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THE ROLE OF UNDEGRADABLE INTAKE PROTEIN IN MANAGEMENT OF THE
YOUNG BEEF FEMALE

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INTRODUCTION

Reproductive failure in young cows is expensive to many beef operations in the Northern Great Plains. Scientists, nutritionists, and producers have typically placed great effort into heifer development and mature cow management at the expense of two- and three-year-old cows. Meek et al. (1999), working with a ranch in the Nebraska Sandhills, found that the net present value (current animal value accounting for time value of money) of beef females peaked at four years old. Why were bred heifers and pregnant two-year-olds not more valuable than four-year-old cows? Reproductive failure in the young cows did not allow them to stay in the herd to generate revenue over time. In most operations, it is important for cows to produce multiple calves to recover the costs of development.

Managing the nutrition program of young females to meet metabolizable protein (MP) requirements may offer an opportunity to improve reproduction. Supplementation with undegradable intake protein (UIP), also known as bypass or escape protein, may be necessary to meet MP requirements in young females.

METABOLIZABLE PROTEIN SYSTEM

In the past, the crude protein (CP) system has been used to define cattle protein requirements and feedstuff protein value (NRC, 1984). Crude protein is calculated by multiplying the amount of nitrogen in a feedstuff by 6.25. Due to the ease of estimating the CP content of a feedstuff and a history of using the CP system to determine animal protein requirements, the CP system is still widely used today in beef cattle nutrition. There is a fundamental flaw in the CP system, however. The CP system erroneously assumes that all protein is equally degraded in the rumen (NRC, 1996).

As ruminants ingest grazed forage or other feedstuffs, the rumen microbes use energetic substrates, ammonia, and some amino acids and peptides to grow and reproduce. The rumen microbes are high in protein content (approximately 64% digestible true protein). As the microbes leave the rumen with fluid and particles, they are digested in the abomasum and small intestine. This microbial crude protein can supply from 50 to 100% of the MP requirement of beef cattle (NRC, 1996). The protein that is degraded in the rumen (used for microbial protein) is called degradable intake protein (DIP). Given adequate DIP, microbial crude protein production is a function of TDN intake. In range and forage based growing diets, the NRC (1996, Level 1) assumes this microbial efficiency to be 13% of TDN intake. In low energy, high forage diets, the microbial efficiency may be as low 7.0%. In addition

to the protein supplied by microbial crude protein, some protein escapes rumen degradation and provides amino acids and peptides directly to the small intestine (UIP). The digestible true protein in microbial protein and UIP make up MP. Metabolizable protein is the protein that is absorbed in the intestine.

In 1996, the Nutrient Requirements of Beef Cattle (NRC) adopted the use of the MP system. This has broad application to foraging cattle. Feedstuffs such as urea, soybean meal, and sunflower meal have protein that is predominately degraded in the rumen (DIP). Feedstuffs such as feather meal, distillers grains, and corn gluten meal are high in UIP. Range forage in the Northern Great Plains contains between 1.0 and 3.5 % UIP on a DM basis. (Johnson et al., 1998; Lardy, 1997). Most feed testing laboratories are still only able to report CP without regard to its rumen degradability. However, the 1996 NRC gives the DIP and UIP content of many common feedstuffs. Table 1 shows CP and protein degradability estimates for some range and feedstuffs used in the Northern Great Plains. Universities are continually publishing more accurate protein degradability values, as the technology for determining degradability is improving. The 1996 NRC comes with software that calculates the metabolizable protein balance of beef cattle when the appropriate inputs are given (intake, diet TDN, CP, DIP, microbial efficiency, and animal/management information).

Table1. Estimates of crude protein, protein degradability, and energy value of native range and common feedstuffs in the Northern Great Plains.

Feedstuff	CP, % DM	UIP, % DM	DIP, % DM	DIP, % CP	TDN ^a
June Range, ND ^b	13.6	3.5	10.1	74.3	68.1
June Range, NE ^c	12.4	2.3	10.1	81.5	67.6
Sept Range, ND ^b	10.2	2.9	7.3	71.6	55.6
Sept Range, NE ^c	6.6	1.0	5.6	84.8	60.7
Dec Range, ND ^b	6.2	1.9	4.3	69.4	53.3
Dec Range, NE ^d	6.1	1.5	4.6	75.4	52.9
Brome Hay ^e	14.4	2.3	12.1	84.0	66.2
Prairie Hay ^e	6.8	1.7	5.1	75.0	49.0
Alfalfa Hay ^e	20.3	3.0	17.3	85.0	67.2
Meadow Hay ^d	8.5	2.2	6.3	74.1	51.5
Soybean Meal ^e	49.9	15.0	34.9	70.0	88.0
Cottonseed Meal ^f	46.1	19.8	26.3	57.0	75.0
Sunflower Meal	33.0	6.6	26.4	80.0	65.0
Feather Meal ^e	85.8	60.0	25.8	30.0	88.0
Corn, dry rolled ^e	8.5	5.1	3.4	40.0	88.0

