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Biogas production potential of transgenic *Vetiveria zizanioides* in mesophilic batch anaerobic digestion

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Transgenic *Vetiveria zizanioides* were anaerobic digested in a batch laboratory scale reactor at mesophilic conditions (30°C). Grinding and shearing, two kinds of processing methods were used. During total fermentation time of 80 days, the production potential of biogas were 310 mL/g·TS, 332 mL/g·VS in the grinding processing group and 322 mL/g·TS, 349 mL/g·VS in the shearing processing group. The results show that the shearing processing was slightly better than the grinding processing for transgenic *V. zizanioides* digestion.

Key words: Transgenic *Vetiveria zizanioides*, mesophilic, anaerobic digestion, biogas production potential.

INTRODUCTION

Vetiveria zizanioides (Linn.) Nash, also referred to as *Gramineae vetiveria*, is a tall tufted, perennial, scented grass with an abundant network of roots. It grows naturally in swamp areas of Northern India, Bangladesh, and is probably naturalized in many parts of Southeast Asia. *Vetiver* is both xerophytes and aquatic plants, and can be grown in very wide pH value environment and various types of soil (Xu, 1999). It is widely used in purifying water quality, water and soil conservation, improvement derelict land and desert land, weave handicraft, etc (Jiang et al., 2008). In addition, *vetiver* can be used as the raw material of essential oil extraction, a huge potential for development (Mao et al., 2008; Feng et al., 2009; Hu et al., 2006).

The biogas potential of the selected transgenic *V. zizanioides* in a batch anaerobic reactor was studied. The objective of this experiment was to assess the possibility of transgenic *V. zizanioides* as energy plant, to provide reference data for the construction of the biogas project using transgenic *V. zizanioides* as raw materials.

MATERIALS AND METHODS

Feedstock and Inoculums

The transgenic *Vetiveria zizanioides* for fermentation came from Dongchuan of Kunming in China, introduced for preventing or controlling flood and reinforcing dam, mature, about 2 m, and had air dried naturally. Blade was bar and of hard quality. Feedstock was grinded and cut into pieces, in order to make fermentation feedstock and inoculums contact fully. Stem and leaf of transgenic *V. zizanioides* were cut into less than 1 cm of small section in Shearing group, stem and leaf of transgenic *V. zizanioides* and were grinded into powder fineness less than 500 mesh in grinding group.

Inoculums were anaerobic activated sludge domesticated by our laboratory. The characteristics of the feedstock and inoculums were

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Table 1. The characteristics of the feedstock and inoculums.

Feedstock				Inoculum		
Grinding Group		Shearing group				
TS (%)	VS (%)	TS (%)	VS (%)	TS (%)	VS (%)	pH
94.42	93.29	93.11	92.32	8.08	50.38	6.5-7.0

TS: total solids, VS: volatile solids.

Table 2. TS, VS and pH value of fermentation liquid before and after fermented and TS, VS degradation rate of fermentation liquid.

Sorts	Treatment	TS (%)	VS (%)	pH	TS degradation rate (%)	VS degradation rate (%)
Grinding group	Before fermented	4.60	63.46	6.5	36.09	6.82
	After fermented	2.94	59.13	6.5		
Shearing group	Before fermented	4.88	67.88	6.5	23.57	12.89
	After fermented	3.73	59.13	7.0		
Control group	Before fermented	3.87	46.13	7.0	51.16	0.50
	After fermented	1.89	45.90	7.0		

TS: total solids, VS: (volatile solids)

shown in Table 1.

According to the total solid (TS) of feedstock and inoculums, experimental group, including grinding group and shearing group, was chosen (4%) as objective fermentation concentration, mass fraction of inoculums set (30%) to preparation. In order to eliminate the gas products of inoculums and get the net gas products of feedstock, the control group is necessary. Three groups of devices in each group were used for parallel comparison. Biogas production from the reactors was monitored daily by water displacement method. The volume of water displaced from the bottle was equivalent to the volume of gas generated. Methane content was judged by observing the flame color. The reactor was mixed manually by means of shaking and swirling once in a day. The reactor was operated at mesophilic conditions (30°C) using a constant temperature water bath.

