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Durian Residues as Potential Resource for Biogas Production in An Anaerobic System

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The potential of durian shell and seed as resources for biogas production in an anaerobic system was investigated. Cow dung was used as the microorganism releaser and five patterns of durian shells and seeds were provided as digestion substrates (durian seeds (T1), small pieces of durian shells (T2), large pieces of durian shells (T3), seeds+ small pieces of durian shells (T4) and seeds+ large pieces of durian shells (T5)). The experiment was conducted for 6 months. Results showed that all patterns of durian shells and seeds produced biogas. The amount of biogas and methane concentration in biogas resulting from each treatment was not significantly different. It was concluded that durian shells and seeds are a potential resource for biogas production.

Keywords: Durian, Biogas, Shell, Seed

Introduction

Presently, renewable energy is an interesting and important topic in many countries. Sunlight, water, wind and also biomass are used as energy resources. Biomass is most commonly used to generate energy. Therefore, many scientists have identified biogas generating substrates from plant residues (Singhal and Rai, 2003; Seppala *et al*., 2009; Tock *et al*., 2010; Nieves *et al*., 2011).

Durian is well-known as the king of fruit that provides a substantial amount of income in Thailand (450 million USD in 2015). The largest durian plantation is located in east Thailand, Chantaburi province which produced 234,514 tons of durian in 2015 (Official of agricultural economics, 2016). The advantage of this fruit is that it is used to make various food products, such as

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chips, dry fruit, or paste. However, the great amount of residue after durian is processed, such as shell and seed, become a pollution problem.

Therefore, the objective of this research was to determine the potential of using durian residue as a renewable energy resource for biogas production. Thus, simultaneously solve the pollution problem of excessive durian residue.

Objective:

1. To study biogas production from durian residue and cow dung in an anaerobic system.

Materials and methods

A floating drum digester was set up as illustrated in fig.1. The experiment consisted of 5 treatments with 3 replications, therefore, 15 floating drum digesters were created. Two of 200 L blue plastic drums were used for an anaerobic digester and water container. The anaerobic digester drum was punctured twice to create 2 holes. One hole was a feed stock inlet and the other hole was the gas outlet channel. A stirrer was added in the feed stock inlet to stir the slurry in the digester drum.

