

Screening the Antibacterial Activity of Chamomile and Basil Essential Oils and Extracts

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Abstract

The experiment was conducted at the Khabat Technical Institute (Erbil Polytechnic University, Kurdistan, Iraq) during spring of 2026. The ever-increasing emergence of bacterial pathogens resistant to antibiotics has motivated the quest for new antimicrobial agents from medicinal plants. To assess the antibacterial activity of aqueous and alcoholic extracts, and essential oils obtained from chamomile (*Matricaria chamomilla* L.) and basil (*Ocimum basilicum* L.), in relation to the antimicrobial susceptibility resistance, we performed a study on three pathogenic Gram-positive bacteria: *Staphylococcus aureus*, *Staphylococcus epidermidis*, and *Streptococcus pyogenes*. Determine the antibacterial activity of the plant preparations in comparison with two traditional antibiotics Vancomycin and Cefotaxime. Different treatments (0.25, 0.5, and 1 ml) of aqueous extracts and essential oils, and (0.25, 0.5, and 1 g) of alcoholic extracts, with three replications were prepared and tested using the agar well diffusion method. The diameter of the inhibition zones surrounding each treatment was measured in order to evaluate the antibacterial efficacy. Significant variations in plant species, extraction techniques, treatments, and bacterial strains were shown by the results. Inhibition zones generally grew as extract and essential oil treatments rose. Compared to basil, chamomile showed more potent antibacterial activity, especially in its alcoholic extract. When tested against *S. epidermidis*, *S. aureus*, and *S. pyogenes*, the alcoholic chamomile extract at 1 ml produced inhibition zones of 6.067, 6.067, and 5.867 cm, respectively, which were comparable to the efficacy of the antibiotics. Basil essential oil showed the highest antibacterial activity among basil preparations, producing inhibition zones of 4.000, 2.567, and 3.533 cm against the respective bacterial species at the highest concentration tested. The aqueous extracts of both plants exhibited the lowest antibacterial activity compared with alcoholic extracts and essential oils.

Keywords: Chamomile, Basil, Extracts, Antibacterial activity.

Introduction

The therapeutic potential of medicinal plants and their usefulness as natural substitutes for synthetic antibacterial medicines have garnered significant scientific attention. Researchers are

looking on plant-based bioactive chemicals since antibiotic-resistant bacteria are becoming a major worldwide health concern [1]. Among these therapeutic herbs, basil (*Ocimum basilicum*) and chamomile (*Matricaria chamomilla*) are

well known for their pharmacological qualities, which include antifungal, antibacterial, antioxidant, and anti-inflammatory effects. Flavonoids, terpenoids, phenolic acids, and essential oils are only a few of the biologically active substances found in these plants that contribute to their antibacterial efficacy against a variety of pathogenic microbes [7], [17]. Among the most prevalent Gram-positive bacteria linked to wound infections, skin infections, and hospital-acquired illnesses include *Staphylococcus aureus*, *Staphylococcus epidermidis*, and *Streptococcus pyogenes*. Because *S. aureus* may manufacture toxins and become resistant to several drugs, particularly methicillin-resistant strains (MRSA), it is regarded as a significant human pathogen. However, *S. epidermidis* has become an opportunistic infection, particularly in immunocompromised patients and people with implanted medical devices, despite being a natural element of the skin flora. Interest in finding natural antibacterial compounds that can stop the growth of these bacteria has increased due to their growing resistance to traditional antibiotics [16]. Chamomile is one of the oldest medicinal herbs traditionally used in herbal medicine. Its flowers contain essential oils rich in compounds such as α -bisabolol, chamazulene, and flavonoids, which possess strong antimicrobial and anti-inflammatory properties. Previous studies demonstrated that chamomile essential oil exhibits inhibitory effects against several pathogenic bacteria, including *Staphylococcus aureus*. A study published in *Molecules* reported that chamomile essential oil showed significant antibacterial activity, especially when formulated as nanoemulsions, which enhanced its effectiveness against Gram-positive bacteria [5]. Furthermore,

combinations of chamomile oil with standard antibiotics were found to improve antibacterial efficacy against *S. aureus* and other microbial pathogens [14], [9].

