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Review Article

Anti-Psoriatic Potential of *Murraya koenigii*: Phytochemistry, Mechanisms, and Therapeutic Prospects

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ABSTRACT

Psoriasis is a chronic immune-mediated inflammatory skin disorder characterized by abnormal keratinocyte proliferation, oxidative stress, immune dysfunction, and excessive production of pro-inflammatory cytokines. Although conventional therapeutic approaches such as corticosteroids, immunosuppressants, and biologics provide symptomatic relief, their long-term use is often associated with adverse effects, high treatment costs, and frequent disease recurrence. Consequently, increasing attention has been directed toward plant-derived multi-target therapeutic agents with improved safety profiles. *Murraya koenigii* (L.) Spreng., commonly known as curry leaf, has been widely employed in traditional medicine for the treatment of inflammatory and dermatological disorders. The present review highlights the ethnomedicinal significance, phytochemical constituents, pharmacological activities, and potential mechanistic pathways supporting the anti-psoriatic potential of *Murraya koenigii*. The plant contains diverse bioactive compounds, including carbazole alkaloids, flavonoids, phenolic acids, and terpenoids, which exhibit significant anti-inflammatory, antioxidant, immunomodulatory, antimicrobial, and wound-healing properties. Experimental evidence suggests that these phytoconstituents regulate key molecular pathways implicated in psoriasis pathogenesis, such as NF- κ B, MAPK, JAK-STAT, STAT3, PI3K/Akt/mTOR, and TGF- β /Smad signaling pathways. Modulation of these pathways contributes to suppression of inflammatory cytokine release, attenuation of oxidative stress, restoration of immune homeostasis, and normalization of keratinocyte proliferation and differentiation. Furthermore, the favorable safety profile and suitability of *Murraya koenigii* for topical and systemic formulations support its potential as an adjunct or alternative therapeutic strategy. However, further investigations involving psoriasis-specific experimental models, pharmacokinetic studies, and well-designed clinical trials are required to validate its clinical efficacy. Overall, *Murraya koenigii* represents a promising natural candidate for the development of safe, multi-mechanistic anti-psoriatic therapies.

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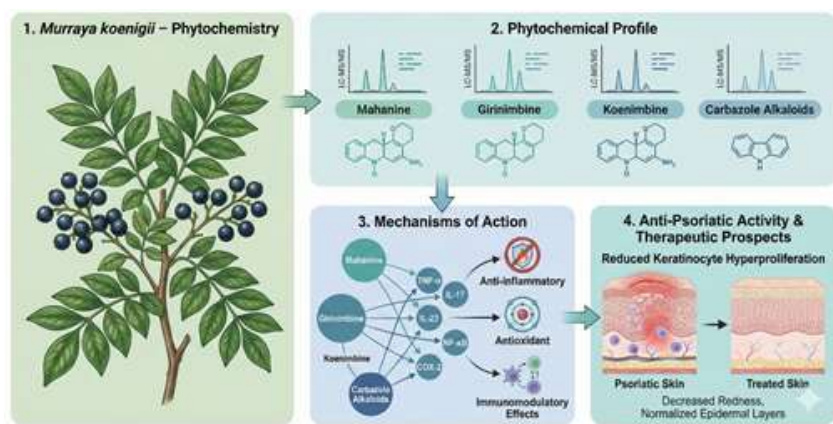


INTRODUCTION

Psoriasis is a chronic, immune-mediated inflammatory skin disorder characterized by erythematous, scaly plaques, keratinocyte hyperproliferation, and immune dysregulation. It affects approximately 2–3% of the global population, with significant regional variation, and is associated with both physical discomfort and psychosocial burden. Psoriatic lesions are commonly observed on the scalp, elbows, knees, and lower back, though generalized forms can occur.[1] Beyond the skin, psoriasis is linked to systemic comorbidities, including psoriatic arthritis, cardiovascular disease, metabolic syndrome, and depression, highlighting the need for effective and comprehensive therapeutic approaches. The pathophysiology of psoriasis is complex, involving a multifaceted interplay of genetic, immunological, and environmental factors. Genetic predisposition includes polymorphisms in genes associated with skin barrier function, immune signaling, and keratinocyte differentiation.[2] Dysregulation of the innate and adaptive immune system, particularly activation of dendritic cells and T helper (Th) cells such as Th1, Th17, and Th22, leads to overproduction of pro-inflammatory cytokines, including TNF- α , IL-17, IL-22, and IL-23. These cytokines drive keratinocyte proliferation, angiogenesis, and chronic inflammation, establishing a self-perpetuating cycle of disease. Oxidative stress further exacerbates inflammation by promoting the generation of reactive oxygen species (ROS), which activate inflammatory pathways and contribute to tissue damage. Current therapeutic strategies for psoriasis include topical agents (corticosteroids, vitamin D analogs, and retinoids),

