FINE-TUNING PROTEIN NUTRITION OF FEEDLOT CATTLE

A. DiCostanzo
Department of Animal Science
University of Minnesota, St. Paul

Introduction

Protein nutrition of feedlot cattle is an issue receiving great interest recently because of protein costs, and a concern that protein supply to the animal meets the animal's demands to prevent over- or underfeeding. Underfeeding protein leads to reduced performance; overfeeding protein leads to excessive nitrogen (N) output into the environment. Protein costs represent up to 15% of total feed costs in the feedlot. Fine-tuning protein needs and matching these needs to a carefully formulated protein supplement should permit some cost savings and is a responsible practice to prevent excessive N output. This paper presents a series of supplementing alternatives for yearling cattle fed various diets. Included are recommendations for minimum crude protein supplementation requirements and maximum urea amounts in the diet and the supplement. These figures merely represent guidelines to help streamline decision making when selecting commercial protein supplements or formulating protein supplements for typical Minnesota barley-, corn- or corn byproduct-based diets.

Definition of Terms

In its simplest form, producers are familiar with protein as crude protein (**CP**). This concept assumes that all protein fed to cattle contains 16% N. Therefore, CP is obtained by multiplying N times 6.25 (100/16). Although not completely correct all the time, this method of defining protein has remained the standard by which producers, feed companies and university personnel evaluate dietary protein supply. The main criticism with this system is that it does not define whether some or all protein is utilized and how it is utilized.

If CP present in the feed is further analyzed, three components are recognized: true protein (blocks of amino acids) and nonprotein nitrogen (**NPN**). Nonprotein N is the fraction of feed CP that comes from nitrogenous compounds, such as urea, not associated with amino acids. This figure is often expressed as a percentage of the diet dry matter. Fermented feeds such as corn silage, haylage and, to some extent, earlage contain much of their protein (as much as 50%) in the form of NPN. Once these protein fractions are swallowed and moved into the rumen, the ruminant microbes act on them according to their degradability. Nonprotein N is rapidly utilized by rumen microbes in the presence of sufficient amounts of energy, amino acids and minerals, such as sulfur, to produce more microbes.

From an accounting perspective, the portion of CP that is readily degraded in the rumen (includes both NPN and true protein) is known as degradable intake protein (**DIP**). This fraction is expressed as a percentage of CP. The fraction that is not degraded in the rumen (expressed as 100 - DIP) is known as undegradable intake protein (**UIP**), commonly recognized as bypass protein. The fate of this protein fraction depends on its degradability in the small intestine. Protein that escapes rumen digestion may or may not be degraded in the small intestine. When degraded, it directly contributes amino acids to the animal. In contrast, rumen DIP is almost totally transformed by rumen microbes into more microbes. This fraction, usually referred to as microbial protein, is highly degradable to amino acids in the small intestine.

Upon absorption by the animal, amino acids are readily utilized for various functions: maintenance, growth, pregnancy, hair growth, lactation, etc. The protein fraction that is utilized for either maintenance or growth of a growing animal is called metabolizable protein (**MP**).

When evaluating diets for steer growth, the terms CP, DIP and NPN are often utilized. The amount of CP and DIP will determine how much MP is available for steer maintenance and growth, while the amount of NPN will contribute to both CP and DIP but may reduce MP, thereby limiting growth. The newest version of the Nutrient Requirements of Beef Cattle (NRC, 1996) is based on MP to define protein needs of beef cattle and on CP and DIP to determine adequacy of diets to meet both MP and DIP requirements (microbial needs). Thus, this system permits evaluation of diets to meet requirements of the rumen microbes (DIP requirement) or the animal (MP requirement). Under ideal conditions, diets are expected to be balanced for both DIP and MP. Nutrient Requirements of Beef Cattle is an excellent tool to help fine-tune protein needs and protein supplements for feedlot cattle.

Evaluation of Base Diets

Table 1 lists compositions of various basal ingredients (no supplemental protein) for diets used throughout the steer feeding regions of Minnesota. This list is by no means all inclusive but attempts to define base diets that some feedlots often utilize in yearling feeding programs. Diets were based on actual diets formulated by a private consultant or University of Minnesota experiment stations and were used to establish guidelines. Therefore, readers are encouraged to obtain dietary concentrations of CP and energy for their specific situation. Diets were evaluated for protein and energy concentration using the software provided with the Nutrient Requirements of Beef Cattle (NRC, 1996) handbook.

When evaluating diets in Table 1, it is quite obvious that regardless of proportion of corn in the diet, presence or absence of other ingredients determines the amount of CP and DIP in the diet. Crude protein percentages for diets in Table 1 ranged from 8 to 11.5%. When diets contain high CP containing ingredients such as barley or corn gluten feed, CP ranged from 10 to 11.5%. According to analyses conducted on these diets, DIP was always deficient, while MP was only deficient in the diet that contained 85% high moisture corn (also a low CP diet). As stated earlier, diets have to be balanced both for degradable and metabolizable protein to meet microbial and animal protein requirements. Therefore, diets with negative DIP balances were not considered adequate for rumen microbial function. This would lead to reduced digestion and utilization of dietary energy. In addition, the high moisture corn diet should be balanced to meet MP requirements as well. Protein requirements and how to meet these will be discussed in the following section.

