Optimizing Bacteriophage-Infused Hybrid-Hydrogel Matrices to Combat Antibiotic-Resistant Infections

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The growing prevalence of antibiotic-resistant bacterial infections has impacted tens of millions of lives by reducing antibiotic effectiveness and worsening infections, which increases healing times and complications. This study evaluates bacteriophage-infused hybrid-hydrogel bandages as an alternative to conventional antibiotics, with a focus on how hydrogel matrix composition influences antimicrobial activity. 210 Mueller-Hinton agar plates were prepared and spread with full lawns of Escherichia coli K-12. Five hydrogel formulations composed of gelatin, agarose, chitosan, and sodium alginate in varying combinations were synthesized and infused with T4r+ bacteriophages before being applied to 1 cm² sections of sterile gauze. Distilled water-treated plates served as the negative control, and neomycin-treated plates were included as a comparative treatment. Each treatment was tested across 30 plates. After incubation (37 °C for 24 hours), zones of inhibition were measured using digital calipers. Statistical analysis was conducted using one-way ANOVA and the Kruskal-Wallis test, followed by post-hoc comparisons. Statistical analysis revealed significant differences among treatments (one-way ANOVA, $p < 0.001$; Kruskal-Wallis $?^2 = 54.96$, $df = 5$, $p < 0.001$). Post-hoc analysis demonstrated that all hybrid-hydrogel-bacteriophage formulations produced significantly greater inhibition than neomycin ($p < 0.01$), with the GACS formulation consistently outperforming all other treatments. These results show that hydrogel matrix composition significantly influences bacteriophage delivery and efficacy, supporting the potential of optimized bacteriophage-hybrid-hydrogel bandages as alternatives to conventional antibiotics for treating antibiotic-resistant wound infections.

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