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Antimicrobial Activity of Ethanolic Extracts of *Zingiber officinale* and *Curcuma longa* Against Selected Clinical Bacterial Isolates

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ABSTRACT

The rise of antimicrobial resistance among common bacterial pathogens poses a significant global health challenge, necessitating the exploration of alternative therapeutic agents. This study evaluated the antimicrobial effects of ethanolic extracts of ginger (*Zingiber officinale*), turmeric (*Curcuma longa*), and their combined formulation against selected bacterial isolates, including *Escherichia coli*, *Staphylococcus aureus*, *Pseudomonas aeruginosa*, and *Salmonella* species. Using the agar well diffusion method, zones of inhibition were measured at concentrations of 50, 100, and 200 mg/mL, with gentamicin serving as a positive control. The combined extracts exhibited the highest antimicrobial activity, particularly against *E. coli* (14.0 ± 0.00 mm) and *Salmonella* species (13.0 ± 0.00 mm) at 200 mg/mL. Individual extracts of ginger and turmeric also demonstrated considerable antibacterial effects, although no activity was observed against *Pseudomonas aeruginosa* at tested concentrations. Minimum inhibitory concentrations (MICs) ranged from 12.5 to 50 mg/mL, while minimum bactericidal concentrations (MBCs) ranged between 25 and 100 mg/mL, confirming the bacteriostatic and bactericidal properties of the extracts. These findings suggest that ginger, turmeric, and their combination, possess significant antimicrobial potential and could serve as alternatives or complements to conventional antibiotics for the management of bacterial infections.

Keywords: Ginger, turmeric, antimicrobial activity, ethanolic extracts, clinical isolates,

INTRODUCTION

Microbial infections caused by bacteria such as *Escherichia coli*, *Staphylococcus aureus*, *Pseudomonas aeruginosa*, and *Salmonella* species represent significant global health concerns,

contributing substantially to morbidity and mortality rates worldwide [1]. These pathogens are responsible for a wide spectrum of diseases ranging from mild skin infections and gastrointestinal disturbances to severe systemic conditions such as septicemia, pneumonia, and urinary tract infections. The treatment of infections caused by these bacteria has been increasingly complicated by the rapid emergence and spread of antimicrobial resistance (AMR), rendering many conventional antibiotics ineffective [2, 3]. This growing resistance not only limits treatment options but also increases healthcare costs and mortality rates, particularly in resource-limited settings.

There has been interest in exploring natural products, especially medicinal plants, as sources of new antimicrobial agents. Medicinal plants have been historically valued for their therapeutic benefits and continue to be a reservoir of bioactive compounds including phenolics, flavonoids, alkaloids, saponins, and essential oils, many of which have demonstrated potent antimicrobial activity against a variety of pathogens [4]. These phytochemicals can disrupt microbial cell walls, interfere with nucleic acid synthesis, or inhibit enzyme activity, thereby exerting bactericidal or bacteriostatic effects.

Among such plants, *Zingiber officinale* and *Curcuma longa* are particularly noteworthy due to their extensive use both as culinary spices and in traditional medicine systems across the world [5]. These spices are well-documented for their broad-spectrum antimicrobial, antifungal, anti-inflammatory, and antioxidant properties, which are attributed largely to their rich phytochemical profiles including gingerols, shogaols, curcuminoids, and essential oils [6-8]. Prior investigations have confirmed that ethanolic extracts of ginger and turmeric exhibit inhibitory effects on various bacterial strains, including multidrug-resistant pathogens [9,10].

In spite of the findings, there remains a paucity of research focusing on the combined antimicrobial effects of ginger and turmeric extracts, which could potentially offer synergistic benefits and enhance efficacy. Therefore, this study aims to evaluate the antimicrobial activity of ethanolic extracts of Ginger, Turmeric, and their combination against selected clinical bacterial isolates. Additionally, the study seeks to determine the minimum inhibitory concentrations and minimum bactericidal concentrations of these extracts to understand their potency and potential application as alternative or complementary antimicrobial agents.

MATERIALS AND METHODS

Chemical and Reagents

The chemicals and reagents used for this study included ethanol (95%) for plant extraction, distilled water, Mueller-Hinton agar, nutrient broth, clinical bacterial isolates (*Escherichia coli*,

Staphylococcus aureus, *Pseudomonas aeruginosa and Salmonella*), standard antibiotics (Gentamicin) as control, sterile cotton swabs, Petri dishes, sterile filter paper discs, 0.5 McFarland standard for inoculum standardization, fresh ginger and turmeric for extract preparation, and incubator. All chemicals and reagents used were of analytical grade.

Sample Collection and Preparation

Fresh ginger rhizomes and turmeric roots were obtained from a local market (Orie-ugba) in Umuahia and were identified and authenticated at the Department of Plant Science and Biotechnology, Michael Okpara University of Agriculture, Umudike, Abia State. Samples were washed, sliced, dried at room temperature, and ground into fine powder. The powdered samples were stored in airtight containers prior to extraction.