^aForage TDN estimated from in vitro dry matter (or) organic matter digestibility.

^bSamples collected in North Dakota mixed grass prairie (Johnson et al., 1998).

^cSamples collected in Nebraska sandhills prairie (Lardy, 1997).

^dSamples collected in Nebraska sandhills prairie (Patterson et al., 2001b).

^eLardy et al., 1998.

^fNRC, 1996.

PROTEIN SUPPLEMENTATION DURING GESTATION

For spring calving operations, mid- to late-gestation occurs during a period of forage dormancy. Many operations supplement protein during this period to reduce body weight and body condition score loss. Positive effects of protein supplementation to mature cows are likely attained by increasing digestibility (Caton et al., 1988) and (or) intake of range forage (Clanton and Zimmerman, 1970). This response is due to the supply of DIP to the rumen microbes. Karges (1990) found that gestating cows consuming low quality prairie had a requirement for supplemental DIP, not UIP, during the winter. Work in the Nebraska Sandhills found that DIP was the first limiting nutrient to mature cows grazing native winter range (Hollingsworth-Jenkins et al., 1996). In other words, a cow grazing sandhills range (predominately warm-season grasses) in the winter can make enough microbial protein for optimal performance if supplemented with DIP. Based on the winter forage data from North Dakota shown in Table 1, DIP is likely first limiting to mature cows grazing cool-season dominated rangelands during the winter as well. Energy may be first limiting in situations of low forage availability or severe weather.

Work in Montana showed that the addition of either blood meal or corn gluten meal (both sources of UIP) to soybean meal supplements for gestating cows decreased body condition score loss over the winter compared to soybean meal supplementation alone (Miner et al., 1990). March calving cows grazing range would be expected to be deficient in MP in the 45-60 days before calving, even with DIP supplementation (NRC, 1996). Cow performance is not consistently improved by supplementing UIP during gestation, however. At a previous Range Beef Cow Symposium, Petersen et al. (1995) concluded that cows responded to UIP supplementation when losing weight.

The bred heifer is different than the mature cow, as she has MP requirements for maintenance, growth, and pregnancy during the winter (Figure 1). The magnitude of growth required is somewhat dependent upon the degree of development of the heifer prior to breeding. A lightly developed heifer, such as to 55% of mature weight prior to breeding, may exhibit a higher growth requirement prior to calving for optimal two-year-old reproduction to be achieved. In addition, the bred heifer may not have the grazed forage intake potential that a mature cow does. Recent research in Nebraska demonstrated that the grazed forage intake (DM basis) of March calving heifers declined from approximately 2.0% of body weight in November to 1.4% in February, even with DIP supplementation (Patterson et al., 2001b). When no hay was fed, DIP supplementation did not alleviate an MP deficiency throughout the fall and winter, and energy became markedly deficient in the two months prior to calving. Undegradable intake protein supplementation, in addition to DIP, did not reverse substantial weight and body condition score loss prior to calving. Supplemental hay in the two months prior to calving was necessary to reduce loss in weight and condition.

Since MP is deficient to heifers grazing native range in the winter, it is important to determine if supplementation to meet MP requirements improves performance and reproduction. Patterson et al. (2001a) used 2,375 pregnant, March calving heifers across two

