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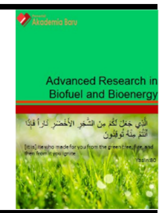

Study of Biorefinery Capsule Husk from *Jatropha Curcas* L. Waste Crude Jatropha Oil as Source for Biogas

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ABSTRACT

Crude Jatropha Oil (CJO) is renewable energy which is environmentally friendly. But, CJO processing produce waste such as seed cake and capsule husk. The capsule husk by the volume of 76% wet weight is not managed properly. The accumulation of capsule husk in the field will decompose and produce methane gas which will give impact to global warming. The disposal to the river will contaminate river water by increasing of BOD and COD. Directly usage of husk as organic fertilizer is not efficient because C/N ratio is still high. Husk will cause a problem if it is used as biogas raw material because of low density. Husk will float in slurry solution so that it will clog digester inlet, make slow degradation process and reduce biogas productivity. Series of research has been and will be conducted to use husk as biogas raw material in bio-refinery concept with the objective to increase efficiency of Jatropha curcas L. cultivation. The study is conducted in Research Farm of PT. Bumimas Ekapersada, Bekasi, West Java from April – July 2011. Husk is managed in two stage digester, hydrolysis and methanogenesis reactor. In methanogenesis reactor, it is filled by husk in the form of liquid. Two study of Jatropha curcas L. cultivar Jatromas will be reported in this paper. First, the study of husk hydrolysis compared to cow dung. And the second, the study on four treatment (1) husk submersion in river water, (2) husk submersion in biogas slurry which has been reused and recycled, and (3) husk submersion in mix between 50% river water and 50% recycled biogas slurry. The observed parameters were pH, temperature, acetic acid content, volatile solid and nutrient level in liquid and solid material in hydrolysis reactor. The conclusion of this research is husk submersion in mix of 50% water and 50% recycled biogas slurry will give optimum methanogenesis reaction in biogas process.

1. Introduction

Biofuel is believed as renewable energy, but the production process will make biomass waste. The processing of biofuel - Crude Jatropha Oil (CJO) produce waste such as seed cake (*Jatropha curcas* press cake, *Jatropha curcas* defatted waste, hulls) approximately 75% from dry seed weight

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and 76% wet weight of capsule husk (jatropha seed husk, jatropha fruit coat, fruit husk) or 8% in dry condition [1]. Those wastes should be managed properly so that biofuel can be environmentally fuel from all aspect.

Bio-refinery is reuse and / or recycle of waste from a process into become raw material of another process. The objective of bio-refinery is to increase of efficiency to add farming revenue. In the concept of bio-refinery, the waste of Crude Jatropha Oil (CJO) industry become one of potential of biogas raw material. The research in Self Sufficient Energy Village, Way Isem, North Lampung which was initiated by Eka Tjipta Foundation (today was managed by D1 Oils) support this opinion, that there is increasing in jatropha farmer revenue by using seed cake as biogas raw material [2].

Some scientists said that biogas productivity from seed cake is higher than manure - cow dung/cattle dung because it contains more nutrients [3-7]. But seed cake has higher economic value as animal feed compared to usage as biogas raw material, organic fertilizer and bio-briquette. This consideration is coming out because seed cake contains nutrients higher than soybean meal [8]. Even, the usage of seed cake as animal feed will face a problem because of phorbol ester as anti nutrition material.

Dhanya *et al.* [9] said that husk produce 162.521/kg DM biogas. Meanwhile, Salafudin *et al.* [10] said that husk has ability to produce 438 mL biogas/g VS. This production capability is bigger than seed cake which can only produce 147 mL biogas/g VS. But, there is a problem, dry husk density is relatively low. In the digester slurry, dry husk will float and clog digester inlet. And because of that, digestion process will not be perfect with the impact biogas productivity will be low.

To solve the density problem, it has been assessed husk management in two step digester, separating hydrolysis and methanogenesis in two different reactors. The main objective is to increase productivity because some scientist said that two stages are more efficient than single stage [11-17].

As first step of the study of two stages digester with jatropha husk as raw material, this paper will present report on research about treatment optimization in hydrolysis reactor as bio-refinery effort.

2. Methodology

The research is conducted from April until July 2011, at Research Farm PT. Bumimas Ekapersada, Bekasi, West Java. It has been conducted two studies on hydrolysis in some treatments which repeated three times arranged in Randomized Complete Design (RCD).The first study is submersion of husk in river water + EM4 as decomposer compared to cow dung. Second study is husk submersion in four solution, (1) husk submersion in river water, (2) submersion in reuse and recycle biogas slurry, and (3) submersion in 50% river water + 50% recycle biogas slurry. The submersion is conducted in four weeks.

