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Data Article

# A comprehensive dataset on anaerobic digestion of cattle manure, source separated organics, and municipal sludge using different inoculum sources



E. Hosseini Koupaie <sup>a</sup>, A. Azizi <sup>a</sup>, A.A. Bazyar Lakeh <sup>a</sup>,  
H. Hafez <sup>a, b</sup>, E. Elbeshbishy <sup>a, \*</sup>

<sup>a</sup> Environmental Research for Resource Recovery, Civil Engineering Department,  
Faculty of Engineering, Architecture and Science, Ryerson University, 350 Victoria Street,  
Toronto, ON, M5B 2K3, Canada

<sup>b</sup> Greenfield Global (Ethanol), Chatham, ON, N7M 5J4, Canada

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## ABSTRACT

The dataset reported in this article provides quantitative data on anaerobic digestion of cattle manure, source separated organics (SSO), primary sludge (PS), and thickened waste activated sludge (TWAS) using different inoculum sources. The discussion and interpretation of the data are provided in another publication entitled “Comparison of liquid and dewatered digestate as inoculum for anaerobic digestion of organic solid wastes” [1]. The data presented in this article include 1) the gas chromatography (GC) procedure of determining the biogas composition, 2) the procedure of converting the daily biogas/methane production data from the experimental condition (mesophilic temperature of 38 °C and room pressure) to the standard temperature (0 °C) and pressure (1 atm) condition, 3) the specific methanogenic activity data, and 4) the methane daily production rate data, and 5) the organics biodegradation kinetic rates.

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\* Corresponding author.

E-mail address: [elsayed.elbeshbishy@ryerson.ca](mailto:elsayed.elbeshbishy@ryerson.ca) (E. Elbeshbishy).

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Specifications table

Subject area	Environmental Engineering
More specific subject area	Anaerobic digestion, organic solid waste treatment, biological treatment, bioenergy recovery
Type of data	Table, figures
How data was acquired	The biogas methane content was measured via gas chromatography (GC). The chemical oxygen demand (COD), carbohydrate, and protein contents of the samples were determined calorimetrically using a DR3900 Hach spectrophotometer. The volume of the biogas produced throughout the biochemical methane potential (BMP) test was measured manually. The production of biogas during the biohydrogen potential test was instantly monitored throughout 72 h. The Minitab Software 17 was used for the statistical analysis.
Data format	Raw, analyzed
Experimental factors	To analyze the soluble content, the sample was first centrifuged using a Fisher Scientific Sorvall Legend XT centrifuge at 90000 rpm for 30 min. Afterwards, the centrate (permeate) of the centrifuged samples was filtered through 0.45 $\mu\text{m}$ microfiber filters.
Experimental features	Three sets of experiment including SMA, BMP, and BHP were conducted. The acetic acid was used as a substrate for the SMA assay. The BMP test was performed with four different organic solid waste including cattle manure, SSO, PS, and TWAS. The substrate for the BHP experiment was glucose. All the experiments were done in triplicates.
Data source location	Toronto, Canada
Data accessibility	Data are presented in this article
Related research article	[1] E. Hosseini Koupaie, A. Azizi, A.A. Bazyar Lakeh, H. Hafez, E. Elbeshbishy, Comparison of liquid and dewatered digestate as inoculum for anaerobic digestion of organic solid wastes, <i>Waste Manage.</i> , 87 (2019) 228–236.

### Value of the Data

- To understand the details on translating the parameters measured under specific laboratory conditions (temperature and pressure) into the standard condition which makes the data easily comparable with other researchers' findings.
- The kinetic data would be useful to compare the digestion rate of various organic waste with respect to the type of inoculum used.
- The data provides comprehensive information on the application of two different inoculum sources on anaerobic digestion of synthetic (acetic acid and glucose) and real organic waste
- The dataset presents the procedure of the analytical method with GC to analyze the biogas composition as well as the detailed information on several measured AD parameters.
- The dataset provided in this article suggests that the startup (seeding) of industrial-scale anaerobic digestion plants can be done using dewatered digestate cake, reducing the transportation volume up to 90% compared to the application of liquid digestate.

