Champion Feed Services Ltd.

Protein Requirements of Feedlot Cattle

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Take Home Message

✓ The new Nutrient Requirements (NRC) of Beef Cattle published in 1996 has shifted from a crude protein (CP) to a metabolizable protein (MP) system.

✓ MP is defined as protein (actually amino acids) which is actually absorbed from the gut of cattle.

Feed protein is considered to fall into one of two categories:
- Protein required to meet the requirements of the rumen microorganisms called rumen degradable intake protein (DIP) and
- Protein that escapes from the rumen into the small intestine of cattle, called rumen undegradable intake protein (UIP).

To gain a proper understanding of the system it is useful to consider:
- the protein requirements of the microorganisms in the rumen;
- the protein requirements of the animals;
- the characteristics of feed protein supplied and how this protein is used to meet the protein requirements of the microorganisms and the animal.

New Information Concerning the Protein Requirements of Beef Cattle

The most widely used information source for beef cattle nutrition is the National Research Council publication 'Nutrient Requirements of Beef Cattle' which is compiled by scientists in the US and Canada. A new edition of the publication appeared in 1996 and made substantial changes in the way we think about protein in beef cattle diets. We are now much more aware of the concept that protein nitrogen which is degraded in the rumen in excess of the amount needed by the rumen microorganisms will be excreted in the urine as a waste product and at a considerable energy cost to cattle. We know also recognize that we must consider the amount of protein intake which is degraded in the rumen (DIP) and the amount that escapes fermentation and passes to the intestinal tract (UIP). This means that there is no single crude protein level in the feed which can satisfy the protein requirements of cattle. The crude protein levels for cattle at a specified weight and growth rate changes depending on the DIP and UIP contents of the diet.

Importance of Protein

The importance of protein in nutrition and health of cattle can not be overemphasized. It is quite appropriate that the Greek word chosen as a name for this nutrient is proteos, meaning primary, or taking first place. Proteins are nitrogen-containing compounds and the amino-acids contained in them are involved in the maintenance and formation of muscles, tissues, organs, bones and other physiological and biochemical process in the body. Proteins are thus essential for life.

Protein Requirements of the Rumen Microorganisms and Amount of Metabolizable Protein Supplied

Sufficient protein must be available in the rumen to supply the needs of the microorganisms so that these organisms can digest the fibre for the animal. In the NRC (1996) system the requirements of the ruminal organisms are considered first. The system assumes that the amount of protein which is required by the microorganisms is equivalent to the amount of microbial protein produced in the rumen. Since the growth of the organisms is proportional to the amount of energy which is fermented in the rumen, the maximum amount of microbial protein (kg) which is produced in the rumen is calculated as the intake of digestible energy (DE, Mcal/day) times 0.0295. As an example, if a steer was eating 10 kg of a diet which provided 3.0 Mcal DE/kg, it would be consuming 30 Mcal DE daily and the maximum amount of microbial protein which would be predicted to be formed in the rumen daily would be 0.885 kg. Microbial production is decreased, however, when the rumen becomes more acid. Since excessive rumen acidity develops when there is insufficient fibre in the diet, microbial protein production in the rumen, and hence microorganism protein requirements is assumed to decrease from 100% of maximum when the amount of effective fibre is outside the range of 20% to 56% of the diet. Dietary effective fibre concentrations of less than 20% or more than 56% will result in reduced microbial protein production. Effective fibre is that fibre which stimulates chewing activity. Effective fibre is assumed to be 30% of neutral detergent fibre (NDF) for grains and up to 100% of NDF for forages. The effective fibre may be lower with chopped forages containing, very fine particles.

Not all of the microbial crude protein is available to the animal as metabolizable protein. One source of loss is that approximately 20% of 'crude protein' is not really protein, but is nitrogen contained in compounds such as nucleic acids. The NRC (1996) calculates true protein content in rumen microorganisms as 80% times crude protein. In addition, not all of the true protein in microbial cells is digested in the intestinal tract and thus it does not yield MP to the animal. The NRC (1996) estimate is that only 80% of the true protein in microorganisms is actually absorbed by the animal. Thus even though enough protein must be supplied to meet the total crude protein requirements of the microorganism, this amount of crude protein only supplies 0.64 times its weight as MP (i.e. 80% true protein content in the microbial protein times 80% of true protein which is absorbed = 64% of crude microbial protein absorbed).

