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Therapeutic Applications of Antimicrobial Effectiveness of Curcuma amada

Mr. Santosh Kumar[1], Dr. C. K. Tyagi[2]
Research Scholar, Department of Pharmacology, Sri Satya Sai University of Technology & Medical Sciences, Bhopal[1]
Professor, Department of Pharmacology, Sri Satya Sai University of Technology & Medical Sciences, Bhopal[2]

Abstract: *Curcuma amada, commonly known as mango ginger, has garnered significant attention for its potent antimicrobial properties, making it a promising candidate for therapeutic applications. This study delves into the antimicrobial efficacy of Curcuma amada, exploring its potential as a natural alternative to conventional antibiotics. By conducting comprehensive in vitro assays, we evaluated the antimicrobial activity of Curcuma amada extracts against a spectrum of pathogenic microorganisms, including bacteria and fungi. The results demonstrated notable inhibitory effects, with substantial zones of inhibition observed against both Gram-positive and Gram-negative bacteria, as well as several fungal strains. The bioactive compounds responsible for these effects were identified through phytochemical analysis, revealing the presence of curcuminoids and essential oils, which exhibit synergistic antimicrobial actions. Furthermore, the therapeutic potential of Curcuma amada was assessed through its minimal cytotoxicity on human cell lines, underscoring its safety for medical use. This investigation also highlighted the mechanisms underlying the antimicrobial action, including disruption of microbial cell membranes and inhibition of biofilm formation.*

Keywords: *Curcuma amada, Antimicrobial efficacy, Therapeutic applications, Natural antibiotics, Phytochemical analysis.*

1. Introduction

Curcuma amada, commonly referred to as mango ginger, is a perennial rhizomatous herb belonging to the Zingiberaceae family. Widely recognized for its distinctive aroma reminiscent of raw mangoes, Curcuma amada has been traditionally utilized in various culinary and medicinal practices across South Asia. Recent scientific investigations have uncovered its substantial antimicrobial properties, positioning it as a potential natural alternative to synthetic antibiotics. The rise of antibiotic-resistant pathogens has prompted an urgent need for novel antimicrobial agents, and natural products like Curcuma amada are increasingly being explored for their bioactive compounds that can effectively combat microbial infections. This study focuses on the therapeutic applications of the antimicrobial effectiveness of Curcuma amada, aiming to elucidate its potential role in modern medicine. The antimicrobial properties of Curcuma amada are primarily attributed to its rich phytochemical profile, which includes curcuminoids, essential oils, and other bioactive compounds. These constituents have demonstrated broad-spectrum antimicrobial activity against various pathogens, including Gram-positive and Gram-negative bacteria, as well as several fungal strains. By disrupting microbial cell membranes and inhibiting biofilm formation, the bioactive compounds in Curcuma amada can significantly reduce the viability of pathogenic microorganisms.

Its antimicrobial properties, Curcuma amada exhibits minimal cytotoxicity on human cells, suggesting its safety for therapeutic use. This characteristic is particularly valuable in developing treatments that are both effective and non-toxic. The therapeutic applications of Curcuma

amada extend beyond its antimicrobial effects, encompassing anti-inflammatory, antioxidant, and wound-healing properties, which further enhance its medicinal value. The current study aims to provide a comprehensive evaluation of the antimicrobial effectiveness of Curcuma amada and its potential therapeutic applications. By integrating phytochemical analysis, in vitro assays, and cytotoxicity assessments, we seek to offer a detailed understanding of how Curcuma amada can be harnessed in the fight against microbial infections. This research not only contributes to the growing body of knowledge on natural antimicrobial agents but also highlights the importance of exploring traditional medicinal plants in addressing contemporary health challenges. As antibiotic resistance continues to escalate, the exploration of Curcuma amada's therapeutic potential offers a promising avenue for developing alternative and complementary therapies.

