids	L-theanine	Neuroprotective, stress-reducing, may modulate insulin action indirectly
Vitamins & Minerals	Vitamin C, Vitamin E, Zinc, Manganese, Selenium, Chromium	Antioxidant defense, insulin cofactor functions, metabolic regulation
Volatile Compounds	Terpenes, aldehydes, alcohols	Contribute to aroma and possible antioxidant properties
Saponins	Various glycosidic compounds	Hypolipidaemic and potential antidiabetic effects

Table 2. Mechanisms of Antidiabetic Action of *Camellia sinensis*

Mechanism	Target / Pathway	Phytoconstituents Involved	Pharmacological Effect
Enhancement of insulin sensitivity	PI3K/Akt signaling → GLUT4 translocation	EGCG, ECG	Improved glucose uptake
Inhibition of carbohydrate digestion	Intestinal α-amylase & α-glucosidase	EGCG, EGC	Reduced postprandial hyperglycemia
β-cell protection	Antioxidant defense, ROS scavenging	EGCG, ECG, Vitamin C	Preservation of insulin secretion
Regulation of hepatic glucose metabolism	↓ PEPCK & G6Pase, ↑ glycogen synthase	Catechins	Lower hepatic glucose output
Anti-inflammatory activity	↓ TNF-α, IL-6, NF-κB signaling	Catechins, L-theanine	Reduction of insulin resistance
Lipid metabolism modulation	↓ Triglycerides, LDL; ↑ HDL	Catechins, caffeine	Cardiometabolic protection

Mechanisms of Antidiabetic Action of Camellia sinensis: The antidiabetic effects of *Camellia sinensis* are attributed primarily to its polyphenolic catechins, especially epigallocatechin gallate (EGCG). These bioactive compounds target multiple metabolic and molecular pathways associated with glucose regulation, insulin sensitivity, and oxidative stress. The pleiotropic nature of green tea makes it effective not only in lowering blood glucose but also in preventing long-term complications of diabetes.

Enhancement of Insulin Sensitivity: Catechins improve insulin receptor signaling by activating the phosphatidylinositol-3-kinase (PI3K)/Akt pathway, leading to enhanced glucose uptake in skeletal muscle and adipose tissue through increased translocation of glucose transporter type 4 (GLUT4).

These effects translate into improved cellular glucose uptake and reduced glucose output in hepatocyte models.

Animal models: In chemically induced (streptozotocin, alloxan) and diet-induced models of diabetes and insulin resistance, green tea extracts generally reduce fasting glucose, improve glucose tolerance, and lower insulin resistance indices. Additional benefits include improved lipid profiles (↓TG, ↓LDL; modest ↑HDL) and reductions in hepatic steatosis, aligning with broader cardiometabolic protection. Histological assessments frequently indicate partial preservation of islet morphology and reduced markers of oxidative damage (e.g., lipid peroxidation products) in pancreatic and hepatic tissues.

Dose/formulation considerations: Efficacy in animals is influenced by extract standardization (total catechins, EGCG content), route (oral gavage vs. diet admixture), and duration. Preparations enriched for EGCG tend to yield more pronounced glycaemic and antioxidant effects, though whole-leaf polyphenol mixtures often show complementary benefits (e.g., broader antioxidant spectrum).

Hpatotoxicity: Isolated reports have associated high-dose green tea extract supplementation with reversible elevations of liver enzymes and, in rare cases, hepatotoxicity. These events are dose-dependent and more commonly observed when extracts are taken on an empty stomach. Thus, standardized dosing and administration with meals are recommended to minimize risk.

