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Review Article

Mallotus philippensis Muell. (Kamela): A Review from Traditional Medicine to Modern Pharmacology and Industrial Applications

Abstract

Objective

This review provides a critical evaluation of the current body of literature on *Mallotus philippensis* Muell. Arg. (Kamela), with an emphasis on synthesizing its ethnomedicinal relevance, phytochemical profile, pharmacological potential, and industrial applications. The objective is to delineate existing research gaps and propose informed directions for future studies aimed at facilitating its development into scientifically validated therapeutic and commercially viable products.

Methods

A comprehensive and systematic literature search was performed across major electronic databases, including ScienceDirect, PubMed, and Google Scholar, using specific keywords such as "*Mallotus philippensis*", "Kamela", "phytochemistry", "pharmacology", and "ethnobotany". All pertinent publications, encompassing in vitro, in vivo, clinical, and ethnobotanical investigations, published up to the year 2024 were identified, reviewed, and critically analysed.

Results

M. philippensis occupies a prominent position in traditional medicinal systems, particularly across South Asia, where it has been employed for the treatment of a number of health conditions encompassing dermatological, helminthic, gastrointestinal, and inflammatory disorders. Its therapeutic efficacy is attributed to a diverse and bioactive phytochemical composition, predominantly comprising phenolic constituents such as rottlerin, in addition to triterpenoids, steroids, cardenolides, and flavonoids. Contemporary pharmacological investigations have substantiated numerous traditional applications, revealing significant anthelmintic, antimicrobial, anti-inflammatory, antioxidant, and anticancer properties. Rottlerin, identified as the principal bioactive compound, functions as a multi-target molecule through mechanisms involving inhibition of protein kinase C delta (PKCδ) and modulation of apoptotic and autophagic pathways. Furthermore, *M. philippensis* possesses considerable socio-economic importance, with established applications in the dye, textile, and food industries.

Conclusion

Mallotus philippensis represents a pharmacologically multifaceted species with significant prospects for therapeutic innovation and commercial utilization. Nevertheless, the effective translation of its traditional uses into evidence-based biomedical applications remains constrained by the limited availability of well-designed clinical investigations, comprehensive toxicological assessments, and standardized extract formulations. To fully realize the pharmacological and industrial potential of this species, future research should prioritize elucidation of its molecular mechanisms of action, detailed pharmacokinetic profiling, and rigorous clinical validation.

Keywords: *Mallotus philippensis* Muell., Kamela, rottlerin, antifungal, ethnopharmacology, phytochemistry, pharmacological activities, natural dye

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1. Introduction

The *genus Mallotus* (family Euphorbiaceae), comprising nearly 20 species in India, is widely distributed throughout the tropical and subtropical regions of the Old World.(Anonymous, 2024; Gangwar et al., 2014) Among these, Mallotus philippensis Muell. Arg., commonly referred to as the *Kamela tree*, is a small to medium-sized evergreen tree or shrub that thrives in the outer Himalayan ranges at elevations up to 1500 meters.(Anonymous, 2007; Gangwar et al., 2014; Shaikh Dilnawaz et al., 2012)

For centuries, this species has held a significant place in traditional medicinal systems such as Ayurveda and Ūnani, reflecting its enduring ethnopharmacological relevance.

The medicinal value of M. philippensis is predominantly ascribed to the glandular hairs and trichomes covering its fruits, which produce a distinctive reddish-orange powder known as "Kamela". (Anonymous, 2007; Shaikh Dilnawaz et al., 2012)

This powder, along with other plant parts including the leaves, bark, and seeds, has been used in the treatment of a broad spectrum of ailments. Ethnobotanical documentation highlights its application in over 140 health conditions, notably those affecting the integumentary, gastrointestinal, and parasitic systems.(Shaikh Dilnawaz et al., 2012)

Despite its rich ethnomedicinal legacy, an integrated analysis connecting traditional knowledge with contemporary scientific validation remains limited. This review seeks to bridge that gap by systematically examining the ethnomedicinal relevance, phytochemical diversity, pharmacological evidence, and industrial potential of *M. philippensis*. Moreover, it aims to identify key research gaps and outline strategic directions for future studies, thereby facilitating the transformation of this traditionally esteemed species into evidence-based therapeutic and sustainable commercial applications.

2. Traditional Uses and Ethnobotany

M. philippensis is deeply embedded in the ethnomedicinal practices of India and neighbouring regions. Its uses, documented in classical texts and folk traditions, are remarkably diverse.

