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ORIGINAL ARTICLE

Evaluation Of Coriandrum Sativum Seed Extracts As Potential Antimicrobial Agents Against Certain Common Pathogens

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ABSTRACT

Background: *Antimicrobial resistance (AMR) poses a major global health threat, necessitating alternative therapeutic agents. Plant-derived compounds offer promising solutions, and Coriandrum sativum (coriander) has traditional medicinal uses against infections.* ***Objective:*** *To evaluate the antibacterial activity of aqueous and methanolic extracts of Coriandrum sativum seeds against Staphylococcus aureus, Escherichia coli, and Pseudomonas aeruginosa.* ***Methods & Materials:*** *This experimental study was conducted at Mymensingh Medical College, Bangladesh, from January to December 2025. Disc diffusion and broth dilution methods were used to evaluate aqueous (ACSE) and methanolic (MCSE) seed extracts against standard bacterial strains (ATCC 25923, 25922, 27853). Zone of inhibition (ZOI) and minimum inhibitory concentration (MIC) were determined. Ciprofloxacin served as the reference antibiotic.* ***Results:*** *ACSE at 1000 mg/ml produced ZOI of 17 mm, 15 mm, and 23 mm against S. aureus, E. coli, and P. aeruginosa, respectively. MCSE showed corresponding ZOI of 17 mm, 16 mm, and 23 mm. MIC values for ACSE were 800, 800, and 700 mg/ml; for MCSE were 700, 750, and 700 mg/ml against the three organisms, respectively. Ciprofloxacin MIC ranged from 0.5 to 1 µg/ml.* ***Conclusion:*** *Coriandrum sativum seed extracts demonstrate significant, broad-spectrum antibacterial activity. Methanolic extracts showed slightly superior efficacy. These findings support traditional medicinal use and warrant further investigation for developing plant-based antimicrobial therapies.*

Keywords: Antibacterial, Coriandrum sativum, Escherichia coli, Minimum inhibitory concentration, Staphylococcus aureus, Traditional medicine

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INTRODUCTION

Antimicrobial resistance (AMR) has emerged as one of the most pressing global public health threats of the twenty-first century. The World Health Organization recognizes AMR as one of the top ten major global public health threats, with an estimated 5 million deaths annually associated with bacterial AMR worldwide [1]. The alarming reality is that, without immediate intervention, AMR could result in up to 10 million deaths per year by 2050, with the burden falling disproportionately on low- and middle-income countries [2]. The primary drivers of this crisis include the misuse and overuse of antimicrobials in human health and food production, which accelerate the natural phenomenon of resistance development and facilitate the spread of multidrug-resistant (MDR) pathogens [3]. The decline in new antibiotic development has further compounded this crisis. Following a "golden period" of antibiotic discovery between 1960 and 1980, the pharmaceutical industry progressively shifted its focus toward more profitable drug categories, resulting in a significant contraction of the antimicrobial pipeline [4]. This dwindling arsenal of effective antibiotics, coupled with the rapid evolution of bacterial resistance mechanisms, has transformed common bacterial infections into potentially life-threatening conditions. The Comprehensive Antibiotic Resistance Database reveals the existence of over 5,000 resistance reference sequences, underscoring the magnitude of the challenge [5]. Consequently, there is an urgent and compelling need to explore alternative antimicrobial agents that can complement or substitute conventional antibiotics [3,5]. In this context, medicinal plants have attracted renewed scientific attention as promising sources of novel antimicrobial compounds. Plant-derived secondary metabolites, including alkaloids, flavonoids, tannins, terpenoids, and phenolic compounds, exhibit diverse antimicrobial mechanisms that often differ from those of conventional antibiotics, potentially offering advantages in circumventing existing resistance pathways [6]. The extensive history of using plants for medicinal purposes provides a strong foundation for investigating their therapeutic potential, and plant extracts have demonstrated successful inhibition of bacteria both independently and in combination with other antimicrobial agents [7,8]. Furthermore, plant-based antimicrobials are often associated with reduced adverse effects, greater biocompatibility, and environmental sustainability [9]. Among the myriad medicinal plants with documented antimicrobial properties, Coriandrum sativum L.