Table A. Preclinical evidence synthesis for *Camellia sinensis*

Evidence domain	Typical experimental setting	Direction of effect	Notes on robustness
Enzyme inhibition (α-amylase/α-glucosidase)	Enzyme assays, intestinal cell lines	Consistent ↓ activity → ↓ postprandial spikes	Strong and reproducible across labs
Insulin signaling & GLUT4	Myocytes/adipocytes (cell lines, primary cells)	↑ Akt phosphorylation; ↑ GLUT4 translocation	Moderate–strong; mechanism-concordant
Hepatic glucose metabolism	Hepatocyte assays; rodent livers	↓ PEPCK & G6Pase; ↑ glycogen synthase	Moderate; supported by gene/protein readouts
β-cell protection	β-cell lines; islet studies	↓ ROS; preserved insulin secretion	Moderate; dose and antioxidant capacity matter
Systemic glycaemia (in vivo)	STZ/alloxan; HFD models	↓ FPG; improved OGTT; ↓ HOMA-IR	Moderate–strong; extract standardization key
Lipids & inflammation	Rodent serum/tissue	↓ TG/LDL; ↓ TNF-α/IL-6; ↓ oxidative markers	Moderate; aligns with cardiometabolic benefits

Table B. Clinical evidence map for *Camellia sinensis* in diabetes/metabolic risk

Outcome domain	Typical intervention formats	Overall signal	Key moderators
Fasting plasma glucose	Standardized catechin extract or brewed green tea, 8–24 weeks	Small ↓ (more consistent with extracts)	Dose (EGCG mg/day), duration, adherence
HbA1c	Extracts, longer trials (≥12 weeks)	Small ↓; not universal	Baseline HbA1c, study power, co-therapies
Postprandial glucose	Beverage or extract taken with/just before meals	Consistent attenuation of excursions	Carbohydrate load, enzyme inhibition potency
Insulin resistance (HOMA-IR)	Extracts; mixed populations	Modest improvement in some studies	Weight change, activity, diet quality
Lipid profile	Beverage or extract	↓ TG and LDL in subsets	Baseline dyslipidaemia, caffeine sensitivity
Safety/tolerability	Beverage/extract	Generally good; rare GI or hepatic signals at high dose	Total catechins, caffeine, liver health

Clinical Evidence (Human Studies): Human data are supportive but heterogeneous. Across adult populations with impaired glucose tolerance, type 2 diabetes, or metabolic syndrome, green tea beverages, extracts, or capsules have been tested as adjuncts to standard care. Glycaemic control. Many trials report modest reductions in fasting plasma glucose and, over longer durations, small improvements in HbA1c. Effects are more evident when standardized, catechin-rich preparations (with defined EGCG content) are used consistently for ≥8–12 weeks. Shorter trials or those using low-catechin beverages often show neutral findings. Postprandial responses. Trials assessing carbohydrate challenge tests commonly observe attenuated postprandial glucose excursions with green tea co-ingestion or prior loading—consistent with α-glucosidase/α-amylase inhibition demonstrated preclinically. Insulin resistance and lipids. Some studies note improvements in HOMA-IR and modest reductions in triglycerides and LDL cholesterol, with variable effects on HDL. Heterogeneity reflects differences in baseline metabolic status, background diet, caffeine exposure, and product standardization. Safety and tolerability. Green tea beverages are generally well tolerated. Concentrated extracts can cause gastrointestinal discomfort in a minority of participants; rare idiosyncratic elevations in liver enzymes have been reported at high doses. Caffeine content and timing may influence tolerability and sleep, and potential additive glucose-lowering effects should be considered alongside antidiabetic medications.

Safety, Interactions, and Contraindications of *Camellia sinensis:* Green tea is widely consumed as a traditional beverage and is generally recognized as safe when taken in moderate amounts. However, the use of concentrated *Camellia sinensis* extracts in clinical or supplemental form warrants careful consideration of safety, especially in patients with diabetes who are often on polypharmacy.

General Safety Profile: Daily consumption of green tea infusion (2–3 cups) is considered safe for healthy individuals and patients with metabolic disorders. Reported adverse effects are usually mild and include gastrointestinal discomfort, nausea, or constipation, which are often linked to high-dose catechin or caffeine intake.