## 1. Data

The measured biogas production data during the SMA, BHP, and BHP experiments are presented in [Table 1](#), [Table 2](#), and [Table 3](#), respectively. The converted values to the standard temperature ( $^{\circ}\text{C}$ ) and pressure (1 atm) condition are shown in [Table 4](#), [Table 5](#), [Table 6](#), respectively. [Table 7](#) presents the daily methane production rate of the SMA digesters at the standard temperature and pressure condition. [Fig. 1](#) illustrates the cumulative methane production of the SMA digesters during the initial operation period along with the linear regression equation of the best-fitted line to each graph. The slope of the linear regression was used to determine the specific methanogenic activity illustrated in [Fig. 2](#). [Fig. 3](#) shows the first-order specific TCOD removal rate constant of the BMP digesters.

## 2. Experimental design, materials, and methods

### 2.1. Data analysis procedures

The conversion of measured biogas volume data from the experimental conditions to the standard temperature and pressure condition was done using Eq. (1).

**Table 1**

Daily biogas production data from the SMA reactors at a temperature of 38 °C (mL).

Day	F/M = 0.25				F/M = 0.5			
	AD digestate	STDEV	AD cake	STDEV	AD digestate	STDEV	AD cake	STDEV
0	0	0	0	0	0	0	0	0
1	16	2	19	3	20	5	24	2
2	25	2	32	9	31	4	34	12
3	36	4	50	6	41	11	59	17
4	50	12	57	4	49	10	86	15
5	57	6	59	11	56	14	104	14
8	83	11	94	8	79	12	164	20
9	96	13	116	18	93	12	185	13
11	108	11	144	11	111	16	227	17
12	124	14	163	7	138	15	267	10
15	154	9	208	18	191	21	365	12
16	159	19	220	20	219	18	406	16
18	188	19	253	19	260	24	480	14
19	205	21	270	9	291	14	516	28
20	221	17	284	17	318	11	544	25
21	240	18	293	17	345	17	570	27
22	263	13	306	21	393	14	588	19
23	279	16	309	19	436	21	599	22
24	294	11	314	14	485	27	610	24
25	304	16	316	14	526	21	622	17
26	317	18	318	20	555	34	627	19
27	323	31	321	17	581	31	633	16
28	329	19	323	24	593	16	636	15
29	334	23	325	24	608	22	641	23
30	340	23	328	18	618	27	643	19
31	342	20	332	23	626	21	644	23
32	342	10	332	25	627	18	646	18
33	343	17	333	23	628	14	647	17
34	343	22	334	13	629	22	647	20
35	344	20	335	23	630	20	647	20

**Table 2**

Daily biohydrogen production data from the BHP reactors at a temperature of 38 °C (mL).

Time (h)	Digestate	STDEV	Digestate cake	STDEV
0	0	0	0	0
1	1	0	2	1
2	1	1	2	1
3	1	1	2	1
4	1	1	3	1
5	1	1	4	1
6	2	1	6	2
7	3	0	6	2
8	4	1	8	4
9	6	3	10	5
10	9	9	10	4
11	13	11	11	2
12	18	10	14	3
13	26	8	19	2
14	36	20	27	2
15	50	28	37	5
16	70	27	50	4
16.5	81	24	56	8
17	93	21	62	4
17.5	104	29	69	11
18	118	25	78	7
18.5	132	23	96	16

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**Table 2** (continued)

Time (h)	Digestate	STDEV	Digestate cake	STDEV
19	148	22	122	20
19.5	163	23	149	23
20	179	17	179	14
20.5	197	21	209	19
21	216	23	235	22
21.5	236	27	254	16
22	258	23	271	32
22.5	283	29	288	25
23	306	21	305	22
23.5	316	23	319	37
24	332	29	331	33
24.5	346	27	338	43
25	354	19	345	53
25.5	362	25	350	24
26	367	27	354	41
26.5	370	23	357	50
27	372	25	359	34
27.5	375	27	360	34
28	378	25	362	43
28.5	380	31	363	38
29	381	29	364	34
30	382	25	366	43
31	382	31	367	43
32	382	27	368	34
33	382	31	368	34
34	382	29	368	26
35	382	25	368	34
36	382	25	368	26

**Table 3**

Daily biogas production data from the BMP reactors at a temperature of 38 °C (mL).

