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Original Research Article

Solvent-dependent antimicrobial and phytochemical extracts of *Curcuma longa* against clinical pathogens

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ABSRTACT

Multi-drug resistance among clinical pathogens is alarming, and plants must be screened for their antimicrobial activity in combating these pathogens. This study aimed to explore the phytochemical and antimicrobial properties of ethanol and aqueous extracts of turmeric (*Curcuma longa*) against *Pseudomonas* spp, *Staphylococcus aureus*, and *Candida albicans*. Turmeric rhizomes were cleaned, dried at 40°C, and ground into a powder. Extraction was performed using 70% ethanol and distilled water via maceration. The agar well diffusion method was used to assess antimicrobial activity, with controls included. The minimum bactericidal concentration (MBC) and minimum inhibitory concentration (MIC) were evaluated using microdilution. Phytoconstituent extract screening was conducted using qualitative tests for various bioactive compounds. Ethanol extracts demonstrated notable antimicrobial effects, with inhibition zones of 15.8 ± 4.4 mm for *C. albicans* and 16.7 ± 3.5 mm for *S. aureus*. Aqueous extracts showed significant activity against *Pseudomonas* spp., with an inhibition zone of 21.1 ± 3.8 mm. MIC values for ethanol extracts were 400 mg/mL for Pseudomonas spp., 200 mg/mL for C. albicans, and 100 mg/mL for *S. aureus*. Aqueous extracts had MIC values of 800 mg/mL for C. albicans, 200 mg/mL for *Pseudomonas* spp., and 400 mg/mL for *S. aureus*. The phytochemical analysis revealed the presence of phenols, glycosides, tannins, anthocyanosides, and phlobatannins in the aqueous extracts, whereas only phenols were detected in the ethanol extracts. Turmeric extracts exhibit significant antimicrobial activity, with varying effectiveness depending on the solvent. The phytochemical diversity underscores turmeric's potential as a natural alternative to synthetic antibiotics.

Keywords: Turmeric, Antimicrobial Activity, Antimicrobial Resistance, Phytochemical Screening, Ethanolic Extracts

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Introduction

Antimicrobials are substances that destroy microorganisms, prevent their multiplication, or interfere with their metabolism, thereby inhibiting the growth of infections. Natural products are substantial sources of these agents, and the activity of several plants against microorganisms is well-documented.[1] The growing public health concern of preventing disease spread and combating resistance has driven global research into new antimicrobial agents from plants with a rich history of traditional application and documented efficacy, such as turmeric. Turmeric, the rhizome of *Curcuma longa*, is an ancient Asian spice used in traditional healing practices for its culinary and pharmacological properties.[2] The primary active compounds in turmeric are curcuminoids, which have been extensively studied for their diverse pharmacological activities.[1] Curcumin, the most potent curcuminoid, exhibits several medicinal benefits, including antioxidant, antimicrobial, anti-inflammatory, anti-allergy, cardio-protective, and antitumor effects.[3] Previous research has demonstrated turmeric's inhibitory effects against some bacteria, including *Staphylococcus aureus*, *Escherichia coli*, and *Bacillus subtilis*.[4] Additionally, turmeric contains other active phytochemicals such as flavonoids, terpenoids, and phenols, which collectively enhance its antimicrobial efficacy.[5]

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Despite the established antimicrobial properties, further studies are needed to elucidate specific modes of action and identify effective extraction methods and concentrations to improve turmeric's antimicrobial effect. This study aimed to investigate the phytochemical and antimicrobial properties of the extracts from turmeric (*C. longa*) against selected bacteria. The research also enhances the understanding of turmeric's antimicrobial mechanisms and explores its potential as a natural alternative to synthetic antibiotics by investigating the phytochemical properties and their antimicrobial activity.

Materials and Methods

Plant collection and identification

Fresh rhizome of *Curcuma longa* was bought in March 2024 from a local market in Nsukka, located at latitude 6.8651849 N 6° 51’55” and longitude 7.4097773 E 7° 24′35”, Southeastern Nigeria. Mr Felix Nwafor, a plant taxonomist in the Department of Pharmacognosy, University of Nigeria, authenticated the plant material. A voucher specimen with specimen number UNN/13113 was deposited at the herbarium for reference purposes.

Extract Preparation

The extraction was carried out according to the method described by Alli *et al*., 2025.[6] Briefly, the fresh turmeric rhizomes were dried at ambient temperature for one week and ground into a fine powder. Subsequently, 500 g of this powder was subjected to extraction using ethanol and water, respectively. Each solvent (2 L) was used to macerate the powder for 72 h (ethanol) or 24 h (water). The resulting solutions were passed through Whatman No. 1 filter paper, and the collected filtrates were concentrated in a heating bath maintained at 50°C.

