PROTEIN (UIP/DIP) SUPPLEMENTATION OF GROWING-FINISHING BEEF CATTLE

Terry Klopfenstein, Rob Cooper, Galen Erickson and Hushton Block
Animal Science Department
University of Nebraska-Lincoln

Beef cattle require amino acids for maintenance and growth. Those digestible amino acids are supplied by microbial protein or feed protein that escapes rumen degradation. The crude protein system that has been used in the past (NRC, 1984) does not directly account for the amount of microbial protein synthesis and assumes all proteins are equal. The 1996 NRC presents a metabolizable protein (MP) system that accounts for bacterial crude protein (BCP) synthesis from degradable intake protein (DIP) and the amount of undegraded intake protein (UIP).

The value .13 × TDN for BCP synthesis (NRC, 1996) is a good generalization but it does not fit all situations. We have tried to illustrate the most important differences in Figure 1. This idealized graph shows BCP efficiency versus diet TDN. Logically, the higher digestibility diet is primarily based on grain. High grain finishing diets have lower rumen pH. This lower pH reduces BCP efficiency (Russell et al., 1992; NRC, 1985).

At low TDN levels (Figure 1) we have also indicated low microbial efficiency. This is likely due to slow passage rates which increase microbial turnover in the rumen and reduce efficiency of growth. There were not sufficient data available to develop a generalized equation for the 1996 NRC. However, based on our experience with the model, we have developed the equation in Figure 1. At this point it can be used a guideline.

UIP Values. Accurate measurement of the UIP values of feedstuffs is critically important to a MP system. Corn and milo protein are high in escape. This is the primary reason why cattle preform well with just urea supplements on high grain diets. The supply of MP from corn is approximately equal to that from bacteria in a dry corn finishing diet. It becomes more complicated when we use high moisture grains, grains such as wheat or barley, or byproducts such as wet gluten feed.

The protein in forages is highly degraded (as a generalization). Green grazed forages contain limited escape protein. Most of the escape protein in alfalfa is in the stems--leaf protein is highly degraded. Measurement of UIP in forages is difficult because of the difficulty in accounting for microbial attachment. Rate of passage of forage particles can be quite variable which can also influence UIP. Both accuracy and precision of in situ and in vitro procedures need to be improved to improve the accuracy of a MP system. We have attempted to improve the in situ procedure by using neutral detergent to remove attached microbes (Mass et al., 1999; Klopfenstein et al., 2000).

Energetics. It is absolutely essential to have the "energetics" correct in the NRC (1996) model before the protein requirements and supplies can be accurately predicted. Level 1 of the NRC model contains net energy adjusters that can be used to achieve accurate prediction of gain by altering the net energy values of the diets.

Data from 325 treatment means in 35 previous beef cattle feeding studies were used to evaluate the 1996 NRC model for accuracy of gain predictions and to develop predictions of net energy adjusters for use with the model. Gain predictions were found to be precise with an R^2 of 0.8741, but inaccurate, as the least squares regression equation (intercept = 0.7275, slope = 0.5387) was different ($P < 0.05$) from the isopleth (intercept = 0, slope = 1) (Figure 2). All predictions were made under thermal neutral conditions which would maximize the prediction and contribute to inaccurate prediction any time the environment was severe enough to affect performance. Therefore, over prediction of gains can be expected by assuming thermal neutral conditions. More effective modeling of environmental effects on gains by growing cattle would bring observed and predicted gains into closer agreement for rapidly gaining cattle where gains were over predicted, but would result in greater discrepancy between observed and predicted gains for slowly growing cattle where gains were under predicted.

Exponential equations were used to fit observed ADG, TDN intake, or TDN concentration to determined NE adjusters. The relationship between determined NE adjuster and ADG existed ($P < 0.05$), but was quite weak ($R^2 = 0.3675$). A stronger relationship ($P < 0.05$; $R^2 = 0.6441$) existed with TDN intake. However, use of TDN intake to predict NE adjusters will be confounded by total DMI. The strongest relationship was with TDN concentration ($P < 0.05$; $R^2 = 0.7707$).

The equation relating TDN concentration to NE adjusters may be used to improve the accuracy of gain predictions by the 1996 NRC model. Consequently, a table of recommended adjusters (Table 1) based upon the equation derived to relate the required NE adjuster to TDN concentration was developed. It is important to note that the recommended NE adjusters do extend beyond the range of 80 to 120% of normal, allowed by the 1996 NRC model computer program.

As an example, if a group of cattle are to be fed a diet with a TDN concentration of 65.9%, (NEm = 0.68 Mcal/lb, NEg = 0.41 Mcal/lb), the appropriate NE adjuster to enter into the NRC model is 0.89, resulting in an adjusted NEm of 0.61 Mcal/lb and an adjusted NEg of 0.37 Mcal/lb. These adjusted NE values are then used in the prediction of gain, and should result in a more accurate prediction of gain.

The NE adjuster for finishing cattle overaged about .8. This reflects environmental effects as these cattle were fed primarily during the fall, winter and spring months. the 1997 to 1998 feeding season for calf feds was not especially cold but had considerable mud and the adjuster needed was .836. Conversely, the 1999 to 2000 season was very dry and reasonably mild. The adjuster needed was 1.0. This suggests to us that for our eastern Nebraska feeding conditions, we would typically expect 0 to 20% increase in energy required due to environmental factors. One could predict the environmental conditions expected and use the NE adjusters — leaving the temperature at 68° F and wind speed at zero.

Growing cattle. Young growing calves have high protein requirements and are generally grown on forages. As stated before, the protein in forages is generally highly degraded in the rumen. It is usually necessary to supplement UIP to meet the MP needs of calves.

