January 2006

Effect of Corn Hybrid and Processing Method on Site and Extent of Nutrient Digestibility Using the Mobile Bag Technique

Matt K. Luebbe
University of Nebraska - Lincoln, mluebbe2@unl.edu

Galen E. Erickson
University of Nebraska-Lincoln, gerickson4@unl.edu

Terry J. Klopfenstein
University of Nebraska-Lincoln, tklopfenstein1@unl.edu

Wayne Fithian
Golden Harvest Seed Co., Waterloo, Neb.

Effect of Corn Hybrid and Processing Method on Site and Extent of Nutrient Digestibility Using the Mobile Bag Technique

Matt K. Luebbe
Galen E. Erickson
Terry J. Klopfenstein
Wayne A. Fithian[1]

Summary

The influence of corn hybrid and processing method onsite and extent of DM, starch, and protein digestibility was determined using the mobile bag technique. Samples consisted of three hybrids with known digestibility and feeding value processed as either dry-rolled corn (DRC) or high-moisture corn (HMC). Ruminal and total tract nutrient digestibilities were greater for HMC compared to DRC. Differences among hybrids existed for all variables measured except ruminal starch digestibility and degradable intake protein. Undegradable intake protein (UIP) digestibility was greater for HMC compared to DRC (77.8 and 73.7%, respectively). However, UIP was lower for HMC than DRC. Differences among processing methods and hybrids exist for site and extent of nutrient digestibility.

Introduction

The site of digestion (i.e., rumen or intestinal) is critical to understanding the impact on performance. More intense corn processing methods or selection of hybrids with desirable kernel traits has been shown to improve the extent of starch digestion by increasing the amount digested in the rumen. Previous research also shows that degradable intake protein (DIP) for high moisture corn increases as moisture and length of ensiling increases. However, the effects of high-moisture ensiling on undegradable intake protein (UIP) digestibility are unknown. The current NRC Beef Cattle Nutrient Requirement model assumes UIP digestibility is 80% for all feedstuffs. Because UIP from corn provides a large amount of metabolizable protein (MP) to finishing cattle, small changes in UIP digestibility can have a large impact on MP. The objectives of this research were to determine site and extent of DM and starch digestibility, and to determine undegradable intake protein digestibility of three hybrids processed as either dry-rolled corn (DRC) or high-moisture corn (HMC).

Procedure

Two ruminally and duodenally cannulated steers were used to incubate 5 x 10 cm dacron bags with a 50 um pore size. Bags were filled with 1.75 g of DM sample ground through a 0.25 in screen to simulate masticated corn. Dry rolled corn samples were ground as-is and HMC samples were ground frozen. The samples consisted of three hybrids: H-8562 (1), 33P67 (2), and H-9230 Bt (3), processed either as DRC or reconstituted HMC. Dry corn was coarsely rolled, reconstituted to 28% moisture and ensiled to mimic early harvested HMC. These hybrids were also fed in previous feedlot and metabolism studies (*2004 Nebraska Beef Reports,* pp. 54; *2006 Nebraska Beef Reports*, pp. 40). A concentrate diet consisting of 68.5% DRC, 20% wet corn gluten feed, 7.5% alfalfa, and 4% supplement was fed at 1.8% BW. Particle size analysis was performed using a wet sieving method to determine the geometric mean diameter and geometric standard deviation. An incubation time of 22 hours was used representing 75% of the mean retention time calculated from the inverse of a passage rate at 3.44%/hour. Fifty-eight bags/sample were ruminally incubated in each animal and frozen. Eight bags/sample were used to measure ruminal digestibility, the remaining 50 bags/sample were thawed and prepared for duodenal insertion. To simulate abomasal digestion, bags were incubated in a pepsin and HCl solution (1 g pepsin/L of 0.01 N HCl) at 37°C for 3 hours. Fourteen bags were inserted daily into the duodenum and subsequently frozen after being recovered in the feces. After intestinal incubation, the ruminally incubated bags and intestinally incubated bags were thawed and machine rinsed along with four bags/sample that were not incubated. The nonincubated bags were used to determine the percentage residue that was washed out without incubation. Residue from twenty bags was composited within animal for the intestinal samples to determine degradable intake protein, undegradable intake protein digestibility, and starch digestibility.

Results

Particle size analysis indicated there were differences among hybrids and processing methods for geometric mean diameter (GMD), and geometric standard deviation (GSD). The GMD was greater ($P < 0.01$) for DRC compared to HMC (2193 μ and 1184 μ, respectively). The differences among processing methods for GMD are comparable to true masticated samples with HMC having a smaller GMD than DRC. Hybrid 2 had the largest GMD, followed by hybrids 1 and 3. There was no attempt to change the particle size among hybrids by altering the knives on the mill. The percent washout for the 0 h samples were 2.4 times greater ($P < 0.01$) for HMC compared to DRC (data not shown). The percent washout for hybrids 1 and 3 were approximately 50% greater ($P = 0.01$) than hybrid 2. There was an inverse relationship (r = -0.94) between GMD and % washout. As the GMD increased, the percent of sample washed out of the bag decreased due to less surface area of the endosperm exposed.

Table 1. Effect of corn hybrid and processing method on nutrient digestibility and particle size.

