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Dry-thermophilic anaerobic digestion of organic fraction of the municipal solid waste: Focusing on the inoculum sources

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Abstract

The effect of inoculum source on anaerobic thermophilic digestion of separately collected organic fraction of municipal solid wastes (SC_OFMSW) has been studied. Performance of laboratory scale reactors (V: 1.1 L) were evaluated using six different inoculums sources: (1) corn silage (CS); (2) restaurant waste digested mixed with rice hulls (RH_OFMSW); (3) cattle excrement (CATTLE); (4) swine excrement (SWINE); (5) digested sludge (SLUDGE); and (6) SWINE mixed with SLUDGE (1:1) (SWINE/SLUDGE). The SC_OFMSW was separately and collected from university restaurant. The selected conditions were: 25% of inoculum, 30% of total solid and 55 °C of temperature, optimum in the thermophilic range. The six inoculum sources showed an initial start-up phase in the range between 2 and 4 days and the initial methane generation began over 10 days operational process. Results indicated that SLUDGE is the best inoculum source for anaerobic thermophilic digestion of the treatment of organic fraction of municipal solid waste at dry conditions (30% TS). Over 60 days operating period, it was confirmed that SLUDGE reactor can achieve 44.0% COD removal efficiency and 43.0% VS removal. In stabilization phase, SLUDGE reactor showed higher volumetric biogas generated of 78.9 mL/day (or 35.6 mL CH_4/day) reaching a methane yield of 0.53 L CH_4/g VS. Also, SWINE/SLUDGE and SWINE were good inoculums at these experimental conditions.

Keywords: Municipal solid waste; Anaerobic digestion; Dry conditions; Inoculum; Thermophilic; Methane

1. Introduction

Anaerobic digestion has been applied to various biosolids waste streams, including agricultural waste, industrial waste, and municipal solid waste (MSW). This technology is an attractive treatment strategy for organic fraction of municipal solid waste (OFMSW), and has been considered the main commercially option for both treatment and recycling of biomass wastes being of great interest from an environmental point of view (Boualagui et al., 2004; De Baere, 2005). There are several reports on anaerobic digestion of different organic wastes: market waste (Mata-Alvarez et al., 1993), fruit and vegetable (Bouallagui et al., 2005), household waste (Krzystek et al., 2001), kitchen waste (Rao and Singh, 2004), biowaste (Gallert et al., 2003) and organic fraction of municipal solid waste (OFMSW) (Bonzonella et al., 2005). Separately collected organic fraction of municipal solid wastes (SC_OFMSW) is all waste produced in large quantities in markets, restaurants and domestic homes, separated in origin for treatment. The SC_OFMSW composition can be affected by various factors, including regional differences, climate, collection frequency, season, cultural practices, as well as changes in the composition which could occur during a year.

Several new approaches have been tried to improve the efficiency of semidry anaerobic digestion (Pavan et al., 1994) and dry conditions (20–35% TS) (Bolzonella et al., 2003), where no or little water, or sludge (De la Rubia et al., 2002), is added to the OFMSW to produce an inert

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biosolid product with higher methane productivity (Mata-Alvarez et al., 2000). Additionally, there is considerable interest in applying the dry anaerobic digestion at thermophilic conditions (55 °C) (Hartmann and Ahring, 2005) to treat the organic fraction of municipal solids waste (OFMSW). The fact that the anaerobic digestion of the OFMSW for biogas production yield much better results in thermophilic temperature conditions than in mesophilic temperature conditions contributed to this interest (Mashad et al., 2004). According to Kim et al. (2000) and Kuo and Lu (2004), thermophilic conditions are reliable for the digestion of organic restaurant wastes.

Inoculum source is a very important operational parameter. Also, it is crucial the selection of waste/inoculum ratio as well as the assessment of anaerobic biodegradability of solid wastes (Sanchez et al., 2001; Lopes et al., 2004). In dry-thermophilic digestion, the inoculum source and the total solid percentage selected are responsible to accomplish rapid onset of a balanced microbial population. The systematic of inoculation, the percentage of inoculation and wetting procedure differs between processes proposes by several authors. The percentage of inoculation for acidogenic fermentation of organic urban wastes is approximately 30% weight/weight (w/w) (Sans and Mata-Alvarez, 1995). In case of the anaerobic biodegradability of solid waste, the use of a highly active anaerobic inoculum or animal inoculum waste will reduce significantly the experimental time, or reduced the amount of inoculum required in full scale batch digesters, and consequently, the corresponding digester volume (Obaja et al., 2003).

The purpose of this paper was to analyze the biomethanization process of food waste (separately collected organic fraction municipal solid waste, SC_OFMSW) from a university restaurant. The emphasis was the comparative study of the performance of six lab-scale reactors (V: 1.1 L) during start-up and steady-state stages at dry (30% total solid) and thermophilic (55 °C) conditions, using six different inoculum sources (25% of inoculation): (1) corn silage (CS); (2) restaurant waste digested mixed with rice hulls (RH_OFMSW); (3) cattle excrement (CATTLE); (4) swine excrement (SWINE); (5) digested municipal sludge (SLUDGE); and (6) SWINE mixed with SLUDGE (1:1) (SWINE/SLUDGE).

