January 2001

Effect of Corn Processing on Degradable Intake Protein Requirement of Finishing Cattle

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- 5.2293) was not displayed because it was not visually distinguishable from the 5,000-head feedyard line. Corn price at which SFC breaks even with DRC can be determined by setting y equal to zero and solving for x. For a 5,000-head feedyard, corn price would need to be at least $67.91/ton ($1.90/bu) in order for SFC to break even with DRC. For a 20,000-head feedyard, corn price would need to be at least $65.37/ton ($1.83/bu) for SFC to break even with DRC. At 10-year average commodity corn price for Nebraska ($2.48/bu; $88.57/ton), SFC would return $30,167 per year above DRC ($1.65/ton on 18,250 ton/year) in a 5,000-head feedyard. In a 20,000-head feedyard, SFC would return $135,510 per year above DRC ($1.86/ton on 73,000 ton/year). These calculations assume 100% capacity, 20 lb/day corn intake (15% moisture basis) and do not account for differences in shrink, moisture appreciation, or labor between DRC and SFC.

Economics of HMC are greatly dependent on the magnitude of discount at which it is purchased compared to dry corn. Clearly, the largest cost associated with HMC is the initial investment in a concrete bunker. High-moisture corn can be economically attractive to a feedyard if the discount at which it is purchased is greater than additional processing costs, shrink and interest above DRC. This probably varies somewhat from feedyard to feedyard. Economics of SFC appear to be more clearly defined given assumptions made in this report. Economics of SFC are highly dependent on commodity corn price, but appear to breakeven at a corn price well below the 10-year average, even in a relatively small 5,000-head feedyard.

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Degradable intake protein requirement of finishing cattle is affected by method of corn processing and presumably rate and extent of ruminal starch fermentation.

Summary

Three finishing trials were conducted to determine effect of corn processing on degradable intake protein requirement of feedlot cattle. Finishing diets consisted of 82% processed corn which was either dry rolled, high moisture, or steam flaked. Degradable intake protein levels were achieved by adding 0 to 2.0% urea (DM basis) to the control diets. Estimates of degradable intake protein requirement for a dry-rolled corn-based diet were approximately 6.3% of dietary DM. Degradable intake protein requirement for high-moisture corn-based diets was approximately 10% of dietary DM. Degradable intake protein requirement for steam-flaked corn-based diet was between 7 and 9.5% of dietary DM.

Introduction

Degradable intake protein (DIP) is the fraction of feed crude protein which is available to the microbial population. In typical diets for finishing cattle, DIP is composed of both degradable true protein and non-protein nitrogen. A deficiency in DIP would have two effects. First, DIP deficiency would lower microbial crude protein production, possibly resulting in metabolizable protein (MP) deficiency if sufficient UIP was not supplemented. Second, DIP deficiency would reduce energy yield from carbohydrate fermentation, thereby lowering volatile fatty acid production and energetic efficiency of the diet. Therefore, a deficiency in DIP may lead to reduced finishing performance even when the animal's metabolizable protein requirement has been met.

Level 1 of the 1996 NRC model predicts that DIP requirement for a typical dry-rolled corn-based finishing diet is approximately 6.8% of dietary DM. Few data exist that directly evaluate the effect of corn processing on DIP requirement. Average ruminal starch digestibilities of 78, 89 and 83% for dry-rolled, high-moisture and steam-flaked corn have been reported. It is our hypothesis that grain processing methods which increase rate and extent of starch fermentation may increase the dietary DIP requirement relative to dry-rolled corn. Objectives of these experiments were to determine DIP requirements of finishing cattle fed dry-rolled, high-moisture and steam-flaked corn-based finishing diets.

Procedure

Trial 1

Two hundred and fifty-two crossbred yearling steers (834 lb) were used in a randomized complete block design to determine DIP requirement of finishing steers fed a high-moisture corn-based diet. Steers were split into three initial weight blocks and randomly assigned to one of 12 pens and to one of four dietary treatments (21 steers per pen, 3 pens per treatment). Dietary treatments consisted of four levels of dietary DIP that were accomplished by adding 0, .4, .8, or 1.2% urea to the base diet (DM basis).