systemic drugs (methotrexate, cyclosporine, and acitretin), and biologic therapies targeting specific cytokines or immune pathways (anti-TNF, anti-IL-17, and anti-IL-23 monoclonal antibodies).[3] Although these treatments can provide symptomatic relief and disease control, they are often associated with limitations such as adverse effects, high cost, partial response, and risk of relapse upon discontinuation. These challenges have driven the search for safer, multi-target, and cost-effective alternatives, particularly from natural products with a long history of medicinal use. Herbal medicines offer a promising approach due to their ability to target multiple pathogenic pathways simultaneously. Among these, *Murraya koenigii* (L.) Spreng., commonly known as curry leaf, has attracted attention for its diverse pharmacological properties.[4] Widely used in South Asian cuisine and traditional medicine, *Murraya koenigii* contains bioactive phytochemicals such as carbazole alkaloids, flavonoids, phenolics, and terpenoids. These compounds exhibit anti-inflammatory, antioxidant, immunomodulatory, anti-proliferative, antimicrobial, and wound-healing activities mechanisms directly relevant to the pathogenesis of psoriasis. The ethnomedicinal use of *Murraya koenigii* in Ayurveda, Siddha, and folk medicine for skin ailments, inflammation, and wound healing provides a historical basis for its therapeutic potential. Leaf pastes, decoctions, and infused oils have traditionally been used to treat rashes, ulcers, itching, and chronic lesions, reflecting empirical knowledge of its anti-inflammatory and healing properties. This intersection of traditional use and modern pharmacology positions *Murraya koenigii* as a compelling candidate for further investigation in psoriasis management.[5]





The purpose of this review is to provide a comprehensive analysis of the anti-psoriatic potential of *Murraya koenigii*. It integrates insights from traditional medicine, phytochemistry, and pharmacology to elucidate mechanisms of action, identify gaps in current research, and propose future directions for preclinical and clinical studies. By highlighting the multi-targeted effects of this medicinal plant, the review underscores its potential as a natural, safe, and effective therapeutic option for psoriasis.[6]

2. BOTANICAL PROFILE OF *MURRAYA KOENIGII*

Murraya koenigii (L.) Spreng., commonly referred to as curry leaf tree, is an aromatic medicinal plant belonging to the family Rutaceae. The genus *Murraya* comprises several species known for their essential oil content and therapeutic importance; however, *Murraya koenigii* remains the most widely cultivated and pharmacologically investigated species. The plant is extensively distributed across tropical and subtropical regions and holds substantial ethnobotanical, nutritional, and medicinal significance. Owing to its rich reservoir of secondary metabolites, *M. koenigii* has attracted increasing scientific attention as a potential source of bioactive compounds applicable in inflammatory and dermatological disorders, including psoriasis.[7]



Figure 1. *Murraya koenigii* [Curry Leaves]

2.1 Taxonomical Classification and Nomenclature

Accurate taxonomic identification is essential for pharmacognostic standardization and therapeutic reproducibility of medicinal plants. *Murraya koenigii* is systematically classified under the order Sapindales, which includes several medicinally valuable aromatic species characterized by alkaloid and terpenoid biosynthesis.[8]

Taxonomical hierarchy of *Murraya koenigii*:

Taxonomic Rank	Classification
Kingdom	Plantae
Division	Magnoliophyta
Class	Magnoliopsida
Order	Sapindales
Family	Rutaceae
Genus	<i>Murraya</i>
Species	<i>Murraya koenigii</i> (L.) Spreng.

The plant is commonly known as curry leaf, sweet neem, or kari patta in India. Despite superficial resemblance, it is botanically distinct from *Azadirachta indica* (neem). Synonyms reported in botanical literature include *Bergera koenigii*, reflecting historical revisions in plant taxonomy.

