



Development of an Insect-Based Biorefinery for Valorization of Non-Recyclable Plastic Textile Waste

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ABSTRACT

Non-recyclable plastic waste, particularly from textile blends with complex multi-material fiber compositions, poses a persistent challenge to circular economy strategies. Conventional disposal methods rely heavily on incineration, emitting approximately 2.5 kg of CO₂ per kilogram of plastic burned, and landfill, which results in permanent material loss. Our team worked to address this challenge by developing a novel insect-based biorefinery using *Galleria mellonella* larvae, which have the unique capacity to digest and transform plastics, including non-recyclable textile-derived polymers, into valuable bioproducts such as proteins, lipids, and chitin. Our team conducted controlled feeding trials comparing survival, larval mass, and pupation success of insects reared on polymeric substrates with those starved or fed on conventional oat bran. Results demonstrate that survival, growth, and pupation on plastics are consistently higher than in starving controls and comparable to oat bran, highlighting the larvae's adaptability and metabolic efficiency after a short acclimatization period. The project also advances engineering aspects by piloting a biorefinery system to process polymer mixtures and co-polymers separated from post-consumer textiles, while optimizing rearing and environmental parameters to maximize conversion efficiency. By fixing up to 67% of CO₂ per kilogram of waste processed, the developed biorefinery offers a disruptive pathway for valorizing difficult-to-recycle plastics, contributing to carbon mitigation, resource recovery, and circular textile industry transformation.

Keywords: biorefinery; circular economy; *Galleria mellonella*; plastic waste; textiles