An Effective Way of Anaerobic Digestion of Chicken Manure with Plant Biomass

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ABSTRACT

Anaerobic digestion of animal manure is a popular disposal method. However, because of higher nitrogen content and relatively lower carbon source, chicken manure is difficult in accomplishing a successful and rapid anaerobic digestion process with earlier acidification to affect the biogas production. Straw and many other crop biomass is one of crop wastes which composed of abundant organic carbon source. In this paper, validity identification and factors affected gas production of co-digestion of chicken manure and rice straw were investigated. Groups added rice straw produced more higher gas than the control, and CH_4 contents of groups added rice straw showed normal level which means added rice straw to chicken manure is useful to the biogas production. Affected degree of factors on co-digestion of chicken manure and retted rice straw followed the sequence of retted time>retted temperature>water content, and best retting condition was 70% of water content, 40°C of retted temperature and 10 days of retted time.

Keywords: chicken manure, straw, mixing fermentation, carbon source

1 INTRODUCTION

With the growth of animal farms around the world, animal manure is becoming a pollution resource especially to nearby populations. Chicken manure is the richest animal manure in nitrogen, phosphorous and potassium (N-P-K). The higher volatile nitrogen content is worse than to the atmosphere than other manures, and many pathogenic bacteria is harmful to people's health[1~2].

Anaerobic digestion(AD) of animal manure is a popular disposal method. However, because of higher nitrogen content and relatively lower carbon source, chicken manure is difficult in accomplishing a successful and rapid anaerobic digestion process with earlier acidification to affect the biogas production[3].

Straw and many other crop biomass is one of crop wastes which composed of abundant organic carbon source[4~8]. In this paper, validity identification and factors affected gas production of co-digestion of chicken manure and rice straw were investigated.

First we studied if it is useful to anaerobic digestion of chicken manure(CM) when no-pretreated rice straw was added. After validity of co-digestion of chicken manure and rice straw was affirmed, factors of retted rice straw affected gas production of co-digestion of chicken manure and rice straw were studied and three factors, water content, retted temperature and retted time, were selected. The results showed that anaerobic digestion of chicken manure by adding crop straws to provide carbon source is an effective way to maximize biogas production.

2 VALIDITY OF PLANT BIOMASS ADDED TO AD OF CM

2.1 Materials and Methods

Rice straw was obtained from one of farm located at Nanjing City of Jiangsu Province in China. The collected materials were first chopped into small sections about 2-3 centimeters with 11% of water content.

Chicken manure was collected from one of chicken farm located at Rugao City of Jiangsu Province in China, and was characterized as 17.5% (w/w) of TS, 158,800 mg/L of COD and 7.8 of pH value.

Original chicken manure and rice straw were mixed and diluted to given water contents. A sludge obtained after anaerobic digestion of excess activated sludge was used as a seed sludge to initiate anaerobic digestion of chicken manure. The mixture digested at 35±1°C in flasks which were tightly sealed and connected to air bags. The gas volume of the gas bags were measured at different time points. The gas contents were analyzed at selected time points. There are three experiments are designed as shown in Table 1.

Experi-ments	CM (g)	Rice straw(g)	Total volume(mL)	Water content(%)
a	128	0	400	-
b	130	16	900	97%
c	130	24	900	93%

Table 1: Designed experiments of validity identification

2.2 Results and Discussions

The results were shown in Figure 1 and Table 2. We can see that experiment b and c of added rice straw showed more higher gas production (nearly 12000~13000mL) than experiment a(without added any rice straw, about 600mL) and CH_4 contents of experiment b and c showed normal level than experiment a(the control). It is clear that added rice straw to chicken manure is useful to the biogas production of anaerobic digestion and it could be an effective way to improving biogas production.

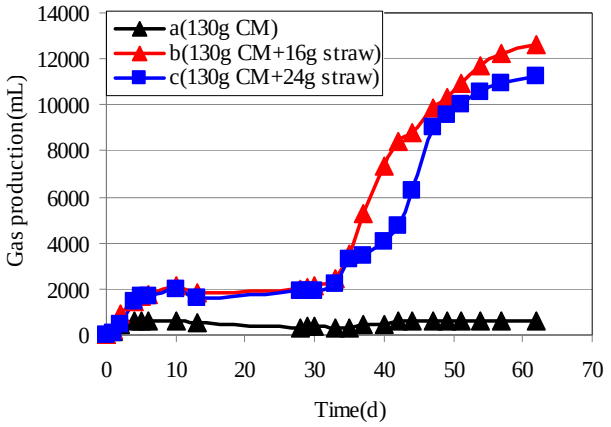

Figure 1: Gas production in each experiments of validity identification

Experi-ments	Mean gas production rate (mLgas/g.dry manure)	CH_4 content(%)
a	20.72	11
b	422.74	57-67
c	376.25	57-65

