"Evaluation of Wormwood Extracts as Natural Antimicrobial Alternatives against UTI Pathogens"

[1]Zeenath Sheikh, *[2]Usha Rani Kandula, [3]Ahmad Shwan, [3]Yahya Rizgar, [3]Huda Miran, [3]Naz Muhammad, [3]Naz Emad

[1]Lecturer, Department of Anaesthesia and Technology, Cihan University-Erbil, Erbil, Kurdistan Region, Iraq

[2]Professor, Department of Community Health Nursing, Cihan University-Erbil, Erbil, Kurdistan Region, Iraq

[3]Final Year Students, Department of Bio-Medical Sciences, Cihan University-Erbil, Erbil, Kurdistan Region, Iraq

***Corresponding Author**

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ABSTRACT

Background: Urinary tract infections are becoming harder to treat due to rising antibiotic resistance, increasing interest in medicinal plants such as wormwood (*Artemisia absinthium*), which contains bioactive compounds with strong antimicrobial properties. Aim: To evaluate the antibacterial activity of aqueous and ethanolic wormwood extracts against *Staphylococcus aureus*, *Streptococcus agalactiae*, and *Enterococcus faecalis*. Materials and Methods: Wormwood extracts were prepared using the maceration method, and antibacterial activity was assessed using the agar well diffusion technique on VITEK-confirmed bacterial isolates standardized to 0.5 McFarland. Results: The aqueous extract showed the strongest antibacterial activity, producing inhibition zones of 28 mm for *S. aureus* and 38 mm for *S. agalactiae*, while ethanolic extracts displayed moderate effects, especially against *E. faecalis*. Discussion: Findings indicate that wormwood—particularly in aqueous form—contains potent antimicrobial compounds capable of inhibiting UTI-causing bacteria, demonstrating potential as a natural alternative to traditional antibiotics. Conclusion: Wormwood extracts exhibit significant antibacterial activity, with aqueous extracts showing superior effectiveness, supporting their potential use as natural antimicrobial agents. Recommendations: Further research should isolate active compounds, test additional extraction methods, evaluate activity against more pathogens, and develop wormwood-based pharmaceutical formulations supported by in vivo studies.

Keywords: Wormwood, *Artemisia absinthium*, antibacterial activity, plant extracts, antibiotic alternatives, urinary tract infections.

INTRODUCTION

Urinary tract infections (UTIs) are among the most prevalent bacterial infections worldwide and pose serious public health challenges, particularly with the rise of antibiotic resistance. The most common causative agents—including *Staphylococcus aureus*, *Streptococcus agalactiae*, and *Enterococcus faecalis*—have increasingly demonstrated reduced susceptibility to conventional antibiotics[1]. This resistance threatens treatment effectiveness and increases the risk of complications, prolonged illness, and healthcare costs. As antibiotic resistance continues to escalate, the search for new therapeutic alternatives has become an urgent global priority[2].

Medicinal plants represent one of the most promising sources for novel antimicrobial compounds. Among these, wormwood (*Artemisia absinthium L.*) has gained significant attention due to its potent bioactive

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constituents, including essential oils, sesquiterpene lactones, phenolics, and flavonoids[3]. Traditionally used across North Africa, Europe, the Middle East, and Asia, wormwood is known for its antimicrobial, antioxidant, antiparasitic, antifungal, and anti-inflammatory properties. These diverse biological activities are attributed to its rich chemical composition, suggesting strong potential for therapeutic use[4].

Natural plant extracts such as wormwood may provide a safer, more sustainable alternative to synthetic antibiotics, particularly in cases where bacterial resistance limits treatment options. Their chemical diversity allows for multiple mechanisms of action, reducing the likelihood of resistance development. Moreover, interest in plant-based antimicrobial agents has grown due to their availability, lower toxicity, and historical use in traditional medicine[5].

Given the increasing need for novel antimicrobial strategies, exploring the antibacterial effects of wormwood can contribute valuable insight into developing natural alternatives to antibiotics, especially for infections such as UTIs, where resistance is becoming widespread[6].

