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Impact of Intake on Methane Production in Growing Steers

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Summary

A study was conducted to evaluate the impact that level of intake has on methane and carbon dioxide production by growing steers. Two treatments were evaluated that included ad-libitum intake compared to limit-fed steers. The ad-libitum fed cattle had greater gains, similar feed efficiency and produced more methane and carbon dioxide per day, while the limit fed cattle produced more methane and carbon dioxide per pound of intake than the ad-libitum fed cattle.

Introduction

Methane production through enteric fermentation in the rumen by cattle has received a lot of attention as an environmental concern. Methane is a potent greenhouse gas with negative impacts on the environment and is an energetic loss to the animal. Methane and carbon dioxide (CO_2) are by-products of volatile fatty acid (acetate, butyrate, and propionate) production created by the microbes in the rumen. Acetate and butyrate formation promotes methane and carbon dioxide production because they produce net H_2 in the rumen that needs to be eructated as CH_4 or CO_2, while propionate, an electron acceptor, does not net any hydrogens during formation and therefore does not contribute to methane production. Favoring propionate production by feeding more concentrates in the diet has been shown to decrease methane production in cattle.

Another way to manipulate methane production is by reducing the steers' level of intake, which is what was done in this growing trial. The amount of feed consumed is well documented as being highly correlated with amount of methane produced. Most previous methane work has been done in head boxes or calorimetry chambers on individual animals. This study was done in the methane barn, which is two enclosed dry lot pens that hold 10 head per pen. The methane barn is monitored for methane and carbon dioxide production every second that the cattle are in the pens. Therefore this method is closer to a production level setting whereas other methods commonly used are small-scale methods.

The objective of this study was verify if the newly constructed methane barn was correctly measuring methane production and if the measurements were realistic using steers fed at two levels of intake to create differences in methane production.

Procedure

A 105-day growing study was conducted using 80 steers (initial BW = 603 ± 97 lb.) fed on a rotation between their feedlot pens and the methane monitoring barns. Five days before the trial began, cattle were limit-fed a common diet of 50% alfalfa and 50% Sweet Bran® at 2% of BW. They were weighed 2 consecutive days and the weights were averaged to get an accurate initial BW. Steers were blocked by body weight and assigned to one of two treatments (Table 1), with 40 steers per treatment. There were 4 blocks with 2 pens per block and 2 treatments, thus the study design is a randomized complete block design (RCBD). The two treatments were *ad-libitum* intake or limit fed steers fed the same diet. Treatment effects were evaluated for methane production and growth performance. Performance and emissions data were analyzed using the MIXED procedure of SAS (SAS Institute, Inc., Cary, N.C.) with pen being the experimental unit.

The limit fed steers were fed 75% of the *ad-libitum* cattle's intake from the week prior of their paired pen (pen in their block). Steers were implanted with Synovex®-Choice on day 1. Methane and carbon dioxide were monitored in the methane barn through a negative pressure system. The methane barns are a completely enclosed facility using two fans per pen to pull air through at a rate of 79 m^3 /min. Near the fan outlets are the sampling ports with pumps that pull air into a sampling line. The air is analyzed using a LI-COR® 7500 for carbon dioxide and a LI-COR® 7700 for methane analyzing The air sampling system cycles between 3 sampling lines; one line in each methane pen (east and west), and one line on the south side of the methane barn to get an ambient supply. Each cycle lasts 20 minutes with 2 minutes in the ambient line, 6 minutes in the west line, 6 minutes in the ambient line, 6 minutes in the east line. This cycles continues non-stop on this 20-minute loop. The ambient line is used in part to flush the system between pen measurements as well as to gather baseline environmental gas measurements.