High-moisture corn-based finishing diet (HMC) is shown in Table 1, while dietary crude protein and DIP values are shown in Table 2. High-moisture corn was harvested at approximately 29% moisture, processed through a rollermill, and stored in a covered concrete bunker. Steers were adapted to finishing diet in 21 days using alfalfa hay to replace high-moisture corn (50% alfalfa for 3 days, 40% of 4 days, 30% for 7 days, and 20% for 7 days, DM basis). Cottonseed hulls were only included in the finishing diet.

Steers were weighed initially on two consecutive days after being limit-fed at 2% of body weight for 5 days in order to minimize differences in gut fill. Steers were implanted with Synovex Plus on day 1 and fed for 108 days. Final weights were calculated using hot carcass weights adjusted to a common dress (63%). Data were analyzed using linear, quadratic and cubic contrasts. Nonlinear analysis of feed/gain was used to predict the DIP requirement.

Trial 2

Two hundred and sixty-four cross-bred yearling steers (781 lb) were used in a completely randomized design to determine DIP requirement of finishing steers fed a steam-flaked corn-based diet. Steers were stratified by initial weight to one of 24 pens (11 steers per pen). Pens were randomly assigned to one of six dietary treatments (4 pens per treatment). Treatments consisted of six levels of dietary DIP which were accomplished by adding 0, .4, .8, 1.2, 1.6, or 2.0% urea to the base diet (DM basis). Steam-flaked corn-based finishing diet (SFC) is shown in Table 1, while dietary crude protein and DIP values are shown in Table 3. Steam-flaked corn was processed to a flake density of 29 lb/bushel at a commercial feedlot facility and hauled to the research feedlot on a weekly basis. Steers were adapted to finishing diet in 21 days using alfalfa hay to replace steam-flaked corn (40% alfalfa for three days, 30% of four days, 20% for seven days and 10% for seven days, DM basis). Cottonseed hulls were included at 5% of DM in all diets.

Steers were weighed initially on two consecutive days after being limit-fed at 2% of body weight for five days to minimize differences in gut fill. Steers were implanted with Synovex C on day 1, reimplanted with Revalor S on day 47 and fed for a total of 129 days. Final weights were calculated using hot carcass weights adjusted to a common dress (63%). Data were analyzed using linear, quadratic and cubic contrasts. Nonlinear analysis of feed/gain was used to predict the DIP requirement.

Trial 3

Ninety crossbred yearling steers (612 lb) were used in a completely randomized design with a 3 x 5 factorial treatment structure to evaluate effect of corn processing on DIP requirement of finishing cattle. Steers were randomly assigned to one of three finishing diets which were based on DRC, HMC, or SFC (Table 1). Within each diet, steers were randomly assigned to five levels of dietary DIP which were accomplished by adding 0, .5, 1.0, 1.5, or 2.0% urea to the base diet (DM basis). Dietary CP and DIP values are shown in Table 4. High-moisture corn and steam-flaked corn were similar to Trials 1 and 2, respectively, while dry-rolled corn was processed so that particle size was as coarse as possible with relatively few whole kernels passing through the rolls. Ideally, kernels were broken into approximately four pieces.

Steers were individually fed using Calan electronic gates. Steers were adapted to their respective finishing diet over an approximately 21-day period. Steers were offered their respective finishing diet on day 1 at 1.8% of body weight (DM basis). Feed offered then was increased .5 lb per day (DM basis) until steers were ad libitum. Steers were weighed initially on three consecutive days after being limit-fed at 2.0% of body weight for five days in order to minimize differences in gut fill. Steers were implanted with Synovex C on day 1, reimplanted with Synovex Plus on day 67, and fed for a total of 167 days. Final weights were calculated using hot carcass weights adjusted to a common dress (63%). Data were analyzed using Least Significance Difference method and linear, quadratic and cubic contrasts. Nonlinear analyses of feed/gain were used to predict DIP requirements.

