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Converting Urban Organic Waste into Aquaculture Feeds: A Two-Step Bioconversion Approach

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Abstract : The generation of urban organic waste is a significant environmental problem due to the potential release of leachate and/or methane into the environment. This contributes to climate change, discharging a valuable resource that could be used in various ways. This research addresses this issue by proposing a two-step approach by linking biowaste management to aquaculture industry via single cell proteins (SCP) production. A mixture of food waste and municipal sewage sludge (FW-MSS) was firstly subjected to a mesophilic (37°C) anaerobic fermentation to produce a liquid stream rich in short-chain fatty acids (SCFAs), which are important building blocks for the following microbial biomass growth. In the frame of stable fermentation activity (after 1 week of operation), the average value of SCFAs was 21.3 ▯ 0.4 g COD/L, with a CODSCFA/CODSOL ratio of 0.77 COD/COD. This indicated the successful strategy to accumulate SCFAs from the biowaste mixture by applying short hydraulic retention time (HRT; 4 days) and medium organic loading rate (OLR; 7 – 12 g VS/L d) in the lab-scale (V = 4 L) continuous stirred tank reactor (CSTR). The SCFA-rich effluent was then utilized as feedstock for the growth of a mixed microbial consortium able to store polyhydroxyalkanoates (PHA), a class of biopolymers completely biodegradable in nature and produced as intracellular carbon/energy source. Given the demonstrated properties of the intracellular PHA as antimicrobial and immunomodulatory effect on various fish species, the PHA-producing culture was intended to be utilized as SCP in aquaculture. The growth of PHA-storing biomass was obtained in a 2-L sequencing batch reactor (SBR), fully aerobic and set at 25°C; to stimulate a certain storage response (PHA production) in the cells, the feast-famine conditions were adopted, consisting in an alternation of cycles during which the biomass was exposed to an initial abundance of substrate (feast phase) followed by a starvation period (famine phase). To avoid the proliferation of other bacteria not able to store PHA, the SBR was maintained at low HRT (2 days). Along the stable growth of the mixed microbial consortium (the growth yield was estimated to be 0.47 COD/COD), the feast-famine strategy enhanced the PHA production capacity, leading to a final PHA content in the biomass equal to 16.5 wt%, which is suitable for the use as SCP. In fact, by incorporating the waste-derived PHA-rich biomass into fish feed at 20 wt%, the final feed could contain a PHA content around 3.0 wt%, within the recommended range (0.2–5.0 wt%) for promoting fish health. Proximate analysis of the PHA-rich biomass revealed a good crude proteins level (around 51 wt%) and the presence of all the essential amino acids (EAA), together accounting for 31% of the SCP total amino acid composition. This suggested that the waste-derived SCP was a source of good quality proteins with a good nutritional value. This approach offers a sustainable solution for urban waste management, potentially establishing a sustainable waste-to-value conversion route by connecting waste management to the growing aquaculture and fish feed production sectors.

Keywords : feed supplement, nutritional value, polyhydroxyalkanoates (PHA), single cell protein (SCP), urban organic waste.
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