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Biogas Production from Peels and Seeds of Longan (*Dimocarpus longan* Lour.) in Anaerobic Ferment System

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Large amount of peels and seeds after longan processing are a serious waste problem at Chanthaburi Province in east Thailand. Therefore, the objective of this study was to investigate the potential of longan peels and seeds as resources for biogas production in an anaerobic system. Pig manure was used as the microorganism releaser and longan peels and seeds were provided as digestion substrates. Four treatments were applied; pig manure (T1), longan seeds fermented with pig manure (T2), longan peels fermented with pig manure (T3), peels and seeds fermented with pig manure (T4). The experiment was conducted from April 2016 to August 2016, for a total of 5 months at the Faculty of Agricultural Technology, Rambhai Barni Rajabhat University. The height of the biogas collecting tank, volume of the biogas collecting tank and inflammable time was recorded daily. The pH and temperature of the fermented solution were recorded monthly. At the end of experiment, nitrogen, phosphorus, and potassium concentrations in the fermented solution were analyzed. Results showed that pH and temperature of the digested solution were not significantly different among treatments. The high amount of biogas production and inflammable time by all treatments was the 1st and 2nd month after starting the experiment and there were no significant difference between treatments. There was significant difference in the results of biogas production and inflammable time the 3rd, 4th and 5th months after starting the experiment. The biogas production and inflammable time of pig manure treatment (T1) and longan seeds fermented with pig manure treatment (T2) were very low the 3rd, 4th and 5th months after starting the experiment. While, the highest biogas production and inflammable time was produced by longan peels fermented with pig manure treatment (T3) the 3rdand 4th months and peels and seeds fermented with pig manure treatment (T4) showed the highest biogas production and inflammable time the 5th month after starting the experiment. Nitrogen, phosphorus and potassium concentrations of digested solution were not significantly different among treatments. However, the treatments containing longan seeds trended to result in higher concentrations of nitrogen and phosphorus than the remaining treatments. It can be suggested that longan peels and seeds could be a potential resource for producing biogas in an anaerobic fermenting system.

Keywords: Longan, Biogas, Peel, Seed

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Introduction

Longan (*Dimocarpus longan* Lour.) is a major economic fruit of Thailand due to export value more than several billions bahts. More than 80 percent of growing area is in the north of Thailand. However, the highest amount of production in 2015 was at Chantaburi province in east Thailand (Official of agricultural economics, 2016). The largest export market is China where the longan is exported mostly as fresh fruit. In addition, longan can be processed in various products such as dried longan, canned, and frozen longan to increase the value for domestic sales and to export abroad. However, peels and seeds after longan processing have created a waste problem. The utilization of peels and seeds of longan in biogas production appears as a potential to solve this waste problem.

Biogas is a type of biofuel and is produced by anaerobic fermentation of organic wastes, manures and agricultural wastes and energy crops. 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). Therefore, the objective of this research was to determine the potential of using longan residue as a renewable energy resource for biogas production. Thus, simultaneously solving the pollution problem of excessive longan residue.

Objective: To study biogas production from peels and seeds of longan (*Dimocarpus longan* Lour.) in an anaerobic fermentation system.

Materials and methods

A floating drum digester was set up as illustrated in Fig.1. The experiment consisted of 4 treatments with 3 replications, therefore, 12 floating drum digesters were created. Two 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. At the beginning, no longan residues (control, T1), longan peels (T2), longan seeds (T3) and longan peels + seeds (T4) were mixed with pig dung and water at a ratio of 2:1:3 by volume in an anaerobic digester drum. The pH 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 for 5 months. The concentrations of nitrogen (N), phosphorus (P) and potassium (K) of solution in the anaerobic digester drum were determined at the end of the experiment. Statistical comparisons were performed by analysis of variance (ANOVA) followed by Duncan's multiple range test (DMRT).