Table 1. Composition of finishing diets (% of DM).

| | Diet[a] | | |
Ingredient	DRC	HMC	SFC
Dry-rolled corn	82.0	—	—
High-moisture corn	—	82.0	—
Steam-flaked corn	—	—	82.0
Alfalfa hay	5.0	5.0	5.0
Cottonseed hulls	5.0	5.0	5.0
Molasses	3.0	3.0	3.0
Dry supplement[b]	5.0	5.0	5.0

[a]DRC = dry-rolled corn, HMC = high-moisture corn, SFC = steam-flaked corn.
[b]All diets supplemented to contain a minimum of .7% Ca, .28% P, .6% K, and .15% S (DM basis). All diets contained 27 g/ton Rumensin and 10 g/ton Tylan (DM basis).

Table 2. Dietary protein composition and finishing performance for high moisture corn-based diet (Trial 1).

| | Treatment | | | | |
Urea, % of DM	0	.4	.8	1.2	SEM
Crude protein, % of DM[a]	10.7	11.9	13.0	14.2	—
DIP, % of DM[a]	7.1	8.2	9.4	10.6	—
DIP balance, g/day	-19	122	262	403	—
MP balance, g/day	78	90	90	90	—
DM intake, lb	27.0	26.7	26.6	26.7	.2
Daily gain, lb[b]	3.75	3.77	4.01	4.08	.07
Feed/gain[b]	7.19	7.09	6.62	6.54	.19
Fat depth, in[c]	.35	.39	.39	.42	.02
Marbling score[bd]	523	507	502	493	8

[a]Based on NRC tabular values.
[b]Linear (P < .03).
[c]Linear (P = .06).
[d]400 = Traces 0, 500 = Small 0, 600 = Modest 0.

Results

Trial 1

Effects of DIP level on performance of finishing steers fed a high-moisture corn-based diet are shown in Table 2. Dry matter intake was not affected (P = .75) by dietary DIP and averaged 26.8 lb/day. However, both average daily gain and feed/gain improved linearly (P < .03) as dietary DIP increased. Non-linear analysis of feed/gain predicted that the DIP requirement would be met by 1.1% urea (95% confidence interval was from 1.0 to 2.2%), which would provide a dietary DIP level of 10.2%. We hypothesized that DIP requirement for a high-moisture corn-based diet would be greater than 7.1% of dietary DM as predicted by 1996 NRC. However, we did not expect the requirement to be as high as 10.2% of dietary DM. This level of DIP is greater than is commonly fed in high moisture corn-based diets.

Trial 2

Effect of DIP level on performance of finishing steers fed a steam-flaked corn-based diet are shown in Table 3. Dry matter intake responded quadratically (P = .01) as dietary DIP increased. In addition, average daily gain and feed/gain also responded quadratically (P < .0001) as dietary DIP increased. Nonlinear analysis of feed/gain predicted a breakpoint at .8% urea (95% confidence interval was .79 to .88%). This dietary urea concentration would provide a dietary DIP value of approximately 7.1%. Level 1 of 1996 NRC model predicted that the DIP requirement would be met at 7.1% of DM.

Trial 3

Effects of DIP level on performance of finishing steers fed dry-rolled, high-moisture, and steam-flaked corn-based diets are shown in Table 4. Processing method x urea level interactions were found (P < .01) for DM intake and daily gain. Simple effects for feed/gain are also shown in Table 4, although no interaction was noted (P = .34). For DRC, dry matter intake (P = .08) and average daily

gain (P = .03) responded linearly with DIP level. However, feed/gain was not affected (P > .50) by DIP level. Nonlinear analysis of feed/gain did not predict a breakpoint suggesting that the DIP requirement was met by the first increment of urea.