When blood meal was compared to soybean meal (Figure 3) maximum gain was .34 lb/day above the control. It took considerably less protein from blood meal to meet the requirement than soybean meal. Blood meal is much higher in UIP than soybean meal so the protein was used with about three times the efficiency. This type of experiment can be used to define the MP requirement as was done by Wilkerson (1993).

We fed several combinations of blood meal and feather meal and found a complementary effect on the protein efficiency values (Figure 4). This is likely due to the lysine in blood meal and sulfur amino acids in feather meal. Clearly, amino acid content of UIP is important for growing calves. We also found a similar complementary effect with three-way combinations of blood meal, meat and bone meal and feather meal. This suggested involvement of more amino acids than just methionine and lysine, probably histidine.

Finally, we have studied the value of the sulfur amino acids in feather meal. A base level of blood meal was fed to supply all amino acids except the sulfur amino acids according to NRC (1996). Either rumen protected methionine or feather meal was used as a source of sulfur amino acids. Methionine fed at 1.5 g/day met the requirement. Sulfur amino acids from feather meal were used at the same efficiency (similar slopes) but the maximum gain was less. This suggests that the sulfur amino acids in feather meal (primarily cystine) can only meet part of the sulfur amino acid requirement. These data further reinforce the importance of considering amino aid profile of UIP for growing calves.

Another situation where UIP is limiting for growing cattle is when they are grazing green grass. Crude protein in green grass is generally high enough to meet the DIP requirements. However, because of high rumen degradability, UIP is deficient. This is illustrated in two studies. Previous winter gains were 1.5 lb/day and .5 lb/day. Summer grazing treatments consisted of 1) no supplementation or 2) supplemental undegraded intake protein. Steers receiving the supplement were individually fed 2.8 lb of supplement every other day, providing 150 g/day of escape protein.

Steers receiving undegraded intake protein supplementation had higher weight gains compared to non-supplemented steers (Table 2). The steers on the fast gaining winter treatment responded to supplementation (.42 lb different) compared to the unsupplemented fast gaining steers. The slow gaining steers responded less to supplementation (.16 lb/day). The positive responses indicate UIP was limiting. However, the extra gain was lost in the feedlot so supplementation is likely not economical.

Finishing cattle

DIP requirements. Level 1 of the NRC (1996) model sets the dietary DIP requirement equal to microbial crude protein (MCP) production. Microbial CP is calculated with the equation: $MCP = (0.13 \times eNDFadj) \times TDN$; where 0.13 equals microbial N efficiency, eNDFadj is an adjustment factor which lowers microbial N efficiency for diets that cause low ruminal pH because of low roughage levels, and TDN equals the total digestible nutrient content of the diet (g/d). Adjusted microbial N efficiency values for typical 90%-concentrate finishing diets are usually between .08 to.09 of TDN, depending on the roughage source.

Carbohydrate digestion in the rumen is likely the most accurate predictor of BCP synthesis, and is used in Level 2 of the NRC (1996) model. However, few data are currently available for the rates of passage and digestion of various carbohydrate fractions in feedstuffs commonly fed in feedlot diets. Therefore, dietary TDN is used in Level 1 of the NRC (1996) model because it is currently the most accurate and readily available estimate of energy value for a diet. However, because Level 1 of the NRC (1996) model uses TDN to predict the dietary DIP requirement, factors that shift the site of digestion of the dietary nutrients, such as grain processing, are not appropriately accounted for.

We have conducted several trials evaluating the effect of corn processing method on the dietary DIP requirement of finishing steers. Shain et al. (1998) conducted two finishing trials with a total of 304 yearling steers. Steers were fed 92.5%-concentrate dry-rolled corn-based diets that were supplemented with 0, .88, 1.34, and 1.96% urea (DM basis). Steers did not respond to dietary urea levels above .88%, indicating that the dietary DIP requirement for a dry-rolled corn-based diet was met at 6.4% of DM.

Cooper et al. (2001) conducted three trials to evaluate the effect of corn processing on the dietary DIP requirement of finishing steers. In Trial 1, 252 steers were fed 90%-concentrate high-moisture corn-based diets which contained 0, .4, .8, or 1.2% urea (DM basis). Nonlinear analysis predicted maximal feed efficiency at 1.09% urea which provided a dietary DIP value of 10.2% of DM. In Trial 2, 264 steers were fed 90%-concentrate steam-flaked corn-based diets which contained 0, .4, .8, 1.2, 1.6, or 2.0% urea (DM basis). Nonlinear analysis predicted maximal feed efficiency at .83% urea which provided a dietary DIP value of 7.1% of DM. In Trial 3, 90 individually-fed steers were fed 90%-concentrate dry-rolled, high-moisture, or steam-flaked corn-based diets. Urea was factored across diets at 0, .5, 1.0, or 2.0% of DM. Dietary CP, DIP, and finishing steer performance are shown in Table 3. For the dry-rolled corn-based diet, nonlinear analysis could not predict a requirement because feed efficiency was not improved beyond the first increment of urea, suggesting that the DIP requirement was met at 6.3% of DM. For the high-moisture corn-based diet, nonlinear analysis predicted maximal feed efficiency at 1.14% urea which provided a dietary DIP value of 10.0% of DM. For the steam-flaked corn based diet, nonlinear analysis predicted maximal feed efficiency at 1.64% urea which provided a dietary DIP value of 9.5% of DM.