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Antibiotic Susceptibility Assay
The sensitivity of the isolates to antibacterial agents was evaluated using the agar well diffusion method.[7,8] Bacterial cultures were evenly spread onto Mueller-Hinton agar culture dishes and standardised to a 0.5 McFarland turbidity. Wells were aseptically created on the inoculated culture plates using a cork cutter, after which varying concentrations of the extract were introduced into these wells. The culture plates were incubated at 37°C for 24 hours before assessing the zones of inhibition in millimetres. The experiment was replicated three times to ensure data reliability.

Minimum Inhibitory Concentration
The MIC was determined by using the agar diffusion technique.[9] The MIC refers to the lowest concentration of extracts that prevents visible bacterial growth on the sterile medium.

Minimum Bactericidal Concentration (MBC)
The agar diffusion technique was used to determine the MBC.[9] Briefly,1 mL of the extracts at specific concentrations was added to the test tubes. 1 mL of the cultured test organism suspension, diluted to added to the test tubes and cultured for 24 hours to achieve a 0.5 McFarland turbidity standard. A loopful of the inoculum was then aseptically transferred to a sterile agar medium and incubated for 24 h.

Phytochemical Screening Procedures
The phytochemical screening was carried out on the crude extracts to detect Phenols, Glycosides, Anthocyanosides, Tannins, Phlobatannins, according to the method described by Ilham *et al*., 2018; Kweki *et al*., 2025; Nazir & Chauhan, 2019.[10,11,12]

Data Analysis
The data collected were analysed using the Statistical Package for the Social Sciences (SPSS) version 21.0 software (IBM). The Analysis of Variance (ANOVA) method was employed to analyse the data.

Results and Discussion

This study investigated the antimicrobial and phytochemical properties of turmeric (*C. longa*) using aqueous and ethanolic extracts against *S. aureus*, *C. albicans*, and *Pseudomonas* spp. The antimicrobial activities of turmeric's aqueous and ethanolic extracts against the selected bacteria, as shown in Table 1, revealed that the ethanolic extract demonstrated strong effectiveness against *C. albicans* and S. *aureus*, with zones of inhibition of approximately 15.8 ± 4.4 mm and 16.7 ± 3.5 mm, respectively. Further observations revealed that the aqueous extract of *C. longa* is highly active against *Pseudomonas* spp., with a zone of inhibition of about 21.1 ± 3.8 mm. The ethanol extract showed high potency against *S. aureus* and *C. albicans*, consistent with the effectiveness of ethanol extracts against S. aureus, as found in previous studies.[13,14] In contrast, the aqueous extract exhibited potent activity against *Pseudomonas* spp. These findings demonstrate the role of the extraction solvent in determining the effectiveness of turmeric extracts, which is likely influenced by the varying solubility of the active compounds.

Table 1: Antimicrobial activity showing the zones of inhibition (mm) of aqueous and ethanol turmeric extract on selected organisms

Isolates	Extract	
	Aqueous	**Ethanol**
Candida albicans	14.0±4.0	15.8±4.4
Staphylococcus aureus	11.0±2.5	16.7±3.5
Pseudomonas spp.	21.1±3.8	11.4±1.7

Mean ± S.D are based on triplicate measurements.

Table 2 presents the determination of turmeric's MIC against these organisms using aqueous and ethanol as solvents. The ethanolic extract had an MIC of 200 mg/ mL, 400 mg/ mL, and 100 mg/ mL against *C. albicans*, *Pseudomonas* spp., and *S. aureus*, respectively. The aqueous extract had MICs of 800 mg/mL, 400 mg/mL, and 200 mg/mL against *C. albicans*, *S. aureus*, *and Pseudomonas* spp., respectively. The ethanolic extract had a lower MIC against *C. albicans* and *S. aureus* than *Pseudomonas* spp., indicating greater effectiveness. Conversely, the aqueous extract showed higher MIC values for *C. albicans* and *S. aureus*, suggesting reduced effectiveness; however, it had a lower MIC for *Pseudomonas* spp., indicating potential efficacy. This variability suggests that different components in turmeric extracts are responsible for their antimicrobial activity against different organisms, consistent with previous studies,[15,16] which found the antibacterial effect of turmeric against *S. aureus* due to curcuminoids, which are more soluble in alcohol.

