Effect of Biochar on Enteric Methane Production and Cattle Performance

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Summary with Implications

Methane is a more potent greenhouse gas than carbon dioxide. Because ruminant animals, including cattle, emit methane, strategies are actively being sought to reduce these emissions. Pistachio shell-sourced biochar was included at 0.5% of a finishing cattle diet to determine effects on methane emissions and cattle performance. Eight pens of cattle were rotated through a 2-chambered emissions barn to analyze methane and carbon dioxide produced by the cattle. Biochar tended to increase methane emissions on a g/d basis with no effect on methane emissions as g/lb of feed intake and no differences in carbon dioxide emissions. There were no differences in cattle performance and most carcass characteristics (daily gain, feed intake, feed:gain, hot carcass weight, ribeye area, marbling) between treatments. The control group did have increased 12th rib fat and yield grade scores compared to the biochar group. Feeding biochar at 0.5% of the diet did not impact enteric methane or cattle performance.

Introduction

Methane (CH_4) is produced in ruminants by microbial fermentation in the rumen. Microbes break down polysaccharides into volatile fatty acids (VFA) to use as energy; however, the by-products of VFA production are carbon dioxide, methane, and hydrogen. Removing methane from the rumen via eructation is important in order for fermentation to continue. Strategies to reduce methane emissions from ruminants has become a widely researched topic. Biochar is produced from cellulose-rich organic matter that has undergone pyrolysis or gasification. Often, biochar is made from wood waste, nut shells, or crop residues, like rice husks. Biochar has been proposed as a potential feed additive to reduce methane emissions; however, the manner of how biochar works to reduce enteric methane is unclear. Some research has speculated that biochar promotes biofilm growth within the rumen that aids microbial growth and crossfeeding, which could lower methane emissions.

The objective of this study was to determine if feeding biochar impacts finishing beef cattle performance and to evaluate the impact of biochar in the diet on enteric methane emissions from beef cattle.

Procedure

A 169-d finishing experiment, utilizing 128 crossbred beef steers was completed at the Eastern Nebraska Research, Extension and Education Center (ENREEC) near Mead, NE. This experiment utilized 2 treatments with 16 pens (8 pens/treatment, 8 steers/pen). Steers were limit-fed a diet consisting of 50% alfalfa hay and 50% Sweet Bran (Cargill Wet Milling; Blair, NE; DM basis) at 2% body weight (BW) for five consecutive days before the start of the experiment. Cattle were then weighed across two consecutive days to establish initial body weight (765 ± 20 lb).

Two treatments were evaluated using a base diet (CON) and a biochar (BIO) diet (Table 1). Biochar replaced 0.5% of dry rolled corn in the diet for the BIO treatment group. Biochar utilized for this experiment was provided by VGrid Energy Systems, Inc. (San Pablo, CA) and was sourced from pistachio shell waste. Biochar was processed to a small particle size to ensure less sorting in the bunk. Samples of biochar were collected weekly and composited to send to Control Laboratories (Watsonville, CA) for chemical analysis. The dry matter of the biochar was 88.2%. On a DM basis, biochar carbon content was 83.9% with a surface area of 427 m^2/g, bulk density of 6.79 lb/ft^3, total N content of 0.69%, ash content of 6.7%, and pH of 9.41. The biochar particle size ranged from less than 0.5 mm (1.4% of biochar) to 4 to 8 mm (3.6% of biochar), with most of the biochar ranging in size from 1 to 4 mm (90% of biochar).

Table 1. Diet composition for finishing beef steers fed biochar

	CON	BIO
Ingredient, % DM		
Dry Rolled Corn	61	60.5
Sweet Bran	30	30
Wheat Straw	5	5
Supplement[1]	4	4
Biochar	0	0.5
Nutrient Analysis, %		
DM	90.1	89.6
OM	93.7	93.2
CP	13.9	13.8
NDF	23.1	23.0

[1] Treatments include a control (CON) group fed no biochar and a biochar (BIO) group fed 0.5% DM of biochar replacing DRC in the diet

[2] Supplement contained 1.65% limestone, 0.4% urea (to meet RDP requirements), 0.30% salt, 0.10% tallow, 0.05% trace mineral premix, 0.015% Vitamin ADE, Rumensin targeted at 30 g/ton (Elanco Animal Health, Greenfield, IN), and Tylan targeted at 8.8 g/ton (Elanco Animal Health) in a fine ground corn carrier

Table 2. Effect of biochar on emissions from cattle

	Treatments[1]			
	CON	BIO	SEM	*P*-Value
Number of Pens	4	4		
DMI, lb/d[2]	27.5	27.0	1.21	0.77
CH_4, g/d	176	194	5.97	0.09
CH_4, g/lb DMI	6.45	7.40	0.56	0.28
CO_2, g/d	10,691	10,854	384.7	0.78
CO_2, g/lb DMI	390	410	13.34	0.34

[1] Treatments include a control (CON) group fed no biochar and a biochar (BIO) group fed 0.5% DM of biochar replacing DRC in the diet

[2] Dry matter intake represents the 5-day period intake while in the methane barn.