RESULTS AND ANALYSIS

TS, volatile solid (VS) and pH value of fermentation liquid before and after fermented: TS, VS and pH value of fermentation liquid before and after fermented and TS, VS decompose rate of fermentation liquid show in Table 2.

Gas production rate

In this fermentation experiment, the grinding group lasted for 80 days, shearing group for 77 days, and control group for 13 days. The definite gas production quantity varying with fermentation time is shown in Figure 1.

Gas production rate varying with fermentation time was gotten by calculating, the result can be seen in Figure 2. Gas production rate reached 85% on the 42nd day in the grinding group, and on 49th day reached the same level in the shearing group. Hence when designing biogas project of transgenic *V. zizanioides* the HRT is suggested to be design for 45 day which is more reasonable and ensure the full decomposition of the raw materials, reduce the investment cost and shorten the payback time.

Analysis on gas production potential

Biogas production potential of transgenic *Vetiveria zizanioides* in anaerobic digestion were statistically analyzed, the results are as shown in Table 3. In order to further evaluate biogas production potential of transgenic *V. zizanioides*, we compared its potential with other materials fermented at the same temperature, and show the result in Table 4. Cellulose and hemicellulose content is high and matter of sugar and fat kind content is low in botanic fermentation material, which digested difficultly and had a long fermentation period. Similar to this kind of materials, the result of transgenic *V. zizanioides* fermentation to produce biogas appears ideal. From Table 3, compared with the traditional fermentation materials, dung and straws, TS gas production rate is 0.75 times of pig manure, and much better than straws. Compared with Eupatorium adenophorum Spreng, a kind of energy plant, the gas production potential is 4.86 times. Therefore, transgenic *V. zizanioides* is a very good methane fermentation raw materials and a good energy

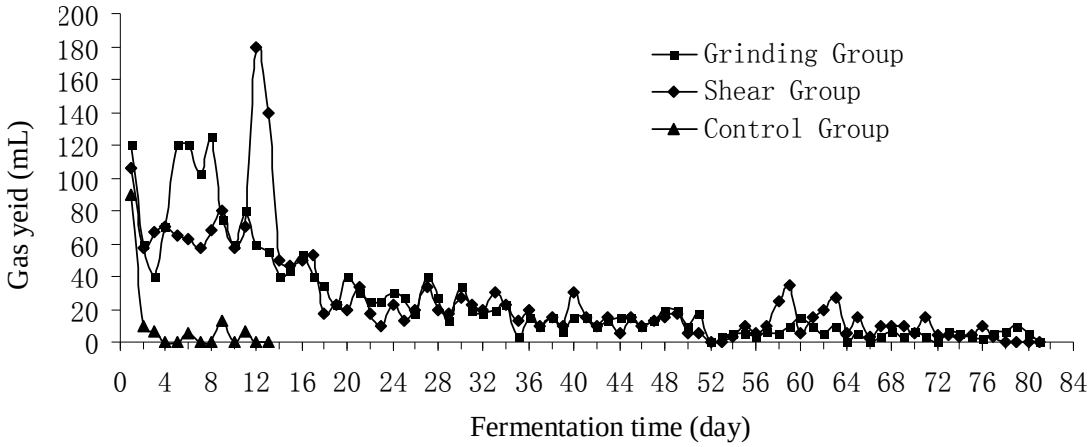

Figure 1. Curve of gas production varying with fermentation time.

