Valorisation of Coffee Waste to Biogas

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Abstract

Coffee waste is rich in organic material and is a potential raw material for biogas production. In this study, 5kg of coffee waste was anaerobically digested for 40 days. The changes in the coffee waste chemical oxygen demand (COD), biological oxygen demand (BOD) and total solids (TS) was monitored every 10 days as well as the biogas production. The amount of biogas produced was measured for both mesophilic conditions of 35 ◦C and thermophilic conditions of 55 ◦C. The amount of biogas produced increased with increase in time with a 60% conversion to biogas being achieved for mesophilic conditions. The enhanced biogas production under mesophilic conditions was related to the 88%, 91% and 90% decrease in COD, BOD and TS. The biogas produced had an average methane content of 70%.

Keywords: Anaerobic digestion; biogas; coffee waste

1.Introduction

The coffee production industry generates a lot waste as its by product from the coffee processing. This coffee waste is highly organic in nature and if left to naturally decompose can result in the generation of greenhouse gases and in overall climate change effects as well as potential volatile gases emissions into the environment. On

the other hand, the coffee waste can be a good raw material for biogas production, a source of renewable and clean energy (Chandra et al., 2012; Battista et al., 2016). The biogas can be used to meet energy requirements in the coffee production plant, cutting the energy cost. Biogas is generated from organic material through the anaerobic process (Cano et al., 2015). The basic biogas production process from organic waste is shown in Figure 1. Biogas production occurs using four major processes mainly: hydrolysis, acidogenesis, acetogenesis and methanogenesis and is mainly composed of methane and carbon dioxide as the major constituents (Lebuhn et al., 2014).

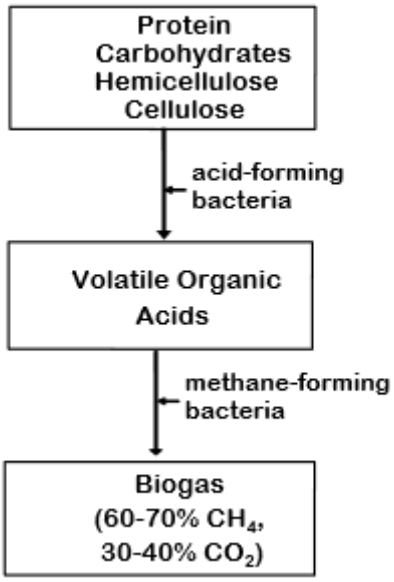

Figure 1: Biogas production process

2.Materials and methods

Coffee waste was obtained from a local coffee estate. The coffee waste was sprayed with water in order to ensure that it had adequate moisture. The coffee waste was analysed for pH., moisture content (%), the biological oxygen demand (BOD) in milligrams per litter (mg/L), the chemical oxygen demand (COD) in mg/L and the total solids (TS) in mg/L. Samples comprising of 4L of the coffee wastes were allowed to undergo anaerobic digestion at mesophilic conditions of 35 ◦C and thermophilic conditions of 55 ◦C for a digestion period of 40 days. The amount of biogas produced as well as the changes in the BOD, COD and TS were monitored and analysed. The composition of the biogas produced was quantified using a Biogas 5000 analyser.

3.Results and discussion

3.1 Coffee waste characteristics

The characteristics of the coffee waste are shown in Table 1. The coffee waste had a high COD and BOD which was an indication of its high biodegradability to biogas. The BOD/COD ratio of the coffee waste ranged from 0.61-0.67.

Table 1. Coffee waste characteristics

Parameter	Value
Moisture content %)	85-90
Ph	6.8-7.5
COD (mg/L)	7942-8360
BOD (mg/L)	5139-5410
TS (mg/L)	12367-1302

3.2 Effect of digestion on BOD

The BOD in the coffee waste decreased with increase in the digestion time of the coffee waste (Figure 2). However, a 12% higher decrease in BOD was noted for mesophilic conditions in comparison to thermophilic conditions during the anaerobic digestion.