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(commonly known as coriander) has garnered considerable scientific interest. Belonging to the Apiaceae family, coriander is cultivated globally. It has been utilized in traditional medicine systems for centuries to treat various ailments, including digestive disorders, inflammatory conditions, and infectious diseases [10]. The seeds of C. sativum contain a rich array of bioactive phytochemicals. Phytochemical analyses have revealed the presence of flavonoids, terpenoids, alkaloids, phenols, and saponins in coriander seed extracts [11]. Gas chromatography-mass spectroscopy studies have identified linalool as the predominant monoterpene component (approximately 53.5%), along with other significant compounds such as γ-terpinene, geraniol, and camphor [12]. These bioactive constituents are believed to contribute to the plant's broad-spectrum antimicrobial activity [10]. The antibacterial potential of Coriandrum sativum extracts has been demonstrated against both Gram-positive and Gram-negative pathogens. Essential oils and extracts obtained from coriander seeds, leaves, and stems have shown varying levels of inhibitory activity against clinically significant bacteria, including Staphylococcus aureus, Escherichia coli, Salmonella spp., and Pseudomonas aeruginosa [12,13]. Both polar and non-polar seed extracts have demonstrated antibacterial activity, with some studies reporting superior efficacy of polar (ethanolic) extracts against various bacterial genera [13]. The antimicrobial mechanisms are believed to involve disruption of bacterial cell membranes, induction of oxidative stress, and inhibition of essential enzymatic functions [9]. Given the rising prevalence of antibiotic-resistant strains of S. aureus, E. coli, and P. aeruginosa—pathogens frequently implicated in hospital-acquired and community-acquired infections—coriander seed extracts represent a particularly attractive candidate for investigation [8]. Despite the growing body of evidence supporting the antibacterial properties of Coriandrum sativum, systematic comparative evaluations of aqueous and methanolic seed extracts against standardized reference strains remain limited, particularly in the South Asian region, where the plant is extensively cultivated and traditionally used [13]. Furthermore, the determination of minimum inhibitory concentrations (MICs) using standardized broth dilution methods is essential for establishing the quantitative efficacy of these extracts and facilitating meaningful comparisons with conventional antibiotics [9]. The present study was therefore designed to evaluate the antibacterial activity of aqueous and methanolic extracts of Coriandrum sativum seeds against standard reference strains of Staphylococcus aureus (ATCC 25923), Escherichia coli (ATCC 25922), and Pseudomonas aeruginosa (ATCC 27853) using disc diffusion and broth dilution methods, with ciprofloxacin serving as the reference antibiotic.

METHODS & MATERIALS

The study population comprised standard reference strains of Staphylococcus aureus ATCC 25923, Escherichia coli ATCC 25922, and Pseudomonas aeruginosa ATCC 27853, obtained from the Department of Microbiology, Mymensingh Medical College, Bangladesh.

Inclusion criteria: Standard reference bacterial strains with documented susceptibility profiles and availability of pure cultures were included. All strains were confirmed for purity and viability before experimentation.

Exclusion criteria: Clinical isolates or strains with unconfirmed identity were excluded. Contaminated or non-viable cultures were also excluded from the study.