2.1. System-Based Traditional Applications

In Ūnani medicine, Kamela is characterized by a hot and dry temperament(Central Council for Research in Unani Medicine, 2001; Hakim Najmul Ghani, 2011) and is esteemed for its anthelmintic, purgative, and cleansing (detersive) properties. It constitutes an essential component of several classical formulations, including:

- *Roghan-e-Kamela and Zimad-e-Jarb*, which are traditionally prescribed for dermatological conditions such as scabies and ringworm. Roghan-e-Kamela, in particular, is recognized for its wound-healing and skin-regenerative properties.(CCRUM, 2006; Hakeem Najmul Ghani, 2010)
- Itrifal Qanbil, Safuf Hikkah, and Itrifal Deedan, which are primarily used to eliminate intestinal worms and other parasitic infections.(Kabeeruddin Allama Mohammad, 2014)

Beyond formal Ūnani formulations, folk medicinal traditions across the Indian subcontinent have also preserved diverse therapeutic applications of Mallotus philippensis:

- **Dermatological Disorders:** The powdered fruit or its oil-based preparations are applied externally for various skin ailments, including scabies, ringworm, wounds, boils, freckles, and herpetic eruptions.(CCRUM, 2006; Shaikh Dilnawaz et al., 2012)
- **Helminthic Infestations:** The reddish-orange powder derived from the glandular hairs of the fruits serves as a well-known vermifuge against tapeworms, roundworms, and other intestinal parasites, often administered with milk or jaggery to enhance efficacy.(Shaikh Dilnawaz et al., 2012)
- **Digestive and Systemic Disorders:** Decoctions of the bark are traditionally employed to relieve stomach pain and dysentery, while fruit-based preparations act as purgatives and are used in the management of spleen disorders and jaundice.(Khan Husain Mohammad Syed, n.d.; Khare C.P., 2007; Shaikh Dilnawaz et al., 2012)

Collectively, these traditional and folk uses highlight the enduring therapeutic versatility of *M. philippensis*, reflecting a deep empirical understanding of its medicinal value that continues to inspire contemporary pharmacological inquiry.

2.2. Socio-Economic Importance

In addition to its medicinal significance, *Mallotus philippensis* holds considerable socio-economic value, particularly within rural and traditional communities. The characteristic red powder obtained from its fruits serves as a natural dye widely used for coloring silk, wool, and indigenous textiles, including traditional Bhutanese fabrics.(Kumar et al., 2020; Shaikh Dilnawaz et al., 2012) Beyond its role in the textile industry, the dye is also utilized as a natural food colorant, in soap and cosmetic production, and as an antioxidant additive for preserving edible oils and ghee.(Kumar et al., 2020; Muthuswamy Ragunathan et al., 2023) Furthermore, the wood of *M. philippensis* is employed as a source of fuel and lightweight timber, while its leaves are commonly used as fodder for livestock. Collectively, these applications underscore the plant's multifaceted contribution to rural livelihoods, traditional industries, and sustainable resource utilization.(Kumar et al., 2020)

3. Phytochemical Constituents

The diverse pharmacological and functional properties of M. philippensis are attributed to its rich and complex phytochemical composition, distributed across various plant parts. These bioactive compounds encompass multiple chemical classes, each contributing distinct biological effects. The following table provides a concise overview of the major phytochemical groups and their representative constituents identified in the species.(Muthuswamy Ragunathan et al., 2023)

Table 1: Major Phytochemical Classes and Constituents in M. philippensis.(Muthuswamy Ragunathan et al., 2023)

Phytochemical Class	Key Constituents	Primary Plant Part
Phenolic Compounds	*Rottlerin, Isorottlerin, Bergenin, Mallotochromene*	*Fruit Glands, Bark, Heartwood*
Triterpenoids	*Friedelin, Lupeol, Betulin-3-acetate, β-Amyrin*	*Stem Bark, Heartwood*
Steroids	*β-Sitosterol, Daucosterol*	*Heartwood, Bark*
Cardenolides	*Corotoxigenin L-rhamnoside, Coroglaucigenin L-rhamnoside*	*Seeds*
Flavonoids	*Kamelachalcone A & B, Mallotophilippens C, D, E*	*Fruits*
Others	*Kamlolenic acid (in seed oil), Tannins*	*Seed Oil, Bark, Fruits*

