e-ISSN: 2320-4230, p-ISSN: 2961-6085

Journal of Drug Discovery and Therapeutics

Available Online at www.jddt.in

CODEN: - JDDTBP (Source: - American Chemical Society)

Volume 13, Issue 4; 2025, 128-132

Review of Pharmacological Evaluation of Antidiabetic Activity of Combined Extract of Gurmar Leaves and Lemon Peel in Streptozocin Induced Diabetic Rats

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Received: 11-04-2025 / Revised: 10-05-2025 / Accepted: 23-06-2025
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Conflict of interest: No conflict of interest.

Abstract:

Diabetes mellitus is a chronic metabolic disorder characterized by persistent hyperglycemia, oxidative stress, and impaired insulin secretion or action. Medicinal plants with antidiabetic and antioxidant properties have gained considerable attention as complementary therapeutic agents. The present review evaluates the antidiabetic potential of a combined extract of Gymnema sylvestre (Gurmar) leaves and Citrus limon (lemon) peel in streptozotocin (STZ)-induced diabetic rat models. Gymnema sylvestre is well known for its insulinotropic and glucose-lowering effects due to the presence of gymnemic acids, while lemon peel is rich in flavonoids, phenolics, and vitamin C, contributing to its antioxidant and antihyperglycemic activity. Administration of the combined extract significantly reduces fasting blood glucose levels and improves body weight compared to diabetic control animals. Biochemical assessments reveal normalization of serum lipid profile, reduction in glycosylated hemoglobin (HbA1c), and improvement in insulin levels. The combined extract also enhances endogenous antioxidant defenses (SOD, CAT, GSH) while decreasing lipid peroxidation (MDA), indicating protection against oxidative stress. Histopathological examination of pancreatic tissue demonstrates regeneration and preservation of β-cell architecture. The findings suggest that the synergistic action of Gymnema sylvestre leaves and Citrus limon peel exerts significant antidiabetic and antioxidative effects, supporting its potential as a natural therapeutic approach for the management of diabetes mellitus.

Keywords: Gymnema sylvestre; Citrus limon; Gurmar; Lemon peel; Antidiabetic activity; Streptozotocin; Oxidative stress; Insulin secretion.

Introduction

Diabetes mellitus is a chronic metabolic disorder characterized by persistent hyperglycemia arising from impaired insulin secretion, insulin action, or both. Glucose normally enters cells under the action of insulin secreted by pancreatic β-cells; when tissues become resistant to insulin or insulin secretion declines, glucose accumulates in the bloodstream, leading to metabolic dysfunction and progressive tissue damage. Uncontrolled hyperglycemia contributes to oxidative stress, advanced glycation end-

product (AGE) formation, and endothelial and mitochondrial dysfunction, ultimately leading to chronic complications such as nephropathy, neuropathy, cardiovascular disease, and retinopathy.[1]

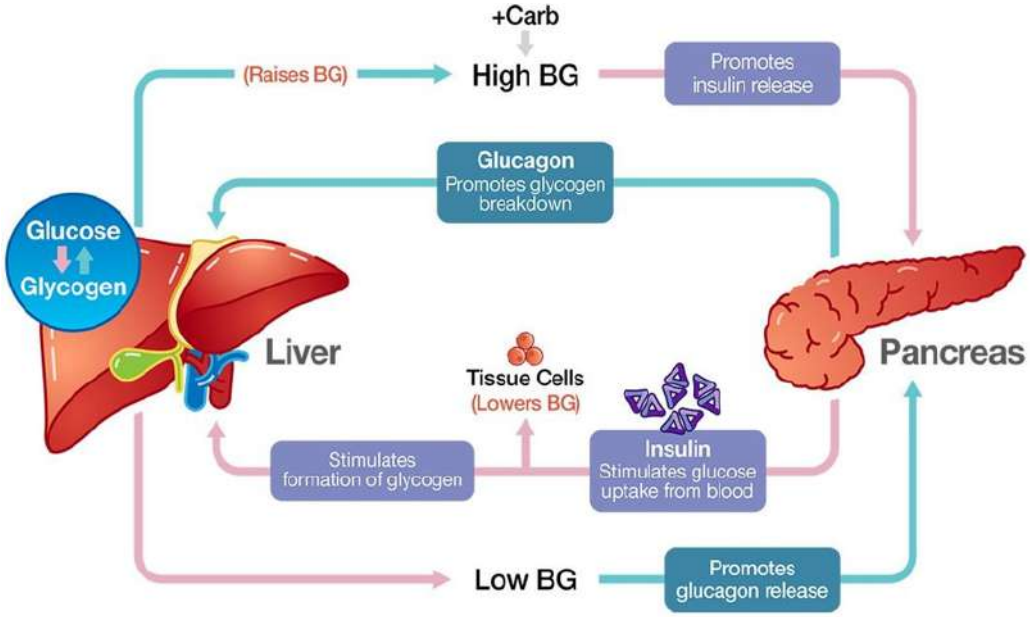

Figure 1: Diabetes Cycle

Global Prevalence of Diabetes: The prevalence of diabetes has significantly increased over the past few decades, making it a major global public health problem. Globally, an estimated 537 million individuals (aged 20–79) had diabetes in 2021; by 2030, that figure is expected to increase to 643 million, and by 2045, it is expected to reach 783 million. The majority of occurrences of diabetes are type 2, which is frequently associated with lifestyle factors including obesity and physical inactivity Rapid urbanization, dietary transitions, and sedentary lifestyles significantly contribute to this rising prevalence.[2]