Drug–Herb Interactions

- **Antidiabetic drugs (e.g., metformin, sulfonylureas, insulin):** Additive glucose-lowering effects may increase the risk of hypoglycemia. Regular monitoring of blood glucose is advisable.
- **Antihypertensives and cardiovascular drugs:** Caffeine content may cause mild elevations in blood pressure or heart rate, potentially counteracting antihypertensive effects in sensitive individuals.
- **Anticoagulants (e.g., warfarin):** Vitamin K content in green tea may antagonize anticoagulant activity, although the effect is typically minor with moderate intake.
- **Iron supplements:** Polyphenols can chelate non-heme iron, reducing its absorption; spacing administration times is advisable.

5. Contraindications and Precautions

- **Pregnancy and lactation:** Excessive caffeine intake from green tea may be unsafe; limited consumption (≤2 cups/day) is considered acceptable.
- **Hepatic disorders:** Patients with pre-existing liver disease should avoid concentrated green tea extract supplements.
- **Caffeine sensitivity:** Individuals prone to insomnia, palpitations, or anxiety should moderate intake.
- **Children and adolescents:** Use of high-dose extracts is not recommended due to lack of long-term safety data.

Recommended Safe Intake

Most clinical studies demonstrating glycaemic benefits use extracts standardized to provide 300–800 mg catechins daily (of which EGCG constitutes 150–400 mg). These doses appear safe for short- to medium-term use (up to 12–16 weeks) when taken with meals. Traditional brewed green tea (2–3 cups/day) provides lower but physiologically relevant catechin exposure and carries minimal risk.

CONCLUSION

Camellia sinensis (green tea) represents one of the most extensively studied medicinal plants with promising potential in the management of diabetes mellitus. Its rich phytochemical profile, particularly catechins such as EGCG, exerts multifaceted pharmacological effects, including enhancement of insulin sensitivity, inhibition of carbohydrate-digesting enzymes, regulation of hepatic glucose output, protection of pancreatic β-cells, and reduction of oxidative and inflammatory stress. Evidence from preclinical models is consistent and strongly supportive, while clinical trials suggest modest yet meaningful improvements in glycaemic control, lipid metabolism, and postprandial glucose regulation. Despite these encouraging findings, variability in study outcomes highlights the importance of standardized extract formulations, defined catechin dosages, and longer-duration clinical evaluations to establish reproducible efficacy. Safety remains generally favorable when consumed as a beverage or in moderate supplemental doses, although concentrated extracts require careful monitoring, particularly in patients with hepatic impairment or polypharmacy. Taken together, green tea is best viewed as a supportive, adjunctive approach rather than a stand-alone therapy for diabetes. Integrating its use into dietary and lifestyle management strategies may enhance metabolic outcomes while reducing the risk of diabetic complications. Future research focusing on pharmacokinetics, dose optimization, and large-scale randomized controlled trials will be critical in translating the traditional and experimental promise of *Camellia sinensis* into evidence-based clinical practice.

REFERENCES

Balarama Krishna Surapaneni B, Le M, Jakobovits J, Vinayek R, Dutta S. Acute severe hepatotoxicity associated with green tea extract: case report. *Integr Cancer Ther.* 2018;17(4):1211–1214. SAGE Journals

Bose M, Lambert JD, Ju J, Reuhl KR, Shapses SA, Yang CS. The major green tea polyphenol, (–)-epigallocatechin-3-gallate, inhibits obesity, metabolic syndrome, and fatty liver disease in high-fat-fed mice. *J Nutr.* 2008;138(9):1677–1683.

Case report and review: green tea extract–associated acute liver injury. *J Hepatol.* 2006;44(3):551–555. NCBI

Catechin adverse events (hemolytic anemia, safety limits). *Health Canada summary.* 2017. Wikipedia

EatingWell – green tea and metabolic syndrome. Eating Well.com article. 2025.