Protein Requirements of the Animal

The next step in determining animal requirements is to consider the amount of protein which the animal's body requires simply to maintain itself. The new NRC (1996) assumes that this is a constant proportion of body weight (i.e. metabolizable protein required equals 3.8 times shrunk body weight to the power of 0.75). To this must be added the amount protein required for lean tissue gain. The amount of protein deposited in tissue ranges between 10 and 20% of the body weight gain; with younger, faster growing animals depositing more protein in each unit of liveweight gain than an older animal. The animal is not 100% efficient in depositing protein in gain; the NRC (1996) estimates are that the efficiency of protein deposition in the animal ranges from 49% to about 75%, with the highest efficiency occurring in the youngest animals. Thus, the total amount of protein which must be absorbed from the digestive tract for weight gain (i.e. the MP requirement for this purpose) equals from 20 to 30% of the amount of weight gain. This must be added to the maintenance requirements to get the total MP requirement of the growing animal. Similar calculations can be made for milk production and reproduction but since we are discussing feedlot animals such calculations will not be considered here.

Calculating The Amount of Feed Protein to Meet Microbial and Animal Requirements

First, the amount of feed protein needed to meet the requirements of the microorganisms is calculated as the amount of microbial crude protein required in the rumen (DIP) divided by the proportion of feed protein which is degradable in the rumen. As an example, for a 200 kg steer growing at 0.4 kg a day, the requirements of the microbes are 395 grams. If the proportion of DIP in the feed was 90%, then the amount of crude protein required to meet microbial needs would equal 395/0.90 = 438 grams. The amount of MP which the DIP protein would supply is 395 g x 0.64 = 253 g. Secondly, the amount of MP which is supplied by UIP in the feed consumed to meet the UIP requirements of the animal is considered. In this case the UIP content of the feed is 0.10, (100 - %DIP) of the total protein in the diet. Thus, the amount of UIP supplied by 438 grams of crude protein is 438 x 0.10 = 43.8 grams. Since UIP requirement for this animal is 88 grams we are short by 88 - 43.8 = 44.2 grams. The crude protein required to provide the additional UIP is 44.2 grams / 0.10 = 442 grams. The total CP for microbes and UIP is 438 + 442 = 880 grams. Therefore the percent crude protein required at a dry matter intake of 5.6 kg by the steer is 0.880 kg x 100/5.6 kg = 15.6%. What this means is that a diet of 15%-16% crude protein is required when the DIP and UIP is 90 and 10%, respectively, when fed at 5.6 kg dry matter. This meets the MP requirements of a 200 kg steer growing at 0.4 kg a day, finishing at 450 kg. and grading at AA.

How to Use the Graphs to Meet Protein Requirements of Feedlot Cattle

To use Figures 1 to 5 we first need to know the undegradable intake protein (UIP) concentration of the diet. Common UIP values are given in **Table 1**. For a diet that is 25% barley silage (UIP = 14%) and 75% barley grain (UIP = 33%) on a dry matter basis, the overall dietary UIP value will be about 28%. If the calf weighs 350 kg (770 lb) and expected gain is 1.2 kg or 2.6 lb/day then from **Figure 3**, we see that the %CP of the diet would need to be about 13%. If gain is higher then the diet % CP must be increased. If the dietary UIP % is not 28% but rather 24%, then the %CP content of the diet should be 12.5%. The graphs assume a finished weight of 550 kg (1100 lb) and a AA marbling score at finish. The various figures (1 to 5) provide a very simple way of determining the CP concentration to use for formulating a ration for the various classes of feedlot cattle.

Finishing weight and marbling score will influence the calculation. For specific dietary protein requirements at other finished weights or marbling scores refer to NRC, 1996 or ration balancing programs such as COWBYTES (Alberta Agriculture Food and Rural Development, 1999).

Table 1. Degradable and Undegradable Protein Contents of Some Common Feeds in Alberta.

