Sustainable Bioactive Composite Hydrogels from Local Waste and Dhofar's Indigenous Plant Extracts: A Frontier in Natural Biomedical Materials

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ABSTRACT

This study aims to develop sustainable and bioactive composite hydrogels by integrating bacterial cellulose (BC) with indigenous plant extracts from Dhofar and local waste sources, targeting biomedical applications. BC was synthesized using food waste as a low-cost carbon source, promoting both environmental and economic sustainability. Ex situ impregnation of BC hydrogel was performed using extracts from Punica granatum (pomegranate) peel, Euclea schimperi, Aloe vera, and cactus plants known for their traditional medicinal value in Dhofar. Comprehensive characterization techniques revealed that the incorporation of these botanical extracts enhanced the hydrogels' liquid retention, mechanical strength, and biological performance. Antimicrobial efficacy was assessed via MIC, MBC, disc diffusion, and plate count methods, demonstrating significant activity against Staphylococcus aureus and Escherichia coli. Notably, composites enriched with Aloe vera and cactus showed superior mechanical integrity, suggesting potential for durable biomedical use. The findings underscore the potential of combining locally sourced waste and traditional plant wisdom to produce eco-friendly, functional biomaterials for pharmaceutical and cosmetic applications.

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