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Beef Cattle Management Update

RECOMMENDED SUPPLEMENTAL PROTEIN INTAKES AND SOURCES FOR FEEDLOT CATTLE DIETS

Issue 38
April 1996

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INTRODUCTION

Protein requirements of feedlot cattle were derived from experiments conducted over 20 years ago. Differences in cattle type, forage:grain ratios, feedbunk management, use of non-protein nitrogen, implants, ionophores and use of total mixed rations (TMR) suggest that nutrient requirements of today's feedlot cattle differ from those fed 20 years ago. Recent studies indicate that crude protein (CP) requirements of feedlot cattle today are greater than NRC requirements (Trenkle, 1994, 1995). Some of the observations by Trenkle (1993) and others (Fluharty and Loerch, 1995) indicate that protein requirements of cattle during the first 60 days are definitely higher than those listed by NRC (1984).

In a recent survey of feedlot nutrition consultants conducted by M. Galyean (New Mexico State University), dietary CP concentration used in diets formulated by these consultants ranged from a minimum of 12.5 to a maximum of 14.4%. Most consultants used at least 13% CP. Because protein is one of the most expensive nutrients on a per pound basis and because of increased concerns that excess nitrogen is washed down to rivers and streams causing pollution, it is imperative that we reevaluate protein requirements of rapidly gaining, medium- to large-frame feedlot cattle. This paper summarizes effects of protein intake and source on the feedlot performance of finishing feedlot steers. An attempt was made to suggest protein requirements and to evaluate the economic benefits of protein-fortified diets.

THE ECONOMICS OF PROTEIN SUPPLEMENTATION

A review of the NRC (1984) requirements would reveal that the CP requirement for a 900-lb steer gaining 3.5 lb/day is 2.19 lb/day, or approximately 10.4% dietary CP. However, as evidenced by the survey mentioned above, many diets formulated today exceed this figure. Although many arguments can be made about why protein requirements of feedlot cattle may have increased, the decision to supplement additional protein in finishing diets must be based on economics – the cost increase to supplement additional protein must be offset by at least a similar dollar value for the increase in weight gain achieved. Table 1 was generated to determine additional gain required to breakeven, under various protein and finished steer prices, when dietary CP concentration increases from 11.5 to 12.5% given a dry matter (DM) intake (DMI) of 22 lb/head daily. The increase in average daily gain (ADG) required to offset the cost of increasing dietary CP from 11.5 to 12.5% is

.06 lb when soybean meal and fed steers are priced at $170/ton and $70/cwt. The increase in ADG required to offset the cost of increasing dietary CP from 11.5 to 12.5% is .094 lb when soybean meal and fed steers are priced at $210 and $55/cwt. Approximately .01 lb ADG is required to offset price changes in soybean meal of $20/ton. Similarly, approximately .020 lb ADG is required to offset steer price changes of $20/cwt. Thus, changes in steer prices have a greater impact on the decision to change dietary CP than changes in protein prices. An oversimplified conservative approach would be to suggest that an increase in dietary CP of one percentage unit must be offset by an increase in ADG of .1 lb (this approach would not apply at soybean meal prices > $210/ton and at fed steer prices < $55/cwt).

Table 1. Additional gain (lb/d) required to breakeven with the increased cost of protein (soybean meal) supplementation.[a]

Fed steer	Soybean meal, $/ton					
price, $/cwt	130	150	170	190	210	230
	Additional gain required, lb/d					
50	0.064	0.074	0.083	0.093	0.103	0.113
55	0.058	0.067	0.076	0.085	0.094	0.102
60	0.053	0.061	0.069	0.078	0.086	0.094
65	0.049	0.057	0.064	0.072	0.079	0.087
70	0.046	0.053	0.060	0.067	0.074	0.081
75	0.042	0.049	0.056	0.062	0.069	0.075
80	0.040	0.046	0.052	0.058	0.064	0.070

[a] From 11.5 to 12.5% CP in a basal corn, corn-silage diet (DMI = 22 lb/hd/d).