Similarly, basil (*Ocimum basilicum*) is an aromatic medicinal plant widely used in traditional medicine and food preservation. Basil contains essential oils rich in linalool, estragole, eugenol, and methyl chavicol, compounds known for their antimicrobial activity. Several investigations have shown that basil essential oil has strong inhibitory effects against Gram-positive bacteria, particularly *Staphylococcus aureus*. An Iraqi study evaluating basil essential oil revealed significant antibacterial activity against *S. aureus*, with inhibition zones indicating the effectiveness of basil oil as a natural antibacterial agent [15]. In another study examining commercially available essential oils, basil oil demonstrated considerable inhibitory activity against drug-resistant Gram-positive pathogens, including methicillin-resistant *S. aureus* [4]. The antibacterial activity of medicinal plants depends greatly on the extraction method used. Aqueous and alcoholic extracts may contain different concentrations of active compounds due to differences in solvent polarity and extraction efficiency. Alcoholic extracts often exhibit stronger antimicrobial activity because ethanol can dissolve a broader range of phytochemicals such as phenols and flavonoids. Essential oils, being concentrated volatile compounds, usually possess higher antibacterial potency than crude extracts. Studies comparing different extraction methods have shown variations in antibacterial effectiveness against pathogenic bacteria, emphasizing the importance of evaluating multiple extract types to determine the most effective natural antimicrobial

preparation [21]. Therefore, this study aimed to evaluate the antibacterial activity of aqueous and alcoholic extracts and essential oils of chamomile and basil against *Staphylococcus aureus*, *Staphylococcus epidermidis*, and *Streptococcus pyogenes*. It also compared the effectiveness of these plant preparations and assessed their potential as natural antibacterial agents that may contribute to developing alternative treatments and reducing reliance on synthetic antibiotics.

Material and method

-Collection and Drying of Plants:

Chamomile and Basil were collected from various locations in Erbil during the spring of 2025-2026. The plant material was then dried by spreading it out in the shade in the laboratory, turning it occasionally to accelerate the drying process and prevent fungal growth. The dried samples were then grounded using grinder. and stored in plastic bags ready for extraction.

Table (1) Plant species and parts used in the research

Collection place	Organs	Family	Scientific name	English name	
Erbil	Flowers	Asteraceae	<i>Matricaria chamomilla L.</i>	Chamomile	1
Erbil	Leaves	Lamiaceae	<i>Ocimum basilicum L.</i>	Basil	2

Preparation of Plant Extract

-Alcoholic Extraction: Soxhlet Extraction

The plant powder was extracted with ethanol solvent by using Soxhlet Extractor. 100gm of plant powder used for the extraction with 750 ml of solvent at 50°C by Soxhlet extraction method for 5 hrs. After extraction the extract filtered through a Whatman No. 2 filter paper for removal of any plant particles present in extract. The filtered extract then evaporated to dryness under vacuum at 60°C by a rotary evaporator. The extracts were stored in refrigerator at 4°C until further use [10].

Aqueous extraction of plant was done by referring [10], 20gm of plant powder was soaked in 250 ml distilled water for 24 hr. at room temperature under constant stirring condition. The extract then filtered. After filtration, the aqueous extracts were concentrated in a water bath at 45°C until the final volume reached 100 mL. The resulting crude extract concentration was 0.2 g/mL (200 mg/mL), equivalent to 20% (w/v).

Afterward, the mixture was centrifuged to separate any remaining impurities, and the extract was then stored in the refrigerator until use.

- Oil Extraction

-Aqueous Extraction:

One hundred grams of dried plant material were mixed with 1000 mL distilled water and distilled for 3 h using a Clevenger-type apparatus. The obtained distillate was extracted with n-hexane using a separation funnel, and the solvent was subsequently removed under reduced pressure using a rotary evaporator to obtain the pure essential oil [20]. The essential oil yield obtained from 100 g of dried chamomile flowers was 1.0% (v/w), corresponding to 1 mL of essential oil. In contrast, the essential oil yield from 100 g of dried basil plant material was 1.5% (v/w), corresponding to 1.5 mL of essential oil.

-Bacteria used in the study:

The bacteria which used were *S. epidermidis*, *S. aureus* and *S. pyogenes* in this investigation. Samples of the bacteria were obtained through the College of Medicine-Hawler Medical University

- Preparation of the blood agar culture medium:

Dissolve the blood agar base powder in distilled water (45 g/L sterile distilled water) and heat until completely dissolved. Sterilize the medium by autoclave for 20 minutes at 121°C. Allow the sterile medium to cool to 35-40°C. Add the blood (5-10 ml of blood per liter of medium) and mix gently. Pour the mixture into sterile Petri dishes while the medium is still liquid. Allow the dishes to solidify, then label them and store in the refrigerator.