Figure 1: A Picture of Wormwood crop

Significance of the study

Medicinal plants have long been recognized as important sources of bioactive compounds with antimicrobial properties. As antibiotic resistance continues to increase globally, these natural products have gained significant attention as potential alternatives to conventional antibiotics[7]. Plant-derived secondary metabolites—such as flavonoids, phenolics, terpenoids, and essential oils—often possess strong antibacterial activity and work through multiple mechanisms, making it more difficult for bacteria to develop resistance. This has led researchers to explore traditional medicinal plants as promising candidates in the search for new antibacterial agents[8].

Wormwood (*Artemisia absinthium L.*) is one of the most notable medicinal plants used historically for treating infections, digestive problems, and parasitic diseases. It is rich in essential oils, sesquiterpene lactones, and phenolic compounds, all of which contribute to its antimicrobial effects[9]. Studies have shown that wormwood extracts, especially those obtained through water distillation and ethanol extraction, are capable of inhibiting a range of pathogenic bacteria. Its broad pharmacological activities and chemical diversity make wormwood an appealing subject for the development of plant-based therapeutics[10].

The rising problem of antibiotic resistance in pathogens such as *Staphylococcus aureus*, *Streptococcus agalactiae*, and *Enterococcus faecalis* has created an urgent need for alternative treatment options[11]. Research demonstrates that wormwood extracts exhibit significant antibacterial activity against these bacteria, often producing inhibition zones comparable to or greater than those of conventional antibiotics. The ability of wormwood compounds to disrupt bacterial cell membranes, interfere with metabolic processes, and induce oxidative stress highlights their potential as effective antimicrobial agents[12].

Overall, evidence from previous studies indicates that wormwood holds strong potential as a natural alternative to antibiotics. Its potent bioactive components, historical medicinal use, and demonstrated effectiveness against UTI-causing bacteria support continued investigation into its role as a safe and sustainable antimicrobial therapy[13].

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MATERIALS AND METHODS

This study was conducted at the microbiology laboratory of Cihan University–Erbil to evaluate the antibacterial potential of wormwood (*Artemisia absinthium*) extracts as an alternative to antibiotics. Dried wormwood plant material was ground and extracted using the maceration method with either ethanol or distilled water. For each extract, 20 g of powdered plant was mixed with 200 mL of solvent, shaken for three days, filtered using a vacuum motor, and concentrated in a drying oven before storage. Antibacterial activity was tested against three UTI-causing bacteria—*Staphylococcus aureus*, *Streptococcus agalactiae*, and *Enterococcus faecalis*. Bacterial strains were confirmed using the VITEK system, standardized to 0.5 McFarland turbidity using a spectrophotometer, and inoculated onto Mueller–Hinton agar plates. Wells were loaded with ethanolic and aqueous wormwood extracts, while ciprofloxacin served as a positive control. After 24 hours of incubation at 37°C, inhibition zones were measured to compare the antibacterial effectiveness of wormwood extracts with standard antibiotics[14, 15] (**Figure1, Figure 2**).

