Innovative Sustainable Bioplastic Production: Unleashing the Potential of Crustacean Waste through a Novel Microbial Synthesis

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ABSTRACT

Fossil fuel-derived plastics, including microplastics, cause significant environmental pollution, necessitating sustainable solutions. Although biodegradable plastics are essential for sustainability, their degradation is often limited to specific conditions, posing significant challenges. Polyhydroxyalkanoates (PHAs), synthesized from sugars and oils by microorganisms, offer a promising solution for their easy degradation in diverse environments, including marine and cold soils. However, the economic feasibility of PHA production is hindered by the high cost of microbial feedstocks. Annually, approximately 8 million tons of crustacean shells are discarded worldwide. The widespread and low-cost availability of these shells, rich in the polysaccharide chitin, suggest their potential as a viable feedstock for PHA production. Thus, this research aimed to discover and analyze microorganisms capable of producing PHA from crab shells, originating from soil with high crab shell accumulation in Toyooka City. Four promising strains were screened using chitin-based selective enrichment culture and PHA indicator analysis. Gas chromatography-mass spectrometry validated their PHA production capabilities, particularly identifying one bacterium capable of synthesizing PHA from crab shells and powdered chitin. Moreover, two strains were novel PHA producers, and polymerase chain reaction analysis suggested the involvement of novel enzyme genes in PHA synthesis. These novel discoveries not only demonstrated the practicality of sourcing PHA from crustacean shells but also highlighted the untapped potential to enhance the capabilities and applications of PHA. By enabling broader global adoption of PHA and reducing carbon emissions through waste utilization, this research represents a significant stride toward fostering a circular economy.