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Review Article

Mucuna pruriens: A Friend or a Foe? Ethnomedicinal Promise, Phytochemical Basis, and Toxicological Concerns of a Dual-Natured Legume

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Mucuna pruriens (L.) DC. (Fabaceae), commonly known as velvet bean or cowhage, occupies a paradoxical place among medicinally important legumes: it is simultaneously a source of the world's only commercially viable natural L-3,4-dihydroxyphenylalanine (L-DOPA), a nutritionally dense tribal pulse, a soil-restoring green manure cover crop, and a plant whose pod trichomes deliver one of the most intense pruritogenic reactions known in botany. This review synthesizes recent primary literature to weigh the therapeutic ("friend") and hazardous ("foe") dimensions of the species. On the beneficial side, clinical and preclinical evidence continues to support the antiparkinsonian efficacy of *M. pruriens* seed powder, which is comparable to synthetic levodopa in several small trials and additionally offers antioxidant, anti-inflammatory, and neuroprotective activity attributed to polyphenols and alkaloids acting alongside L-DOPA. The species also shows reproducible benefit in stress-related male subfertility and continues to be promoted globally as a nitrogen-fixing, weed-suppressing cover crop. On the adverse side, the cysteine protease mucunain and co-localised serotonin in pod trichomes activate protease-activated receptors PAR-2 and PAR-4 to produce histamine-independent pruritus, and the raw seed carries a burden of antinutritional and potentially toxic constituents (tannins, phytates, hydrogen cyanide, trypsin inhibitors, and unmetabolized L-DOPA itself) that necessitate processing before dietary or medicinal use. Reported cases of accidental seed poisoning underscore that “natural” does not equate to “risk-free.” We conclude that M. pruriens is best understood not as strictly friend or foe but as a pharmacologically potent, agronomically valuable, and genuinely hazardous plant whose safe exploitation depends on genotype selection (trichome-reduced cultivars), standardized processing, and dose-controlled clinical use.

Keywords: *Mucuna pruriens, Ethnomedicinal, Phytochemical, Toxicology, a friend or a foe, cowhage*

Introduction

The genus *Mucuna* Adans. (Fabaceae, Papilionoideae) comprises roughly 100 species of twining lianas distributed through the tropics and subtropics of both hemispheres. Among these, *Mucuna pruriens* (L.) DC. known variously as velvet bean, cowhage, cow-itch, or kapikachhu in Ayurveda has attracted disproportionate scientific attention because it is one of only a handful of plant species found to accumulate L-DOPA in quantities sufficient for pharmaceutical exploitation, with seeds typically containing 4–9% L-DOPA by dry weight, positioning the species as a natural alternative or adjunct to synthetic levodopa in the management of Parkinson's disease (PD) (Hammoud et al., 2025; Zaigham & Paeng, 2024).

At the same time, the plant is notorious in agricultural and dermatological contexts for the intensely pruritic hairs (trichomes/spicules) that densely cover its young pods, a trait that has historically discouraged cultivation and led to reports of accidental human poisoning and severe contact reactions (Epriliati 2020; Kouakou et al., 2022). This duality a plant that is both a recognized nutraceutical/pharmaceutical resource and a documented irritant/toxicant motivates the present review. We synthesize the recent primary literature on the botany, phytochemistry, pharmacological potential, and toxicological/antinutritional burden of *M. pruriens*, framing the discussion around the central question posed in the title: is this species best regarded as a therapeutic friend, an agroecological asset, or a biological hazard or, more realistically, all three depending on context, plant part, processing, and dose?

Botanical Description and Distribution

M. pruriens is an annual to short-lived perennial, herbaceous climbing vine that can extend more than 15 m in length. Young stems and leaves are densely pubescent, becoming glabrous with age. Leaves are trifoliate with asymmetrical lateral leaflets; inflorescences are showy, pendent, many-flowered racemes bearing dark purple to white flowers. The diagnostic feature of the species is its pod: a curved, longitudinally ribbed legume 4–13 cm long, bearing 4–6 seeds, and densely covered particularly while young with thousands of persistent, pale-brown to orange trichomes (spicules) that detach readily on contact (Archana & Ramesh, 2025; Singh & Dhawan, 2018). A trichome-less ("non-stinging") variety, *M. pruriens* var. *utilis*, has been selected and is preferentially cultivated where the plant is grown as a food or forage crop (Archana & Ramesh, 2025).

The species is pantropical in distribution, native probably to South and Southeast Asia but long naturalized across Africa, the Caribbean, and the Americas. Weed-risk assessments generally classify it as a minor to moderate agricultural weed in select countries (e.g., listed as a "serious" weed in Mexico and Mozambique and a "principal weed" in Jamaica and Madagascar) rather than as a globally aggressive invader, and it is naturalized in south-eastern Florida and parts of the Pacific islands (Epriliati 2020).

