Programmed Feeding of Protein to Finishing Beef Steers

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Allen Trenkle, professor of animal science

Summary

Six-hundred pound Angus steer calves were fed corn-based finishing diets for 180 days to determine the effects of stepwise reduction of protein in the diet on performance and carcass characteristics. Reducing protein in the diet, but satisfying the requirements projected by the National Research Council model for Nutrient Requirements of Beef Cattle, did not affect performance or carcass measurements. Further reduction in protein content of the diet, so the projected requirement of the rumen microorganisms was not being met, did not affect performance or carcass measurements. It is concluded that quantity of protein fed to finishing cattle can be programmed and substantially reduced. These reductions will result in substantially less nitrogen excreted in manure from larger feedlots.

Introduction

The metabolizable protein model for beef cattle developed at Iowa State University in 1974 provided a method to formulate diets that would provide the protein required by the animal as well as the nitrogen needed by the rumen microorganisms. Protein required by the animal is a function of rate and composition of gain. Nitrogen required by the rumen microorganisms is related to the feed, amount of fermentable energy, and protein degraded in the rumen. The metabolizable protein model was modified in 1996 by the National Research Council (NRC) Committee on Nutrient Requirements for Beef Cattle to improve its precision with broader application. Introduction of the use of trenbolone acetate in implant programs for feedlot cattle resulted in a marked increase in growth rate, especially of muscle. This resulted in a dramatic change in protein required during the period immediately following implantation, and research showed that feedlot cattle would respond to feeding more protein than was generally recommended at the time (A.S. Leaflet R919, 1992). Use of the NRC model to evaluate diets indicates that early in the finishing period, when steers are adjusting to grain diets and still growing considerable lean tissue, corn-based diets have to be supplemented with preformed protein that will escape degradation in the rumen. However, after steers reach about 850 lbs. and are on full feed of a corn-based diet, supplementation with urea alone will provide adequate metabolizable protein. When steers weigh 950 – 1000 lbs., supplementing a corn-based diet with urea provides more metabolizable protein than required for growth and maintenance at that time. However, the model indicates that urea should continue to be fed at relatively high levels to provide adequate available nitrogen for the rumen microorganisms. At best, growing animals retain a small portion of dietary nitrogen in tissue growth. When protein is overfed, the excess is excreted and contributes to the environmental impact of animal production. The primary objective of this experiment was to determine if feeding protein to finishing beef cattle could be programmed to more closely meet required levels as steers progressed through the finishing period, thereby reducing the cost of protein supplementation and the environmental impact of beef cattle. A second objective was to determine if the requirement for rumminally available nitrogen as projected by the NRC model has to be fulfilled for cattle fed high-starch diets.

Materials and Methods

Three programs for feeding protein were studied in this experiment (Figure 1). One hundred and twenty Angus steer calves were purchased for this experiment. When the study was started, the average weight of the steers was 600 lbs. The steers were divided into 2 groups based on frame score calculated from measured height at the hips and days of age. Steers were randomly allotted from these 2 groups to 20 pens of 6 steers each. Four pens of cattle (2 of each frame score) were allotted to Program I and 8 pens (4 of each frame score) were allotted to Programs II and III. Program I started the cattle on a diet containing 13% crude protein, and then changed after 84 days to a diet containing 11.85% crude protein. Program II started the steers on the diet containing 13% crude protein, then changed to 11.85% at 84 days, then to 11.25% at 112 days. Program III started the cattle on 13% crude protein, then changed to 11.85% at 84 days, then to 10.0% at 112 days.

Program I started the steers, during Period A, on a diet providing metabolizable protein and ruminally degraded protein according to the 1996 NRC recommendations. When the protein was lowered to 11.85% during Period B, the diet continued to provide the recommended requirements for a period of time and then during Period C, provided excess metabolizable protein.

Program II reduced the protein again, at 112 days, to eliminate the overfeeding of metabolizable protein but to continue to provide recommended ruminally degraded protein during Period C.

Program III was planned to provide a greater reduction in the amount of protein fed during Period C, to provide metabolizable protein closer to the recommended requirement but resulting in underfeeding of ruminally degraded protein.

