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Anaerobic Digestion of Finishing Cattle Manure

Andrea K. Watson
University of Nebraska-Lincoln, awatson3@unl.edu

Galen E. Erickson
University of Nebraska-Lincoln, gerickson4@unl.edu

Terry Klopfenstein Klopfenstein
Universitiy of Nebraska--Lincoln, tklopfenstein1@unl.edu

Samodha C. Fernando
University of Nebraska–Lincoln, samodha@unl.edu

Jana L. Harding
University of Nebraska–Lincoln, jharding3@unl.edu

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Summary

Utilizing manure from cattle fed distillers grains in anaerobic digesters improved methane production and DM degradation of manure compared to manure from cattle fed no distillers grains. Manure from cattle fed in open lot pens had soil contamination which decreased OM content and led to decreased total methane production (L/day), but not when expressed as methane/g OM. If ash buildup is avoided, open lot manure can be used as anaerobic digester feedstock.

Introduction

A traditional grain ethanol system that utilizes distillers grains for cattle feed and cattle manure for biogas generation to power the ethanol plant has been referred to as a "closed loop" system. Distillers grains from the ethanol plant are fed to feedlot cattle and manure from the feedlot is used to feed anaerobic digesters. Biogas produced by anaerobic fermentation within the digester is then used to power the ethanol plant and excess heat from the ethanol plant can be used to heat the digester. The effluent or material removed from the digester can be used as fertilizer for crop production to produce grain for ethanol production. Numerous studies have looked at the impact of feeding distillers grains to cattle. Likewise, studies have evaluated optimal conditions for microbial growth within anaerobic digesters; but, not the impact of feeding distillers grains on manure digestion. Experiment 1 was conducted to determine if feeding distillers grains to cattle impacts manure characteristics and changes methane production within anaerobic digesters. Experiment 2 was conducted to determine if open lot manure with soil contamination is a viable feedstock for anaerobic digesters as a large majority of the cattle in Nebraska are fed in open lot pens.

Procedure

Seven small scale (1-L) anaerobic digesters were utilized to study biogas generation from feedlot cattle manure. In Experiment 1, manure treatment was due to diet fed and consisted of a corn based control diet (CONT) or manure from a diet with wet distillers grains plus solubles replacing 40% of the corn (WDGS). For Experiment 2, treatment was manure from two types of cattle housing systems. Manure was collected from cattle in complete confinement (LOASH) or from cattle fed in open lot pens with a soil surface (SOIL). Complete cattle diets are shown in Table 1. For both trials, digesters were continually stirred, temperature was maintained at 37°C (99°F) and pH was maintained between 6.5 and 7.5 through the addition of sodium hydroxide. A constant flow of N_2 gas was pumped through the digesters to ensure that anaerobic conditions were maintained and to allow for measurement of methane concentration with a known gas flow using a flow meter attached to each digester. Concentration of methane was measured twice per day. Knowing flow rate and methane concentration allows for amount produced per day to be evaluated.

Complete manure collection (urine and feces) for Experiment 1 was done on four steers per treatment for three days prior to the start of the trial. Manure was mixed and subsampled for analysis of DM, OM and mineral content. Based on DM, manure was frozen in individual allotments equal to one days feeding for each digester. Each day, seven individual cups were thawed and hot water was added to bring the volume to 50 mL of slurry that was 9% DM. The digesters were allowed to stabilize for 37 days and daily sampling was performed for 5 days. Treatments were then switched and digesters were allowed to stabilize for 37 days followed by 5 days of measurements, thus all treatments were evaluated in all digesters.

For Experiment 2, manure was collected from cattle on a 40% DGS diet in confinement very similar to Experiment 1, or from cattle in open feedlot pens fed a similar diet. Open feedlot pens were cleaned at the end of the feeding period with manure piled in the pens and subsampled. Manure was freeze dried and ground through a 1-mm screen before being

Table 1. Composition of diets fed to cattle for manure collection and digester feeding.

	Experiment 1		Experiment 2	
Ingredient, % of DM	CONT	WDGS	LOASH	SOIL
Dry rolled corn	82.5	47.5	47.5	25.5
High moisture corn	—	—	—	25.5
WDGS[2]	—	40	40	—
MDGS[2]	—	—	—	40
Alfalfa Hay	7.5	7.5	7.5	—
Corn Stover	—	—	—	4
Molasses	5	—	—	—
Supplement	5	5	5	5
Urea	0.986	—	—	—
Monensin, g/ton	30	30	30	30
Tylosin, g/ton	8	8	8	8
Thiamine, g/ton	11	11	11	11

[1]Treatments were due to cattle diet, CONT and WDGS, or due to type of cattle housing with cattle in complete confinement (LOASH) or open lot pens (SOIL).
[2]WDGS = wet distillers grains plus solubles; MDGS = modified distillers grains plus solubles

Table 2. Degradation of manure and methane production within anaerobic digesters.