Our data suggest that dietary DIP requirements for dry-rolled, high-moisture, and steam flaked corn-based diets are approximately 6.4, 10.0, and 9.5% of DM, respectively. Level 1 of the NRC (1996) model predicts that the dietary DIP requirement for a 90%-concentrate dry-rolled corn-based diet is approximately 6.8% of DM. Our value of 6.4% is in close agreement with the predicted value. Milton et al. (1997) in two separate finishing trials found dietary DIP requirements of 6.9 and 7.1% of DM for 90%-concentrate dry-rolled corn-based diets. Therefore, it appears Level 1 of the NRC (1996) model is relatively accurate in predicting the dietary DIP requirement for dry-rolled corn-based diets. However Level 1 does not appropriately account for the increased ruminal starch digestion, and thus BCP production, in high-moisture and steam-flaked corn-based diets. Our data suggest that high-moisture and steam-flaked corn-based diets require approximately 50% more dietary DIP than a comparable dry-rolled corn-based diet.

UIP requirements. Dietary UIP requirements are equal to the MP requirement of the animal minus MP supplied from BCP. Often, typical corn-based finishing diets do not need to be supplemented with additional UIP because base-diet UIP and MP from BCP are sufficient to meet the needs of the animal. Corn usually contains between 8 and 10% CP, with approximately 60% of the CP as UIP. In diets containing 85% corn, this results in 4.1 to 5.1% of the diet being UIP (NRC, 1996). We have found that 4.6% UIP in addition to BCP is sufficient to meet the MP needs of finishing yearling steers (Sindt et al., 1994; Shain et al., 1994), indicating supplemental UIP would not be needed in this case. However, supplemental UIP may be needed in diets with lower inherent UIP such as high-moisture corn, or in animals with high MP needs such as rapidly-growing lightweight calves.

MP requirements. Level 1 of the NRC (1996) model predicts large changes in protein requirements throughout the feeding period due to changes in intake, body weight, and composition of gain. The DIP requirement increases due to a gradual increase in intake as body weight increases (Figure 5). The UIP requirement decreases as body weight increases due to both a larger supply of BCP and from a lower requirement because the composition of gain is increasingly more fat and less lean (Figure 5). The overall MP requirement for the animal does not change significantly with time on feed because as the MP needed for gain decreases, the MP needed for maintenance increases (Figure 6). Figures 5 and 6 were developed with performance parameters described in Table 4, which will be discussed later, and assumes a 90%-concentrate dry-rolled corn-based diet with alfalfa as the roughage source. Because the type of protein needed (DIP vs UIP) to meet the MP requirement changes with days on feed, a single finishing diet fed through the feeding period is inadequate, being deficient up to body weight for which it was balanced and excessive from that point on. Therefore, a series of finishing diets fed in sequential order in order to meet, but not exceed both the DIP and UIP requirements throughout the feeding period (phase-feeding), should be beneficial.

There are several reasons for feeding protein levels at, but not above, requirements. If UIP is supplemented to meet the MP requirements of finishing calves early in the feeding period, it is economically beneficial to remove this costly form of protein supplementation when it is no longer needed to maintain maximum performance. However, we feel the primary reason for feeding protein levels at, but not above, the requirement is pending environmental regulations. In trials conducted at the University of Nebraska (Erickson et al., 1999) yearling steers were fed finishing diets containing 13.5% crude protein, which was approximately 123% of the predicted requirement. During the 137 day feeding period from May to September, each steer excreted approximately 65 pounds of nitrogen onto the pen surface, of which, approximately 71% volatilized into the air. In 192-day calf-finishing trials conducted from October to May, steers excreted approximately 71 lbs of nitrogen onto the pen surface, of which, approximately 41% volatilized into the air.

It is important to note that in order to utilize phase-feeding as a nutrient management strategy without adversely affecting performance, one must know or be able to accurately predict the performance of a given group of cattle. Past feeding history is likely the best indication of future performance. We have summarized the performance of finishing calves at the University of Nebraska ARDC Beef Feedlot (Table 4). This summary contains approximately 640 animals fed as calves from 1994 to 1997 on a high-concentrate corn-based diet. All animals were implanted with at least one TBA-combination implant, and did not have a significant treatment effect in their respective trial. Intermediate performance was based on intake records and intermediate weights which were pencil shrunk 4%. The 1996 NRC model does not predict intake and NE requirement very well early and late in the feeding because the equations are based on feeding period averages. Discussion later shows how to handle that problem with the model.

Erickson et al. (1999) conducted four finishing trials, two with calf-feds and two with yearlings, to evaluate phase-feeding diets in order to minimize N excretion versus feeding a typical high-concentrate finishing diet that was formulated to industry standards and fed throughout the feeding period. The standard diet was 92.5% concentrate and formulated to contain 13.5% CP. Phase-fed diets were also 92.5% concentrate and formulated to match DIP, UIP, and MP requirements throughout the feeding period. For yearlings, three phase-fed finishing diets were used which were fed for 28, 28, and 54 days. For calves, eight phase-fed finishing diets were used which were switched every 14 days, with the eighth diet being fed for 73 days. Finishing performance and N balance are shown in Table 5. In yearlings, phase-feeding diets to match protein requirements improved feed/gain by 5% compared to the standard 13.5% CP diet. Nitrogen excretion to the pen surface was reduced by 22%, while total N volatilized into the atmosphere was reduced by 32% for the phase-fed diets compared to the standard diet. In finishing calves, phase-feeding reduced feed efficiency by approximately 4% compared to the standard diet. Nitrogen excretion to the pen surface was reduced by 13%, while total N volatilized into the atmosphere was reduced by 15% for the phase-fed diets compared to the standard diet. Differences in N volatilization between the yearling and calves are likely due to cooler temperatures during the calf-finishing studies (November to May) compared to the yearling-finishing studies (May to October).

