

*Microbial Science Archives* (ISSN: 2583-1666)

An International Research Journal

Journal homepage: [www.microbial.sciencearchives.org](http://www.microbial.sciencearchives.org)

<https://doi.org/10.47587/MSA.2025.5302>

Research Article



## Influence of *Syzygium aromaticum* and *Zingiber officinale* on dual biofilm of *Staphylococcus aureus* and *Acinetobacter baumannii*

Najlaa Nabhan Yaseen , Shaymaa Suhail Najim , Heba Khaleel Tawfeeq 

Department of Biology, College of Science, University of Baghdad, Al-Jadriyah Campus, Baghdad 10071, Iraq

Received: Aug 2, 2025/ Revised: Aug 27, 2025/Accepted: Sept 03, 2025

(✉) Corresponding Author: [najlaa.nabhan@sc.uobaghdad.edu.iq](mailto:najlaa.nabhan@sc.uobaghdad.edu.iq)

### Abstract

*Staphylococcus aureus* and *Acinetobacter baumannii* have a great concern due to their high capacity to cause diseases in addition to their capability to resist antibiotic treatments and its hospital environments persistence. Because of the high emergence of antibiotics resistance, treatments by alternatives should be applied to overcome this problem. Hence, this study aimed to determine the influence of *Syzygium aromaticum* and *Zingiber officinale* watery boiled extract on dual biofilm composed of *Staphylococcus aureus* and *Acinetobacter baumannii*. Both types of *Staphylococcus aureus* and *Acinetobacter baumannii* were obtained from Department of Biology at the College of Science which belongs to the University of Baghdad. General protocol of biofilm formation assay was accomplished for each bacterial type, then performing dual biofilm (bacteria in combination). Watery boiled extracts for each herb was prepared, and then the MIC of their extracts was determined, which was then added to the dual biofilm to detect their watery extracts at sub-MIC of these herbs. Results indicated that all tested isolates of *Staphylococcus aureus* and *Acinetobacter baumannii* were strongly produced biofilm. There was a highly significant differences of MIC among tested herbs ( $p$ -values  $\leq 0.001$ ) and there was a significant differences between the effect of these herbs on dual biofilm. *Syzygium aromaticum* caused an increase in dual biofilm formation instead of inhibiting its formation rather than *Zingiber officinale*. It can be concluded that the watery boiled extracts of these tested herbs are unsuitable for dual biofilm inhibition or their related infections treatment and the usage of their essential oil is more effective.

**Keywords:** *Staphylococcus aureus*, *Acinetobacter baumannii*, Dual biofilm, *Syzygium aromaticum* and *Zingiber officinale*

### Introduction

*Acinetobacter baumannii* is a Gram-negative opportunistic bacterium which can remarkably colonize humans. Nowadays, referring to its capability to resist treatments by antibiotics and its persistence in hospital environments, is considered as a major nosocomial pathogen that has the priority health threat because of its ability to resist carbapenems that are considered the last option for multidrug-resistant infections treatment (Perez et al., 2007; Tacconelli et al., 2018). Infections of this bacteria are expressly difficult to be treated and may be

concordant with excessive rates of mortality when compared with those resulted from further resistant pathogens (Babiker et al., 2021). Its capacity to assemble biofilms (which are communities of heterogeneous microorganisms adhere to abiotic or biotic surfaces, encased in a matrix of extracellular polymeric substance (EPS) to compose a complex structure) (Anderson et al., 2003; Cavalheiro et al., 2018), on the surfaces of hospital and persistence in healthcare settings accelerate its outspread, particularly in the units of the intensive care (Baranzelli et al., 2013). In addition, *Staphylococcus aureus* is a considerable human germ that

