Optimised Pilot Biorefinery Processes for the Valorisation of Seafood By-products into Valuable Biofertilisers and Biofuels

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The continuous expansion of the seafood industry has intensified concerns around the disposal of highly putrescible processing byproducts, often resulting in added disposal costs for facilities. However, these nutrient-rich residues offer significant potential as feedstock for biorefineries, where they can be valorised into valuable bioproducts through biochemical and thermochemical processes. Such biorefineries align with circular economy principles by closing nutrient loops, though their feasibility depends on maximising revenue [1]. In this regard, Corinne et al. [2] proposed various biorefinery schemes for mollusc and fish byproducts for the Italian Adriatic coast and reported that a combination of fish and mollusc byproduct biorefinery resulted in higher revenues.

This study aimed to optimise pilot-scale processes, including enzymatic hydrolysis, pyrolysis, aerobic composting, and anaerobic digestion, to valorise both raw process leftovers and secondary byproducts resulting from these processes. Recovered grounded mollusc shells showed higher liming efficiency in pot tests compared to commercial liming agents, while mixed fish and mollusc meat yielded quality protein hydrolysates (4.82±0.17% total nitrogen) with biostimulant potential. Hydrolysis residues exhibited promising biogas yields (515.5±45.6 L/kgVS) via anaerobic digestion. Co-pyrolysis of fish and agricultural waste produced high-quality biochar (40.50-43.20%) compliant with EU standards, alongside bio-oil and syngas, all under optimised, energy-efficient conditions. Furthermore, the application of biochar as a compost amendment in raw composting piles of fish waste and agricultural bulking resulted in nitrogen-rich compost that complied with Italian and EU regulations in terms of temperature requirement to ensure pathogens-free and mature compost while reducing environmental impacts and its potential for use as a soil amendment. However, pot and field trials are required to assess the overall effects of these bio-fertilisers on soil and plants. Overall, the optimised processes improved chemical and energy requirements as well as environmental sustainability. However, there is a further need to investigate the potential for optimisation of anaerobic digestion for biogas production from hydrolysis residues.

Keywords: *circular economy, seafood byproducts, biorefinery, bioproducts, bio-fertilisers, biofuels*

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