Literature Cited

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Buffers and High Moisture Corn Digestion

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Story in Brief

High moisture corn (HMC) of two moisture levels, 23 and 30 percent, with added dolomitic limestone, bentonite, Liquid Trace Mineral or sodium bicarbonate were fed to 20 steers. Digestibility of the wetter HMC was higher, largely due to greater starch availability. Intakes and feed efficiencies were slightly greater with wetter HMC. One additive, dolomitic limestone, elevated fecal pH, but with a calcium level at 0.45 of the ration, no added materials improved digestibility of starch, dry matter or protein. A low calcium level, 0.36 percent, may reduce dry matter and starch digestibility. Elevating fecal pH from 6.2 to 6.9 with added buffers did not increase digestibility of starch from high moisture corn.

Introduction

The recent symposium on High Moisture Corn Research (High Moisture Corn Conference, 1976) indicated that nutritive value of high moisture corn (HMC) may vary with moisture content. A higher moisture level (26-30 percent) is generally used more efficiently by feedlot steers than drier HMC. Greater starch digestibility in the rumen and intestines may be responsible.

Work from Purdue University (Wheeler and Noller, 1976) has suggested that digestibility of starch in the intestine of cattle is inhibited by acid, and that added buffers aid in digestion of starch. Acidity of feces generally paralleled the amount of starch present in feces.

The objective of this study was to examine the influence of 5 diet additives on starch and dry matter digestibility of HMC of two moisture contents when fed to steers. Efficiency of feed use was also monitored.

Materials and Methods

Ten Angus steers averaging 870 lbs were fed each of 2 HMC. The wetter HMC contained 30.3 percent moisture and the drier HMC analyzed 23.4 percent moisture. Further composition is shown in Table 1. Mixtures of the HMC-cottonseed hull-bufferred supplement (Tables 2 and 3) were fed *ad libitum* for 10 day periods with chromic oxide, an indigestible marker, included the final 7 days. Steers were rotated among buffer treatments within a corn moisture level. On day 10 of each period, steers were weighed and fecal samples were obtained from each of the 20 steers. Determinations on feces and on feed samples included pH, starch, dry matter, chromium, protein and ash. By relating level of the indigestible added chromium in feed to its level in feces, digestibilities of starch, dry matter, protein, ash and organic matter were calculated.

Table 1. Corn analyses

Corn	Wetter	Drier
Moisture	30.3	23.4
Protein, % of dry matter	8.96	8.87
Soluble N, % of total N	50.2	17.0

Table 2. Ration composition, percent of dry matter

Item	%
High moisture corn	80.6
Cottonseed hulls	10.0
Supplement	9.4

Results and Discussion

HMC moisture level

Fecal pH was markedly lower with the drier HMC (Table 4). Also starch content was almost tripled in feces from steers fed the drier HMC as compared with steers fed the wetter HMC. In an earlier trial in this publication (Thornton *et al.*, Rumensin and Digestibility of Feedlot Rations) these same steers produced feces from a whole corn-rumensin-supplemental ration containing 12.2 percent starch. Heifers in a local feedlot fed a whole corn ration averaged 19.4 percent starch in feces. Ash content also indicates lower digestibility of the drier HMC. Digestibility of dry matter and starch (Table 5) proved lower with the drier corn, but protein digestibility was unchanged. Lower starch digestion and lower fecal pH would suggest that some relationship exists, and elevating fecal pH may aid digestion.

Performance over the trial is shown in Table 6. Intakes and performance certainly were below that observed in feedlots. This may be due to the close confinement conditions or to the small mature size of the Angus steers used in this trial. Intakes, performance and feed efficiency tended to favor the wetter HMC. Calculated metabolizable energy was over 5 percent greater and digestibility about 3 percent greater for the wetter HMC than the drier HMC. Slightly greater energy loss during drying also would be expected with the

wetter HMC. Results suggest that HMC containing 30 percent moisture is 3 to 5 percent more useful for feedlot steers than HMC at 23 percent moisture. Fermentation and vaporization losses may be slightly greater, but oxidation loss should be less with 30 percent moisture corn.

Visually, the drier HMC is bright, floury and dusty. The wetter HMC is brown-orange to gray and more sour. Its high soluble nitrogen level has been criticized in the past, but performance and digestibility results of this trial indicate more value from the wetter HMC. Whether water addition to drier

Table 3. Supplement compositions, as percent of total ration

Ration	Lime	Dolo lime	Bent.	LTM	Sodium bicarb	Low Lime
Soybean meal	4.3	4.2	4.2	4.2	4.2	4.3
Alfalfa meal	.83	.82	.81	1.06	.81	.83
KCl	.12	.12	.12	.12	.12	.12
TM Salt	.24	.24	.24	.24	.24	.24
Vit A & D	+	+	+	+	+	+
Rumensin	+	+	+	+	+	+
Limestone	1.23	0	1.20	1.20	1.20	.90
Dolomite	- - - -	1.90	- - - -	- - - -	- - - -	- - - -
Bentonite	- - - -	- - - -	1.99	- - - -	- - - -	- - - -
LTM	- - - -	- - - -	- - - -	.075	- - - -	- - - -
Bicarbonate	- - - -	- - - -	- - - -	- - - -	1.50	- - - -
Ground corn	2.62	2.03	.85	2.70	1.28	2.93
Ration analyses						
N, %	1.61	1.57	1.57	1.60	1.59	1.59
Ca, %	.47	.44	.46	.49	.46	.36

Table 4. Intakes and composition of feces from steers fed HMC

Corn moisture, %	30.3	23.4
pH	6.75[a]	6.31[b]
Starch[c]	6.7[a]	17.7[b]
Ash[c]	10.6[a]	8.8[b]

[ab]Means with different superscripts differ statistically (P<.01).
[c]As percentage of dry matter.