Cooper et al. (2000) conducted a calf-finishing trial to evaluate phase-feeding of metabolizable protein in order to match requirements. Treatments were: 1) one finishing diet which matched requirements at initial body weight (700 lb); 2) one finishing diet which matched requirements at mid-weight (950 lb); and 3) six finishing diets fed in sequential order which matched requirements throughout the feeding period (every 100 lb increment in body weight). No performance differences were observed. We projected performance differences; however, due to mud during the feeding period, gain and efficiency were lower than projected for all treatments, causing protein requirements to be over predicted. Phase-feeding metabolizable protein did maintain equal performance while reducing nitrogen excretion to the pen by approximately 9% compared to the diet balanced for the initial weight of the steers. This trial emphasizes the need for accurate predictions of performance in order to feed at, but not above, metabolizable protein requirements of finishing cattle.

We believe that phase-feeding of metabolizable protein will eventually become a common practice in the feedlot industry. Currently, the idea of incorporating multiple supplements and finishing diets is not very popular in today's efficiency-driven feedlot industry. Cost savings on protein supplementation are likely to be small and offset by additional management needed for phase-feeding. However, we believe that environmental compliance, rather than economics, may be the primary factor that launches the management practice of phase-feeding for finishing cattle.

The 1996 NRC Model can be used very effectively because it contains the correct basic concepts. We have several suggestions on use of the Model in Table 6. Our recommended values for feedstuffs are in Table 7.

Literature Cited

Block, H., T. Patterson, T. Klopfenstein, and M. Moore. 2001. Evaluation of 1996 Beef Cattle NRC Model and development of Net Energy Modifiers. *Nebraska Beef Cattle Rep.* (In press).

Cooper, R. T. Milton, T. Klopfenstein, D. Jordon. 2001. Effect of corn processing on degradable intake protein requirement of finishing cattle. *Nebraska Beef Cattle Rep.* (In press).

Cooper, R., T. Milton, and T. Klopfenstein. 2000. Phase-feeding metabolizable protein for finishing steers. *Nebraska Beef Cattle Rep.* MP 73-A:63:65.

Erickson, G. T. Klopfenstein, T. Milton, and D. Herold. 1999. Effects of matching protein to requirements on performance and waste management in the feedlot. *Nebraska Beef Cattle Rep.* MP 71-A:60-63.

Klopfenstein, T., R. Mass, K. Creighton, and T. Patterson. 2000. Estimating forage protein degradation in the rumen. *J. Anim. Sci.* 78 (Suppl. 1):121.

Mass, R. A., G. P. Lardy, R. J. Grant, and T. J. Klopfenstein. 1999. In situ neutral detergent insoluble nitrogen as a method for measuring forage protein degradability. *J. Anim. Sci.* 77:1565-1571.

Milton, C. T., R. T. Brandt, Jr., and E. C. Titgemeyer. 1997b. Urea in dry-rolled corn diets: finishing steer performance, nutrient digestion, and microbial protein production. *J. Anim. Sci.* 75:1415-1424

National Research Council. 1984. *Nutrient Requirements of Beef Cattle (6th Edition).* National Academy Press, Washington, D.C.

National Research Council. 1996. *Nutrient Requirements of Beef Cattle (7th Ed.).* National Academy Press, Washington, D.C.

Russell, J. B., J. D. O'Connor, D. G. Fox, P. J. Van Soest, and C. J. Sniffen. 1992. A net carbohydrate and protein system for evaluating cattle diets: I. Ruminal fermentation. *J. Anim. Sci.* 70:3551.

Shain, D. H., R. A. Stock, T. J. Klopfenstein, and D. W. Herold. 1998. Effect of degradable intake protein level on finishing cattle performance and ruminal metabolism. *J. Anim. Sci.* 76:242-248.

Shain, D. H., R. A. Stock, T. J. Klopfenstein, and R. P. Huffman. 1994. Level of rumen degradable nitrogen in finishing cattle diets. *J. Anim. Sci.* 72(Suppl. 1):923 (abstr.).

Sindt, M. H., R. A. Stock, and T. J. Klopfenstein. 1994. Urea versus urea and escape protein for finishing calves and yearlings. *Anim. Feed Sci. Tech.* 49:103-117.

Wilkerson, V. A., T. J. Klopfenstein, R. A. Britton, R. A. Stock, and P. S. Miller. 1993. Metabolizable protein and amino acid requirements of growing beef cattle. *J. Anim. Sci.* 71:2777.

Table 1. NE adjuster values based on TDN concentration[a]

TDN concentration[b]	NE adjuster[c]
0.500	1.51
0.538	1.25
0.577	1.08
0.615	0.97
0.653	0.90
0.692	0.85
0.730	0.82
0.768	0.80
0.807	0.79
0.845	0.78

[a] Equation is $y = 183 \times 10^{(-4.78x)} + .7628$. (Block et al., 2001)

[b] TDN concentration, lb/lb/of DM.

[c] Predicted NE adjuster, decimal form.

Table 2. Response of compensating yearlings to UIP

	Protein, UIP		
Winter gain	0	+	Difference
Slow, .05 lb/day	2.38	2.54	.16
Fast, 1.5 lb/day	1.88	2.30	.42

[a] ADG (lb) grazing Sandhills range; smooth brome or warm-season grasses.

[b] Difference during grazing on range.

Table 3. Dietary protein composition and finishing performance for steers fed dry-rolled, high-moisture, and steam-flaked corn-based diets (Cooper et al., 2001; Trial 3)[a]

	Treatment				
Urea, % of DM	0	.5	1.0	1.5	2.0
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]
HMC	23.0[c]	21.1	21.4	21.8	20.8[d]
SFC[f]	17.8[d]	22.3	20.8	21.9	18.7[e]
Daily gain, lb/day					
DRC[g]	3.39[c]	3.61[cd]	3.38[c]	3.96	3.70[c]
HMC[h]	3.70[c]	3.45[c]	3.51[cd]	3.75	3.32[d]
SFC[f]	2.99[d]	3.79[d]	3.72[d]	4.07	3.45[cd]
Feed/gain					
DRC	6.41	5.81	6.49[c]	5.88[c]	6.17[c]
HMC	6.21	6.13	6.06[cd]	5.81[cd]	6.25[c]
SFC[g]	5.95	5.85	5.59[d]	5.38[d]	5.38[d]

[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 ($P < .05$).

