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Waste Happens: Converting Local Agro-industrial Byproducts into Fully Biodegradable Materials

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Abstract

Given the severe environmental impact of petrochemical plastics, along with the accumulation of agro-industrial waste, the need for sustainable and biodegradable alternatives is continuously growing. In this context, polyhydroxyalkanoates (PHAs) are promising biopolymers. Produced by microorganisms under carbon-excess and nutrient-limited conditions, PHAs represent a viable and fully biodegradable substitute for conventional plastics.(Castro-Sowinski et al., 2010) Despite their potential, PHAs use in consumer goods is limited, as their production costs remain notably high. The use of nutrient-rich waste streams as growth media for PHA producing strains can alleviate this economic hurdle. In this work, we investigated the biosynthesis of PHAs by two PHA producers, utilizing anaerobically co-digested agro-industrial waste(Maragkaki et al., 2026) as low-cost and carbon-rich growth media.(Vu et al., 2022). Cupriavidus necator and Pseudomonas putida were screened for their ability to grow and accumulate PHAs in various substrates after mesophilic anaerobic co-digestion. These included cheese whey, co-digested with other agro-industrial residues, including olive mill waste and food waste(Maragkaki et al., 2026). Among the two strains, Cupriavidus demonstrated notably higher growth and high PHA productivity, compared to Pseudomonas. The optimization of the cultivation and extraction of PHAs in terms of yields and environmental impact will be discussed. The chemical and physical characterization of the produced polymers confirmed the high-purity of PHB and PHB-co-HV copolymers, exhibiting molecular weights and thermal properties comparable with those of commercial standards. PHA polymeric films degradation behavior was evaluated providing valuable insights into their potential performance for practical applications. Overall, this study highlights the potential of anaerobically digested agro-industrial waste, especially cheese whey-based mixtures, as efficient and sustainable substrates for PHA production. Our results demonstrate that agro-industrial waste can be valorized within a sustainable circular system to produce biodegradable polymers capable of meeting the growing demand for plastic materials.

Keywords: anaerobic digestion, agro-industrial waste, wastewater, PHA, biodegradable films

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