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To develop the classification method of Agricultural by-productions for biogas production

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Abstract

The objective of this study was to develop the classification method of various organic wastes. Specifically, the effects of proximate composition on the biogas production and degradation rates of agricultural by-production was investigated and a new standards for mixture of various organic wastes based on proximate composition combination was developed. Agricultural by-products (ABPs) with medium total carbohydrate, medium crude protein and low fat contents demonstrated the single step digestion process. ABPs with low total carbohydrate, high crude protein and high fat contents demonstrated the two step digestion process of Diauxic growth. The single ABP (Class No. 15) and the mixed ABPs (Class No. 12+18, 6+12+22, 9+12+18) after 10days showed the similar biogas yield pattern. We can use the classification method for the more ABPs and organic wastes from factory and municipal waste treatment plant for the high efficient biogas production.

Keywords: *Biogas, Anaerobic digestion, Agricultural by-product, proximate composition, Diauxic growth lag-phase*

1. INTRODUCTION

Energy production from renewable organic waste has become alternative technology for substituting the limited fossil fuels. Methane production by anaerobic digestion has been already commercialized in the world. The anaerobic digestion can produce the energy from the various organic wastes of agricultural by-products, kitchen food wastes and factory organic wastes. But the evaluation of such a large variety of organic wastes is needed for the optimum utilization of them. The uneven biogas production of various organic wastes mainly came from Diauxic growth lag-phase. Those lag-phase might affect retardation of biogas production *(VDL 4630, 2006).* In general, proximate composition of high carbohydrates and high fat on agriculture by-product content tends to be in diauxic growth lag-phase *[1]*.

The objective of this study was to develop the classification method of agricultural by-productions. Specifically, it was investigated the effects of proximate composition on the biogas production and degradation rates of agricultural by-production and developed a new classification method for mixture of

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various organic wastes based on proximate composition combination.

2. THEORY

2.1 Anaerobic digestion

Anaerobic digestion involves the breakdown of biodegradable material in the absence of oxygen by micro-organism called methanogens and results mainly in the formation of a carbon dioxide and methane gas mixture known as "Biogas". The anaerobic digestion process and production of methane is divided into three stages which often are used to illustrate the sequence of microbial events during the digestion process. These stages are hydrolysis, acid forming, and methanogenesis *[2]*.

2.2 Gas formation curve

Figure 1 shows some typical shapes for biogas cumulative frequency curves. Easily convertible substances are converted rapidly into biogas and the corresponding curve is characterized by a steep increase in the accumulated biogas quantity. Substances which degrade with difficulty (such as substances containing lignin, a few fats) exhibit a retarded gas formation curve. The shape of this curve can also be due to slight inhibition. If degradation takes place in two stages (the curve resembles stairway steps), this may be due to a two-phase decomposition (Diauxia) *[3]*.

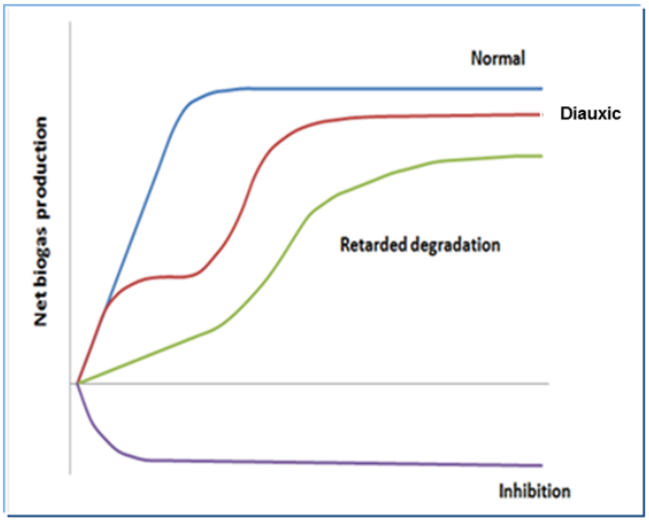

Figure 1. Typical Shapes of Gas Formation Curve *[3]*

3. EXPERIMENTS

3.1 experiment design

Agricultural by-productions (ABPs) were classified by the levels (table 1) of (low, medium and high) chemical contents of proximate composition based on standard tables of feed composition in KOREA *[4]*. To evaluate the biogas production based on proximate composition, batch tests of ABPs were conducted. For maximum utilization of ABPs, the most biogas production classes (class No. 15 Radich waste, No. 21 Corn DDGS 21) were selected and the levels of chemical contents of the selected classes were composed by various ABPs and mixing ratio of them. The batch tests were carried out in 1L glass bottles (liquid volume 0.8L). Experiment were performed using the biogas potential test at feed to microorganism ratio (F/M) of 0.5.

The anaerobic digesters were maintained mesophilic condition. Biogas production of digester was determined by the pressure meter setup (figure 2).

