Evaluation of Rumen Metabolism and Digestibility when Treated Crop Residues are Fed in Cattle Finishing Diets

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Summary

A metabolism trial was conducted to evaluate rumen pH, digestibility, and ruminal VFA concentrations of steers fed 25% CaO treated or untreated cobs, wheat straw, and corn stover. Treated diets had greater digestibility of DM, OM, and NDF compared to untreated diets. Substituting 15 percentage units of corn and 10% roughage with 25 percentage units of 5% CaO treated cobs, wheat straw, or corn stover resulted in similar DM digestibility, rumen pH and VFA concentrations.

Introduction

A previous trial (Shreck et al., *2012 Nebraska Beef Cattle Report*, pp. 105-107) compared treated or native cobs, wheat straw, and corn stalks and noted no difference in performance or carcass characteristics between treated residues and a control diet that contained 10% units more dry rolled corn (DRC) and 10% roughage. In the same study, treated forages had greater ADG and lower F:G than native. The objective of this trial was to compare digestibility and rumen metabolism of treated and untreated crop residues as replacements for corn grain.

Procedure

This experiment was designed as a 5 x 7 incomplete Latin square with a 2 x 3 + 1 factorial arrangement of treatments. Ruminally fistulated steers (n = 5) were assigned randomly and acclimated to each diet for seven 15-day periods, with a 10-day adaptation period and a 5-day collection period. Factors were chemical treatment (treated or native) and forage fraction (cobs, corn stalks, and wheat straw). Chemical treatment consisted of water, CaO (granular Standard Quicklime, Mississippi Lime Co, Kansas City, Mo.), and ground residue weighed and mixed in Roto-Mix feed trucks. The mixture was targeted for a 50% final DM (treated cobs, wheat straw, and corn stalks used during experiment were: 52.1, 51.6, and 45.6% DM, respectively) with calcium oxide added at 5% of the forage (DM basis). Feed trucks dispensed treated residue into a silage bag and the treatment process was completed at least seven days prior to start of experiment. Untreated residue was only ground and fed in its native form (cobs, wheat straw, and corn stalks used during experiment were: 93.0, 87.2, and 72.8% DM, respectively). The pH of treated cobs, wheat straw, and corn stalks were 8.05, 7.90, and 7.79, respectively, when sampled over the feeding period. Cobs were ground through a 0.75-inch screen while wheat straw and corn stalks were ground through a 3-inch screen. Treated and untreated forage residues were fed at 25% of diet DM and replaced DRC (Table 1). Wet distillers grains plus solubles (WDGS; 33.9% DM) was included in all diets at 40% (DM basis). The control contained 46% DRC and an equal blend of the three native forage residues, totaling 10% of diet DM. All diets contained 4% dry meal supplement and were formulated to supply similar diet Ca (1.47% limestone in control and native diets and treated diets contained no added limestone). Diets were mixed twice each week and kept in a cooler (32°F) until used to ensure fresh feed for the entire experiment. The diets provided 320 to 360 mg/steer of monensin, 90 mg/steer of tylosin, and 150 mg/steer of thiamine daily.

Steers were ruminally dosed with 7.5 g of Cr_2O_3 twice daily at 0800 and 1600 hours. Fecal grab samples were collected at 0800, 1200, and 1600 hours from day 11 to day 15. Within a day, fecal samples were composited on a wet basis into a daily composite, then freeze-dried. From daily composites, a steer within period fecal composite sample was made and analyzed for NDF, OM, and Cr percentage. Samples for NDF were first prepared by removal of fat by biphasic ether extraction. Ruminal pH was recorded every minute using wireless pH probes (Dascor Inc; Escondido, Calif.) from day 11 to day 15. Rumen contents were sampled on day 15 at 0800, 1100, 1400, 1700, 2000, and 2300 hours using the suction strainer technique and a composite sample of steer within period was analyzed for VFA, using gas chromatography. Feeds offered and refused were analyzed for DM, OM, and NDF percentage. Dry matter was determined using a forced-air oven set at 60°C for 48 hours. Digestibility and VFA data were analyzed using the MIXED procedure of SAS (SAS Inst., Inc., Cary, N.C.) with steer as a random effect and period as a fixed effect. Ruminal pH was analyzed as a repeated measure using the GLIMMIX procedure with day as the repeated measure. Means

Table 1. Diet composition of diets offered to steers during experiment.