Plant Profile

Gurmar (Gymnema sylvestre)

Figure 2: Gymnma Sylvestre Plant

Plant Description: Gymnema sylvestre is a slow-growing woody climber widely distributed in dry forests of India up to 600 meters, especially in Central and Southern India, Western Ghats, Banda, Konkan, and parts of Northern and Western India.[3]

Table 1: Taxonomical Classification of Gymnma Sylvestre Plant

Kingdom	Plantae
Subkingdom	Tracheobionta
Superdivision	Spermatophyta
Division	Magnoliophyta
Class	Magnoliopsida
Subclass	Asteridae
Order	Genitianales
Family	Apocynaceae
Subfamily	Asclepiadaceae
Genus	Gymnema
Species	Sylvestre R.Br.

Pharmacological Activities [4]

Potent antidiabetic effect: Exhibits strong glucose-lowering activity by promoting β-cell regeneration, enhancing insulin secretion, and delaying intestinal glucose absorption.

Anti-inflammatory and antioxidant effects: Possesses significant free-radical scavenging and inflammation-reducing properties due to its rich flavonoid and phenolic content.

Anticancer and cytotoxic activity: Shows cytotoxic and antiproliferative effects through triterpenoids and gymnemic acids that induce apoptosis in cancer cells.

Antimicrobial and antifungal activity: Demonstrates broad-spectrum antibacterial and antifungal activity attributed to tannins, saponins, and flavonoids.

Antihyperlipidemic and hepatoprotective actions: Helps reduce cholesterol, triglycerides, and LDL while improving liver function and protecting hepatocytes from oxidative damage

Immunostimulatory and wound-healing activity: Enhances immune response and accelerates wound contraction, collagen synthesis, and epithelial repair, aiding diabetic wound healing.

Lemon (Citrus limon)

Figure 3: Citrus Limon Plant

Plant Description

Citrus limon is a flowering plant belonging to the Rutaceae family. It is believed to have originated in Northeast India (Assam), Northern Burma, and China. Lemon fruits, peel, leaves, and seeds contain rich phytochemicals including flavonoids, terpenes, limonoids, vitamin C, organic acids, minerals, and volatile oils. Lemon peel essential oil contains over 200 volatile and non-volatile compounds, with limonene (70%), γ-terpinene, β-pinene, coumarins, furanocoumarins, and esters. Lemon juice is an excellent source of vitamin C, containing ~50 mg/100 mL, along with citric acid contributing to antimicrobial and antioxidant activity.

Lemon has traditional uses in treating colds, sore throat, hypertension, respiratory issues, infections, and digestive disturbances due to its anti-inflammatory, antioxidant, antimicrobial, and depurative properties.[5]

Table 1: Taxonomical Classification of Citrus Limon Plant [6]

Kingdom	Plantae
Division	Magnoliophyta
Class	Magnoliopsida
Subclass	Rosidae
Family	Rutaceae
Order	Sapindales
Genus	Citrus
Subgenus	Amygdalus
Species	Limon

Pharmacological Activities of Citrus limon [7,8]

Antioxidant activity: Lemon peel exhibits strong antioxidant properties due to its high content of vitamin C, flavonoids, and limonoids, which help neutralize free radicals and reduce oxidative stress.

Antidiabetic effects: Extracts inhibit key carbohydrate-digesting enzymes such as α-amylase and α-glucosidase and enhance insulin sensitivity, contributing to better glycemic regulation.

Antimicrobial and antifungal activity: Lemon peel contains bioactive compounds with proven antibacterial and antifungal effects, helping inhibit microbial growth.

Anti-inflammatory and analgesic effects: Essential oil constituents like limonene and β-pinene reduce inflammation and provide mild analgesic effects.

Cardioprotective and antihyperlipidemic actions: Lemon flavonoids help lower cholesterol, improve lipid profile, and support cardiovascular health by reducing oxidative damage and improving endothelial function.

Anticancer properties:

Compounds such as limonene and citral demonstrate cytotoxic and antiproliferative effects against various cancer cell lines.

Aromatherapy benefits:

Lemon essential oil improves mental alertness, reduces fatigue, and promotes relaxation when inhaled.

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