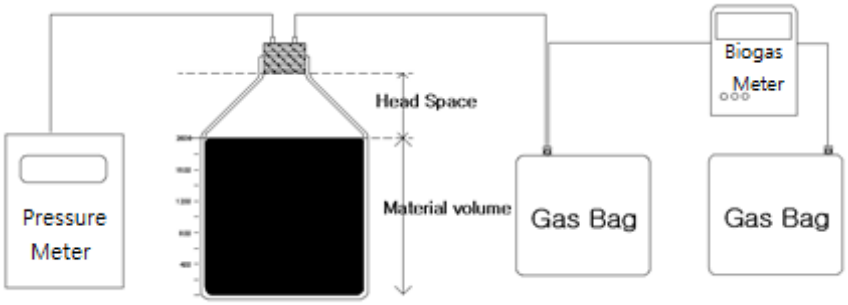

Figure 2. The batch test set up

Table 1. Main parameters

	Units	Low (L)	Medium (M)	High (H)
Total Carbohydrate (TC)	%	<50	50-70	>70
Crude Protein (CP)	%	<15	15-30	>30
Fat (Ether Extract, EE)	%	<7.5	7.5-15.0	>15

The classification of the ABPs based on their proximate compositions are summarized in figure 3. Mixed ABPs are made of individual ABPs using similar proximate composition of Radish waste (Class No. 15) and Corn DDGS (Class No. 21). The mixed ABPs have within 5% difference of TC, CP and EE compared to those of Radish waste and Corn DDGS. Proximate composition of mixed ABPs were shown table 2.

Class No. of ABPs	TC[a]	CP[a]	EE[a]	Class No. of ABPs	TC	CP	EE	Class No. of ABPs	TC	CP	EE
1	H	H	H	10	M	H	H	19	L	H	H
2	H	H	M	11	M	H	M	20	L	H	M
3	H	H	L	12	M	H	L	21	L	H	L
4	H	M	H	13	M	M	H	22	L	M	H
5	H	M	M	14	M	M	M	23	L	M	M
6	H	M	L	15	M	M	L	24	L	M	L
7	H	L	H	16	M	L	H	25	L	L	H
8	H	L	M	17	M	L	M	26	L	L	M
9	H	L	L	18	M	L	L	27	L	L	L

[a] TC: total carbohydrates; CP: crude protein; EE: ether extract

Figure 3. Classification of ABPs based on proximate composition

Table 2. Proximate composition of mixed ABPs

Class No.	Class No. of ABPs			Mixing ratio (% VS basis)	TC	CP	EE
					(%)		
15 (Radish waste)	18 (Cabbage)	12 (Skimmilk)		46.5 / 53.5	62.21	23.91	1.62
	22 (Perilla seed)	6 (Sugar cane)	12 (Skimmilk)	0.8 / 11.7 / 87.5	56.50	25.21	2.77
	9 (Cheese whey)	12 (Skimmilk)	18 (Carrot)	23.6 / 59.1 / 17.3	63.57	23.05	2.89
21 (Corn DDGS)	19 (Bean curd)	15 (Radish)		9.8 / 90.2	45.98	30.01	7.41
	19 (Bean curd)	12 (Skimmilk)		9.1 / 90.9	48.21	38.83	5.33

3.2 Analytical methods

In the batch test the daily biogas production of each digester was determined by the volume of biogas produced which was calculated from the volume and pressure in the headspace of the digester, as previously established. The pressure was measured using a WAL-BMP-Test system pressure gauge (type 3150, Wal, Germany). The biogas samples were taken from the gas collection line and checked the content of CH_4, CO_2 and H_2S using a Biogas Check (Biogas5000, Geotech, England). The gas analyzer was calibrated using a Gas Chromatograph (GC) (GC-2014, Shimadzu, Japan). Total solids (TS) and Volatile solids (VS) were determined in the well mixed samples in triplicates according to standard methods *[5]*.

4. RESULTS AND DISCUSSION

4.1 BMP tests of ABPs

Class No. 15 of ABPs with medium total carbohydrate, medium crude protein and low fat contents demonstrated the single step digestion process shown figure 4. During the first 1-3days biogas production was observed in large amount and rapidly decreased for some day then began to increase. These types were shown rapid acidification of ABPs then can cause acidification in the digester due to accumulation of volatile fatty acids (VFAs), if used at higher organic loading rates *[6]*. When using these substrates, 90% of the total biogas production occurred within 32-35days. The biogas and methane potential for these substrate were found to 497.17 mL/g VS and 311.22 mL/g VS. The methane content was 62.6%.