resulted in diseases in a wide spectrum. Outbreaks of methicillin-resistant *S. aureus* (MRSA) had been noted worldwide (Galdbart et al., 2000). It may generate numerous of infectious illnesses, like septicemia, pericarditis and meningitis (Wu et al., 2021). A serious obstacle in treatment of bacterial infections had been increased with the increasing of antibiotics resistance by pathogenic microorganism. Hence, besides novel agents of therapies, an alternate drug target must be focused to reach a functional solution of infections resulted from Multidrug-Resistant (MDR) (Boyle et al., 2001; Chastre & Fragon, 2002). In case to this issue, a great interest of using essential oils (EOs), including those of *Syzygium aromaticum* (clove) had been gained due to their antimicrobial capabilities. Eugenol is a bioactive compound that is able to disrupt membranes of bacteria, altering enzymes processes, and prompt lysis of the cell. Besides, these bioactive composites are able to infiltrate the protective barriers of biofilm, disperse them, and target the bacterial cells directly (Çelik et al., 2016). *Syzygium aromaticum* (clove) is a spice used in preparation of food. It is an anticancer agent, considered as a remedy for multiple digestive system diseases, dental and respiratory disorders, asthma, sore throats and headaches, besides being valued for its flavoring properties (Singh et al., 2012). Clove can be broadly used in treatment of gastritis, dyspepsia and diarrhea. (Lee et al., 2009). Additionally to its antibacterial, antiviral, antifungal and antioxidant effects, its essential oil shows an anti-inflammatory, cytotoxic, and anesthetic activities (Chaieb et al., 2007). Eugenol which is a phenylpropene is the main constituent of clove that is behind its strong aroma (Shobana & Naidu, 2000). Another important herb is *Zingiber officinale* (Ginger) is a plant which is extensively used in medicine for treatment a variety of diseases (Elbestawy et al., 2023). A volatile oil of Ginger is drawn from roots and has potential application in the drug, cosmetics, and food fields (Mesomo et al., 2013). Ginger is also used to treat gastro-intestinal problems (Ali et al., 2008). It was described as an arthritis pain relief, low back pain, muscle tenderness, menstrual pain, stomach and chest pain. In addition to treat upper respiratory tract infections, cough, and bronchitis (Shukla & Singh, 2007). Ginger active component is used as antacid and laxative medication, besides causing body warm for circulation boosting and high blood pressure

lowering. The principal aim of the present study is to detect the effect of these two herbs on dual bacterial biofilm composed of MRSA and *Acinetobacter baumannii*.

## Materials and methods

### Bacterial isolates

Both types of MRSA and *Acinetobacter baumannii* were obtained from Department of Biology at the College of Science belonging to the University of Baghdad. They were formerly recognized by Vitek-2 system.

### General protocol of biofilm formation assay.

Tested isolates were cultured in trytone soy broth (HiMedia) and overnight incubation at 37°C was done. 100 µl of bacterial inoculum was added to 2 ml of sterilized normal saline in order to obtain a turbidity compatible to no. 0.5 McFarland standard. Thereafter, addition of 180 µl of tryptone soy broth with 1% glucose to microtiter plates of flat bottom was performed and then, three wells of the plate were filled with bacterial suspension in a volume of 20 µl. Negative control was done by adding only trytone soy broth to six wells. Plate was covered with the supplied lid and incubated at 37°C overnight. After incubation, performing of bacterial culture removal from wells was done and non-adherent cells were pulled out by washing 2-3 times with distilled water. Afterwards, 200 µl of absolute methanol (10 min) was accomplished for bacterial fixation of the adherent cells, then washing and air-drying of the wells was accomplished. All assays were done in triplicates. 0.1% of Crystal violet (200 µl) was included to wells for 15 minutes for biofilm staining. Washing (2-3 times) by distilled water was conducted to take off the stain excess. The amount of stain that was extricated by glycial acetic acid addition (33%) in 200 µl (HiMedia) in each well was quantified by measuring the optical density by spectrophotometer 630nm through a microplate reader (Naves et al, 2008; Ibtissem et al., 2013). The categories of all isolates are based on the ODc value as illustrated in Table 1.

**Table 1. Classification of bacterial adhesion on microtiter plates (Zhao & Liu, 2010).**

Mean OD (630 nm)	Biofilm Intensity
OD≤ODc	No production of biofilm
2ODc>OD>ODc	Weak production of biofilm
4ODc>OD>2ODc	Moderate production of biofilm
OD>4ODc	Strong production of biofilm

### **Preparation of *Syzygium aromaticum* and *Zingiber officinale* watery boiled extracts.**

Both herbs were obtained from the local market in Baghdad, Iraq. Distilled water was used for washing the rhizomes of *Z. officinale* and buds of *S. aromaticum*, dried, afterwards they were cut into small parts and an electrical blender was used to ground them to powder form.

A volume of 100 mL of boiled sterilized distilled water was mixed with powdered ten grams of both herbs to generate watery extract, which allowed to soak for 3 minutes in boiling water on heat, then take it from heater and left for 10 minutes at room temperature. Filtration of the extracts was performed using Whatman No. 1 filter paper throughout the time spent soaking. Filtrates were kept in opaque vials and frozen at 10 °C until their usage. Procedure was done according to (Elbestawy et al., 2013) with some modifications.