		Time (d)																		
		0	2	4	5	7	8	10	11	13	14	17	19	22	25	28	31	35	42	
TWAS	Digestate	Average	0	41	75	95	115	127	146	170	196	233	406	547	762	856	885	896	897	898
		STDEV	0	6	15	9	16	10	14	23	17	22	38	45	39	34	34	38	40	42
	Digestate	Average	0	87	126	149	178	201	235	274	314	370	580	707	853	884	922	945	945	950
	cake	STDEV	0	4	6	9	5	17	14	18	24	35	48	39	26	58	60	71	71	73
PS	Digestate	Average	0	24	39	103	151	179	203	210	235	249	308	344	425	595	869	1015	1028	1046
		STDEV	2	13	17	48	31	24	20	23	27	31	40	38	19	37	48	20	25	30
	Digestate	Average	0	51	75	123	201	232	264	308	335	374	557	681	858	980	1055	1084	1084	1084
	cake	STDEV	2	12	13	20	6	7	18	13	16	22	37	47	52	55	61	67	67	67
SSO	Digestate	Average	0	7	69	135	183	204	222	241	271	334	657	807	1020	1146	1234	1280	1300	1300
		STDEV	60	8	15	18	19	21	16	11	16	17	51	66	49	62	52	57	54	54
	Digestate	Average	41	84	144	206	239	259	307	394	503	606	872	986	1128	1215	1265	1265	1265	1265
	cake	STDEV	1	7	15	20	21	24	33	45	52	56	79	78	96	111	109	109	109	109
Manure	Digestate	Average	0	12	40	77	137	182	243	307	370	434	589	640	720	785	833	854	856	863
		STDEV	2	6	17	25	32	46	51	43	66	64	74	45	84	56	36	40	59	50
	Digestate	Average	0	32	87	166	288	382	488	551	605	643	722	750	786	804	815	827	831	835
	cake	STDEV	2	4	8	12	18	26	35	44	53	59	70	74	77	81	83	88	88	88

$$V_{STP} = V_m \left( \frac{T_{STP}}{T_m} \right) \left( \frac{P_m}{P_{STP}} \right) \quad (1)$$

where.

 $V_{STP}$ : Biogas volume at the standard temperature and pressure condition (mL). $V_m$ : Measured biogas volume (mL).

**Table 4**

Converted daily biogas production data from the SMA reactors to the standard temperature and pressure condition (mL).

Day	F/M = 0.25				F/M = 0.5			
	AD digestate	STDEV	AD cake	STDEV	AD digestate	STDEV	AD cake	STDEV
0	0	0	0	0	0	0	0	0
1	14	2	17	3	18	5	21	2
2	23	2	28	8	28	3	30	10
3	32	3	44	5	36	10	52	15
4	44	10	50	3	43	9	76	14
5	51	5	53	10	50	13	92	13
8	74	10	83	7	70	11	145	18
9	85	11	103	16	82	11	164	11
11	96	10	128	9	98	14	201	15
12	110	13	144	6	123	13	236	9
15	136	8	184	16	170	19	324	10
16	141	17	195	18	194	16	360	14
18	167	17	224	17	231	21	426	12
19	182	18	239	8	258	12	457	25
20	196	15	252	15	282	10	482	22
21	212	16	260	15	306	15	506	24
22	233	12	271	19	348	12	521	17
23	247	14	274	16	386	19	531	19
24	260	10	278	13	430	24	541	21
25	269	14	280	12	466	19	551	15
26	281	16	282	18	492	30	555	17
27	286	28	285	15	515	28	561	14
28	292	17	286	21	526	15	564	13
29	296	21	288	22	539	20	568	20
30	301	20	291	16	547	24	570	17
31	303	17	294	20	555	18	571	20
32	304	9	295	22	556	16	572	16
33	304	15	295	20	557	12	573	15
34	304	20	296	11	558	20	574	18
35	304	17	297	20	558	18	574	18

**Table 5**

Converted daily biohydrogen production data from the BHP reactors to the standard temperature and pressure condition (mL).