The 8 pens of steers are rotated through the barn on a weekly basis by block, with two pens in the barn at a time, with both treatments being present in the barn at all times. The steers entered the barn on Thursdays, and were removed on Tuesdays, yielding 5 days of measurements. The barn then sits empty on Tuesday just reading manure gas production without cattle present. On Wednesday am, pens were scraped

Table 1. Dietary treatment for steers that were either ad-libitum or limit fed (DM basis)

	Treatment	
	Ad-Libitum	Limit Fed[3]
Alfalfa	45	45
Sorghum Silage	30	30
MDGS[1]	22	22
Supplement[2]	3	3

[1]MDGS = modified distillers grains plus solubes
[2] Formulated to contain 200 mg/d monensin
[3]Fed 75% of *Ad-libitum* intake from previous week

Table 2. The effect of level of intake in growing steers on performance and methane production

	Treatments			
	Ad-Libitum	Limit	SEM	*P*-value
Performance				
Initial BW, lb	603	602	24.7	0.99
Ending BW, lb	842	786	23.8	0.15
DMI, lb	18.4	13.6	0.32	<0.01
ADG, lb	2.28	1.75	0.04	<0.01
F:G	8.10	7.83	0.18	0.36
Gas Production				
$C0_2$ g/d	6831	6032	163	0.04
CH_4 g/d	156.2	125.6	2.29	<0.01
CO_2 g/lb/DMI	370.8	441.9	10.2	0.02
CH_4 g/lb/DMI	8.48	9.19	0.17	0.06
CO_2 g/lb/ADG	3004	3465	151	0.12
CH_4 g/lb/ADG	68.7	72.1	0.06	0.46
CH4:CO2	0.023	0.021	.0003	0.02

Table 3. Gas production from manure vs. no manure

	Manure vs. No Manure			
Manure		No Manure	SEM	*P*-value
CO_2 g/d	555	456	16.7	<0.01
CH_4 g/d	0.34	0.20	0.05	0.08

clean and sit empty, taking measurements on no cattle and no manure. Based on this rotation, 4 weeks are required to monitor all 8 pens through the barn (one turn) to determine emissions. This study lasted 105 days (3 turns) but just one turn of gas measurements were usable due to monitoring errors for methane in the first two turns.

Results

Performance

Performance results (Table 2) from this growing period show that the *ad-libitum* cattle had greater feed intakes and gains ($P< 0.01$) compared to limit fed cattle. Although not statistically significant, the *ad-libitum* cattle had numerically heavier ending BW compared to limit fed cattle. The feed to gain ratio was not different between treatments ($P \geq 0.36$).

Emissions

Gas production results (Table 2) show that the *ad-libitum* cattle produced more grams of carbon dioxide ($P= 0.04$) and methane ($P< 0.01$) per head per day than the limit fed cattle. Gas production per pound of DMI was statistically different for carbon dioxide ($P = 0.01$) and tended to be different for methane ($P = 0.06$) with the limit fed calves producing more carbon dioxide and methane than the *ad-libitum* cattle when corrected for DMI amounts. When analyzed as an amount per lb. of gain, no differences for carbon dioxide ($P \geq 0.12$) or methane ($P \geq 0.46$) production were observed between treatments. Carbon dioxide production was significantly higher ($P< 0.01$) and methane tended to be higher ($P = 0.08$) for empty pens with manure than empty pens without manure (Table 3). This occurs because cattle manure, although in small amounts, produces methane and carbon dioxide due to fermentation of organic matter in the manure. All data reported in tables 2 and 3 have ambient levels of methane and carbon dioxide removed from the levels measured in each pen to get true animal production of gas. Carbon dioxide and methane production are thought to be highly correlated, and therefore one can be determined based on a ratio if the other is known. Many studies have been done using carbon dioxide numbers to estimate methane numbers, but in this study it was found that the ratio was significantly different between treatments ($P = 0.02$), implying that intake level can alter the ratio.

All of the gas production results shown in tables 2 and 3 are pen totals divided by ten to get individual totals. Results are presented in grams to be consistent with how other work presents gas production in cattle. This trial accomplished its two goals: verify if *ad-libitum* cattle produce more carbon dioxide and methane, as well as confirm that the methane barn is robust enough to pick up differing amounts of methane and carbon dioxide produced in each pen. *Ad-libitum* cattle produced more methane and carbon dioxide per day than limit fed cattle, however the limit fed cattle produced more methane and carbon dioxide per unit of intake than the *Ad-libitum* cattle. Producers should feed Ad-libitum rather than restrict intakes to get better growth performance, but will be producing more total methane and carbon dioxide in the process.

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