2.2 Morphological Characteristics

Murraya koenigii is a perennial evergreen shrub or small tree typically attaining a height ranging between 2 and 6 meters under cultivated conditions, although favorable environmental factors may support greater growth. The plant exhibits a semi-deciduous nature in dry climatic regions and demonstrates strong regenerative capability following pruning. The stem is slender with grayish-brown bark displaying longitudinal striations. Young branches are green and glabrous, gradually becoming woody with maturation.[1] Leaves are alternate, imparipinnate, and composed of 11–21 leaflets arranged along a central rachis. Individual leaflets are ovate to lanceolate in shape, measuring approximately 2–4 cm in length, possessing smooth margins and a glossy surface. The presence of numerous secretory oil glands contributes to the characteristic aromatic odor released upon crushing. Flowers are small, bisexual, white, and highly fragrant, typically arranged in terminal cymose inflorescences. Flowering generally occurs during spring and early summer seasons. The fruits are ellipsoidal or ovoid berries that transition from green to deep purplish-black upon maturation. Each fruit contains one or occasionally two seeds surrounded by a thin pulp layer. Although fruits are edible, seeds are considered mildly toxic and are not used medicinally. The root system consists of fibrous lateral roots capable of efficient nutrient absorption, enabling adaptation to diverse soil environments.[9]

2.3 Microscopic and Pharmacognostic Characteristics

Microscopic evaluation plays a crucial role in authentication and quality control of herbal raw materials. Transverse sections of *Murraya koenigii* leaves reveal a dorsiventral structure comprising a well-defined upper epidermis covered by a thin cuticle layer. The mesophyll region differentiates into palisade and spongy parenchyma containing chloroplast-rich cells responsible for photosynthetic activity. Abundant oil glands and secretory cavities are distributed throughout mesophyll tissues, representing major sites of essential oil accumulation. Calcium oxalate crystals and vascular bundles surrounded by sclerenchymatous tissues are frequently observed. Stomata are predominantly of the anomocytic type and occur mainly on the lower epidermal surface, supporting efficient gaseous exchange. Powder microscopy demonstrates diagnostic features such as fragments of epidermal cells, spiral vessels, oil globules, and lignified fibers, which are useful markers for identification and prevention of adulteration.[10]

2.4 Geographical Distribution and Habitat

Murraya koenigii is indigenous to the Indian subcontinent, particularly India and Sri Lanka, and has subsequently spread across Southeast Asia including Nepal, Bangladesh, Myanmar, Thailand, Malaysia, and Indonesia. The plant is also cultivated in tropical regions of Australia, Africa, and parts of the Middle East due to increasing global demand. The species thrives optimally in warm climatic conditions with temperatures ranging between 20–35°C and moderate rainfall. It grows well in well-drained loamy soils with slightly acidic to neutral pH. Although drought-tolerant to some extent, prolonged waterlogging adversely affects root development. The plant demonstrates adaptability to both cultivated



agricultural lands and semi-wild environments such as roadside vegetation and home gardens.[11]

2.5 Cultivation Practices and Agronomic Aspects

Cultivation of *Murraya koenigii* is generally achieved through seed propagation, stem cuttings, or root suckers. Seeds exhibit high germination rates when sown immediately after extraction due to rapid loss of viability during storage. Vegetative propagation methods are increasingly preferred for maintaining phytochemical uniformity and genetic consistency. Regular pruning enhances leaf biomass production, which represents the primary medicinally utilized plant part. Organic fertilization and adequate sunlight exposure significantly influence essential oil concentration and alkaloid biosynthesis. Harvesting is typically performed multiple times annually without causing permanent damage to plant growth. Environmental factors such as soil nutrients, climatic variation, and harvesting stage markedly influence phytochemical yield, emphasizing the need for standardized cultivation protocols for pharmaceutical applications.[12]

2.6 Traditional, Nutritional, and Economic Importance

Beyond its medicinal relevance, *Murraya koenigii* occupies a central role in South Asian culinary traditions, where fresh leaves are extensively used as flavoring agents. Nutritionally, curry leaves contain vitamins A, B-complex, C, and E along with minerals such as calcium, iron, and phosphorus, contributing to antioxidant and health-promoting properties. Traditional medicine systems employ leaves, bark, and roots for management of inflammation, diabetes, gastrointestinal disturbances, infections, and skin disorders. The widespread dietary consumption of curry leaves supports its favorable safety profile,

an important consideration for long-term therapeutic development. From an economic perspective, increasing global demand for natural therapeutics, nutraceuticals, and herbal cosmetics has elevated *Murraya koenigii* as a commercially valuable medicinal plant.[13]