Time (h)	Digestate	STDEV	Digestate cake	STDEV
0	0	0	0	0
1	0	0	1	1
2	1	1	2	1
3	1	1	2	1
4	1	1	3	1
5	1	1	3	1
6	2	1	5	2
7	2	0	6	2
8	3	1	7	4
9	5	3	8	5
10	8	8	9	4
11	12	10	10	2
12	16	9	12	2
13	23	7	17	2
14	32	18	24	2
15	44	25	33	4
16	62	24	44	4
16.5	71	21	50	7
17	82	19	55	4
17.5	92	25	61	10
18	104	23	69	6

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**Table 5** (continued)

Time (h)	Digestate	STDEV	Digestate cake	STDEV
18.5	117	20	85	14
19	131	20	108	17
19.5	145	20	132	20
20	159	15	159	13
20.5	175	19	185	17
21	191	20	208	19
21.5	209	24	225	14
22	228	20	240	28
22.5	251	25	255	23
23	271	19	270	20
23.5	280	20	283	33
24	295	25	293	29
24.5	307	24	300	38
25	314	17	306	47
25.5	321	22	310	21
26	325	24	314	36
26.5	328	20	316	45
27	330	22	318	30
27.5	333	24	320	30
28	335	22	321	38
28.5	337	27	322	34
29	337	25	323	31
30	338	22	324	38
31	338	27	325	38
32	338	24	326	31
33	338	27	326	31
34	338	25	326	23
35	338	22	326	31
36	338	22	326	23

**Table 6**

Converted daily biogas production data from the BMP reactors to the standard temperature and pressure condition (mL).

		Time (d)																		
		0	2	4	5	7	8	10	11	13	14	17	19	22	25	28	31	35	42	
TWAS	Digestate	Average	0	36	66	84	102	112	129	151	174	207	360	485	675	759	785	794	795	796
		STDEV	0	5	13	8	14	9	12	20	15	19	33	40	35	30	30	34	35	38
	Digestate	Average	0	77	112	132	158	178	208	243	278	328	514	626	756	783	817	838	838	842
		STDEV	0	4	5	8	4	15	12	16	21	31	42	35	23	51	53	63	63	64
PS	Digestate	Average	0	21	34	91	134	158	180	186	208	221	273	304	376	528	770	899	911	927
		STDEV	1	12	15	43	28	21	18	21	24	28	36	33	17	33	43	18	22	27
	Digestate	Average	0	45	66	109	178	205	234	273	297	332	494	603	760	869	935	960	960	960
		STDEV	1	11	12	18	5	6	16	12	15	19	33	42	46	48	54	59	59	59
SSO	Digestate	Average	0	6	61	120	162	180	196	214	240	296	582	715	904	1016	1094	1135	1152	1152
		STDEV	53	7	13	16	17	19	14	10	14	15	45	58	43	55	47	51	47	47
	Digestate	Average	37	74	127	182	212	230	272	349	445	537	773	874	1000	1077	1121	1121	1121	1121
		STDEV	1	6	13	18	19	21	30	40	46	50	70	69	85	99	96	96	96	96
Manure	Digestate	Average	0	10	36	69	121	161	216	272	328	385	522	567	638	696	739	757	759	765
		STDEV	1	5	15	22	29	40	45	38	58	57	66	40	75	49	32	35	53	44
	Digestate	Average	0	29	77	147	255	338	433	488	536	570	640	665	697	712	723	733	736	740
		STDEV	1	4	7	11	16	23	31	39	47	53	62	66	69	72	74	78	78	78

$T_{STP}$ : Standard temperature (273.15°C).

$T_m$ : Digester temperature (273.15 + 38 = 311.15°C).

$P_m$ : Pressure at the time of measuring the biogas volume (atm).

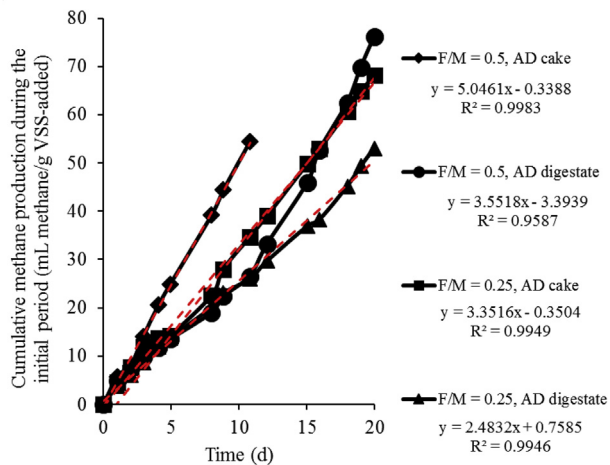
$P_{STP}$ : Standard pressure (1 atm).