### **Determination of Herbal Minimum Inhibitory Concentration (MIC)**

Method of broth dilution was conducted to determine the MIC of tested herbs. Double serial dilutions (from 1024 to 0.5µg/ml) of both herbs were prepared to initiate 100 mg/ml stock solution in test tubes using Mueller Hinton broth as a diluent. Preparation of serial dilutions was accomplished according to CLSI (2024).

### **Dual bacterial biofilm**

The procedure of performing dual biofilm was accomplished according to (Tawfeeq, 2021).

1- A bacterial suspension of *S. aureus* and *A. baumannii* was prepared separately compatible to McFarland standard No. 1 ( $3 \times 10^8$  CFU / ml).

2- Equal volumes (100 µl) of each bacterial isolate suspension were mixed together.

3- Similar procedure described in (General protocol of biofilm formation assay) was followed.

### **Effect of sub-MIC of either *S. aromaticum* and *Z. officinale* watery boiled extract on dual biofilm formation.**

Similar procedure of dual bacterial biofilm was followed to detect the impact of *S. aromaticum* or *Z. officinale* watery extract on dual biofilm. Hence, the culture medium contained the herbal watery extract at sub-MIC.

### **Statistical analysis**

Statistical analysis was conducted using SPSS version 28.0, with employing of one-way analysis of variance (ANOVA) to assess significant differences among group means. When the ANOVA results indicated statistical significance ( $P < 0.05$ ), a post-hoc Tukey's significant difference (HSD) test was applied to determine which groups differed significantly. A significance level of  $\alpha = 0.05$  was used for all analyses, and results were reported accordingly.

## **Results and Discussion**

### **Bacterial biofilm formation**

All tested isolates of *S. aureus* and *A. baumannii* were strong biofilm producers which indicate their high pathogenicity and their high virulence.

### **Herbal Minimum Inhibitory Concentration (MIC)**

Current results demonstrated that the MIC values of *S. aromaticum* and *Z. officinale* watery boiled extract on tested bacterial isolates in dual had a range of 0.781 mg/ml to 100 mg/ml for clove, while ginger gave the same MIC for all tested isolates which was 100 mg/ml. There was a highly significant differences of MIC between the tested herbs ( $p$ -values  $\leq 0.001$ ) According to these results, it is obvious that clove showed a high potency against tested bacterial isolates as towards some of them, very low concentrations of clove were able to inhibit bacterial growth more than that obtained by using ginger. Table 2 illustrates the results of MIC of *S. aromaticum* and *Z. officinale* watery boiled extracts

**Table 2: MIC of *S. aromaticum* and *Z. officinale* watery boiled extract in dual biofilm.**

Isolates no.	MIC of <i>S. aromaticum</i> (mg/ml)	MIC of <i>Z. officinale</i> (mg/ml)
Sa1+Ac1	12.5	100
Sa2+Ac2	3.125	100
Sa3+Ac3	50	100
Sa4+Ac4	25	100
Sa5+Ac5	0.781	100
Sa6+Ac6	100	100
Sa7+Ac7	50	100
Sa8+Ac8	25	100
Sa9+Ac9	25	100
Sa10+Ac10	25	100

\*In isolates no. column, the letters and numbers means bacterial isolate and its number. Sa for *S. aureus* and Ac for *A. baumannii*.

The activity of *S. aromaticum* as antibacterial can be referred to its content of essential oils that are aromatics and volatile mixture compounds which are often composed of terpenes and, in small quantities, phenols, ethers, aldehydes and alcohols, even though they are thought to be poorly soluble in water (Firenzuoli et al, 2008), but they may showed little effectiveness. Figure 1 showed the MIC values of clove on dual biofilm of MRSA and *A. baumannii*.