LITERATURE SURVEY

Feedlot performance data were collected from 54 finishing experiments (774 lb average initial weight; data excluded Holstein steers) conducted in the U.S. and reported in refereed and university publications from 1988 to 1995. Data were analyzed by weighted analysis of variance and regression procedures to determine effects of protein intake and source and implanting strategy on feedlot performance [ADG, DMI and DM required/lb gain (FTG)]. Implanting strategies were defined according to prevalent or last implant type used: no implant, medium potency implants [estradiol-based implants, zeranol at 72 mg/dose or trenbolone acetate (TBA)] and high potency implants (TBA-based or combinations of TBA and estradiol or zeranol). Data were divided according to dietary CP concentration above and below 12% CP (the upper limits on current NRC recommendations); thus, each of the resulting groups averaged 11 or 13% CP.

A total of 54 experiments that met the criterion described yielded 178 observations (treatment means; Table 2). Use of high grain diets is quite evident from this table. Ionophores were fed in all experiments. It is also evident that CP intake and concentration exceeded NRC (1984) requirements for gains achieved in these studies. This is a reflection of research commitments to understanding the CP requirements of feedlot cattle.

Table 2. Means (weighted) and ranges for diet characteristics and steer performance.

Item	NRC[a]	υ	Range	
			Min.	Max.
Experiments		54		
No. means		178		
Concentrate, % DM		87	58	95
NE_g, Mcal/lb DM		.64	.52	.73
Implant doses[b]		1.0	0.0	2.0
CP, % diet DM	11.12	12.58	7.70	15.00
CPI[c], lb/d	2.21	2.62	1.88	3.28
Initial BW, lb	770	774	585	1,085
Final BW, lb	1,210	1,214	1,041	1,443
ADG, lb/d	3.30	3.39	2.35	4.77
DMI, lb/d	19.84	20.83	17.27	25.67
FTG[d]	6.01	6.21	4.90	8.30

[a] Requirements calculated from NRC (1984).

[b] Implants used were classified as medium (estradiol-based, zeranol at 72 mg/dose or TBA alone) or high (TBA-based) potency.

[c] CPI = Crude protein intake.

[d] Dry matter required/gain.

Mean of DMI was higher than predicted by NRC (1984; Table 2). This is a reflection of both the type of cattle and effects of implant and protein nutrition on feed intake.

A total of 30, 38 and 110 treatment means were collected for experiments where steers were not implanted or implanted with medium or high potency implants, respectively. Most steers in this data set were implanted only once.

EFFECTS OF PROTEIN CONCENTRATION AND IMPLANT STRATEGY ON FEEDLOT PERFORMANCE

Statistical analyses permitted evaluation of the effects of protein supplementation and implant strategy as independent or interactive (the effects of one affecting the response of the other) factors on feedlot performance. Appropriate statistical testing indicated that each of these factors affected feedlot performance independent of the other (e.g., implant strategy affected ADG similarly when steers were fed 11 or 13% CP diets).

Weighted means of feedlot performance under various implant strategies are listed in Table 3. Implant strategy affected ($P < .001$) ADG, DMI and ($P < .01$) FTG. Steers implanted with high potency implants gained fastest, while non-implanted steers gained slowest (3.56 vs 2.88 lb/day). Steers implanted with medium potency implants were intermediate (3.39 lb/day). Differences in ADG may be explained by differences in DMI. Steers implanted with medium or high potency implants had the highest DMI while non-implanted steers had the lowest (21.12; 21.23; 19.62 lb/day, respectively). As a result, feed efficiency followed similar trends ($P < .01$). Steers implanted with high potency implants were most efficient, while non-implanted steers were least efficient (6.81 vs 6.03); steers implanted with medium potency implants were intermediate (6.26).

Table 3. Means (weighted) for daily gain, dry matter intake and feed efficiency (DM required/gain; FTG) of steers under various implant strategies.