Table 4. University of Nebraska ARDC Beef Feedlot performance parameters for finishing calves

	Body weight lb	DM intake lb/d	DM intake % of body weight	Daily gain lb/d	Feed/Gain
	600	18.0	3.00	3.6	5.0
	700	19.0	2.71	3.6	5.3
	800	20.0	2.50	3.6	5.6
	900	21.0	2.33	3.6	5.8
	1000	21.5	2.15	3.6	6.0
	1100	22.0	2.00	3.6	6.1
	1200	22.5	1.88	3.6	6.3
	1300	23.0	1.77	3.6	6.4
Average	950	20.9	2.29	3.6	5.8

Table 5. Performance of finishing yearlings and calves fed either a standard finishing diet or phase-fed multiple finishing diets in order to match protein requirements (Erickson et al., 1999)

	Treatment[a]		
Urea, % of DM	Standard	Phase-fed	P =
Yearlings			
DM intake, lb	25.2	24.5	.03
Daily gain, lb	3.98	4.07	.27
Feed/gain	6.33	6.02	.01
N intake, total lb	72.82	59.39	.01
N retention, total lb	7.90	7.92	.80
N Excretion, total lb	64.92	51.47	.01
N volatilization, total lb	46.04	31.25	.01
Calves			
DM intake, lb	20.3	20.7	.21
Daily gain, lb	3.45	3.40	.43
Feed/gain	5.88	6.10	.04
N intake, lb/head	81.40	72.23	.01
N retention, lb/head	10.14	10.04	.28
N Excretion, lb/head	71.26	62.18	.01
N volatilization, lb/head	29.31	24.91	.32

[a] Standard diet balanced to contain 13.5% CP; Phase-fed diets were fed in sequential order and were balanced to match MP requirements throughout the feeding period.

Table 6. Suggested inputs and guidelines for use of the 1996 NRC model

1. **Units and Levels Section.**
   Use only Level 1, unless rates of digestion of all feed fractions are known.

2. **Animal Section.**
   Remember that your choice of breed affects maintenance energy requirements. *Bos indicus* cattle have lower NE_m requirements, while dairy and dual purpose breeds have higher requirements. This is discussed in detail in the textbook accompanying the NRC Model.

3. **Management Section.**
   A. **Microbial Yield.** With growing and finishing diets the model uses the effective NDF values of the feedstuffs to predict a ruminal pH, which is used to calculate microbial yield or efficiency. Use effective NDF values listed in Table 7. For cattle fed finishing diets the model will automatically adjust the microbial yield using effective NDF.

   For grazing cattle use 13% (default) for all vegetative forages and forages above 60% digestibility. For lower quality forages such as winter range or hays below 55% TDN use a microbial efficiency of 9 to 10%. Values as low as 8% may be necessary when the diet consists of mainly straw, stover, or other forages below 50% TDN which have lower passage rates. After calving, intakes and passage rates increase, therefore, microbial efficiency should be increased one percentage unit above that of a gestating cow fed the same forage. The equation in Figure 1 can be used as a guide.

   B. **Microbial Yield (Site of digestion).** As rumen digestion of finishing diets increases, the microbial efficiency value can be adjusted to increase microbial yield and consequently the DIP requirement. Each unit increase in microbial efficiency (increasing from .13 to .14) increases DIP-requirement and bacterial protein supply by about 10%. Increased TDN levels, such as with steam flaked corn, also increase the DIP requirement and must be accounted for.

   C. **Diet NE_m and NE_g Adjusters.** Use these to adjust performance predicted by the NRC Model to match the actual closeout performance or pen projected performance. The model may calculate unrealistically high feed efficiency and ADG for calves early in the finishing period. We suggest using the following adjustments for Diet NE_m and NE_g. For every 100 lb from the midpoint weight, change both NE_m and NE_g adjusters by 6 percentage units. For example, if calves are being fed from 600 lb to 1200 lb, the midpoint is 900 lb. When the calves weigh 700 lb, set the NE_m and NE_g adjusters at 88. At 1100 lb the adjusters would be 112. Use this as a guideline only.

D. **Diet $_{NEm}$ and NE_g Adjusters (TDN concentration).** Table 2 can be used as a guide for selection of adjusters. These adjusters include environmental effects. For finishing cattle it may be useful to use temperature to reduce cattle performance 0 to 20% as indicated in the text (or more) so that the NE_m and NE_g adjusters can be used to adjust for time on feed (See C. above). One can use the previous temperature to increase maintenance requirement and thereby reduce predicted gain. Reducing previous temperature from 68° F down to 0 to 10° F has the effect of reducing NE efficiency by 10%.

E. **Using the 'On Pasture' feature in the management section** will increase maintenance energy requirements by approximately 25% with level terrain and 50% with hilly terrain. The value can be input as a range between 1 (level) and 2 (hilly) in 0.1 unit increments. We recommend using this feature cautiously. In many cases, maintenance energy requirement is not increased by 25% while cattle are on pasture. Requirements are calculated accurately for pasture cattle even if this 'On Pasture' feature is turned off.