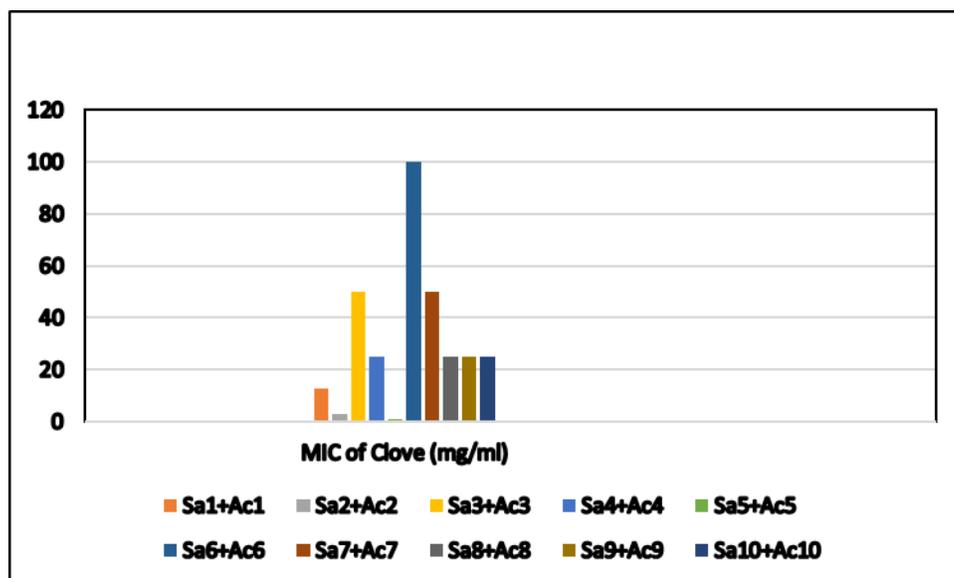


Figure 1: MIC values of clove on dual biofilm of MRSA and *A. baumannii*

Eugenol is the principal component (60-90%) of clove essential oil (da Costa et al., 2020). Emergence of resistance is highly reduced when using clove since it is composed of plenty of compounds that are difficult to resist (Iseppi et al., 2021). This may explain the reason behind appearing clove antibacterial activity even in very low concentrations as appeared in current results. Research on clove and ginger watery boiled extract as an antibacterial had not been done a lot, therefore, this study aimed to test the effect of their watery boiled extract on dual bacterial biofilm composed of *S. aureus* and *A. baumannii*. Current results of clove MIC are disagreed with another study which reported that 2.5 µg/ml of clove oil had the capacity to prevent MRSA from growing (Hashim & Ibrahim, 2024), which is perhaps related to the elevated concentrations of previous mentioned components of clove in oil extract that can affect bacterial growth even in low concentrations. It was found that MIC range was between 0.78 µL/mL to 12.5 µL/mL of clove essential oils, which seems to be very low concentrations (Nihal et al., 2025). Figure 2 shows the MIC values of ginger on dual biofilm of *S. aureus* and *A. baumannii*.

Ginger comprises multiple biological compounds, zingiberene, 6-gingerol, and  $\alpha$ -curcumene are the most important compounds (Kieliszek et al., 2020). Previously, it was reported that the MIC of zingerone against MRSA strains was 512 µg/ml, which is disagreed with present results (Laleh et al., 2024).

#### ***Results of the effect of sub-MIC of either S. aromaticum and Z. officinale watery boiled extract on dual biofilm formation***

Results revealed that there was a highly significant differences between the two herbal watery boiled extract on dual biofilm formation ( $p$ -value  $\leq 0.001$ ), while there was no significant differences in dual biofilm formation without any treatment. It appeared that the addition of sub-MIC of *S. aromaticum* and *Z. officinale* watery boiled extract that were added separately, caused activation of dual biofilm formation rather than inhibiting its formation. This unusual result can be explained by that the watery boiled extract of each herb at sub-MIC may contain low concentrations of the biological effective components that instead of preventing bacterial adherence on microtiter plate surfaces activated it and resulted in enhancing biofilm formation. Another expected explanation is that these extracts that were added in separate, contain components that can be easily utilized as nutritional supply by the tested bacterial cells that led to increase bacterial growth and cell number which play a principal role in bacterial biofilm formation or even interfere with the EPS synthesis which is very important in biofilm formation. Besides, bacteria in combination may help each other in a form of synergism to enhance bacterial biofilm formation that enable bacteria to overcome adverse conditions (Yin et al., 2019). Table 3 and figure 3 illustrate the mean of OD values of dual biofilm with the determined sub-MIC of *S. aromaticum* and *Z. officinale* watery boiled extract that were added separately for the dual biofilm.