2. Material

2.1. Experimental set up

Schematic diagram of the experimental reactor is shown in Fig. 1. The essays were carried out in batch discontinuous reactors with an internal diameter of 10.45 cm and a total height of 32.15 cm. The total volume capacity was 1.1 L (laboratory scale). The system was conformed by six reactors. Each reactor had independent agitation system and electric control. The main axis contained 14 horizontal and cylindrical crosses willing to different heights, and it rotated in alternate senses by means of a cylindrical temporize, capable to maintain uniform moisture content and to redistribute soluble substrate and bacteria. The operational temperature was 55 °C, controlled and monitored by means of thermostatic bath model SELECT CORP. The conditions selected were dry anaerobic digestion (30% TS), 25% of inoculation and single phase thermophilic (55 °C) process.

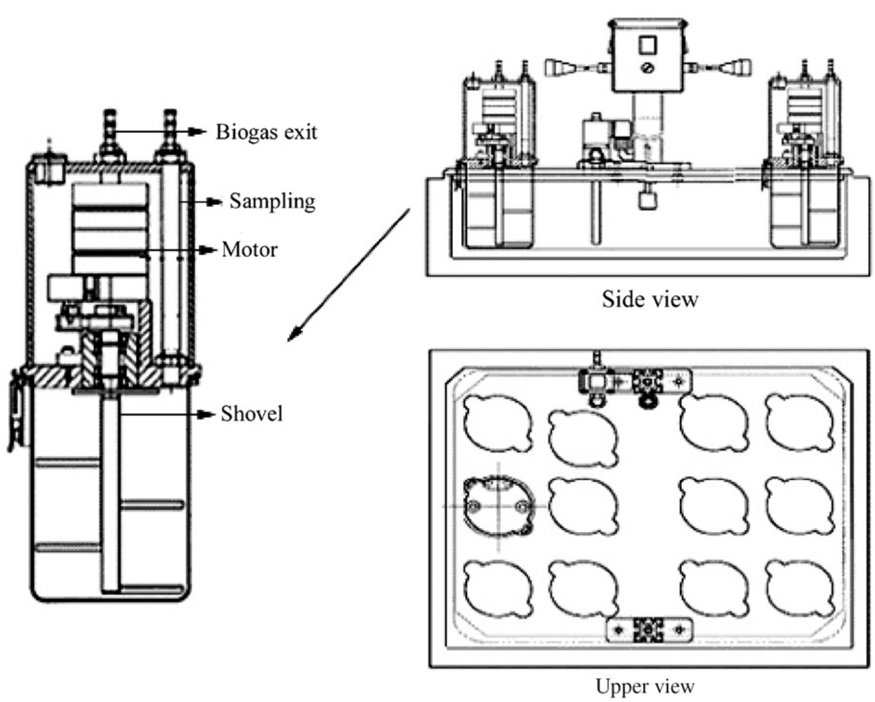

Fig. 1. Schematic diagram of the experimental discontinuous reactors (V: 1.1 L).

2.2. Feedstock preparation and operating conditions

The fresh samples of organic fraction of municipal solid waste were collected from the university restaurant of the Faculty of Sea Science and Environmental Sciences of University of Cadiz, Spain. Pre-treatment of SC_OFMSW was required in order to provide a suitable refined digested material. The SC_OFMSW was initially dried (until 10–20% moisture content) and shredded in cross-beater mill to average particle size of about 2 mm, obtaining an homogenous sample (Forster-Carneiro et al., 2004b).

The following inoculums were selected: (1) corn silage (CS); (2) restaurant waste digested mixed with rice hulls (RH-OFMSW); (3) cattle excrement (CATTLE); (4) swine excrement (SWINE); (5) digested sludge (SLUDGE); and (6) SWINE mixed with SLUDGE (1:1) (SWINE/SLUDGE).

RH_OFMSW is a homogeneous mixture waste with 16.4% TS obtained from previous experiments at dry-thermophilic digestion (Forster-Carneiro et al., 2004a). Digested sludge was obtained from the recirculation line of anaerobic mesophilic digester from "Guadalete Wastewater Treatment Plant placed to Jerez de la Frontera (Spain)", used with success in previous works (De la Rubia et al., 2002). Other four inoculum, corn silage, rice hulls, swine and cattle were obtained from different farms located in El Puerto de Santa Maria, Cádiz Spain.

The effect of the inoculum source on the control of anaerobic process was evaluated during start-up and stabilization stages. Before closing reactors, 25% weight/weight (w/w) inoculums and water were added to the feed mixture at keeping the same final characteristics of total solids (30% TS). Table 1 resumes the characteristics of each reactor.

