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Effects of Brown Midrib Corn Silage Hybrids with or without Kernel Processing at Harvest on Nutrient Metabolism in Beef Steers

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Summary with Implications

A 2 × 3 factorial digestion study evaluated three corn silage hybrids and kernel processing for finishing steers. The three hybrids included a control corn silage, a brown midrib, and a brown midrib with a softer endosperm. Both brown midrib hybrids had greater fiber digestibility than the traditional control corn silage hybrid. No differences were observed between brown midrib hybrids for all other nutrients. Cattle fed brown midrib hybrids had a lower average ruminal pH compared to the control suggesting more fermentation, but no differences in volatile fatty acid concentration or proportions. Kernel processing had no effect on apparent total tract nutrient digestibility for any nutrients measured in this study. Kernel processing did not impact any ruminal characteristics or metabolism by beef steers. In finishing diets including elevated levels of corn silage, brown midrib corn silage hybrids allow for improved fiber digestibility and more energy available to the animal for improved growth performance over cattle fed control corn silages. Kernel processing did not appear to affect any ruminal fermentation and digestibility parameters, despite an observed improvement in feed efficiency in a similar finishing trial.

Introduction

Corn silage has been a useful ingredient for producers because of it utilizes the entire plant, provides a year-round feed source, and delivers both roughage and energy (*2013 Nebraska Beef Cattle Report*, pp.74–75). A drawback of corn silage is its high lignin content, which may limit energy intake through gut fill. Improving fiber digestibility is beneficial as it allows for increased DMI in high-forage diets, and subsequent gain. Brown midrib hybrids of corn silage have a lower lignin concentration resulting in improved fiber digestibility (*2018 Nebraska Beef Cattle Report*, pp. 49–51). Some research indicates kernel processing at harvest may improve corn silage starch digestibility, presumably by reducing kernel size and increasing surface area for ruminal microbes. However, despite the fact starch digestibility is improved, a reduction in fiber digestibility has been observed, negating the positive effects of the kernel processing, resulting in no overall change in DM digestibility. Research is needed to determine if performance improvements are due to improved fiber digestibility of *bm3* hybrids in beef cattle finishing diets and if kernel processing plays a role in beef cattle finishing diets. The objective of this experiment was to determine whether kernel processing improved digestibility of a diet containing 40% of conventional or brown midrib corn silage.

Table 1. Diet composition (DM Basis) for beef cattle fed three different corn silage hybrids[1] that had been kernel processed (+KP) or not (-KP)

	CON		*bm3*		*bm3*-EXP	
Item	-KP	+KP	-KP	+KP	-KP	+KP
CON Corn Silage	40.0	40.0				
bm3 Corn Silage			40.0	40.0		
bm3-EXP Corn Silage					40.0	40.0
Modified distillers grains	30.0	30.0	30.0	30.0	30.0	30.0
Dry-rolled corn	25.0	25.0	25.0	25.0	25.0	25.0
Supplement[2]	5.0	5.0	5.0	5.0	5.0	5.0

[1]Treatments were control (CON; hybrid-TMF2H708), a *bm3* hybrid (*bm3*; hybrid-F15579S2), and an experimental *bm3* hybrid (*bm3*-EXP; hybrid-F15578XT) with a softer endosperm

[2]Supplement formulated to be fed at 5% of diet DM, Supplement consisted of 2.98% fine ground corn, 1.50% limestone, 0.125% tallow, 0.30% salt, 0.05% trace mineral package, 0.015% Vitamin A-D-E package as a percentage of the final diet. It was also formulated for 30 g/ton Rumensin®(Elanco Animal Health, DM Basis) and 8.8 g/ton Tylan® (Elanco Animal Health, DM basis).

Procedures

Corn silage was harvested at the Eastern Nebraska Research and Education Center (ENREC) near Mead, Nebraska, between September 2 and 12, 2016. Corn silage harvest was initiated when the field was approximately ¾ milkline and 37% DM. The three hybrids (Mycogen® seeds) utilized were a control (CON; hybrid TMF2H708), a brown midrib hybrid (*bm3*; hybrid F15579S2), and Unified™ corn silage with SilaSoft™ kernel technology brown midrib silage with a floury endosperm (*bm3*-EXP; hybrid-F15578XT). Dry matter samples were taken from each truckload of corn silage and dried in a 60°C forced-air oven for 48 h to determine DM of the silage at harvest. Each corn silage hybrid was split into two within the field, one being chopped to 0.75 in chop length with 2 mm kernel processing, and the other chopped at 0.75 in chop length, with no kernel processing. Silages were stored in sealed AgBags® and opened after 21 d. Silage was sampled for fermentation analysis and dry matter DM (forced air oven at 60°C (140°F), 48 h). All feeds were sampled weekly for DM, and monthly composites were analyzed for nutrient composition.

