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Effects of pre-treatment and bioaugmentation strategies on the anaerobic digestion of chicken feathers

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HIGHLIGHTS

- BMP assays were performed at different TS concentrations of chicken feathers waste.
- The specific methane production was 123 ± 3 L CH_4 kg^{-1} VS with 2.5% TS.
- Pre-treatments have contributed to an increase in waste solubilisation up to 96%.
- *Fervidobacterium pennivorans* bioaugmentation increased the solubilisation to 64%.
- Conversion of soluble organic matter to methane was the limiting step.

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ABSTRACT

Anaerobic digestion of raw chicken feather waste and its co-digestion with poultry litter were assessed in batch assays. Following, two strategies were evaluated to improve methane production from chicken feathers: (i) waste pre-hydrolysis through thermochemical treatment using lime and sodium hydroxide, and (ii) amendment of digestion broth with the proteolytic bacterium *Fervidobacterium pennivorans*. Anaerobic digestion of the raw waste (2.5% total solids) allowed a specific methane production of 123 ± 3 L CH_4 kg^{-1} VS. Pre-treatment and bioaugmentation strategies did not improve methane production from feather waste, despite the significant increase in waste solubilisation, from 45 ± 5% up to 64 ± 1% using *F. pennivorans* and up to 96% after pre-treatment with 2 g NaOH g^{-1} waste. These results indicate that conversion of soluble organic matter to methane, and not the hydrolysis rate, was the limiting step for the anaerobic digestion of chicken feather waste.

1. Introduction

Market demand for cheap meat, such as poultry meat and its derivates, has shown a significant increase driven by the current economic crisis. Growth of the poultry industry resulted in the generation of an increased quantity of organic solid wastes, including poultry feathers, which represent 5–7% of the body weight of a domestic chicken (Kelleher et al., 2002; Onifade et al., 1998). Feather waste has been recycled by incorporation in animal feed, but due to the high risk of disease transmission through the food chain, food laws have become very restrictive (Salminen and Rintala, 2002; Gousterova et al., 2005). Anaerobic digestion of feathers is a suitable alternative for waste valorisation as it combines waste treatment, energy production and production of a by-product (compost) that can be used in agriculture for nutrient recycling (Salminen et al., 2003).

During anaerobic digestion, keratin present in feathers is hydrolysed to amino acids and polypeptides, which are then fermented to organic acids, ammonia, sulphur-containing compounds, carbon dioxide and hydrogen. Organic acids and hydrogen are further converted to methane through methanogenesis (Xia et al., 2012). However, the first step in keratin degradation, i.e. keratin hydrolysis, is difficult due to the insolubility and highly stability of this protein (Kashani, 2009). Furthermore, the high concentration of organic nitrogen in feathers results in the accumulation of ammonia during the anaerobic digestion process (Bujoczek et al., 2000). Co-digestion with other wastes, such as poultry litter that is nitrogen deficient, can be advantageous in terms of macronutrients equilibrium.

Several methods to improve the hydrolysis of feathers, including chemical and enzymatic treatments, have been investigated (Coward-Kelly et al., 2006; Friedrich and Antranikian, 1996; Gousterova et al., 2005; Kashani, 2009; Kim et al., 2002; Salminen

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