

Evaluation of Antibacterial Potential and Phytochemical Properties of Tulsi (*Ocimum sanctum*), Turmeric (*Curcuma longa*), and Curry Leaf (*Murraya koenigii*) Against Gram-Negative Bacteria: Current Findings and Future Prospects

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Abstract - Antibiotic resistance among Gram-negative bacteria is a pressing global challenge. This study investigates the antibacterial activity and phytochemical composition of Tulsi, Turmeric, and Curry Leaf, three plants central to Indian ethnomedicine. Phytochemical screening revealed diverse bioactive compounds including flavonoids, alkaloids, tannins, phenols, and curcuminoids. Antibacterial assays demonstrated significant inhibition zones, particularly for Tulsi and Turmeric against *Escherichia coli* and *Klebsiella pneumoniae*. Curry Leaf showed moderate activity but strong antioxidant potential. While the study establishes the antibacterial efficacy of these plants, further work is needed to isolate active compounds, explore synergistic effects, and validate findings in vivo.

Keywords - Antibiotic resistance, Gram-negative bacteria, Medicinal plants, Tulsi (*Ocimum sanctum*), Turmeric (*Curcuma longa*).

I. INTRODUCTION

Antibiotic resistance in Gram-negative bacteria such as *Escherichia coli* and *Klebsiella pneumoniae* has become a global health crisis, limiting the effectiveness of conventional drugs (Bauer et al., 1966; Cowan, 1999). Medicinal plants are increasingly recognized as promising alternatives due to their rich phytochemical diversity and traditional use in ethnomedicine (Harborne, 1998; Sofowora, 1993).

Tulsi (*Ocimum sanctum*) is widely revered in Ayurveda for its antimicrobial, immunomodulatory, and antioxidant properties (Prakash & Gupta, 2005; Puntambekar et al., 2025). Turmeric (*Curcuma longa*) contains curcuminoids, which exhibit broad-spectrum antibacterial and anti-inflammatory activity (Gupta et al., 2013; Jadheerahsan et al., 2022).

Curry Leaf (*Murraya koenigii*) is traditionally used for gastrointestinal disorders and has demonstrated antioxidant and antibacterial effects (Gahlawat et al., 2014; Singh et al., 2011).

This study is unique in comparing these three plants simultaneously against Gram-negative bacteria, integrating phytochemical profiling with antibacterial assays (Anitha et al., 2025; Iqbal et al., 2024).

II. REVIEW OF LITERATURE

Several studies have highlighted the antibacterial potential of Tulsi. Prakash & Gupta (2005) reported its therapeutic uses in traditional medicine, while Puntambekar et al. (2025) demonstrated its phytochemical diversity and antibacterial efficacy. Jadheerahsan et al. (2022) compared Tulsi and

Turmeric extracts, showing strong inhibition against *E. coli*.

Turmeric has been extensively studied for its curcuminoids. Gupta et al. (2013) reviewed its therapeutic roles, emphasizing antibacterial and anti-inflammatory properties. Cowan (1999) also noted plant-derived compounds like curcumin as effective antimicrobial agents.

Curry Leaf has received attention for its antioxidant and antibacterial properties. Singh et al. (2011) demonstrated its antimicrobial activity, while Gahlawat et al. (2014) reviewed its phytochemistry and pharmacological potential. Iqbal et al. (2024) further confirmed its bioactive potential in comparative studies with Tulsi and Ashoka.

Classical phytochemical methods described by Harborne (1998) and Sofowora (1993) remain foundational for screening bioactive compounds. These methods have been applied in recent studies (Anitha et al., 2025) to evaluate medicinal plants against bacterial pathogens.

III. MATERIALS AND METHODS

Plant material: Fresh Tulsi leaves, Turmeric rhizomes, Curry Leaf leaves were collected and authenticated. Methanolic and aqueous extracts were prepared using standard protocols (Harborne, 1998).

Phytochemical screening was conducted to detect alkaloids, flavonoids, tannins, saponins, and phenols. Antibacterial activity was assessed using the disc diffusion method against *Escherichia coli* and *Klebsiella pneumoniae* (Bauer et al., 1966). Ciprofloxacin served as the positive control.

Results

Phytochemical Composition:

- Tulsi: Alkaloids, flavonoids, tannins, phenols.
- Turmeric: Curcuminoids, essential oils, phenolic compounds.
- Curry Leaf: Alkaloids, phenolic content, antioxidants.
- Antibacterial Activity:

- Tulsi extract showed strong inhibition against *E. coli* (zone >15 mm).
- Turmeric extract demonstrated moderate to strong activity due to curcumin's bactericidal properties.
- Curry Leaf extract exhibited mild antibacterial activity, but notable antioxidant potential.

Discussion

The synergistic effect of phytochemicals enhances antibacterial activity. Tulsi and Turmeric are more effective against Gram-negative bacteria compared to Curry Leaf, consistent with earlier findings (Jadheeransan et al., 2022; Singh et al., 2011). Curry Leaf's antioxidant properties may complement antibacterial activity in combined formulations.

This study is novel because it directly compares three culturally significant plants and integrates phytochemical screening with antibacterial assays (Anitha et al., 2025; Iqbal et al., 2024).

IV. CONCLUSION

Tulsi, Turmeric, and Curry Leaf possess significant phytochemical diversity and antibacterial potential. Tulsi and Turmeric are particularly effective against Gram-negative bacteria, suggesting their role in combating antibiotic resistance.

Future Scope

- Compound isolation & characterization (via GC-MS, LC-MS, NMR).
- Synergistic formulations combining Tulsi, Turmeric, and Curry Leaf.
- Nanotechnology applications: herbal nanoparticles for resistant Gram-negative bacteria.
- In vivo validation in animal infection models.
- Clinical translation: herbal-based adjunct therapies with antibiotics.
- Green extraction methods for sustainable phytochemical recovery.

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