Table 1. Composition and nutrient content of some common Minnesota feedlot diets.

	Composition, % DM				
Ingredient	Corn	Corn	High moisture corn	Corn mix	Barley
Dry corn	71.51	85.50		42.42	
High moisture corn			82.50	31.84	
Barley					71.27
Corn gluten feed	20.00			20.00	
Earlage			10.00		
Hay	3.79			5.75	
Haylage			7.50		
Corn silage	4.70	14.50			5.82
DMI, lb/day	21.10	21.78	20.60	23.01	20.26
NE_g, Mcal/lb	.66	.68	.68	.67	.59
CP, %	10.60	8.10	9.10	10.40	11.5
DIP, % CP	57.3	48.70	71.1	62.3	68.9
DIP balance, g	-267	-514	-100	-193	-120
MP balance, g	120	101	-128	57	103

Protein Requirements and Protein Supplementation

A separate effort was conducted on an independent data set to calculate CP requirements of steers exposed to various implant strategies (DiCostanzo, 1996). Table 2 lists suggested protein requirements for yearling steers weighing over 770 lb and consuming diets containing over 58 Mcal NE_g/cwt. Three implant strategy systems are included in Table 2 as implant status may affect protein requirements. These strategies were: no implant (none); use of a medium potency implant, such as Synovex-S, Implus-S, Compudose, Magnum or Finaplix-S (medium); or a high potency implant such as Revalor-S (high). At similar CP intakes, implanted steers respond with higher daily gains. Therefore, implanted steers are more efficient feed utilizers than nonimplanted steers. Furthermore, steers implanted with high potency implants are more efficient feed utilizers than those implanted with medium potency implants. The CP requirement of a yearling steer should fall between 2.7 and 2.8 lb/head/day (Table 2). Recommendations for CP concentration of steers at variable intakes are given in Table 3.

Table 2. 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:

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

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).

Table 3. Crude protein concentration at various intakes.

Dry matter intake, lb/day	CP, lb/head/day 2.65	2.75	2.85
18	14.72	15.28	15.83
19	13.95	14.47	15.00
20	13.25	13.75	14.25
21	12.62	13.10	13.57
22	12.04	12.50	12.95
23	11.52	11.96	12.39
24	11.04	11.46	11.88
25	10.60	11.00	11.40

Data obtained in the independent set were analyzed for effects of protein source on feedlot performance (DiCostanzo, 1996). Table 4 lists affects of urea concentration in diet DM on feedlot performance. Data were averaged across various implant strategies because there were no implant strategy interactions with urea concentration. Concentration of urea affected dry matter intake and daily gain. Steers fed moderate amounts of urea (.9% urea in diet DM) consumed more DM and gained faster than those fed high amounts of urea (1.2% urea in diet DM). Steers fed low amounts of urea (.5% urea in diet DM) had intermediate intakes and gains. Urea concentration in the diet did not affect DM required per gain. Therefore, when supplementing high energy diets of yearling steers, the maximum urea concentration should be set at 1% diet DM.

Table 4. Weighted least square means for daily gain, dry matter intake and feed efficiency (DM required per gain) of steers fed various urea concentrations in diet DM.

	Urea, % diet DM			
Item	.5	.9	1.2	SE
CP, % diet DM	12.1	12.1	12.1	
Initial BW, lb	799	799	792	
Final BW, lb	1,232	1,241	1,208	
ADG, lb	3.23[ab]	3.33[b]	3.09[a]	.057
DMI, lb/day	21.14[ab]	21.37[b]	20.55[a]	.211
FTG [c]	6.54	6.52	6.76	.141
CPI [d], lb/day	2.55	2.59	2.49	.03

[ab] Means differe ($P < .05$).
[c] Dry matter required/gain.
[d] Crude protein intake.

When formulating supplements for yearling steers, CP concentration of the basal diet and DM intake are necessary. Diets containing high CP ingredients and consumed at moderate to high intakes will require the least amount of CP supplementation. These diets can be supplemented with urea as a major supplemental protein ingredient. Table 5 depicts effects of basal diet CP concentration and DMI on maximum percentage contribution of urea to supplemental protein. This maximum is based on the limit of 1% urea in diet DM and a requirement of 2.75 lb CP/head/day. When dietary ingredients yield low CP diets (such as corn and grass hay diets), contributions of urea to total supplemental CP can range from 39 to 80% for intakes between 18 and 22 lb DM. When dietary ingredients yield high CP diets (such as barley, legume hay or haylage and corn gluten feed), contributions of urea to total supplemental CP can range from 49 to 100% for intakes between 18 and 22 lb DM. For intakes over 22 lb DM, urea contributions to supplemental CP may be between 70 and 100%.

