

Pharmacological Profiling and In-Vitro Antimicrobial Activity of *Eurycoma Longifolia* Jack (Tongkat Ali): A Comprehensive Review

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Abstract—The rapid escalation of antimicrobial resistance and the associated decline in the effectiveness of conventional antibiotics have intensified the global search for alternative therapeutic agents derived from natural sources. Medicinal plants continue to serve as valuable reservoirs of structurally diverse bioactive compounds with broad pharmacological potential. *Eurycoma longifolia* Jack (family: Simaroubaceae), commonly known as Tongkat Ali, is a traditional medicinal plant indigenous to Southeast Asia and widely used for the treatment of fever, infections, malaria, fatigue, and sexual dysfunction. Although the aphrodisiac and antimalarial properties of *E. longifolia* are well established, increasing experimental evidence suggests significant antimicrobial activity against a variety of bacterial and fungal pathogens. This review critically compiles and evaluates published literature on the phytochemical composition, pharmacological properties, and in-vitro antimicrobial activity of *Eurycoma longifolia*. Emphasis is placed on studies conducted by different researchers, extraction strategies, experimental methodologies, antimicrobial efficacy against Gram-positive and Gram-negative bacteria as well as pathogenic fungi, and proposed mechanisms of action. Challenges related to standardization, reproducibility, and clinical translation are discussed. Overall, *E. longifolia* emerges as a promising natural source of antimicrobial agents with potential applications in combating drug-resistant infections.

Keywords—*Eurycoma longifolia*; Tongkat Ali; antimicrobial activity; phytochemistry; quassinoids; medicinal plants

I. INTRODUCTION

Eurycoma longifolia Jack (Tongkat Ali) is a medicinal plant native to Southeast Asia with a long history of ethnopharmacological use in treating fever, infections, fatigue, and reproductive disorders. Traditionally valued as a health tonic and aphrodisiac, the plant—particularly its root—has gained global recognition as a nutraceutical ingredient, leading to extensive commercialization.

Botanically classified under the family Simaroubaceae, *E. longifolia* is rich in bioactive phytochemicals such as quassinoids, alkaloids, flavonoids, saponins, and triterpenes, which underpin its diverse pharmacological activities including aphrodisiac, antimalarial, anticancer, antioxidant, anti-inflammatory, antidiabetic, and immunomodulatory effects. Although its role in enhancing male vitality is well documented, ethnobotanical evidence and preliminary experimental studies suggest that the plant may also possess antimicrobial potential, as indicated by its traditional use in infectious and febrile conditions and the known antimicrobial properties of its constituent compounds. However, antimicrobial investigations on *E. longifolia* remain limited, fragmented, and lack systematic profiling against clinically relevant pathogens, mechanistic elucidation, and comparison with standard antimicrobial agents. Given the global rise in antimicrobial resistance, the phytochemical richness of *E. longifolia*, and existing gaps in antimicrobial research, comprehensive pharmacological profiling and focused antimicrobial evaluation are scientifically justified and may contribute to the discovery of novel plant-based antimicrobial agents while expanding the therapeutic and commercial scope of Tongkat Ali.

Antimicrobial resistance (AMR) represents one of the most critical public health challenges of the twenty-first century. The widespread misuse and overuse of antibiotics have accelerated the emergence of resistant strains of bacteria and fungi, leading to treatment failure, prolonged illness, and increased mortality. Pathogens such as methicillin-resistant *Staphylococcus aureus*, multidrug-resistant *Pseudomonas aeruginosa*, and azole-resistant *Candida* species pose serious threats to global healthcare systems.

Natural products, particularly medicinal plants, have historically played a pivotal role in drug discovery and development. Plant-derived compounds offer unique chemical scaffolds and often act through multiple biological targets, reducing the likelihood of resistance development. Consequently, there is renewed scientific interest in exploring traditional medicinal plants as potential sources of novel antimicrobial agents.

Eurycoma longifolia Jack is a medicinal plant extensively used in Southeast Asian traditional medicine. While most research has focused on its aphrodisiac and testosterone-enhancing properties, recent investigations indicate that *E. longifolia* possesses noteworthy antimicrobial activity. This review aims to provide a comprehensive and critical analysis of studies conducted by various researchers on the antimicrobial potential of *E. longifolia*, with particular emphasis on in-vitro investigations.

II. BOTANICAL DESCRIPTION AND ETHNOMEDICINAL BACKGROUND

3.1 Major Phytochemical Classes

Table 1

Major phytochemical constituents of *Eurycoma longifolia*

Phytochemical class	Representative compounds	Biological relevance
Quassinoids	Eurycomanone, eurycomalactone	Antimicrobial, antimalarial
Alkaloids	Canthin-6-one	Antibacterial, antifungal
Flavonoids	Quercetin derivatives	Antioxidant
Saponins	Glycosidic saponins	Membrane-active
Triterpenes	Tirucallane derivatives	Cytoprotective

Quassinoids are considered the principal bioactive constituents and are largely responsible for the pharmacological effects of the plant.