The daily methane production rate was determined via Eq. (2)

**Table 7**Daily methane production rate of the SMA digesters at the standard temperature and pressure condition (mL/g TCOD<sub>added</sub>.d).

Day	F/M = 0.25				F/M = 0.5			
	AD digestate	STDEV	AD cake	STDEV	AD digestate	STDEV	AD cake	STDEV
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	14.0	3.8	17.0	5.4	9.1	4.6	10.7	2.2
2	9.0	1.6	11.9	7.0	4.9	1.2	4.5	3.1
3	10.3	2.2	17.3	4.0	4.9	2.7	12.1	7.0
4	10.8	5.1	5.6	0.7	3.2	1.4	10.8	3.9
5	8.2	1.6	2.7	1.0	3.8	1.9	9.4	2.6
8	7.7	2.0	10.1	1.6	3.4	1.0	8.9	2.2
9	12.9	3.4	<b>23.7<sup>a</sup></b>	7.2	7.4	1.9	11.2	1.6
11	5.6	1.2	12.9	1.9	4.0	1.2	9.6	1.4
12	11.0	2.5	12.9	1.1	9.8	2.1	14.0	1.0
15	9.2	1.1	13.7	2.3	8.1	1.8	15.1	1.0
16	5.6	1.3	12.7	2.3	14.0	2.3	<b>20.4<sup>a</sup></b>	1.6
18	12.7	2.5	14.3	2.1	9.0	1.6	16.3	0.9
19	15.6	3.1	15.6	1.0	13.7	1.3	16.0	1.8
20	14.0	2.1	12.4	1.5	12.1	0.9	12.7	1.2
21	16.8	2.5	8.1	0.9	12.5	1.2	11.9	1.1
22	<b>21.1<sup>a</sup></b>	2.1	11.8	1.6	21.3	1.5	7.8	0.5
23	14.1	1.6	3.1	0.4	19.5	1.9	5.1	0.4
24	13.8	1.0	3.9	0.4	<b>22.4<sup>a</sup></b>	2.5	5.1	0.4
25	8.9	0.9	2.0	0.2	18.3	1.5	5.2	0.3
26	11.7	1.3	1.8	0.2	13.1	1.6	2.2	0.1
27	5.8	1.1	2.9	0.3	11.8	1.3	2.7	0.1
28	5.6	0.7	1.3	0.2	5.5	0.3	1.7	0.1
29	4.4	0.6	2.4	0.4	6.7	0.5	2.2	0.2
30	5.0	0.7	2.9	0.3	4.4	0.4	0.7	0.0
31	2.1	0.2	3.0	0.4	3.8	0.3	0.6	0.0
32	0.4	0.0	0.6	0.1	0.4	0.0	0.6	0.0
33	0.4	0.0	0.7	0.1	0.5	0.0	0.6	0.0
34	0.4	0.0	0.7	0.1	0.5	0.0	0.1	0.0
35	0.3	0.0	0.7	0.1	0.3	0.0	0.1	0.0

<sup>a</sup> The maximum daily methane production rate values are highlighted in blue.



**Fig. 1.** Cumulative methane production of the SMA digesters during the initial operation period.

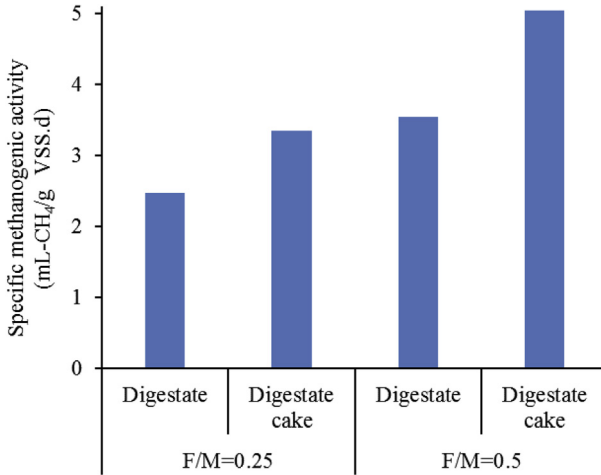


Fig. 2. The specific methanogenic activity of the SMA digesters (determined via the slope of the best-fitted line to the Fig. 1 graphs).