The diets are shown in Table 1. During Period A, appearance of the feces and behavior of the cattle indicated that the steers were not being fed adequate fiber; so at 84 days, the diets were modified by reducing corn silage and adding ground hay. Corn fed in this experiment was processed in a roller mill to a smaller particle size than usually fed at the research farm and probably reduced the effectiveness of the fiber in the corn. The mixed grass hay was ground through a 2-in. screen. The concentrate portion of the diets was prepared as a mix in a stationary horizontal mixer and weighed in a mixer wagon separately from the corn silage and ground hay. After mixing, total mixed diets were fed to the cattle twice per day. Periodic samples of the mixed diet, corn silage, hay, and corn grain were sampled to determine of dry matter and crude protein. The cattle were started on feed by gradually increasing the amount of feed offered, until their appetite was satisfied. If the amount of feed consumed decreased during the trial, they were offered less feed, and feed accumulated in the bunks was removed and sampled to determine dry matter before increasing the quantity of feed offered. The steers were fed an average of 180 days in this experiment. Feed removed from the bunks was sampled to determine dry matter.

The steers were implanted with Component E-S® at the start of the trial and reimplanted with Component TE-S® 84 days later (96 days prior to harvest). The steers were sold in 2 groups 4 days apart to facilitate collection of carcass data. Steers fed the 3 protein programs were equally represented in each sale group. Weights of hot carcasses were taken after slaughter, and measurements on the carcasses were obtained after 24-hr. postmortem chill. The federal grader called marbling; kidney, pelvic, and heart fat (KPH); and yield grades. Ribeyes between the 12th and 13th ribs on the left side of the carcass were photographed with a digital camera, and fat thickness and muscle area were measured from the digital image using a calibrated computer software program.

Pen means were used as the experimental unit in the statistical analysis. Data were analyzed by analysis of variance, with protein program as the treatment and frame score as a block. Standard error of the means and least significant differences were calculated.

Figure 1. Experimental design.

	Crude protein, % diet DM		
Program I	13.0	11.85	11.85
Program II	13.0	11.85	11.25
Program III	13.0	11.85	10.0
Period when fed, days	A, 1 to 84	B, 85 to 112	C, 113 to 180
Implanted	Yes	Yes	No

Table 1. Composition of diets (dry basis).

Item	Diet, % crude protein			
	13.0	11.85	11.25	10.0
Cracked corn	69.93	79.53	81.89	82.35
Corn silage	16.00	10.00	10.00	10.00
Chopped hay		5.00	5.00	5.00
Molasses	0.75	0.75	0.75	0.75
Soybean meal	11.80	2.52		
Urea		0.79	0.94	0.48
Limestone	1.10	0.88	0.88	0.88
Potassium chloride		0.11	0.11	0.11
Salt	0.30	0.30	0.30	0.30
Vitamin A[a]	0.08	0.08	0.08	0.08
Trace minerals	0.024	0.024	0.024	0.024
Rumensin®[b]	0.0195	0.0195	0.0195	0.0195
Elemental sulfur		0.025	0.030	0.015
MP ratio[c]	0.90	1.10	1.19	1.07
DP ratio[d]	1.05	1.00	0.96	0.80

[a]Provided 1,400 IU of vitamin A activity per pound of dry matter.
[b]Provided 15.6 mg sodium monensin per pound of dry matter.
[c]Metabolizable protein ratio is percentage of requirement from1996 NRC model.
[d]Degraded protein in the rumen ratio is the percentage of ruminal available nitrogen requirement from 1996 NRC model.

Results and Discussion

Performance over the entire experiment is summarized in Table 2. Steers fed Program I tended to gain more weight and be more efficient; however, this difference occurred during Periods A and B, when they were being fed the same diets as the steers in the other two programs. This difference is due to variability of experiments and random allotment of cattle to pens and treatments. In Program II, during Period C when dietary protein was reduced but kept adequate to meet the requirements of the animal as well as the rumen microorganisms, steers showed a gain similar to steers that continued to be fed the higher level of protein. In Program III, decreasing urea to provide 80% of the estimated bacterial requirement for degradable protein during Period C did not affect performance of the steers.