Eight kilograms dry husk cultivar JatroMas was submersed for one night by ratio 1:10 in hydrolysis reactor in the form of plastic drum – HDPE (High Density Poly Ethylene). The total volume of the drum is approximately 160 liters and in 25% of its height from the bottom was assembled with water faucet. The solution was taken out from the drum by water faucet and streamed into methanogenesis reactor. The observation parameter in hydrolysis reactor is divided into two observation time, daily and weekly. The daily observations were pH and temperature and weekly observations were acetic acid content, volatile solid (VS), nutrient ingredient in solution and solid material in hydrolysis reactor, fat, protein and carbohydrate value.

3. Result

3.1. Material Composition in Capsule Husk

Table 1 shows nutrient composition data, C/N ratio, density, VS, fat, carbohydrate and protein value in capsule husk compared to seed cake and cow dung.

Table 1
Nutrient Composition, C/N ratio, Density, Fat, Protein, Carbohydrate in Seed Cake, Husk and Cow dung

Sample	Moisture (%)	Ca (%)	K (%)	Mg (%)	P (%)	B (ppm)	Cu (ppm)	Fe (ppm)	Mn (ppm)
Jatropha Seed Cake	6.3	0.14	0.08	0.21	0.258	6.58	4.99	140	31.3
Jatropha Capsule Husk	3.49	0.03	1.05	0.03	0.012	3.99	0.27	23.5	28.9
Cow Dung	1.65	1.07	1.35	0.41	0.201	8.76	11.2	29102	983

Na (ppm)	Zn (ppm)	Cl (%)	C (%)	N (%)	C/N	VS (%)	Density	Fat (%)	Carbohydrate (%)	Protein (%)
39.8	18.1	0.47	51	3.06	17	84.5	1.20	1.07	52.44	20.74
199	1.88	0.52	48.9	1.01	49	78.6	0.59	0.83	65.64	5.61
330	199	0.24	19	0.9	21	32.8	1.01	0.4	41.15	9.55

Table 1 shows husk density is relatively low. C/N ratio of husk is relatively high so that it is not feasible to be used as organic fertilizer. Table 1 supports previous research [3-7] that seed cake and husk has more potency to be biogas raw material compared to cow dung which showed by higher VS, fat, carbohydrate and protein value. Table 1 also support conclusion that husk is having positive influence compared to seed cake for biogas productivity [10] because N and fat value is relatively low.

Biogas is produced from four biochemical reaction stages. First three stages of the reaction can be grouped and known as acid fermentation and the second one is known as methonegenesis reaction [18]. pH range in those two reaction also different, as stated by some scientist [14, 18-21], pH range for acid fermentation is 4.0 – 6.5 while pH range for methanogenesis is 6.2 – 8.5.

3.2. First Study

By reference of previous research that optimum pH methanogenesisi solution is 6.2 – 8.5, it has been conducted pH observation in hydrolysis reactor by husk as raw material. In this research, husk was submersed in EM-4 solution (10 cc / l water) compared to submersion in river water (pH > 8) by ratio 1:10 and manure in river water solution by ratio 1:2. The result of this research is showed in Fig. 1.

Figure 1 shows that pH curve of cow dung (treatment 1a) is higher or better than pH curve of husk + water (treatment 1b) and pH on solution added by EM-4 (treatment 1c). Figure 1 also shows that EM-4 is effective to assist hydrolysis reaction better than river water. But, based on pH methanogenesis solution standard, treatment of husk submersion in the water (treatment 1b) and in water + EM4 (treatment 1c) is not feasible to apply because pH has decreased since fifth days.

Andrianus *et al.* [18] said that complex organic solid material of biogas raw material is having disintegration process become carbohydrate, protein and fat. And after that, it will become acetic acid as biogas basic ingredient. Paul and Robert [22] said that methane is constructed by 73% of acetic acid. The observation of acetic acid content (g/l) in hydrolysis solution is shown in Fig. 2.