Experiment 1	CONT	WDGS	SEM	*P*-value
DMD, %	42.7	44.9	1.1	0.05
OMD, %	51.0	52.9	1.1	0.10
Methane, L/day	0.55	0.63	0.05	0.10
Methane, L/g OM fed	0.12	0.14	0.01	0.05
Methane, L/g OM degraded	0.24	0.26	0.03	0.44
Experiment 2	LOASH	SOIL	SEM	*P*-value
DMD, %	39.0	19.9	2.8	<0.01
OMD, %	46.7	24.8	3.1	<0.01
Methane, L/day	0.48	0.23	0.07	<0.01
Methane, L/g OM fed	0.10	0.19	0.03	0.01

[1]Treatments in Experiment 1 were due to cattle diet, a corn based diet (CONT) or a 40% WDGS diet (WDGS). Experiment 2 treatments were due to type of cattle housing with cattle in complete confinement (LOASH) or open lot pens (SOIL).

fed to digesters as a slurry. Digesters on the two treatments were fed an equal amount of DM per day which resulted in LOASH digesters being fed approximately 70% more OM per d. Digesters were allowed to stabilize for 37 days after which measurements were taken on five consecutive days. Three digesters were on the LOASH treatment and 4 digesters on the SOIL treatment. Three of the four digesters on SOIL failed within 10 days due to ash buildup within the digester. Results reported come from 3 digesters on LOASH and the 1 remaining digester on SOIL. Pseudo-replication for statistical analysis was obtained from repeated measures taken on each digester with five days of measurements for OM and DM degradation and methane concentration measured twice per day for 5 days.

Results

Experiment 1—Diet impact

Nutrients (minus OM) were approximately doubled in effluent compared to manure due to the degradation of OM within the digesters. The WDGS effluent had increased N, P and Na compared to CONT effluent ($P < 0.01$). Digesters fed CONT manure had DM degradation of 42.7% and OM degradation of 51.0% (Table 2). Feeding slurry from cattle fed WDGS slightly increased DM degradation to 44.9% ($P = 0.05$) and OM degradation to 52.9% ($P = 0.10$). Methane production was 0.55 L/day for CONT and 0.63 L/day for WDGS ($P = 0.10$). This is equal to 0.12 and 0.14 L/g OM fed for CONT and WDGS, respectively ($P = 0.05$). Methane produced per g of OM degraded was not different between treatments ($P = 0.44$). This suggests that differences in methane produced are due to rate of OM degradation and not due to more methane being produced from that amount of OM. Because diets containing distillers grains are less digestible than corn-based diets (*2013 Nebraska Beef Report*, p. 62 Nuttelman wet vs dry metabolism study) manure from cattle consuming distillers grains contains greater amounts of OM, much of which is highly digestible fiber. This is available for degradation by microbes within anaerobic digesters. The change in OM composition of manure from distillers grains fed cattle may be causing microbial compositional changes that result in increased OM degradation.

Experiment 2

Both DM and OM degradation of manure were greater in LOASH than SOIL ($P < 0.01$; Table 2). Total methane production was greater for LOASH at 0.48 L/day compared to 0.23 L/day for SOIL ($P < 0.01$). The low OM SOIL manure produced 0.19 L methane/g OM fed compared to 0.10 L/g OM fed for LOASH digesters. Consistent with the current results, past research suggests that feeding lower levels of OM reduces the overall amount of methane produced while increasing the amount of methane produced per g of OM fed. Feeding greater amounts of SOIL manure would result in greater OM to be degraded, but would also result in more rapid ash buildup. These small scale digesters were not able to handle the ash load and three out of the four failed. The greater concentration of ash or soil in the manure, the more inefficient and challenging it is for methane production, partially due to decreases in OM to microbe interactions. Furthermore, we do not understand how soil microbes influence methane production and OM degradation within anaerobic digesters. Open lot manure appears to be a viable feedstock for anaerobic digesters if ash buildup could be avoided.

[1]Andrea K. Watson, research technician; Galen E. Erickson, professor; Terry J. Klopfenstein, professor; Samodha C. Fernando, assistant professor; Jana L. Harding, research technician, University of Nebraska–Lincoln Department of Animal Science, Lincoln, Neb.