

BAB 5

KESIMPULAN DAN SARAN

5.1 Kesimpulan

1. Kombinasi klindamisin dan asam galat menunjukkan aktivitas dalam menghambat pembentukan biofilm bakteri *Staphylococcus aureus*.
2. Efektivitas kombinasi klindamisin dan asam galat menunjukkan efisiensi dosis dibandingkan dengan penggunaan tunggal masing-masing senyawa. Hal ini dibuktikan melalui penurunan nilai MBIC₅₀ dari kedua senyawa.
3. Interaksi antara klindamisin dan asam galat dalam menghambat biofilm bakteri *Staphylococcus aureus* diklasifikasikan sebagai aditif.

5.2 Saran

1. Perlu dilakukan penelitian lebih lanjut untuk menguji rasio kombinasi yang berbeda (selain rasio 1:1) dengan harapan dapat mencapai efek sinergisme ($FBIC_i \leq 0,5$).
2. Perlu dilakukan penelitian lebih lanjut untuk menguji mekanisme aksi dari asam galat secara molekuler, sehingga dapat memvalidasi hipotesis mekanisme kerja *multi-targeting* dari kombinasi klindamisin dan asam galat.
3. Dapat dilakukan pengujian aktivitas antibiofilm dengan menggunakan metode berbeda seperti MBEC assay (*Minimum Biofilm Eradication Concentration*) untuk mengetahui efektivitasnya pada biofilm yang sudah matang.

DAFTAR PUSTAKA

- Abdilah, F. and Kurniawan. 2022. "Morphological Characteristics of Air Bacteria." *Borneo Journal of Medical Laboratory Technology* Vol 3
- Aboelnaga, N., Elsayed, S.W., Abdelsalam, N.A., Salem, S. and Saif, N.A. 2024. "Deciphering the Dynamics of Methicillin - Resistant *Staphylococcus aureus* Biofilm Formation : From Molecular Signaling to Nanotherapeutic Advances." *Cell Communication and Signaling*
- Aprilika, K. dan Advinda, L. 2025. "Deteksi *Staphylococcus aureus* pada Beberapa Jenis Jajanan di SD Negeri 19 Air Tawar Padang." *Jurnal Biologi dan Pembelajarannya (JB&P)*
- Besan, E.J., Rahmawati, I. and Saptarini, O. 2023. "Aktivitas Antibiofilm Ekstrak dan Fraksi-Fraksi Bunga Telang (*Clitoria ternatea l.*) terhadap *Staphylococcus aureus*." *PHARMACY: Jurnal Farmasi Indonesia*
- Bouarab-chibane, L., Forquet, V., Lantéri, P. and Clément, Y. 2019. "Antibacterial Properties of Polyphenols : Characterization and QSAR (Quantitative Structure – Activity Relationship) Models." *Frontiers in Microbiology*
- Boubakeur, B., Drabo, M.S., Khadem, H., Segda, R. and Shah, M.S. 2020. "Antimicrobial, Antibiofilm, and Probiofilm Effect of Gallic Acid on Exopolysaccharide Dependent and Idenpendent Biofilm of Model Strains *Streptococcus thermophilus* CNRZ 447 and *Staphylococcus aureus* ATCC 43300." *Journal of Microbiology, Biotechnology and Food Sciences*
- Brindle, R., Williams, O.M., Davies, P., Harris, T., Jarman, H., Hay, A.D. and Featherstone, P. 2017. "Adjunctive Clindamycin for Cellulitis : A Clinical Trial Comparing Flucloxacillin with or without Clindamycin for The Treatment of Limb Cellulitis." *BMJ Open*.
- Chan, Y.L., Chee, C.F., Tang, S.N. and Tay, S.T. 2024. "Unveiling Genetic Profiles and Correlations of Biofilm - Associated Genes, Quorum Sensing, and Antibiotic Resistance in *Staphylococcus aureus* Isolated from a Malaysian Teaching Hospital." *European Journal of Medical Research*
- Chen, X., Thomsen, T.R., Winkler, H. and Xu, Y. 2020. "Influence of Biofilm Growth Age, Media, Antibiotic Concentration and Exposure Time on *Staphylococcus aureus* and *Pseudomonas aeruginosa* Biofilm Removal in Vitro." *BMC Microbiology*

