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Solid-state co-digestion of expired dog food and corn stover for methane production

Fuqing Xu, Yebo Li *

Department of Food, Agricultural and Biological Engineering, The Ohio State University/Ohio Agricultural Research and Development Center, 1680 Madison Ave, Wooster, OH 44691-4096, USA

HIGHLIGHTS

- Solid-state co-digestion of corn stover (CS) with expired dog food (DF).
- Co-digestion increased methane yield and reduced start-up time.
- The highest methane yield of 304.4 L/kg VS_{feed} was obtained at CS:DF ratio of 1:1.
- Anaerobic digestion process failed at high proportion of DF.
- Biogas production was mainly contributed by the degradation of DF.

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ABSTRACT

Expired dog food was co-digested with corn stover for biogas production via solid-state anaerobic digestion (SS-AD) at feedstock-to-effluent (F/E) ratios of 2, 4, and 6 using effluent from a sewage sludge digester as inoculum. Degradation of the main components in dog food and corn stover was measured. Higher methane yields were obtained at lower F/E ratios and at higher percentages of dog food in the substrate. The highest methane yield of 304.4 L/kg VS_{feed} was obtained for the substrate containing 50% corn stover and 50% dog food, which was an increase of 229% and 109% compared to digesting corn stover and dog food alone, respectively. Co-digestion of corn stover with dog food reduced the start-up time and volatile fatty acid (VFA) accumulation, but decreased the cellulose and xylan degradation of corn stover.

1. Introduction

Anaerobic digestion (AD) offers multiple benefits for treating organic waste, such as generating biogas as renewable energy, reducing greenhouse gas emissions, and producing organic fertilizer (Liu et al., 2012; Luste et al., 2012). Wastes with high moisture content, such as manure, food processing wastewater, and sewage sludge, are usually treated by liquid anaerobic digestion (L-AD), while waste streams with high solid content, such as yard waste, crop residues, and municipal solid waste (MSW), are suitable for solid-state anaerobic digestion (SS-AD) which operates at 15–40% total solids (TS) (Li et al., 2011a). Compared with L-AD, SS-AD may need longer digestion time, due to slower mass transfer (Li et al., 2011a). However, problems related to the floating and stratification of fibrous material can be solved with SS-AD (Nordberg and Edstro, 1997). Advantages of SS-AD also include a higher volumetric loading capacity, higher volumetric productivity, and reduced energy needs for mixing and heating the extra water as required in L-AD (Guendouz et al., 2010). The digestate from the SS-AD is a compost-like residue which has a low water content and is easier to handle than L-AD effluent (Li et al., 2011a). In 2010, SS-AD represented almost 59% of the total installed AD capacity for the treatment of MSW in Europe and the number was expected to increase (Mattheeuws, 2010).

Expired dog food, mainly composed of starch, protein, and lipids, can serve as a valuable substrate for SS-AD. Dog food is one of the largest categories of packaged food in the U.S., with about 300 manufacturers producing more than 7 million tons of pet food each year (Avizienis, 2011). In the 1990's, pet food manufacturing was an $8 billion industry which fed America's 52 million dogs and 63 million cats (Avizienis, 2011). In 2010, this industry has grown to an $18.7 billion business (American Pet Products Association, 2011), in which one single plant can produce more than 1 million tons of pet food annually (Petfoodindustry.com, 2011). The disposal of expired dog food is a problem for both manufactures and retail stores, especially in countries like Korea or Canada, where landfill of organic waste is restricted by legislation (Lee et al., 2009; Xia et al., 2012). In the U.S., the majority of expired dog food is currently sent to landfills. However, if expired dog food

* Corresponding author. Tel.: +1 330 263 3855.
E-mail address: li.851@osu.edu (Y. Li).

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