Study procedure: This experimental study was conducted from January to December 2025 at Mymensingh Medical College, Bangladesh. Coriander seeds were collected, dried, ground into powder, and extracted using distilled water (aqueous extract, ACSE) and methanol (methanolic extract, MCSE) following the maceration method described by Pa W et al. [14]. Antibacterial susceptibility was evaluated using the Kirby-Bauer disc diffusion method as per Clinical and Laboratory Standards Institute (CLSI) guidelines [15]. Bacterial suspensions adjusted to 0.5 McFarland standard (1.5×10^8 CFU/ml) were inoculated onto Mueller-Hinton agar plates. Filter paper discs (6 mm) impregnated with varying extract concentrations (100–1000 mg/ml) were placed on the agar and incubated at 37°C for 24 hours. Zones of inhibition were measured in millimeters. Minimum inhibitory concentrations were determined using the broth dilution method in nutrient broth, with ciprofloxacin as the reference antibiotic. Subculture studies confirmed MIC results by plating onto nutrient agar.

Data analysis: All experiments were performed in triplicate. Results were expressed as mean± standard deviation. Zone of inhibition and MIC values were recorded and tabulated for comparative analysis.

RESULT

Antibacterial activity of aqueous and methanolic extracts: Both aqueous (ACSE) and methanolic (MCSE) extracts of Coriandrum sativum seeds demonstrated concentration-dependent antibacterial activity against all three test organisms. At 1000 mg/ml, ACSE produced zones of inhibition (ZOI) of 17 mm, 15 mm, and 23 mm against S. aureus, E. coli, and P. aeruginosa, respectively. MCSE at the same concentration showed corresponding ZOI of 17 mm, 16 mm, and 23 mm. At 900 mg/ml, ACSE exhibited ZOI of 15 mm, 7 mm, and 20 mm, while MCSE showed 15 mm, 15 mm, and 20 mm against the three organisms, respectively. At 800 mg/ml, MCSE retained activity against S. aureus (13 mm) and E. coli (9 mm), whereas ACSE showed no inhibition at this concentration for any organism. No antibacterial activity (ZOI ≤ 6 mm) was observed at concentrations of 700 mg/ml and below for both extracts. The negative controls (10% DMSO for ACSE, 95% methanol for MCSE) produced no zones of inhibition. Repeat experiments confirmed these findings, with ACSE showing activity at 850 mg/ml against S. aureus (15 mm) and P. aeruginosa (13 mm), and at 950 mg/ml against E. coli (12 mm); MCSE showed activity at 750 mg/ml against S. aureus (6 mm), and at 850 mg/ml against E. coli (6 mm) and P. aeruginosa (15 mm). Among the tested organisms, P. aeruginosa exhibited the highest susceptibility to both extracts. These results are presented in *Figure 1* and summarized in *Table I*. Minimum inhibitory concentrations: The MIC values determined by the broth dilution method for ACSE were 800 mg/ml against S. aureus, 800 mg/ml against E. coli, and 700 mg/ml against P. aeruginosa. For MCSE, the MIC values were 700 mg/ml, 750 mg/ml, and 700 mg/ml against S. aureus, E. coli, and P. aeruginosa, respectively. Ciprofloxacin, the reference antibiotic, showed MIC values of 1 µg/ml against S. aureus, 1 µg/ml against E. coli, and 0.5 µg/ml against P. aeruginosa. The methanolic extract demonstrated lower MIC values than the aqueous extract against all test organisms, indicating superior efficacy. Control groups showed expected

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results: Control-1 (extract with bacterial inoculum) showed no growth at 1000 mg/ml, Control-2 (nutrient broth with bacteria) showed visible growth, and Control-3 (nutrient broth without bacteria) remained clear. Subculture studies from effective concentrations onto nutrient agar plates confirmed these MIC results, with growth observed only from tubes showing turbidity in the original experiments. These findings are presented in *Figure 2* and summarized in *Table II*.

Table I: Zone of inhibition of aqueous and methanolic coriander seed extracts against test organisms.