3.1. Key Bioactive Compound: Rottlerin

Rottlerin (also known as Mallotoxin) represents the principal and most extensively investigated bioactive constituent of *Mallotus philippensis*. Although originally characterized as a selective inhibitor of protein kinase C delta (PKCδ), subsequent studies have revealed that rottlerin exerts a broad spectrum of biological activities through its multi-target mechanisms of action, influencing pathways involved in apoptosis, autophagy, and inflammation. (Maioli et al., 2009; Manhas et al., 2021)

The compound is predominantly localized within the glandular structures of the fruit and is considered chiefly responsible for the plant's anthelmintic, antimicrobial, and anticancer activities. Its multifaceted bioactivity underscores its potential as a promising lead molecule for future pharmacological and therapeutic development. (Soltoff, 2001)

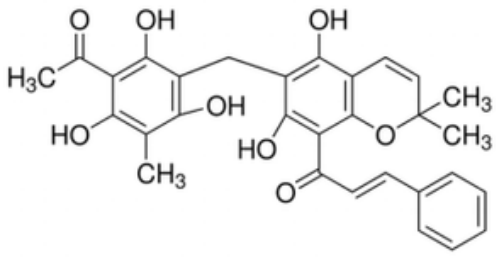

Figure 1: Chemical structure of rottlerin, the key bioactive phloroglucinol derivative from M. philippensis.(Maioli et al., 2009)

4. Pharmacological Activities and Mechanistic Insights

Contemporary pharmacological investigations have provided substantial scientific validation for many of the traditional therapeutic applications of Mallotus philippensis. The plant's diverse biological activities can largely be attributed to its rich phytochemical composition, particularly the presence of rottlerin and other bioactive secondary metabolites.(Muthuswamy Ragunathan et al., 2023; Sreedevi et al., 2015)

4.1. Anthelmintic Activity

The traditional use of Kamela as an anthelmintic agent is strongly corroborated by experimental evidence. Rottlerin, the principal active compound, has been identified as the key mediator of this activity. It exerts a neurotoxic effect on helminths, inducing paralysis and facilitating their expulsion from the host system. Experimental models involving earthworms and parasitic nematodes have consistently demonstrated the potent vermicidal efficacy of M. philippensis extracts.(Kabeeruddin Allama Mohammad, 2014; Kumar et al., 2020; Muthuswamy Ragunathan et al., 2023)

4.2. Antimicrobial and Dermatological Efficacy

The extensive ethnomedicinal use of *M. philippensis* for skin infections is well supported by its broad-spectrum antimicrobial and anti-inflammatory properties.

- **Antifungal and Antibacterial Activities:** Rottlerin-rich extracts exhibit significant inhibitory effects against dermatophytic fungi such as *Trichophyton* species, which are responsible for ringworm, as well as bacterial pathogens including *Staphylococcus aureus*. (Said Mohammed Hakim, 1970) These findings substantiate its traditional application in managing scabies, ringworm, and other skin infections.
- **Anti-inflammatory and Antioxidant Effects:** The plant's extracts suppress pro-inflammatory mediators, including cytokines and cyclooxygenase (COX) enzymes, thereby mitigating inflammation and skin irritation. Concurrently, antioxidant compounds such as condensed tannins contribute to cellular protection and wound healing through the neutralization of reactive oxygen species.(Hakeem Najmul Ghani, 2010; Kumar et al., 2020)

4.3. Anti-inflammatory and Analgesic Activities

Beyond dermatological applications, *M. philippensis* exhibits systemic anti-inflammatory and analgesic effects. Experimental studies have shown significant inhibition of carrageenan-induced paw edema in animal models, suggesting suppression of inflammatory pathways. These effects are attributed to flavonoids and triterpenoids, particularly lupeol, which possess well-documented cytokine-modulating and anti-oedematous properties.(CCRUM, 2006; Kumar et al., 2020)

4.4. Anticancer Potential

Rottlerin has emerged as a promising candidate for anticancer drug development due to its multifaceted molecular mechanisms:

- PKCδ Inhibition: Induces mitochondrial dysfunction and promotes apoptosis in malignant cells.
- Autophagy Induction: Mediated through downregulation of transglutaminase 2 (TG2).
- Inhibition of Cell Proliferation: Demonstrated across multiple cancer cell lines, including breast and pancreatic cancers. (Ministry of Health and Family Welfare, 1993; Mueller Argoviensis & Linnaea, 2020)

Although most findings to date are based on in vitro studies, they provide a compelling foundation for further preclinical and clinical investigations into Kamela-derived anticancer compounds.

4.5. Other Pharmacological Activities

Preliminary evidence also indicates additional pharmacological potentials, including hepatoprotective, antidiabetic, and antiallergic effects.(CCRUM, 2001; Kumar et al., 2020) While these findings remain exploratory, they underscore the need for comprehensive mechanistic and toxicological studies to elucidate the full therapeutic scope of *M. philippensis*.