-Testing vancomycin and Cefotaxime:

Discs containing known concentrations of Vancomycin (30 µg / disk) and Cefotaxime (30 µg / disk) are placed on a blood agar plate culture with bacteria. After incubation, the diameter of the inhibition zone around the disc is measured to determine the percentage of bacterial inhibition.

The percentage of inhibition was calculated according to the following equation: (The diameter of the petri dishes used is 9 cm) .

$$\text{Inhibition \%} = \frac{\text{Zone diameter}}{\text{Total plate diameter}} \times 100$$

-Testing of different treatments of the extraction of the plants against the bacteria:

A well in the middle of a blood agar plate containing bacteria was filled with 0.25, 0.5, and 1 ml of aqueous extract and oil extract, and 0.25, 0.5, and 1 g of alcoholic extract. The percentage of bacterial growth inhibition was calculated by measuring the diameter of the inhibition zone surrounding the disc following incubation.

According to analyses of variance performed using the Statistical Analysis System SAS the data was statistically analyzed for each of the evaluated characteristics, and Duncan's multiple range test (DMRT) was used.

Results and discussion:

Table (2) Antibacterial activity of chamomile extracts.

Inhibition zone						Treatment
Inhibition %	<i>S. pyogenes</i> cm	Inhibition %	<i>S. aureus</i> cm	Inhibition %	<i>S. epidermidis</i> cm	
85.56%	7.700 a	87.03%	7.833 a	83.33%	7.500 a	Vancomycin
86.3%	7.767 a	89.26%	8.033 a	82.2%	7.400 a	Cefotaxime
4.81%	0.433 f	4.44%	0.400 g	3.33%	0.300 e	Aqueous Chamomile Extract 0.25 ml
23.33%	2.100 e	17.03%	1.533 ef	11.11%	1.000 de	Aqueous Chamomile Extract 0.5ml
28.14%	2.533 de	25.56%	2.300 de	20%	1.800 d	Aqueous Chamomile Extract 1ml
18.52%	1.667 e	51.86%	4.667 c	37.78%	3.400 c	Alcoholic Chamomile Extract 0.25 g
50%	4.500 c	45.92%	4.133 c	46.3%	4.167 c	Alcoholic Chamomile Extract 0.5 g
65.19%	5.867 c	67.41%	6.067 b	67.41%	6.067 b	Alcoholic Chamomile Extract 1g
7.03%	0.633 e	9.26%	0.833 fg	7.41%	0.667 e	Oil of chamomile 0.25 ml
35.92%	3.233 d	28.52%	2.567 d	20%	1.800 d	Oil of chamomile 0.5 ml
50.74%	4.567 c	47.78%	4.300 c	40%	3.600 c	Oil of chamomile 1 ml
0	0.000 f	0	0.000 g	0	0.000 e	Control

The results presented in Table (2) demonstrate significant differences in the antibacterial activity of aqueous extracts, alcoholic extracts, and essential oil of chamomile against *S. aureus*, *S. epidermidis*, and *S. pyogenes*. In general, the inhibition zones increased with increasing extract concentration, indicating a dose-dependent antibacterial effect. The antibiotic treatments (Vancomycin and Cefotaxime) exhibited the highest antibacterial activity against all tested bacterial species, producing inhibition zones ranging reached 7.5, 7.83, 7.7 cm and 7.4, 8.03 7.767 cm respectively. These findings are expected because these antibiotics possess well-established bactericidal

mechanisms that effectively inhibit Gram-positive bacteria, including staphylococci and streptococci. Among the chamomile preparations, the alcoholic extract demonstrated the strongest antibacterial activity. At a concentration of 1 g, the alcoholic extract produced inhibition zones of 6.067 cm against *S. epidermidis*, 6.067 cm against *S. aureus*, and 5.867 cm against *S. pyogenes*. These values approached those obtained with the standard antibiotics, indicating a potent antimicrobial effect. The superior activity of the alcoholic extract may be attributed to the ability of ethanol to extract greater quantities of bioactive compounds such as flavonoids,