Concentration (mg/ml)	Extract Type	S. aureus (mm)	E. coli (mm)	P. aeruginosa (mm)
1000	ACSE	17 ± 0.5	15 ± 0.4	23 ± 0.6
1000	MCSE	17 ± 0.4	16 ± 0.5	23 ± 0.6
900	ACSE	15 ± 0.3	7 ± 0.2	20 ± 0.5
900	MCSE	15 ± 0.3	15 ± 0.4	20 ± 0.5
800	ACSE	6 ± 0.0	6 ± 0.0	6 ± 0.0
800	MCSE	13 ± 0.3	9 ± 0.2	6 ± 0.0

Values are mean ± SD of triplicate experiments. Disc diameter: 6 mm; ZOI ≤ 6 mm indicates no activity. ACSE: Aqueous Coriander Seed Extract; MCSE: Methanolic Coriander Seed Extract.

Table II: Minimum inhibitory concentrations of ACSE, MCSE, and ciprofloxacin against test organisms.

Test Organism	ACSE (mg/ml)	MCSE (mg/ml)	Ciprofloxacin (µg/ml)
S. aureus	800	700	1
E. coli	800	750	1
P. aeruginosa	700	700	0.5

MIC values determined by the broth dilution method. Values represent the lowest concentration inhibiting visible bacterial growth after 24 hours of incubation at 37°C. Subculture studies confirmed these results.

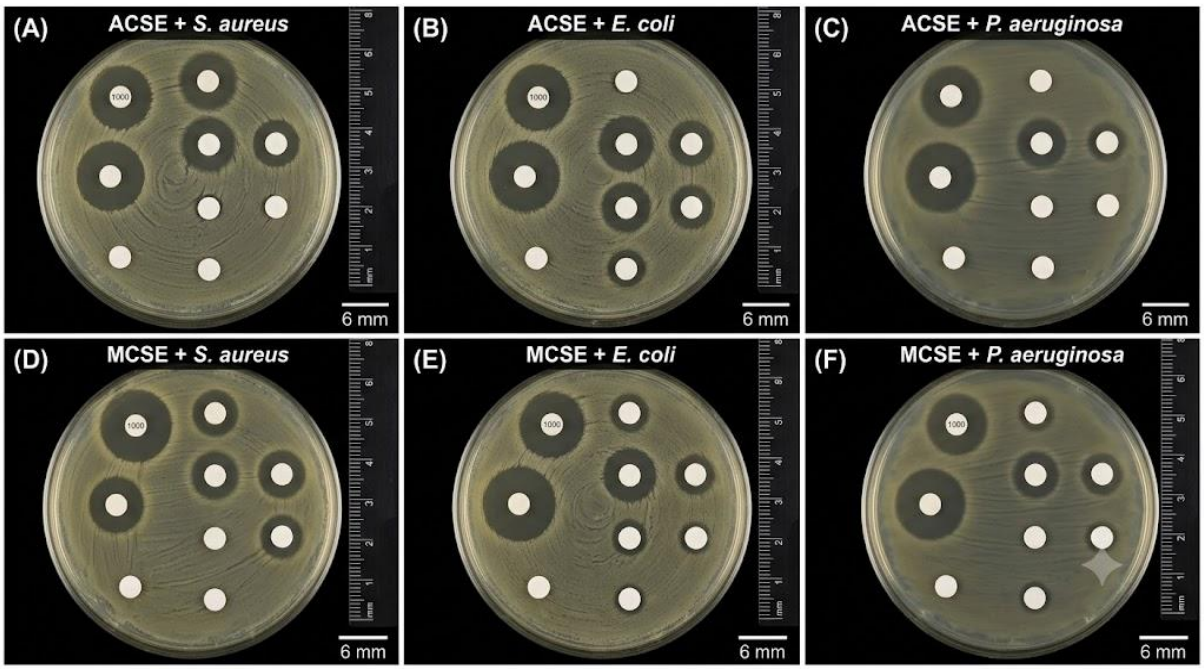

Figure 1: Representative disc diffusion plates showing ZOI for both extracts against all three organisms

