Feedlot Performance of Cattle Program Fed Supplemental Protein

A.S. Leaflet R1832

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Summary

One hundred sixty eight 12 to 13 month-old steers weighing 740 lbs were allotted to 28 pens. Seven pens were allotted to each of four programs for providing supplemental protein. The programs were I: Continuous supplementation with soybean meal (12.4% crude protein), II: Continuous supplementation with urea (11.7% crude protein), III: Feeding supplemental soybean meal (12.4% crude protein) and changing to urea supplementation (11.7% crude protein) at 42 days and IV: Feeding supplemental soybean meal (12.4% crude protein), changing to urea (11.7% crude protein) at 42 days followed by decreasing the concentration of supplemental urea (10% crude protein) at 84 days. During the first 42 days, Programs I, III and IV provided adequate metabolizable protein and ruminally available nitrogen and Program II provided adequate ruminally available nitrogen but inadequate metabolizable protein. During the period from 42 to 84 days all programs provided adequate ruminally available nitrogen and metabolizable protein in excess of requirement. Metabolizable protein was provided in greater excess during the final period of 84 to 135 days by Programs I, II and III. Program IV was designed to provide ruminally available nitrogen at 80% of predicted needs during the final stage of finishing. During the final period, Program IV provided metabolizable protein in excess of requirement but less than the other three programs. Steers fed the diet containing soybean meal during the first period gained more and were more efficient than those fed urea. There were no differences in performance among programs during the second and third periods. Overall steers fed soybean meal tended to have increased gain and improved feed efficiency. These results indicate finishing steers can be fed less supplemental protein during the final stages of finishing and be fed less ruminally available nitrogen than predicted needs without affecting feedlot performance. Carcasses averaged 79% low Choice or better and were 68% yield grade 1 and 2. Other than weight, carcass measurements were not affected by the programs to furnish supplemental protein. Total feed costs were decreased by reducing supplemental protein as the steers finished, but the greatest benefit was reduction in nitrogen excretion; 5.4 and 2.5 lbs nitrogen/steer in Program IV compared with Programs I and III, respectively. The results of this experiment indicate it is possible to reduce the environmental impact of feedlot cattle on the environment by program feeding of supplemental protein.

Introduction

Two needs must be considered when formulating the protein requirements of finishing cattle. One is the requirement by the animal for metabolizable protein (amino acids) and the second is the requirement by the microorganisms for available nitrogen in the rumen. The 1996 NRC publication “Nutrient Requirements of Beef Cattle” provides a model for formulating diets to meet both of these needs. This model is also available as Beef Feedlot Ration Analysis (MCS-7) provided by ISU Extension. If metabolizable protein is inadequate, growth of the animal will be limited. If nitrogen available to the microorganisms is inadequate, growth of the microbes will be reduced, presumably limiting digestion in the rumen and reducing the supply of metabolizable protein from the microorganisms. The proteins in corn grain are relatively slowly degraded in the rumen and do not provide adequate degraded nitrogen to satisfy the nitrogen requirements of the rumen microorganisms digesting the carbohydrates in corn. Therefore high-corn diets must be supplemented with a ruminally available source of nitrogen, usually urea. We have demonstrated in earlier experiments that supplementation of corn-based diets with urea alone will not provide sufficient metabolizable protein for optimum gain when high-performing cattle are started on feed (A.S. Leaflet R1235, 1995). The NRC model predicts that corn-based diets supplemented with urea supply more metabolizable protein than required for finishing cattle after they reach about 900 lbs and are on full feed. However the model calculates a need for continued supplementation with a degradable source of protein to supply the available nitrogen requirement of the microbes.