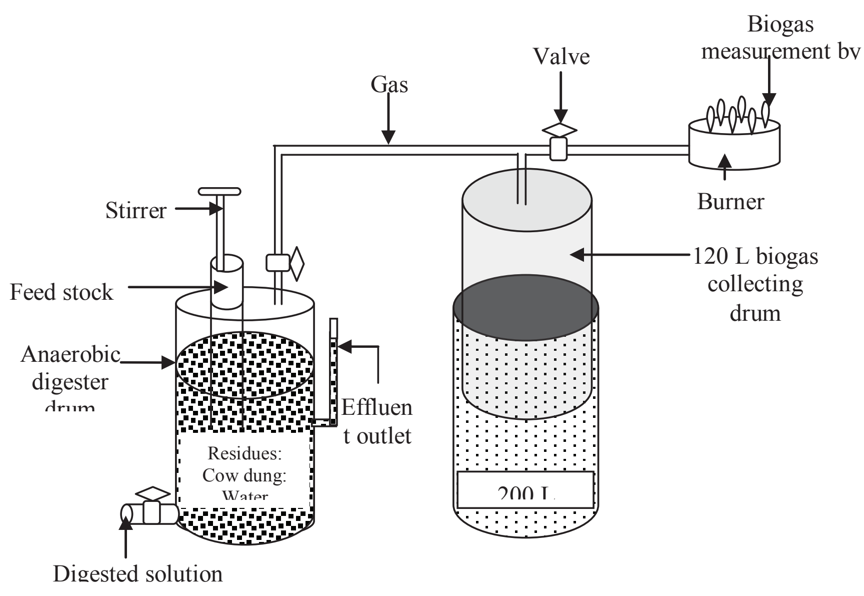

Fig.1. Diagram of a floating drum digester

At the beginning, 5 patterns of durian residue durian seed (T1), small pieces of durian shells approximately 3x5 cm^2 (T2), large pieces of durian shells approximately 5x15 cm^2 (T3), seed+ small pieces of durian shells (T4) and seed+ large pieces of durian shells (T5) were mixed with cow dung and water at a ratio of 2:1:3 by volume in an anaerobic digester drum. The pH, EC and temperature of solution in the digester drum were determined the first day of the experiment and every month thereafter. Biogas production and inflammable time were recorded daily. The concentrations of nitrogen (N), phosphorus (P) and potassium (K) of solution in the anaerobic digester drum were determined at the beginning of the experiment and three, and six months later. The biogas was sampled and methane concentration measured the 2^{nd} month after the experiment was initiated. Statistical comparisons were performed by analysis of variance (ANOVA) followed by Duncan's multiple range test (DMRT).

Results

Biogas production, inflammable time and methane concentration

The experimental results showed that all types of durian residues produced biogas after fermenting with cow dung for 6 months. The highest amount of biogas production by all treatments was in 1^{st} and 2^{nd} month after starting the experiment. Then, the production volume resulting from all treatments gradually declined. However, there was no significant difference between treatments throughout the experiment (Table 1).

Table 1. Biogas production from durian residues and cow dung.

Treatment	Biogas Production (m^3/month)						
	1^{st} month	2^{nd} month	3^{rd} month	4^{th} month	5^{th} month	6^{th} month	Total
Durian seeds (T1)	0.61	0.76	0.40	0.23	0.07	0.02	2.10
Small pieces of durian shells (T2)	0.48	0.52	0.25	0.15	0.12	0.05	1.58
Large pieces of durian shells (T3)	0.55	0.43	0.26	0.21	0.08	0.03	1.56
Seeds+ small pieces of durian shells (T4)	0.67	0.56	0.24	0.13	0.12	0.05	1.77
Seeds+ large pieces of durian shells (T5)	0.58	0.76	0.31	0.14	0.06	0.03	1.89
F-test	ns	ns	ns	ns	ns	ns	ns

ns = not significant at $P \leq 0.05$.

All treatments resulted in a long inflammable time the 1^{st} and 2^{nd} month after the experiment was initiated. Then, the inflammable time resulting from all treatments gradually declined until the end of the experiment. The longest inflammable time was 630.51 minutes resulting from the durian seed treatment (T1), however, it was not significantly different compared with the other treatments. The decline in inflammable time was consistent with the decline in biogas production (Table 2).

Table 2. Inflammable time by burning biogas

Treatment	Inflammable time (minute/month)						
	1st month	2nd month	3rd month	4th month	5th month	6th month	Total
Durian seeds (T1)	224.73	214.94	109.07	59.54	14.31	7.93	630.51
Small pieces of durian shells (T2)	182.61	137.37	69.71	21.97	23.28	20.65	455.59
Large pieces of durian shells (T3)	161.73	128.84	64.71	45.90	10.38	7.92	419.48
Seeds+ small pieces of durian shells (T4)	197.08	138.67	76.18	32.06	25.77	14.55	484.30
Seeds+ large pieces of durian shells (T5)	178.03	203.91	82.38	36.05	18.32	11.75	530.45
F-test	ns	ns	ns	ns	ns	ns	ns

ns = not significant at P≤0.05.

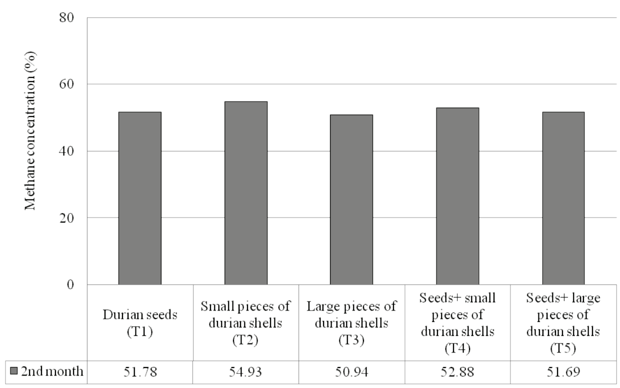

Fig. 2. Effects of various treatments on methane concentration in biogas produced.