The analytical parameters generally indicated the biodegradability of complex substrates, the initial characteristics of SC_OFMSW and inoculums showed a heterogeneous substrate (Table 2). The initial density of SC_OFMSW was 500 kg/m^3, the total solid and total organic carbon were 868.0 g TS/kg (86.8%) and 25.0 g TOC/kg, respectively, indicating the abundance of organic matter in the waste (69.8%, measured as VS). C/N ratio was 3.7 and the ammon-N contained was 0.06 $gNH_4^+ - N/kg$ with an alkalinity of 0.01 g $CaCO_3$/kg.

The six selected inoculums had different physical and chemical characteristics. For example, density varied from 350.0 kg/m^3 (CS) up to 1270.0 kg/m^3 (CATTLE); carbon percentages (measure as organic matter) were between 31.3 (CATTLE) and 57.9 (SLUDGE). The COD/N ratios

Table 1
Composition of six reactors in the discontinue batch systems

Reactors	Mass fraction
(1) SC_OFMSW + CS	80 g SC_OFMSW + 448 mL water + 56 g CS
(2) SC_OFMSW + RH	80 g SC_OFMSW + 448 mL water + 128 g RH_OFMSW
(3) SC_OFMSW + CATTLE	80 g SC_OFMSW + 448 mL water + 203.2 g CATTLE
(4) SC_OFMSW + SWINE	80 g SC_OFMSW + 448 mL water + 176 g SWINE
(5) SC_OFMSW + SLUDGE	80 g SC_OFMSW + 448 mL water + 160 g SLUDGE
(6) SC_OFMSW + SWINE/SLUDGE	80 g SC_OFMSW + 448 mL water + 168 g SS

Table 2
Initial mean characteristic of the selected collected municipal solid waste and different inoculum sources

Parameter	Weight fraction or ratio					
	SC_OFMSW	CS	RH_OFMSW	CATTLE	SWINE	SLUDGE
Density (kg/m^3)	500.0	350.0	800.0	1270.0	1100.0	1000.0
Moisture (%)	13.2	67.7	83.6	46.4	70.4	98.7
Solids (%)	86.8	32.3	16.4	53.6	29.6	1.3
Total solids (g/kg)	868.0	323.0	164.0	536.0	296.0	23.5
Volatile solids (g/kg)	698.4	283.0	84.0	76.0	203.0	12.5
TSS (%)	3.6	4.0	7.9	7.0	6.7	11.4
VSS (%)	3.4	3.5	6.9	3.5	6.0	7.4
FSS (%)	0.2	0.5	1.0	3.5	0.7	4.0
TDS (%)	86.4	31.9	15.6	52.9	28.9	1.2
VDS (%)	16.6	27.9	7.7	7.2	19.7	0.5
FDS (%)	6.9	33.9	7.9	45.6	9.2	0.7
Alkalinity (g/kg)	0.01	0.03	0.19	0.15	0.19	0.69
Amon-N (g/kg)	0.06	0.02	0.13	0.06	0.50	2.07
TNK (g/kg)	1.3	5.0	4.8	2.2	8.4	6.7
N-total (%)	0.1	0.5	0.5	0.2	0.8	0.7
TOC (g/kg)	25.0	23.7	33.8	36.5	32.9	11.4
COD (g/kg)	16.0	46.0	33.2	52.8	15.2	25.5
Carbon (%)	48.1	55.7	53.4	31.3	39.8	57.9
C/N ratio (organic matter)	37.8	11.0	11.0	14.0	4.7	8.7

were around 100/7.1 for CATTLE and 100/21.1 for SWINE. Ammonia-N levels were in the range 0.02 $gNH_4^+ - N/kg$ for CS and 2.07 $gNH_4^+ - N/kg$ for SLUDGE. Alkalinities for these reactors were 0.03 and 0.69 g $CaCO_3$/kg respectively.

2.3. Analytical methods

The parameters analyzed for the characterization of SC_OFMSW and inoculums sources were: Density, Total Solids (TS), Volatile Solids (VS), Fixed Solids (FS), Total Suspended Solids (TSS), Volatile Suspended Solids (VSS), Fixed Suspended Solids (FSS), pH, Alkalinity, Total Nitrogen Kjeldahl (TNK), Total Acid, Ammonia Nitrogen (Ammon-N), Total organic Carbon (TOC) and Chemical Oxygen Demand (COD).

Determining the following quantities monitored the digestion process: TS, VS, and FS, pH, alkalinity, TKN, Amon-N, COD, TOC, Total acid and composition and production of biogas. All analytical determinations were performed according to "Standard Methods" (APHA, 1989), after drying, grinding and dilution of the samples. This procedure is more representative due the semi-solid characteristic of the substrate (except for TN, TS, and VS that is not necessary to dilute the samples) (Guitian and Carballas, 1975).

The TOC analysis was carried out in a SHIMADZU 5050 TOC Analyzer, for combustion-infrared (5310B) of "Standard Methods". TS and VS analysis were determined by glass filter method; and the TSS samples were dried in an oven at 105–110 °C, and for VSS to the dried ash waste in a furnace at 550 ± 5 °C. The alkalinity of samples was determined in COMPACT TITRATOR S^+ Crison Instruments SA.