Overall, the growing body of pharmacological research reaffirms the traditional wisdom surrounding *M. philippensis* while highlighting its untapped potential as a source of novel therapeutic agents.

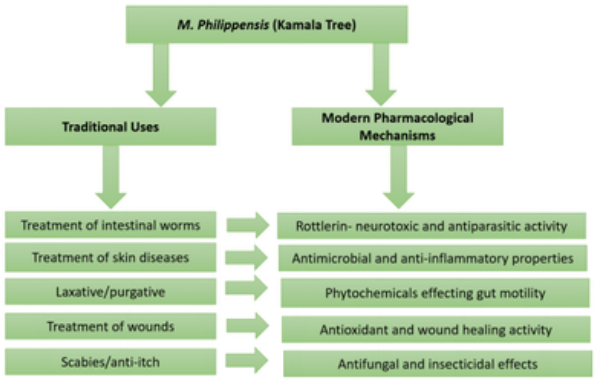

Figure 2: Conceptual diagram linking traditional uses of M. Philippensis to modern pharmacological mechanisms.

5. Industrial and Commercial Applications

Beyond its medicinal value, Mallotus philippensis possesses significant economic and industrial importance.

- **Natural Dye Industry:** The red pigment from Kamela serves as a sustainable and eco-friendly alternative to synthetic dyes for textiles such as silk and wool. The primary coloring agents are rottlerin and its derivatives.(Kumar et al., 2020)
- **Food and Cosmetic Applications**: Kamela dye is utilized for coloring a variety of products, including foodstuffs, beverages, soaps, and ice cream. Its antioxidant properties further offer potential as a natural preservative for oils and fats.(Kumar et al., 2020)
- **Wood and Fuel:** The timber of *M. philippensis* is employed in the manufacture of tool handles and packaging materials and serves as a source of fuelwood, emphasizing its utility in rural economies.

6. Discussion and Future Perspectives

The evidence presented in this review highlights the considerable pharmacological potential of M. philippensis, deeply rooted in centuries of traditional use and increasingly corroborated by modern scientific studies. The alignment between ethnomedicinal applications, such as treatment of helminthic infections and skin disorders, and mechanistic insights, particularly regarding rottlerin's neurotoxic and antimicrobial actions, underscores the plant's promise as a source of novel therapeutic agents.

Nevertheless, several critical gaps must be addressed to fully realize its clinical and commercial potential:

1. **Bridging Ethnobotany and Mechanistic Understanding:** While certain activities, including anthelmintic and antimicrobial effects, are well-documented, other traditional claims, such as treatment of bone fractures or use as a psychological cathartic, remain experimentally unvalidated. Targeted research is needed to explore these under-investigated uses.
2. **Translating Phytochemistry into Clinical Evidence:** Current studies are largely limited to in vitro and preliminary in vivo experiments. There is a pressing need for rigorous, randomized controlled clinical trials to establish safety, efficacy, and appropriate dosing in humans.
3. **Toxicological and Pharmacokinetic Evaluation:** Comprehensive toxicology assessments and pharmacokinetic profiling, particularly of rottlerin, are scarce. Detailed understanding of absorption, distribution, metabolism, and excretion (ADME) is essential for advancing drug development.
4. **Standardization and Quality Control:** The frequent adulteration of *Kamela* powder(Gangwar et al., 2014) highlights the importance of robust analytical techniques, such as HPLC-based fingerprinting, to ensure standardization of extracts using bioactive markers like rottlerin.
5. **Sustainable Sourcing and Industrial Optimization:** To meet growing demand, sustainable cultivation and harvesting strategies are critical. Additionally, refining extraction and processing methods for both medicinal and industrial applications will enhance economic feasibility and environmental sustainability.

7. Conclusion

Mallotus philippensis represents a rich repository of bioactive compounds with substantial potential across pharmaceutical, cosmetic, and industrial domains. Rottlerin, in particular, emerges as a versatile molecule with promising chemotherapeutic and antimicrobial properties. This review consolidates current knowledge and emphasizes that unlocking the full therapeutic and economic potential of this species will require interdisciplinary collaboration among ethnobotanists, phytochemists, pharmacologists, and clinicians. By systematically addressing the identified research gaps, M. philippensis can be responsibly developed into evidence-based therapeutics and sustainable industrial products.

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Conflicts of Interest

The authors declare no conflict of interest.

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