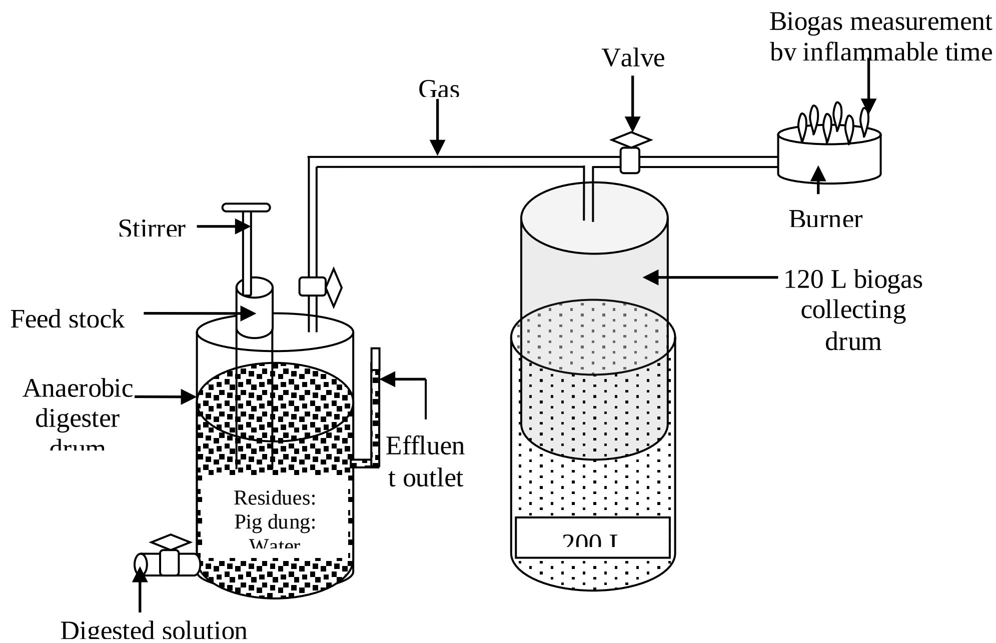

Figure1. Diagram of a floating drum digester

Results

Average pH and temperature of solution in the anaerobic digester drum

There was no significant difference in pH of solution in the anaerobic digester drum among treatments throughout the experimental period. The average pH of solution in the anaerobic digester drum of only pig manure (control, T1), longan seeds fermented with pig manure (T2), longan peels fermented with pig manure (T3) and longan peels and seeds fermented with pig manure (T4) was 5.56, 5.71, 5.55 and 5.45, respectively and they were not significantly different (Table 1). Similarly, the average temperature of solution in the anaerobic digester drum of pig manure (control, T1), longan seeds fermented with pig manure (T2), longan peels fermented with pig manure (T3) and longan peels and seeds fermented with pig manure (T4) was 31.83, 31.77, 31.9 and 32.17 ℃, respectively and the average temperature between treatments did not differ significantly after 5 months (Fig. 2).

Table 1. Monthly digested solution pH in the anaerobic digester drum

Treatment	pH						
	Start day	1st month	2nd month	3rd month	4th month	5th month	Average
only pig manure (T1)	6.1	5.42	5.38	5.55	5.45	5.45	5.56
Longan seeds fermented with pig manure (T2)	5.62	5.39	5.33	5.54	5.33	5.41	5.71
Longan peels fermented with pig manure (T3)	5.89	5.5	5.43	5.48	5.39	5.6	5.55
Longan peels and seeds fermented with pig manure (T4)	5.9	5.47	5.4	5.36	5.32	5.57	5.45
F-test	ns	ns	ns	ns	ns	ns	ns

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

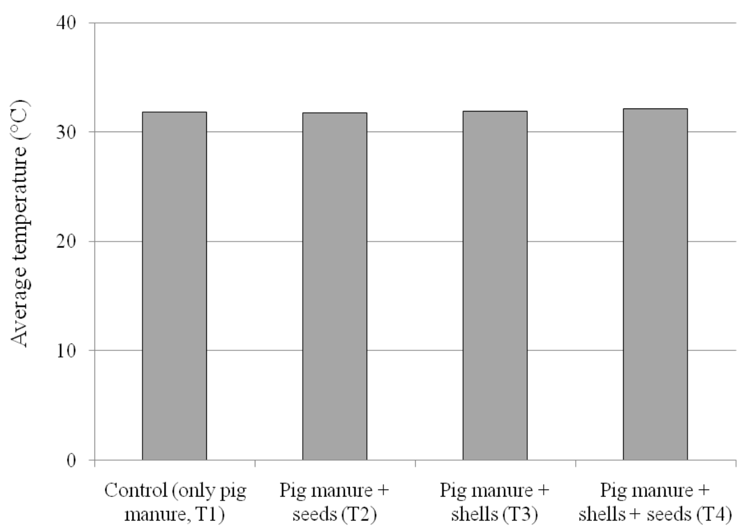

Figure 2. Average temperature of solution in the anaerobic digester drum for 5 months duration