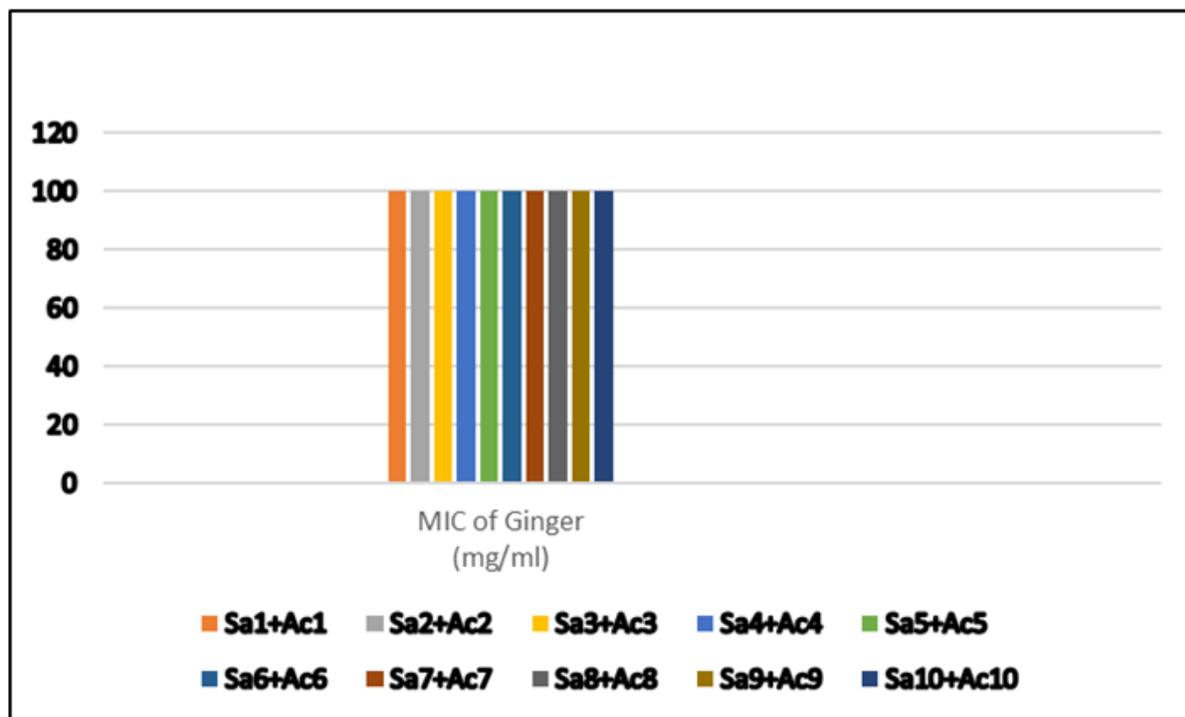
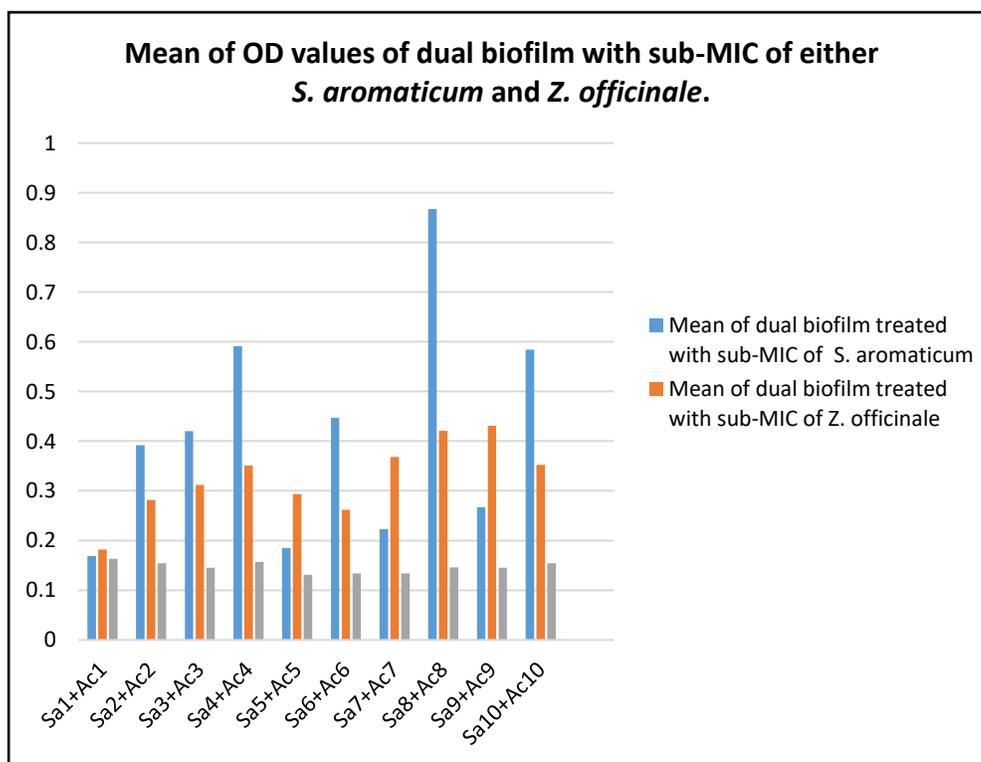