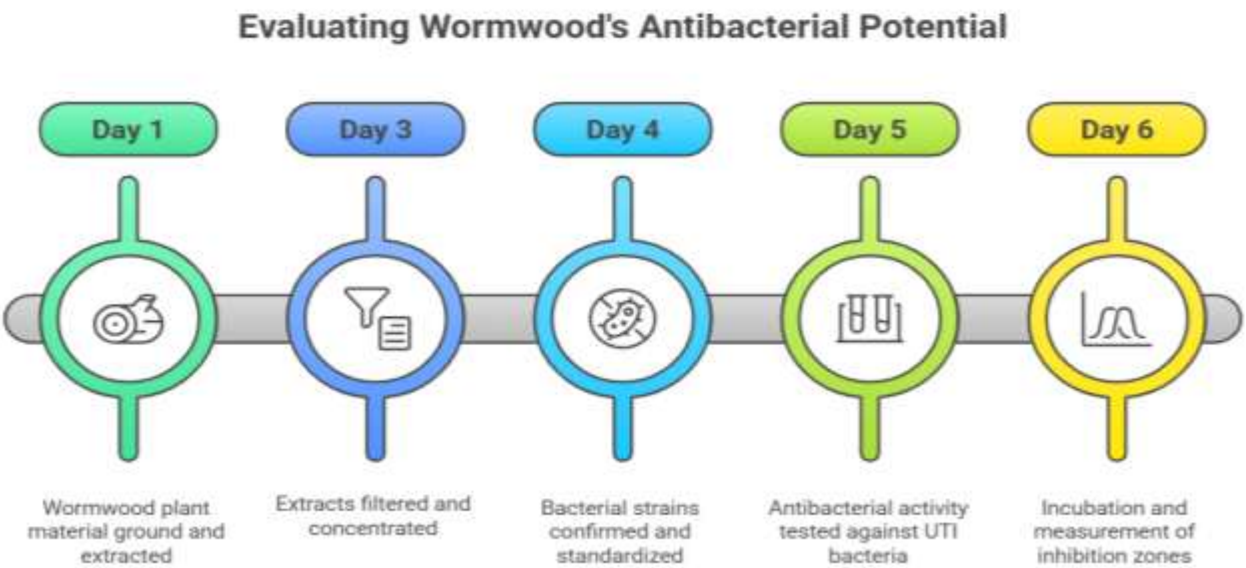

Figure 2: Evaluation of wormwood’s Antibacterial Potential

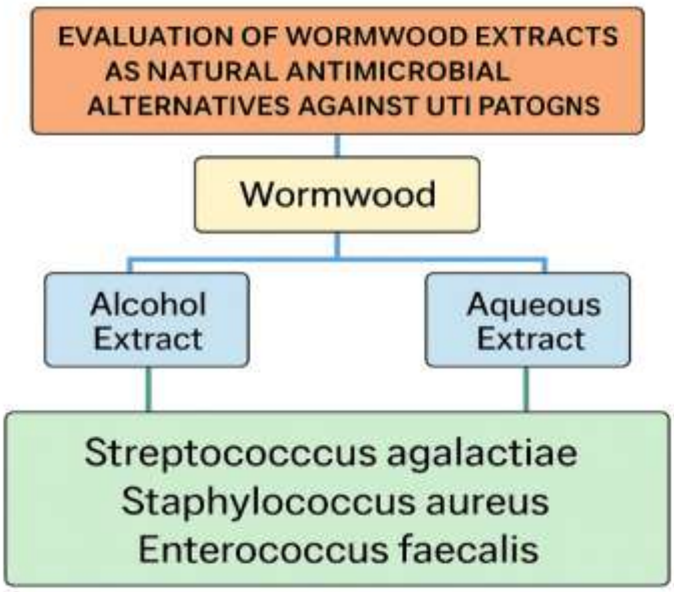

Figure 3: Methodology on evaluation of wormwood extracts as natural antimicrobial alternatives against UTI pathogens

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RESULTS

The antibacterial activity of wormwood (*Artemisia absinthium*) extracts was evaluated against three major UTI-causing bacteria—*Enterococcus faecalis*, *Staphylococcus aureus*, and *Streptococcus agalactiae*. Both aqueous (distilled water) and alcoholic (ethanolic) extracts were tested using the agar well diffusion method and compared with standard antibiotics to determine the potential of wormwood as an alternative antimicrobial agent.

For *Enterococcus faecalis*, the ethanolic wormwood extract produced an inhibition zone of **13 mm**, demonstrating moderate antibacterial activity. Although antibiotics such as ciprofloxacin (23 mm) showed greater inhibition, wormwood extract still exhibited clear bacteriostatic effects (**Figure 4**).

