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Review Article

Phytotherapeutic Potential and Pharmacological Dynamics of *Catharanthus pusillus* in Metabolic Disorders

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Metabolic disorders, particularly Diabetes Mellitus (DM) and associated secondary hyperlipidemia, pose a critical global public health burden. Medicinal plants have historically served as indispensable reservoirs for therapeutic discovery, offering complex bioactive secondary metabolites with multi-target mechanisms. *Catharanthus pusillus* (Murray) G. Don (Family: Apocynaceae), commonly known as "Tiny Periwinkle," is an ethnobotanically significant annual herb indigenous to India and Sri Lanka. Though closely related to the pharmacologically celebrated *Catharanthus roseus*, *C. pusillus* remains under-explored despite its rich repository of bioactive alkaloids, flavonoids, phenolic compounds, and terpenoids. This comprehensive review synthesizes current knowledge on the botanical features, phytoconstituent profiles, traditional applications, and mechanisms of action of *C. pusillus*. Particular focus is given to its dual therapeutic roles in modulating glycemic control via pancreatic β-cell restoration and α-amylase inhibition, as well as mitigating dyslipidemia by targeting atherogenic lipid fractions.

Keywords: C*atharanthus pusillus*; diabetes mellitus; hyperlipidemia; antihyperglycemic activity.

INTRODUCTION

Introduction and Global Burden of Diabetes and Hyperlipidemia

1.1 Global Epidemiology & Pathophysiology of Diabetes Mellitus

Diabetes Mellitus (DM) represents a heterogeneous cluster of chronic metabolic dysfunctions characterized by persistent fasting and postprandial hyperglycemia. The global prevalence has escalated dramatically, with current estimates indicating that approximately 1 in 11 adults worldwide suffers from DM, with Type 2 Diabetes Mellitus (T2DM) accounting for 90–95% of cases.

- **Type 1 Diabetes Mellitus (T1DM):** Characterized by selective, immune-mediated destruction of insulin-secreting β-cells within the pancreatic islets of Langerhans, resulting in absolute insulin deficiency.
- **Type 2 Diabetes Mellitus (T2DM):** Characterized by a dual defect involving peripheral insulin resistance (in skeletal muscle, adipose tissue, and liver) and progressive β-cell exhaustion/dysfunction.

Under normal physiological conditions, elevated circulating glucose enters pancreatic β-cells via GLUT-2 transporters. Subsequent glycolysis and mitochondrial respiration elevate intracellular ATP/ADP ratios, inducing closure of ATP-sensitive $K^+(K_{\text{ATP}})$ channels. The resulting membrane depolarization opens voltage-gated L-type Ca^{2+}channels, triggering exocytosis of insulin-containing granules. In T2DM, chronic glucolipotoxicity, endoplasmic reticulum (ER) stress,

elevated reactive oxygen species (ROS), and low-grade systemic inflammation impair this excitation-secretion coupling, culminating in severe metabolic disruption.

1.2 Pathophysiology of Secondary Hyperlipidemia

Uncontrolled hyperglycemia disrupts normal lipid transport and metabolic pathways. Insulin physiologically suppresses hormone-sensitive lipase (HSL) in adipose tissue and activates endothelial lipoprotein lipase (LPL). Insulin deficiency or resistance leads to:

1. Uninhibited lipolysis in adipocytes, releasing excessive free fatty acids (FFAs) into circulation.
2. Increased hepatic flux of FFAs, stimulating overproduction and secretion of Very Low-Density Lipoproteins (VLDL).
3. Impaired clearance of triglyceride-rich lipoproteins, leading to hypertriglyceridemia, elevated Low-Density Lipoprotein Cholesterol (LDL-C), and depleted High-Density Lipoprotein Cholesterol (HDL-C).

When circulating LDL-C penetrates the sub-endothelial space of arterial walls, it undergoes oxidation. Oxidized LDL (ox-LDL) induces local endothelial damage, upregulates adhesion molecules, and attracts circulating monocytes that differentiate into macrophages. Macrophages engulf ox-LDL via scavenger receptors, transforming into foam cells—the pathognomonic feature of early atherosclerotic fatty streaks.