To reduce the environmental impact of excreted nitrogen from feedlot cattle, it seems prudent to consider changing the supplementation of diets so they more closely meet the protein requirements of cattle as they progress through the finishing phase. The purpose of this study was to evaluate programmed feeding of protein supplements to cattle fed high-corn diets on performance and carcass measurements. The primary objectives were to determine 1) if cattle would compensate during the finishing period if the entire requirement for metabolizable protein is not met when cattle are started on feed, and 2) if the dietary supply of degradable nitrogen can be reduced during the final period of finishing when corn-based diets are oversupplying metabolizable protein. Secondary objectives were to determine 1) if performance of cattle is affected during short periods of time following changes in protein supplements and 2) if a protein supplement supplying more metabolizable protein is superior after cattle receive the final implant containing trenbolone acetate.

Materials and Methods

Four programs for feeding protein were studied in this experiment (Figure 1). The diets were formulated using the protein model described in the 1986 NRC publication "Nutrient Requirements of Beef Cattle" except the protein requirements for maintenance were calculated using the equations described in the 1985 NRC publication "Ruminant Nitrogen Usage". One hundred-sixty eight crossbred steers with an average age of 12 to 13 months and weight of 740 lbs and visually appraised to be of medium frame score were used for this experiment. Steers were randomly allotted from weight outcome groups to twenty-eight pens of six steers each. Seven pens of cattle were allotted to each of the four programs. Program I was feeding the steers a diet containing soybean meal (12.4% crude protein) throughout the study. This diet contained adequate ruminally-degraded protein to provide available nitrogen to the microorganisms throughout the study and adequate metabolizable protein during the first period (42 days).

Figure 1. Experimental design.

	Crude protein, % diet DM		
	↓Implanted	↓Implanted	
Program I	12.4[a]	12.4	12.4[b]
Program II	11.7	11.7	11.7
Program III	12.4	11.7	11.7
Program IV	12.4	11.7	10.0[b]
Period when fed, days	A, 1 to 42	B, 43 to 84	C, 85 to 135

[a]Diet with 12.4% crude protein supplemented with soybean meal and urea.
[b]Diets with 11.7% and 10.0% crude protein supplemented with urea.

In Program II, steers were fed a diet supplemented with urea alone (11.7% crude protein). This diet contained adequate ruminally-degraded protein, but was inadequate in metabolizable protein during the first period. In Program III, steers were fed the diet supplemented with soybean meal during the initial 42 days and then changed to the urea-supplemented diet (11.7% crude protein). In Program IV, steers were fed similarly to Program III up to 84 days and then changed to a diet containing less urea (10.0% crude protein). This diet provided adequate metabolizable protein throughout, but according to the NRC model was deficient in ruminally-degraded protein during the last period (51 days). The composition of the three diets is shown in Table 1.

Table 1. Composition of diets (dry basis).

	Diet, % crude protein		
Item	12.4	11.7	10.0
Cracked corn	75.04	81.37	82.00
Corn silage	15.00	15.00	15.00
Molasses	0.75	0.75	0.75
Soybean meal	7.44		
Urea	0.35	1.15	0.54
Limestone	0.98	0.98	0.98
Potassium chloride		0.29	0.29
Salt	0.30	0.30	0.30
Vitamin A[a]	0.08	0.08	0.08
Trace minerals	0.024	0.024	0.024
Rumensin[b]	0.0195	0.0195	0.0195
Elemental sulfur	0.011	0.037	0.017

[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.

The adequacy of the diets in providing metabolizable protein and ruminally-degraded protein as projected by the NRC model is presented in Figure 2. Program I was designed to start the steers during Period A on a diet that would provide metabolizable protein and ruminally degraded protein according to the 1996 NRC recommendations and continue feeding this diet during the study. It can be seen that feeding the diet supplemented with soybean meal provided adequate metabolizable protein when the steers started on feed, but provided a surplus after the steers were on feed for 42 days and feed intake had increased. Program II was designed to feed a urea-supplemented diet throughout the study realizing this program was limiting in metabolizable protein during Period A, but adequate or more than adequate during Periods B and C. Program III was designed to meet the requirement for metabolizable protein during Period A and then changed to a lower protein diet during Periods B and C to reduce overfeeding metabolizable protein. However metabolizable protein was overfed during Period C. Programs I, II and III were designed to provide all the available nitrogen required by the microorganisms. This results in overfeeding metabolizable protein during Period C when cattle are fed high-corn diets. Program IV was designed to reduce the supply of metabolizable protein during Period C and to test the accuracy of the projected requirement for degradable protein in a diet providing adequate metabolizable protein.

