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Natural Approach to Overcome Bacterial Infections: Phytochemicals with Antibiofilm Activity – A Systematic Review

Nusyaibah Mohd Asri[a], Indah Mohd Amin[b*], Nurhayati Mohamad Zain[b]

Structured Abstract

Background: Persistent bacterial infections associated with biofilm formation present a major clinical challenge due to resistance to conventional antibiotics and evasion of host immune responses. Biofilms are structured microbial communities embedded in an extracellular polymeric matrix that enhances bacterial survival and contributes to chronic and recurrent infections, particularly on medical devices. In response to these challenges, plant-derived phytochemicals have emerged as promising antibiofilm agents. These compounds exhibit diverse antimicrobial properties and target multiple pathways involved in biofilm development. This systematic review evaluates current evidence on phytochemicals with antibiofilm activity, emphasizing their effectiveness, spectrum of action, and underlying mechanisms for managing persistence.

Methods: This systematic review was conducted following PRISMA guidelines. A literature search was performed using Scopus, ScienceDirect, and Web of Science databases. Studies on plant-derived phytochemicals with antibiofilm activity were selected based on predefined inclusion and exclusion criteria. Methodological quality was assessed using the Joanna Briggs Institute (JBI) Critical Appraisal Tool. Relevant data on phytochemical classes, target bacteria, antibiofilm outcomes, and mechanisms of action were extracted and synthesized qualitatively.

Results: Fourteen experimental studies published between 2021 and 2025 were included in this review. Phytochemicals from major classes such as phenolics, flavonoids, terpenoids, saponins, and quinones demonstrated notable antibiofilm activity against both Gram-positive and Gram-negative bacteria, including multidrug-resistant strains. Most compounds were effective in inhibiting biofilm formation, while several also showed activity against established biofilms. Key mechanisms involved membrane disruption, quorum sensing inhibition, downregulation of biofilm-related genes, and interference with extracellular polymeric substance matrix integrity. Overall, the included studies exhibited high methodological quality based on JBI assessment.

Conclusion: This systematic review demonstrates the strong potential of phytochemicals as natural antibiofilm agents for managing persistent bacterial infections. Their broad-spectrum activity and multi-target mechanisms support their use as alternative or complementary strategies to conventional antibiotics. However, further standardized experimental and translational studies are required to validate their efficacy and support future clinical application.

Keywords: Phytochemicals, Antibiofilm Activity, Biofilm-Associated Infections, Natural Antimicrobials, Systematic Review

*Correspondence: indahma@uitm.edu.my

[a] School of Biology, Faculty of Applied Sciences, Universiti Teknologi MARA, Shah Alam, Malaysia

[b] Faculty of Dentistry, Universiti Teknologi MARA, Sungai Buluh Campus, Sungai Buluh Selangor