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Nutrient Digestibility and Fermentation of Brown Midrib Corn Fed to Growing Beef Steers

F. Henry Hilscher
University of Nebraska-Lincoln, henry.hilscher@unl.edu

Melissa L. Jolly-Breithaupt
University of Nebraska-Lincoln, melissa_jolly_brethaupt@unl.edu

Jana L. Gramkow Gramkow
University of Nebraska-Lincoln, jharding3@unl.edu

Hannah C. Wilson
University of Nebraska-Lincoln, hhamilton6@unl.edu

Mitch M. Norman
University of Nebraska - Lincoln, mnorman2@unl.edu

See next page for additional authors

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Authors

F. Henry Hilscher, Melissa L. Jolly-Breithaupt, Jana L. Gramkow Gramkow, Hannah C. Wilson, Mitch M. Norman, John N. Anderson, and Galen E. Erickson

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Summary with Implications

A digestion study evaluated three corn silage hybrids for growing crossbred steers. The three hybrids were: a standard corn silage hybrid which served as the control, a brown midrib hybrid (bm3), and an experimental bm3 hybrid with a softer endosperm. Both bm3 hybrids had greater organic matter and fiber digestibility compared to the control corn silage. However, no differences were observed between the two bm3 hybrids. Rumen pH was reduced for BM3 and BM3-EXP compared to the control suggesting greater rumen fermentation. In vitro gas production was increased for the bm3 hybrids compared to the control further supporting greater rumen fermentation.

Introduction

Feeding corn silage allows cattle feeders to take advantage of the entire corn plant at a time of maximum quality and tonnage as well as secure substantial quantities of roughage/grain inventory (*2013 Nebraska Beef Cattle Report,* pp. 74–75). Incorporating corn silage based growing diets containing 80% corn silage in combination with distillers grains has been shown as a potentially economical and efficient way to grow steers prior to the finishing phase (*2011 Nebraska Beef Cattle Report, pp*. 16–17). However, in corn silage growing diets, gut fill and fiber digestion limit DMI and thus ADG. The brown mid rib (*bm3*) mutation has been shown in previous research to lower lignin concentrations and improve fiber digestibility. Unfortunately, little research has been done in beef growing diets for corn silage incorporating the *bm3* trait. Research is needed on growth performance as a result of increased fiber digestion due to *bm3* within corn silage. Therefore, the objective of this experiment was to determine the effect of feeding two *bm3* corn silage hybrids on growing steer nutrient digestibility and ruminal fermentation.

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Table 1. Diet (DM basis) fed to growing steers

	Treatment[1]		
Ingredient	CON	BM3	BM3-EXP
Control corn silage	80.0	-	-
BM3 corn silage	-	80.0	-
BM3-EXP corn silage	-	-	80.0
Modified distillers grains plus solubles	15.0	15.0	15.0
Supplement[2]	5.0	5.0	5.0

[1] Treatments were control (CON; hybrid-TMR2R720), a *bm3* hybrid (BM3; hybrid-F15579S2), and an experimental *bm3* hybrid (BM3-EXP; hybrid-F15578XT) with softer endosperm

[2] Supplement consisted of 3.0% Fine ground corn, 0.916% limestone, 0.574% urea, 0.125% tallow, 0.30 % salt, 0.05% trace mineral package (10% Mg, 6% Zn, 4.5% Fe, 2% Mn, 0.05% Cu, 0.3% I, and 0.05 Co), 0.015% Vitamin A-D-E package (1,500 IU of vit A, 3,000 IU of vit D, 3.7 IU of vit E) as percentages of the final diet (DM basis). Supplement was formulated to provide 200 mg/steer of Rumension® daily.

Procedure

Three hybrids of corn silage were grown and harvested at the Eastern Nebraska Research and Extension Center (ENREC) near Mead, NE. The three hybrids were a standard corn silage hybrid which served as the control (CON; hybrid-TMR2R720), a *bm3* hybrid with the brown midrib trait (BM3; hybrid-F15579S2), and an experimental *bm3* hybrid (BM3-EXP; hybrid-F15578XT) with a greater proportion of softer endosperm. Silage was harvested from 9/11/15 through 9/16/15 and stored in concrete wall bunkers until the initiation of the trial. Bunker samples were analyzed for DM and fermentation analysis 28 d after harvesting to ensure proper ensiling. All feeds were sampled weekly for DM, and monthly composites analyzed for nutrients.