- Darmawansyah, A., Nurlansi. and Haeruddin. 2023. “Pemisahan Senyawa Terpenoid Ekstrak N-Heksan Daun Kaembu-Embu (*Blumea Balsamifera*) Menggunakan Kromatografi Kolom Gravitasi.” *Jurnal Kimia dan Pendidikan Kimia*
- Deralitha, M.S. and Ernawati, T. 2024. “Penatalaksanaan Holistik Penyakit Impetigo pada Anak Usia 12 Tahun di Puskesmas Kampung Sawah Melalui Pendekatan Kedokteran Keluarga.” *Medical Profession Journal of Lampung*
- Dwi, G., Putra, S., Khairullah, A.R., Effendi, M.H., Widodo, A., Ramadhani, S. and Muhammad T. 2023. “Detection of Multidrug-Resistant *Staphylococcus aureus* Isolated from Dairies Milk in Medowo Village of Kediri District , Indonesia.” *Biodiversitas Journal of Biological Diversity*
- Fadrian. 2023. Antibiotik, Infeksi, dan Resistensi. *Andalas University Press*.
- Fatmawati, A. 2016. “Sensitivitas Antibiotik Betalaktam terhadap Bakteri Hasil Isolat Kultur Urine pada Penderita Infeksi Saluran Kemih.” *Jurnal Medika*
- Gobin, M., Proust, R., Lack, S., Duciel, L., Des Courtils, C., Pauthe, E., Grand, A., Seyer, D. 2022. “A Combination of the Natural Molecules Gallic Acid and Carvacrol Eradicates *P. aeruginosa* and *S. aureus* Mature Biofilms.” *International Journal of Molecular Sciences*.
- Hamidah, M.N., Rianingsih, L. and Romadhon, R. 2019. “Aktivitas Antibakteri Isolat Bakteri Asam Laktat Dari Peda dengan Jenis Ikan Berbeda terhadap *E. Coli* dan *S. aureus*.” *Jurnal Ilmu dan Teknologi Perikanan*
- Hanina, H., Humaryanto, H., Gading, P.W., Aurora, W.H.I. and Harahap, H. 2022. “Peningkatan Pengetahuan Siswa Pondok Pesantren Nurul Iman tentang Infeksi *Staphylococcus aureus* di Kulit dengan Metode Penyuluhan.” *Jurnal Pengabdian kepada Masyarakat FKIK*
- Hidayati, A.N., Sari, M., Damayanti, Y., Reza, N.R., and Widia, Y. 2019. Infeksi Bakteri Di Kulit (Seri Dermatologi Dan Venereologi 1). Airlangga University Press.
- Hu, H., Ramezanpour, M., Hayes, A.J., Liu, S., Psaltis, A.J., Wormald, P.J. and Vreugde, S. 2019. “Sub-Inhibitory Clindamycin and Azithromycin reduce *S. aureus* Exoprotein Induced Toxicity, Inflammation, Barrier Disruption and Invasion.” *J Clin Med*.

- Irjayanti, A., Wambrauw, A., Wahyuni, I. and Maranden, A.A. 2023. "Personal Hygiene with the Incidence of Skin Diseases." *Jurnal Ilmiah Kesehatan Sandi Husada*
- Kasper, N., Alhede, M., Kvich, L. and Bjarnsholt, T. 2019. "Into the Well — A Close Look at the Complex Structures of a Microtiter Biofilm and the Crystal Violet Assay." *Biofilm*
- Katzung, B.G., Masters, SB. and Trevor, A.J. 2012. *Basic & Clinical Pharmacology Edition 12th.*
- Kwaengmuang, P., Chaiyawong, K., Warong, T., Rattanakiat, S. and Pulbutr, P. 2023. "Antibiofilm and Antibacterial Activities of Lupinifolin in Combination with Protein Synthesis Inhibitors against *Methicillin-Resistant Staphylococcus aureus*." *Journal of Herbmec Pharmacology*
- Kyaw, B.W., Arora, S. and Lim, C.S. 2012. "Bactericidal Antibiotic-Phytochemical Combinations Against Methicillin Resistant." *Brazilian Journal of Microbiology*
- Lasmini, T., Saphira, A., Marlina, L.B.D. and Margareta, T.S. 2022. "Identifikasi Bakteri *Staphylococcus aureus* pada Swab Rongga Hidung Penjamah Makanan di Jalan Durian Kota Pekanbaru." *Rakernas VII*
- Leclercq, R. 2002. "Mechanisms of Resistance to Macrolides and Lincosamides : Nature of the Resistance Elements and Their Clinical Implications." *CID* 34.
- Liu, H.Y., Prentice, E.L. and Webber, M.A. 2024. "Mechanisms of Antimicrobial Resistance in Biofilms." *NPJ Antimicrobials and Resistance*
- Liu, X., Yao, H., Zhao, X. and Ge, C. 2023. "Biofilm Formation and Control of Foodborne Pathogenic Bacteria." *Molecules*
- Lyles, R.H., Poindexter, C., Evans, A., Brown, M. and Cooper, C.R. 2008. "Nonlinear Model-Based Estimates of IC 50 for Studies Involving Continuous Therapeutic Dose – Response Data." *Contemporary Clinical Trials*
- Majhi, S., Dash, M., Mohapatra, D., Mohapatra, A. and Chayanin, N. 2016. "Detection of Inducible and Constitutive Clindamycin Resistance among *Staphylococcus aureus* Isolates in a Tertiary Care Hospital, Eastern India." *Avicenna J Med*