Extraction Procedure

Ethanolic extracts were prepared by soaking 100 g of powdered ginger and turmeric separately in 500 mL of 95% ethanol for 72 hours at room temperature with occasional shaking. The mixtures were filtered using Whatman No.1 filter paper, and the filtrates were concentrated under reduced pressure using a rotary evaporator, model: Büchi Rotavap R-210 rotary evaporator manufactured in Switzerland. The extracts were stored at 4°C.

Test Organisms

Clinical isolates of *Escherichia coli*, *Staphylococcus aureus*, *Pseudomonas aeruginosa*, and *Salmonella* species were obtained from the microbiology laboratory and maintained on nutrient agar slants.

Antimicrobial Susceptibility Testing

The agar well diffusion method was employed to evaluate antibacterial activity. Mueller-Hinton agar plates were inoculated with standardized bacterial suspensions (0.5 McFarland standard). Wells of 6 mm diameter were bored into the agar and filled with 100 µL of extract solutions at concentrations of 50, 100, and 200 mg/mL. Plates were incubated at 37°C for 24 hours, and zones of inhibition were measured in millimeters. Gentamicin (10 µg) was used as the positive control.

Determination of Minimum Inhibitory Concentration and Minimum Bactericidal Concentration

MIC and MBC values were determined using the broth dilution method. Serial two-fold dilutions of extracts (ranging from 0.78 to 100 mg/mL) were prepared in nutrient broth. Each

dilution was inoculated with bacterial suspensions and incubated at 37°C for 24 hours. The lowest concentration showing no visible growth was recorded as the MIC. To determine the MBC, aliquots from clear tubes were plated onto nutrient agar and incubated; the lowest concentration with no bacterial growth on agar was recorded as the MBC.

Statistical Analysis

Experiments were performed in duplicate, and results were expressed as mean ± standard deviation.

RESULTS AND DISCUSSION

Table 1 shows the mean diameter zones of inhibition produced by various concentrations (200, 100, and 50 mg/ml) of Ginger extract against the selected bacteria. Activity was observed primarily against *E. coli*, *S. aureus*, and *Salmonella*, with *P. aeruginosa* showing resistance.

Table 1: Mean Diameter Zones of Inhibition (mm) produced by ethanolic extracts of ginger against selected clinical isolates

Test Organisms	Concentration (mg/ml)			Control
	200	100	50	Gentamicin
Escherichia coli	10.5 ± 0.70	0.0 ± 0.00	0.0 ± 0.00	25.0 ± 1.41
Staphylococcus aureus	15.0 ± 0.14	11.0 ± 0.00	9.0 ± 0.00	21.0 ± 0.70
Pseudomonas aeruginosa	0.0 ± 0.00	0.0 ± 0.00	0.0 ± 0.00	19.0 ± 0.00
Salmonella species	12.0 ± 0.00	10.0 ± 0.00	0.0 ± 0.00	22.0 ± 0.70

Values in the table are the mean ± standard deviation from the results of two replication of each experiment.

Table 2 presents the inhibition zones for turmeric extract, revealing similar trends, good activity against *E. coli*, *S. aureus*, and *Salmonella*, but no activity against *P. aeruginosa* at the tested concentrations.

Table 2: Mean Diameter Zones of Inhibition (mm) produced by ethanolic extracts of tumeric against selected clinical isolates

Test Organisms	Concentration (mg/ml)			Control
	200	100	50	Gentamicin
Escherichia coli	13.0 ± 0.00	11.5 ± 0.70	0.0 ± 0.00	25.0 ± 1.41
Staphylococcus aureus	11.0 ± 0.02	10.0 ± 0.70	0.0 ± 0.00	21.0 ± 0.70
Pseudomonas aeruginosa	0.0 ± 0.00	0.0 ± 0.00	0.0 ± 0.00	19.0 ± 0.00
Salmonella species	12.0 ± 0.00	10.0 ± 0.00	0.0 ± 0.00	22.0 ± 0.70

Values in the table are the mean ± standard deviation from the results of two replication of each experiment.

Table 3 illustrates the antibacterial effect of combined Ginger and Turmeric extracts, generally showing enhanced or comparable activity compared to the individual extracts, especially at higher concentrations (200 mg/ml).

Table 3: Mean Diameter Zones of Inhibition (mm) produced by ethanolic extracts of combined ginger and tumeric against selected clinical isolates

Test Organisms	Concentration (mg/ml) 200	100	50	Control Gentamicin
Escherichia coli	14.0 ± 0.00	12.0 ± 0.00	9.0 ± 0.00	25.0 ± 1.41
Staphylococcus aureus	12.5 ± 0.14	10.0 ± 0.00	0.0 ± 0.00	21.0 ± 0.70
Pseudomonas aeruginosa	0.0 ± 0.00	0.0 ± 0.00	0.0 ± 0.00	19.0 ± 0.00
Salmonella species	13.0 ± 0.00	11.5 ± 0.70	0.0 ± 0.00	22.0 ± 0.70

Values in the table are the mean ± standard deviation from the results of two replication of each experiment.