Figure 2: Shows the MIC values of ginger on dual biofilm of MRSA and *A. baumannii*.

Table 3: Mean of OD values of dual biofilm with the determined sub-MIC of *S. aromaticum* and *Z. officinale* watery boiled extract that were added separately

Isolates dual code	Mean of dual biofilm exposed to sub-MIC of <i>S. aromaticum</i>	Mean of dual biofilm exposed to sub-MIC of <i>Z. officinale</i>	Mean of dual biofilm (Control)
Sa1+Ac1	0.169	0.182	0.163
Sa2+Ac2	0.392	0.282	0.154
Sa3+Ac3	0.420	0.312	0.145
Sa4+Ac4	0.591	0.351	0.157
Sa5+Ac5	0.185	0.293	0.131
Sa6+Ac6	0.447	0.262	0.134
Sa7+Ac7	0.223	0.368	0.134
Sa8+Ac8	0.867	0.421	0.146
Sa9+Ac9	0.267	0.431	0.145
Sa10+Ac10	0.584	0.352	0.154



**Figure 3: Mean of OD values of dual biofilm with sub-MIC of either *S. aromaticum* and *Z. officinale* watery boiled extracts.**

Even though the most previous studies were done to detect the role of essential oils of *S. aromaticum* and *Z. officinale* on MRSA and *A. baumannii* (Kashi et al., 2024; Nihal et al., 2025; Silva & Marques, 2020; Kačániová et al., 2021), there is a very limitation in studying the effect of watery boiled extracts of these herbs. According to our knowledge, this is the first study deals with the watery boiled extracts effectiveness on dual biofilm formation that composed of *S. aureus* and *A. baumannii*.

### Conclusion

As a conclusion, the sub-MIC of either *S. aromaticum* and *Z. officinale* watery boiled extracts had the potency to increase the biofilm formations in dual pattern instead of inhibiting them, which is lead to conclude that the watery boiled extracts of these plants aren't recommended to be used in the treatment of MRSA and *A. baumannii* dual biofilm or the infections resulted from these bacteria in combination.

### Author Contributions

Each author has significantly contributed to the study's conception, design, data collection, analysis, and interpretation. All authors were involved in writing the manuscript or critically reviewing it for its intellectual value. They have reviewed and approved the final version for

submission and publication and accept full responsibility for the content and integrity of the work.

### Financial Support

The authors declare that no external funding was received for this study.

### Conflicts of Interest

The authors state that there are no financial, personal, or professional conflicts of interest associated with this research.

### Ethical Approvals

This research did not involve the use of human participants or animal subjects and therefore did not require ethical clearance.

### Publisher's Note

The Journal stays neutral about jurisdictional claims in published maps and institutional affiliations

### References

Ali, B.H., Blunden, G., Tanira, M.O., Nemmar, A. (2008). Some phytochemical, pharmacological and toxicological properties of ginger (*Zingiber officinale* Roscoe): a review