Figure 2. Calculated adequacy of different protein supplementation programs on meeting the requirements for metabolizable protein and ruminally available protein as steers progress through the finishing phase.

	Period		
Program	A (1-42 d)	B (43-84 d)	C (85-135 d)
I - Continuous SBM			
MP[a], % of requirement	104[b]	127	151
DIP[c], % of requirement	101[b]	101	101
II – Continuous urea			
MP, % of requirement	96	117	138
DIP, % of requirement	101	101	101
III – SBM - Urea			
MP, % of requirement	104	119	140
DIP, % of requirement	101	101	101
IV- SBM – Urea – Low urea			
MP, % of requirement	104	119	123
DIP, % of requirement	101	101	80

[a]Metabolizable protein. The requirement for MP is based on rate and composition of gain of the cattle and is provided by undegraded feed proteins and rumen microorganisms.
[b]Calculated values derived from the 1996 NRC – Nutrient Requirements of Beef Cattle Model.
[c]Degraded intake protein. DIP is a characteristic of the diet. The requirement is based on growth of rumen microorganisms, which is related to the availability of fermentable carbohydrates in the diet. DIP is provided by degradation of dietary proteins and nonprotein nitrogen in the rumen.

All ingredients in the dry portion of the diets were mixed separately from the silage. When the steers were fed, the appropriate amounts of grain portion and silage were mixed in a mixer wagon. Total mixed diets were fed to the cattle twice per day. Periodic samples of the grain portion of the diets, corn silage, hay, and corn grain were sampled for determination 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, weighed and sampled for determination of dry matter. The steers were fed for 135 days.

Blood samples were taken from two animals in each pen on days 0, 42, 84 and 135 when the animals were weighed. Days 42 and 84 were the last day of the period after the steers were changed from one program to another. Plasma was obtained from the blood samples, frozen and used for determination of plasma urea nitrogen.

The steers were implanted with Component E-S at the start of the trial and reimplanted with Component TE-S 62 days later (73 days prior to harvest). The steers were sold to a commercial beef processor as one 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 score; kidney, pelvic, and heart fat (KPH); and yield grades. Thickness of backfat between the 12th and 13th ribs on the left side of the carcass was measured and ribeyes were traced on acetate sheets. The area of ribeyes was measured from the tracings. Yield grades were calculated from the carcass data using the standard yield grade equation.

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. Standard error of the means was calculated and significance difference among means was determined using Student-Newman-Keuls test or calculation of least significant differences.

Results and Discussion

The performance of the steers is summarized by interim periods and the whole finishing period in Table 2. During the first 42 days, the steers supplemented with soybean meal had greater gains than those fed the urea-supplemented diet as projected by the NRC model. After 42 days when the steers were on full feed and weighing 900 lbs, the urea-supplemented diet provided adequate metabolizable protein and supported gain similar to the diet containing soybean meal. Two factors are involved in explaining why the urea-supplemented ration supplied enough metabolizable protein after 42 days, 1) the cattle are more mature and protein makes up a smaller portion of gain, and 2) the cattle are consuming more feed (Figure 3) which generates more metabolizable protein.

During the total finishing period, steers fed adequate metabolizable protein during the first period had greater overall gains than those fed the metabolizable protein deficient diet during the first period, however the only statistically significant difference was between Programs IV and II. Previous studies indicated that cattle fed adequate metabolizable protein when started on feed had superior overall gains when fed for less than 140 days (A.S. Leaflet R1235, 1995) but not in longer feeding periods (A.S. Leaflet R1237, 1995). Seemingly in longer feeding periods, cattle not fed adequate metabolizable protein at the beginning have sufficient time to compensate for the slower earlier gains.