Six steers (initial BW = 604 ± 60 lb) were used in a replicated 3 × 6 Latin rectangle with 3 treatments fed each period, for six periods (Table 1). All diets included 15% modified distillers grains plus solubles (MDGS) and 5% supplement. Rumensin was added in the supplement to supply 200 mg / steer daily. The remainder of the diet consisted of 80% corn silage of 1 of the three hybrids (CON, BM3 or BM3-EXP: Table 1). Each period was 21 d in length consisting of 16 d adaptation and a 5 d collection. Beginning on day 10 of each period, titanium dioxide was dosed at 5 g/steer twice daily at 0700 and 1500 hours for seven days before and during the collection period. Fecal grab samples were collected at 0700, 1100, 1500, and 1900 hours during day 1–4 of the collection period. Fecal samples were composited and subsequently analyzed for neutral detergent fiber (NDF), acid detergent fiber (ADF), starch, organic matter (OM), and Ti concentration. Ruminal pH was recorded every minute using wireless pH probes from day 1 to 4 of the collection period. Feeds offered and refused were analyzed for dry matter (DM), OM, NDF, ADF, starch, and lignin percentage.

Whole rumen contents were collected on d 5 at 1400 (6 hours post feeding). Rumen samples at 0 h post collection were immediately frozen after collection, and remained frozen until VFA concentration was measured. Rumen samples were incubated and stirred for 2, 4, and 6 hr post collection to determine VFA production. At time of analysis, rumen fluid samples were thawed

in a cooler (4°C) to ensure no additional fermentation occurred. Each sample collected was analyzed twice for VFA concentration to ensure an accurate value was obtained. Gas production was measured for 6 h at 0, 2, 4 and 6 h post rumen sampling. Gas production was measured using ANKOM RF gas production bottles with 1 g of whole rumen contents weighed into a 250 mL bottle. Two bottle per steer were analyzed per period continuously for 20 h post rumen sampling.

Digestibility data were analyzed as a Latin rectangle using the mixed procedure of SAS (SAS Inst., Inc., Cary, N.C.) with period and treatment as fixed effects and steer as a random effect. Ruminal pH data were analyzed as repeated measures using the GLIMMIX procedure with day as the repeated measure, treatment as a fixed effect, and steer as a random effect. Rumen VFA data were analyzed using the mixed procedure of SAS, with fixed effect of treatment and steer as a random effect. Gas production data were analyzed using the mixed procedure of SAS, response variables were total gas production and gas production rate. Run was the experimental unit. Rate of gas production was generated by analyzing the gas production data in a modified Gompertz model using the NLIN procedure of SAS.

Results

Corn silage was targeted to be harvested at 35% DM. However, after fermentation, DM declined slightly (Table 2). The fermentation analysis of the three corn silage hybrids indicated that proper fermentation did occur as pH was below 3.9, and total acids were greater than 7.3%. The starch and sugar (water soluble carbohydrates) percentages remained consistent across all three silage hybrids. The ADF and lignin concentrations were numerically lower in both the BM3 and BM3-EXP compared to the CON, as expected.

Feeding corn silage with the *bm3* trait tended to increase ($P = 0.11$) DMI and OM intake compared to CON (Table 3), which was observed in a growing study with identical diets fed to steers (*Hilscher et al., growing report*). Digestibility of DM tended to be impacted by treatment ($P = 0.11$) with steers fed BM3 and BM3-EXP having

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

	CON		BM3		BM3-EXP	
Nutrient[2]	Mean	CV[3]	Mean	CV[3]	Mean	CV[3]
DM[2]	31.9	6.4	32.4	5.3	33.0	6.9
CP	8.6	3.4	9.6	7.8	9.1	3.9
NDF, %	40.9	4.3	41.0	4.4	39.0	3.6
ADF, %	27.1	2.5	26.7	2.2	23.6	3.0
Lignin, %	4.3	27.5	3.7	24.2	2.81	34.6
Starch, %	31.0	8.8	32.0	8.9	30.8	6.7
Sugar, %	2.3	28.1	2.4	37.8	2.8	22.4
pH	3.89	2.5	3.86	1.9	3.81	6.3
Lactic Acid, %	5.6	17.1	6.2	16.6	6.0	15.6
Acetic acid, %	1.4	31.2	1.6	30.9	1.5	34.4
Propionic acid, %	0.34	40.5	0.43	48.7	0.46	0.54
Butyric acid, %	< 0.01	0.0	< 0.01	0.0	< 0.01	0.0
Total acids, %	7.3	10.4	8.2	11.0	7.9	10.8