The methane concentration resulting from durian seeds (T1), small pieces of durian shells (T2), large pieces of durian shells (T3), seeds+ small pieces of durian shells (T4) and seeds+ large pieces of durian shells (T5) treatments was

51.78, 54.93, 50.94, 52.88 and 51.69 %, respectively and were not significantly different(Fig. 2).

Monthly pH, EC and temperature of solution in the anaerobic digester drum.

Results revealed that the pH of solution at the start day was lowest in comparison with the other measurement period in all treatments. The solution pH of each treatment differed at the start day and at month 4, while, pH did not differ the 1st, 2nd, 3rd, 5th and 6th month. The average pH of all treatments was 6.99 to 7.17 and there was no significant difference between treatments (Table 3).

In case of EC, the tendency was similar to the results of solution pH. Namely, the difference of solution EC was expressed only in month 4 while the other experimental period did not show a significant difference. The solution EC increased from the start day to one month later, thereafter, the change of solution EC was minimal (Table 4).

Significant difference of solution temperature was found in the start day, 1st, 3rd, 4th and 5th month. However, the difference of highest and lowest temperature of each measurement did not exceed 3Cº. The average temperature throughout the experiment ranged from 29.80 to 30.40 Cº (Table 5).

Table 3. Monthly digested solution pH in an anaerobic system

Treatment	pH							
	Start day	1st month	2nd month	3rd month	4th month	5th month	6th month	Average
Durian seeds (T1)	6.72a	6.96	7.24	7.65	7.41 c	7.51	7.00	7.17
Small pieces of durian shells (T2)	5.44c	7.04	7.19	7.73	7.40 c	7.12	7.13	6.99
Large pieces of durian shells (T3)	6.44a	7.08	7.05	7.37	7.60 bc	6.89	7.02	7.06
Seeds+ small pieces of durian shells (T4)	5.68bc	7.18	7.20	7.35	8.02 a	7.27	7.10	7.11
Seeds+ large pieces of durian shells (T5)	6.27ab	6.95	7.23	7.32	7.77 ab	6.96	6.99	7.07
F-test	*	ns	ns	ns	*	ns	ns	ns

Means with different letters in each column are significantly different ($P \leq 0.05$) according to DMRT. *significant at $P \leq 0.05$; ns = not significant at $P \leq 0.05$.

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Table 4. Monthly digested solution EC in an anaerobic system.

Treatment	EC (ds/m)							
	Started day	1st month	2nd month	3rd month	4th month	5th month	6th month	Average
Durian seeds (T1)	1.79	5.92	5.62	6.46	6.94 a	5.29	5.58	5.38
Small pieces of durian shells (T2)	1.42	4.92	4.95	6.03	6.62 a	5.12	4.60	4.81
Large pieces of durian shells (T3)	1.88	4.85	4.68	5.84	3.80 c	4.55	4.33	4.28
Seeds+ small pieces of durian shells (T4)	1.85	5.73	5.41	5.48	5.06 b	5.84	5.81	5.03
Seeds+ large pieces of durian shells (T5)	2.54	5.76	5.91	4.72	4.61 bc	5.55	5.03	4.87
F-test	ns	ns	ns	ns	*	ns	ns	ns

Means with different letters in each column are significantly different (P≤0.05) according to DMRT.
*significant at P≤0.05; ns = not significant at P≤0.05.

Table 5. Monthly digested solution temperature in an anaerobic system

Treatment	Temperature (ºC)							
	Start day	1st month	2nd month	3rd month	4th month	5th month	6th month	Average
Durian seeds (T1)	29.20 c	29.53 a	31.67	33.77 ab	33.13 b	27.80 b	27.63	30.39 ab
Small pieces of durian shells (T2)	29.27 bc	29.23 ab	31.63	34.60 a	34.43 a	28.17 ab	27.87	30.75 a
Large pieces of durian shells (T3)	29.33 bc	29.03 bc	31.37	33.67 ab	31.73 c	28.50 a	27.67	30.18 bc
Seeds+ small pieces of durian shells (T4)	29.37 b	28.67 c	31.40	32.90 b	33.77 b	28.60 a	28.10	30.40 ab
Seeds+ large pieces of durian shells (T5)	29.53 a	27.80 d	31.10	31.90 c	32.10 c	28.80 a	27.80	29.86 c
F-test	*	*	ns	*	*	*	ns	*

Means with different letters in each column are significantly different (P≤0.05) according to DMRT.
*significant at P≤0.05; ns = not significant at P≤0.05.