Ethnomedicinal and Traditional Uses

In Ayurveda, the seed (known as kapikachhu or atmagupta) is classified as a vajikarana (aphrodisiac/rejuvenative) drug and is used to treat male sexual debility, as a nervine tonic, and, more recently, as an adjunct antiparkinsonian remedy (Shukla et al., 2010; Archana & Ramesh, 2025). Roots are traditionally regarded as bitter, thermogenic, anthelmintic, diuretic, and aphrodisiac. Paradoxically, the same irritant pod trichomes that cause dermatitis have their own traditional application: dried hairs, prepared as an ointment or mixed with honey, have been used topically and orally as an anthelmintic/vermifuge. Pods themselves are consumed as a vegetable in parts of South and Southeast Asia after appropriate processing, and the seeds form an under-utilized tribal pulse valued for their protein, mineral, and essential amino acid content (Fitriyah et al., 2021; Shelke et al., 2022).

Phytochemistry

The pharmacological profile of *M. pruriens* is underpinned by a chemically diverse constituent pool. The signature compound is the non-protein amino acid L-DOPA, concentrated mainly in the seed coat and cotyledon, alongside related catecholamines (dopamine, adrenaline, noradrenaline) detectable in seminal and blood plasma of treated subjects (Shelke et al., 2022). Seeds additionally contain alkaloids (mucunine, mucunadine, prurienine), saponins, sterols, flavonoids, and polyphenols, along with the essential amino acids threonine, valine, isoleucine, tyrosine, phenylalanine, and histidine, though methionine and cysteine remain limiting (Fitriyah et al., 2021; Archana & Ramesh, 2025). Seed lipids are rich in unsaturated fatty acids, predominantly linoleic acid (Pathania et al., 2020). Distinct from the seed chemistry, the pod trichomes harbour the true irritant apparatus of the plant: a cysteine protease named mucunain, co-localised with serotonin, embedded within rigid, barbed unicellular hairs roughly 2 mm long (Singh & Dhawan, 2018).

Pharmacological Potential: The "Friend"
Antiparkinsonian activity

The best-substantiated clinical use of *M. pruriens* is in Parkinson's disease. A 2025 systematic review of clinical trials identified five controlled studies (108 participants total) comparing *M. pruriens* seed powder with synthetic levodopa, and although trial quality was heterogeneous, several studies reported that *M. pruriens* produced motor benefit comparable to standard levodopa, with faster onset of the "ON" state and reduced dyskinesia in some cohorts, reflecting the plant's recognized anti-inflammatory, antioxidant, antiapoptotic, and antiparkinsonian properties alongside its substantial natural L-DOPA content (Hammoud et al., 2025). Preclinical work supports a mechanism beyond simple dopamine replacement: in a rotenone-intoxicated mouse model, both *M. pruriens* extract and synthetic L-DOPA reduced motor and olfactory deficits and lowered pro-inflammatory cytokines (IL-6, IL-12, TGF-β1), suggesting an anti-neuroinflammatory contribution from the plant's non-L-DOPA constituents (Zaigham & Paeng, 2024). Comparable neuroprotection has separately been demonstrated for levodopa-reduced *M. pruriens* extracts across microglial, neuroblastoma, Caenorhabditis elegans, and Drosophila models, indicating that antioxidant polyphenols in the seed act synergistically with, and partly independently of, L-DOPA itself (Johnson et al., 2018). These findings are broadly consistent with a wider comparative review of clinical and preclinical trials evaluating *M. pruriens* across Parkinson's disease, diabetes, and erectile dysfunction (Misra et al., 2021).

Male reproductive and stress-related effects

Clinical studies in men with infertility associated with psychological stress report that oral *M. pruriens* seed powder (5 g/day for three months) significantly improved sperm count, motility, and seminal antioxidant status (superoxide dismutase, catalase, glutathione, ascorbic acid) while lowering serum cortisol and seminal lipid peroxidation (Shukla et al., 2010). Mechanistic follow-up work indicates action along the hypothalamic–pituitary–gonadal axis, with normalization of testosterone, luteinising hormone, and seminal catecholamines (Shukla et al., 2009). More recent preclinical studies extend this to protection against drug-induced (e.g., fluoxetine-induced) testicular dysfunction under chronic stress, reinforcing an antioxidant-mediated reproductive-protective role (Vasanthalaxmi et al., 2024).

Agroecological value

Beyond direct pharmacology, *M. pruriens* var. *utilis* is widely promoted as a green manure/cover crop (GMCC) in tropical smallholder systems (Jadhav et al., 2022). Its rapid canopy closure suppresses weeds, its extensive root system reduces soil erosion, and, as a nitrogen-fixing legume, it enriches soil nitrogen and organic carbon on incorporation, with documented benefits for subsequent maize and vegetable yields across sub-Saharan Africa and Latin America (Jadhav et al., 2022). Because the crop is dual-purpose providing both biomass for soil fertility and an edible, protein-rich seed once processed, it has been proposed as an underused resource for sustainable smallholder agriculture, although historically low adoption has been attributed in part to the very irritant trait discussed below (Renata et al., 2015).