Table 4 summarizes the MIC and MBC values for the extracts. It provides insight into the lowest concentrations required to inhibit (MIC) and kill (MBC) the bacterial isolates. The combination extract often shows lower MIC values, indicating possible synergistic effects, particularly against *E. coli*, *S. aureus*, and *Salmonella*.

Table 4: MIC and MBC values (mg/ml) of extracts of Garlic and Tumeric against the Isolates

Extract	Organisms	100	50	25	12.5	6.25	3.12	1.56	0.78	MIC	MBC
Tumeric	*Escherichia coli*	-	-	-	+	+	+	+	+	12.5	25
	Staphylococcus aureus	-	-	+	+	+	+	+	+	25	50
	Pseudomonas aeruginosa	-	+	+	+	+	+	+	+	50	100
	Salmonella species	-	+	+	+	+	+	+	+	50	100
Ginger	*Escherichia coli*	-	-	+	+	+	+	+	+	25	50
	Staphylococcus aureus	-	-	-	+	+	+	+	+	12.5	25
	Pseudomonas aeruginosa	-	-	+	+	+	+	+	+	25	50
	Salmonella species	-	+	+	+	+	+	+	+	50	100
Ginger + Tumeric	*Escherichia coli*	-	-	-	+	+	+	+	+	12.5	25
	Staphylococcus aureus	-	-	+	+	+	+	+	+	25	50
	Pseudomonas aeruginosa	-	+	+	+	+	+	+	+	50	100
	Salmonella species	-	-	-	+	+	+	+	+	12.5	100

+: growth of the organism indicated by turbidity in the broth medium; -= Absence of growth of the test organism shown by no form of turbidity in the medium

The antimicrobial activities of ethanolic extracts of *Zingiber officinale*, *Curcuma longa*, and their combined extracts were evaluated against selected clinical isolates, namely *Escherichia coli*, *Staphylococcus aureus*, *Pseudomonas aeruginosa*, and *Salmonella* species. The results showed variable inhibition zones, indicating differential sensitivity among the bacterial species tested [11, 12].

Ginger extract demonstrated notable antibacterial activity against *Staphylococcus aureus* (15.0 ± 0.14 mm at 200 mg/mL) and *Salmonella* species (12.0 ± 0.00 mm at 200 mg/mL), while *Escherichia coli* exhibited moderate susceptibility (10.5 ± 0.70 mm), similar to the findings of Duraipandiyan et al. [13] and Jafarzadeh et al. [14]. No inhibitory effect was observed on *Pseudomonas aeruginosa* at any tested concentration, which aligns with previous studies highlighting the intrinsic resistance of *P. aeruginosa* to many plant-based antimicrobials [15, 16].

Similarly, turmeric extract showed comparable zones of inhibition against *E. coli* (13.0 ± 0.00 mm), *S. aureus* (11.0 ± 0.02 mm), and *Salmonella* species (12.0 ± 0.00 mm) at the highest concentration, but also lacked activity against *P. aeruginosa* [17, 18]. These results align with prior findings where both ginger and turmeric extracts exhibited potent antibacterial effects against Gram-negative and Gram-positive bacteria but showed limited or no activity against *Pseudomonas* species [19-22].

The inherent resistance of *Pseudomonas aeruginosa* to many antimicrobial agents is well-documented and may be attributed to its efflux systems and impermeable outer membrane [22-24].

The combination of ginger and turmeric extracts resulted in enhanced antibacterial activity, especially against *E. coli* (14.0 ± 0.00 mm) and *Salmonella* species (13.0 ± 0.00 mm), suggesting a possible synergistic interaction [25, 26]. This synergism corroborates findings by Nandini et al. [25], who reported increased antimicrobial efficacy when combining plant extracts, likely due to the diverse phytochemical compounds complementing each other's mechanisms of action [26, 27].

Minimum inhibitory concentration and minimum bactericidal concentration values further confirmed the antibacterial potential of these extracts. MIC values ranged from 12.5 to 50 mg/mL, with the combined extract showing the lowest MICs for *E. coli* and *S. aureus*, indicating greater potency [28-31]. The MBC values ranged between 25 and 100 mg/mL, showing that at higher concentrations, the extracts could exert bactericidal effects. These

results are consistent with prior studies demonstrating MIC values for Ginger and Turmeric extracts against similar pathogens within this concentration range [32-34].

The lack of activity against *Pseudomonas aeruginosa* even at higher extract concentrations and MBCs suggests that these plant extracts, though effective against many pathogens, might not be sufficient alone to treat infections caused by this resistant bacterium. This highlights the need for continued research into combinatorial therapies or novel formulations to overcome such resistance.

CONCLUSION

The study confirms the significant antimicrobial properties of ethanolic extracts of Ginger, Turmeric, and their combination against key bacterial pathogens such as *Escherichia coli*, *Staphylococcus aureus*, and *Salmonella* species. The combined extracts exhibited enhanced antibacterial activity, indicating potential synergistic effects. However, *Pseudomonas aeruginosa* showed resistance to all tested extracts. These findings support the potential use of Ginger and Turmeric extracts as alternative or complementary antimicrobial agents, especially against antibiotic-resistant strains, though further research into formulation and efficacy in vivo is recommended.

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