Table 3. Effect of biochar on cattle performance and carcass characteristics

	Treatments[1]			
	CON	BIO	SEM	*P*-Value
Number of Pens	8	8		
Cattle Performance[2]				
Final BW, lb	1550	1532	14.7	0.40
DMI, lb/d	29.0	29.2	0.30	0.76
ADG, lb	4.64	4.54	0.08	0.39
Feed: Gain	6.32	6.37	—	0.71
Carcass Characteristics				
HCW, lb	976	965	9.25	0.39
LM area, in²	14.6	14.7	0.15	0.82
Yield Grade[3]	3.80	3.68	0.04	0.06
12th Rib Fat, in	0.72	0.68	0.02	0.07
Marbling[4]	575	590	16.2	0.51

[1] Treatments include a control (CON) group fed no biochar and a biochar (BIO) group fed 0.5% DM of biochar replacing DRC in the diet

[2] All performance data shown on a carcass-adjusted basis using a common 63% dress

[3] Yield Grade calculated from the USDA Yield Grade equation

[4] Marbling Score 400-Small00, 500 = Modest00

Steers were implanted with Revalor-XS (Merck Animal Health USA, Summit, NJ) on day 0 of the experiment. Interim individual body weights were taken on day 90 of the experiment. Steers were weighed in the morning before feeding and body weights were shrunk 4% to account for feed and water gut fill. On days 139 to 167, Optaflexx (ractopamine hydrochloride; Elanco Animal Health, Greenfield, IN) was included in the diet at 300 mg/steer daily. Steers were fed for 169 days before harvest. Carcass-adjusted final BW was calculated from a common 63% dress. Carcass adjusted final BW was used to determine average daily gain (ADG) and Feed:Gain (F:G).

Gas emissions were analyzed using the UNL ENREEC emissions barn equipped with a negative pressure system to monitor and record CH_4 and carbon dioxide (CO_2) production. Emissions were analyzed for 8 consecutive weeks. Eight pens, 4 control pens and 4 biochar pens, were selected randomly to enter the emissions barn for monitoring. On the second cycle through the emissions barn, pens were on the opposite chamber of the emissions barn to account for any chamber effects. Manure CO_2 and CH_4 emissions were measured from the accumulation of 5 days of manure buildup and were calculated for the remainder of Monday after cattle were removed from the barn. Barns were cleaned using a skid steer on Tuesday to develop a baseline emission level. Baseline emissions were subtracted from manure emissions and final values were divided over 5 days and 8 steers to account for individual animal emissions.

Data were analyzed using the MIXED procedure of SAS (SAS Institute, Inc., Cary, N.C.) as a generalized randomized design, with pen as the experimental unit and treatment as a fixed effect.

Results

Emissions

Gas emissions of CH_4 and CO_2 are reported as g/d and g/lb of DMI (Table 2). Weekly feed intakes for each treatment group rotated through the emissions barn were averaged and used to calculate dry matter intake (DMI, lb/d) while in the emissions barn. Dry matter intake between the control and biochar groups did not statistically differ while in the emissions barn ($P = 0.77$). On a g/d basis, biochar tended to increase CH_4 emissions ($P = 0.09$). On a g/lb of DMI basis, there were no statistical differences between the control and the biochar groups ($P = 0.28$). For CO_2, there were no statistical differences between the control and biochar groups for g/d ($P = 0.78$) or g/lb of DMI ($P = 0.34$).

Performance

For day 90 interim performance, there were no statistical differences between the control and biochar treatment for BW, ADG, F:G, or DMI ($P \geq 0.23$). For final carcass adjusted performance, there were no statistical differences between the control and biochar treatment for carcass adjusted final body weight, carcass adjusted ADG, carcass adjusted F:G, or DMI ($P \geq 0.39$).

Carcass Characteristics

Hot carcass weight was not statistically different between the biochar and control treatments ($P = 0.39$). For carcass quality measures of LM area and marbling, there were no statistical differences between treatments ($P \geq 0.51$). The control treatment tended to have greater amounts of 12th rib fat ($P = 0.07$) and greater YG ($P = 0.06$) compared to the biochar treatment.

Conclusion

Utilizing a pistachio shell-sourced biochar in finishing beef cattle diets did not reduce emissions of CH_4 or CO_2 measured as g/d or g/lb of DMI and did not impact performance of steers. When fed at 0.5% of a corn based finishing diet, biochar was not an effective mitigator of enteric methane production from cattle.

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