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Curry Leaf as a Natural Shield: Antimicrobial Potential of Murraya Koenigii against Gram-negative Bacteria

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ABSTRACT

The global rise of multidrug-resistant (MDR) Gram-negative bacteria such as Escherichia coli, Klebsiella pneumoniae, and Salmonella typhi poses a major public health challenge. Conventional antibiotics are losing efficacy due to resistance mechanisms, including efflux pumps, enzymatic degradation, and biofilm formation. This study investigates the antimicrobial activity of ethanol extracts of Murraya koenigii (Curry Leaf), a medicinal plant belonging to the Rutaceae family. The leaves are rich in carbazole alkaloids like mahanimbine, girinimbine, and koenimbine, which have demonstrated antibacterial and antioxidant potential. Ethanolic extracts were tested using the agar well diffusion method against Gram-negative strains. Results revealed moderate inhibitory effects, with inhibition zones of 13.6 mm for E. coli, 12.9 mm for K. pneumoniae, and 12.4 mm for S. typhi, compared to 22–24 mm for ciprofloxacin. Although less potent than standard antibiotics, M. koenigii offers promising natural antimicrobial properties with reduced chances of resistance. This research validates traditional medicinal use and highlights its potential in developing plant-based antimicrobial formulations.

***Keywords**: Murraya Koenigii, Gram-Negative Bacteria, Resistances Antimicrobial Activity, Carbazole Alkaloids, Herbal Medicine, Multidrug Resistance.*

Introduction

Antibiotic resistance has become a pressing global issue, particularly among Gram-negative bacteria such as *Escherichia coli, Klebsiella pneumoniae*, and *Salmonella typhi*. The World Health Organization (2024) has recognized antimicrobial resistance as one of the top ten threats to global health. Gram-negative bacteria pose special challenges due to their outer membrane, which limits drug entry, and their ability to form biofilms that protect them from conventional antibiotics.

In recent years, researchers have turned to medicinal plants as alternative sources of antimicrobial agents. Unlike synthetic antibiotics, plant-derived compounds are structurally diverse, targeting bacteria through multiple pathways and thus reducing the likelihood of resistance development. *Murraya koenigii*, commonly known as Curry Leaf, is a traditional culinary and medicinal plant in India and Southeast Asia. Rich in bioactive alkaloids, flavonoids, and terpenoids, it is traditionally used for treating gastrointestinal disorders, infections, and inflammation (Sultana *et al*., 2020).

This study aims to assess the antimicrobial activity of *M. koenigii* leaf extracts against clinically significant Gram-negative pathogens, thereby validating its ethnomedicinal relevance.

Literature Review

The search for natural antimicrobials has gained momentum as resistance to synthetic drugs continues to rise. Among various medicinal plants, *Murraya koenigii* (Curry Leaf) has attracted scientific attention due to its rich phytochemistry, including carbazole alkaloids such as mahanimbine, girinimbine, and koenimbine, which display antibacterial, antioxidant, and hepatoprotective properties (Kumar *et al.,* 2019).

Ali *et al*. (2017) first demonstrated the effectiveness of curry leaf extracts against multidrug-resistant pathogens. Sultana *et al.* (2020) showed its phytochemicals can disrupt bacterial biofilms. Singh *et al.* (2022) reported synergistic effects when carbazole alkaloids were combined with ciprofloxacin, leading to enhanced bacterial inhibition. Joshi *et al.* (2023) provided direct evidence of efficacy against Salmonella typhi. Khan *et al.* (2023) revealed alkaloids interfere with bacterial cell wall synthesis. Verma *et al.* (2023) highlighted activity against resistant Salmonella strains. Patel *et al.* (2024) demonstrated the role of nanocarriers in improving bioavailability, and Sharma *et al.* (2024) confirmed biofilm inhibition by curry leaf alkaloids.

Despite these encouraging findings, most studies have relied on crude extracts or in vitro assays, leaving gaps in standardization, in vivo validation, and clinical applicability. The present study addresses this by evaluating the direct antimicrobial activity of ethanolic extracts of *M. koenigii* against clinically relevant Gram-negative bacteria (*E. coli, K. pneumoniae,* and *S. typhi).*

Methodology

Plant Collection and Extraction: Fresh leaves of *Murraya koenigii* were collected from local sources in Jaipur, Rajasthan. Leaves were washed, shade-dried, powdered, and extracted using ethanol in a Soxhlet apparatus. Extracts were concentrated with rotary evaporation and stored at 4°C.

Microorganisms Used: Standard strains of *E. coli, K. pneumoniae,* and *S. typhi* were obtained from a certified microbiology laboratory.

Antimicrobial Assay: The agar well diffusion method was used. Wells were loaded with 100 µL of ethanolic extract, and ciprofloxacin (10 µg) was used as the standard control. Plates were incubated at 37°C for 24 hours, and zones of inhibition were measured in millimeters.

Results

The ethanolic extract of *M. koenigii* demonstrated moderate antibacterial activity.

Test Organism	Zone of Inhibition (mm)	Ciprofloxacin (Control)
Escherichia coli	13.6	22–24
Klebsiella pneumoniae	12.9	22–24
Salmonella typhi	12.4	22–24

Although the inhibition zones were smaller compared to ciprofloxacin, the results indicate clear antimicrobial potential.

Discussion

The findings support earlier research that carbazole alkaloids in *M. koenigii* possess antibacterial properties. The moderate activity observed is significant considering that plant extracts often act through multiple pathways. This multi-target nature makes bacterial resistance less likely compared to conventional antibiotics.

The relatively lower potency compared to ciprofloxacin indicates that crude extracts may require purification and concentration of active compounds. Advanced drug delivery methods, such as nanoparticles, have been shown to enhance antimicrobial efficacy of plant-derived compounds (Patel *et al.,* 2024). Moreover, combining curry leaf extract with standard antibiotics may yield synergistic effects, as suggested by Singh *et al.* (2022).

Conclusion

This study validates the antimicrobial activity of *Murraya koenigii* ethanol extracts against Gram-negative bacteria. While less potent than ciprofloxacin, the extracts demonstrate significant antibacterial potential, making them promising candidates for herbal drug development. Their affordability, safety, and accessibility further enhance their value in combating antimicrobial resistance.

Future Scope

- Isolation and purification of specific carbazole alkaloids.
- In vivo studies and clinical trials for safety and efficacy.
- Development of standardized herbal formulations.
- Synergistic studies with conventional antibiotics.
- Application of nanotechnology to enhance delivery and bioavailability.

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