Table 3. Comprehensive Botanical and Pharmacognostic Profile of *Murraya koenigii*

Parameter	Description
Plant Habit	Evergreen aromatic shrub/tree
Height	2–6 m
Leaf Type	Imparipinnate, aromatic
Inflorescence	Terminal cymes
Flower Color	White
Fruit Type	Purplish-black berry
Diagnostic Microscopy	Oil glands, anomocytic stomata
Native Region	India and Sri Lanka
Propagation	Seeds and stem cuttings
Medicinal Parts	Leaves, bark, roots
Major Use	Culinary and medicinal applications

3. ETHNOMEDICINAL USES RELATED TO SKIN AND INFLAMMATORY DISORDERS

Murraya koenigii has been extensively utilized across traditional medicine systems for the management of dermatological and inflammatory conditions. While classical Ayurvedic and Siddha texts do not specifically reference psoriasis, numerous applications correspond to the hallmark clinical manifestations of the disease, including erythema, scaling, pruritus, and chronic skin lesions. In Ayurveda, the plant is described as possessing katu (pungent) and tikta (bitter) properties, which are traditionally believed to pacify the Pitta and Vata doshas, both of which are often implicated in the pathophysiology of inflammatory skin disorders. Empirical evidence from historical texts and ethnobotanical surveys indicates that *M. koenigii* leaves are frequently prepared as pastes or poultices for topical application to rashes, pruritic eruptions, and



inflamed lesions. Decoctions or leaf-based infusions are also utilized to manage chronic wounds and ulcers, while oral administration of leaf or root extracts has been employed for systemic detoxification, blood purification, and reduction of internal inflammatory states. Infused oils and leaf pastes have been traditionally applied to alleviate minor burns, promote tissue regeneration, and manage erythematous or hyperkeratotic lesions.[14]

Siddha and regional folk medicine practices in South Asia further corroborate the dermatological relevance of *M. koenigii*. In these systems, leaf juice or paste is commonly applied to inflamed, scaly, or pruritic patches, often in combination with adjunctive agents such as turmeric (*Curcuma longa*) or coconut oil (*Cocos nucifera*), which enhance anti-inflammatory and antimicrobial effects. Topical oils and decoctions are also used to accelerate wound healing, prevent secondary infections, and maintain skin integrity. Ethnobotanical reports indicate that these practices are prevalent across India, Sri Lanka, and neighboring regions, reflecting a long-standing empirical understanding of the plant's therapeutic potential for chronic inflammatory and dermal conditions.[15]

From a mechanistic perspective, these ethnomedicinal applications are consistent with contemporary pharmacological findings. The observed anti-inflammatory effects in traditional use align with the inhibition of cyclooxygenase (COX) and lipoxygenase (LOX) pathways and downregulation of pro-inflammatory cytokines documented in preclinical studies. Wound-healing applications correlate with the stimulation of collagen synthesis, epithelialization, and antimicrobial protection. The application of leaf pastes and juices on chronic lesions suggests potential regulation of keratinocyte proliferation

and differentiation, while combinations with adjunctive botanicals imply synergistic enhancement of antioxidant and immunomodulatory activity. Collectively, the historical, regional, and mechanistic evidence positions *Murraya koenigii* as a scientifically justified candidate for psoriasis management, providing a strong rationale for further investigation into its bioactive constituents and multi-target pharmacological effects.[16]

4. PHYTOCHEMISTRY OF *MURRAYA KOENIGII*

The therapeutic potential of *Murraya koenigii* is closely associated with its rich and chemically diverse phytoconstituents, which exhibit a spectrum of biological activities relevant to inflammatory skin disorders such as psoriasis. The plant is particularly notable for its carbazole alkaloids, which are considered its signature bioactive compounds. Major carbazole alkaloids, including mahanimbine, girinimbine, koenimbine, and murrayazoline, have been shown to exert potent anti-inflammatory effects by modulating key signaling pathways such as NF- κ B and MAPK, resulting in the downregulation of pro-inflammatory cytokines (TNF- α , IL-6, IL-17) implicated in keratinocyte hyperproliferation and chronic skin inflammation. In addition to their immunomodulatory activity, these alkaloids possess antioxidant properties, mitigating reactive oxygen species (ROS)-induced cellular damage, and demonstrate anti-proliferative effects by promoting apoptosis in hyperactive keratinocytes, thereby addressing one of the central pathophysiological mechanisms in psoriasis.[17]