		Cobs		Straw		Stalks	
Ingredient, % of DM	Control	Treated	Native	Treated	Native	Treated	Native
DRC	46.0	31.0	31.0	31.0	31.0	31.0	31.0
Cobs-treated[1]	—	25.0	—	—	—	—	—
Straw-treated[1]	—	—	—	25.0	—	—	—
Stalks-treated[1]	—	—	—	—	—	25.0	—
Cobs-not treated	3.33	—	25.0	—	—	—	—
Straw-not treated	3.33	—	—	—	25.0	—	—
Stalks-not treated	3.33	—	—	—	—	—	25.0
WDGS	40.0	40.0	40.0	40.0	40.0	40.0	40.0
Supplement	4.0	4.0	4.0	4.0	4.0	4.0	4.0

[1]Treated with 5% CaO and water added to equal 50% moisture.

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Table 2. Digestibility and intake of nutrients.

									P-value			
		Corn Cobs		Wheat Straw		Corn Stover			All diets		Factorial	
Item	Control	Treated	Native	Treated	Native	Treated	Native	SEM	F-test	T[1]	F[2]	TxF[3]
DM intake, lb/day	21.6	21.6^{yz}	22.9^{xy}	22.2^{xy}	19.8^{z}	20.7^{yz}	22.9^{xy}	1.25	0.46	0.36	0.08	0.01
DM digestibility, %	70.3^{abc}	71.9^{abxy}	68.9^{abcxyz}	74.7^{ax}	66.2^{bcyz}	74.5^{ax}	63.2^{cz}	2.95	0.11	0.001	0.51	0.29
OM intake, lb/day	20.7^{ab}	20.7^{abxy}	21.8^{ax}	20.9^{abxy}	18.7^{bz}	19.6^{abyz}	21.8^{ax}	0.55	0.02	0.06	0.01	0.001
OM digestibility, %	72.1^{abc}	74.1^{ab}	69.8^{bc}	78.4^{a}	69.3^{bc}	78.4^{a}	66.3^{c}	2.86	0.04	0.001	0.80	0.33
NDF intake, lb/day	4.8^{c}	6.8^{b}	7.9^{ab}	6.8^{b}	7.3^{ab}	6.8^{b}	8.1^{a}	0.22	0.003	0.001	0.21	0.57
NDF digestibility, %	43.9^{d}	63.7^{ab}	55.3^{bc}	68.7^{a}	54.5^{bcd}	68.1^{a}	44.8^{cd}	4.58	0.002	<0.001	0.61	0.14

[1]Main effect of chemical treatment.
[2]Main Effect of forage fraction.
[3]Interaction of chemical treatment x forage fraction.
[abcd]From the F-test, means lacking common superscripts, differ $P < 0.10$.
[xyz]From the interaction of chemical treatment x forage fraction, means lacking common superscripts, differ $P < 0.10$.

Table 3. Ruminal VFA and pH.

