

Biomethane Potential of Solid Fish Waste

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Introduction

The fish canning industries are an important sector in Galicia (NW of Spain), manufacturing a high variety of raw materials. Tuna and bonito processing account for more than half of the total production; sardine processing also involves an important percentage and other species are processed in a minor quantity. The solid waste generated in fish canning industries is important; during the manufacturing processes of species, the amount of raw products converted into waste can reach up to 50% by weight (Garcia-Sanda *et al.*, 2003).

Anaerobic digestion has a strong potential for treating biodegradable solid waste. This technology is considered as organic recycling as it produces renewable energy (biogas) and a digestate that can be used as organic fertilizer. Anaerobic digestion of organic solid wastes is an established technology in Europe, with 200 full-scale plants treating almost 6 million tons per year (de Baere, 2010). The biomethane potential of solid waste is a key parameter for assessing design, economic and managing issues for the full scale implementation of the anaerobic digestion process. The purpose of this work was to study the biomethane potential of solid fish waste; to this end, batch assays were performed with tuna, sardine, mackerel and needle fish waste.

Materials and Methods

Solid fish waste was obtained from a canning industry in Galicia (NW of Spain) and consisted mainly of heads, tails, fish bones and viscera. After collection, the fish waste was dried and ground to 3-5 mm particle size using an electronic kitchen blender. The ground fishes were individually characterized and their biomethane potential was determined using batch assays.

The biomethane potential assays were performed in triplicate using glass flasks with coiled butyl rubber stoppers (Angelidaki *et al.*, 2009). For each fish waste, three total solid concentrations were tested: 1, 2.5 and 5%TS; the waste/inoculum ratios varied between 1.1-1.3, 2.8-3.3 and 5.7-6.5 g VS_{waste}/g VS_{inoculum}, respectively. The headspace was flushed with N₂/CO₂ (80/20% as volume) and Na₂S was added as a reducing agent. The vials were then incubated at 37°C and the pressure increase was monitored using a hand held pressure transducer. At regular time intervals, the methane content of biogas was analysed and the volume of methane produced was corrected to standard temperature and pressure conditions. The methane production due to biomass decay and the presence of possible residual substrates was discounted by performing blank controls.

Preliminary Results

The ground fishes were individually characterized and their biomethane potential was determined using batch assays. Moisture content and solids were similar for all waste: 63-75% and 0.74-0.85 g VS/g dry waste. The organic matter significantly varied for the different fishes: 1.13, 1.25, 1.39 and 1.42 g COD/g dry waste for sardine, needle fish, tuna and mackerel, respectively. With regard to nitrogen, very similar values were obtained for all waste: 0.09-0.10 g TKN/g dry waste. Finally, the lipids content also changed for the different fishes: 0.07, 0.10, 0.16 and 0.37 g lipids/g dry waste for sardine, tuna, needle fish and mackerel, respectively.

For each fish waste, the biomethane potential was tested at 1, 2.5 and 5%TS. The methane production in the assays with tuna and sardine waste is presented in Fig. 1, the results obtained with mackerel

and needle fish were very similar. The methane production was, for all fish waste, higher at 1%TS and decreased when the total solids increased. The increase in the waste/inoculum ratio could lead to overload due to VFA and/or LCFA accumulation. VFA and LCFA were not detected at the end of assays at 1%TS but at 2.5 and 5%TS, they reached high concentrations. For example, in tests with sardine waste at 2.5 and 5%TS, the final VFA concentration raised to 9.8 and 26 g COD/L and the final LCFA concentration reached 5.4 and 8.3 g COD/L, respectively. The LCFA were analysed in the liquid and solid matrix since they were adsorbed/accumulated onto the solid matrix (Neves *et al.*, 2009). For all the LCFA detected, palmitic (C16:0) and myristic (C14:0) acids were the ones in the major proportion.

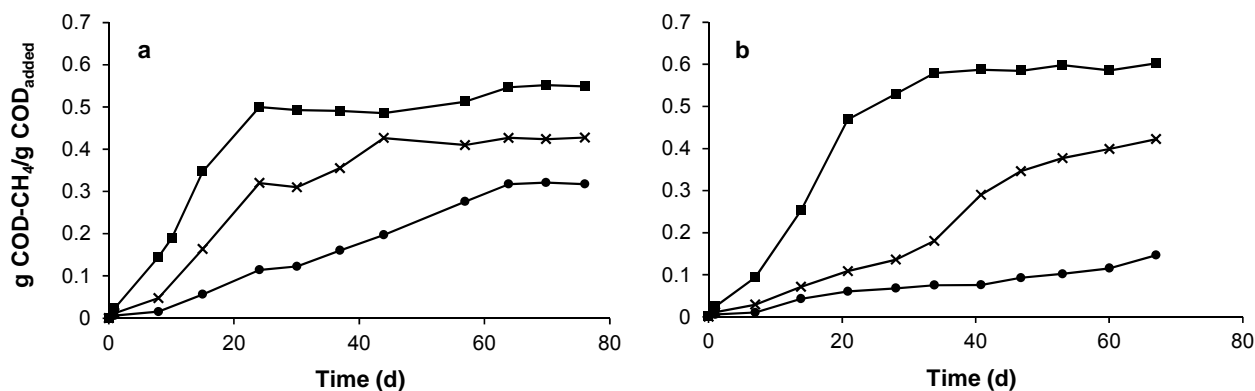


Fig. 1. Methane production versus COD added obtained in the assays with tuna waste (a) and sardine waste (b) using 1%TS (■), 2.5%TS (x) and 5%TS (●).

Other factor that could inhibit anaerobic digestion was ammonia since high levels were produced. The final total ammonia concentration reached 3.6 and 4.8 g/L in assays with 5% of tuna and sardine waste, respectively. Ammonia is produced by the biological degradation of the nitrogenous matter, mostly in the form of proteins. The unbalance nitrogen of fish waste, characterised by a low C/N ratio, could be an important limitation factor to anaerobic digestion. A wide range of inhibiting ammonia concentrations has been reported in the literature, with the inhibitory total ammonia nitrogen that caused a 50% reduction in methane production ranging from 1.7 to 14 g/L (Chen *et al.*, 2008).

Therefore, the maximum methane production was obtained at 1%TS and was 0.46, 0.47, 0.48 and 0.59 g COD-CH₄/g COD_{added} for tuna, sardine, needle fish and mackerel waste, respectively. The highest production was attained with mackerel waste; this could be due to the highest lipid content. Waste lipids are ideal substrates for methane production, since theoretically their degradation produces more biogas with higher methane content, when compared with proteins or carbohydrates.

The anaerobic digestion of solid fish waste seems to be a viable alternative for recovering energy in the form of biogas at the same abating environmental pollution. Different approaches will be attempted to enhance methane production of fish waste, such as use of a more active inoculum and co-digestion with other wastes. For example the assays with mackerel at 2.5%TS were performed with another inoculum and the methane production improved from 0.11 to 0.47 g COD-CH₄/g COD_{added}. The first sludge was obtained from an urban wastewater treatment plant and the second one from the wastewater treatment plant of a brewery industry.

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