In addition to carbazole alkaloids, *M. koenigii* is enriched with flavonoids and phenolic compounds such as quercetin, kaempferol, rutin, myricetin, gallic acid, caffeic acid, chlorogenic acid, and ferulic acid. These compounds contribute to the



plant's antioxidant capacity by scavenging free radicals, reducing lipid peroxidation, and enhancing endogenous antioxidant enzyme activity, including superoxide dismutase (SOD), catalase, and glutathione peroxidase. Flavonoids and phenolics also exhibit anti-inflammatory activity through inhibition of COX and LOX enzymes and downregulation of inflammatory cytokines, while their immunomodulatory effects help restore T-cell balance, further supporting their relevance in psoriasis management. *Murraya koenigii* also contains a variety of terpenoids and

essential oils, including monoterpenes and sesquiterpenes such as limonene, β -caryophyllene, α -pinene, sabinene, and linalool. These volatile compounds contribute to the characteristic aroma of curry leaves and possess additional therapeutic properties. Terpenoids exhibit anti-inflammatory and antimicrobial activity, and several are known to enhance dermal penetration of co-administered compounds, making them particularly useful for topical formulations targeting psoriatic plaques.[18]

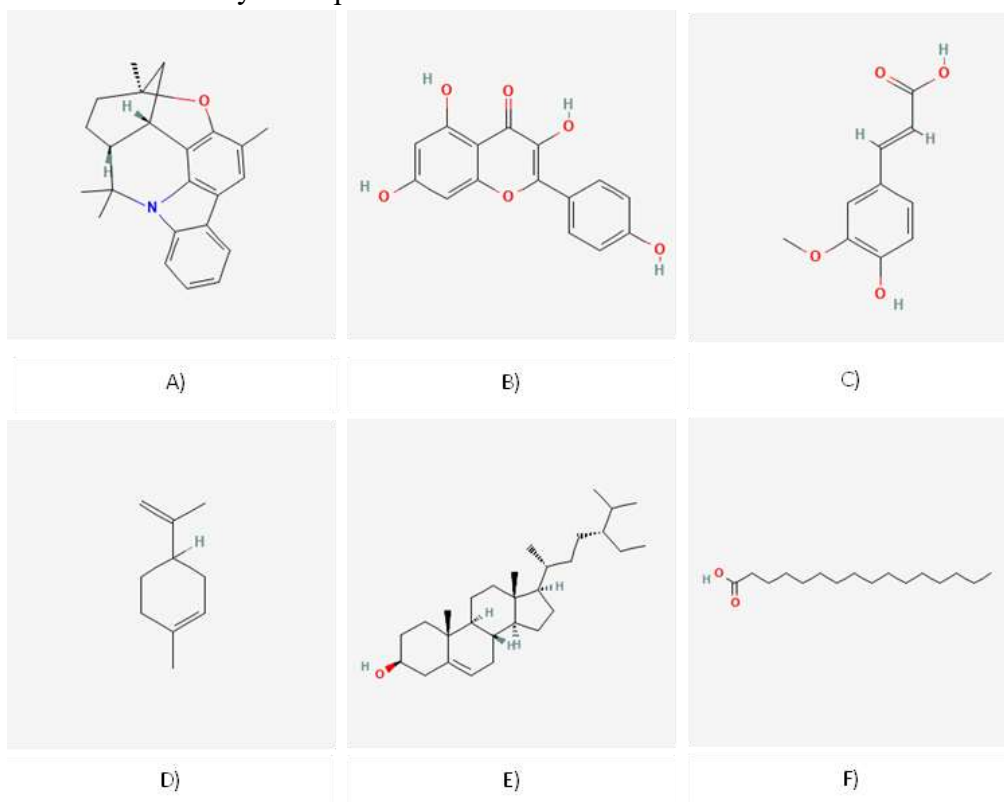


Figure 2: Representative Scaffolds of Major Natural Product Classes: (A) Hapalindole A, (B) Kaempferol, (C) Ferulic acid, (D) Limonene, (E) β -Sitosterol, and (F) Stearic acid.