In the HMC diet, dry matter intake was not affected (P > .10), while average daily gain responded cubically (P = .03) with DIP level. Feed/gain was not af-

fected (P > .10). Nonlinear analysis of feed/gain predicted a breakpoint at 1.1% urea. This level of urea suggests that dietary DIP requirement for HMC is approximately 10% of dietary DM, which agrees well with results from Trial 1.

In the SFC diet, dry matter intake and average daily gain responded quadratically (P < .001) with DIP level. Feed/gain responded linearly (P = .007) with DIP level. Nonlinear analysis of feed/

Table 3. Dietary protein composition and finishing performance for steam flaked corn-based diet (Trial 2).

| | Treatment | | | | | | |
Urea, % of DM	0	.4	.8	1.2	1.6	2.0	SEM
Crude protein, % of DM[a]	9.5	10.6	11.8	13.0	14.1	15.3	—
DIP, % of DM[a]	4.7	5.8	7.0	8.2	9.3	10.5	—
DIP balance, g/day	-264	-135	-6	123	251	380	—
MP balance, g/day	-107	-24	58	62	62	62	—
DM intake, lb[b]	22.6	23.8	24.3	24.3	24.8	24.1	.4
Daily gain, lb[c]	3.17	3.82	4.40	4.40	4.44	4.48	.10
Feed/gain[c]	7.11	6.22	5.53	5.53	5.57	5.37	.19
Fat depth, in[d]	.37	.47	.51	.49	.51	.50	.02
Marbling score[de]	479	520	532	504	519	511	13

[a]Based on NRC tabular values.
[b]Quadratic (P = .01).
[c]Quadratic (P < .001).
[d]Quadratic (P < .10).
[e]400 = Traces 0, 500 = Small 0, 600 = Modest 0.

Table 4. Dietary protein composition and finishing performance for Trial 3[a].

| | Treatment | | | | | |
Urea, % of DM	0	.5	1.0	1.5	2.0	SEM
Crude protein, % of DM[b]	9.5	10.9	12.4	13.8	15.3	—
DIP, % of DM[b]						
DRC	4.8	6.3	7.7	9.2	10.6	—
HMC	6.7	8.1	9.6	11.0	12.5	—
SFC	4.7	6.1	7.6	9.0	10.5	—
DM intake, lb/day						
DRC	21.8[c]	21.1	21.9	23.4	22.8[c]	.8
HMC	23.0[c]	21.1	21.4	21.8	20.8[d]	.8
SFC[f]	17.8[d]	22.3	20.8	21.9	18.7[e]	.8
Daily gain, lb/day						
DRC[g]	3.39[c]	3.61[cd]	3.38[c]	3.96	3.70[c]	.14
HMC[h]	3.70[c]	3.45[c]	3.51[cd]	3.75	3.32[d]	.14
SFC[f]	2.99[d]	3.79[d]	3.72[d]	4.07	3.45[cd]	.14
Feed/gain						
DRC	6.41	5.81	6.49[c]	5.88[c]	6.17[c]	.22
HMC	6.21	6.13	6.06[cd]	5.81[cd]	6.25[c]	.22
SFC[g]	5.95	5.85	5.59[d]	5.38[d]	5.38[d]	.22
Fat depth, in	.42	.45	.45	.53	.43	.03
Marbling score[i]	511	530	519	535	501	13

[a]DRC = dry-rolled corn, HMC = high-moisture corn, SFC = steam-flaked corn.
[b]Based on NRC tabular values.
[cde]Means with unlike superscript within column differ (P < .10).
[f]Quadratic effect of urea level (P < .05).
[g]Linear effect of urea level (P < .05).
[h]Cubic effect of urea level (P < .05).
[i]500 = Small 0, 600 = Modest 0.

gain predicted a breakpoint at 1.6% urea (95% confidence interval was 1.55 to 1.66%). This level of urea suggests that dietary DIP requirement for SFC-based diet is approximately 9.5% of dietary DM.