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

At the end of experiment, the results of nitrogen concentration in solution of only pig manure (control, T1), longan peels (T2), longan seeds (T3) and longan peels + seeds (T4) was 0.36, 0.56, 0.42 and 0.49%, respectively and they were not significantly different (Figure 3A). Similarly, there was no significant difference in the phosphorus and potassium concentration among treatments (Fig. 3B and 3C). However, the treatments consisting of longan seeds trend to be higher nitrogen, phosphorus and potassium concentrations than the others.

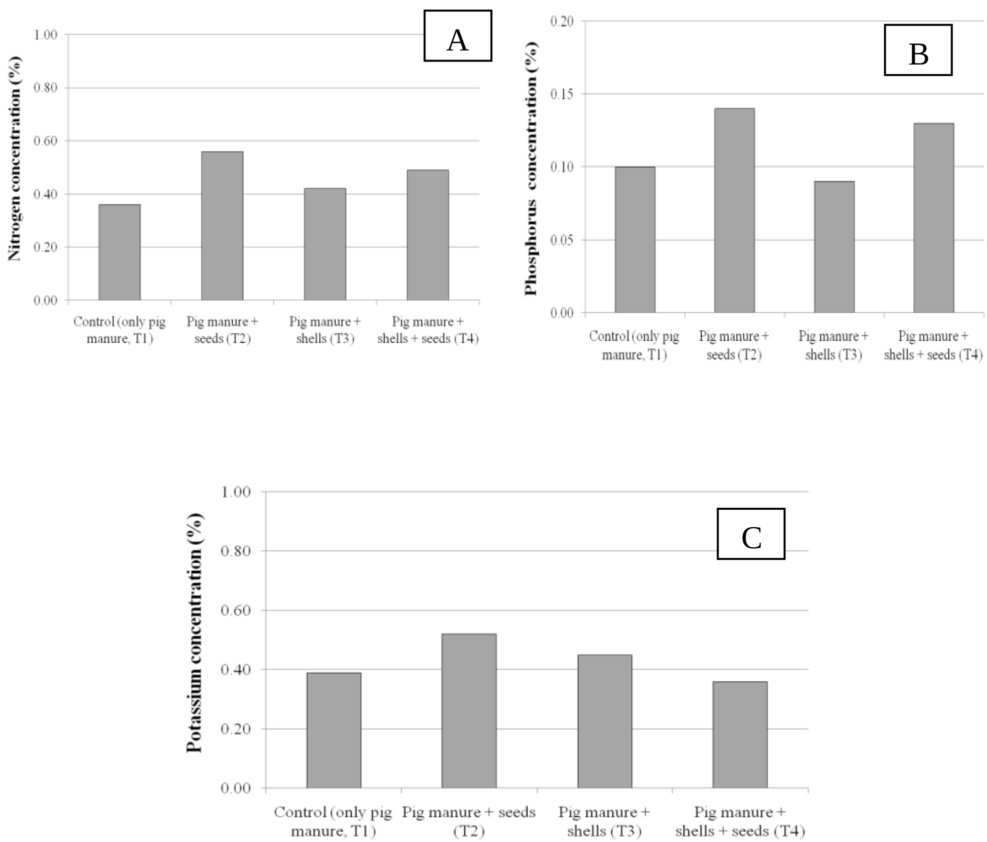

Figure 3. Nitrogen (A), phosphorus (B) and potassium (C) concentrations in solution at the end of experiment

Biogas production and inflammable time

The highest amount of biogas production by all treatments was in the 1st and 2nd month after starting the experiment and there were no significant difference among treatments. There was significant difference in the results of biogas production the 3rd, 4th and 5th months after starting the experiment. The biogas production of pig manure treatment (T1) and longan seeds fermented with pig manure treatment (T2) were very low the 3rd, 4th and 5th months after starting the experiment. The highest biogas production resulted from the longan peels fermented with pig manure treatment (T3) the 3rd and 4th months(0.009 and 0.035 m^3, respectively).The highest biogas production the 5th month after starting the experiment resulted from longan peels and seeds fermented with pig manure treatment (T4) (Table 2).