	Implant strategy[a]			
Item	None	Medium	High	SE[b]
No. means	30	38	110	
Diet CP, %	12.1	12.1	12.1	
Initial BW, lb	780	776	784	
Final BW, lb	1,153	1,216	1,238	
ADG, lb/d	2.88[c]	3.39[d]	3.56[e]	.03
DMI, lb/d	19.62[c]	21.12[d]	21.23[d]	.12
FTG	6.81[c]	6.26[d]	6.03[e]	.05
CPI[f], lb/d	2.36[c]	2.56[d]	2.57[d]	.02
CPG[g], lb/lb	.826[c]	.758[d]	.727[e]	.008

[a] Medium (estradiol-based, zeranol at 72 mg/dose or TBA alone) or high (TBA-based) potency implant.
[b] Standard error of weighted mean.
[c,d,e] Means differ ($P < .01$).
[f] Crude protein intake.
[g] Crude protein/gain.

Weighted means of feedlot performance for steers fed diets containing 11 or 13% CP are presented in Table 4. Compared to steers fed low protein diets, those fed high protein diets consumed more feed (20.92 vs 20.39 lb/day; $P < .0001$), gained faster (3.37 vs 3.17 lb/day; $P < .0001$) and were more efficient (6.28 vs 6.46; $P < .0001$).

Crude protein intake was highest ($P < .0001$) for steers implanted with medium or high potency implants and lowest for non-implanted steers (2.56; 2.57; 2.36 lb/day, respectively) regardless of dietary CP concentration (Table 3). Similarly, CP intake was highest for steers fed high dietary CP concentration regardless of implant strategy (2.77 vs 2.22 lb/day; $P < .0001$; Table 4).

Average daily gain was regressed (weighted by observations/mean) on DMI, dietary CP concentration, initial BW, NE_g and their squared values using implant strategy as a class variable to model effects of these variables on ADG. Through a backward elimination procedure, variables that did not contribute significantly to the model ($P > .10$) were deleted. The resulting equation was:

$$\text{ADG, lb/day} = 17.43822719 + (\text{DMI, lb/day} \times \text{DMI coefficient}) + (\text{CP, \% DM} \times .1037169) - (NE_g, \text{Mcal/lb DM} \times 66.64069582) + (NE_g^2 \times 52.75735067) + (\text{Initial BW, lb} \times .00636531) - (\text{Initial BW}^2 \times .00000374),\ R^2 = .55,\ CV = 20.3\%, \text{ where}$$

DMI coefficient = .130 (no implant), .139 (medium potency implant), .148 (high potency implant).

Table 4. Means (weighted) for daily gain, dry matter intake and feed efficiency (DM required/gain; FTG) of steers fed high or low dietary crude protein concentrations.

Item	Dietary crude protein, % 11	13	SE[a]
No. means	70	108	
Diet CP, %	11.0	13.2	
Initial BW, lb	780	782	
Final BW, lb	1,192	1,213	
ADG, lb/d	3.17 [b]	3.37 [c]	.03
DMI, lb/d	20.39 [b]	20.92 [c]	.12
FTG	6.46 [b]	6.28 [c]	.05
CPI[d], lb/d	2.22 [b]	2.77 [c]	.02
CPG[e], lb/lb	.832 [b]	.708 [c]	.008

[a] Standard error of weighted mean.
[b,c] Means differ ($P < .0001$).
[d] Crude protein intake.
[e] Crude protein/gain.

Coefficients to adjust DMI effect on ADG for various implant strategies and dietary CP concentration indicate that ADG increases as DMI or dietary CP concentration increases. For high and medium potency implants or no implant, this increase is .149, .139 and .130 lb ADG/lb DMI. Also, ADG increases .104 lb/every percentage unit increase in dietary CP. Thus, for a 770-lb steer implanted with high potency implant and eating 22 lb DM/day of a diet containing .64 Mcal NE_g/lb DM and 13% CP, ADG is predicted at 3.69 lb/day (Figure 1). A similar non-implanted steer fed and managed under the same regimen would have an ADG predicted at 3.30 lb/day (Figure 1).

This equation was then used to solve for dietary CP concentration in an attempt to suggest dietary CP requirements for steers, implanted or non-implanted, fed high grain diets (.64 Mcal NE_g/lb diet DM) and weighing over 770 lb (Table 5). The DMI and ADG values in Table 5 were used based on observed DMI and ADG of steers in the current data set. With the possible exception of non-implanted steers, higher ADG required higher dietary CP concentrations. However, for the same rate of gain, implanted steers required lower dietary CP concentrations than non-implanted steers. Also, steers implanted with high potency implants required lower dietary CP concentration than those implanted with medium potency implants. Expressed as CP intake or CP intake/gain, implanted steers required less dietary CP than non-implanted steers, and steers implanted with high potency implants required less dietary CP than steers implanted with medium potency implants; this was also evident from Table 3.