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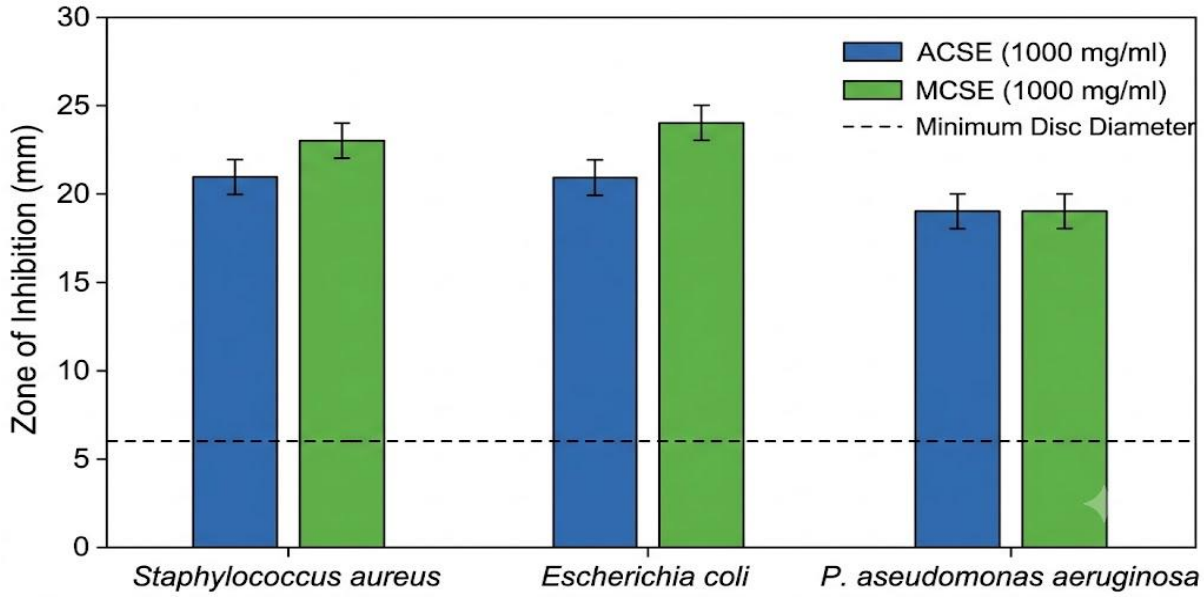

Figure 2: Bar chart comparing ZOI at 1000 mg/ml concentration for ACSE and MCSE against all three organisms