The results of this experiment do not provide an explanation for this observation, but the nitrogen requirement of rumen bacteria fermenting starch is more complex than the requirement of bacteria fermenting fiber. The starch-digesting bacteria require amino acids as well as ammonia. The 10% protein diet fed during Period C may have provided adequate amino acids and ammonia. Different studies will be required to explain this observation. The carcass measurements summarized in Table 3 indicate that reducing the protein in the diet during Period C had no effect on carcass measurements or grades.

It is a common practice to not change concentration of protein in diets of finishing cattle as they mature. Although there was not a treatment of continuous feeding of 13% crude protein in this study, the fact that performance of steers fed Program III was not different from the other programs suggests that feeding more protein would not have benefited these cattle. The reductions in quantity of nitrogen fed in Program II and Program III compared with Program I were 1.4 lbs. and 4.3 lbs. per steer, respectively, over the 180 days. This is not very significant for small feedlots, but it becomes significant for a 1000-head lot that might feed two groups per year, being equivalent to 3.1 tons of urea per year for Program II and 9.6 tons per year for Program III. If cattle do not respond to feeding more protein, the entire extra is excreted.

The results of this study suggest that it is probable that less protein can be fed to finishing cattle without affecting performance. However, the findings of this study need to be confirmed through additional studies and the requirement for ruminally available protein needs to be established for high concentrate diets before recommendations can be made for changing the amount of protein to feed finishing cattle.

Implications

The results of this study suggest that the amount of protein fed to finishing cattle can be reduced as the cattle mature without affecting performance or carcass value. The results also suggest that the requirement for ruminally degraded protein as estimated by the NRC model does not have to be completely satisfied when cattle are fed high-concentrate diets.

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Table 2. Performance of steer calves fed 3 protein programs.

	Program			
Item	I	II	III	SEM[a]
Overall, 1 to 180 days				
Starting wt., lbs.	601.4	608.9	604.8	4.44
Ending wt., lbs.	1217.1	1204.6	1207.0	9.26
Daily gain, lbs.	3.42	3.31	3.34	0.046
Feed DM per day, lbs.	17.7	18.0	18.0	0.26
Feed/gain	5.18[b]	5.43[c]	5.39[c]	0.061
Period A, 1 to 84 days				
Ending wt., lbs.	892.5	902.9	896.9	
Daily gain, lbs.	3.47	3.50	3.46	0.064
Feed DM per day, lbs.	14.4[b]	15.0[c]	14.8[b,c]	0.14
Feed/gain	4.16	4.30	4.29	0.086
Period B, 85–112 days				
Ending wt., lbs.	992.3	989.8	985.3	
Daily gain, lbs.	3.56	3.24	3.27	0.185
Feed DM per day, lbs.	19.2	20.3	20.0	0.58
Feed/gain	5.49	6.55	6.20	0.509
Period C, 113–180 days				
Daily gain, lbs.	3.30	3.16	3.26	0.103
Feed DM per day, lbs.	21.4	21.0	21.5	0.48
Feed/gain	6.56	6.66	6.61	0.222

[a]Standard error of the mean.
[b,c]Means with different superscripts are significantly different ($P < .05$).

Table 3. Carcass characteristics of steer calves fed 3 protein programs.

	Program			
Item	I	II	III	SEM[a]
Carcass wt., lbs.	749.8	738.5	739.2	5.32
Dressing percent	61.6	61.3	61.2	0.21
Fat thickness, in.	0.46	0.45	0.43	0.021
Ribeye area, sq in.	12.4	12.8	12.7	0.21
KPH, %	1.76	1.69	1.74	0.087
Marbling[b]	555	545	548	18.9
Carcass grades				
Percent Choice	27.3	22.9	16.7	
Percent Choice -	50.0	54.2	64.6	
Percent Select	22.7	20.8	18.7	
Percent Standard		2.1		
Percent Yield Grade 1		10.4	4.2	
Percent Yield Grade 2	68.2	58.3	72.9	
Percent Yield Grade 3	31.8	27.1	22.9	
Percent Yield Grade 4		4.2		
Percent Certified Angus Beef	22.7	22.9	16.7	
Calculated yield grade	2.78	2.69	2.66	0.772

[a]Standard error of mean.
[b]500 = Small^0, 400 = Slight^0