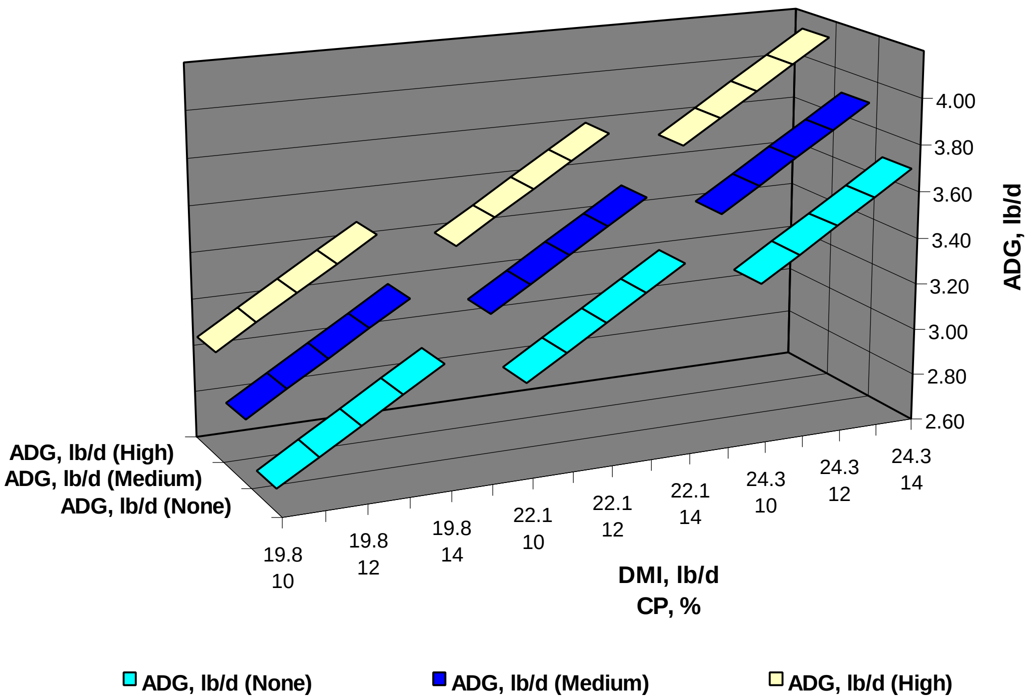

Figure 1. Relationship between DM intake, CP concentration and daily gain for steers weighing 770 lb and consuming diets containing .64 Mcal NE_g/lb.

Table 5. Crude protein requirements[a] for 770-lb steers fed diets containing .64 Mcal NE_g/lb DM under various implant strategies.

Implant strategy[b]	DMI, lb/d	ADG, lb/d	CP required, %	CP required, lb/d	CP required, lb/lb gain
None	17.60	2.6	12.3	2.16	.818
None	19.36	2.9	12.2	2.36	.824
None	20.90	3.1	12.4	2.59	.839
Medium	19.80	3.1	12.1	2.39	.775
Medium	20.90	3.3	12.7	2.66	.805
Medium	21.78	3.5	13.6	2.97	.844
High	20.24	3.3	11.8	2.39	.724
High	21.34	3.5	12.4	2.64	.749
High	22.00	3.7	13.5	2.98	.797

[a] Derived from the following equation when solved for CP concentration:

$$\text{ADG, lb/d} = 17.43822719 + (\text{DMI, lb/d} \times \text{DMI coefficient}) + (\text{CP, \% DM} \times .1037169) - (NE_g\text{, Mcal/lb DM} \times 66.64069582) + (NE_g^2 \times 52.75735067) + (\text{Initial BW, lb} \times .00636531) - (\text{Initial BW}^2 \times .00000371),\ R^2 = .55,\ \text{where}$$

DMI coefficient = .13008482 (no implant),
.13894936 (medium potency implant),
.14805743 (high potency implant).