A strategy may be to feed a high CP diet (over 13% CP) to yearling steers during the initial 60 days in the feedlot using a supplement that contains no more than 55% of the total CP from urea. Then, steers would be fed a finishing diet supplemented to provide between 11.5 and 12.5% CP depending on expected DMI with most of the supplemental CP coming from urea (over 70%). This strategy was tested various times in research experiments conducted at Iowa State University (Trenkle, 1995). Steers fed the switch-over diets gained as fast and as efficiently as steers fed high CP diets continuously.

Table 5. Suggested urea contributions[a] to protein supplementation.

	CP in basal diet, % DM						
Dry matter intake, lb/day	8	8.5	9	9.5	10	10.5	11
18	39	41	45	49	53	59	66
19	43	47	51	56	63	71	81
20	49	54	59	66	75	86	100
21	55	61	69	78	91	100	100
22	62	70	80	94	100	100	100
23	71	81	95	100	100	100	100
24	81	95	100	100	100	100	100
25	94	100	100	100	100	100	100

[a] Protein derived from urea (maximum contribution of .9 to 1% diet DM) as a percentage of total supplemental protein to provide 2.75 lb CP/head/day.

Diets in Table 1 were supplemented with a maximum of 1% urea in diet DM and soybean meal to bring CP intake to 2.75 lb/head/day. These diets were evaluated (NRC, 1996) as to the balance of protein fractions (Table 6). In most instances, the simple rule of thumb is to supplement protein to 2.75 lb/head/day with no more than 1% dietary urea contributed to either reducing or eliminating DIP deficits observed in the basal diets (compare Tables 1 and 6). In the high moisture corn diet where MP and DIP were deficient, DIP was balanced. Metabolizable protein was still somewhat deficient. Further adjustments may need to be made with protein sources other than soybean meal to eliminate this deficit.

Thus, the recommendation to supplement diets to 2.75 lb CP/head/day with urea at 1% diet DM and the balance made up of a good quality protein source such as soybean meal contributes well to meeting protein requirements of rumen microbes and the animal. Some further adjustments may need to be made when initial CP concentration of the basal diet is low (9% or below) or the degradability of CP in the basal diet is low (below 55%).

Table 6. Evaluation[a] of diets shown in Table 1 balanced to deliver 2.75 lb CP/head/day using urea (up to 1% diet DM) and soybean meal.

	Composition, % diet DM				
Ingredient	Corn	Corn	High moisture corn	Corn mix	Barley
Dry corn	70.40	81.85		42.18	
High moisture corn			78.81	31.68	
Barley					70.75
Corn gluten feed	19.67			19.88	
Earlage			9.55		
Hay	3.73			5.70	
Haylage			7.14		
Corn silage	4.66	13.89			28.52
Urea	.98	.97	.93	.55	.73
Soybean meal	.56	3.30	3.57		
DMI, lb/day	21.45	22.75	21.57	23.13	20.41
NE_g, Mcal/lb	.65	.67	.67	.66	.59
CP, %	13.6	12.2	13.2	11.9	13.6
DIP, % CP	66.4	62.8	76.2	67.3	73.8
DIP balance, g	26	-133	255	-23	80
MP balance, g	126	145	-82	56	102

[a] Level 1 of NRC (1996).

Conclusions

The advent of new systems to evaluate protein needs of feedlot cattle should permit some fine-tuning and savings in CP supplementation costs. However, producers should be informed about the meaning of protein fractions included in new systems and how they may affect performance. A simple recommendation derived from an independent data set indicated that protein requirements of implanted steers should fall between 2.7 and 2.8 lb CP/head/day. Further evaluation of this data set indicated that urea should not exceed 1% diet DM as a supplemental protein source (optimum may be at .9% diet DM). Thus, a recommendation was made to balance diets for 2.75 lb CP intake/head/day with no more than 1% urea in diet DM. This recommendation appears to correspond well with new requirements for protein fractions defined by NRC (1996). A suggested action list for feedlot operators is provided:

1. Determine CP in main feed ingredients to be used (disregard supplement ingredients).
2. Determine CP of the basal diet.
3. Ask your nutritionist or feedlot consultant to evaluate basal diet in NRC (1996). Determine MP and DIP balance from this analysis.
4. For a CP intake of 2.75 lb/head/day, follow recommendations for selecting a supplement based on basal CP and expected DMI in Table 5.
5. Ask your nutritionist or feedlot consultant to evaluate diet plus supplement in NRC (1996). Determine MP and DIP balance.
6. Make sure diet ingredients are blended and delivered properly to the bunk and that steers have good access to bunks at all times.
7. Evaluate close-out records and compare with projections in Step 5.

Steps 3 and 5 are optional but may help provide some information should adjustments to recommendations be necessary.

Literature Cited

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