IV. PHARMACOLOGICAL ACTIVITIES

Beyond antimicrobial activity, *E. longifolia* exhibits a broad spectrum of pharmacological effects.

4.1 Aphrodisiac and Endocrine Effects

Multiple studies report increased serum testosterone levels, improved spermatogenesis, and enhanced libido following administration of *E. longifolia* extracts.

4.2 Antimalarial Activity

Quassinoids isolated from the roots show potent activity against *Plasmodium falciparum*, validating traditional antimalarial use.

Eurycoma longifolia is a slender, slow-growing tree that can reach heights of up to 15 m. It is characterized by pinnate leaves, small reddish-brown flowers, and a long, bitter taproot that serves as the primary medicinal part. The plant is native to Malaysia, Indonesia, Thailand, and Vietnam, where it grows in lowland and hilly rainforests.

Traditionally, the roots of *E. longifolia* are prepared as decoctions or powders and used to treat fever, malaria, gastrointestinal infections, fatigue, and sexual disorders. In folk medicine, the plant is regarded as a general health tonic and immune enhancer. These ethnomedicinal claims have prompted extensive scientific investigations into its phytochemistry and pharmacological activities.

III. PHYTOCHEMICAL COMPOSITION

Phytochemical studies have revealed that *E. longifolia* contains a diverse array of bioactive compounds, with quassinoids being the most prominent.

4.3 Anticancer and Cytotoxic Properties

In-vitro studies demonstrate cytotoxic activity against several cancer cell lines via apoptosis induction and inhibition of DNA synthesis.

4.4 Antioxidant and Anti-Inflammatory Effects

Flavonoids and phenolic compounds contribute to antioxidant defense and modulation of inflammatory pathways.

V. IN-VITRO ANTIMICROBIAL ACTIVITY

5.1 Antibacterial Studies

Numerous researchers have investigated the antibacterial activity of *E. longifolia* using agar diffusion and broth dilution methods.

Table 2

Summary of antibacterial studies on *Eurycoma longifolia*

Author (Year)	Extract type	Test organisms	Key observations
Sunil et al.	Ethanollic root extract	<i>S. aureus</i> , <i>E. coli</i>	Significant inhibition zones
Hemant et al.	Methanolic extract	<i>B. subtilis</i>	Low MIC values
Yasmin et al.	Quassinoid fraction	MRSA	Enhanced antibacterial effect

Overall, Gram-positive bacteria appear more susceptible than Gram-negative species, likely due to differences in cell wall architecture.

5.2 Antifungal Studies

Antifungal activity has been reported against *Candida albicans* and *Aspergillus* species.

Table 3

Antifungal activity of *Eurycoma longifolia*

Fungal strain	Extract/fraction	Outcome
<i>Candida albicans</i>	Methanolic extract	Growth inhibition
<i>Aspergillus niger</i>	Alkaloid fraction	Reduced sporulation

5.3 Synergistic Interactions

Some studies report synergistic effects when *E. longifolia* extracts are combined with conventional antibiotics, resulting in reduced minimum inhibitory concentrations. This suggests possible efflux pump inhibition or enhanced membrane permeability.

- In-vivo antimicrobial and toxicity studies
- Molecular target identification
- Clinical validation and formulation development

VI. MECHANISMS OF ANTIMICROBIAL ACTION

Proposed mechanisms underlying the antimicrobial activity of *E. longifolia* include:

- Disruption of microbial cell membranes
- Inhibition of nucleic acid and protein synthesis
- Enzyme inhibition
- Induction of oxidative stress in microbial cells

The presence of multiple active constituents supports a multi-target mode of action.

VII. LIMITATIONS AND RESEARCH GAPS

Despite promising results, existing studies show several limitations:

- Predominance of in-vitro investigations
- Lack of standardized extracts
- Limited mechanistic and molecular studies
- Absence of robust clinical trials

VIII. FUTURE PERSPECTIVES

Future research should focus on:

- Standardization based on marker quassinoids

IX. CONCLUSION

Eurycoma longifolia Jack is a pharmacologically important medicinal plant with significant in-vitro antimicrobial activity supported by studies from multiple researchers. The presence of quassinoids, alkaloids, and flavonoids contributes to its broad antimicrobial spectrum and multi-mechanistic action. Although further in-vivo and clinical investigations are required, *E. longifolia* holds strong potential as a natural source for the development of novel antimicrobial agents, particularly in the era of rising drug resistance.

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