During the third period, steers fed 80% of the degradable protein that the model indicated (Program IV) gained similarly to those fed greater quantities of degradable protein. This result is similar to that observed in an earlier experiment (A.S. Leaflet R1774, 2002) in which steers fed 80% of the degradable protein requirement during the late stages of the finishing period gained similar to those fed adequate runinally available nitrogen. One explanation of this observation is that the NRC model overestimates the requirement for degradable protein. A second explanation is that the model does not account for available nitrogen in the blood that is recycled into the rumen. During the final period of the finishing phase the excess metabolizable protein being provided to cattle fed corn-based diets (Figure 2) is being converted to urea and available for recycling to the rumen. In less mature cattle or cattle consuming less feed in which metabolizable protein is not being consumed in excess, there would be less nitrogen recycled to the rumen. Concentrations of plasma urea (Figure 4) support the second explanation. Steers on all treatments had similar concentrations of plasma urea nitrogen at the beginning of the study. Urea concentrations were low at this time because metabolizable protein was not being overfed. At 42 days, steers fed the urea-supplemented diet had somewhat lower concentrations of urea nitrogen, but were not statistically different from those fed soybean meal. At 84 days, steers continuing to be fed soybean meal (12.4% crude protein) were receiving excess metabolizable protein in comparison with those fed the urea supplemented diets and consequently had significantly greater concentrations of plasma urea nitrogen. At 135 days, urea nitrogen concentrations were significantly lower in steers fed the diet supplying less degradable nitrogen than predicted required by the model (10% crude protein). These steers also were receiving less excess metabolizable protein (Figure 2). Additional experiments need to be conducted to determine if changes need to be made in the model or when cattle fed corn-based diets can be fed less than predicted ruminally available nitrogen.

During periods 21 to 42 days and 43 to 62 days, gains (data not shown in tables) for steers fed soybean meal (Program I), steers fed continuous urea (Program II) and those changed from soybean meal to urea at 42 days (Programs III and IV) were 4.54, 4.25 & 4.68 and 4.45, 4.23 & 4.05 lbs/d, respectively. These data though not statistically significant suggest there might have been some adjustment during the 20 days following changing the diet from soybean meal to urea (compare gains of 4.45 with 4.05). The gains of these groups prior to the dietary change were similar (4.54 and 4.68). Similar apparent adjustments were observed in previous experiments in the periods immediately following changing the supplements from soybean meal to urea.

The administration of the terminal implant (62 d) containing trenbolone acetate was timed to occur after the cattle in Programs III and IV had some time to adjust to the change in diet. The gains of cattle fed soybean meal (Program I), cattle fed urea continuously (Program II) and those changed from soybean meal to urea at 42 days (Programs III and IV) during the period of 63 to 84 days (20 days following the terminal implant) were 4.21, 4.51 and 4.52 lbs/d, respectively. These data indicate the cattle fed the diet containing urea (11.7% crude protein) were receiving adequate metabolizable protein during the period immediately following the terminal implant.

Table 2. Performance of finishing steers fed four different protein supplementation programs.

Item	Program I	Program II	Program III	Program IV	SE
Start weight, lbs	743.5	744.1	744.3	743.4	1.7
Ending weight, lbs	1254.7	1237.8	1245.2	1260.8	7.7
0-42 days					
Gain, lbs/d	3.95^{v}	3.56^{x}	4.13^{v}	4.03^{v}	0.09
Feed DM, lbs/d	15.7	15.6	15.7	15.6	0.06
Feed/gain	3.99^{v}	4.40^{x}	3.80^{v}	3.88^{v}	0.09
43-84 days					
Gain, lbs/d	4.32	4.38	4.16	4.44	0.14
Feed DM, lbs/d	21.6	21.3	21.1	21.3	0.28
Feed/gain	5.02	4.90	5.11	4.81	0.13
85-135 days					
Gain, lbs/d	3.21	3.14	2.99	3.17	0.12
Feed DM, lbs/d	22.5	22.2	22.3	22.8	0.57
Feed/gain	7.04	7.20	7.45	7.29	0.22
0-135 days					
Gain, lbs/d	3.79^{vx}	3.66^{v}	3.71^{vx}	3.83^{x}	0.06
Feed DM, lbs/d	20.1	20.0	19.9	20.1	0.27
Feed/gain	5.32^{y}	5.48^{z}	5.35^{yz}	5.23^{y}	0.05