Table 2. Biogas production from longan residues and pig manure

Treatment	Biogas Production (m^3)				
	1st month	2nd month	3rd month	4th month	5th month
only pig manure (T1)	0.091	0.087	0.000^b	0.009^{bc}	0.000^b
Longan seeds fermented with pig manure (T2)	0.068	0.081	0.002^b	0.003^c	0.000^b
Longan peels fermented with pig manure (T3)	0.079	0.07	0.009^a	0.035^a	0.014^b
Longan peels and seeds fermented with pig manure (T4)	0.091	0.047	0.000^b	0.032^{ab}	0.035^a
F-test	ns	ns	**	**	**

Means with different letters in each column are significantly different ($P \leq 0.05$) according to DMRT. **significant at $P \leq 0.01$; ns = not significant at $P \leq 0.05$.

All treatments resulted in a long inflammable time the 1st and 2nd month after the experiment was initiated; however, there was no significant difference in the inflammable time at 1st and 2nd month. Results of inflammable time showed a significant difference in 3rd, 4th and 5th months after starting the experiment. Namely, inflammable time of only pig manure treatment (T1) and longan seeds fermented with pig manure treatment (T2) unabled burning with a flammable time of zero while the longan peels fermented with pig manure treatment (T3) and longan peels and seeds fermented with pig manure treatment (T4) produced a long inflammable timethe3rd, 4th and 5th months after starting the experiment (Table 3).

Table 3. Inflammable time by burning biogas

Treatment	Inflammable time (minute)				
	1st month	2nd month	3rd month	4th month	5th month
only pig manure (T1)	22.47	21.96	0.00[b]	1.67[b]	0.00[b]
Longan seeds fermented with pig manure (T2)	16.38	18.96	0.72[b]	1.05[b]	0.00[b]
Longan peels fermented with pig manure (T3)	19.58	17.03	1.80[a]	9.59[a]	2.84[b]
Longan peels and seeds fermented with pig manure (T4)	22.09	11.56	0.00[b]	4.04a[b]	8.81[a]
F-test	ns	ns	**	**	**

Means with different letters in each column are significantly different (P≤0.05) according to DMRT. **significant at P≤0.01; ns = not significant at P≤0.05.

Discussion

The amount of biogas production depends on various factors such as the environmental factors, microorganism releaser, substrate or fermentation system. Pig manure is an efficient microorganism releaser, therefore, it was used in many biogas experiments (Qi *et al*., 2005; Qiao *et al*., 2011; Strik *et al*., 2006). In this experiment, the control (only pig manure) and other treatments resulted in high biogas production and a long inflammable time the 1st and 2nd month after the experiment was initiated. However, there were no significant differences. This indicated that the biogas production and inflammable time the1st and 2nd month was produced from pig manure. The control (only pig manure) did not produce or produced only a small amount of biogas and a short inflammable time in 3rd, 4th and 5th months after starting the experiment. Longan peels fermented with pig manure treatment (T3) and longan peels and seeds fermented with pig manure treatment (T4) produces a high amount of biogas and a longer inflammable time. This shows that biogas production and inflammable time the 3rd, 4th and 5th months after starting the experiment were produced from longan peels and seeds. This experiment demonstrated a potential for longan peels and seeds as biogas resources, since results were similar to other plant residues that produced biogas (Satyanarayan *et al*., 2008; Zahid *et al*., 2014; Tumutegyereize *et al*., 2011; Zhang *et al*., 2013).

Results of concentrations of N, P and Kin solution at the end of experiment showed that the treatments consisting of longan seeds tended to produce higher nitrogen, phosphorus and potassium concentrations than the remaining treatments. This may due to the high nutrient concentration in longan seed that was digested and released into the slurry. Satyanarayan *et al*. (2010) also reported that addition of soya sludge to cattle dung digesters improved mineral 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 biogas effluent of longan residues should be further investigated for its utilization in biogas production.

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