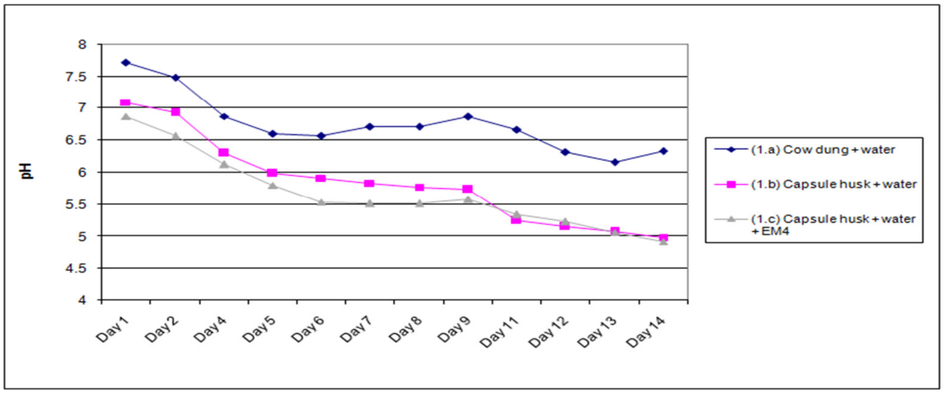

Fig. 1. Curve of pH in hydrolysis solution on husk compared to cow dung

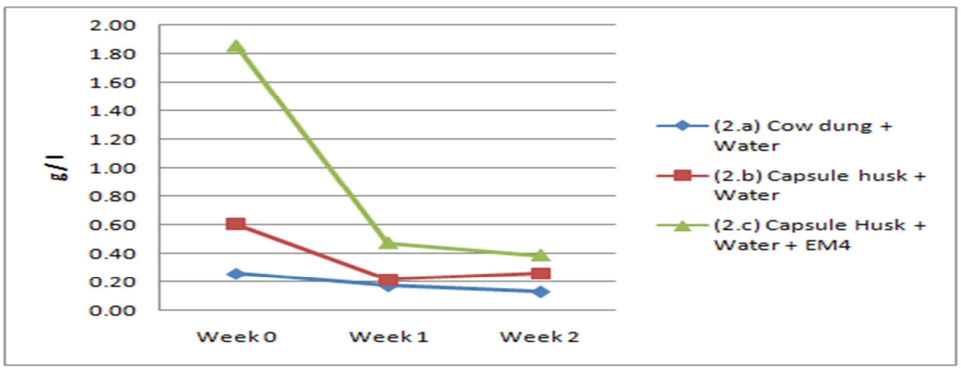

Fig. 2. Curve of acetic acid (g/l) on three material in outlet solution of hydrolysis reactor

Figure 2 shows that curve of acetic acid content in treatment cow dung + water (treatment 2a) relative more stable than other two treatments. Husk submersion in water + EM4 (treatment 2c) produce higher acetic acid in week 0 and decline sharply in week 1. This condition is also supported by decreasing pH since beginning as seen in Fig. 1. Treatment 2b produces acetic acid lower than treatment 2c. This shows effectiveness of EM4 as described in discussion of Fig. 1. Figure 2 also shows that manure / cow dung produce the lowest of acetic acid. This data support VS data in Table 1 that capsule husk is more potential to produce biogas as shown by its capability to produce acetic acid higher than manure / cow dung.

3.2. Second Study

Completing first study, the further observation on reuses / recycle biogas slurry as implementation of bio-refinery concept has been conducted. The average of pH of slurry that is being used as reuse or recycle in second study is around 6.00 – 8.00. The result of study is shown in Fig. 3.

Figure 3 shows same trend as first study that pH of husk submerse in river water (treatment 3a) was decreasing on pH since day 5. Reuse or recycle slurry was able to increase hydrolysis solution pH. The pH in 100% slurry is higher than pH on 50% slurry + 50% river water. The usage of recycling 50% slurry is more effective and efficient because:

a) On the usage of 100% recycling slurry, it will increase of pH in methanogenesis solution
b) On the usage of 50% of slurry. there will be slurry residue which can be used as liquid organic fertilizer

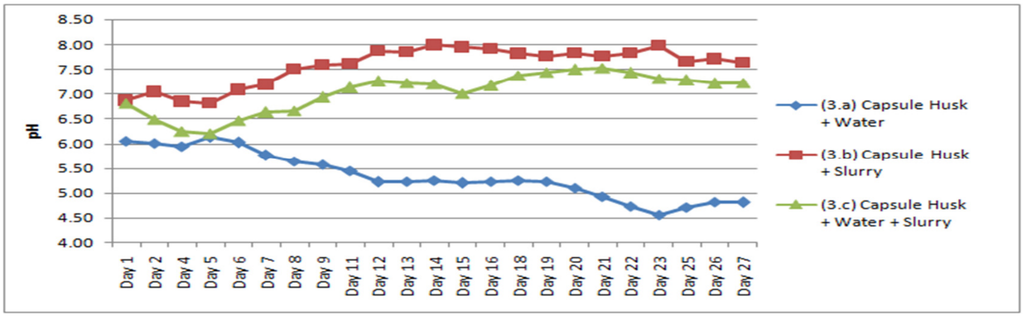

Fig. 3. pH curve of hydrolysis solution on husk material mix with water, slurry and water + slurry

The raising of methanogenesis pH as said in point (a) above with the impact of decreasing of biogas production is shown in Fig. 4.