^{vx}Means without a common superscript significant at P < .05.
^{yz}Means without a common superscript significant at P < .1.

The carcass data are summarized in Table 3. Steers fed soybean meal continuously or during the first period, had heavier carcasses than those fed the urea supplemented diet continuously. The steers fed soybean meal continuously had higher dressing percents, but there is no apparent explanation for this observation. There were no other significantly different carcass measurements related to protein supplementation program. Overall the steers had excellent carcass grades, 79% Low Choice or better and 68% yield grades 1 and 2. Programming protein supplementation did not affect grading of the carcasses. Value of the carcasses adjusted for quality grade ($116 and $111/cwt carcass for Choice and Select) were $880, $864, $876 and $886, for Programs I, II, III and IV, respectively.

Table 3. Carcass measurements from finished steers fed four different protein supplementation programs.

Item	Program I	Program II	Program III	Program IV	SE
Carcass weight, lbs	772.7^{v}	755.0^{x}	759.9^{vx}	769.8^{v}	5.5
Dressing percent	61.6^{v}	61.0^{x}	61.0^{x}	61.1^{x}	0.17
Marbling score	543.8	535.5	526.9	533.6	8.9
Backfat, in.	0.46	0.42	0.44	0.44	0.02
Ribeye area, sq. in.	13.2	13.2	13.2	13.2	0.18
KPH, %	2.08	2.11	2.19	2.14	0.06
Quality grades					
Average Choice[a]	6	4	1	5	
Low Choice	27	25	35	29	
Select	9	13	6	7	
Yield grades					
1	5	6	5	6	
2	18	26	24	24	
3	19	10	12	11	
4			1		
Average	2.78^{y}	2.60^{z}	2.68^{yz}	2.72^{yz}	0.09

[a]Quality grades were assigned based on marbling score, 600 = average Choice (Modest^{0}), 500 = low Choice (Small^{0}), 400 = Select (Slight^{0}).
^{vx}Means without a common superscript significant at P < .05.
^{yz}Means without a common superscript significant at P < .1.

There was a $12 to $22/head advantage for the steers fed soybean meal during the initial period. There was no loss in carcass value by changing protein supplement from soybean meal to urea after 42 days or decreasing the urea in the supplement after 84 days.

The potential benefits for phase feeding of protein supplements to finishing cattle are related more to reducing nitrogen excretion and the subsequent environmental impacts than to reducing feed costs. Total feed costs (corn $2.35/bu; silage $20/ton; molasses $100/ton; soybean meal $170/ton; urea $240/ton; potassium chloride $300/ton and additives $400/ton) were $7.91/head less for Program II compared with Program I, but there was a $16/head advantage in carcass value of steers fed Program I. Changing to a urea supplement at 42 days resulted in about $6/head savings in feed cost with no change in carcass value. Reducing the urea at 84 days (Program IV) did not result in any savings in feed costs compared with Programs II or III because the steers in Program IV consumed somewhat more feed (Table 2). The quantity of nitrogen fed was 3.65 lbs/head less for Program II compared with Program I. The steers fed Program III consumed 2.89 lbs less nitrogen than Program I, but 0.77 lbs more than Program II. The steers in Program IV consumed 5.42 lbs less nitrogen than Program I and 2.53 lbs less than steers in Program III. Because performance of the steers was not greatly different among the four programs, the differences in quantity of nitrogen excreted would be similar to the differences in consumed nitrogen. Expanding the numbers to a feedlot of 5,000 head turned twice per year results in estimated reduced nitrogen excretion of 54,000 lbs/year for Program IV compared with Program I and a reduction of 25,000 lbs/year for Program IV compared with Program III.