4. **Environment Section.**

A. **Temperature.** The long time period cattle are on feed is subject to large variations in temperature, such that an average temperature over the entire period (or over a month or a week or even a day) does not reveal the true impact of the short-term environmental extremes which are responsible for altering animal performance. Further, because cattle behavior is impacted by wind speed, cattle are not subjected to reported wind speeds. Reported wind speeds are measured by anemometers positioned 10 feet above the ground. Finally, mud, not cold stress, likely impacts cattle performance the most. Therefore, we recommend use of the NE adjusters to adjust for the impact of environment and include adjustment with previous temperature, as show in 3D above, to account for adjustments more than 20%.

5. **Feeds Section.**

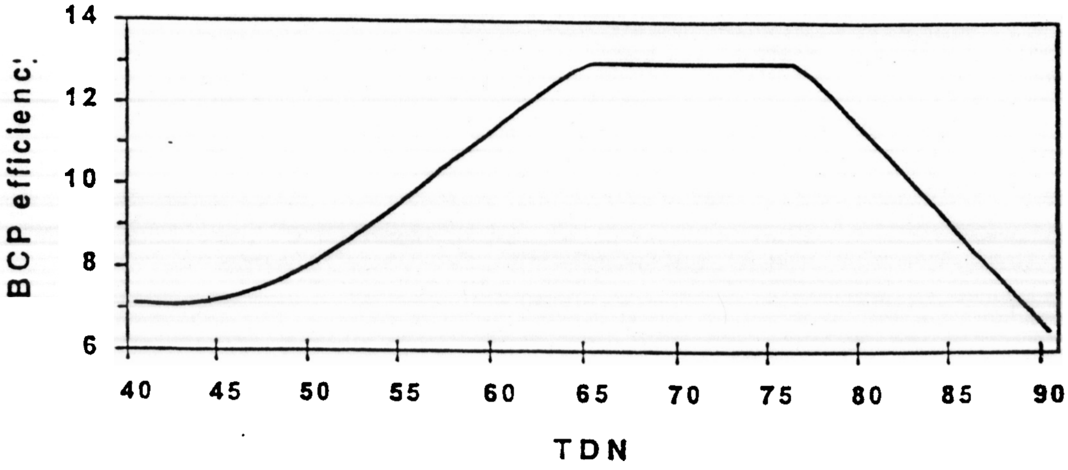
A. Use the **Feed Library** (a feature separate from the model) to make global changes to feedstuff composition. Use the **Feed Composition** feature to make feed composition changes specific to a ration or problem (composition changes made in this manner will be specific to that input file only).

B. When estimates of feed intake are unavailable or unknown, use the NRC estimated intake as a guideline. As a general guideline, use 3% of body weight when the finisher diet is first fed as an estimate of feeding period intake for calves and yearlings.

For cows using the following as general guidelines. Dry gestating cows will generally consume 1.8 to 2.0% of body weight, while lactating cows will consume 2.3 to 2.5% of body weight.

Table 7. Suggested values for feedstuffs commonly used by Nebraska cattle producers

Protein meals	eNDF	TDN	CP	DIP
Soybean meal	0	88	49.9	70
Sunflower meal	0	65	25.9	81
Cottonseed meal	0	75	46.1	57
Feather meal	0	88	85.8	30
Blood meal	0	88	90.5	25
Harvested forages				
Corn silage	71	75	7.4	75
Alfalfa hay	100	60	16	82
Brome hay, mid bloom	100	66	14.4	84
Alfalfa hay, early vegetative	100	74	30	93
Alfalfa hay, late vegetative	100	67	20.3	85
Meadow hay, high quality	100	67	16.2	87
Prairie hay	100	49	6.8	80
Prairie hay	100	53	7.7	75
Grazed forages				
Sandhills range, June diet	100	68	12.4	82
Sandhills range, July diet	100	67	10.9	82
Sandhills range, August diet	100	64	10.0	84
Sandhills range, September diet	100	55	8.2	82
Winter native range	100	50	5.5	75
Grains				
High moisture corn	0	90	8.4	60
Dry corn	0	88	8.4	40
Steam flaked corn	0	98	8.4	40
Rolled sorghum grain	0	79	10.5	40
Byproducts				
Distillers solubles (dry milling)	0	88	28	80
Distillers solubles/steep liquor (wet milling)	0	88	36	70
Wet corn gluten feed	18	88	22	75
Sorghum distillers grains + solubles (wet)	18	96	34	40
Corn distillers grains + solubles (wet)	18	106	30	40



If TDN < 65% then BCP = $2.619948 + 1.782321X - .095981X^2 + .001777X^3 - .000010524X^4$ WHERE X = % TDN.

Figure 1. BCP efficiency.