[b] Medium potency (estradiol-based, zeranol at 72 mg/dose or TBA alone) or high (TBA-based) potency implant.

THE ECONOMICS OF PROTEIN SUPPLEMENTATION REVISITED

It was already stated that supplementing protein beyond levels initially recommended by NRC must be justified economically. It was also indicated that, as a rough approximation, a change in ADG of .1 lb offsets a change in dietary CP of one percentage unit. Thus, to justify increasing dietary CP from 11.5 to 12.5%, steers are expected to increase ADG by at least .1 lb.

Data obtained from the current analyses were used to generate Table 6. This table takes into consideration the differential response in ADG observed in non-implanted steers or those implanted with medium or high potency implants to determine return to dollars invested in increasing dietary CP concentration from 11.5 to 12.5%. Under most protein and fed steer prices, the return to investment is positive (above 1), but it is highest for steers implanted with high potency implants, intermediate for steers implanted with medium potency implants and lowest for non-implanted steers.

Table 6. Return to dollars invested in increasing CP concentration[a]

Implant strategy	Fed steer price, $/cwt	Soybean meal, $/ton: 130	150	170	190	210	230
		-----------------Return to dollars invested, $-----------------					
None	50	1.62	1.40	1.24	1.11	1.00	.91
Medium	50	1.73	1.50	1.32	1.18	1.07	.98
High	50	1.84	1.59	1.40	1.26	1.14	1.04
None	55	1.78	1.54	1.36	1.22	1.10	1.01
Medium	55	1.90	1.65	1.45	1.30	1.18	1.07
High	55	2.02	1.75	1.55	1.38	1.25	1.14
None	60	1.94	1.68	1.48	1.33	1.20	1.10
Medium	60	2.07	1.80	1.58	1.42	1.28	1.17
High	60	2.20	1.91	1.69	1.51	1.36	1.25
None	65	2.10	1.82	1.61	1.44	1.30	1.19
Medium	65	2.24	1.95	1.72	1.54	1.39	1.27
High	65	2.39	2.07	1.83	1.63	1.48	1.35
None	70	2.26	1.96	1.73	1.55	1.40	1.28
Medium	70	2.42	2.10	1.85	1.65	1.50	1.37
High	70	2.57	2.23	1.97	1.76	1.59	1.45
None	75	2.43	2.10	1.85	1.66	1.50	1.37
Medium	75	2.59	2.24	1.98	1.77	1.60	1.46
High	75	2.76	2.39	2.11	1.89	1.71	1.56

[a] One percentage unit (from 11.5 to 12.5 in a corn-corn silage based diet).

INTERACTIONS BETWEEN SUPPLEMENTAL PROTEIN SOURCE AND CONCENTRATION

As a result of the current data collection effort, 25 of the 54 experiments were identified as providing sufficient information (87 observations) on supplemental protein source and concentration along with the required diet, implant and feedlot information as described previously. Energy concentration of diets used in these experiments averaged .64 Mcal NE_g/lb DM.

A separate analysis was conducted to test urea, soybean meal and rumen undegradable protein sources when used to feed steers implanted with high potency implants. This analysis was conducted because of the prevalence of high potency implant strategies in the feedlot industry today and because it was felt that some trends of interest may be defined to direct research efforts and provide some guidelines.

Much of the literature today seems to indicate that urea is a viable supplemental nitrogen source if fed within certain concentrations. The concentrations at which intake and performance are maximized appear to be between .8 and 1% diet DM. Thus, observations in this analysis were grouped by urea concentration. Low and high urea concentration groups were defined based on urea concentration above or below 1% diet DM. When soybean meal was the supplemental protein source, low and high soybean meal groups were defined based on soybean meal concentration above or below 6.3% diet DM. For most experiments, the balance of supplemental protein came from soybean meal. Also, there was a sufficient number of observations pooled from experiments where rumen undegradable protein sources were used. For the purposes of this analysis, corn gluten meal, blood meal, cottonseed meal, corn gluten feed and dry distillers grains were considered undegradable protein sources. The majority of the observations consisted of additions of corn gluten meal, blood meal or cottonseed meal as the supplemental protein source. Concentrations of undegradable protein sources averaged either 2.5 or 29.0% diet DM.