									P-value			
		Corn Cobs		Wheat Straw		Corn Stover			All Diets		Factorial	
Item	Control	Treated	Native	Treated	Native	Treated	Native	SE	F-test	T[1]	F[2]	TxF[3]
Maximum pH	6.49^{bc}	6.52^{b}	6.38^{c}	6.56^{b}	6.60^{b}	6.85^{a}	6.76^{a}	0.07	<0.001	0.94	<0.001	0.24
Average pH	5.99^{ab}	5.98^{bxy}	5.84^{by}	5.81^{by}	6.05^{abxy}	6.23^{axy}	5.95^{bxy}	0.114	0.11	0.98	0.43	0.08
Minimium pH	5.44	5.49^{xy}	5.42^{xy}	5.30^{y}	5.57^{x}	5.52^{x}	5.28^{y}	0.116	0.47	0.88	0.97	0.03
Total VFA, mM	109.1^{ab}	109.6^{a}	92.3^{bcd}	102.3^{abc}	92.8^{abcd}	82.6^{d}	89.6^{cd}	6.74	0.03	0.15	0.05	0.15
Molar proportion, mol/ 100 mol												
Acetate	57.7	61.7	61.5	56.6	59.7	60.3	60.4	1.81	0.12	0.48	0.08	0.38
Propionate	23.1^{abc}	20.6^{c}	23.8^{ab}	24.5^{a}	24.2^{ab}	21.0^{bc}	24.3^{a}	1.71	0.05	0.03	0.15	0.15
Butyrate	12.5	11.1	10.7	12.4	10.0	12.5	9.74	1.11	0.15	0.03	0.85	0.44

[1]Fixed effect of chemical treatment.
[2]Fixed Effect of forage fraction.
[3]Interaction of chemical treatment x forage fraction.
[4]Acetate:Propionate ratio.
[abcd]Within a row, values lacking common superscripts, differ $P < 0.10$.
[xyz]From the interaction of chemical treatment x forage fraction, means lacking common superscripts, differ $P < 0.10$.

across all diets were separated using the pdiff option when the F-test was significant. Main effects of chemical treatment and forage type and the interaction were tested as well with simple effects presented but discussed as main effects (no interaction) or simple effects (with significant interaction).

Results

Greater DM (73.7 vs. 66.1%; $P = 0.001$), OM (77.0 vs. 68.5%; $P = 0.001$), and NDF (66.8 vs. 51.5%; $P < 0.001$) digestibilities (Table 2) were noted for treated compared to untreated. However, no difference ($P > 0.10$) was found between control and treated diets for DM (70.7 vs. 73.7%) or OM (72.1 vs. 76.9%) digestibility. An interaction ($P = 0.01$) for DMI was observed where untreated cobs and corn stalks had greater DMI compared to treated, whereas untreated straw had lower DMI compared to treated. Lower ($P = 0.001$) NDF intake was observed for treated diets (6.8 vs. 7.7 lb/day), suggesting that CaO treatment partially solubilized NDF thereby decreasing measurable NDF intake. Analysis of treated residues showed that CaO treatment solubilized (relative to untreated) 16.6, 21.0, and 15.6% of the NDF for treated cobs, wheat straw, and corn stover, respectively. An interaction was noted for average ruminal pH (Table 3.) as treated cobs (6.52 vs. 6.38) and stover (6.23 vs. 5.95) had greater pH but treated straw (5.81) had lower ($P = 0.08$) rumen pH compared to untreated (6.05). An interaction ($P = 0.06$) was observed for acetate:propionate (A:P) ratio (Table 3.). Chemical treatment of cobs (3.1 vs. 2.6) and corn stover (2.9 vs. 2.6) resulted in greater A:P but treated wheat straw had lower A:P (2.4 vs. 2.6) compared to untreated. No difference ($P > 0.10$) was observed between treated straw or stover compared to control (2.6) for A:P. Chemical treatment increased ($P = 0.03$) butyrate concentration. Propionate concentration tended to interact ($P = 0.15$). Lower propionate concentration was observed for treated cobs and corn stalks compared to untreated, but propionate was similar for straw diets. Results suggest that treated crop residues can substitute for a portion of grain in feedlot diets and result in similar nutrient supply to the animal. The improvements in digestibility when treated residues are fed compared with untreated residues are related to fiber solubilization and improved fiber digestibility.

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