[1] Hybrids were control (CON; hybrid-TMR2R720), a *bm3* hybrid (BM3; hybrid-F15579S2), and an experimental *bm3* hybrid (BM3-EXP; hybrid-F15578XT) with a softer endosperm
[2] DM was calculated using weekly samples and oven dried for 48 h at 60° C. All other nutrient assays are based on monthly composites of weekly samples taken during the finishing trial, and analyzed at Dairy One Labs (Ithaca, NY).
[3] C.V. = coefficient of variation and is calculated by dividing the standard deviation by the mean and is expressed as a percentage.

Table 3. Effects of feeding two different bm3 corn silage hybrids on intake and digestibility of nutrients

	Treatments[1]				
Item	Control	BM3	BM3-EXP	SEM	P-Value
DM					
Intake, lb/d	15.0	16.5	16.2	1.1	0.11
Excreted, lb/d	5.3	5.4	4.9	0.4	0.39
Digestibility, %	64.5	67.7	69.0	1.6	0.11
OM					
Intake, lb/d	13.8	15.1	15.1	1.0	0.11
Excreted, lb/d	4.6	4.6	4.2	0.3	0.36
Digestibility, %	66.8[b]	70.0[ab]	71.6[a]	1.4	0.05
NDF					
Intake, lb/d	5.9	6.5	6.1	0.4	0.08
Excreted, lb/d	3.1[b]	2.7[a]	2.6[a]	0.2	0.01
Digestibility, %	45.3[b]	57.8[a]	57.0[a]	2.2	<0.01
ADF					
Intake, lb/d	3.7[ab]	4.0[a]	3.5[b]	0.2	0.03
Excreted, lb/d	2.1[b]	1.6[a]	1.5[a]	0.1	<0.01
Digestibility, %	41.9[b]	59.6[a]	56.1[a]	2.5	<0.01
Starch					
Intake, lb/d	4.5	4.6	5.0	0.4	0.11
Excreted, lb/d	0.16[b]	0.25[a]	0.20[ab]	0.03	0.03
Digestibility, %	96.6[b]	94.6[a]	95.8[ab]	0.7	0.03

[1] Treatments were control (CON; hybrid-TMR2R720), a *bm3* hybrid (BM3; hybrid-F15579S2), and an experimental *bm3* hybrid (BM3-EXP; hybrid-F15578XT) with a softer endosperm.
[a,b,c] Means with different superscripts differ ($P < 0.05$).

Table 4. Effects of feeding two different bm3 corn silage hybrids on rumen pH measurements and gas production rates

	Treatments				
Variable	CON	BM3	BM3-EXP	SEM	P-value
Maximum pH	6.64[b]	6.37[a]	6.41[a]	0.07	<0.01
Average pH	6.50[b]	6.22[a]	6.26[a]	0.07	<0.01
Minimum pH	6.38[b]	6.08[a]	6.12[a]	0.07	<0.01
Change in pH	0.26[b]	0.29[a]	0.29[a]	0.17	<0.01
Variance in pH, %	0.60[b]	0.85[a]	0.90[a]	0.11	<0.01
Gas production rate, mL/g DM	25.74[b]	30.77[a]	28.72[a]	2.44	0.03

[a,b,c] Means with different superscripts differ ($P < 0.05$).
[1] Treatments were control (CON; hybrid-TMR2R720), a *bm3* hybrid (BM3; hybrid-F15579S2), and an experimental *bm3* hybrid (BM3-EXP; hybrid-F15578XT) with a softer endosperm.