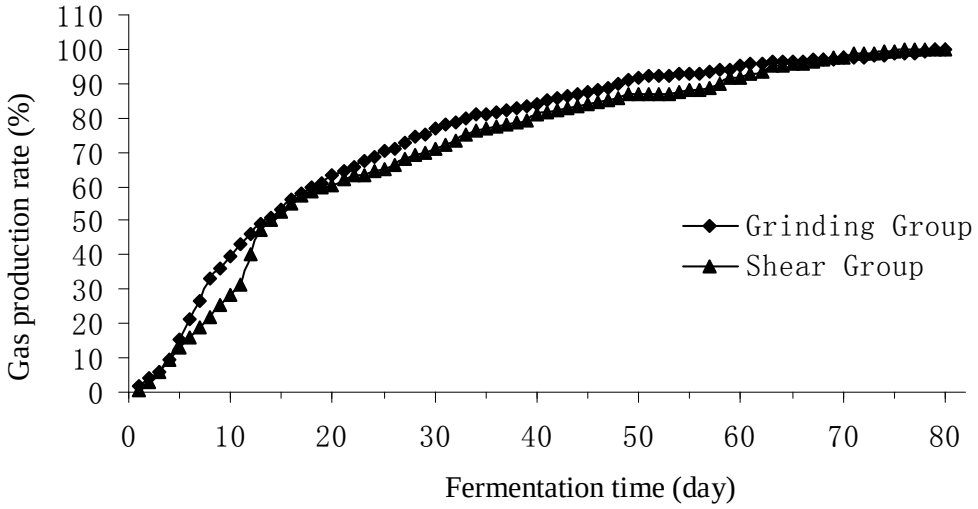

Figure 2. Curve of gas production rate varying with fermentation time.

Table 3. Biogas production potential of transgenic *Vetiveria zizanioides* in anaerobic digestion.

Sorts	Net gas production (mL)	TS gas production rate (mL/g·TS)	VS gas production rate (mL/g·TS)	Tank volume gas production rate (mL/mL·d)	Raw material gas production (mL/g)
Grinding Group	1950	310	332	0.06	293
Shearing Group	2000	322	349	0.06	300

TS: total solids, VS: volatile solids.

plant (Hu et al., 2008; Yang et al., 2011; Zhang et al., 2004).

Conclusion

In the experiment of anaerobic digestion to produce biogas by transgenic *Vetiveria zizanioides*, the production potential of biogas were 310 mL/g•TS and 332 mL/g•VS of the grinding processing group, and 322 mL/g•TS and 349 mL/g•VS of the shearing processing group. From the gas production and VS degradation rate two advantages can be judged that *vetiver* fermentation shearing processing is slightly better than the grinding processing.

Table 4. Gas production potential of different raw materials.

Fermentation material	Fermentation time (day)	TS gas production potential (mL/g·TS)	TS gas production potential multiple	Reference
Transgenic *Vetiveria zizanioides*	80	316	1.00	-
Vetiveria zizanioides	90	471	0.67	HU et al. (2008)
Pig dung	-	420	0.75	ZHANG et al. (2004)
Wheat straw	70	207	1.53	FENG et al. (2009)
Bean straw	70	269	1.17	FENG et al. (2009)
Eupatorium adenophorum Spreng	80	65	4.86	HU et al. (2006)
Dianthus caryophllus straw	32	266	1.19	YANG et al. (2011)

TS (total solids) gas production potential multiple is the ratio of the gas production potential of tobacco residues into the gas production potential of other fermentation materials.

Transgenic *V. zizanioides* fermentation lasted for 80 days. Gas production rate by different processing reached 85% respectively on the 42nd day and 49th day, hence when designing biogas project of transgenic *V. zizanioides* the HRT is suggested to design for 45 days.

The biogas potential of anaerobic digestion of transgenic *V. zizanioides* can achieve the gas potential of excrement kind material, and much better than the straw materials. In addition to purifying water quality, water and soil conservation, improvement derelict land and desert land, transgenic *V. zizanioides* is a very good methane fermentation raw materials and a good energy plant.

Conflict of Interests

The author(s) have not declared any conflict of interests.

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