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Ensiling of fish industry waste for biogas production: A lab scale evaluation of biochemical methane potential (BMP) and kinetics

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HIGHLIGHTS

- Fish waste (FW) was ensiled by mixing with bread waste (BW) and brewery grain waste (BGW).
- The mixture of FW and BW produced good quality silages than the mixture of FW and BGW.
- The methane potential for FW silage was calculated in the range of 441–482 mL/g VS added.
- The modified Gompertz model better predicted the methane yield than the first-order kinetic model.
- A hydraulic retention time >41–53 days is suggested for continuous digestion of FW silages.

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ABSTRACT

Fish waste (FW) obtained from a fish processor was ensiled for biogas production. The FW silages were prepared by mixing FW with bread waste (BW) and brewery grain waste (BGW), and the quality of the prepared silages were evaluated. The biogas potentials of BW, BGW, three different types of FW, and FW silages were measured. A first-order kinetic model and the modified Gompertz model were also used to predict methane yield. The biogas and methane yield for FW silages after 96 days was calculated to be 671–763 mL/g VS and 441–482 mL/g VS, respectively. There were smaller differences between measured and predicted methane yield for FW silages when using a modified Gompertz model (1.1–4.3%) than when using a first-order kinetic model (22.5–32.4%). The critical HRTs and technical digestion times (T_{80-90}) for the FW silages were calculated to be 21.0–23.8 days and 40.5–52.8 days, respectively.

1. Introduction

The worldwide consumption of fish per capita nearly doubled over the last 45 years, leading to larger quantities of fish processing wastes (Ward and Løes, 2011). Fish processing wastes have a large potential as an energy source. The increase in fish processing wastes and the expansion of the renewable energy market mean that fish processing wastes could play a part as a future source of biofuels. The amount of solid waste generated in fish canning operations is large as the amount of raw products converted into waste can be as high as 50% by weight (Ward and Løes, 2011). Anaerobic digestion could be a good approach for fish waste (FW) utilisation because it can not only produce a biofuel but also a mineralised solid residue that can be used as a bio-fertiliser with a high NPK concentration (Díaz et al., 2011).

Currently, the literature on methane production from FW is sparse. Ward and Løes (2011) examined the potential of using fish

Abbreviations: %, percentage; ADF, acid detergent fiber; BGW, brewery grain waste; BMP, biochemical methane potential; BR, mass of biogas removed (g); BW, bread waste; C/N, carbon to nitrogen ratio; CF, crude fiber; CFW, cuttle fish waste; CP, crude protein; d, day; EE, ether extract; *F*/*I*, feed to inoculum ratio; FW, fish waste; FW:BGW silage, fish waste:brewery grain waste silage; FW:BW silage, fish waste:bread waste silage; g, gram; HRT, hydraulic retention time (days); *K*, kinetic constant (1/day); K_{CH}, Chen and Hashimoto kinetic constant; L, liter; MFW, mackerel fish waste; mL, milli liter; NDF, neutral detergent fiber; NFE, nitrogen free extract; FL, feed loading (g VS/L); ppm, parts per million; PSFW, Pacific saury fish waste; SD, standard deviation; STP, standard temperature (0 °C) and pressure (1 atm.); TA, total alkalinity (mg/L $CaCO_3$); TCOD, total chemical oxygen demand (mg/L); TS, total solids (%); TVFA, total volatile fatty acids (mg/L acetate); VS, volatile solids (%); λ, lag phase (day); μ, maximum specific growth rate of microorganisms (1/day).

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