Six ruminally cannulated beef steers (1148 ± 88 lb) were utilized in a 6 × 6 Latin square with six treatments per period. The steers were housed in individual concrete slatted pens with *ad libitum* access to feed and water. Steers were assigned randomly to

Table 2. Nutrient and fermentation analysis of silage hybrids[1]

	CON		*bm3*		*bm3*-EXP	
Item	-KP	+KP	-KP	+KP	-KP	+KP
DM[2]	38.58	35.35	34.85	34.43	35.80	35.96
CP	8.17	8.16	9.41	8.67	8.63	8.50
NDF, %	43.4	44.3	45.6	44.9	46.2	47.3
ADF, %	33.5	33.1	32.2	30.3	32.7	30.4
Starch, %	33.1	34.1	30.2	32.1	29.8	31.4
pH	3.8	4.1	4.2	4.2	4.0	9
Lactic acid, %	5.55	3.10	2.27	2.10	3.85	5.27
Acetic acid, %	0.87	3.75	5.16	5.02	3.50	2.66
Propionic acid, %	0.00	0.34	0.87	0.83	0.55	0.22
Butyric acid, %	0.00	0.00	0.00	0.00	0.00	0.00
Total Acids, %	6.42	7.19	8.31	7.95	7.89	8.16

[1]Treatments were control (CON; hybrid-TMF2H708), a *bm3* hybrid (*bm3*; hybrid-F15579S2), and an experimental *bm3* hybrid (*bm3*-EXP; hybrid-F15578XT) with a softer endosperm, and not kernel processed (-KP) and kernel processed (+KP)

[2]DM was calculated using weekly samples and oven dried for 48 h at 60°C.

Note: Fermentation analysis was conducted only on d 21 silage samples. All other analyses (DM, CP, NDF, ADF, starch) are based on composites of weekly samples taken during the finishing trial, and analyzed at Dairyland Labs (St. Cloud, MN).

Table 3. Main effect of corn silage hybrid on digestibility of cattle fed corn silage-based finishing diets

	Treatment[1]				
	Control	*bm3*	*bm3*-EXP	SEM	*P*-Value[2]
Dry Matter					
Intake, lb/d	22.2	23.4	21.7	0.63	0.17
Digestibility, %	64.6	66.1	68.0	1.10	0.12
Organic Matter					
Intake, lb/d	21.0	22.0	20.4	0.59	0.19
Digestibility, %	67.5[a]	69.0[ab]	71.1[b]	1.085	0.08
NDF					
Intake, lb/d	6.4	6.8	6.5	0.20	0.33
Digestibility, %	45.5[a]	54.4[b]	58.2[b]	1.88	<0.01
ADF					
Intake, lb/d	4.2	4.1	3.8	0.12	0.12
Digestibility, %	47.6[a]	54.2[b]	55.9[b]	2.27	0.04
Starch					
Intake, lb/d	7.9	7.9	7.4	0.20	0.11
Digestibility, %	88.5	89.5	90.5	1.12	0.47
Energy					
Gross Energy Intake, Mcal	46.42[a]	50.04[b]	46.28[a]	1.333	0.10
DE, Mcal/d	30.93[a]	34.6[b]	32.69[ab]	1.045	0.07
DE, Mcal/lb intake	1.39[a]	1.48[b]	1.50[b]	0.109	0.01
TDN, %	70.2[a]	73.8[b]	75.7[b]	1.11	0.01

[a,b]Means with different superscripts differ ($P < 0.10$).

[1]Treatments were control (CON; hybrid-TMF2H708), a *bm3* hybrid (*bm3*; hybrid-F15579S2), and an experimental *bm3* hybrid (*bm3*-EXP; hybrid-F15578XT) with a softer endosperm