- Manandhar, S., Singh, A., Varma, A., Pandey, S. and Shrivastava, N. 2018. "Biofilm Producing Clinical *Staphylococcus aureus* Isolates Augmented Prevalence of Antibiotic Resistant Cases in Tertiary Care Hospitals of Nepal." *Frontiers in Microbiology*
- Mastini, I.A.K. 2004. "Isolasi Asam Galat Dari Daun Jambu Biji (*Psidium guajava l.*)."
- Mishra, R., Amrita K.P., Surajit D.M. and Shakeel, M. 2020. "Natural Anti-Biofilm Agents: Strategies to Control Biofilm-Forming Pathogens." *Frontiers in Microbiology*
- Nadar, S., Khan, K. and Patching, S.M. 2022. "Development of Antibiofilm Therapeutics Strategies to Overcome Antimicrobial Drug Resistance." *Microorganisms*
- Neopane, P., Nepal, H.P., Shrestha, R., Uehara, O. and Abiko, Y. 2018. "In Vitro Biofilm Formation by *Staphylococcus aureus* Isolated from Wounds of Hospital-Admitted Patients and Their Association with Antimicrobial Resistance." *International Journal of General Medicine*
- Nur, K., Yuniati, L., Aرسال, A.S.F., Hermiaty. and Syamsu, R.F. 2023. "Efektifitas Ekstrak Daun Kemangi & Ekstrak Daun Sirih Merah Sebagai Anti Mikropa *Staphylococcus aureus* Penyebab Furunkle." *Fakumi Medical Journal: Jurnal Mahasiswa Kedokteran*
- Pamudi, B.F., Munira, M. and Nasir, M. 2024. "Uji Aktivitas Antibiofilm Ekstrak Daun Kirinyuh (*Chromolaena odorata l.*) dari Kawasan Geotermal Ie Seum terhadap *Staphylococcus aureus*." *Jurnal SAGO*.
- Paulson, D. 2025. "A Comprehensive Review of Bacterial Skin Infections: Clinical Insights and Life-Threatening Outcomes." *Preprints*
- Prabhu, K., Rao, S. and Rao, V. 2011. "Inducible Clindamycin Resistance in *Staphylococcus aureus* Isolated from Clinical Samples." *Journal of Laboratory Physicians*
- Prasetyawa, H.R., Kusumawati, I. and Primaharinastiti, R. 2024. "Teknik Aplikasi Sampel pada Pengujian Kuantitatif Kromatografi Lapis Tipis: Tinjauan terhadap Area dan Faktor Retensi." *Media Farmasi*
- Pratama, D., Suprihadi, A. and Raharjo, B. 2017. "Efektivitas Kombinasi Ekstrak Herbal (Mengkudu, Pepaya, Kunyit) terhadap Daya Hambat Perumbuhan *Aeromonas hydrophila* secara In Vitro." *Jurnal Biologi*
- Pratiwi, S.A., Februyani, N. and Basith, A. 2023. "Skринing Dan Uji

Penggolongan Fitokimia Dengan Metode KLT Pada Ekstrak Etanol Kemangi (*Ocimum basilicum l*) dan Sereh Dapur (*Cymbopogon ciratus*).” *Pharmacy Medical Journal*