Feed	DM%	CP%	DIP % of CP	UIP % of CP
Alfalfa silage (Early bloom)	35	19.50	92	8
Alfalfa silage (Mid bloom)	38	17	91	9
Alfalfa silage (Full bloom)	40	16	91	9
Barley silage	39	11.90	86	14
Barley straw	91	4-4	30	70
Barley grain	88	13-14	67	33
Oat grain	89	13.60	76	24
Oat green hay	91	9.5	68	32
Timothy hay	89	6 - 9.70	50-69	50-31
Brome hay	89	6-14	48-79	52-21
Orchard grass	89	8-9	64-84	36-16
Alfalfa hay	91	12-30	90-75	10-25
Alfalfa pellets	90	17.3	54	46
Red clover	86	13.7	78	22
Creeping red fescue	89	10.2	71	29
Wheat grain	90	14.2	74	26
Canola meal	92	40.9	68	32
Legume-grass hay	90	12 - 19	70	30

Crude protein is on a dry matter basis. Please note that you can get the DIP and UIP concentrations of the various feedstuffs from the NRC (1996) publication.

Figure 1. Effect of dietary Undegradable Intake Protein on % Crude Protein for cattle at various weights, which will Grade AA (26.8% body fat) and finish at 1200 lb.

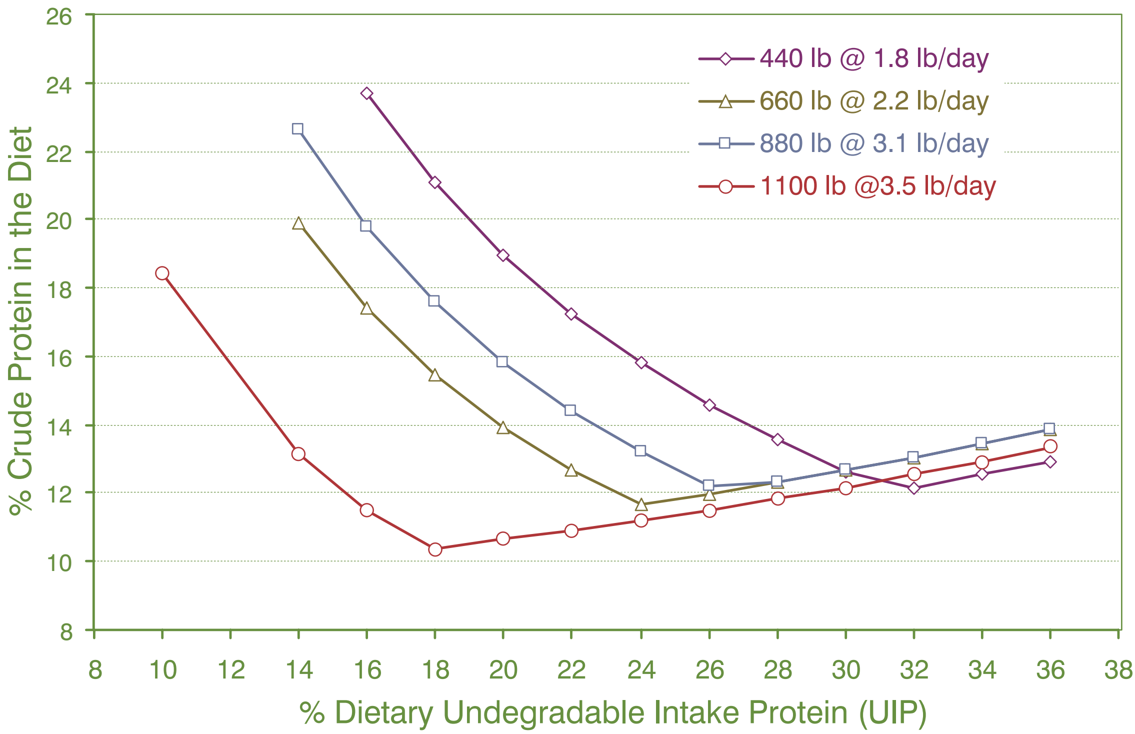

Figure 2. Protein requirements of 550 lb cattle, which will grade AA (26.8% body fat) and finish at 1200 lb at differing Undegradable Intake Protein and gain levels.