Table 5. Effects of feeding two different bm3 corn silage hybrids on rumen VFA concentrations and VFA production rates

	Treatments[1]				
VFA, mol/100 mol	CON	BM3	BM3-EXP	SEM	P-value
Acetate	61.75[a]	59.28[b]	61.53[a]	0.81	<0.01
Propionate	23.29[a]	24.91[b]	23.13[a]	0.65	0.03
Butyrate	10.19[b]	11.54[a]	11.41[a]	0.30	<0.01
A:P ratio	2.69[a]	2.47[b]	2.80[a]	0.10	0.02
Total VFA (mM)	148.21	164.09	159.84	6.82	0.13
VFA production rate, mM/g DM	41.79	55.10	49.14	5.04	0.17

[a,b,c] Means with different superscripts differ ($P < 0.05$).
[1] Treatments were control (CON; hybrid-TMR2R720), a *bm3* hybrid (BM3; hybrid-F15579S2), and an experimental *bm3* hybrid (BM3-EXP; hybrid-F15578XT) with a softer endosperm.

greater DM digestibility than steers fed CON. Digestibility of OM was impacted by treatment ($P = 0.05$), with steers fed BM3-EXP having greater OM digestibility than steers fed CON, and steers fed BM3 being intermediate.

There were significant differences in NDF excretion and NDF digestibility due to treatment ($P < 0.01$). Steers fed both BM3 (57.8%) and BM3-EXP (57.0%) had greater ($P < 0.01$) NDF digestibility compared to the CON (45.3%). Intake of ADF was greatest ($P = 0.03$) for BM3 and lowest for BM3-EXP with CON being intermediate. However, there were no differences ($P > 0.10$) in ADF digestibility between BM3 (59.6%) and BM3-EXP (56.1%), but both had greater ($P < 0.01$) ADF digestibility than CON (41.9%). Cattle fed the BM3 treatment excreted the greatest ($P = 0.03$) amount of starch, with CON having the least amount of starch excreted. Starch digestibility was greater than 94.5% for cattle fed all three silages, but steers fed CON (96.6%) corn silage had the greatest ($P = 0.03$) starch digestibility with BM3-EXP (95.8%) being intermediate and BM3 (94.6%) having the least starch digestibility. The general improvements in NDF, ADF, and OM digestibility for steers fed BM3 and BM3-EXP likely explain the greater DMI observed in this study and the growing study as well as the greater gain observed in a previous growing study (*Hilscher et al., growing report*).

There was a significant decrease ($P < 0.01$) in average ruminal pH between the *bm3* hybrids (6.24) and the control silage (6.50; Table 4.). Additionally, the BM3 and BM3-EXP treatments had lower ($P < 0.01$) maximum pH and lower ($P < 0.01$) minimum pH compared to the CON. The lower pH is likely do greater fermentation due to greater rumen digestibility of *bm3* silage, all treatments had a minimum pH greater than 6.0. Gas production rates of whole rumen contents when collected at peak fermentation showed a significant increase in gas production rate over 20 h for the BM3 and BM3-EXP compared to CON ($P = 0.03$), but were not different between *bm3* varieties.

Acetate concentrations were greater ($P < 0.01$) in CON and BM3-EXP compared to the BM3 treatment (Table 5.). However, the CON (23.3) and BM3-EXP (23.1) treatments had lower ($P < 0.01$) concentrations of propionate compared to the BM3 (24.9). The BM3 and BM3-EXP cattle did have higher ($P < 0.01$) concentrations of butyrate compared to CON. The BM3 treatment had a lower ($P = 0.02$) acetate to propionate ratio (2.47) compared to CON and BM3-EXP (2.69 and 2.80, respectively). Greater VFA concentrations for bm3 silage may be related to greater fermentation and improved rumen digestibility and is further supported by greater ($P < 0.01$) total VFA concentrations compared to the control silage. Production rates of VFA whole rumen contents when collected at peak fermentation showed numerical increases in gas production rate over 6 h for the BM3 and BM3-EXP compared to CON, but were highest numerically for the BM3 treatment.

Conclusions

The BM3-EXP with softer endosperm improved starch digestibility compared to BM3 but there was no difference between BM3 and BM3-EXP for OM, NDF, or ADF digestibility. However, feeding corn silage hybrids with the *bm3* trait at 80% of the diet DM resulted in greater fiber and OM digestion compared to corn silage without the trait. Based on rumen pH, VFA concentration, and VFA and gas production, greater fermentation and a more suitable rumen environment is likely for cattle fed corn silage with the *bm3* trait compared to a control corn silage without the *bm3* trait.

F. Henry Hilscher, graduate student

Melissa L. Jolly-Breithaupt, research technician

Jana L. Gramkow, research technician

Hannah C. Wilson, research technician

Mitch M. Norman, student technician

Galen E. Erickson, professor, Animal Science, University of Nebraska, Lincoln Neb.

John N. Anderson, Mycogen Seeds, Indianapolis Ind.