[2]*P*-value for the main effect of corn silage hybrid

each dietary treatment for six, 21-d periods, each with a 14-d adaptation followed by a 7-d collection period. Diets (Table 1) were mixed twice weekly and stored in a cooler (0°C) to ensure fresh feed for animals. The diet supplement was formulated to provide 30 g/ton of DM monensin (Rumensin: Elanco Animal Health) and 8.8 g/ton of tylosin (Tylan; Elanco Animal Health). Steers were dosed with 5 g/steer of titanium dioxide inserted through the rumen cannula twice daily at 0800 and 1600 h initiated on d-7 of each period. Fecal grab samples were collected at 0700, 1100, 1500, and 1900 h on days 17 to 20 of each period. Fecal samples were composited on a wet basis into a daily composite, freeze dried, and composited by steer within each period. Samples were analyzed for neutral detergent fiber (NDF), acid detergent fiber (ADF), organic matter (OM), starch, and titanium concentration. Orts were removed daily and dried for 48 h in a 60°C forced-air oven to determine dry matter intake. Feed offered and refused were analyzed for DM, OM, NDF, ADF, starch and lignin percentage. Ruminal pH was recorded every minute using wireless pH probes from days 15 to 21. Rumen fluid samples were collected on day 20 of each collection period at 0800, 1100, 1400, 1700 and 2000 h for ruminal VFA analysis.

Apparent total tract digestibility of the diets and total nutrient intake were analyzed using the MIXED procedure of SAS, with period and treatment considered fixed effects, and steer nested within period used as a random effect. Ruminal pH parameters were analyzed using the GLIMMIX procedure of SAS. *P*-values below 0.10 were considered significant.

Results

The six silage samples that underwent fermentation analyses had a pH of less than 4.2, and total acids in the silage were greater than 6.4% (Table 2). Acid detergent fiber, the cellulose and lignin portions were numerically lower for *bm3* and *bm3*-EXP silages as compared to CON (Table 2).

Corn Silage Hybrid

There were no interactions between corn silage hybrid and kernel processing on nutrient digestibility ($P > 0.14$). The effect of corn silage hybrid on apparent total

Table 4. Main effect of corn silage hybrid on VFA concentration and ruminal pH response variables of cattle fed corn silage-based finishing diets

	Treatment[1]				
	Control	*bm3*	*bm3*-EXP	SEM	*P*-Values[2]
VFA, mol/100 mol					
Acetate	57.5	55.3	59.5	33.14	0.65
Propionate	28.3	27.8	27.2	3.19	0.96
Butyrate	13.9	12.1	14.0	1.23	0.46
A:P Ratio	2.55	2.27	2.54	0.29	0.72
Ruminal pH Variable					
Maximum pH	7.06	6.80	6.75	0.1209	0.11
Average pH[3]	6.12[a]	5.89[ab]	5.83[b]	0.109	0.09
Minimum pH	5.17	5.00	4.86	0.130	0.21
Time below pH 5.6, min/day	270	435	562	122.13	0.19
Time below pH 5.0 min/day	2.9	26.0	36	14.256	0.19

[1]Treatments were control (CON; hybrid-TMF2H708), a *bm3* hybrid (*bm3*; hybrid-F15579S2), and an experimental *bm3* hybrid (*bm3*-EXP; hybrid-F15578XT) with a softer endosperm

[2]*P*-value for the main effect of corn silage hybrid

[3]Means with different superscripts differ ($P < 0.10$)

Table 5. Main effect of kernel processing on digestibility of cattle fed corn silage-based finishing diets

	Treatment[1]			
	-KP	+KP	SEM	*P*-Values[2]
Dry Matter				
Intake, lb/day	22.9	22.0	0.52	0.23
Digestibility, %	66.3	66.1	0.90	0.99
Organic Matter				
Intake, lb/day	21.6	20.7	0.48	0.21
Digestibility, %	69.2	69.2	0.89	0.96
NDF				
Intake, lb/day	6.7	6.4	0.17	0.18
Digestibility, %	52.5	52.9	1.53	0.86
ADF				
Intake, lb/day	4.1	3.9	0.10	0.13
Digestibility, %	52.6	52.5	1.85	0.95
Starch				
Intake, lb/day	7.9	7.5	0.16	0.13
Digestibility, %	89.0	89.9	0.91	0.49
Energy				
Gross Energy Intake, Mcal	48.9	46.3	1.09	0.11
DE, Mcal/day	33.7	31.8	0.85	0.11
DE, Mcal/lb intake	1.47	1.45	0.196	0.37
TDN, %	73.8	72.6	0.91	0.36

[1]Treatments were not kernel processed (-KP) and kernel processed (+KP).