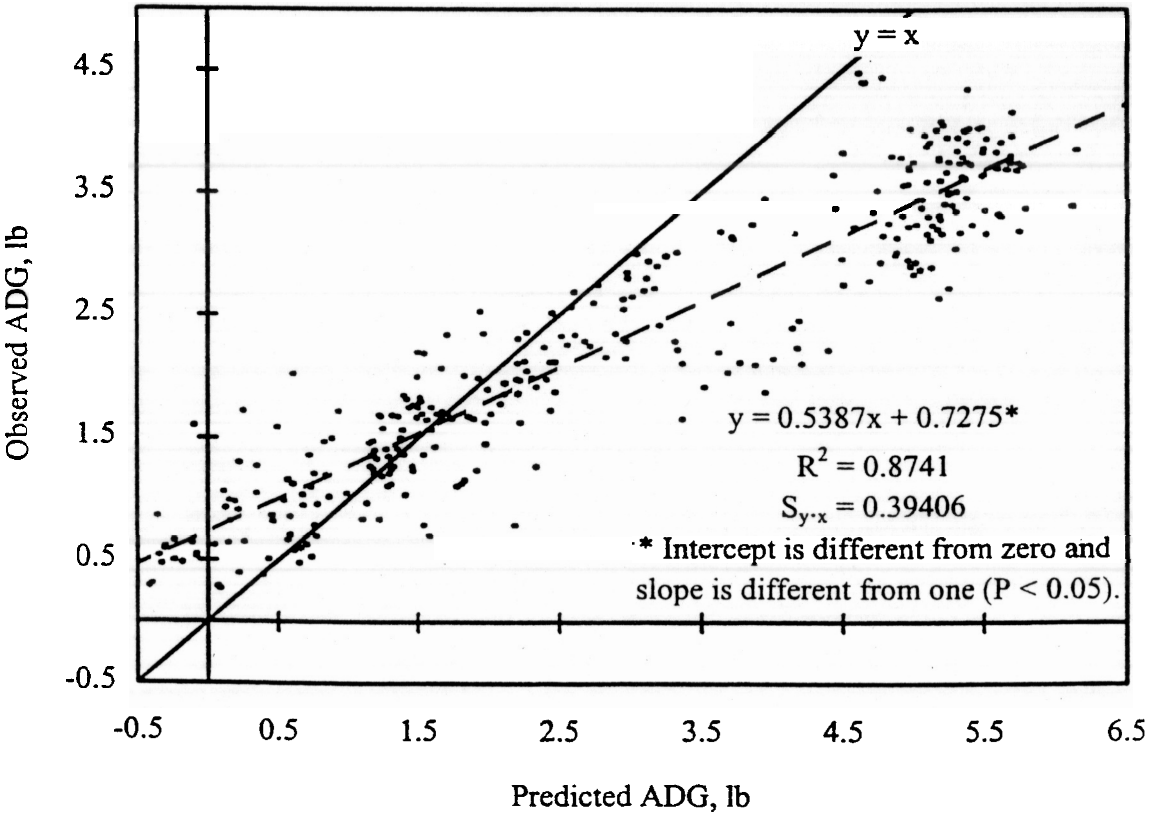


Figure 2. Accuracy of gain predictions. Each point represents a treatment mean (n = 325).

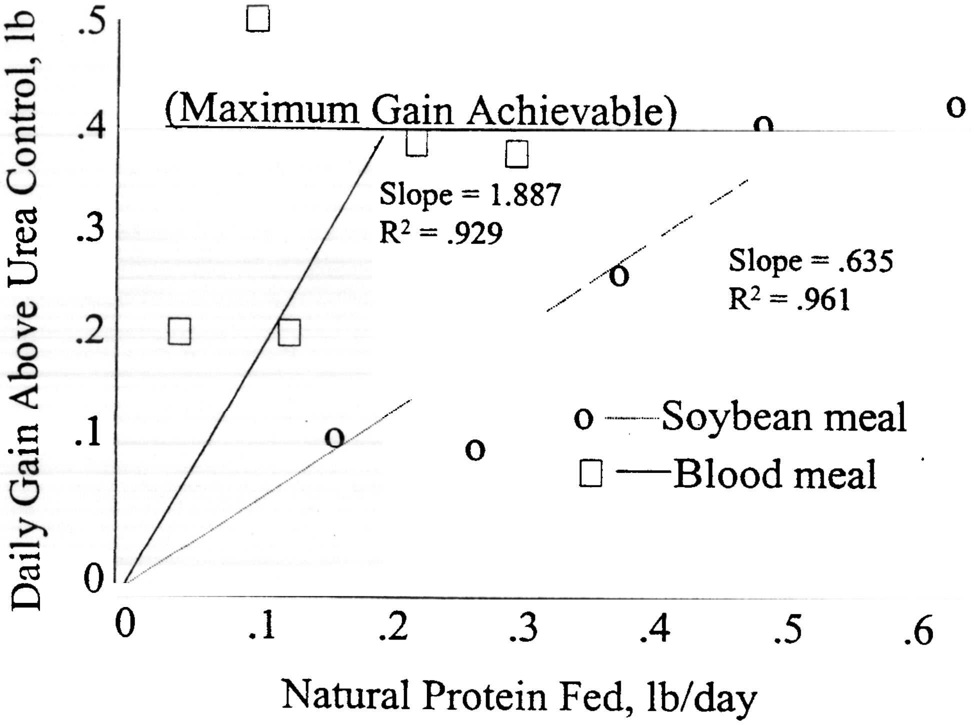


Figure 3. Natural protein fed/day vs daily gain above urea control.

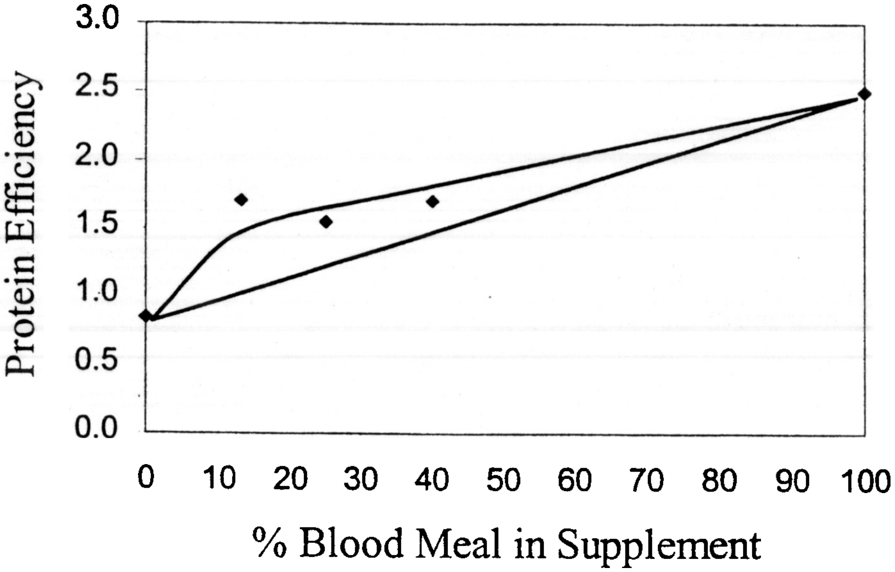


Figure 4. Complementary effect of feather meal-blood meal combinations.