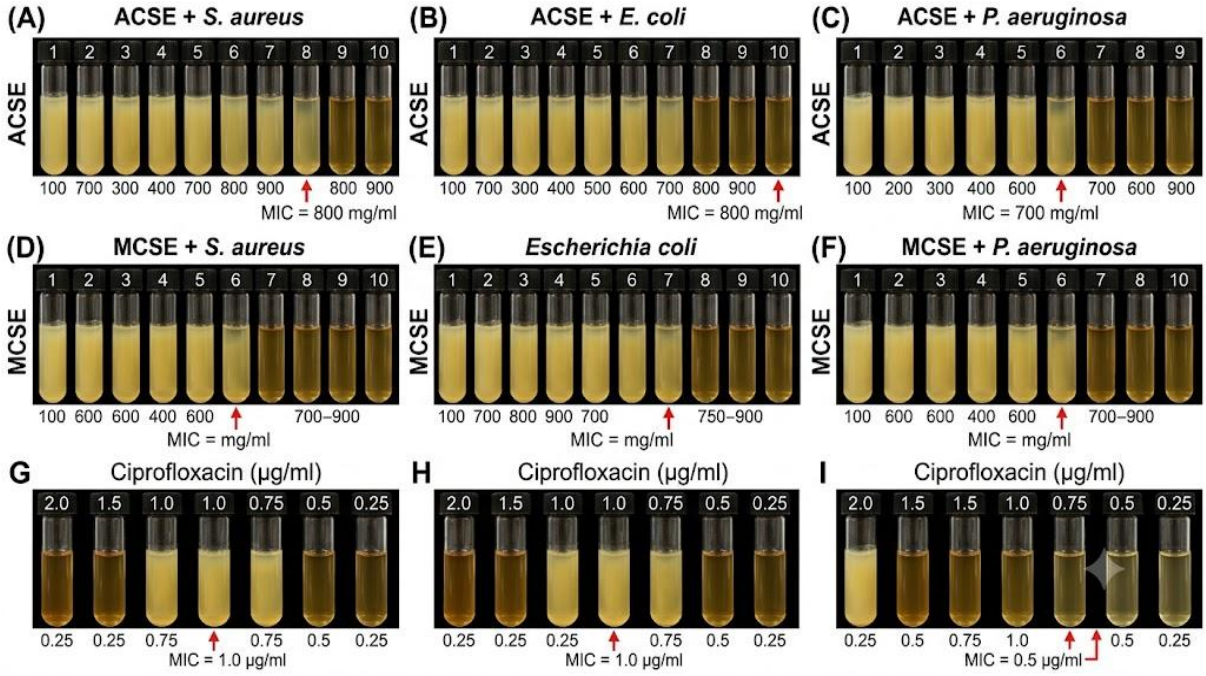

Figure 3: Representative MIC determination plates

DISCUSSION

The present study investigated the antibacterial potential of aqueous and methanolic extracts of Coriandrum sativum seeds against three clinically significant bacterial pathogens: Staphylococcus aureus, Escherichia coli, and Pseudomonas aeruginosa. The findings demonstrate that both extracts possess concentration-dependent antibacterial activity, with the methanolic extract exhibiting relatively superior efficacy compared to the aqueous extract. The disc diffusion assay revealed that at 1000 mg/ml, both extracts produced substantial zones of inhibition against all three test organisms, with the highest activity recorded against P. aeruginosa (23 mm for both extracts). The broth dilution method confirmed these findings through MIC determination, with MCSE showing lower MIC values than ACSE against all tested organisms. The observed antibacterial activity of Coriandrum sativum seed extracts aligns with previous investigations. Earlier studies have reported that coriander seed extracts exhibit varying levels of inhibitory effects against both Gram-positive and Gram-negative bacteria [15,16]. The present findings are consistent with those of Al-Jabri et al., who demonstrated ZOI values of 18 mm, 16 mm, and 22 mm for aqueous coriander extract against S. aureus, E. coli, and P. aeruginosa, respectively, at 1000 mg/ml concentration [12]. Similarly, another study reported ZOI values of 16 mm, 14 mm, and 20 mm against the same organisms using aqueous

