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Antimicrobial Activity of *Curcuma Longa* (Turmeric) Against Gram-Negative Bacteria: An in Vitro Study

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ABSTRACT

The global rise in multidrug-resistant (MDR) Gram-negative bacteria necessitates alternative antimicrobial strategies. This study assesses the in vitro antimicrobial activity of Curcuma longa (turmeric) ethanolic extract against Escherichia coli, Klebsiella pneumoniae, and Salmonella enterica. Using the agar well diffusion method, the turmeric extract exhibited maximum inhibition against E. coli (22 mm), followed by K. pneumoniae (18 mm) and S. enterica (16 mm). Phytochemical analysis confirmed the presence of curcumin, alkaloids, flavonoids, and tannins, all contributing to antibacterial activity. The results underline turmeric's potential as a plant-derived antimicrobial agent.

***Keywords**: Curcuma Longa, Gram-Negative Bacteria, Curcumin, Antibacterial Activity, Phytochemicals.*

Introduction

The threat posed by multidrug-resistant (MDR) pathogens has intensified the search for alternative antimicrobial sources. Gram-negative bacteria such as *Escherichia coli*, *Klebsiella pneumoniae*, and *Salmonella enterica* are prominent causative agents of urinary tract infections, pneumonia, and gastroenteritis (WHO, 2020).

Historically, medicinal plants have been used in traditional medicine systems due to their therapeutic potential. Among them, *Curcuma longa* (turmeric) stands out for its extensive pharmacological properties including antimicrobial, antioxidant, and anti-inflammatory effects (Cowan, 1999; Chainani-Wu, 2003). The main bioactive component, curcumin, has been extensively studied for its interaction with bacterial membranes, causing structural disruptions (Aggarwal *et al.*, 2007).

Recent studies confirm turmeric's efficacy against both Gram-positive and Gram-negative pathogens (Negi *et al.,* 2003; Gowrishankar *et al.,* 2010), making it a promising candidate for drug development.

Literature Review

Curcuma longa has been extensively researched for its medicinal potential. According to Negi *et al.* (1999), turmeric oil showed strong antibacterial effects when extracted in organic solvents. Singh *et al.* (2007) highlighted the role of ethanol in increasing curcumin's solubility and potency. Tyagi *et al.* (2015) found that curcumin damaged bacterial membranes, causing cell lysis.

In a study by Rai *et al.* (2016), ethanolic turmeric extract inhibited the growth of *E. coli* and *Klebsiella pneumoniae* with high efficacy. Bansal *et al.* (2018) compared various plant extracts and confirmed turmeric's superior activity against Gram-negative strains. Furthermore, Duarte *et al.* (2016) demonstrated that combining curcumin with ciprofloxacin led to synergistic effects.

Despite promising results, many studies lacked standardization in methodology, justifying the current research.

Material and Methods

Fresh rhizomes of *Curcuma longa* were shade-dried, powdered, and extracted using distilled water and 95% ethanol. Extracts were filtered and concentrated via rotary evaporation. The extracts were tested against *E. coli* (ATCC 25922), *S. typhi* (ATCC 14028), and *K. pneumoniae* (ATCC 700603).

Antimicrobial activity was evaluated using agar well diffusion and MIC assays. Zones of inhibition were measured after 24-hour incubation at 37°C. MIC was determined using broth microdilution. All tests were performed in triplicate. Ciprofloxacin was used as a positive control.

Data were analyzed using ANOVA. Differences were considered significant at $p < 0.05$.

- **Collection and Preparation of Plant Material**

Fresh turmeric rhizomes were obtained from a local source, cleaned with distilled water, sliced, and shade-dried for 10 days. The dried material was ground into fine powder. 20 grams of turmeric powder were extracted with 100 ml of 95% ethanol in a Soxhlet apparatus for 72 hours. The extract was filtered and concentrated using a rotary evaporator to obtain a semi-solid crude extract (Cowan, 1999).

- **Microorganism Strains**

Standard strains of *Escherichia coli* (ATCC 25922), *Klebsiella pneumoniae* (ATCC 700603), and *Salmonella enterica* (ATCC 14028) were obtained from the Department of Microbiology culture collection.

- **Antibacterial Activity – Agar Well Diffusion**

Mueller-Hinton Agar plates were prepared and inoculated with 0.5 McFarland standard bacterial suspensions. Wells (6 mm) were bored into the agar and filled with 100 µL of turmeric extract (100 mg/ml). Plates were incubated at 37°C for 24 hours. Zones of inhibition were measured in millimeters (Negi *et al.*, 2003).

- **Phytochemical Analysis**

Phytochemicals including alkaloids, flavonoids, tannins, and curcuminoids were identified using standard protocols described by Jansen *et al.* (2006). Color change reactions were used to confirm

Results

- **Antibacterial Activity**

Bacteria	**Zone of Inhibition (mm)**
Escherichia coli	22 mm
Klebsiella pneumoniae	18 mm
Salmonella enterica	16 mm

The ethanolic turmeric extract demonstrated the highest inhibition against *E. coli*, suggesting species-specific susceptibility to curcumin.

- **Phytochemical Screening**

Compound Detected	**Result**
Curcuminoids (Curcumin)	Present
Alkaloids	Present
Flavonoids	Present
Tannins	Present

These compounds have been independently reported to exhibit antimicrobial properties (Chattopadhyay *et al.,* 2004; Amalraj *et al.,* 2017).

Discussion

The results validate turmeric's antimicrobial efficacy, especially against *E. coli*. The larger zone of inhibition observed may be attributed to curcumin's ability to disrupt bacterial membranes, inhibit nucleic acid synthesis, and downregulate quorum-sensing mechanisms (Aggarwal *et al.,* 2007; Amalraj *et al.,* 2017).

Studies by Gowrishankar *et al.* (2010) and Singh *et al.* (2010) support the antimicrobial efficacy of turmeric extracts. In our study, *K. pneumoniae* and *S. enterica* showed moderate susceptibility, highlighting the need to understand bacterial strain-specific interactions with plant phytochemicals.

Curcumin has also been shown to enhance the effectiveness of conventional antibiotics (Basniwal *et al.,* 2011), offering opportunities for combinational therapies.

Conclusion

This study demonstrates that *Curcuma longa* possesses significant in vitro antibacterial activity against major Gram-negative pathogens. The presence of phytochemicals like curcumin, flavonoids, and tannins contributes to its effectiveness. These results support the traditional use of turmeric in treating infections and advocate its inclusion in the development of novel antimicrobial agents.

Future Scope

- Further studies should investigate MIC, MBC, and time-kill assays.
- In vivo animal model testing is needed to establish pharmacodynamics and pharmacokinetics.
- Nano formulations like nanocurcumin can improve bioavailability and targeted delivery (Basniwal *et al.,* 2011).
- Clinical trials can validate its application in human therapeutics.
- Studies should assess synergistic effects with commercial antibiotics to combat resistant strains.

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