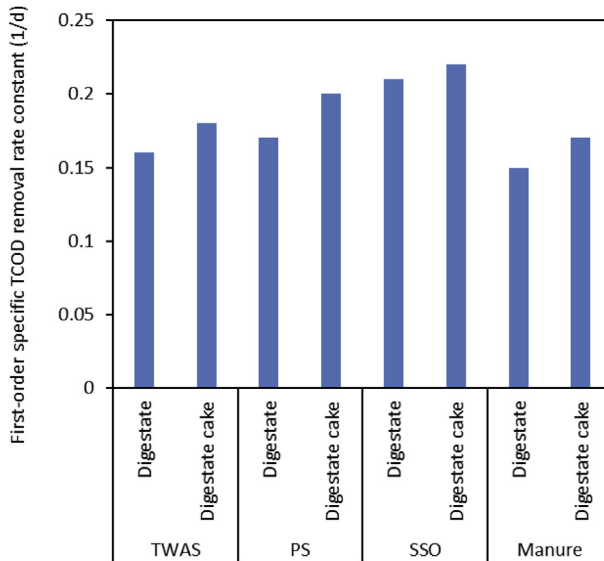


Fig. 3. First-order specific TCOD removal rate constant of the BMP digesters.

$$R_i = \frac{V_{i+1} - V_i}{\Delta t}, \quad i \geq 0 \quad (2)$$

$R_i$ : Daily methane production rate (mL/g TCOD<sub>added,d</sub>).

$V_i$ : Cumulative biogas production yield until  $i^{\text{th}}$  measurement (mL/g TCOD<sub>added</sub>).

$V_{i+1}$ : Cumulative biogas production until  $(i+1)^{\text{th}}$  measurement (mL/g TCOD<sub>added</sub>).

$\Delta t$ : Time difference between the  $i^{\text{th}}$  and  $(i+1)^{\text{th}}$  biogas measurement (d).

Previous studies have proven that the first-order reaction model can represent the biogas production as well as the organics removal during the AD process [2–6]. Eq. (3) shows the first-order reaction model that was utilized to calculate the specific reaction rate constant of the BMP digesters.



$$r_{su} = \frac{dC}{dt} = -kC \quad (3)$$

in which  $r_{su}$ ,  $C$  and  $k$  are TCOD removal rate (mg/L.d), TCOD concentration (mg/L) and first-order specific rate constant (1/d), respectively. Eq. (4) is derived after integration and rearrangement of Eq. (3).

$$L_t = L_u e^{-kt} \quad (4)$$

in which  $L_t$ ,  $L_u$  and  $t$  are TCOD concentration in the digester at time  $t$  (mg/L), ultimate biodegradable TCOD (mg/L) and digestion time, respectively.

## 2.2. Analytical procedure

The methane content of the produced biogas was measured with a Thermo Scientific Trace 1310 gas chromatograph (GC). The GC had a TG-Bond Msieve 5A packed column with diameter and length of 0.53 mm and 30 m, respectively. It was also equipped with a thermal conductivity detector running at the oven, detector, and filament temperatures of 80, 100, and 250 °C, respectively. The chemical oxygen demand (COD), carbohydrate, and protein contents of the samples were determined calorimetrically using a DR3900 Hach spectrophotometer. The volume of the biogas produced throughout the biochemical methane potential (BMP) test was measured with a 100 mL air-tight glass syringe (Poulsen & Graf Fortuna™). The production of biogas during the biohydrogen potential test was monitored using an AMPTS II gas-measuring device (Bioprocess Control, Lund, Sweden). The analysis of variance (ANOVA) was performed using Minitab Software 17. The COD analysis was carried out using the closed reflux colorimetric method described by the Standard Methods [7]. The analyses of carbohydrate and protein were performed according to the colorimetric methods developed by Dubois et al. (1956) and Frolund et al. (1995), respectively [8,9].

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## Transparency document

Transparency document associated with this article can be found in the online version at <https://doi.org/10.1016/j.dib.2019.103913>.

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