Table 5. Digestibility of ration nutrients from HMC rations

Corn moisture, %	30.3	23.4
Dry matter, %	78.2[a]	76.1[b]
Starch, %	97.3[c]	92.2[d]
Protein, %	67.4	66.1

[ab]Means with different superscripts differ statistically (P<.10).
[cd]Means with different superscripts differ statistically (P<.01).

Table 6. Performance[a] of steers fed HMC rations

Corn moisture, %	30.3	23.4
Intake, lbs. dry matter	14.6	14.3
Daily gain, lbs.	2.41	2.12
Feed/gain	6.41	7.02

[a]Averaged over 51 day trial.

corn or reconstitution can restore starch availability to a level equal to that of corn grain harvested at a higher moisture level is not certain.

Buffer additions

The level of calcium in all rations (except the low lime ration) was 0.44 percent or above. This is similar to feedlot rations used in the Great Plains. The "low lime" ration contained 0.36 percent calcium, considerably above the estimated requirement of 0.28 percent stated by the NRC. Dolomitic limestone level (1.90 percent of diet) provided an equal level of calcium as the limestone ration (1.23 percent supplemental limestone). Bentonite, liquid trace mineral and sodium bicarbonate were added to the limestone supplemented ration. Additives were included at recommended levels; results may not apply to other additive levels, other basal calcium levels or other feedstuffs.

Feed intakes were not statistically altered by treatments (Table 7). Fecal pH was consistently elevated by dolomitic limestone addition. This has been noted with dairy cattle previously (Wheeler and Noller, 1976). The lowest fecal pH was with the low limestone ration. Fecal starch concentration was not influenced by treatment. The treatment that produced feces with the highest pH had the third highest fecal starch content. This fact questions whether starch digestion can be altered by modifying fecal pH through feed additives.

Fecal ash content was higher with dolomitic limestone and bentonite additions. Of the minerals added beyond limestone, virtually none (6 and 4 percent) of the added dolomitic limestone and bentonite was absorbed. The dolomitic limestone buffered fecal pH, but the bentonite did not. Sodium bicarbonate may have buffered rumen pH, it would not appear in feces due to release of CO_2 and absorption of the sodium.

Digestibility of dry matter and starch were slightly higher with limestone alone than with further additives. The low limestone seemed especially low, suggesting that digestibility may be enhanced by feeding limestone at levels to exceed the NRC requirement. Protein digestibility also was low for the low limestone ration. Bentonite previously has been shown to complex with ammonia and depress apparent protein digestion. None of the tested additives improved starch or protein availability when added to a 0.45 percent calcium feedlot ration. Dolomitic limestone increased pH of feces but did not improve starch digestion. At lower diet calcium levels or fecal pH, effects of pH on starch digestion may be found.

Averaged within treatments, starch content of feces increased an average of 3 percent for every 1 unit drop in pH. The scatter of points was large, but the relationship was negative in all but one of the 12 corn-buffer combinations. This suggests a definite relationship of fecal pH and starch content, but failure of buffers to alter the two together questions whether this is a cause-effect relationship.

Table 7. Buffer additions, intake and feces composition

Additive	Lime	Dolo. lime	Bent.	LTM	Sodium bicarb	Low lime
Feed intake, lb dry matter	14.2	15.1	14.0	15.0	13.9	14.4
Fecal pH	6.54[b]	6.79[c]	6.55[b]	6.58[b]	6.53[b]	6.19[a]
Fecal starch, %	11.8	12.4	9.6	12.9	14.6	11.8
Fecal ash, %	8.5[a]	10.5[b]	14.6[c]	8.7[ab]	7.8[a]	8.0[a]

[abc]Means with different superscripts, differ statistically (P<.05).

Table 8. Buffer additions and digestibility

Additive	Lime	Dolo. lime	Bent.	LTM	Sodium bicarb.	Low lime
Dry matter, %	80.2	77.7	74.4	77.2	76.7	76.3
Starch, %	95.6	94.7	95.5	94.3	93.6	94.8
Protein, %	71.8[c]	66.0[ab]	62.6[a]	68.6[bc]	67.7[abc]	63.9[ab]

[abc]Means with different superscripts, differ statistically (P< .05).

Casual observation of fecal starch content with feed intake of individual steers revealed that within a corn-additive combination, high intakes markedly increased fecal starch. Additives or feeding systems which cause cattle to nibble rather than engorge feed and to reduce wide swings in feed intake should improve starch digestibility.

Literature Cited

Wheeler, W. E., and C. H. Noller. 1976. Limestone buffers in complete mixed rations for dairy cattle. J. Dairy Sci. 59:1788-1793.