	Dietary Treatment[a]									
	DRC			HMC				*P*-value[c]		
Item	1	2	3	1	2	3	SEM[b]	Process	Hybrid	Inter
Dry Matter Digestibility										
Ruminal	51.3	44.2	49.8	64.7	59.8	68.7	4.9	< 0.01	0.01	0.54
Postruminal[d]	76.3^{gh}	71.9^{f}	74.9^{g}	74.8^{g}	77.9^{h}	71.9^{f}	1.1	0.49	0.02	< 0.01
Total-tract	88.5^{h}	84.3^{f}	87.4^{g}	91.0^{i}	91.0^{i}	91.4^{i}	0.5	< 0.01	< 0.01	< 0.01
Starch Digestibility										
Ruminal	56.1	44.8	52.3	68.9	66.0	75.2	1.7	< 0.01	0.48	0.85
Postruminal[d]	93.6	91.0	93.1	97.0	93.7	96.1	2.6	< 0.01	< 0.01	0.99
Total-tract	97.1	95.1	96.7	99.0	97.7	99.0	0.3	< 0.01	< 0.01	0.52
Protein Digestibility										
DIP (%CP)	57.0	49.1	56.5	72.8	68.0	74.6	4.9	< 0.01	0.12	0.90
UIP (%CP)	43.0	50.9	43.5	27.2	32.0	25.4	4.9	< 0.01	0.12	0.90
Total-tract CP	90.5^{gh}	84.2^{f}	88.6^{g}	94.0^{i}	92.7^{hi}	94.2^{i}	1.2	< 0.01	<0.01	0.02
UI*P* Digestibility[d]	78.2	69.0	73.8	80.1	76.7	76.5	3.0	0.03	0.02	0.35
Particle Size[e]										
GMD	2184	2648	1747	1131	1380	1039	143	< 0.01	< 0.01	0.08
GSD	2.98	2.43	3.42	4.73	4.34	4.89	0.14	< 0.01	< 0.01	0.16

[a]Hybrids consisted of Golden Harvest H-8562 (1), Pioneer 33P67 (2), and Golden Harvest H-9230Bt (3); processed as dry-rolled corn (DRC) or high-moisture corn (HMC).
[b]SEM = Standard error of the mean for the hybrid by processing method interaction.
[c]Process = Main effects of dry-rolling versus high-moisture ensiling; Hybrid = main effect of hybrid; Inter = interaction of processing method and hybrid.
[d]Postruminal digestibility expressed as a percent entering the duodenum.
[e]GMD= Geometric mean diameter, GSD = geometric standard deviation.
[f,g,h,i]Significant hybrid by processing method interaction. Means within row with unlike superscripts differ ($P < 0.05$).

Dry-matter digestibility

Ruminal dry-matter digestibility (RDMD) was influenced by both hybrid and processing method. The RDMD for HMC was 33% greater compared to DRC. Ruminal DMD for hybrids 1 and 3 were greater compared to hybrid 2. A significant hybrid by processing method interaction existed for postruminal DMD expressed as a percent entering the duodenum. Postruminal DMD for hybrids 1 and 3 processed as DRC were greater compared to hybrid 2. When processed as HMC, postruminal digestibility was greater for hybrid 2 compared to hybrids 1 and 3. A greater postruminal DMD for hybrids 1 and 3 processed as DRC might be due to simply less residue entering the duodenum because of a greater ruminal DMD for these hybrids. However, this does not account for the differences among hybrids when processed as HMC. One explanation might be that after a greater extent of RDMD for HMC, the residue inserted into the duodenum is less digestible. A hybrid by processing method interaction also existed for total-tract DMD. When processed as DRC, DMD for hybrid 1 was 1% greater ($P < 0.01$) than hybrid 3, and 5% greater than hybrid 2. However, when processed as HMC there were no differences among hybrids. Ruminal DMD trends were similar to total tract DMD, but not statistically different due to the smaller number of bags used for ruminal DMD (n = 8) compared to total-tract DMD (n = 50).

Starch digestibility

There were no differences among hybrids for ruminal starch digestibility (SD). Ruminal SD was 37% greater for HMC compared to DRC (70.1, and 51.1%, respectively). Postruminal SD was greater for hybrids 1 and 3 compared to hybrid 2. Total-tract SD was also greater for hybrids 1 and 3 compared to hybrid 2. Postruminal and total-tract SD were also greater ($P < 0.01$) for HMC compared toDRC. Because starch is more digestible than the total residue entering the duodenum for postruminal DMD, postruminal SD (expressed as a percentage entering duodenum) is greater for samples that are digested more in the rumen.

Protein digestibility

Degradable intake protein (DIP) was greater for HMC samples compared to DRC similar to results found in a previous study (*2005 Nebraska Beef Report, pp.31*). Undegradable intake protein digestibility was greater for HMC compared to DRC (77.8 and 73.7%, respectively). Digestible UI*P* among hybrids was greatest for hybrid 1, intermediate for hybrid 3, and lowest for hybrid 2. A hybrid by processing method interaction also existed for total-tract C*P* digestibility. Total-tract C*P* digestibility was greater for hybrids 1 and 3 processed as HMC compared to hybrid 2. Crude protein digestibility for hybrid 2 processed as HMC was similar to hybrid 1 processed as DRC. When processed as DRC, total-tract C*P* digestibility was lowest for hybrid 2, intermediate for hybrid 3, and greatest for hybrid 1.

The values presented are not absolute values but do show relative differences for nutrient digestibility among hybrids and processing methods. The lower UIP digestibility for DRC may have an impact on metabolizable protein due to a greater proportion of UIP for DRC compared to HMC. Differences among processing methods and hybrids exist for site and extent of nutrient digestibility.

[1] Matt Luebbe, research technician; Galen Erickson, assistant professor; Terry Klopfenstein, professor, Animal Science, Lincoln; Wayne Fithian, agronomy systems manager, Golden Harvest Seed Co., Waterloo, Neb.