Gaseous analyses were determined by removing a representative sample from the reactor. The volume of gas produced in the reactor was directly measured using a high precision flow gas meter—WET DRUM TG 0.1 (mbar)—Trallero and Schlee SA—through a bag Tedlar. The biogas composition was carried out by gas chromatography separation (SHIMADZU GC-14B) with a stainless steel column packed with Carbosive SII (diameter of 3.2 mm and 2.0 m length) and thermal conductivity detector (TCD). The injected sample volume was 1 cm^3 and operational conditions were as follows: 7 min at 55 °C; ramped at 27 °C min^{-1} until 150 °C; detector temperature: 255 °C; injector temperature: 100 °C. The carrier was helium and the flow rate used was 30 mL min^{-1}. A standard gas (by Carburos metálicos SA); composition: 4.65% H_2; 5.3% N_2; 69.9% CH_4 and 20.1% CO_2 was used for the calibration of the system.

The fatty acids levels were determined by a gas chromatograph SHIMADZU GC17A equipped with a flame-ionisation detector and capillary column filled with Nikol (polyethylene glycol modified by nitro-terephthalic acid). The temperature of the injection port and detector were 200 and 250 °C, respectively. Helium was the carrier gas at 50 mL min^{-1}. In addition, nitrogen gas was used at 30 mL min^{-1} flow rate. In addition, nitrogen gas was used at 30 mL min^{-1} flow rate. Total VFA were calculated as addition of individual VFA levels. Total acid concentrations were calculated as addition of individual volatile fatty acid levels.

3. Results and discussion

3.1. Substrates characteristics and biodegradation of food waste

Six different inoculum sources were used in the dry-thermophilic anaerobic digestion of SC_OFMSW. Table 3 shows initial SC_OFMSW/inoculum mixture compositions in terms of parameters that generally indicated the biodegradability of complex substrates. The TS mass fraction in all reactors had an average of approximately 278.0 g/kg (27.8%) with a mean organic content of 24.7% (measured by VS). Initial COD was in the range 69–88 g/kg. The COD/N ratio was balanced, being around 100/2.6 and therefore, no nitrogen or phosphorus was added to the reactors. The initial pH of reactors had an average of approximately 4.5. In all essays, an adjustment of the pH with hydroxide sodium (6N) was necessary until reached 8.5. In this way, the pH and alkalinity (proximally to 0.3 g $CaCO_3$/kg) showed suitable values in order to maintain a stable condition in the digester for optimal biological activity.

Fig. 2 shows reactors performance data: temporal evolution of VS and COD removal (%) in biomethanization processes of SC_OFMSW reactor with different inoculum sources. As can be seen, over 60 days operational process, COD and VS temporal evolutions removal efficiencies were similar for each reactor. All essays showed optimal microbial activity, reaching stable values after 30 days since inoculation. The best organic matter removal efficiencies were observed in the range 0–30 days, coinciding with the hydrolytic, acidogenic and acetogenic phases. Over 60 days operating period, SLUDGE, SWINE and SWINE/SLUDGE reactors showed the greatest efficiency of substrate removal with values near to 44.0%, 39.0% and 37.0% COD removal, respectively. VS removals showed similar values to COD removals. Again, the best values of VS removal were for SLUDGE, followed by SWINE/SLUDGE and SWINE, with 43.0%, 38.8% and 35.4% VS removal efficiency. The less efficient inoculums were CATTLE and CS, with 19–27% COD and 1525% VS removal efficiencies in the reactors. Hence, we conclude that organic matter removal in the reactors took place during the first 30 days, and the DOC removal efficiencies values were high for SLUDGE and SWINE/SLUDGE, showing 30.5% and 28.3% DOC, respectively.

3.2. Volatile fatty acids degradation

The evolutions of individual and total volatile fatty acids (mg/L) in the reactors are shown in Fig. 3. Total fatty

Table 3
Chemical composition of initial mixture SC_OFMSW/inoculum

Parameter	Weight fraction or ratio					
	1 SC_OFMSW + CS	2 SC_OFMSW + RH_OFMSW	3 SC_OFMSW + CATTLE	2 SC_OFMSW + SWINE	2 SC_OFMSW + SLUDGE	2 SC_OFMSW + SWINE/SLUDGE
Density (kg/m^3)	1100.0	1100.0	1100.0	1100.0	1000.0	1100.0
Moisture (%)	71.1	71.1	72.4	73.6	72.0	72.8
Solids (%)	29.0	28.9	27.6	26.4	28.0	27.2
Total solids (g/kg)	289.5	289.0	275.6	263.5	280.0	272.4
Volatile solids (g/kg)	276.0	230.0	254.2	233.4	251.0	237.0
TSS (%)	6.5	7.3	6.7	6.7	7.1	6.8
VSS (%)	6.0	6.5	6.2	5.5	6.5	6.3
FSS (%)	0.5	0.8	0.5	1.2	0.6	0.5
TDS (%)	28.3	28.2	26.9	25.6	27.2	26.5
VDS (%)	27.0	22.3	24.8	22.7	24.4	23.0
FDS (%)	1.3	5.8	2.0	2.9	2.8	3.5
pH	8.5	8.5	8.6	8.6	8.5	8.5
Alkalinity (g/kg)	0.37	0.21	0.26	0.29	0.26	0.22
Ammon-N (g/kg)	0.46	0.31	0.46	0.46	0.31	0.46
TNK (g/kg)	1.0	1.3	1.6	1.1	1.1	1.5
N-total (%)	0.1	0.1	0.2	0.1	0.1	0.1
TOC (g/kg)	76.5	73.7	75.9	76.4	75.8	70.6
COD (g/kg)	82.1	80.4	68.6	86.4	84.0	87.9
Carbon (%)	55.0	49.2	53.4	50.2	54.2	47.1
C/N ratio (organic matter)	54.0	39.2	32.5	46.4	48.4	31.7

