Synergistic Enhancement of Oxacillin Efficacy Against MRSA Using Green Synthesized Silver Nanoparticles from *Syzygium cumini* Leaf Extract

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Methicillin-resistant *Staphylococcus aureus* (MRSA) is a major global health concern due to its resistance to beta-lactam antibiotics, including oxacillin. Nanoparticles have emerged as a promising alternative antimicrobial strategy, particularly when combined with existing antibiotics. This study aimed to synthesize and characterize silver nanoparticles (AgNPs) using *Syzygium cumini* leaf extract and evaluate their synergistic antibacterial activity with oxacillin against MRSA. Silver nanoparticles were synthesized via a green method by reacting 1 mM $AgNO_3$ with aqueous leaf extract (1:5 ratio, pH 8.15). Formation of AgNPs was confirmed by a colour change to brown and a characteristic surface plasmon resonance peak at 411 nm in UV-visible spectroscopy. Dynamic light scattering analysis revealed a mean hydrodynamic diameter of 155 nm and a high polydispersity index (0.92), indicating a heterogeneous nanoparticle distribution. An ATR-FTIR analysis confirmed the presence of functional groups from plant-derived biomolecules acting as reducing and stabilizing agents. Scanning electron microscopy was used to characterize the surface morphology and microstructure of AgNPs. Antimicrobial activity was evaluated using the disk diffusion method against four genetically confirmed MRSA strains and methicillin-susceptible *Staphylococcus aureus* (MSSA, ATCC 25923), with AgNPs alone, oxacillin alone and the AgNP-oxacillin combination alongside distilled water as a negative control. Silver nanoparticles exhibited concentration-dependent antibacterial activity against MRSA ($p < 0.001$, $\eta^2 = 0.554$). The combination of AgNPs with oxacillin produced significantly larger zones than AgNPs alone ($p = 0.010$), indicating a significant synergistic effect. Against MSSA, the combination demonstrated significantly greater activity than the individual treatments ($p < 0.001$, $\eta^2 = 0.942$). These findings highlight the potential of *S. cumini*-mediated AgNPs as antibiotic adjuvants and support further investigation into nanoparticle-based combination therapies to combat multidrug-resistant pathogens.

Keywords: Silver Nanoparticles (AgNPs), green synthesis, *Syzygium cumini*, Methicillin-resistant *Staphylococcus aureus* (MRSA), oxacillin