Impact of Biochar Supplementation in Growing Diets on Greenhouse Gas Emissions

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Summary with Implications

A study was conducted to evaluate the impact of feeding biochar growing diets on cattle performance and methane and carbon dioxide emissions. Two treatments were evaluated, a forage-based control diet without biochar and a diet with biochar included at 0.8% of the diet dry matter, replacing fine ground corn in the supplement. Pens of cattle were rotated through a two-sided emissions barn (2 pens evaluated simultaneously) to capture CH_4 and CO_2 production. There were no statistical differences in performance or gas emissions for steers fed a biochar supplemented diet compared to control. Numerically, biochar supplemented steers had a 2.9% improvement in feed conversion and 3.4% increase in gas emissions compared to control steers.

Introduction

Biochar, a carbonized charcoal, has recently gained popularity in livestock feeding as a potential feed supplementation to reduce greenhouse gas (GHG) emissions. Cattle feeders have demonstrated interest in including biochar as part of the feeding regimen, but the broad characterization of the product and its varying attributes create a barrier for commercial feedlot application. The inclusion of biochar in cattle diets has been suggested to reduce GHG production, primarily in the form of methane (CH_4). Methane is a potent GHG and is of environmental concern. Enteric emission of CH_4 represents an energetic loss in cattle as well, estimated between 2 to 12% of total energy intake. When included in the diet, there are several theories on mode of action. Biochar may act as carbon sink, adsorb methane, or impact microbial community in the rumen, resulting in reduced methane produced during rumination and eructation. The objective of this study was to quantify the impact of biochar supplementation on overall performance and carbon dioxide (CO_2) and CH_4 emissions of growing steers.

It is important to note that biochar is not currently approved by the FDA to be fed to cattle intended for human consumption. While these cattle were not harvested at the end of this growing trial, a food use authorization from the FDA was obtained before the start of the trial.

Table 1. Diet composition for steers fed a grower diet with or without biochar inclusion (DM basis)

Ingredient, %	Biochar	Control
Wheat Straw	40	40
Corn Silage	40	40
MDGS[1]	15	15
Supplement[2]	4.2	5
Biochar[3]	0.8	0

[1]MDGS= Modified distillers grains plus solubles

[2]Formulated to provide 0.3% salt, 1% urea, 1.31% limestone, 0.125% tallow, beef trace mineral, vitamin A-D-E, and 200 mg/d monensin (Rumensin, Elanco Animal Health, Greenfield, IN) as % of diet DM, utilizing fine ground corn as the carrier

[3]Biochar was added as an ingredient to the feed truck and replaced fine ground corn inclusion in the supplement

Procedure

A 77-day feedlot growing study was conducted at the University of Nebraska-Lincoln Eastern Nebraska Research and Extension Center (ENREC) near Mead, NE. Yearling steers (n=160; initial BW=788 lb) were assigned to two treatments (Table 1); a negative control grower diet (no biochar inclusion) and grower diet with 0.8% biochar inclusion. Diets were identical other than biochar inclusion, and contained wheat straw, corn silage, and modified distillers grains plus solubles.

Pens were assigned randomly to treatment (8 pens/treatment) and steers were stratified into 3 BW blocks and assigned randomly to pen (10hd/pen). Before trial initiation, steers were limit-fed a common diet of 50% alfalfa hay and 50% Sweet Bran (Cargill, Blair, NE) offered at 2% of BW. Steers were weighed in the morning of day 0 and 1 of trial and weights were averaged to establish initial BW. Steers were implanted with Revalor-IS (200mg trenbalone acetate + 40mg estradiol; Merck Animal Health, Summit, NJ) on day 1 of study.

Biochar was provided by High Plains Biochar (Laramie, WY), and was sourced from forest wood waste, primarily ponderosa pine trees. Dry matter of the biochar fluctuated with moisture in the air from 57% to 76% DM with an average of 70%. On a DM basis, carbon (C) content of the biochar was 82.8%, with a surface area of 426 m^2/g, bulk density of 6.73 lb/ft^3, and pH of 9.49. Biochar particle size ranged from < 0.5-mm to 8-mm, approximately 66% of biochar sampled sizing <u><2-mm and 1%</u> of biochar sampled ≥4-mm.