Other bioactive constituents include sterols, notably β -sitosterol, which may facilitate anti-inflammatory and wound-healing processes, and fatty acids, which support skin barrier integrity. Vitamins A, C, and E, naturally present in the leaves, further enhance antioxidant defenses, promote collagen synthesis, and aid tissue repair.

The combined presence of these phytochemicals confers a multi-targeted pharmacological profile, addressing inflammation, oxidative stress, immune dysregulation, keratinocyte hyperproliferation, and tissue repair simultaneously.[19]

Table 2. Key Phytochemicals of *Murraya koenigii* and Their Biological Activities

Phytochemical Class	Representative Compounds	Biological Activities
Carbazole Alkaloids	Mahanimbine, Girinimbine, Koenimbine, Murrayazoline	Anti-inflammatory, immunomodulatory, antioxidant, anti-proliferative
Flavonoids	Quercetin, Kaempferol, Rutin, Myricetin	Antioxidant, immunomodulatory, anti-inflammatory
Phenolics	Gallic acid, Caffeic acid, Chlorogenic acid, Ferulic acid	Free radical scavenging, anti-inflammatory, anti-proliferative
Terpenoids & Essential Oils	Limonene, β -Caryophyllene, α -Pinene, Linalool	Anti-inflammatory, antimicrobial, skin penetration enhancement
Sterols & Fatty Acids	β -Sitosterol, palmitic acid	Anti-inflammatory, wound healing, skin barrier support
Vitamins	A, C, E	Antioxidant, tissue repair, immune modulation

The chemical diversity of *Murraya koenigii* underpins its multi-faceted pharmacological effects, making it a promising candidate for natural anti-psoriatic therapy by targeting multiple disease pathways simultaneously.[20]

5. PHARMACOLOGICAL EVIDENCE SUPPORTING ANTI-PSORIATIC ACTIVITY

The pharmacological potential of *Murraya koenigii* in the context of psoriasis is increasingly supported by preclinical studies demonstrating its multi-targeted effects on inflammation, oxidative stress, immune dysregulation, keratinocyte hyperproliferation, and tissue repair. Inflammation, a central hallmark of psoriasis, is characterized by elevated levels of pro-inflammatory cytokines such as TNF- α , IL-6, IL-17, and IL-23. Experimental evidence indicates that extracts and isolated carbazole alkaloids from *M. koenigii*, including mahanimbine and girinimbine, effectively attenuate inflammatory responses by inhibiting cyclooxygenase (COX) and lipoxygenase (LOX) activity, suppressing nitric oxide production in activated macrophages, and downregulating NF- κ B and MAPK signaling pathways. These actions result in reduced cytokine production and diminished recruitment of

inflammatory immune cells to affected skin tissues, directly addressing the cytokine-driven pathology of psoriatic lesions.[21]

Oxidative stress, which exacerbates keratinocyte activation and inflammation, is also mitigated by *M. koenigii*. Its rich content of flavonoids (quercetin, kaempferol, myricetin) and phenolics (gallic acid, caffeic acid, chlorogenic acid) provides potent free radical scavenging activity, reduces lipid peroxidation, and enhances endogenous antioxidant defenses, including superoxide dismutase (SOD), catalase, and glutathione peroxidase. These antioxidant effects protect keratinocytes and dermal cells from ROS-induced damage, thereby attenuating oxidative amplification of inflammatory cascades and supporting tissue integrity.[1] Immune modulation is another key mechanism through which *M. koenigii* exerts anti-psoriatic effects. Preclinical studies suggest that its bioactive constituents can restore Th1/Th17/Treg balance, suppress dendritic cell activation, and reduce chemokine-mediated recruitment of inflammatory cells into the skin. By re-establishing immune homeostasis, *M. koenigii* addresses one of the core drivers of psoriasis pathogenesis—chronic immune-mediated skin inflammation.[22]