terpenoids, phenolic acids, coumarins, and sesquiterpene lactones. These phytochemicals are known to disrupt bacterial cell membranes, interfere with enzyme activity, and inhibit microbial growth. The aqueous extract showed comparatively lower antibacterial activity. At the highest treatment (1 ml), inhibition zones reached only 1.800 cm, 2.300 cm, and 2.533 cm against *S. epidermidis*, *S. aureus*, and *S. pyogenes*, respectively. The reduced efficacy of the aqueous extract may result from the limited solubility of many antimicrobial constituents in water. Several active compounds in chamomile, particularly essential oil treatments and certain flavonoids, are more efficiently extracted using organic solvents than water. The essential oil of chamomile exhibited moderate antibacterial activity. Increasing the treatments from 0.25 ml to 1 ml significantly enhanced the inhibition zones, reaching 3.600 cm, 4.300 cm, and 4.567 cm against *S. epidermidis*, *S. aureus*, and *S. pyogenes*, respectively. The antibacterial effect of chamomile essential oil is mainly associated with bioactive compounds such as α -bisabolol, chamazulene, bisabolol oxides, and various terpenes. These compounds can penetrate bacterial cell membranes, increase membrane permeability, and cause leakage of intracellular components, ultimately leading to cell death. The results further indicate differences in bacterial susceptibility. *S. aureus* appeared to be the most susceptible species to the alcoholic extract and essential oil,

whereas *S. epidermidis* showed slightly greater resistance. Such differences may be related to variations in cell wall structure, membrane composition, and physiological adaptations among bacterial species. Nevertheless, all tested bacteria were susceptible to chamomile-derived preparations to varying degrees.

These results agree with many other studies that have also found the antimicrobial effects of chamomile extracts. According to [2], Chamomile has many different biological compounds that can work as antimicrobials. They are especially flavonoids and terpenoids. For example, [6] showed that the alcoholic extracts of chamomile have more potent antibacterial activity compared to aqueous extracts against some Gram-positive bacteria due to increased extraction of phenolic compounds. Also [12] found that chamomile essential oil considerably inhibited the growth of *S. aureus* and pinned the effect on α -bisabolol and chamazulene. In a similar study, [13] noted that methanolic and ethanolic extracts of medicinal plants generally give higher antibacterial activities than aqueous extracts because organic solvents extract a wider spectrum of antimicrobial phytochemicals. The increase observed in the current study also agrees with the findings of [11], who reported that higher treatment of chamomile extracts produced larger inhibition zones against Gram-positive bacteria due to increased availability of active compounds capable of damaging bacterial cells.

Table (3) Antibacterial activity of basil extracts.

Inhibition zone						Treatment
Inhibition %	<i>S. pyogenes</i> cm	Inhibition %	<i>S. aureus</i> cm	Inhibition %	<i>S. epidermidis</i> cm	
89.63%	8.067 a	84.08%	7.567 b	85.56%	7.700 a	Vancomycin
82.97%	7.467 b	91.15%	8.233 a	81.11%	7.300 a	Cefotaxime
15.56%	1.400 e	0	0.000 g	5.92%	0.533 f	Aqueous basil Extract 0.25 ml
20%	1.800 e	6.3%	0.567 f	9.63%	0.867 f	Aqueous basil Extract 0.5ml
27.03%	2.433 d	15.19%	1.367 e	16.3%	1.467 e	Aqueous basil Extract 1ml
15.56%	1.400 e	12.94%	1.167 e	15.92%	1.433 e	Alcoholic basil Extract 0.25 g
18.14%	1.633 d	14.44%	1.300 e	18.89%	1.700 de	Alcoholic basil Extract 0.5 g
20.74%	1.867 e	21.11%	1.900 d	27.78%	2.500 c	Alcoholic basil Extract 1g
17.78%	1.600 e	1.86%	0.167 g	1%	0.900 f	Oil of basil 0.25 ml
27.78%	2.500 d	13.7%	1.233 e	22.22%	2.000 d	Oil of basil 0.5 ml
39.26%	3.533 c	28.52%	2.567 c	44.44%	4.000 b	Oil of basil 1 ml
0	0.000 f	0	0.000 g	0	0.000 g	Control

Table (3) shows clear differences in the level of antibacterial activity of basil aqueous extracts, alcoholic extracts, and essential oil against *S. epidermidis*, *S. aureus*, and *S. pyogenes*. The zone of inhibition increased with the treatment of the extracts, indicating that the antibacterial activity of basil depends on the level of concentration. However, the degree to which the zones were inhibited differed with the type of extract and the species of bacteria. As expected, the conventional antibiotics Vancomycin and Cefotaxime showed the most significant antibacterial efficacy against all bacteria tested. The zones of inhibition recorded were 7.7, 7.567, and 8.067 cm for Vancomycin and 7.300-8.233, and 7.467 cm for Cefotaxime.