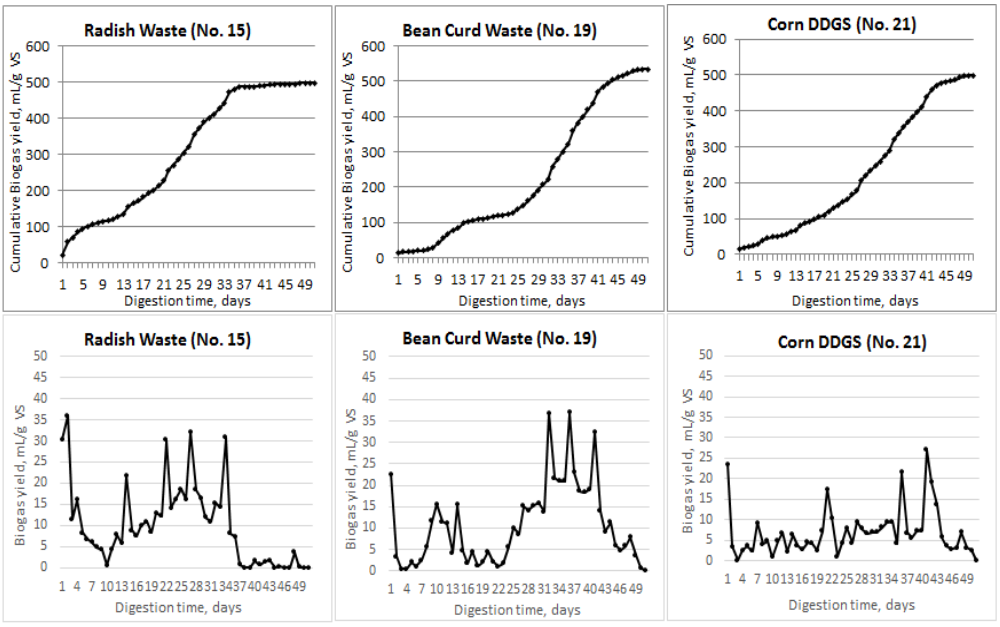

Figure 4. Cumulative biogas yield and biogas production rate for ABPs

Class No. 19 of ABPs with low total carbohydrate, high crude protein and high fat contents demonstrated the two step digestion process of Diauxic growth shown figure 4. On the other hands, Category No. 21 of ABPs with high crude protein and low fat contents was not appeared the Diauxic growth lag-phase. During the initial digestion period, the biogas production rate was very low compared to substrates with low fat contents. The reason for slow biogas production may be slow degradation rate of fats compared to that of total carbohydrates and proteins *[3]*. The biogas and methane potential for low total carbohydrate, high or medium crude protein and high fat contents of ABPs range from 507.59 to 533.27 mL/g VS and 385.77-404.75 mL/g VS. The methane contents were calculate to be in the range from 60.3% to 76.1%. When using these substrates, 90% of the total biogas production occurred within 41-52days.

4.2 BMP tests of mixed ABPs

Cumulative biogas yield of mixed ABPs and single ABP which have similar levels of chemical contents shown figure 5. The mixed ABPs (Class No. 12+18, 6+12+22, 9+12+18) were slow initial degradation rates as compared to the single ABP (Class No. 15). But after 10days showed the similar biogas yield. Class No. 21 of ABP was also showed a similar biogas yield with the mixed ABPs (Class. 15+19, 12+19) after 9days.

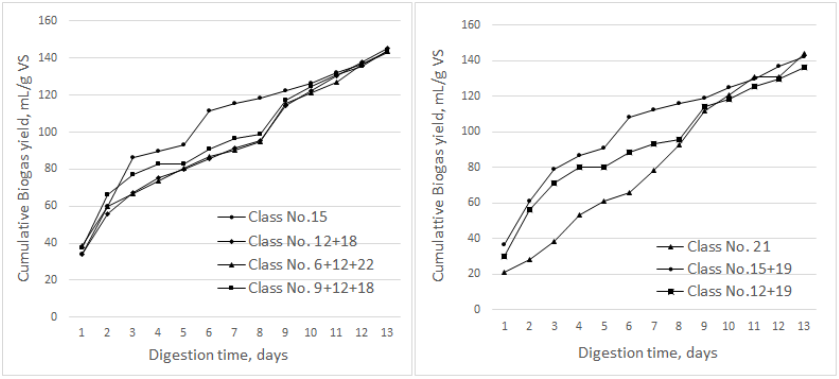

Figure 5. Cumulative biogas yield of mixed ABPs and single

5. CONCLUSION

The selected that agricultural by-productions (ABPs) are potential substrates based on proximate composition for biogas production. The proximate compositions of the ABPs affected biogas productivity and degradation rates. The degradation rate was faster for the agricultural by-productions with high or medium total carbohydrate contents than high crude protein and fat contents. While Biogas production was higher with high contents of crude protein and fat compared to high and medium total carbohydrate. The combination of agricultural by-productions based on chemical contents of proximate composition could be obtained for the higher biogas production even with ABPs low BMP. This method enhanced the utilization of ABPs which cannot be used individually because of low gas production and low efficiency. We can use the classification method for the more ABPs and organic wastes from factory and municipal waste treatment plant.

ACKNOWLEDMENT

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