Additionally, hyperproliferation and abnormal differentiation of keratinocytes, a defining feature of psoriatic plaques, are regulated by *M. koenigii* extracts. Carbazole alkaloids and flavonoids inhibit keratinocyte overgrowth, induce apoptosis in hyperactive epidermal cells, and normalize differentiation, thereby reducing epidermal thickening, scaling, and plaque formation. These effects are further complemented by wound-healing and tissue repair properties, including enhanced collagen synthesis, accelerated epithelialization, promotion of wound contraction, and antimicrobial protection to prevent secondary infections in compromised skin.[23] Collectively, these preclinical findings indicate that *Murraya koenigii* exhibits multi-mechanistic anti-psoriatic activity, simultaneously suppressing inflammatory cascades, mitigating oxidative stress, modulating immune responses, regulating keratinocyte proliferation, and promoting tissue repair. Although direct clinical studies in psoriasis patients are currently limited, the convergence of traditional use, phytochemical composition, and experimental pharmacology positions *M. koenigii* as a promising natural therapeutic candidate for psoriasis, warranting further investigation in disease-specific in vivo models and human clinical trials.[24]

6. POTENTIAL MECHANISTIC PATHWAYS

The therapeutic effects of *Murraya koenigii* in psoriasis can be attributed to the combined action of its diverse phytochemicals on multiple pathogenic mechanisms. Its bioactive constituents including carbazole alkaloids, flavonoids, phenolics, and terpenoids interact with inflammatory, oxidative, immune, and proliferative pathways, providing a multi-targeted approach to disease management.

6.1 Inhibition of Inflammatory Signaling Pathways- Chronic inflammation is a hallmark of psoriasis, largely driven by overactivation of signaling cascades such as NF- κ B, MAPK (ERK, JNK, p38), and STAT3, which induce the production of pro-inflammatory cytokines including TNF- α , IL-6, IL-17, and IL-23. Bioactive carbazole alkaloids from *Murraya koenigii*, such as mahanimbine and koenimbine, inhibit NF- κ B nuclear translocation and modulate MAPK phosphorylation, thereby suppressing downstream cytokine expression. In addition, the plant constituents downregulate COX-2 and LOX enzymes, reducing prostaglandin and leukotriene synthesis, which collectively dampen the inflammatory microenvironment in psoriatic lesions.[25]

6.2 Modulation of Oxidative Stress- Oxidative stress contributes to keratinocyte activation, immune dysregulation, and tissue damage in psoriasis. Flavonoids and phenolic compounds in *M. koenigii* effectively scavenge reactive oxygen species (ROS) and free radicals, while enhancing the activity of endogenous antioxidant enzymes such as superoxide dismutase (SOD), catalase, and glutathione peroxidase. This antioxidant activity not only protects epidermal and dermal cells from ROS-mediated injury but also prevents ROS-driven activation of inflammatory signaling pathways like NF- κ B and MAPK, thereby reducing both oxidative and inflammatory stress simultaneously.[26]

6.3 Immune System Regulation- Psoriasis is characterized by dysregulated T-cell responses, particularly the overactivation of Th1 and Th17 pathways. Phytochemicals from *M. koenigii* help restore immune homeostasis by rebalancing Th1/Th17/Treg populations, suppressing dendritic cell activation, and inhibiting chemokine-mediated infiltration of inflammatory immune



cells into psoriatic skin. Modulation of the STAT3 and JAK-STAT signaling pathways further attenuates IL-23/IL-17 axis-driven chronic inflammation, highlighting the plant's capacity to regulate both innate and adaptive immune responses effectively.[27]

6.4 Regulation of Keratinocyte Proliferation and Differentiation-

Hyperproliferation and abnormal differentiation of keratinocytes contribute to epidermal thickening, scaling, and plaque formation in psoriasis. Carbazole alkaloids and flavonoids from *M. koenigii* inhibit keratinocyte overgrowth by modulating cyclin-dependent kinases (CDKs) and survival pathways such as PI3K/Akt/mTOR, while promoting apoptosis in hyperactive cells. These effects normalize epidermal differentiation and turnover, reduce hyperkeratosis, and help restore the structural integrity of psoriatic skin.[28]

6.5 Enhancement of Wound Healing and Tissue Repair-

Psoriatic lesions often exhibit impaired barrier function and delayed healing. *Murraya koenigii* promotes tissue repair through activation of TGF- β /Smad signaling, which enhances collagen synthesis, epithelialization, and wound contraction. Additionally, terpenoids such as β -caryophyllene and limonene provide antimicrobial protection, preventing secondary infections in compromised skin. By simultaneously supporting structural repair and controlling microbial load, the plant contributes to both functional and protective restoration of psoriatic skin.[29]