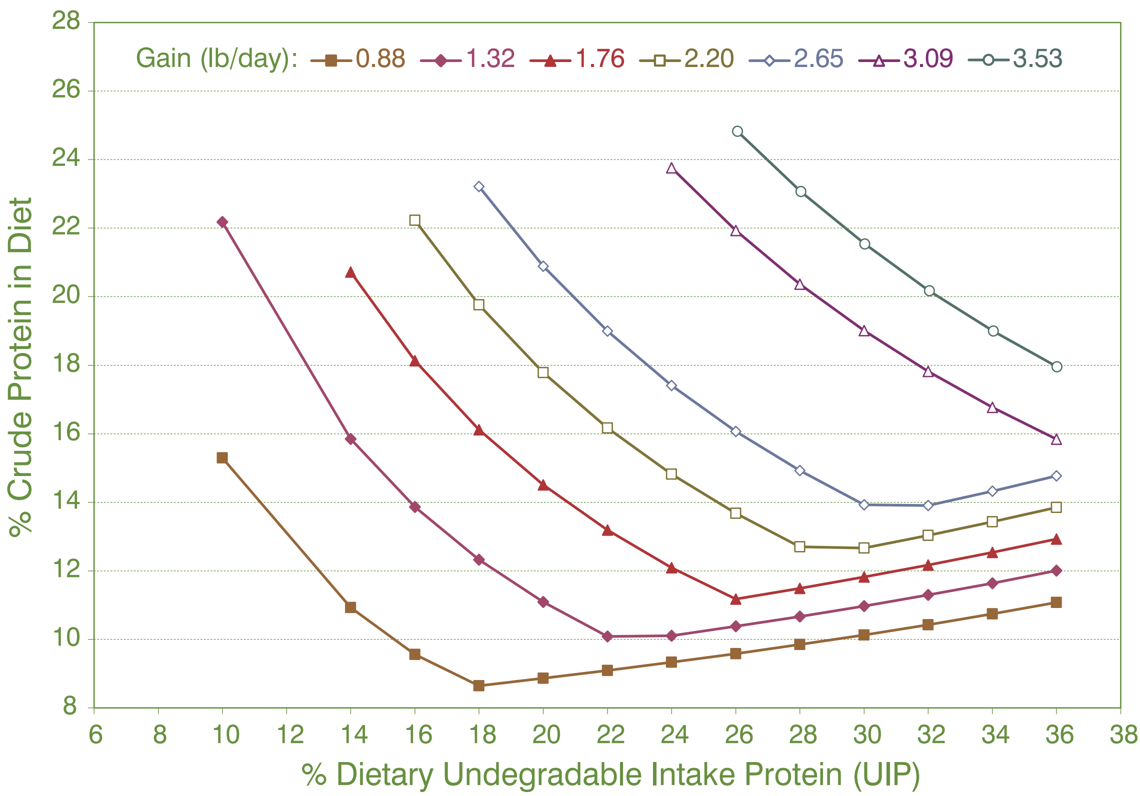

Figure 3. Protein requirements of 770 lb cattle, which will grade AA (26.8% body fat) and finish at 1200 lb at differing Undegradable Intake Protein and gain levels.