- of recent research. Food and Chemical Toxicology. 46(2):409–420.
- Anderson, G.G., Palermo, J.J., Schilling, J.D., Roth, R., Heuser, J., Hultgren, S.J. (2003). Intracellular Bacterial Biofilm-Like Pods in Urinary Tract Infections. Science, 301: 105–107.
- Babiker, A., Clarke, L.G., Saul, M. et al. (2021). Changing Epidemiology and Decreased Mortality Associated with Carbapenem-resistant Gram-negative Bacteria 2000–2017. Clinical Infectious Diseases, 73: 4521–4530.
- Baranzelli, A., Wallyn, F., et Nseir, S. (2013). Infections bronchopulmonaires à *Stenotrophomonas maltophilia* et à *Acinetobacter baumannii*. Revue de Pneumologie Clinique, 69: 250–59.
- Boyle, E.M., Ainsworth, J.R., Levin, A.V., Campbell, A.N., Watkinson, M. (2001). Ophthalmic Pseudomonas infection in infancy. Arch Dis Child Fetal Neonatal Ed, 85(2): F139–40.
- Cavalheiro, M., & Teixeira, M.C. (2018). Candida Biofilms: Threats, Challenges, and Promising Strategies. Front. Med, 5, 28.
- Çelik, C., Tutar, U., Karaman, İ., et al. (2016). Evaluation of the Antibiofilm and Antimicrobial Properties of *Ziziphora Tenuior* L. Essential Oil Against Multidrug-Resistant *Acinetobacter Baumannii*. International journal of pharmacology, 12: 28-35.
- Chaieb, K., Zmantar, T., Ksouri, R., Hajlaoui, H., Mahdouani, K., Abdelly, C., Bakhrouf, A. (2007). Antioxidant properties of the essential oil of *Eugenia caryophyllata* and its antifungal activity against a large number of clinical *Candida* species. Mycoses, 50: 403–406.
- Chastre, J., & Fragon, J.Y. (2002). Ventilator-associated pneumonia. Am J Respir Crit Care Med. 165(7):867-903.
- CLSI. Performance Standards for Antimicrobial Susceptibility Testing. 34th edition. CLSI supplement M100S. (2024). Clinical and Laboratory Standards Institute.
- Costa, J. S., Barroso, A. S., Mourão, R. H. V., da Silva, J. K. R., Maia, J. G. S., Figueiredo, P. L. B. (2020). Seasonal and antioxidant evaluation of essential oil from *Eugenia uniflora* L., curzerene-rich, thermally produced in situ. Biomolecules, 10(2), 328.
- Elbestawy, M.K.M., El-Sherbiny, G.M., Moghannem, S.A., Farghal, E.E. (2023). Antibacterial, Antibiofilm, and Anti-Inflammatory Activities of Ginger Extract against *Helicobacter pylori*. Microbiol. Res. 14: 1124–1138.
- Firenzuoli, F. (2008). Fitoterapia Guida All'uso Clinico Delle Piante Medicinali, 4th ed.; Edra S.p.A: Milan, Italy.
- Galdbart, J. O., Morvan, A., El Solh, N. (2000). Phenotypic and molecular typing of nosocomial methicillin-resistant *Staphylococcus aureus* strains susceptible to gentamicin isolated in France from 1995 to 1997. J. Clin. Microbiol. 38:185–190.
- Hashim, M.U., & Ibrahim, M.S.O. (2024). Extraction and Identification of the Main Components of Cloves (*Syzygium Aromaticum* L.) Oil Extract and its Antimicrobial Activity against MRSA strain. J Fac Med Bagdad 66(2):184-191.
- Ibtissem, K.T., Hafida, H., et al. (2013). Detection of *icaA* and *icaD* genes and biofilm formation in *Staphylococcus* spp. isolated from urinary catheters at the University Hospital of Tlemcen (Algeria). African Journal of Microbiology Research, 7(47): 5350-5357.
- Iseppi, R., Mariani, M., Cond., C., Sabia, C., Messi, P. (2021). Essential Oils: A Natural Weapon against Antibiotic-Resistant Bacteria Responsible for Nosocomial Infections. Antibiotics, 10: 417.
- Kačániová, M., Galovičová, L., Borotová, P., Valková, V., D'úránová, H., Kowalczewski, P.L., Said-Al Ahl, H.A.H., Hikal, W.M., Vukic, M., Savitskaya, T., et al. (2021). Chemical Composition, *In Vitro* and *In Situ* Antimicrobial and Antibiofilm Activities of *Syzygium aromaticum* (Clove) Essential Oil. Plants, 10:2185.
- Kashi, M., Noei, M., Chegini, Z., Shariati, A. (2024). Natural compounds in the fight against *Staphylococcus aureus* biofilms: a review of antibiofilm strategies. Front. Pharmacol. 15:1491363.
- Kieliszek, M., Edris, A., Kot, A.M., Piwowarek, K. (2020). Biological activity of some aromatic plants and their metabolites, with an emphasis on health-promoting properties. Molecules, 25: 2478.
- Larjani, L., Shafiei, M., Ghasemi Pirbalouti, A., Ferdousi, A., Chiani, M. (2024). Antibacterial and antibiofilm activities of zingerone and niosomal zingerone against methicillin-resistant *Staphylococcus aureus* (MRSA). Iran J Microbiol. Jun;16(3):366-375.
- Lee, S., Najiah, M., Wendy, W., Nadirah, M. (2009). Chemical composition and antimicrobial activity of the essential oil of *Syzygium aromaticum* flower bud (Clove) against fish systemic bacteria isolated from aquaculture sites. Front. Agric. China, 3:332–336.
- Mesomo, M.C., Corazza, M.L., Ndiaye, P.M., Dalla Santa, O.R., Cardozo, L., de Paula Scheer, A. (2013). Supercritical CO<sub>2</sub> extracts and essential oil of ginger (*Zingiber officinale* R.): Chemical composition and antibacterial activity. J. Supercrit. Fluids, 80: 44–49.
- Naves, P., del Prado, G., et al. (2008). Measurement of biofilm formation by clinical isolates of *Escherichia coli* is method-dependent. J Appl Microbiol. 105(2):585-90.
- Nihal, E., Oumaima, Z., Amal, R., Asmaa, W., Mohamed, A., Zohra, L.(2025). Antibacterial Activity and Antibiofilm of Essential Oils of Clove and Thyme Against Clinical Isolates of Multidrug-Resistant *Acinetobacter baumannii* Associated with Nosocomial Infections. Archives of Microbiology and Immunology. 9: 90-97.
- Perez, F., Hujer, A.M., Hujer, K.M. et al. (2007). Global Challenge of Multidrug-Resistant *Acinetobacter baumannii*. Antimicrobial Agents and Chemotherapy 51 (10):3471–3484. doi: [10.1128/AAC.01464-06](https://doi.org/10.1128/AAC.01464-06).
- Shobana, S., & Naidu, K.A. (2000). Antioxidant activity of selected Indian spices. Prostaglandins Leukot. Essent. Fat. Acids (PLEFA), 62:107–110.
- Shukla, Y., & Singh, M. (2007). Cancer preventive properties of ginger: a brief review. Food and Chemical Toxicology. 45(5):683–690.