2. Botanical Profile, Taxonomy, and Phytochemistry of *Catharanthus pusillus*

2.1 Botanical Characteristics and Taxonomy

Catharanthus pusillus (Murray) G. Don is a small, erect, annual or decumbent herb reaching up to 1 meter in height, exuding white latex upon injury. The stem is sharply quadrangular and branching, with internodes noticeably longer than the leaves. Leaves are opposite, simple, entire, shiny, and thin-leathery, measuring 1–4.5 cm in length and 3–13 mm in width. The roots consist of a taproot system that is carrot-shaped and up to 70 cm long. Flowers are small, 5-merous, white to pale pink with a green/pinkish cylindrical corolla tube (15–22 mm long). The fruit is a pair of erect, slender, striate follicles (1.5–5 cm long) containing 10–20 small, black, grooved seeds.

Taxonomic Hierarchy:

- Kingdom: Plantae
- Phylum: Tracheophyta
- Class: Magnoliopsida
- Order: Gentianales
- Family: Apocynaceae
- Genus: Catharanthus
- Species: Catharanthus pusillus (Murr.) G. Don

2.2 Phytochemical Composition

Phytochemical investigations demonstrate that *C. pusillus* synthesizes a diverse spectrum of bioactives:

- **Alkaloids:** Indole alkaloids and pyrrolizidine alkaloids, including (R)-petranine, vindoline, and catharanthine.
- **Phenolics and Flavonoids:** Rich in quercetin derivatives, kaempferol glycosides, and phenolic acids that function as potent free-radical scavengers.
- **Terpenoids and Steroids:** Monoterpenoids, sesquiterpenoids, diterpenes, and sterols.
- **Fatty Acid Derivatives:** Hexadecanoic acid methyl ester, palmitic acid, and associated lipid compounds possessing antioxidant and membrane-stabilizing activities.

3. Systematic Literature Review of Biological Activities

A synthesis of historical and contemporary research highlights the pharmacological properties of *C. pusillus*:

Author & Year	Experimental Model / Assay	Key Pharmacological Findings
Zarate et al. (2001)	Accumulation kinetics in developmental stages	Established that young expanding leaves serve as the primary site of terpenoid indole alkaloid accumulation, yielding high concentrations of vindoline (≈ 4.8 mg/g DW) and catharanthine (≈ 2.2 mg/g DW).
Navitha et al. (2012)	STZ-induced diabetic rats (18-h fasting & OGTT)	Confirmed that ethanolic extract of *C. pusillus* significantly reduces blood glucose levels and improves glucose tolerance.
Nithya et al. (2013)	Isolation & spectral characterization	Successfully isolated and structurally elucidated (R)-petranine, a novel pyrrolizidine alkaloid from whole plant extracts.
Subbaiyan et al. (2013, 2014)	GC-MS profiling & antimicrobial testing	Identified major phytochemical classes (alkaloids, tannins, saponins, coumarins) and demonstrated strong zone-of-inhibition antibacterial activity against *Streptococcus faecalis* (24.6 mm) and *Klebsiella pneumoniae* (23.6 mm).
Chandran & Saj (2015)	HPLC & GC-MS chemical profiling	Identified 15 major compounds via HPLC and 37 compounds via GC-MS, confirming high abundance of monoterpenoids, sesquiterpenoids, and polyphenols.
Nithya et al. (2016, 2018)	DPPH, ABTS scavenging & GC-MS (NIST)	Screened whole-plant methanolic extracts, identifying 33 distinct bioactive compounds and demonstrating robust free-radical scavenging capacity.
Vaity et al. (2021)	Pharmacognostic & microscopic standardization	Characterized dorsiventral leaf architecture, multicellular stem trichomes, stone cell patches in the cortex, and unicellular covering trichomes.

4. Mechanisms of Action in Diabetes and Hyperlipidemia

4.1 Glycemic Regulation Pathways

1. **Enzymatic Inhibition (α-Amylase and α-Glucosidase):** Polyphenols and flavonoids in *C. pusillus* bind to the active sites of pancreatic α-amylase and intestinal α-glucosidase, retarding carbohydrate digestion and reducing postprandial glucose spikes.

2. **Insulin Mimetic and Translocation Activity:** Phytoconstituents activate the Insulin Receptor Substrate 1 (IRS-1) / Phosphoinositide 3-kinase (PI3K) / Akt (Protein Kinase B) signaling cascade. Active Akt stimulates AS160, promoting translocation of Glucose Transporter 4 (GLUT-4) storage vesicles to the plasma membrane in skeletal muscle and adipose tissue.

3. **Hepatic Gluconeogenesis Suppression:** Extract constituents induce AMP-activated protein kinase (AMPK) phosphorylation, downregulating key gluconeogenic enzymes (PEPCK and Glucose-6-Phosphatase).