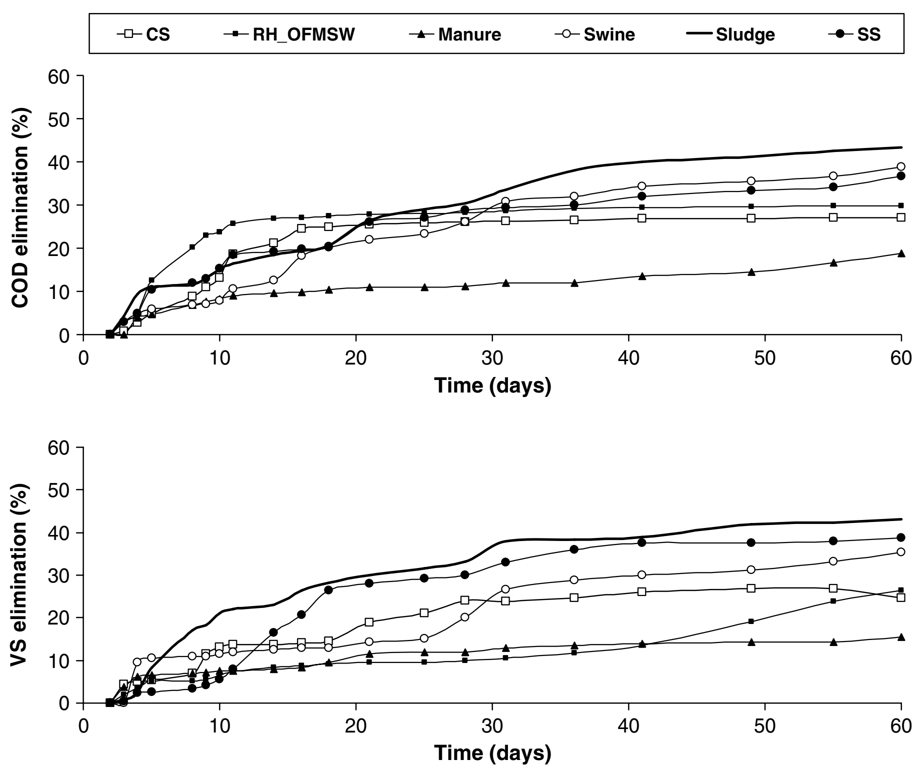

Fig. 2. Reactor performance data of VS and COD removal levels of different inoculum source in the SC_OFMSW treatment.

acids (as addition of acetic and butyric acids) are expressed in mg/L. Volatile acids represent a critical parameter in the operation and control of anaerobic digestion, in this study all reactors showed a typical evolution. Initially, hydrolytic and acidogenic stages were observed (0–5 days) with a high fatty acids generations. Fig. 3 showed a low total acid production between the day 6 and 25–30. After the day 30, the hydrolyzed organic matter was transformed to volatile