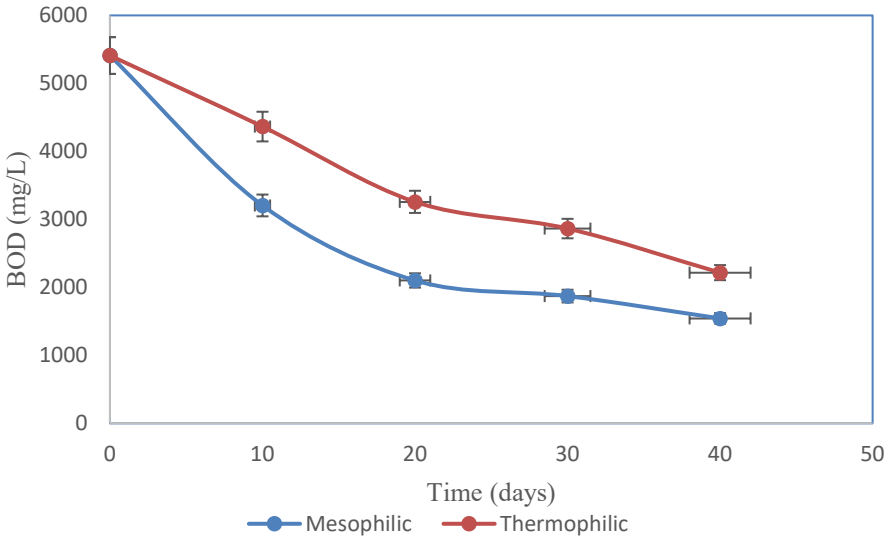

Figure 2: BOD changes during coffee waste digestion

3.3 Effect of digestion on COD

The COD decreased significantly with increase in the digestion period during the biogas production from coffee waste (Figure 3). An 89% decrease in the COD decrease was reported for mesophilic conditions whereas the COD decrease was 24% lower under thermophilic conditions. Decreases of 64.4% in COD were also reported by Qiao et al., (2013) during the thermophilic anaerobic digestion of coffee waste in activated sludge system for 160 days.

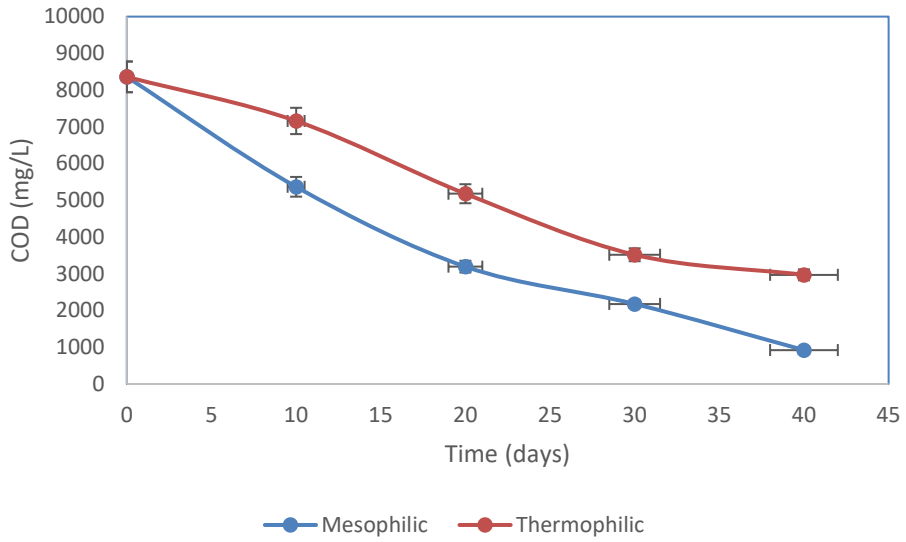

Figure 3: COD changes during coffee waste digestion

3.4 Effect on TS

The TS content decreased with increase in the digestion period of the coffee waste to biogas (Figure 4). Significant reduction in the TS were noted for mesophilic conditions with decreases as high as 90%. Although decreases of 62% were noted for thermophilic conditions, it can be concluded that mesophilic conditions were ideal for coffee waste digestion to biogas.