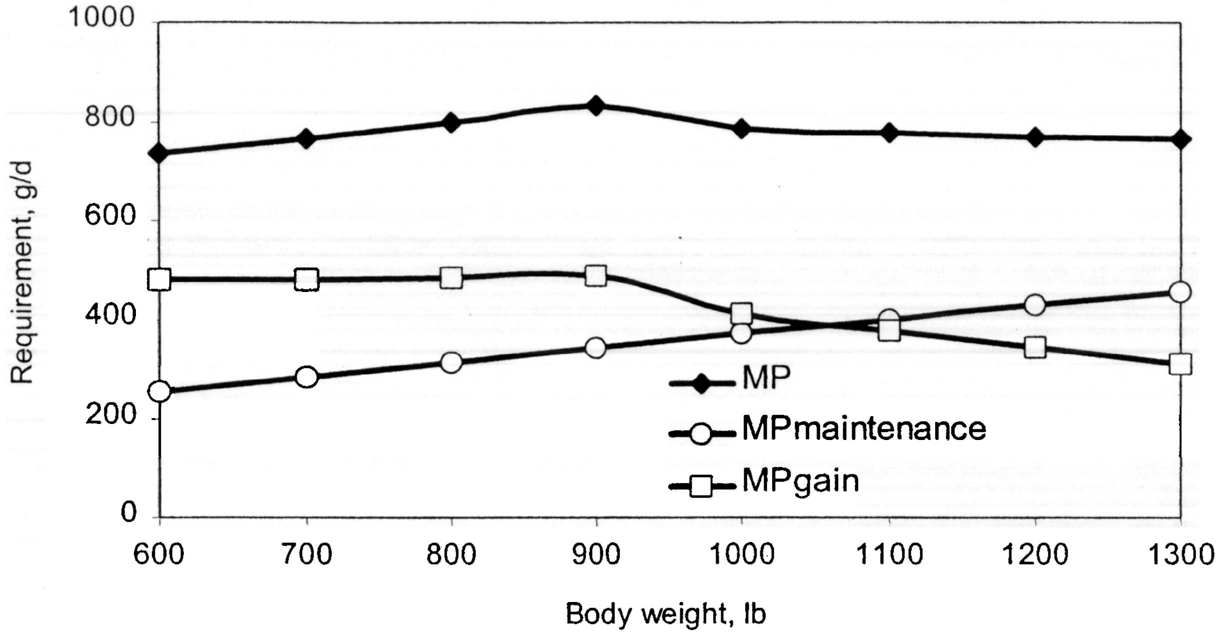


Figure 5. Metabolizable protein requirements for finishing calves throughout the feeding period.

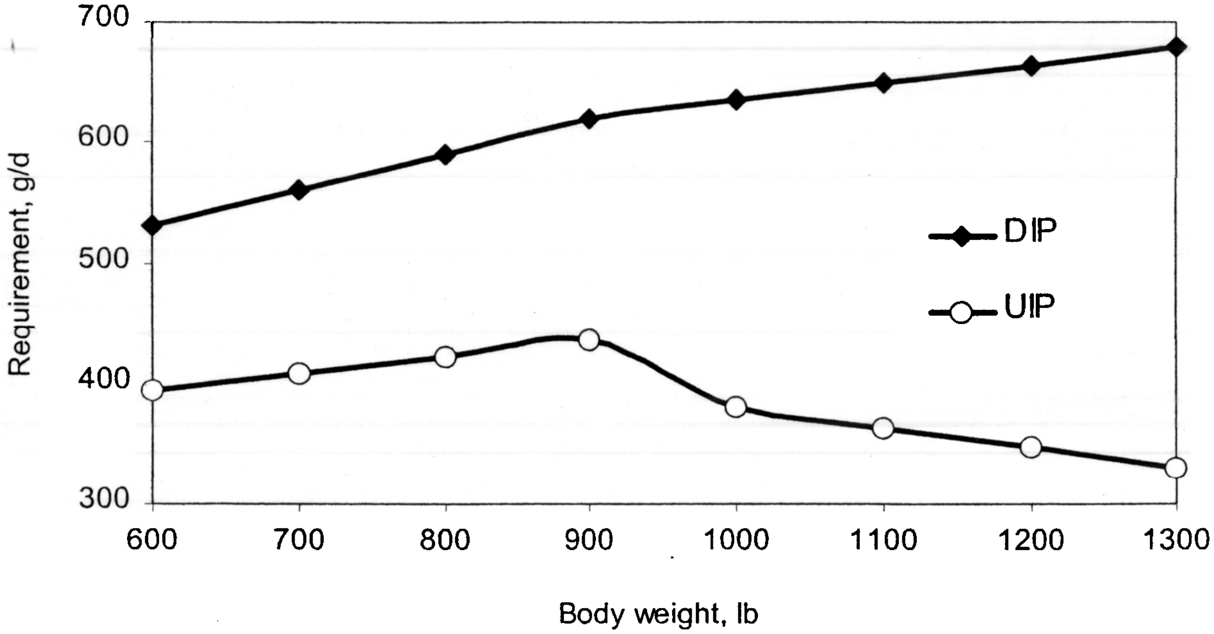


Figure 6. Degradable and undegradable intake protein requirements of finishing calves throughout the feeding period.