- Quave, C.L., Plano, R.L.W., Pantuso, T. and Bennett, B.C. 2008. “Effects of Extracts from Italian Medicinal Plants on Planktonic Growth, Biofilm Formation and Adherence of Methicillin-Resistant *Staphylococcus aureus*.” *Journal Ethnopharmacol*
- Ramadhani, S., Khairullah, A.R., Effendi, M.H., Sukmanadi, M., Tyasningsih, W., Millannia, S.K., Afnani, D.A., *et al.* 2024. “Detection of the Methicillin-Resistant *Staphylococcus aureus* Gene Encoding MecA in Nasal Swabs of Cats in Surabaya, Indonesia.” *Open Veterinary Journal*
- Rayan, M., Lafi, S.A., Falah, M., Kacergius, T., Kirkliauskiene, A., Gabe, V. and Rayan, A. 2023. “Alkyl Gallates as Potential Antibiofilm Agents: A Review.” *Molecules*
- Regmi, R.S., Khadka, S., Sapkota, S., Adhikari, S., Thapa, S., Subedi, S., Shrestha, P. and Rana, J.C. 2020. “Phenotypic Detection of Inducible Clindamycin Resistance among Clinical Isolates of *Staphylococcus aureus* in
- Riza, A., Marfu’ah, N. and Amal, S. 2018. “Aktivitas Antibakteri Kayu Siwak (*Salvadora persica*) Fraksi Eter terhadap Bakteri *Staphylococcus aureus* Secara In Vitro.” *Pharmaceutical Journal of Islamic Pharmacy*
- Şabîk, A.E., Mohammed, F.S. and Sevîndîk, M. 2024. “Gallic Acid: Derivatives and Biosynthesis, Pharmacological and Therapeutic Gallic Acid: Derivatives and Biosynthesis, Pharmacological and Therapeutic Effect, Biological Activity.” *Bulletin of University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca. Food Science and Technology*:
- Sang, H., Jin, H., Song, P., Xu, W. and Wang, F. 2024. “Gallic Acid Exerts Antibiofilm Activity by Inhibiting Methicillin-Resistant *Staphylococcus aureus* Adhesion.” *Scientific Reports*
- Shang, D., Liu, Y., Jiang, F., Ji, F., Wang, H. and Han, X. 2019. “Synergistic Antibacterial Activity of Designed Trp-Containing Antibacterial Peptides in Combination With Antibiotics Against Multidrug-Resistant *Staphylococcus epidermidis*.” *Frontiers in Microbiology*

- Sianturi, A., Hitijahubessy, H., Rumangun, A.P.M. and Samid, A. 2023. "Uji Aktivitas Antibakteri *Vibrio sp* dengan Ekstrak Etanol Daun Sirsak (*Annona muricata l.*)" *BIOFAAIL Journal*
- Van De Sijpe, G., Mylemans, M., Álvarez, L.A., Ozbey, A.C. Allegaert, K., Rozenski, J., Annaert, P., Desmet, S. and Spriet, I. 2023. "Assessment of in Vitro Antimicrobial Activity of Clindamycin Metabolites against *Staphylococcus* Species." *Clinical Microbiology and Infection*
- Timsina, R., Shrestha, U., Singh, A. and Timalisina, B. 2021. "Inducible Clindamycin Resistance and Erm Genes in *Staphylococcus aureus* in School Children in Kathmandu, Nepal." *Future Science OA*
- Verma, P. and Maheswari. 2017. "Minimum Biofilm Eradication Concentration (MBEC) Assay of Silver and Selenium Nanoparticles against Biofilm Forming *Staphylococcus aureus*." *Journal of Medical Science And clinical Research*
- Wardaniati, I. and Yanti, R. 2020. "Uji Aktivitas Antioksidan Ekstrak Etanol Propolis Lebah Trigona (*Trigona itama*)." *Journal Of Pharmacy and Science*
- Yanto, R.B., Satriawan, E. and Suryani, A. 2021. "Identifikasi dan Uji Resistensi *Staphylococcus aureus* terhadap Antibiotik (*Chloramphenicol* dan *Cefotaxime Sodium*) dari Pus Infeksi Piogenik di Puskesmas Proppo." *Jurnal Kimia Riset*