The UNL ENREC emission barn, equipped with a negative pressure system to monitor and record CH_4 and CO_2 production, was utilized for 8 consecutive weeks to monitor emissions from growing steers. The emission barn has 2 isolated pens (no emission cross-over) and operates using two air sensors, the LI-COR 7500 and LI-COR 7700 (LI-COR, Lincoln, NE) to monitor CO_2 and CH_4, respectively. Eight pens of cattle, 4 control and 4 biochar, were randomized to rotate through the methane barn by pairing replications

Table 2. Effect of biochar supplementation to growing steers on performance and gas emissions

	Treatments			
	Biochar	Control	SEM	*P*-value
Performance				
Initial BW, lb	800	800	2.0	0.96
Ending BW, lb	1055	1051	4.5	0.50
DMI, lb/d	18.6	18.9	0.17	0.23
ADG, lb	3.24	3.19	0.050	0.46
F:G[1]	5.71	5.88	—	0.25
Emissions daily				
CH_4, g/steer	203.8	196.2	6.62	0.45
CO_2, g/steer	5982	5725	143.1	0.25
CH_4, g/lb of DMI	9.5	9.3	0.30	0.60
CO_2, g/lb of DMI	263.7	254.6	4.90	0.24

[1]Analyzed as G:F, the reciprocal of F:G

within BW block (1 rep per treatment). Pairings were rotated through the barn for two 5-d periods, with each treatment represented in the barn concurrently. Each week, steers entered the barn Wednesday morning and remained in the barn until Monday morning when they were returned back to their feedlot pen. Manure CO_2 and CH_4 emissions were calculated from the remainder of Monday, when cattle were absent from barn. The barns were scraped clean each Tuesday to develop a baseline emission level post manure removal. Baseline emission levels of CO_2 and CH_4 were subtracted from manure emission levels of CO_2 and CH_4 and final values were divided over 5 days and 10 head, to account for individual animal emissions. Following these steps, an average CO_2 value of 16.89 g per steer and CH_4 value of 0.08 g per steer were subtracted from the daily emission total for CO_2 and CH_4.

Performance and emissions data were analyzed using the MIXED procedure of SAS (SAS Institute, Inc., Cary, NC) with pen as the experimental unit. For performance data, BW block was included as a fixed effect. For emissions data, day was a repeated measure. Six days (out of 40 total) were not usable due to complications with barn sensor recording. Concentrations of CO_2 and CH_4 reached above 60 ppm at certain points throughout the day, these concentrations are greater than what has been reported in previous literature. High concentrations of CO_2 and CH_4 in this study were due to housing 10 head/pen in the barn and the high inclusion of low quality forage in the diet.

Results

Results from this study show no statistical difference in performance outcomes between biochar supplemented steers and control ($P \geq 0.23$; Table 2). Numerically, average daily gain (ADG) was greater ($P = 0.46$) and dry matter intake (DMI) was lower ($P = 0.23$) for biochar supplemented cattle. This led to a 2.9% improvement in feed conversion for biochar supplemented steers, that was not statistically significant ($P = 0.25$). Although 8 replicates were analyzed per treatment, the limitation of studying only two treatments leads to insufficient statistical power, and F:G response should be further evaluated to determine repeatability.

Emissions of CO_2 and CH_4 did not statistically differ between steers fed biochar and control treatments ($P \geq 0.24$). Carbon dioxide and methane emissions were numerically lower for control steers compared to biochar supplemented steers when reported as g per day (4.0% lower) or g per lb of DMI (2.8% lower). Based on results from this study, there was no indication that feeding biochar reduces methane emissions in growing steers, especially when considering numerically lower DMI, which measured 18.6 lb/d for biochar supplemented cattle compared to 18.9 lb/d for control.

Recent work evaluating biochar fed to cattle has had mixed results. One study completed in Southeast Asia reported a 24% reduction in CH_4 emissions from cattle, while a study completed in Canada found no differences in CO_2 or CH_4 emissions. Previous work evaluated biochar supplemented to cattle at 0.8 and 3.0% of diet and measured emissions using headbox technology, reporting a decrease in CH_4 emissions for cattle supplemented biochar at these dietary concentrations (*2019 Nebraska Beef Cattle Report*, pp. 56–59). Type of diet, physical properties of the biochar, and inclusion percentage of biochar in the diet are all potential reasons for differing results.

In conclusion, biochar of this characterization supplemented at 0.8% of diet in growing steers does not have a significant impact on GHG emission reduction when compared to negative control.

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