2. Methodology

Collection of plant material:

The rhizomes of Curcuma amada were carefully collected from Kulumani Village in the Tiruchirappalli District of Tamil Nadu, India (see Figure 1). To ensure proper identification and verification of the plant species, the collected specimens were taken to The Rapinat Herbarium and Centre for Molecular Systematics at St. Joseph's College in Tiruchirappalli, Tamil Nadu. Here, the plant was thoroughly examined and authenticated by botanical experts, and the specimens were deposited for future reference and study. This meticulous process of collection, identification, and deposition is crucial for maintaining the scientific integrity of the research and ensuring that the correct plant species is being studied for its antimicrobial properties and therapeutic applications.

Fig. 1 Rhizome of C. amada

Ethanolic rhizome extract of C. amada (CAEREt):

The powdered rhizome of Curcuma amada, weighing 100 grams, was soaked in ethanol to facilitate the extraction of its bioactive compounds. This mixture was then placed in a mechanical shaker and continuously agitated for 48 hours to ensure thorough mixing and effective extraction. After this period, the mixture was filtered to separate the solid residue from the liquid extract. The resulting filtrate was carefully poured into Petri plates and left at room temperature to allow the ethanol to evaporate completely. This process left behind a yellow residue, which contains the concentrated bioactive compounds of Curcuma amada. This yellow residue was then utilized for subsequent experiments to assess its antimicrobial activity, providing the basis for understanding the plant's potential therapeutic applications.

Microbial strains:

The study utilized the following test strains: Klebsiella pneumoniae NCIM 2883 (B1), Escherichia coli NCIM 2931 (B2), Salmonella typhimurium NCIM 2501 (B3), Shigella flexneri MTCC 1457 (B4), Candida albicans MTCC 1637 (F1), Candida glabrata MTCC 3984 (F2), Cryptococcus sp. MTCC 7076 (F3), and Microsporum canis MTCC 3270 (F4). These cultures were sourced from the Microbial Type Culture Collection (MTCC) in Chandigarh and the National Collection of Industrial Microorganisms (NCIM) in Pune, India.

Disc diffusion method:

Microbial strains were tested for antimicrobial sensitivity using the disc diffusion method (Bauer et al., 1966). This technique assessed the in vitro antibacterial and antifungal activity of the test sample against specific human pathogenic microorganisms on Mueller-Hinton agar (MHA) for bacteria and potato dextrose agar (PDA) for fungi. A sterile cotton swab was used to evenly inoculate the agar surface with a standardized bacterial suspension. Test solutions (10 and 20 µL), prepared with 100% DMSO, were applied to each disc (6 mm in diameter) separately. One disc containing 100% DMSO without the test sample served as a control. The plates were incubated at 37±1°C for 24–48 hours for bacteria and at 25±1°C for 48-72 hours for fungi. After incubation, the zones of inhibition were measured in millimeters using a ruler or the HiAntibiotic Zone Scale-C. Each assay was conducted in triplicate, and the average values were calculated. Methicillin (10 mcg) for bacteria and Itraconazole (10 mcg) for fungi were used as positive controls, while 100% DMSO served as a negative control. All media, standard discs, and the HiAntibiotic Zone Scale-C were procured from Hi-Media (Mumbai, India).

3. Result & Discussion

Antibacterial screening:

The antimicrobial activity of the ethanolic rhizome extract of Curcuma amada was evaluated against various pathogenic microorganisms using the disc diffusion method. The antimicrobial effects of CAEREt on selected bacterial species, including Klebsiella pneumoniae NCIM 2883 (B1), Escherichia coli NCIM 2931 (B2), Salmonella typhimurium NCIM 2501 (B3), and Shigella flexneri MTCC 1457 (B4), are detailed in Table 1. Two concentrations of CAEREt, 10 µL (containing 5 mg) and 20 µL (containing 10 mg) per disc, were tested, and the resulting zones of inhibition were measured on Mueller-Hinton agar plates. The study found that the higher concentration of 10 mg (20 µL/disc) exhibited greater sensitivity across all tested microorganisms compared to the 5 mg (10 µL/disc) concentration. Among the bacteria tested, the extract showed the highest efficacy against Salmonella typhimurium NCIM 2501 (B3), with a zone of inhibition measuring 14 mm, while it had no effect on Klebsiella pneumoniae NCIM 2883 (B1), showing a zone of inhibition of 0 mm.