Nitrogen (N), phosphorus (P) and potassium (K) concentrations in solution

The lowest concentration of N, P and K was in the start day and remarkably increased one month later. For N, the average concentrations of all treatments in 2nd month seem to be higher than that in 3rd month. P concentration increased from the start day and continued until 6 month later.

However, there was no significant difference of P concentration during the experimental duration. The treatments containing durian seeds (T1, T3 and T5) resulted in the high concentration of K in month 6 (Table 6).

Table 6. Nitrogen (N), phosphorus (P) and potassium (K) concentrations in a digested solution at start day, 3rd, and 4th month after the experiment.

Treatment	N concentration (ppm)			P concentration (ppm)			K concentration (ppm)		
	Start day	3rd month	6th month	Start day	3rd month	6th month	Start day	3rd month	6th month
Durian seeds (T1)	70.00 bc	1405.85 a	912.37 a	46.67	59.68	136.37	456.67 ab	1216.92	1305.40 a
Small pieces of durian shells (T2)	70.00 bc	753.25 c	879.67 a	50.00	34.03	130.95	343.33 b	718.78	800.48 b
Large pieces of durian shells (T3)	50.00 c	619.94 c	762.07 b	46.67	106.82	130.98	393.33 b	968.20	723.29 b
Seeds+ small pieces of durian shells (T4)	73.33 b	1036.69 b	763.66 b	60.00	110.99	144.12	463.33 ab	1066.15	1108.45 a
Seeds+ large pieces of durian shells (T5)	113.33 a	985.70 b	694.70 c	76.67	106.69	138.27	600.00 a	1104.33	1095.00 a
Average	75.33	960.29	802.49	56.00	83.64	136.14	451.33	1014.88	1006.52
F-test	*	*	*	ns	ns	ns	*	ns	*

Means with different letters in each column are significantly different (P≤0.05) according to DMRT.
*significant at P≤0.05; ns = not significant at P≤0.05.

Discussions

Results showed that durian seeds and shells produced biogas after fermented with cow dung for 6 months in an anaerobic digester system. This experiment demonstrated a potential of durian shells and seeds as biogas resource, since results were to similar other plant residues that produced biogas (Satyanarayan *et al*., 2008; Zahid *et al*., 2014; Tumutegyereize *et al*., 2011; Zhang *et al*., 2013).

The production process for maximum biogas depended on various factors such as pH, temperature, and organic loading rate. pH is an important parameter affecting the growth of microbes during anaerobic fermentation. pH of the digester should be kept within a desired range of 6.8-7.2 (Yadvika *et al*., 2004). In this experiment, the average solution pH resulted in all treatments was 6.99 to 7.17 and there was no significant difference between treatments. The monthly solution pH of all treatments was more than 5.0. Moreover, the change of solution temperature between treatments each month did not exceed 3ºC. These results may be the cause of no difference in biogas production, methane concentration and inflammable time between treatments.

After fermentation starting, the concentrations of N, P and K increased and the concentrations of N, P and K was still high at the end of experiment. These results indicated that the nutrients in durian shells and seeds were digested and released to the slurry. Satyanarayan *et al*. (2010) also reported that soya sludge addition to cattle dung digesters improves manurial value in term of nitrogen and phosphate content and showed a marked improvement in sludge quality. Therefore, many researchers continued to study the effect of biogas effluent on plant growth (Kumpukul and Chantsavang, 1995; Panichsakpatana, 1995; Ausungnoen *et al*., 2014). The effluent of durian biogas should be studied for its utilization.

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