If the cattle are properly described and adequate adjustments made for environmental effects, the NRC model acceptably projects performance of feedlot cattle. Feed intakes projected by the NRC model were greater than observed during Period A, less than observed during Period B and identical during Period C (Figure 3). The cattle were limit fed during Period A as they were being brought up on feed. The steers were being fed to appetite during Period B and the greater than predicted intakes during this period were probably the result of compensation for the low intakes during the first period. With some adjustments in providing ruminally available nitrogen, the model can be effectively utilized to make nutritional modifications to reduce the environmental impacts of feedlot cattle.

Implications

The results of this study suggest that protein supplementation of finishing steers can be programmed to reduce the amount of protein fed without affecting feedlot performance. Further more it seems that during the late stages of the finishing period the amount of ruminally available nitrogen can be reduced below that indicated as required by the NRC model, further reducing the quantities of nitrogen fed to finishing steers.

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Figure 3. Projected and measured feed dry matter intake within the three periods of the experiment.

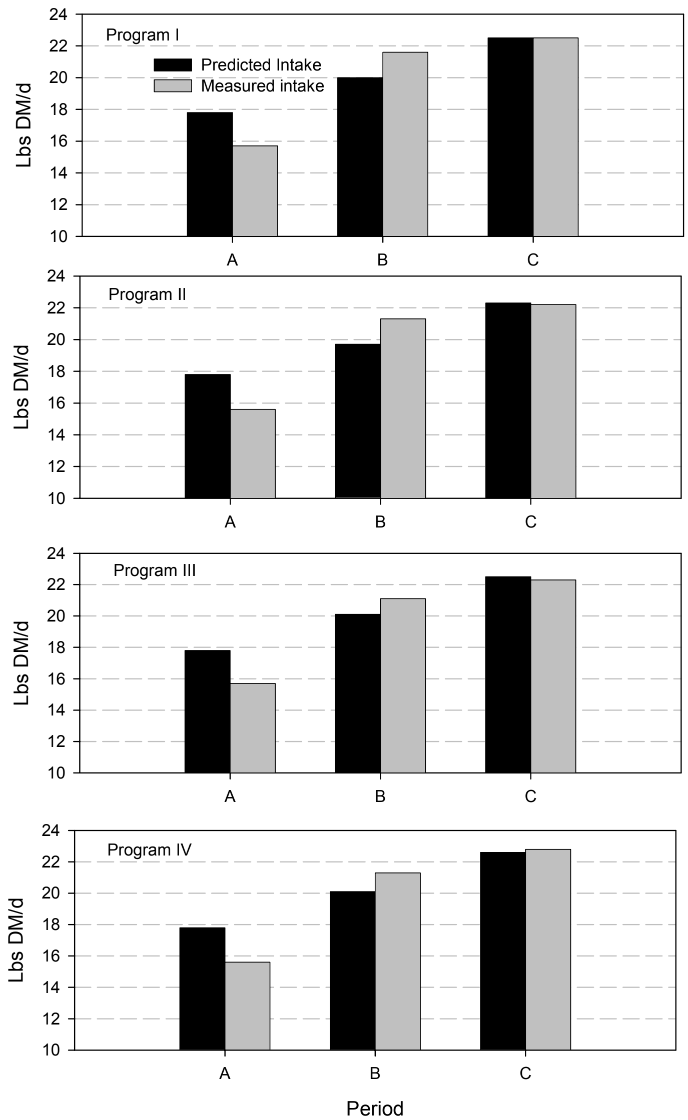

Figure 4. Plasma urea nitrogen concentrations in steers fed four programs of supplemental protein. Program I significantly higher than Programs II, III and IV at 84 days (P < .01). Programs I, II and III significantly higher than Program IV at 135 days (P < .05).