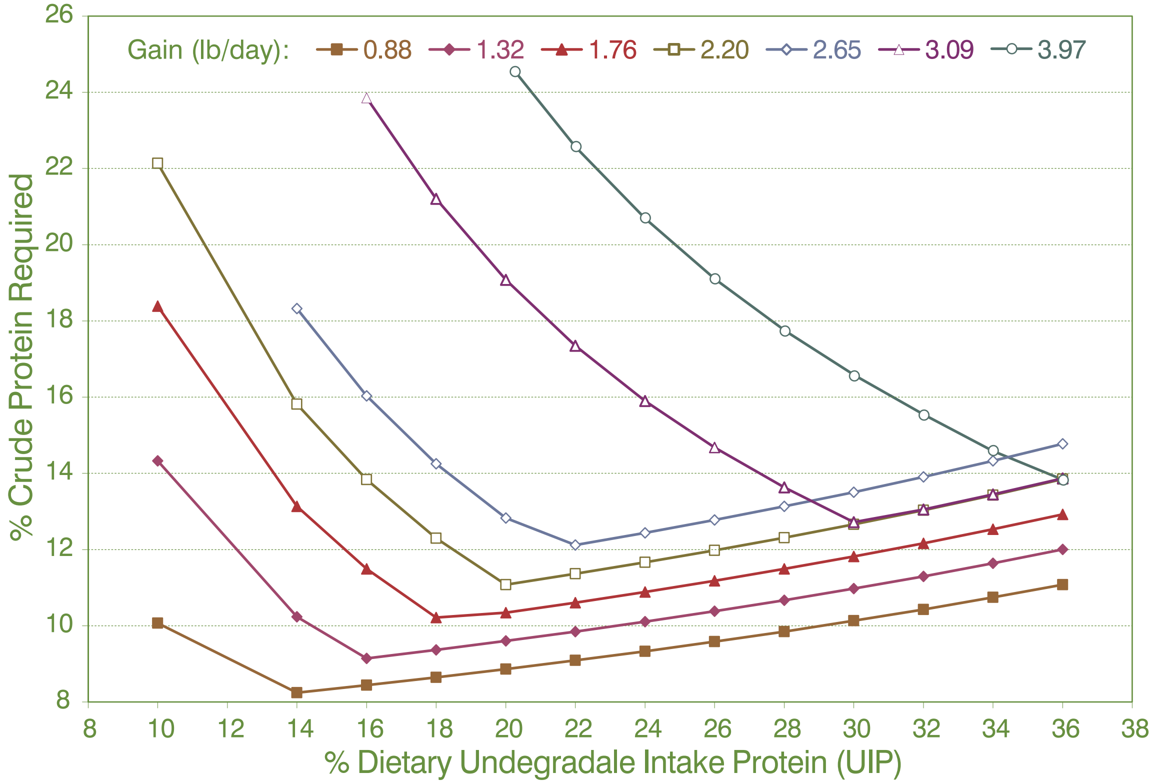

Figure 4. Protein requirements of 770 lb cattle, which will grade AA (26.8% body fat) and finish at 1200 lb at differing Undegradable Intake Protein and gain levels.

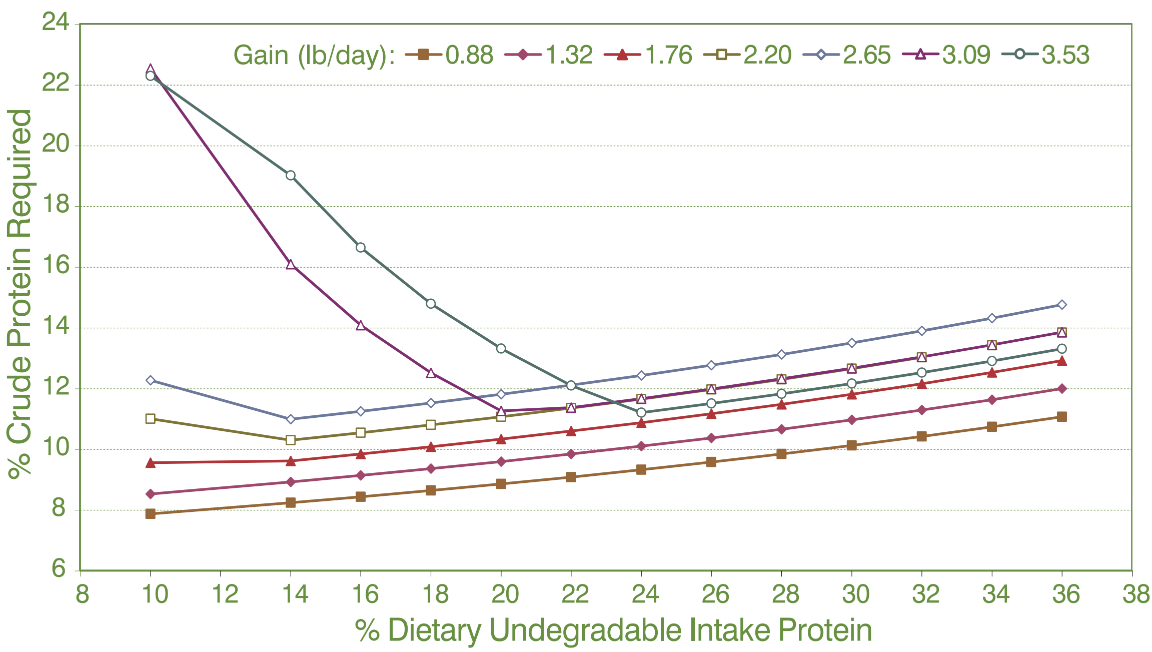

Figure 5. Protein requirements of 1100 lb cattle, which will grade AA (26.8% body fat) and finish at 1200 lb at differing Undegradable Intake Protein and gain levels.