Table 2: Gas production rate and CH_4 contents in each experiments of validity identification

We also noted during the digestion process at Day 5 acidification was occurred and at Day 20 Sodium Bicarbonate was added to modify pH value and after 10 days the gas production was going on. The possibe reason of acidification could be improper added amout of straw which leads to more or less carbon source. Undoubtedly there are many other factors affected gas prodution. Next we selected three factors(water content, temperature and time) about retted rice straw to research how to affect anaerobic digestion of chicken manure with plant biomass.

3 FACTORS AFFECTED GAS PRODUCTION

3.1 Retted and anaerobic digstion process

Retted process of rice straw: 20g original rice straw was retted with diluted chicken manure(97% of water content) used as a seed to initiate anaerobic digestion of chicken manure(without seed sludge). The amount of added diluted chicken manure was decided by the water content set in the related experiments. The mixture of rice straw and digestion seed was put into 500mL jars and retted at steady temperature.

Anaerobic digestion process of chicken manure: 200 mL diluted chicken manure with 93% of water content and above retted rice straw were mixed and began to digest at 35±1°C in flasks which were tightly sealed and connected to air bags. The gas volume of the gas bags were measured at different time points. The gas contents were analyzed at selected time points.

3.2 Experimental design

Three factors, water content, retted temperature and retted time, were selected to research how to affect anaerobic digestion of chicken manure with plant biomass. According to orthogonal experiments design, three levels of each factor were set(shown in Table 3) and there were 9 experiments were conducted(shown in Table 4).

Level	Factors		
	Water content (%)	Temperature (°C)	Time (d)
1	60	20	5
2	70	30	10
3	80	40	15

Table 3: Level of three factors

Number of experiments	Factors		
	Water content (%)	Temperature (°C)	Time (d)
1	60	20	5
2	60	30	10
3	60	40	15
4	70	20	10
5	70	30	15
6	70	40	5
7	80	20	15
8	80	30	5
9	80	40	10

Table 4: Design of orthogonal experiments of retted process of rice straw

3.3 Results and Discussions

(1) pH of retted end

pH values of each expeiments were shown in Table 5. We can see that lower pH values accompied with shorter

retted time and all of pH values of 9 experiments were lower than 7.0 which could be led to acidification during sequent anaerobic digestion of chicken manure with rice straw.

Number of experiments	Time （d）	pH of retted end
1	5	6.68
2	10	6.24
3	15	6.55
4	10	6.45
5	15	6.00
6	5	6.50
7	15	5.91
8	5	6.56
9	10	6.40

Table 5: pH values of retted end in each experiments

We also observed in the experiments that color of reeted rice straw was lighter and looser with lower temperature and shorter time(experiment 1, 2 and 5); and deeper color and tighter with higher temperature and longer time at the end of retted process. In theory retted rice straw with looser cellulose construction is useful to improve decomposing rate and enhance digestion process.

(2)Biogas production and acidification

Biogas production of chicken manure with rice straw with the digestion time of 9 experiments were shown in Figure 2 to Figure 4 according to retted time of rice straw. With increasing of retted time from 5d to 10d, gas production was decreasing from nearly 4500mL to about 800mL, so retting time of rice straw before added into digesters of chicken manure should be proper. The same to water content and retted temperature during retted process of rice straw.

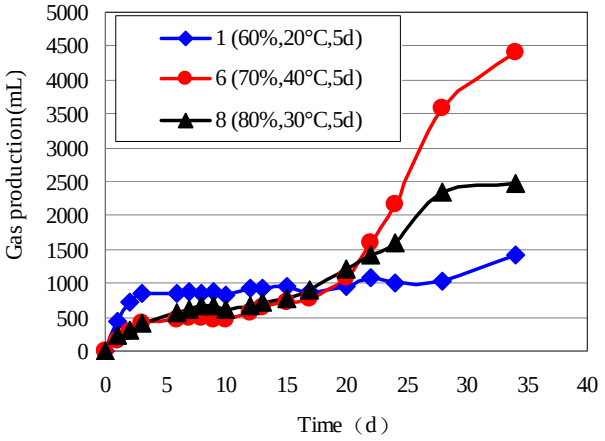

Figure 2：Biogas production of experiments 1,6,8.

