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The anaerobic co-digestion of food waste and cattle manure

Cunsheng Zhang, Gang Xiao, Liyu Peng, Haijia Su *, Tianwei Tan

Beijing Key Laboratory of Bioprocess, Beijing University of Chemical Technology, Beijing 100029, PR China

HIGHLIGHTS

- ▶ The separate anaerobic digestion of food waste or cattle manure was hardly feasible.
- ▶ Co-digestion produced significant quantities of biogas, with high methane content.
- ▶ Addition of cattle manure enhanced the buffer capacity of anaerobic system.
- ▶ In co-digestion, the C/N ratio contributed to the improving biogas production.

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ABSTRACT

This study assessed the anaerobic co-digestion of food waste and cattle manure, in order to identify the key parameters that determine the biogas and methane yield. Results of both batch and semi-continuous tests indicated that the total methane production is enhanced in co-digestion, with an optimum food waste (FM) to cattle manure (CM) ratio of 2. At this ratio, the total methane production in batch tests was enhanced by 41.1%, and the corresponding methane yield was 388 mL/g-VS. In the semi-continuous mode, the total methane production in co-digestion, at the organic loading rate (OLR) of 10 g-VS_{FW}/L/d, increased by 55.2%, corresponding to the methane yield of 317 mL/g-VS. Addition of cattle manure enhanced the buffer capacity (created by NH_4^+ and VFAs), allowing high organic load without pH control. The C/N ratio and the higher biodegradation of lipids might be the main reasons for the biogas production improvement.

1. Introduction

Anaerobic digestion has been proven to be an efficient and green technology in disposing of sewage sludge, crop residues, food waste and animal manure (Wan et al., 2011; Li et al., 2009). Advantages are the production of renewable energy in the form of biogas and the possibility to recycle valuable nutrients, concentrated in the digestion residue (Zhang et al., 2012; Angelidaki et al., 2003). Food waste has already been considered as a very attractive feedstock for anaerobic digestion due to its high methane potential (Zhang et al., 2011). Li et al. (2010) reported that the fat content of food waste is about 23%. Under specific operating conditions, lipid-rich waste such as fat and oil will significantly contribute to the methane production (Wan et al., 2011). However, long-chain fatty acids (LCFAs) are formed during the degradation of fat and lipids: the 18-C LCFAs (such as oleic and stearic acid) are inhibitory at concentrations exceeding 1.0 g/L (Appels et al., 2008). LCFAs can moreover be toxic to both *syntrophic acetogens* and *methanogens* (Hanaki et al., 1981) and limit the transport of nutrients to cells due to being adsorbed on the microbial surfaces (Pereira et al., 2005). It was therefore difficult if not impossible to treat only FW by anaerobic digestion (Resch et al., 2011; Zhang et al., 2011; Palatsi et al., 2011).

Anaerobic digestion was also found to be unstable when the cattle manure is used as mono-substrate due to the low C/N ratio (5–8) (Li et al., 2009). It is therefore important to examine an alternative approach for anaerobic digestion of FW or CM, co-digestion possibly helping to overcome the deficiencies of mono-digestion. This co-digestion is studied in the present research.

The carbon to nitrogen (C/N) ratio is one of the important parameters influencing the digestion process (Kumar et al., 2010). Zhu (2007) suggested that anaerobic digestion could be carried out efficiently when the C/N ratio is 15. Kumar et al. (2010) found that a C/N ratio range from 13.9 to 19.6 is acceptable for digestion.

Anaerobic co-digestion of different organic materials may enhance the stability of the anaerobic process because of a better carbon to nitrogen (C/N) balance (El-Mashad and Zhang, 2010; Mshandete et al., 2004). Co-digestion may moreover alleviate the inhibitory effect of high ammonia and sulfide concentrations (Hartmann et al., 2003), and exhibit a more stable biogas production

* Corresponding author. Tel.: +86 10 644452756; fax: +86 10 64414268.
E-mail address: suhj@mail.buct.edu.cn (H. Su).

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