

# Research Progress on the Intervention of *Callicarpa nudiflora* in Methamphetamine-induced Neurotoxicity and its Forensic Toxicological Significance

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## Abstract

The abuse of methamphetamine (METH) remains a critical global health concern due to its profound neurotoxicity and associated mortality. Extensive experimental evidence has demonstrated that oxidative stress and neuroinflammation constitute the central pathophysiological mechanisms underlying METH-induced neuronal injury. Excessive reactive oxygen species production, mitochondrial dysfunction, blood–brain barrier disruption, and activation of microglial-mediated inflammatory cascades collectively contribute to progressive neurodegeneration. Despite advances in understanding these mechanisms, effective mechanism-targeted interventions remain limited. *Callicarpa nudiflora* (CN), a traditional medicinal herb widely used in Li ethnomedicine of Hainan, has attracted increasing attention due to its well-characterized phytochemical profile, particularly flavonoids and phenylethanol glycosides. Pharmacological studies have demonstrated that these constituents exert potent antioxidant and anti-inflammatory effects through modulation of the Nrf2/ARE signaling pathway and suppression of NF- $\kappa$ B–mediated inflammatory responses. Notably, these signaling pathways overlap substantially with the molecular networks implicated in METH-induced neurotoxicity. This review systematically summarizes the current phytochemical characterization and pharmacological evidence of CN, with particular emphasis on its regulatory effects on oxidative and inflammatory signaling pathways. Furthermore, the potential mechanistic intersections between CN bioactive compounds and METH-induced neurotoxic cascades are critically analyzed. By integrating evidence from toxicological, pharmacological, and molecular studies, this review provides a mechanistic framework for evaluating CN as a potential modulatory agent against METH-induced neurotoxicity and highlights future directions for experimental validation.

## Keywords

*Callicarpa nudiflora*, Methamphetamine, Neurotoxicity, Oxidative Stress, Neuroinflammation, Forensic Toxicology, Neuroprotection