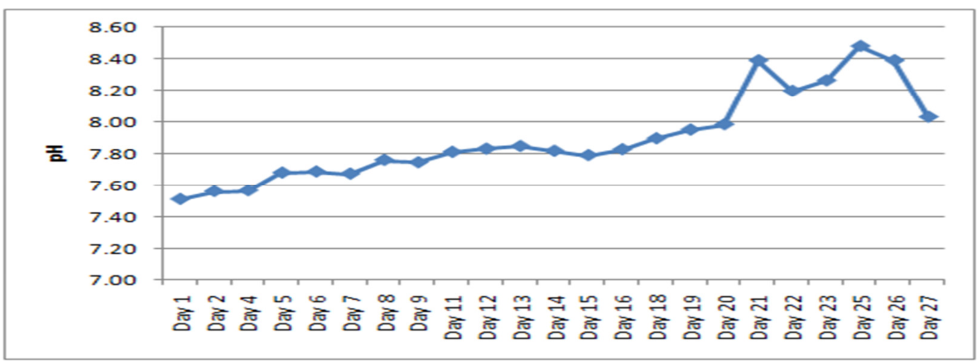

Fig. 4. pH curve in digester outlet on using of recycling slurry

Completing above data, in the Fig. 5 below shows an observation data of Volatile Solid (VS). Massoud *et al*. [23] said that VS value is approaching value from material that can be changed by microbe into become biogas.

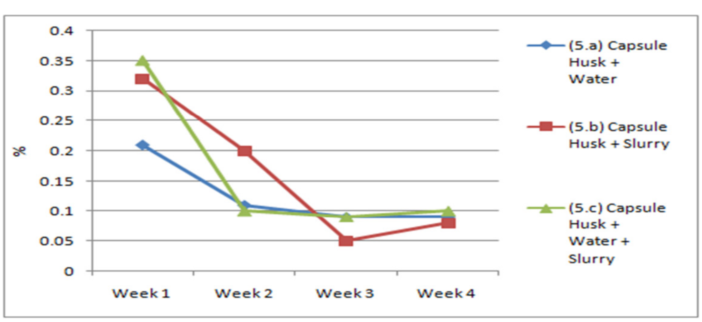

Fig. 5. Curve of Percentage of Volatile Solid on husk submersion

Figure 5 shows that husk which was submersed in water (treatment 5a) has the lowest VS even in the second week and third week has same value as submersion in 50% water + 50% slurry treatment. This data supports Picture 3 about pH in treatment 3a. Figure 5 supports result in Fig. 3 that treatment of 50% water + 50% slurry is the best treatment. It shows by submersion treatment in 100% slurry. VS value in second week is the highest among others. It means, disintegration or hydrolysis in treatment 5b is relatively lower than two other treatments. Observation on acetic acid content (gram/liter) on second study is shown in Figure 6.

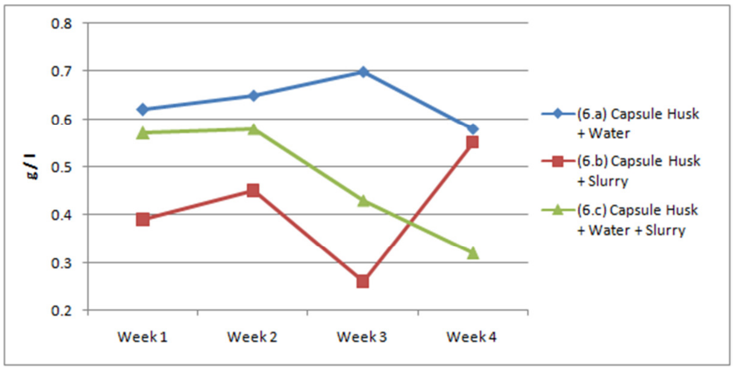

Fig. 6. Acetic acid curve on husk submersion in three treatments

Figure 6 shows that treatment 6a (capsule husk + water) produce highest acetic acid. This data supports pH observation in treatment 3a and VS observation in treatment 5a. Treatment 6b (submersion in 100% slurry) produce the lowest acetic acid content since first week. This data is equal to VS observation in treatment 5b. Treatment 6c, submersion 50% water + 50% slurry produce higher acetic acid than treatment 6b. In fourth week, treatment 6c produce the lowest acetic acid, it means disintegration process was already maximal in previous weeks.

4. Conclusion and Recommendation

From the series of the study, it can be concluded that capsule husk which submerse in 50% river water and 50% recycling slurry is the best treatment for hydrolysis reaction. It is require do furthering study on fresh capsule husk and prolonging submersion time with the objective to get manpower efficiency.

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