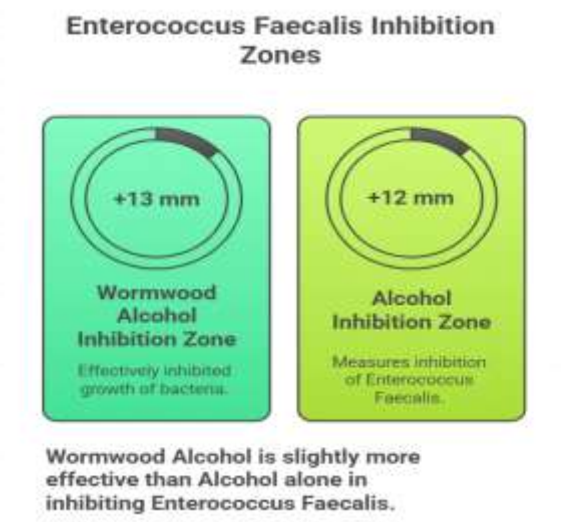

Figure 4: Enterococcus Faecalis Inhibition Zones

For *Staphylococcus aureus*, wormwood displayed stronger activity. The aqueous extract produced a **28 mm** inhibition zone, while the ethanolic extract resulted in a **20 mm** zone. These values indicate that wormwood—particularly in aqueous form—has potent antibacterial effects that in some cases approach or surpass standard antibiotics, such as ciprofloxacin (9 mm) but not sulfamethoxazole (27 mm) (**Figure 5**).

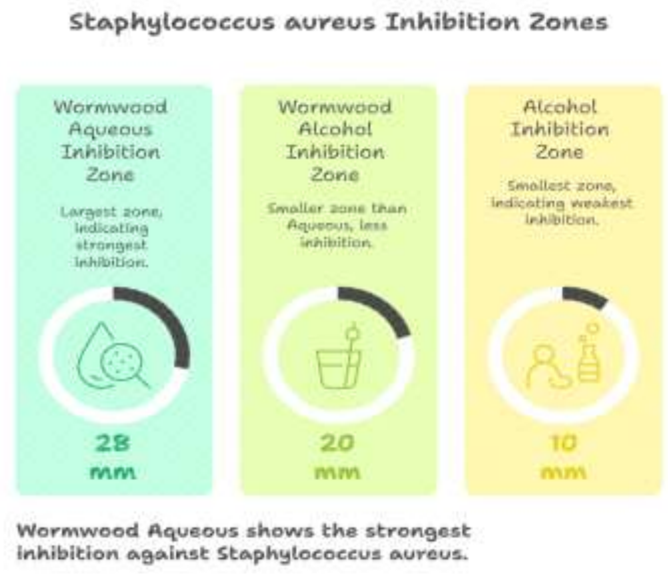

Figure 5: Staphylococcus Aureus Inhibition Zones

The strongest results were observed against *Streptococcus agalactiae*. The aqueous wormwood extract produced a notably large inhibition zone of 38 mm, exceeding those produced by standard antibiotics like

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sulfamethoxazole (27 mm) and approaching ciprofloxacin (35 mm). The ethanolic wormwood extract showed weaker activity at 12 mm**,** but still demonstrated measurable antibacterial action (**Figure 6**).

Figure 6: Inhibitory Zones of wormwood Extracts on Streptococcus Agalactiae

Across all bacteria, aqueous wormwood extract consistently demonstrated the highest inhibition zones, indicating that water-based extraction yields stronger antibacterial compounds than ethanolic extraction. These results support wormwood's potential as a natural antimicrobial agent and a promising alternative to conventional antibiotics, especially in cases where pathogens show resistance (**Figure 7**).