4.2 Lipid Modulation Pathways

1. **Enzymatic Modulation of LCAT and HMG-CoA Reductase:** Bioactive compounds enhance Lecithin-Cholesterol Acyltransferase (LCAT) activity—facilitating cholesterol esterification and reverse cholesterol transport to the liver via HDL—while partially inhibiting 3-hydroxy-3-methylglutaryl-coenzyme A (HMG-CoA) reductase.

Lipoprotein Lipase (LPL) Activation: By restoring endogenous insulin signaling, *C. pusillus* activates vascular LPL, clearing circulating chylomicrons and VLDL, thereby lowering serum triglycerides.

REFERENCES

1. Hoffman David, 2003, Medical Herbalism: The Science and Practice of Herbal Medicine, Inner Traditions / Bear & Co, pp. 6.
2. Rivera J, Loya A and Canallos R, 2013. Use of herbal medicines and implications for conventional drug therapy medical science. Alternative and Integrative Medicine, Vol. 2, Issue 6, pp.2-6.

3. Ameh SJ, Obodozie OO, Babalola PC, Gamaniel KS. 2011. Medical Herbalism and Herbal clinical research: A global perspective. British Journal of Pharmaceutical Research, 1(4): 99-123.
4. Wambebe, C. (2008). From plants to medicines: challenges and prospects. The Nigerian Academy of Sciences. Public Lecture. Reiz Continental Hotel, Abuja. May 22, 2008. pp 1-17.
5. American Diabetes Association. Diagnosis and classification of diabetes mellitus. Diabetes Care. 2014;37:S81–90. [PubMed] [Google Scholar]
6. American Diabetes Association. Introduction: Standards of medical care in diabetes—2018. Diabetes Care. 2018;41: S1–2. [PubMed] [Google Scholar]
7. Noor, A., S. Gunasekaran, A.S. Manickam and M.A. Vijayalakshmi, 2008. Antidiabetic activity of Aloe vera and histology of organs in streptozotocininduced diabetic rats. Curr. Sci., 94: 1070-1076.
8. Joseph B. and Jini D., 2011. Insight into the hypoglycaemic effect of traditional Indian herbs used in the treatment of diabetes. Research Journal of Medicinal plants, 5(4): 352-376.
9. http://www.annals.org/site/misc/about.xhtml
10. http://www.archive.org/stream/ondiabetesmelli00kleegoog/ondiabetesmelli00kleegoog_djvu.t xt
11. Banday MZ, Sameer AS, Nissar S. 2020. Pathophysiology of diabetes: An overview. Avicenna Journal of Medicine, 10(4): 174-188.
12. Rajaei E, Jalali MT, Shahrabi S, Asnafi AA, Pezeshki SMS. HLAs in Autoimmune Diseases: Dependable Diagnostic Biomarkers? Curr Rheumatol Rev. 2019;15(4):269-276. [PubMed]
13. Klein BE, Klein R, Moss SE, Cruickshanks KJ. Parental history of diabetes in a population-based study. Diabetes Care. 1996 Aug;19(8):827-30. [PubMed]
14. Barnett AH, Eff C, Leslie RD, Pyke DA. Diabetes in identical twins. A study of 200 pairs. Diabetologia. 1981 Feb;20(2):87-93. [PubMed]
15. Sapra A, Bhandari P. Diabetes. [Updated 2023 Jun 21]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2023 Jan-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK551501/
16. Stumvoll M., Goldstein B.J., van Haeften T.W. Type 2 diabetes: Principles of pathogenesis and therapy. Lancet. 2005; 365:1333–1346. doi: 10.1016/S0140-6736(05)61032-X
17. Cerf M.E. Beta cell dysfunction and insulin resistance. Front. Endocrinol. (Lausanne) 2013; 4:37. doi: 10.3389/fendo.2013.00037.
18. Zheng Y., Ley S.H., Hu F.B. Global aetiology and epidemiology of type 2 diabetes mellitus and its complications. Nat. Rev. Endocrinol. 2018; 14:88–98. doi: 10.1038/nrendo.2017.151.
19. Hu F.B., Manson J.E., Stampfer M.J., Colditz G., Liu S., Solomon C.G., Willett W.C. Diet, lifestyle, and the risk of type 2 diabetes mellitus in women. N. Engl. J. Med. 2001; 345:790–797. doi: 10.1056/NEJMoa010492.

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