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Biochar triggering multipath methanogenesis and subdued propionic acid accumulation during semi-continuous anaerobic digestion

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ABSTRACT

The semi-continuous anaerobic digestion (AD) performances of dry chicken manure (DCM) were investigated at the temperature of 35 ± 1 °C with and without biochar. The average specific methane productions of 0.18 L/g VS_{added} and 0.17 L/g VS_{added} were achieved without biochar at the organic loading rate (OLR) of 3.125 and 6.25 g VS/L/d, respectively. An increase of 12% in methane production was obtained in the presence of biochar at the two operational OLRs. Accumulation of propionic acid was observed associating with AD of DCM, which was substantially alleviated by biochar supplement. The buffer capacity of biochar was supposed to develop through strengthening the buffer system established by NH_4^+ and volatile fatty acids. *Methanosarcina* that can utilize multiple nutrients for methanogenesis was the dominant archaea in the presence of biochar, while the strictly aceticlastic *Methanosaeta* was dominant in control digester. These results suggest that biochar enhanced methanogenesis through intensifying its available pathway.

1. Introduction

The increasing demand and consumption in chicken meat and eggs over recent years has boosted the development of poultry industry, which resulted in a growing generation of poultry wastes in form of chicken manure (CM) (Tanczuk et al., 2019). For the livestock farms not equipped with the biogas sector in China, yarding of raw CM is a common procedure that generates huge amounts of air-dried chicken manure (DCM). Compared with raw CM, DCM is easier to handle, transport, store and apply with less odour and NH_3 emissions (Fournel et al., 2012), but its treatment remains problematic. Since CM is rich in biodegradable organic matters, its traditional utilizations include enriching soil, composting as fertilizer, and combustion for energy production (Li et al., 2018; Nie et al., 2015). However, the contained pathogens and high water content of CM limit its traditional application. The anaerobic digestion (AD) technology allows the recovery of the caloric value contained in biomass waste through biogas generation with additional nutrients recovery and hazardous contents removal (Wu et al., 2016). Even though the process performance during AD of raw CM has been well studied (Fuchs et al., 2018; Song et al., 2019), studies on AD treating DCM are limited.

The AD process depends on a consortium of microorganisms completing successive steps including hydrolysis, acidogenesis, acetogenesis, and methanogenesis (Siddique and Ab Wahid, 2018). Various factors like temperature and organic loading rate (OLR) can affect the stability and efficiency of AD process (Abdelsalam et al., 2017). Temperature greatly influences AD performance by affecting the microbial community and thermodynamic equilibrium of biochemical reactions (Lin et al., 2017). The AD process can operate more stable under mesophilic conditions (35–40 °C) due to the larger diversity of microorganisms (Stolze et al., 2016). OLR is an important operational parameter as well. Even though high OLR implies high treatment capacity and methane yield, it is easy to suffer overloading and result in process instability or system failure (Duan et al., 2019). During AD process, the high content of undigested protein and uric acid in CM will be decomposed into free ammonia (NH_3) and ammonium ion (NH_4^+), which are harmful to methanogenesis under excessive concentration (Astals et al., 2018). The volatile fatty acids (VFAs) produced in the acidogenesis phase are also important for the system performance because they can affect the pH levels and alkalinity in the digester (Liu et al.,

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