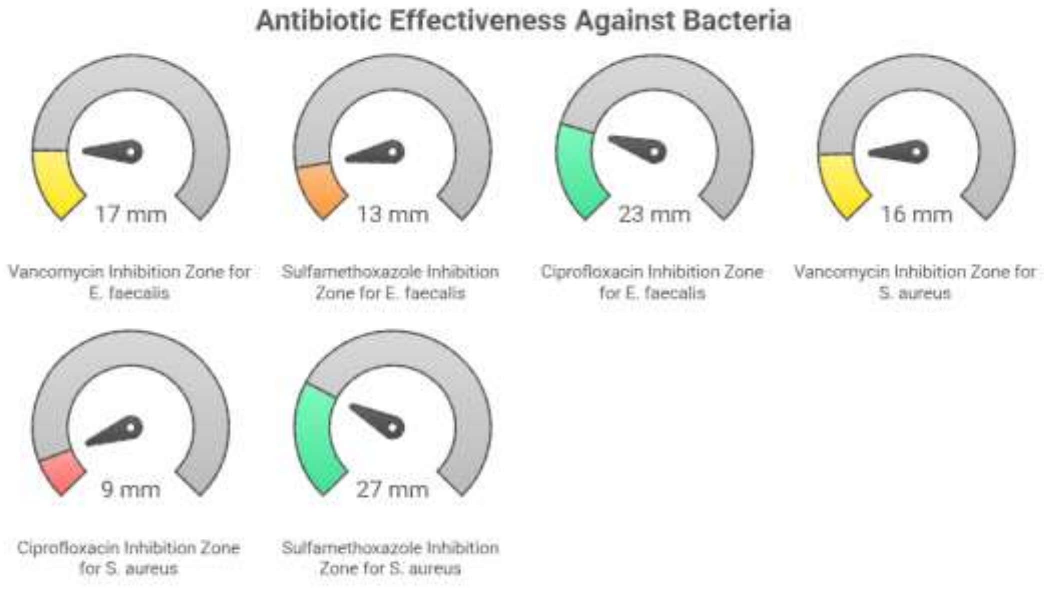

Figure 7: Antibiotic Effectiveness Against Bacteria

The antibiotic sensitivity results show that *Staphylococcus aureus* is sensitive to Vancomycin (16 mm) and Sulfamethoxazole (27 mm) but resistant to Ciprofloxacin (9 mm), indicating that Ciprofloxacin is ineffective against this organism. *Enterococcus faecalis* demonstrates good sensitivity to both Vancomycin (17 mm) and Ciprofloxacin (23 mm), while showing resistance to Sulfamethoxazole (13 mm), which aligns with the organism's known reduced responsiveness to sulphonamides. *Streptococcus agalactiae* exhibits strong sensitivity to all three antibiotics—Vancomycin (22 mm), Ciprofloxacin (35 mm), and Sulfamethoxazole (27 mm)—making it the most susceptible organism in this dataset. Overall, Vancomycin is effective against all three bacteria, Ciprofloxacin shows limited efficacy only failing against S. aureus, and Sulfamethoxazole is ineffective only against Enterococcus faecalis (**Table 1**).

Table1: Antibiotic Sensitivity Pattern of Staphylococcus aureus, Enterococcus faecalis, and Streptococcus agalactiae

S.No	Bacteria	Antibiotic (Disc Strength)	Sensitivity (mm)	Intermediate (mm)	Resistance (mm)
1	**Staphylococcus aureus**	Vancomycin (30 mcg)	16 mm	–	–
		Ciprofloxacin (10 mcg)	–	–	9 mm
		Sulfamethoxazole (25 mcg)	27 mm	–	–
2	**Enterococcus faecalis**	Vancomycin (30 mcg)	17 mm	–	–
		Ciprofloxacin (10 mcg)	23 mm	–	–
		Sulfamethoxazole (25 mcg)	–	–	13 mm
3	**Streptococcus agalactiae**	Vancomycin (30 mcg)	22 mm	–	–
		Ciprofloxacin (10 mcg)	35 mm	–	–
		Sulfamethoxazole (25 mcg)	27 mm	–	–

The results show that Wormwood plant extracts exhibit strong antibacterial activity**,** particularly in aqueous form, while alcohol alone shows only mild inhibition across all tested bacteria. Against *Enterococcus faecalis*, only alcohol-based extracts were effective, with Wormwood showing a slightly higher inhibition zone (13 mm) than alcohol alone (12 mm). For *Staphylococcus aureus*, Wormwood demonstrated significant activity in both aqueous (28 mm) and alcohol extracts (20 mm), whereas alcohol alone produced only a weak 10 mm zone. The strongest activity overall was seen with Wormwood aqueous extract against *Streptococcus agalactiae* (38 mm)**,** followed by its alcohol extract (12 mm), while alcohol alone again showed minimal effect (11 mm). Overall, Wormwood—especially in aqueous form—proved to be the most effective plant extract**,** while alcohol alone consistently showed the weakest antibacterial action (Table 2)**.**

Table 2: Antibacterial Activity of Wormwood Plant Extract (Aqueous and Alcohol) Against Selected Bacteria