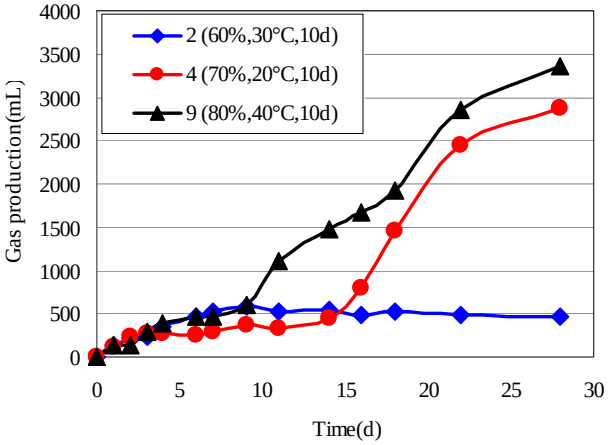

Figure 3：Biogas production of experiments 2,4,9.

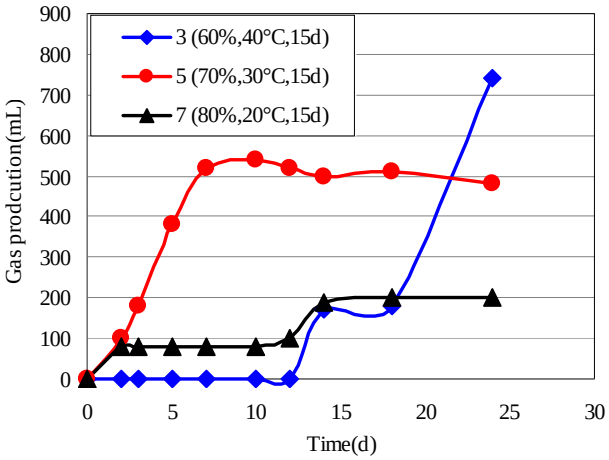

Figure 4：Biogas production of experiments 3,5,7.

Experiment 3 and 7 occurred acidification at the beginning of anaerobic digestion(shown in Figure 4) which leads to no gas production. We also noted that without any pH modification, some experiments like 3,4,6,8 and 9 could produce biogas and give higher production at day 10-20 of digestion. That means the co-digestion system of chicken manure and retted rice straw had ability of self-improvement possible because of digestion microorganisms.

(3) Factors affected biogas production

Table 6 analysed the data results of orthogonal test. Based on the criterion of gas prodution rate, affected degree of factors on co-digestion of chicken manure and retted rice straw followed the sequence of retted time>retted temperature>water content. And best retting condition was A2B3C2, that was 70% of water content, 40°C of retted temperature and 10 days of retted time. Best gas production will be gained at best retting condition.

Clean Technology 2011, www.ct-si.org, ISBN 978-1-4398-8189-7

Num-ber	Factors			Criterion
	Water content （%）	Tempe-rature （°C）	Time （d）	Gas prodution rate mL/(kg.COD.d)
1	1	1	1	0.002938
2	1	2	2	0.001353
3	1	3	3	0.001682
4	2	1	2	0.009000
5	2	2	3	0.004706
6	2	3	1	0.011304
7	3	1	3	0.000833
8	3	2	1	0.004117
9	3	3	2	0.008816
K1	0.001991	0.004257	0.00612	
K2	0.008337	0.003392	0.00639	
K3	0.004589	0.007267	0.002407	
R	0.006346	0.003875	0.003983	
Accroding to the criterion, the better results is:				
A2	**B3**	**C2**		

Table 6: Results of orthogonal test

4 CONCLUSION

Plant biomass with abundant organic carbon source could provide to digestion of animal manure with higher nitrogen content and relatively lower carbon source. Validity identification and factors affected gas production of co-digestion of chicken manure and rice straw were investigated in this paper.

The results of validity identification experiments showed that groups added rice straw produced more higher gas (nearly 12000~13000mL) than the control(about 600mL), and CH_4 contents of groups added rice straw showed normal level which means added rice straw to chicken manure is useful to the biogas production of anaerobic digestion.

Analysis of factors affected gas production for retted rice straw showed that affected degree of factors on co-digestion of chicken manure and retted rice straw followed the sequence of retted time>retted temperature>water content. And best retting condition was 70% of water content, 40°C of retted temperature and 10 days of retted time.

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