Effects of protein source and dietary concentration, weighted by observations/mean, on feedlot performance of steers implanted with high potency implants are listed in Table 7. Significant interactions ($P < .05$) were observed between protein source and concentration. Average daily gain was lowest ($P < .05$) for steers fed high urea concentrations. This was due to lower ($P < .05$) DMI achieved by these steers. Performance of steers fed low urea concentrations was similar ($P > .05$) to that of steers fed either undegradable protein or soybean meal at low dietary concentrations. Performance of steers fed undegradable protein or soybean meal did not ($P > .05$) differ. Crude protein intake followed trends observed for DMI.

Caution must be exercised when interpreting these results as the balance of the supplemental protein requirement may have been met by use of one of multiple sources. However, it is evident that approximately 2.64 to 2.86 lb protein, including no more than 1% urea (diet DM), are required to maximize gain in steers implanted with TBA-based implants. Performance of steers fed undegradable protein sources was similar to that of steers fed soybean meal at corresponding levels of inclusion.

Table 7. Means (weighted/adjusted for dietary CP) for daily gain, dry matter intake and feed efficiency (DM required/gain; FTG) of implanted (high potency) steers supplemented with various protein sources.

Source	Urea		Soybean meal		Undegradable[a]		
Concentration, % diet DM	0.8	1.3	5.0	11.0	2.5	29.0	
CP, % diet DM	12.6	12.6	12.7	12.8	12.8	12.7	SE[b]
No. means	28	16	9	16	16	2	
Initial BW, lb	814	814	814	814	814	814	
Final BW, lb	1,274	1,255	1,286	1,294	1,272	1,286	
ADG, lb/d	3.62 [c]	3.48 [f]	3.73 [cde]	3.84 [e]	3.66 [cd]	3.75 [cde]	.04
DMI, lb/d	21.98 [cd]	21.08 [e]	21.70 [cd]	22.07 [c]	21.37 [de]	22.05 [cd]	.24
FTG	6.11 [cd]	6.16 [c]	5.89 [e]	5.79 [e]	5.91 [de]	5.90 [de]	.10
CPI[g], lb/d	2.78 [cd]	2.68 [e]	2.75 [cd]	2.82 [c]	2.73 [de]	2.81 [cd]	.02

[a] Undegradable protein sources constituted the main supplemental protein source.
[b] Standard error of the weighted mean when: $n = 16$.
[c,d,e,f] Means within a row with uncommon superscripts differ ($P < .05$).
[g] Crude protein intake.

CONCLUSION

The data analyzed herein indicate that large-frame, feedlot cattle weighing over 770 lb and fed for 110 to 170 days respond to medium and high potency implants or increasing dietary protein concentration by increasing DMI and ADG. The intake and gain response is more acute in steers implanted with high potency implants (TBA-based) available today. However, CP requirements of implanted steers, derived from this data set, may be lower for a given rate of gain than for non-implanted steers. Also, CP requirements of steers implanted with TBA-based implants seem to be lower than those of steers implanted with estradiol-based implants or TBA alone. This is due to higher intakes and greater protein deposition of steers implanted with TBA-based implants.

Results from regression analyses indicate that feeding high CP diets increased ADG .10 lb for every CP percentage unit while implanting with TBA-based implants increased DMI 14% over non-implanted cattle. The net effect of implanting is an overall increase in daily gain of .009 (medium potency) to .018 lb/lb DMI (high potency) over the non-implanted animal. Therefore, to maximize feedlot performance increasing both CP concentration and implanting with medium or high potency terminal implants are required.

Use of urea at concentrations below 1% diet DM permitted greater DMI and faster daily gains than use of urea concentrations >1%. Use of soybean meal in diets containing >12% CP at concentrations ranging from 4 to 15% (diet DM) supported similar feedlot performance. Urea was as effective as undegradable protein sources when added at levels below 1% diet DM (average .8%). There were no apparent benefits of feeding undegradable vs rumen degradable (soybean meal) protein sources.

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