Degradable intake protein requirement for DRC-based diets could not be determined by nonlinear analysis because the first increment of urea provided the best feed/gain. This suggests that the DIP requirement for the DRC-based diet was met at 6.3% of dietary DM. Degradable intake protein requirement for HMC was consistent between Trials 1 and 3 (approximately 10% of dietary DM) and considerably higher than predicted level (7.1% of DM). The greater DIP requirement for HMC is most likely due to greater rate and extent of starch fermentation with HMC compared to DRC. Degradable intake protein requirement for SFC was the same as predicted in Trial 2 (7.1% of DM), but higher in Trial 3 (9.5% of DM). Reasons for differences in estimated DIP requirement for a SFC-based diet are not clear, but may be due to differences in initial weight, intake, and/or method of grain adaptation.

Our results suggest that the average dietary DIP requirements for DRC, HMC, and SFC-based diets are 6.3, 10.0, and 8.3% of DM, respectively. These dietary DIP requirements are highly related to ruminal starch digestibilities reported in literature (78, 89, and 83% for DRC, HMC, and SFC, respectively). Level 1 of the NRC (1996) accurately predicts the DIP requirement for a DRC-based diet. However, DIP requirements for HMC and SFC-based diets are underestimated because Level 1 of the NRC does not account for differences in ruminal starch digestion. Level 2 of the NRC (1996) accounts for differences in ruminal starch digestion, and therefore, may more accurately predict DIP requirements for HMC and SFC-based diets.

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High Moisture and Dry-Rolled High-Oil Corn for Finishing Feedlot Steers

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When fed in the dry rolled form, high-oil corn improved feed efficiency over normal corn. However, high-oil corn did not improve efficiency over normal corn when fed in the high moisture form.

Summary

Finishing steers fed diets containing dry-rolled high-oil corn had a 2.5% reduction in dry matter intake and 4.2% better feed efficiency than steers fed diets containing dry-rolled normal corn. Hot carcass weight, dressing percent, liver abscess score, rib fat thickness, marbling score and yield grade did not differ among treatments. Steers fed high-moisture high-oil corn had larger ribeye area and greater percent kidney, pelvic and heart fat than steers fed high moisture normal corn. No differences in performance or efficiency were detected from substituting high-oil high moisture corn for normal high moisture corn.

Introduction

Nutritionally modified grain varieties, such as "high-oil" (HO) corn, have been developed that may improve efficiency of livestock production. Higher oil content of grain increases energy density of the diet and aids in dust control. However, the ideal management systems (processing method; fat, ionophore, mineral supplementation) for nutritionally modified grains may differ from those ideal for normal grain. For example, South Dakota State University researchers detected a processing by corn type interaction between normal and high-oil corn. Dry matter intakes and gains were 5 to 10% greater for steers fed rolled HO corn than steers fed whole HO corn. These results indicate that HO corn may need to be processed prior to feeding to finishing beef cattle. To date, no information has been published on HO corn harvested, stored and fed as high moisture grain to feedlot cattle. The objective of this study was to evaluate high-oil corn versus normal corn when fed as dry-rolled or high moisture grain to finishing feedlot steers.

Procedure

In separate locations, normal (N) and high-oil (HO) corn varieties were planted at the University of Nebraska, Northeast Research and Extension Center in Concord, Neb. Varieties were harvested as both high-moisture (HM) and as dry corn. At harvest each load of corn was sampled and analyzed for DM content. High-oil and normal high moisture corn were harvested at 28 % DM. Corn harvested as HM grain was rolled and stored in two separate bunker silos. Dry corn (D) was coarsely rolled prior to feeding.

Three hundred eighty British x continental crossbred steers were purchased in early November 1998 and were processed in mid- to late November. Processing included: weighing, implanting, tagging, vaccinating, and deworming. Weights at processing were used to divide the steers into light (LWG) and heavy (HWG) weight groups. On Dec. 7, the LWG again was weighed and sorted by weight into additional groups and placed into their respective trial pens on Dec. 8. Initial weight for the LWG was an average of full live weights taken on Dec. 7 and Dec. 8. The HWG was treated the same as the LWG, with full live weights taken