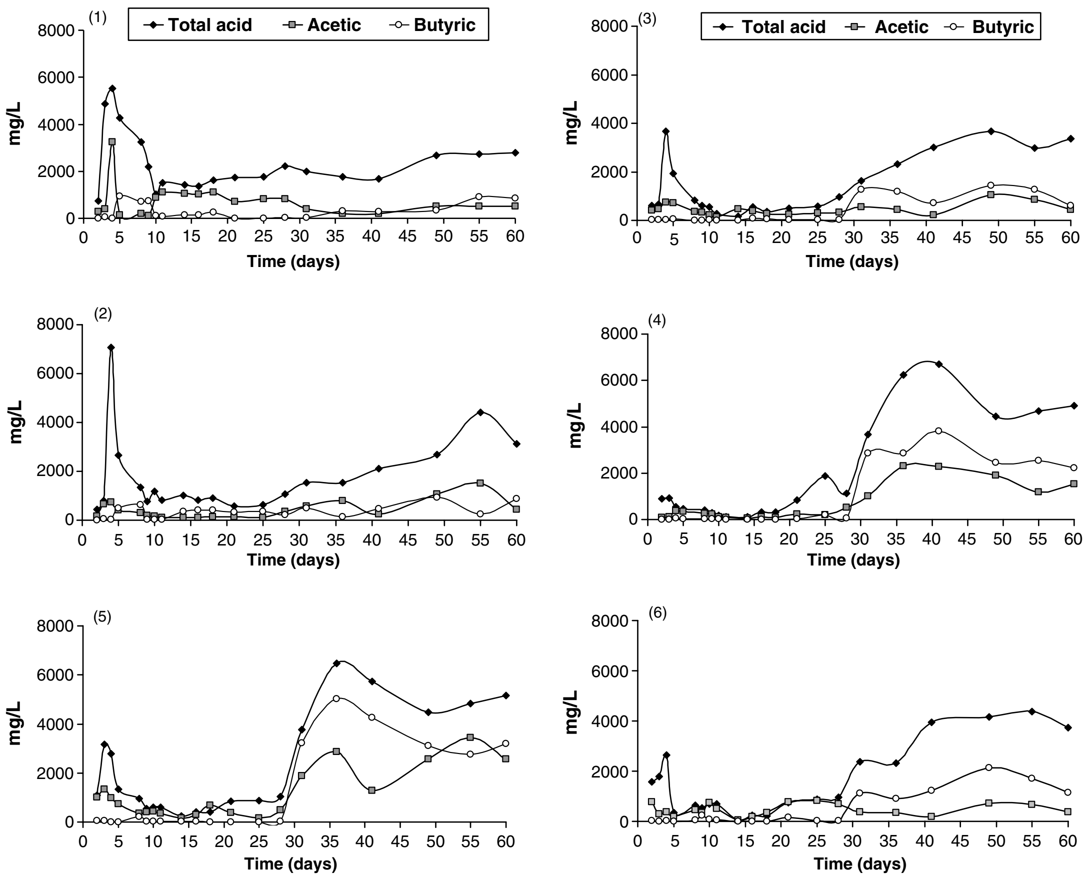

Fig. 3. Reactor performance data of total acid, and VFA (acetic and butyric) (mg/L) in discontinuous SC_OFMSW reactor with different inoculum sources: (1) CS; (2) RH_OFMSW; (3) CATTLE; (4) SWINE; (5) SLUDGE; (6) SWINE_SLUDGE.

fatty acids, mainly butyric and acetic acids, suggesting the stabilization phase. The concentration of these volatile acids in the digester is determined by their production rate and their removal rate; in this case, the acetic acid removal rate is superior to its production rate.

The lower concentrations of volatile fatty acids generated were for SC and CATTLE reactors, with values in the range 173.0–1507.0 mg acetic/L and 66.0–872.0 mg butyric/L. The higher values of total VFA acids for SLUDGE and SWINE increased to a maximum value of 6478 and 6710 mg/L, respectively, and not destabilization was observed. These results were compared with other researches and studies which have been conducted previously, where approximately 70% of the digester methane was originated from acetate (the most important precursor on which to focus) and the remainder of the digester methane (approximately 30%) was originated mainly from the reduction of dioxide of carbon by hydrogen (Chynoweth et al., 2001).

3.3. Biogas generation and methane efficiency

Fig. 4 shows the biogas generation and methane composition of different reactors. The average daily biogas production of SWINE, SLUDGE and SWINE/SLUDGE amounted to 95.6, 71.7 and 64.1 mL/day with 26.6%, 41.6% and 40.0% methane content, respectively (Fig. 3). These values are higher than those obtained for CS, RH-OFMSW and CATTLE reactors. Hence, it was possible to differentiate two different group of inoculum and different behaviors of biogas and methane production:

- *CS, RH-OFMSW and CATTLE reactors*: The biogas generation was very high until day 20. The produced biogas contained high H_2 concentrations, reaching 20% volume coinciding with the decreasing in CO_2 concentrations. When H_2 disappeared, it was observed CH_4 generation in the biogas composition. During the period between 20–30 days, no biogas generation were observed. Certain combinations of the feedstocks and operating conditions may result in microbial population imbalance or temporaries decreased of the activity. Any compounds such as fats and protein produce a higher percentage of the methane than oxidized compounds such as sugars. Finally, during the stabilization phase, a high biogas and methane generation was observed associated to the acetic acid consumption. The average of biogas productions were 72.2, 48.2 and 46.9 mL/day for CS, RH_OFMSW and CATTLE, respectively. Corresponding methane productions were 27.3, 19.4 and

