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Enhanced methane production from pig manure anaerobic digestion using fish and biodiesel wastes as co-substrates

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HIGHLIGHTS

- Fish and biodiesel waste were used as co-substrates in pig manure anaerobic digestion.
- Both co-substrates improved methane yield but caused VFA and ammonium accumulation.
- Shorter HRT and FW < 10% in the feeding allow to control ammonium inhibition.
- Biodiesel waste co-digestion requires feeding shares < 6% and/or fed-batch operation.
- The poorer the co-digester operation, the higher the *Methanosarcina/Methanosaeta* ratio.

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ABSTRACT

Co-digestion of pig manure (PM[1]) with fish (FW[2]) and biodiesel waste (BW[3]) was evaluated and compared with sole PM digestion. Results indicated that co-digestion of PM with FW and/or BW is possible as long as ammonium and volatile fatty acids remained under inhibitory levels by adjusting the operating conditions, such as feed composition, organic loading rate (OLR) and hydraulic retention time (HRT). PM and FW co-digestion (90:10 and 95:5, w/w[4]) was possible at OLR of 1–1.5 g COD/L d, resulting in biogas production rates of 0.4–0.6 L/L d and COD removal efficiencies of 65–70%. Regarding BW, good results (biogas production of 0.9 L/L d and COD elimination of 85%) were achieved with less than 5% feeding rate. Overall, operating at the same OLR, the biogas production and methane content in the co-digester was higher than in the only PM digester.

1. Introduction

In the last years, anaerobic digestion of animal wastes has been promoted in order to avoid the uncontrolled emissions of CH_4 during storage (Novak and Fiorelli, 2010). Pig manure (PM[5]) can be an excellent base substrate for anaerobic digestion due to its inherent buffering capacity and high content of a wide range of nutrients required for the development of anaerobic microorganisms. However, PM has a low biogas yield, around 20–30 m^3/ton (Angelidaki and Ellegaard, 2003), and high ammonium concentrations (2–3 g $N–NH_4^+$/L). Consequently, PM is preferably co-digested with high carbon content wastes, on one hand, to improve the C/N ratio (Hartman and Ahring, 2006), and on the other hand, to increase the biogas production, essential for the plant's economy. It has been shown that bioenergy production in farm biogas plants could be enhanced by 80–400% by using organic wastes and by-products as co-substrates (Braun and Wellinger, 2003; Weiland, 2010). Despite the well-known reported co-digestion benefits, such as optimum humidity and C/N ratio or inhibitory substances dilution (Mata-Álvarez et al., 2000), it is not clear whether some substrates have adverse impact when they are co-digested with another waste (Callaghan et al., 2002). Therefore, it is critical to obtain an optimal mixture of the available co-substrates as well as the optimum operating conditions which allow high biogas yields without compromising the stability of the process (Alvarez et al., 2010).

Fish and shellfish canning industry is an important sector in Galicia (NW of Spain), with around 65% of the total Spanish production and representing 45% of the Galician factories and 67% of the jobs (Garcia et al., 2003). This sector generates different

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[1] PM, pig manure;
[2] FW, fish waste;
[3] BW, biodiesel waste;
[4] w/w, wet weight basis;
[5] PM, pig manure;

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