extract at the same concentration [13]. The slight variations in ZOI values between studies may be attributed to differences in extraction procedures, geographical origin of the plant material, and variations in bacterial strain susceptibility. The superior activity of the methanolic extract over the aqueous extract observed in this study is consistent with the findings of several researchers [17,18]. Methanol, being a more polar organic solvent, is known to extract a broader range of bioactive phytochemicals, including flavonoids, phenolic compounds, and terpenoids, which are responsible for antibacterial activity [9]. The aqueous extract, while showing activity at higher concentrations, likely contains a more limited spectrum of bioactive compounds due to the solubility constraints of certain phytochemicals in water. This observation has practical implications for traditional medicinal practices, where aqueous preparations are commonly used, suggesting that while effective, they may require higher concentrations to achieve therapeutic effects. The MIC values obtained in this study provide quantitative evidence of the antibacterial efficacy of coriander seed extracts. For ACSE, the MIC values were 800 mg/ml against S. aureus, 800 mg/ml against E. coli, and 700 mg/ml against P. aeruginosa. For MCSE, the corresponding MIC values were 700 mg/ml, 750 mg/ml, and 700 mg/ml, respectively. These values, while higher than those of the reference antibiotic ciprofloxacin (MIC: 0.5–1 µg/ml), are comparable to those reported in previous studies. The relatively higher MIC values of plant extracts compared to synthetic antibiotics are expected, as crude extracts contain a mixture of compounds with varying potencies, whereas pure antibiotics are highly concentrated single agents [9]. Nevertheless, the observed activity against all three organisms, including the notoriously multidrug-resistant P. aeruginosa, is noteworthy and underscores the potential of coriander seed extracts as sources of antimicrobial compounds. The higher susceptibility of P. aeruginosa to both extracts compared to S. aureus and E. coli is an interesting finding. While P. aeruginosa is typically considered more resistant to antimicrobial agents due to its intrinsic resistance mechanisms and biofilm-forming ability, the present results suggest that the bioactive compounds in coriander seeds may be particularly effective against this pathogen [19]. This observation is supported by recent studies demonstrating the anti-pseudomonal activity of coriander seed extracts [18,20]. The mechanism underlying this susceptibility may involve the disruption of the bacterial cell membrane, as coriander essential oil has been shown to cause membrane damage leading to cell death [7]. The presence of linalool, the predominant monoterpene component of coriander seed oil, has been associated with antimicrobial activity against various pathogens, including P. aeruginosa [12,20]. The broad-spectrum activity observed in this study, encompassing both Gram-positive (S. aureus) and Gram-negative (E. coli and P. aeruginosa) bacteria, suggests that the antibacterial mechanism of coriander seed extracts may involve multiple targets. The phytochemical composition of coriander seeds, including flavonoids, phenolic acids, tannins, and terpenoids, contributes to this multi-target activity [11]. These compounds can act synergistically to disrupt bacterial cell walls, inhibit essential enzymes, interfere with nucleic acid synthesis, and induce oxidative stress [6,7]. This multi-mechanistic approach is particularly advantageous in the context of antimicrobial resistance, as it reduces the likelihood of bacteria developing resistance to the extract [7]. The findings of this study have significant clinical and public health implications. The rising prevalence of antimicrobial resistance, particularly among S. aureus (including MRSA), E. coli (including ESBL-producing strains), and P. aeruginosa (including carbapenem-resistant strains), has necessitated the search for alternative therapeutic agents [3,4]. Coriandrum sativum, being a widely available, affordable, and culturally accepted spice in South Asia and other regions, represents a promising candidate for the development of plant-based antimicrobial therapies. The seeds are readily available year-round and have a well-established safety profile through centuries of culinary use [10]. The present study provides scientific validation for the traditional use of coriander seeds in treating infections and supports further investigation into their therapeutic potential.

LIMITATIONS

This study has several limitations. Being an in vitro investigation, the results may not directly translate to in vivo efficacy. The crude extracts required relatively high concentrations, and the specific bioactive compounds responsible for the observed activity were not identified. Additionally, the study was limited to standard reference strains and did not include clinical isolates.

CONCLUSION

The present study confirms that Coriandrum sativum seed extracts possess significant, broad-spectrum antibacterial activity against S. aureus, E. coli, and P. aeruginosa. The methanolic extract demonstrated superior efficacy compared to the aqueous extract, with P. aeruginosa being the most susceptible organism. These findings provide scientific validation for the traditional medicinal use of coriander seeds and highlight their potential as accessible, cost-effective sources of antimicrobial compounds. Further research focused on isolation of active principles and in vivo evaluation is warranted for therapeutic development.

RECOMMENDATION

Future studies should focus on isolating and characterizing the specific bioactive compounds responsible for the antibacterial activity. In vivo efficacy and safety evaluation in animal models is recommended. Synergistic studies with conventional antibiotics against multidrug-resistant clinical isolates are warranted. Standardization of extraction protocols for consistent therapeutic application is also suggested.

CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest. No funding was received for this study. The corresponding author had full access to all data and final responsibility for the decision to submit for publication.

AI DECLARATION

Artificial intelligence tools contributed marginally to manuscript preparation and development. All core scientific content was human-verified.

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