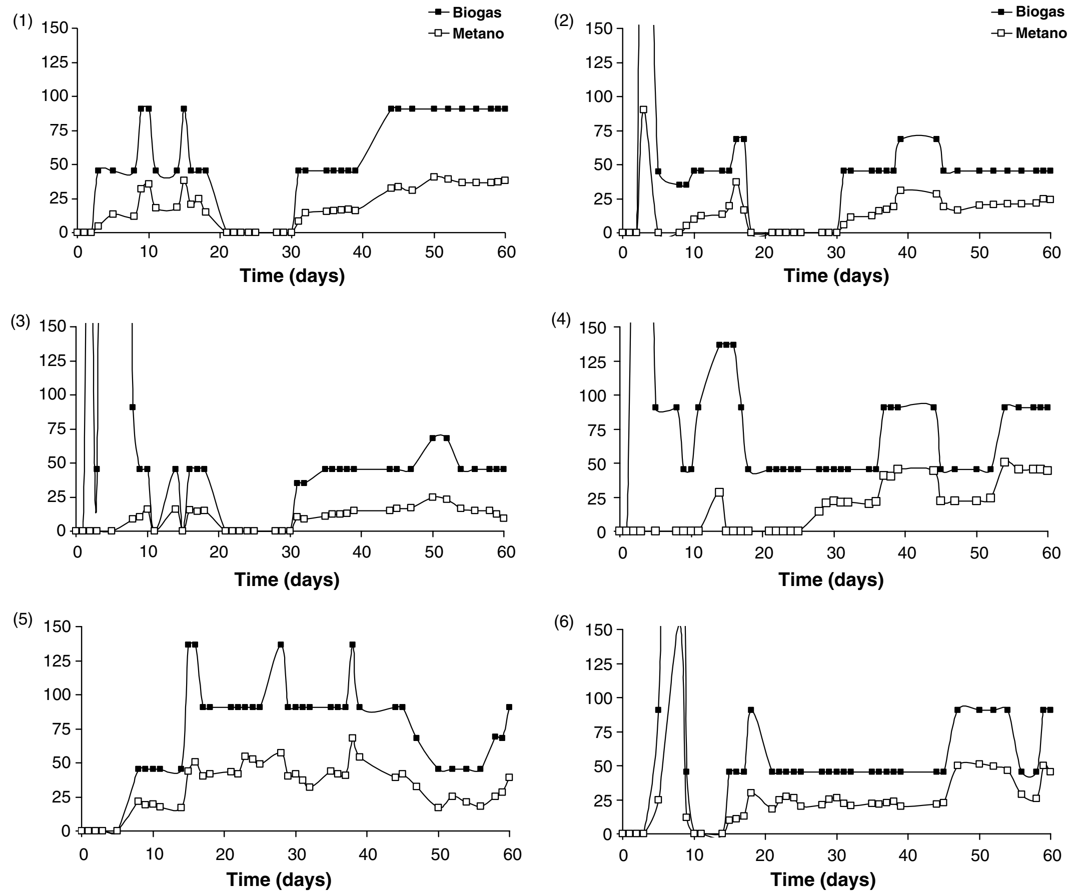

Fig. 4. The biogas production and methane composition of different inoculum source in the SC_OFMSW treatment.

14.5 mL CH_4/day. Methane yields in al process were 0.11, 0.22 and 0.03 L CH_4/g VS for CS, RH_OFMSW and CATTLE. Considering the range 30 and 60 days the methane yields increase for 0.19, 0.34 and 0.06 L CH_4/g VS for CS, RH_OFMSW and CATTLE, respectively.

- *SWINE, SLUDGE and SWINE/SLUDGE reactors*: The biogas generation values were constant and very high during all the experimental study (75–100 mL/day associated with a methanogenic process without lag stage. At the end of the process (between 30 and 60 days), the averages of biogas generated were 69.5, 78.9 and 61.5 mL/day, and 33.9, 35.7 and 32.0 mL CH_4/day for SWINE, SLUDGE and SWINE/SLUDGE treatments, respectively. The SLUDGE reactor generated a constant amount of biogas, 32.3 mL/day, during all the process, which was higher than the other reactors. Fig. 5 shows reactor performance data of accumulated biogas and methane in the reactors. Biogas was generated from the beginning (second day since inoculation). The biogas and methane accumulation for SWINE, SLUDGE and SWINE/SLUDGE reactors reached after 60 days were 3727.3, 3796.7 and 2500.0 mL and 661.2, 1257.1 and 988 mL CH_4, respectively. In this way, the SWINE, SLUDGE and SWINE/SLUDGE showed the highest methane yield and similar evolution of methane efficiency. However, the SLUDGE reactor is considered the best of inoculum source because it present the higher methane yield (0.53 L CH_4/g VS) in both periods: start-up and stabilization (Table 4).

3.4. Comparative process efficiency

Table 4 shows a summary of performance data at the end of the process for all six reactors studied. In all cases, COD removals were similar to VS removals. The highest methane production was observed in the SLUDGE and SWINE/SLUDGE after the second week of inoculation, while SWINE reactor only showed important generation efficiency after the day 25. Over 60 day's operation process, the greatest methane yield (LCH_4/g VS) was obtained for SLUDGE reactor, followed to SWINE/SLUDGE reactor and SWINE, with values in the range 0.29, 0.27 and 0.18 LCH_4/g VS.