S.No	Medicinal Plant	Bacteria	Diameter – Aqueous Solution	Diameter – Alcohol
1	Wormwood Plant	Enterococcus faecalis	–	13 mm
2	Alcohol Alone	Enterococcus faecalis	–	12 mm
3	Wormwood Plant	Staphylococcus aureus	28 mm	20 mm

4	Alcohol Alone	Staphylococcus aureus	–	10 mm
5	Wormwood Plant	Streptococcus agalactiae	38 mm	12 mm
6	Alcohol Alone	Streptococcus agalactiae	–	11 mm

DISCUSSION

The findings of this study clearly demonstrate the strong antibacterial potential of wormwood (*Artemisia absinthium*) extracts, supporting their possible use as natural alternatives to conventional antibiotics. Among all tested pathogens, the aqueous wormwood extract showed the most remarkable activity, particularly against *Streptococcus agalactiae*, where it produced a 38 mm inhibition zone—surpassing the zones produced by standard antibiotics such as ciprofloxacin, vancomycin, and sulfamethoxazole[16]. This suggests that water-based extraction is highly effective in isolating potent antimicrobial compounds from wormwood, likely due to enhanced solubility of its active phytochemicals[17].

The ethanolic extract of wormwood also exhibited inhibitory effects against all tested bacteria, though generally less potent than the aqueous extract. However, its clear antibacterial action against *Enterococcus faecalis* and *Staphylococcus aureus* confirms that wormwood contains multiple bioactive compounds capable of disrupting bacterial growth through various mechanisms[18]. These mechanisms may include cell membrane disruption, interference with metabolic pathways, and oxidative stress induction—all of which reduce the likelihood of bacterial resistance[19].

The strong antimicrobial performance of wormwood against *S. agalactiae* is particularly significant, as this bacterium is known to cause severe infections in vulnerable populations. The superior activity of wormwood compared to standard antibiotics indicates that this plant could play a meaningful role in managing infections where conventional treatments fail or when antibiotic resistance is present[20].

Given its effectiveness, wormwood extract holds promising potential for development into topical or oral therapeutic forms such as gels, ointments, or liquid suspensions. These formulations could serve as alternative treatments for individuals who cannot tolerate synthetic antibiotics or for cases where natural remedies are preferred. Furthermore, because wormwood contains a diverse mixture of phytochemicals, bacteria may find it more difficult to develop resistance, making it a valuable candidate in the global effort to combat antimicrobial resistance[21].

Overall, the results of this study contribute to the growing body of evidence supporting medicinal plants—particularly wormwood—as viable, eco-friendly, and effective alternatives to traditional antibiotics. By demonstrating potent antibacterial activity against clinically relevant pathogens, wormwood emerges as a promising natural resource deserving further investigation, purification studies, and potential pharmaceutical development[22].

Figure8: Effective treatment against bacteria

CONCLUSION

This study shows that wormwood (*Artemisia absinthium*) has strong antibacterial potential and can serve as a promising natural alternative to conventional antibiotics. Both ethanolic and aqueous wormwood extracts inhibited the growth of major UTI-causing bacteria, with the aqueous extract showing the highest effectiveness, particularly against *Streptococcus agalactiae*. The strong inhibition zones produced by wormwood indicate that its bioactive compounds are capable of suppressing bacterial growth and may offer a safer, more sustainable option in addressing antibiotic resistance.

RECOMMENDATIONS

Further research is recommended to isolate the active compounds in wormwood, test additional extraction methods, and evaluate its antibacterial effects against more resistant pathogens. Development of wormwood-based pharmaceutical formulations and conducting in vivo or clinical studies are essential steps toward safe medical application. Overall, wormwood should be explored further as a potential natural antimicrobial agent that could complement or reduce reliance on synthetic antibiotics.

Declarations

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Conflicts of Interest:

The author declares no conflicts of interest.

Ethical Approval:

Obtained from Cihan University-Erbil, Erbil, Kurdistan Region, Iraq.

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Author Contributions:

The author conceptualized, researched, wrote, and reviewed the manuscript independently.

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