6.6 Integrated Multi-Target Mechanism- The cumulative effects of *Murraya koenigii* involve coordinated action across NF- κ B, MAPK, STAT3, JAK-STAT, PI3K/Akt/mTOR, and TGF- β /Smad pathways, along with ROS scavenging and immune modulation. This multi-mechanistic profile addresses the interconnected processes of inflammation, oxidative stress, immune

dysregulation, keratinocyte hyperproliferation, and impaired wound healing, underscoring the potential of *M. koenigii* as a natural, multi-target anti-psoriatic therapeutic.[30]

7. THERAPEUTIC PROSPECTS AND FUTURE RESEARCH NEEDS

Murraya koenigii demonstrates a unique multi-targeted pharmacological profile that addresses the complex pathophysiology of psoriasis. Its bioactive phytochemicals, including carbazole alkaloids, flavonoids, phenolics, and terpenoids, act synergistically to suppress inflammation, mitigate oxidative stress, regulate immune responses, control keratinocyte proliferation, and promote tissue repair. This integrated action positions the plant as a holistic therapeutic candidate capable of targeting multiple pathogenic pathways simultaneously, overcoming the limitations of conventional single-target therapies. Topical formulations, such as creams, gels, ointments, or infused oils, provide a practical approach for localized intervention, with terpenoids like β -caryophyllene and limonene enhancing skin penetration and bioavailability of active constituents.[31] Additionally, the established culinary and ethnomedicinal safety profile of *M. koenigii* supports its potential use as an oral adjunct to systemic treatments, potentially reducing drug dosage and adverse effects. The plant may also complement conventional therapies, including corticosteroids, vitamin D analogs, and biologics targeting TNF- α or IL-17, by modulating multiple inflammatory, oxidative, and proliferative pathways, thereby improving therapeutic outcomes and reducing the risk of relapse. Despite promising preclinical evidence, several gaps hinder clinical translation, including a lack of studies in psoriasis-specific animal models, limited understanding of the contribution of individual phytochemicals, insufficient



pharmacokinetic and bioavailability data, and absence of randomized controlled clinical trials to assess efficacy, safety, and optimal dosing in human subjects.[32] Future research should focus on validated disease models such as imiquimod-induced psoriasis, isolation and mechanistic characterization of active constituents, cytokine profiling, and investigation of key signaling pathways including NF- κ B, MAPK, STAT3, JAK-STAT, PI3K/Akt/mTOR, and TGF- β /Smad. Furthermore, formulation studies are essential to optimize stability, bioavailability, and targeted delivery, while clinical evaluation is critical to establish safety, efficacy, and long-term outcomes. Addressing these gaps could position *Murraya koenigii* as a cost-effective, safe, multi-target natural therapy, bridging traditional knowledge with modern dermatological interventions, reducing reliance on synthetic drugs, and providing holistic benefits to patients with psoriasis.[33]

CONCLUSION

Murraya koenigii demonstrates significant potential as a multi-target natural therapy for psoriasis, a chronic inflammatory skin disorder with complex pathophysiology. Its rich phytochemical composition including carbazole alkaloids, flavonoids, phenolics, and terpenoids underpins its anti-inflammatory, antioxidant, immunomodulatory, anti-proliferative, and wound-healing activities. Traditional and ethnomedicinal use further supports its safety and therapeutic relevance for skin disorders. Preclinical evidence indicates that *Murraya koenigii* can modulate key pathogenic mechanisms in psoriasis, such as inflammatory cascades, oxidative stress, immune dysregulation, and keratinocyte hyperproliferation. These multi-mechanistic actions suggest that the plant could serve as a natural, safe, and effective adjunct or

alternative to conventional therapies. However, current research is largely limited to in vitro and general anti-inflammatory studies. Comprehensive studies using psoriasis-specific models, isolation of active compounds, formulation development, and clinical trials are essential to fully validate its therapeutic efficacy. Overall, *Murraya koenigii* represents a promising source of anti-psoriatic agents with potential for integration into modern dermatological therapeutics, bridging traditional knowledge with contemporary pharmacological research.

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