[2]*P*-value for the main effect of corn silage hybrid

tract nutrient digestibility are in Table 3. Organic matter digestibility was greater for *bm3*-EXP fed steers than CON fed steers ($P = 0.03$), with *bm3* as an intermediate between the two ($P \geq 0.17$). Neutral detergent fiber digestibility was greater for *bm3* and *bm3*-EXP compared to CON fed steers ($P < 0.01$), with no difference between the brown midrib hybrids ($P = 0.16$). Acid detergent fiber digestibility followed a similar trend to NDF digestibility. Acid detergent fiber digestibility was greatest for *bm3* and *bm3*-EXP over CON ($P < 0.05$), with no difference between the two brown midrib hybrids ($P = 0.60$). The improvement in fiber digestibility of the brown midrib hybrids was expected, as a decrease in lignin concentration was observed, allowing for more fiber to be available for microbial digestion, resulting in the improvement observed in OM digestibility. There was no difference in starch digestibility for the three hybrids ($P = 0.47$), which suggests the floury endosperm may not play a significant role in how that silage hybrid is utilized by the animal.

There were slight differences in energy intake between corn silage hybrids (Table 3). Gross energy intake (Mcal/day) was greatest for *bm3* ($P < 0.07$) with *bm3*-EXP and CON having similar gross energy intakes ($P = 0.94$). Digestible energy (Mcal/day) was greater ($P < 0.10$) for *bm3* compared with control, but was similar to *bm3*-EXP ($P = 0.21$). Steers fed CON had lower ($P < 0.10$) DE compared with *bm3,* but was similar to steers fed *bm3*-EXP ($P = 0.25$). Digestible energy per unit of dry matter intake (Mcal/lb) was greater for *bm3* and *bm3*-EXP ($P < 0.05$) compared to CON. Total digestible nutrients were greater ($P < 0.01$) for cattle fed *bm3* and *bm3*-EXP compared to CON. This is expected, as those animals fed the brown midrib hybrids had greater fiber digestibility, likely providing extra DE.

There were no differences ($P > 0.46$; Table 4) between the three corn silage hybrids for VFA concentration within the rumen. Acetate molar proportion averaged 57.4 mmol/100 mmol, and propionate averaged 27.7 mmol/100 mmol, resulting in an average A:P ratio of 2.45. This was not expected, as there were differences in fiber digestibility. Average ruminal pH was lower for the brown midrib hybrids ($P = 0.09$),

Table 6. Main effect of kernel processing on VFA concentration of cattle fed corn silage-based finishing diets.

	Treatment			
	-KP	+KP	SEM	*P*-Values
VFA, mol/100 mol				
Acetate	57.8	57.1	2.57	0.85
Propionate	29.5	25.9	2.93	0.37
Butyrate	13.1	13.6	1.01	0.69
A:P Ratio	2.38	2.52	0.251	0.67
Ruminal pH Variable				
Maximum pH	6.81	6.94	0.095	0.33
Average pH	5.94	5.95	0.080	0.88
Minimum pH	5.10	4.92	0.103	0.21
Time below pH 5.6, min/day	401	444	96.3	0.74
Time below pH 5.0 min/day	9.9	33.4	11.25	0.14

[1]Treatments were not kernel processed (-KP) and kernel processed (+KP).

[2]*P*-value for the main effect of corn silage hybrid

likely attributable to improved ruminal fermentation from improved fiber digestibility. A shift in average lower ruminal pH may have been due to an increase in VFA concentration but did not create a shift in VFA proportions observed in the rumen. Generally, in high fiber diets, greater acetate vs. propionate molar proportions are observed.

Kernel Processing

Kernel processing did not influence apparent total tract nutrient digestibility of any of the nutrients measured (Table 5; $P \geq 0.13$). This was unexpected, as there was an improved feed conversion due to kernel processing in a previous trial with identical diets (*2018 Nebraska Beef Cattle Report*, pp. 89–91). Additionally, there was no effect of kernel processing on dietary energy variables measured ($P \geq 0.11$). Digestible energy per pound of intake was 3.25 Mcal/lb and 3.20 Mcal/lb for non-kernel processed and kernel processed, respectively ($P = 0.37$). Total digestible nutrient content of the diet was not affected ($P = 0.36$) by kernel processing. Kernel processing did not affect ruminal VFA concentration (Table 6, $P \geq 0.37$). No differences were observed ($P \geq 0.14$) for any ruminal pH parameters measured due to kernel processing (Table 6). With no observable changes in digestion, ruminal pH or VFA concentration, the digestion trial results do not support the observed performance in the growth trial.

Conclusion

Feeding *bm3* and *bm3*-EXP corn silage hybrids improved OM digestibility, greatly improved NDF and ADF digestibility, with no appreciable difference in starch digestibility. In addition, DE intake per pound of DM intake was greater for *bm3* and *bm3*-EXP corn silage hybrids as well. No appreciable differences were observed due to kernel processing of silage hybrids on any metabolism response variable analyzed.

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