Table 2: Minimum Inhibitory Concentration (MIC)

ISOLATES	ZONE OF INHIBITIONS (mm)									
	Aqueous (mg/ mL)					**Ethanol(mg/ mL)**				
	1600	**800**	**400**	**200**	**100**	**1600**	**800**	**400**	**200**	**100**
Candida albicans	14.0	2.3	0	0	0	15.2	9.4	5.1	0	0
Staphylococcus aureus	17.5	12.3	5.0	0	0	19.0	13.7	9.7	7.5	3.0
Pseudomonas spp.	18.3	11.4	7.3	2.1	0	14.7	7.9	4.0	0	0

Table 3 presents the results of the antibiotic susceptibility tests conducted on the selected organisms. On the gram-positive disc, *S. aureus* exhibited high resistance to all the antibiotics, with a resistance index of 0.9. On the gram-negative disc, the species of *Pseudomonas* exhibited resistance to some antibiotics, except Levofloxacin and Azithromycin, to which these bacteria are sensitive and intermediate, respectively, with a resistance index of 0.8. *C. albicans* showed no zone of inhibition, implying that antibiotics do not affect it. The antibiotic susceptibility tests conducted in this study revealed substantial resistance among the tested organisms, particularly *S. aureus* and *Pseudomonas* spp. This resistance underscores the challenges in treating infections with standard antibiotics and emphasises the urgent need for alternative antimicrobial strategies. In this study, turmeric extracts demonstrated efficacy against these resistant strains, suggesting their potential as alternative therapeutic agents, consistent with findings from previous studies.[17,18]

Table 4 presents the phytochemical assessment of turmeric's aqueous and ethanol extracts. The phytochemical screening, using the aqueous turmeric extract as the solvent, indicated the presence of phenols, glycosides, tannins, anthocyanosides, and phlobatannins. Only phenol was present as the bioactive constituent in the ethanol extract. The phytochemical analysis of turmeric's aqueous extract revealed a diverse range of bioactive compounds, including phenols, glycosides, anthocyanosides, tannins, and phlobatannins. In contrast, the ethanolic extract primarily contains phenols. These findings are consistent with previous research,[19,20] which has demonstrated the antimicrobial, anti-inflammatory, and antioxidant properties associated with phenolic compounds, flavonoids, and tannins found in turmeric.

While this study provides valuable insights, the following limitations should be acknowledged: First, the study focused on in vitro antimicrobial activity, which may not fully represent in vivo conditions. Second, the specific mechanisms of action of the bioactive phytochemicals in turmeric were not elucidated. Finally, the study did not investigate the potential synergistic interactions between turmeric extracts and standard antibiotics.

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Table 3: Antibiotic Susceptibility Test

Gram Positive Disc

ISOLATE	PEF	CN	APX	Z	AM	R	CPX	SXT	Resistance Index
Staphylococcus aureus	2(R)	0(R)	2(R)	6(R)	0(R)	6(R)	4(R)	0(R)	0.9

Keys: R = Resistance (0─10 mm), I = Intermediate (11─16 mm), S = Sensitive (≥ 17mm)
PEF: Perfloxacin (10µg), CN: Gentamycin (10µg), APX: Ampiclox (30µg), Z: Zinnacef (20µg), AM: Amoxicillin (30µg), R: Rocephin (25µg), CPX: Ciprofloxacin (10µg), SXT: Sulfamethoxazole/Trimethoprim (10µg).

Gram Negative Disc

ISOLATE	CPX	AM	AU	CN	PEF	OFX	AZ	LEV	CF	Resistance Index
Pseudomonas spp.	12(R)	8(R)	0(R)	0(R)	10(R)	0(R)	14(I)	20(S)	0(R)	0.8

Keys: R = Resistance (0─10 mm), I = Intermediate (11─16 mm), S = Sensitive (≥ 17mm)
CPX: Ciprofloxacin (10µg), AM: Amoxicillin (30µg), AU: Augmentin (10µg), CN: Gentamycin (10µg), PEF: Perfloxacin (10µg), OFX: Tarivid (10µg), AZ:Azithromycin (12µg), LEV: Levofloxacin (20µg), CF: Cefotaxime (10µg)

ISOLATE	
Candida albicans	No zone

Table 4: Phytochemical Results

	Phenol	Glycosides	Anthocyanosides	Tannins	Phlobatannins
Aqueous	+	+	+	+	+
Ethanol	+	-	-	-	-

Keys: + = Present, - = Absent

Conclusion

This study demonstrated that the ethanolic extract exhibited significant antimicrobial efficacy against *C. albicans* and *S. aureus*, while the aqueous extract was notably effective against *Pseudomonas* spp. These findings highlight the crucial role of solvent selection in determining the efficacy of extracts. The phytochemical analysis identified various bioactive compounds in the extracts, including phenols, glycosides, anthocyanosides, tannins, and phlobatannins, which contribute to their antimicrobial properties. The observed resistance of *S. aureus* and *Pseudomonas* spp. to standard antibiotics underscores the need for alternative treatments, with turmeric extracts showing promise as natural antimicrobial agents. Therefore, turmeric demonstrates potential as a source of natural antimicrobial compounds. Further research should investigate the specific mechanisms of action, optimise extraction methods, and assess in vivo efficacy to realise the therapeutic potential of this compound.

Conflict of interest

The authors declare no conflict of interest

Authors' Declaration

The authors hereby declare that the work presented in this article is original and that any liability for claims relating to the content of this article will be borne by them.

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