These results further confirm the high susceptibility of the tested Gram-positive bacteria to these standard antibiotics and provide a good baseline for the efficacy testing of basil extracts. Of all the treatments that were obtained from basil, the essential oil proved to have the most notable antibacterial properties. When applied at the highest treatment of 1 ml, the basil essential oil showed inhibition zones measuring 4.000 cm against *S. epidermidis*, 2.567 cm against *S. aureus*, and 3.533 cm against *S. pyogenes*. The enhanced efficacy of the essential oil can be linked to the high treatment of volatile bioactive compounds, which include linalool, eugenol, methyl chavicol (estragole), methyl eugenol, and cineole. These are known for their

strong antimicrobial activities against bacteria due to their action of cell membrane disruption, modification of membrane permeability, enzyme system inhibition, and interference with cellular metabolism that eventually leads to the cessation of bacterial growth. The alcoholic extract showed moderate antibacterial activity as compared to the essential oil. At a concentration of 1 g, the inhibition zones were recorded as 2.500 cm for *S. epidermidis*, 1.900 cm for *S. aureus*, and 1.867 cm for *S. pyogenes*. The superior effectiveness of the alcoholic extract to the aqueous one can be attributed to better extraction of phenolic compounds, flavonoids, tannins, and terpenoids, as facilitated by ethanol. These are phytochemicals known to exert antimicrobial effects through such mechanisms as denaturation of proteins, inhibition of enzymes, and disruption of bacterial cell walls. Of all basil extracts tested, the aqueous extract was the least antibacterial. The maximum zones of inhibition recorded against *S. epidermidis*, *S. aureus*, and *S. pyogenes* at a concentration of 1 ml were only 1.467 cm, 1.367 cm, and 2.433 cm, respectively though the trend was toward an increase in inhibitory effect with increasing treatments. The relatively low efficacy of aqueous extracts is probably due to the fact that many active antimicrobial compounds present in basil leaves are poorly soluble in water. Consequently, water extracts will contain lower concentrations of bioactive compounds as compared to alcoholic extracts and essential oils. Clear variations were observed in the susceptibility of bacteria. Of all the organisms tested, *S. epidermidis* proved to be most sensitive to basil essential oil

and alcoholic extracts; *S. aureus* was the least sensitive. *S. pyogenes* came in between, particularly with the essential oil treatment. Such differences could be attributed to variances in the architecture of the cell wall, membrane composition, metabolic activities, and mechanisms of adaptive resistance that exist between the bacterial species under study. The present study clearly demonstrates a concentration-dependent enhancement of antibacterial activity. This observation is in line with previous reports which indicated that higher treatment of basil extracts possess increased levels of active phytochemicals that can inhibit bacterial growth. From the results, the essential oil appears to be a stronger and more biologically active combination of antimicrobial components than both aqueous and alcoholic extracts. The findings of this study are in line with several previous works. As stated by [8], the essential oil of basil has strong antibacterial activities against some Gram-positive bacteria, such as *S. aureus*; mainly, these properties are due to linalool and eugenol. Similarly, essential oils from basil were found by [18] to greatly inhibit the growth of pathogenic bacteria and fungi, confirming once more their broad antimicrobial activities. Also, it was shown in a study by [3] that the ethanol extracts of basil showed the best antibacterial properties compared to water extracts since ethanol helps in extracting high levels of phenolic compounds and flavonoids. For instance, in another study, [19] noted that basil's essential oil had better inhibition against Gram-positive bacteria than the extracts with crude solvents, because of the high concentration of volatile antimicrobial compounds.

Conclusion

chamomile exhibited stronger antibacterial activity, compared to basil, particularly in its alcoholic extract. When tested against *Staphylococcus epidermidis*, *Staphylococcus aureus*, and *Streptococcus pyogenes*, the results were comparable to those of antibiotics. Basil essential oil also demonstrated high antibacterial activity among basil preparations against the aforementioned bacterial species at the highest tested concentration. Aqueous extracts of both plants showed less antibacterial activity compared to the alcoholic extracts and essential oils.

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