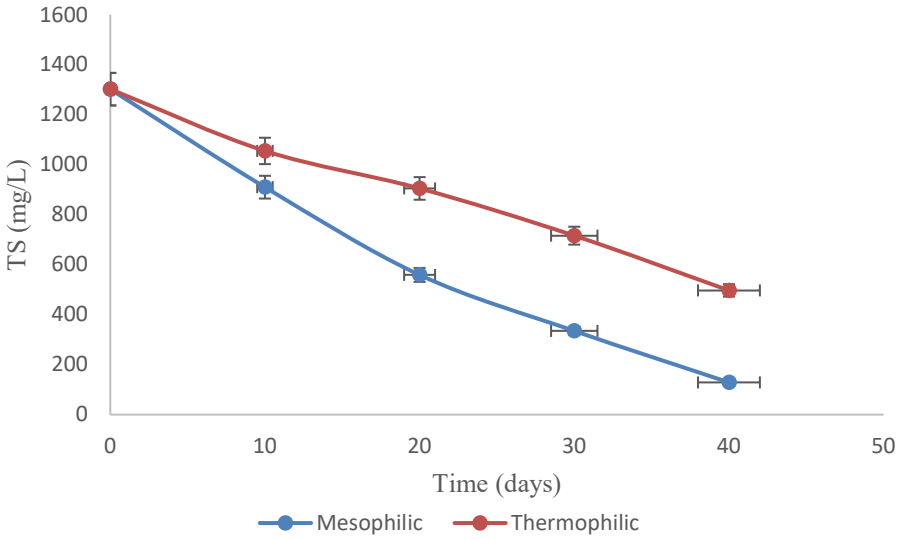

Figure 4: TS changes during coffee waste digestion

3.5 Biogas production mesophilic and thermophilic conditions

The amount of biogas produced from coffee waste increased with increase in the anaerobic digestion time (Figure 5). The mesophilic conditions reported a superior biogas quantity which was almost 50% higher in comparison to quantities produced at thermophilic conditions (Figure 5). Superior biogas production from coffee waste under mesophilic conditions have also been reported by several authors (Neves et al., 2006; Battista et al., 2016).

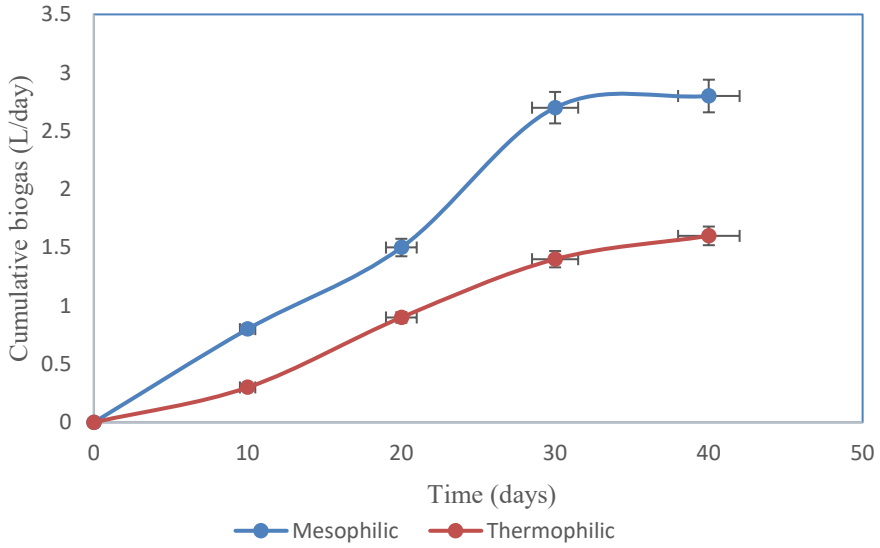

Figure 5: Cumulative biogas production from coffee waste

3.6 Biogas composition

The composition of the biogas from the coffee waste is indicated in Table 2. The biogas from the coffee waste had a methane composition of 65-70%, which was quite on the high side and presents a great opportunity for utilization as an alternative source of energy. The biogas composition fell in the same range with similar studies related to coffee waste digestion to biogas (Qia et al., 2013).

Table 2. Coffee waste biogas composition

Biogas component	Composition
Methane (CH_4)	65-70%
Carbon dioxide (CO_2)	25-35%
Hydrogen sulphide (H_2S)	125-130 ppm
Hydrogen (H_2)	1-2%
Ammonia (NH_3)	1-2%

4. Conclusion

The anaerobic digestion of coffee waste can both be used as a waste management technique as well as for production of biogas, a source of green energy. The anaerobic digestion process was optimal under mesophilic conditions of 35 ◦C with high biogas yield of 30% being achieved in comparison to thermophilic conditions. The coffee waste biogas had a composition range of 65-70%.

Acknowledgements

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Biographies

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