Toxicological and Antinutritional Concerns - The "Foe"
Dermatological hazard: mucunain-mediated pruritus

The pod and, to a lesser extent, calyx trichomes of *M. pruriens* are tipped with the cysteine protease mucunain and contain serotonin. On skin penetration, mucunain cleaves and activates protease-activated receptors PAR-2 and PAR-4 on cutaneous sensory afferents, producing an intense, histamine-independent itch accompanied by erythema and papular wheals that can persist up to 30 minutes and is classically used in experimental itch research as a non-histaminergic pruritogen (Oyeleye et al., 2023). Genetic and trichome-morphology studies confirm substantial variation in trichome length and density among accessions, with wild genotypes bearing the longest trichomes and the white-seeded, low-trichome variety being comparatively suitable for large-scale cultivation; a finding now being exploited in breeding programmes seeking trichome-less, high-L-DOPA cultivars.

Acute seed poisoning

Beyond localized dermatitis, ingestion of raw or improperly processed seed carries systemic risk. Case reports, including a cluster of poisonings following accidental ingestion of *M. pruriens* seeds on Réunion Island, describe gastrointestinal and neuropsychiatric symptoms consistent with acute L-DOPA/catecholamine overload, underscoring that the same compound responsible for the plant's antiparkinsonian value becomes a hazard outside a controlled therapeutic dose (Archana & Ramesh, 2025).

Antinutritional burden of the raw seed

Independent of trichome and L-DOPA effects, raw *M. pruriens* seed carries a substantial antinutritional load such as tannins, phytic acid, trypsin/chymotrypsin inhibitors, oligosaccharides (notably verbascose), hydrogen cyanide, and saponins. These antinutrients impairs protein digestibility and mineral bioavailability and restricts its direct use as a food pulse (Chinapolaiah et al., 2019; Pathania et al., 2020; Oyeleye et al., 2023). Processing studies consistently show that soaking, boiling, autoclaving, and fermentation substantially reduce these factors: for example, extended soaking (up to 144 h) progressively lowers hydrogen cyanide, tannin, and phenolic content, while autoclaving achieves greater than 70% reduction in hydrogen cyanide relative to raw seed (Kumar et al., 2020; Pathania et al., 2020). Notably, several of these same treatments also reduce L-DOPA content, illustrating an inherent trade-off between detoxifying the seed and preserving its principal therapeutic compound (Renata et al., 2015; Chinapolaiah et al., 2019).

Organ-level toxicity at high dose

Preclinical toxicology work cautions that even purified seed extracts are not free of dose-dependent risk: histopathological changes in brain, lung, heart, testis, liver, and kidney have been reported in rodents receiving high extract doses (e.g., 400 mg/kg/day for 28 days), although lower, therapeutically relevant doses in the same and related studies have instead demonstrated hepato-renal and testicular protection against co-administered toxicants (e.g., sodium arsenite), highlighting a hormetic, dose-dependent duality that mirrors the "friend-or-foe" framing of this review at the pharmacological level (Concessao et al., 2023).

Reconciling the Duality: Genotype, Processing, and Dose

Taken together, the recent literature suggests that the apparent contradiction in *M. pruriens* simultaneously prized medicinal legume and feared skin irritant/toxicant resolves largely along three axes. First, genotype: trichome density and length vary substantially among accessions, and breeding or selection of low-trichome, high-L-DOPA cultivars can substantially reduce dermatological risk without sacrificing therapeutic yield (Singh & Dhawan, 2018).

Second, processing: soaking, thermal treatment, and fermentation reliably reduce antinutritional and cyanogenic content in the seed, at some cost to L-DOPA retention, meaning that pharmaceutical and dietary preparations require distinct optimization strategies (Renata et al., 2015; Tripathi et al., 2018). Third, dose and context: L-DOPA and associated alkaloids behave beneficially within a narrow therapeutic window (as in PD management or male-fertility support) but produce toxicity outside it, whether through deliberate high-dose experimental extracts or accidental ingestion of unprocessed seed (Concessao et al., 2023; Jadhav et al., 2022).

Conclusion and Future Directions

Mucuna pruriens is neither uniformly friend nor uniformly foe; it is a pharmacologically and agronomically important legume whose risk profile is governed by plant part, genotype, processing, and dose rather than by any single intrinsic property. Continued clinical evaluation of standardized seed-powder formulations against synthetic levodopa, larger and better-controlled trials in male reproductive health, further breeding of trichome-reduced/high-L-DOPA cultivars, and refinement of processing protocols that jointly minimize antinutritional load while preserving bioactive L-DOPA content represent the most promising directions for converting this dual-natured plant into a reliably safe therapeutic and agricultural resource.

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