- Silva, N.B.S., Marques, L.A., Röder, D.D.B. (2020) Antibiofilm Activity of Natural Products: Promising Strategies for Combating Microbial Biofilms. *Ann Public Health Reports*, 4(1):92-99.
- Singh, J., Baghotia, A., Goel, S.P. (2012). *Eugenia caryophyllata* Thunberg (Family Myrtaceae): A review. *Int. J. Res. Pharm. Biomed. Sci.* 3: 1469–1475.
- Tacconelli, E., Carrara, E., Savoldi, A. et al. (2018). Discovery, Research, and Development of New Antibiotics: The WHO Priority List of Antibiotic-Resistant Bacteria and Tuberculosis. *The Lancet Infectious Diseases*, 18: 318-327.
- Tawfeeq, H. K. (2021). Response of *pseudomonas aeruginosa* and methicillin resistance *staphylococcus aureus* under antibacterial stress. Thesis. Anbar University.
- Wu, S., Zhang, J., Peng, Q., Liu, Y., Lei, L., Zhang, H. (2021). The role of YycFG in gene regulation, biofilm organization and drug resistance. *Antibiotics* (Basel, Switzerland) 10:1555. doi: 10.3390/antibiotics10121555.
- Yin, W., Wang, Y., Liu, L., He, J. (2019). Biofilms: the microbial “protective clothing” in extreme environments. *International Journal of Molecular Sciences*, 20(14):p. 3423.
- Zhao, T., & Lium, Y. (2010). N-acetylcysteine inhibit biofilms produced by *Pseudomonas aeruginosa*. *BMC Microbiol.* 12(10):140.

**How to cite this article**

Yaseen, N.N., Najim, S.S. Tawfeeq, H.K. (2025). Influence of *Syzygium aromaticum* and *Zingiber officinale* on dual biofilm of *Staphylococcus aureus* and *Acinetobacter baumannii*. *Microbial Science Archives*, Vol. 5 (3), 24-30.  
<https://doi.org/10.47587/MSA.2025.5302>

This work is licensed under a [Creative Commons Attribution 4.0 International License](https://creativecommons.org/licenses/by/4.0/)

