Effects of post-pyrolysis treated biochars on nutrient disappearance, methane production and ruminal fermentation of a silage-based diet in an artificial rumen (RUSITEC)

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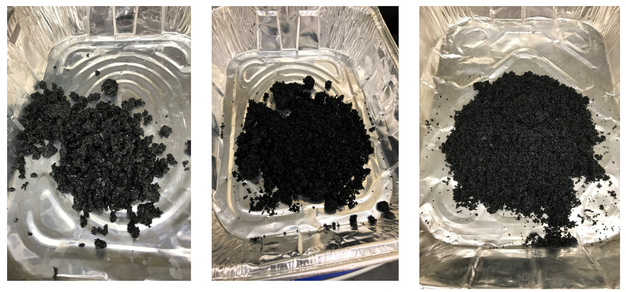
Introduction

- Enteric fermentation from the livestock industry contributes approximately 5.6% of global anthropogenic greenhouse gas emissions (FAO, 2017)
- Methane (CH_4) mitigation through dietary manipulation using feed additives can modify ruminal conditions affecting pH, fermentation pathways and feed digestion (Haque, 2018).
- This study assessed the effects of biochar products treated with salt or two acids post-pyrolysis on nutrient disappearance, CH_4 and rumen fermentation in a rumen simulation system (RUSITEC) fed a barley silage-based diet.

Materials and Methods

Experiment design and treatments

- Randomized complete block design
- Three spruce-based biochars with post-pyrolysis treatments (zinc chloride, hydrochloric acid/nitric acid mixture or sulfuric acid) were used.
- Substrate: 10 g of TMR (600 g barley silage: 400 g concentrate/ kg DM basis).
- Treatments: 1) Control (TMR only), 2) TMR + biochar $ZnCl_2$, 3) TMR + biochar H_2SO_4, 4) TMR + biochar HCl/HNO_3
- Biochar included at 2% of total diet DM.



From left to right: biochars treated with Zinc Chloride, Hydrochloric acid/Nitric acid mixture and Sulfuric acid post-pyrolysis

Inoculum source and laboratory methods

- Experiment period: 15 d (8 d adaptation and 7 d sampling)
- Each fermenter : 700 ml RF + 200 ml artificial saliva (McDougall 1948) in a 39°C circulating water bath. Artificial saliva infused via peristaltic pump (26 ml/h)
- Parameters measured:
  - Total gas and CH_4, fermentation parameters and DM digestibility (d 9-13)
  - Protozoal counts (d 9-13)
  - Microbial protein synthesis (d14-15)

Statistical analysis

- Data were analyzed using PROC MIXED in SAS, and results with $P<0.05$ were considered significant
- Fixed effects in the experiment model was treatment, random effects were RUSITEC apparatus and vessels.
- Control vs biochar: *P* values obtained from the comparison of the TMR mean and the average mean of the three biochar treatments

Results

- Biochar inclusion did not affect nutrient disappearance compared to the control, irrespective of post-pyrolysis treatment ($P>0.05$; Table 1)

Table 1. Nutrient disappearance in control (TMR) and biochar treatments measured over a 5-d sampling period.

Parameter	Treatments				SEM	*P* value	
	Control (TMR only)	Biochar $ZnCl_2$	Biochar H_2SO_4	Biochar HCl/HNO_3		Treatment	Control vs biochar
Nutrient disappearance							
DM	0.64	0.64	0.63	0.67	0.012	0.10	0.49
OM	0.67	0.66	0.67	0.65	0.134	0.49	0.60
CP	0.71	0.72	0.75	0.71	0.114	0.06	0.14
NDF	0.36	0.33	0.35	0.35	0.185	0.69	0.48
ADF	0.26	0.24	0.24	0.23	0.108	0.36	0.11
Starch	0.96	0.96	0.96	0.94	0.073	0.12	0.58

- Biochar did not affect total gas production ($P=0.31$) or CH_4 produced expressed as a % of total gas production ($P=0.06$), mg/d ($P = 0.70$), mg/g of DM incubated ($P=0.74$), or mg/g of DM digested ($P=0.64$; Table 2)
- Biochar had no effect on total VFA ($P=0.56$) or NH_3-N ($P=0.20$) production.
- Microbial protein synthesis and total protozoa count were also unaffected by biochar inclusion ($P>0.05$; Table 3).

Table 2. Total gas and methane production (CH_4) in control (TMR) and biochar treatments measured over a 5-d sampling period.

Parameter	Treatments				SEM	*P* value	
	Control (TMR only)	Biochar $ZnCl_2$	Biochar H_2SO_4	Biochar HCl/HNO_3		Treatment	Control vs biochar
Total gas production, L/day	1.4	1.4	1.4	1.5	0.08	0.41	0.31
Methane production							
CH_4, % of total gas production	4.0	3.3	3.6	3.5	0.21	0.20	0.06
CH_4, mg/day	59.9	53.8	64.5	67.6	4.54	0.23	0.70
CH_4, mg/g DM incubated	4.7	4.3	4.8	5.2	0.28	0.15	0.74
CH_4, mg/g DM disappeared	8.1	6.8	8.3	8.4	0.64	0.28	0.64

Table 3. Rumen pH, VFA and NH_3-N production, total microbial N and protozoa counts in control (TMR) and biochar treatments measured over a 5-d sampling period.

Parameter	Treatments				SEM	*P* value	
	Control (TMR only)	Biochar $ZnCl_2$	Biochar H_2SO_4	Biochar HCl/HNO_3		Treatment	Control vs biochar
pH	6.7	6.7	6.7	6.7	0.01	0.10	0.50
Total VFA, mmol/d	56.8	56.5	56.4	60.4	1.54	0.27	0.56
Acetate	29.6	28.2	28.9	31.4	1.14	0.26	0.96
Propionate	16.2	16.1	15.5	17.1	0.55	0.26	0.93
Butyrate	7.2	7.1	7.2	6.9	0.30	0.82	0.77
NH_3-N, mmol/d	6.8	6.5	6.5	6.6	0.19	0.55	0.20
Total bacterial N, mg/d	76.8	84.7	84.0	79.2	3.83	0.41	0.20
Protozoa[4], × 10^4/mL	3.0	3.4	4.1	4.0	0.81	0.67	0.37

Conclusions

- Inclusion of biochar products differing in post-pyrolysis treatment did not offer potential to mitigate CH_4, improve nutrient disappearance or rumen fermentation in a TMR diet in RUSITEC

References

- Food and Agriculture Organization of the United Nations, 2017., Global Livestock Environmental Assessment Model (GLEAM). https://www.fao.org/gleam/en/
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