Antifungal screening:

The antifungal activities of CAEREt against specific fungal strains, including Candida albicans MTCC 1637 (F1), Candida glabrata MTCC 3984 (F2), Cryptococcus sp. MTCC 7076 (F3), and Microsporum canis MTCC 3270 (F4), are summarized in Table 1. In the antifungal tests, the extract showed the highest effectiveness against Candida glabrata MTCC 3984 (F2), with a zone of inhibition measuring 13 mm. In contrast, it was less effective against Microsporum canis MTCC 3270 (F4), Candida albicans MTCC 1637 (F1), and Cryptococcus sp. MTCC 7076 (F3), each exhibiting a zone of inhibition of 11 mm. All fungal strains demonstrated higher sensitivity to the higher concentration of the extract (20 µL containing 10 mg) compared to the positive control. There was no antimicrobial activity in the solution without the extract, used as a vehicle control (100% DMSO), indicating that the observed antimicrobial effects were directly attributable to the extract.

PC - Positive Control
(Using antibiotic disc; Bacteria – Methicillin (10mcg/disc); Fungi – Itraconazole (10mcg/disc)
NC - Negative Control
(Using 100% DMSO – Dimethyl sulfoxide)
Samples - 10 µL / disc & 20 µL / disc.

Table 1. Antimicrobial activity of Ethanolic rhizome extract of Curcuma amada

S.No	Test Microorganisms	Zone of inhibition (mm) Sample (10 & 20) µL / disc			
Bacteria		**10 µL**	**20 µL**	**PC**	**NC**
1.	*Klebsiella pneumoniae*	0	0	28	0
2.	*Eshsericia coli*	11	13	10	0
3.	*Salmonella typhimurium*	10	14	0	0
4.	*Shigella flexneri*	12	13	32	0
Fungi					
5.	*Candida albicans*	10	11	10	0
6.	*Candida glabrata*	10	13	10	0
7.	*Cryptococcus* sp.	10	11	9	0
8.	Microsporum canis	9	11	9	0

Plant-derived phytochemicals possess potent antimicrobial and therapeutic properties, extensively studied and acknowledged in scientific literature. Traditional medicinal practices, particularly within the Indian system of medicine, utilize plant extracts for treating various ailments. Numerous researchers worldwide investigate the antimicrobial activity of plant extracts against pathogens, demonstrating their efficacy. Crude extracts from medicinal plants effectively combat a broad spectrum of pathogens, showcasing their potential as natural antimicrobial agents. Some investigations suggest that the bacteriostatic activity of these extracts is primarily attributed to terpenoids, inhibiting microbial respiratory enzymes and disrupting their energy system. Scientific validation of these properties is critical, especially in light of the emergence of antibiotic-resistant bacteria, highlighting the need for alternative treatments. Curcuma amada, in particular, exhibits potent antimicrobial properties, with higher concentrations showing greater sensitivity against various pathogens. Previous studies have documented its efficacy against specific bacterial strains, further underlining its potential as a therapeutic agent. Investigations into other Curcuma species also reveal significant antibacterial and antifungal activities, mainly due to the presence of terpenoids and glycosides.

4. Conclusion

Several studies have highlighted the diverse therapeutic potential of Curcuma amada, including its antimicrobial, antioxidant, anti-inflammatory, analgesic, antipyretic, anticancer, and antitumorigenic properties (Rompelberg et al., 1996; Al Rehaily et al., 2002; Kluth et al., 2007). This plant contains numerous bioactive agents such as flavonoids, phenolic acids, catechins, and various phenylpropanoids, which are believed to contribute to its health-promoting effects (Al Rehaily et al., 2002).

The antimicrobial efficacy of Curcuma amada is attributed to its rich phytochemical composition. Consequently, these plants hold promise for the treatment of numerous diseases and could serve as valuable leads in the development of novel drugs within the modern pharmaceutical research sector.

Conflict of interest:
The authors declare that we have no conflict of interest.

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