EatingWell – green tea extract gummies lower blood sugar and gut inflammation. 2022. EatingWell

Effects of dietary EGCG supplementation on insulin resistance and metabolic factors (RCT). *Diabetes Obes Metab.* 2008;10(6):493–503. PubMed

EGCG toxicity thresholds according to EFSA. Safety review. EFSA J. 2018;16(4):5235. Wikipedia+1

Green Tea — LiverTox: Clinical and Research Information on Drug-Induced Liver Injury. *NCBI Bookshelf.* NIH. NCBI

Kahn N, Mukhtar H. Tea polyphenols for health promotion. Life Sci. 2007;81(7):519–533. PubMed

Kao YH, Chang HH, Lee MJ, Chen CL. Tea, obesity, and diabetes. *Mol Nutr Food Res.* 2006; 50(2):188–210. PubMed

Lambert JD, Yang CS. Mechanisms of cancer prevention by tea constituents. J Nutr. 2003;133(10):3262S–3267S.

Mazzanti G, Di Sotto A, Vitalone A. Hepatotoxicity of green tea: an update. Arch Toxicol. 2015;89(5):647–658. NCBIPubMed

Murase T, Nagasawa A, Suzuki J, Hase T, Tokimitsu I. Beneficial effects of tea catechins on diet-induced obesity: stimulation of lipid catabolism in the liver. *Int J Obes Relat Metab Disord.* 2002;26(10):1459–1464. PubMed

NTP Toxicology Studies of EGCG and GTE in rats and mice. NTP Technical Report. 2022. NCBI

Reddit summary on *Camellia sinensis* pharmacology. Nutraceuticalscience subreddit. 2023

Research on weight loss supplement SlimQuick® and liver injury. *J Hepatol.* 2016;65(3):592–593. ResearchGate

The safety of green tea and green tea extract consumption in adults — systematic review. Regul Toxicol Pharmacol. 2018;95:412–433. PubMed

Time magazine – green tea health summary; liver risk at high dose. 2024. TIME

US Pharmacopeia comprehensive review of GTE hepatotoxicity. Regul Toxicol Pharmacol. 2020;114:104–110. PubMed

US Pharmacopeia safety review (2007). Clin Toxicol. 2008; 46(7):595–601. PubMed

Verywell Health – Green tea benefits for blood sugar and others. *Verywell Health article*. 2023. Verywell Health

Verywell Health – what happens to your body when you drink green tea daily. 2025. Verywell Health

Wang H, Proctor SD, Song Z. EGCG prevents progression to glucose intolerance in db/db mice. *J Nutr.* 2012;142(12):2174–2181. PubMed

Wikipedia – Catechin: adverse effects and EFSA recommendation. 2025.

Wikipedia – Epigallocatechin gallate: toxicity and safety levels. 2025.

Wikipedia – Green tea: health effects, limited evidence, liver toxicity. 2025.

Wolfram S, Raederstorff D, Wang Y, Teixeira SR, Elste V, Weber P. TEAVIGO™, a green tea extract rich in EGCG, influences obesity and blood glucose in mice. J Nutr. 2005;135(12):2828–2834.

Wu LY, Juan CC, Hwang LS, Hsu YP, Ho PH, Ho LT. Green tea supplementation ameliorates insulin resistance and increases GLUT4 content in fructose-fed rats. Eur J Nutr. 2004;43(2):116–124.

Wu ZQ, Zhang Y, Xie BY, et al. Epigallocatechin gallate supplementation ameliorates diabetes in rodent models. *J Nutr Biochem.* 2006;17(8):518–524. PubMed

Zhang XQ, Simonyi A, Sun AY. Vascular and metabolic actions of EGCG (green tea catechin) in animal models of metabolic syndrome and diabetes. *Mol Nutr Food Res.* 2015; 59(7):1004–1012. PMC

****