Considering only the stabilization stage (30–60 days), the reactor with SC_OFMSW with SLUDGE was the most effectively inoculum, showing a methane yield of 0.53 L CH_4/g VS. Jerger and Tsao (1987) determinates the upper theoretical methane yields for several different biomasses and waste feedstocks and found similar results for municipal solid waste (0.512 L CH_4/kg VS) and primary sludge 0.793 L CH_4/kg VS. The SLUDGE have a

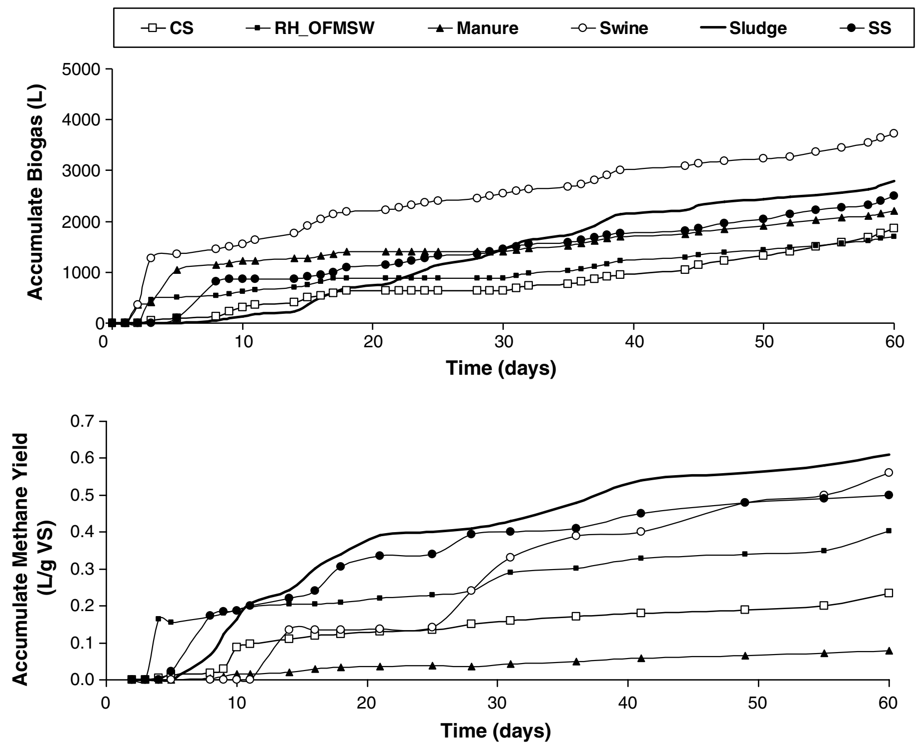

Fig. 5. The accumulate biogas and methane yield of different inoculum source in the SC_OFMSW treatment.

Table 4
Summary performance of process in discontinue reactor with different inoculum sources after 60 days of experiment

	Organic matter removal			Methane yield	
	VS (%)	DOC (%)	COD (%)	L CH_4/g VS (after 60 days)	L CH_4/g VS (30–60 days)
(1) SC_OFMSW + CS	24.6	20.4	27.1	0.11	0.19
(2) SC_OFMSW + RH	26.5	17.9	29.9	0.22	0.34
(3) SC_OFMSW + CATTLE	15.4	15.2	18.9	0.03	0.06
(4) SC_OFMSW + SWINE	35.4	18.4	38.8	0.18	0.44
(5) SC_OFMSW + SLUDGE	43.0	30.5	43.2	0.29	0.53
(6) SC_OFMSW + SS	38.8	28.3	36.6	0.27	0.42

substantially higher methane yield than the others inoculum and adapted to the mesophilic and thermophilic temperatures.

4. Conclusions

The six inoculum sources showed an initial start-up phase of 2–4 days. The initial methane generation began after 10 days of operation. After 30 days, all reactors, except SLUDGE reactor, reached the stabilization stage (methanogenesis) with little COD and VS removals and high methane yield. SLUDGE reactor that showed a methanogenic behavior during all the experimentation.

Values of the biogas generation and methane composition of SWINE, SLUDGE and SWINE/SLUDGE are higher than those observed for CS, RH-OFMSW and CATTLE reactors, suggesting two different groups: inoculums with more or smaller adaptation to the municipal solid waste. The greatest methane yield (LCH_4/g VS) was obtained for SLUDGE reactor, followed to SWINE/SLUDGE reactor and SWINE, with values in the range 0.29, 0.27 and 0.18 L CH_4/g VS, respectively, after 60 days. The lower methane yield was observed for CS, RH_OFMSW and CATTLE with values of 0.19, 0.34 and 0.06 L CH_4/g VS.

In conclusion, all analytical parameters indicated that SLUDGE is the best inoculum for anaerobic thermophilic digestion of SC-OFMSW at dry conditions (30% TS). SLUDGE reactor can achieve 44.0% COD removal efficiency and 43.0% VS removal after 60 days of the experimentation. In stabilization phase, SLUDGE reactor showed higher volumetric biogas generated of 78.9 mL/day (or 35.6 CH_4 mL/day) reaching a methane yield of 0.53 L CH_4/g VS. The SWINE/SLUDGE and SWINE were also good inoculums. A CATTLE was the worst inoculum in terms of organic matter removal and methane yield.

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