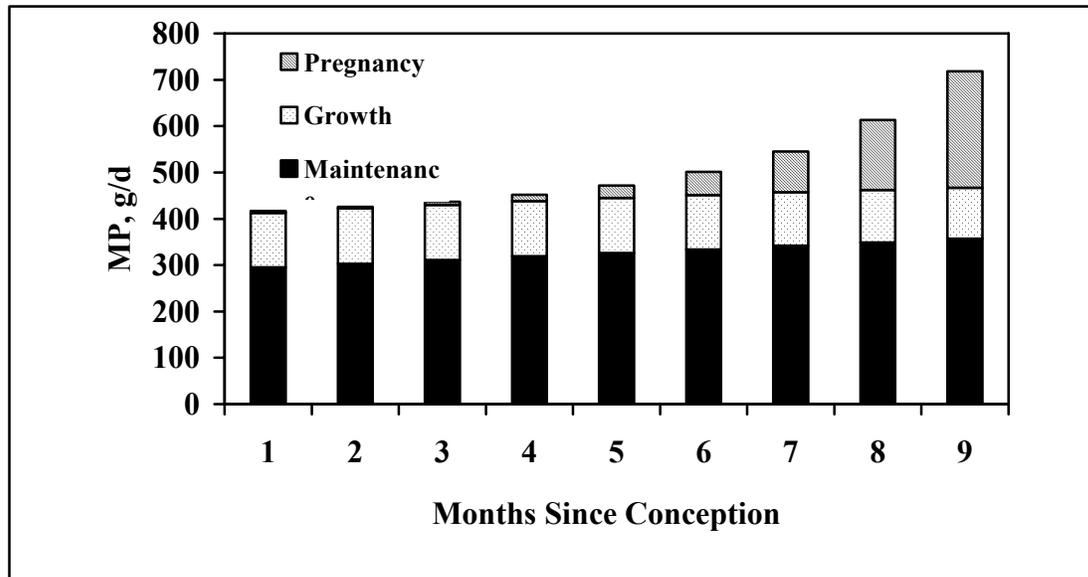


Figure 1. Metabolizable protein (MP) requirements of heifers with advancing gestation (NRC, 1996).

production years and two units of a commercial ranch in the Nebraska Sandhills. Heifers were supplemented to either meet CP or MP requirements from early October to mid-February. The treatment designed to meet CP requirements consisted of 0.9 lb/day (DM basis) of cottonseed meal based supplement (51% CP, 13% UIP). The treatment designed to meet MP requirements consisted of graded levels (0.7 lb/day in October to 1.6 lb/day in February) of a sunflower meal/wheat middling based supplement containing 40% feather meal (53% CP, 27% UIP). Hay feeding varied, but meadow hay was typically fed at 4.5 lb/day in mid to late December and gradually increased to 18 lb/day by February.

There were no differences in body weight or body condition score change of the heifers during the winter, but there was an effect on subsequent two-year-old pregnancy. The response depended on location and year (Table 2). When the pregnancy rate of heifers supplemented to meet CP requirements was 75% (body condition score of all heifers at that location averaged 5.0 at calving), there was a nine percentage unit response in two-year-old pregnancy to supplementation to meet MP requirements. When the pregnancy rate of CP supplemented heifers was at 95% (average body condition score approximately 5.5 at calving), there was no response to treatments. With pregnancy rates of CP supplemented heifers between 85-88% (average body condition score approximately 5.25 at calving), supplementation to meet MP requirements improved pregnancy between four and seven percentage units. The response to UIP supplementation (to meet MP requirements) was likely related to the level of nutrition, or energy balance, of each respective herd prior to calving. Another interesting point is that the last day the experimental supplements were fed was approximately 30 days prior to the average calving date. Supplementing the heifers to meet MP requirements in late gestation may have changed or primed endocrine systems to improve two-year-old pregnancy.

Table 2. Pregnancy rates in two-year-old cows, across two years and two locations, that were supplemented the previous winter to meet metabolizable protein (MP) or crude protein (CP) requirements while grazing sandhills range and consuming meadow hay^{a,b}.

Item	Location A		Location B	
	MP req.	CP req.	MP req.	CP req.
1997-98 ^c	95	95	84	75
1998-99 ^d	95	88	89	85

^aPatterson et al., 2001a.

^bTreatment × Year × Location interaction (P = .07).

^cTreatments differ at Location B (P = .01).

^dTreatments differ at Location A (P = .01) and Location B (P = .15)

It is important to consider costs and returns when evaluating nutrition programs. In the Nebraska study described above, supplement costs per heifer from October to mid-February were \$17.45 and \$15.64 for the high UIP and the conventional supplement, respectively. The average value (in current dollars) of each heifer that started the experiment was estimated to be \$13.64 higher for heifers supplemented to meet MP requirements.

SUPPLEMENTING PROTEIN DURING LACTATION

Due to the high protein requirements of cows during lactation, many diets are deficient in MP to young cows during the postpartum period. Patterson et al. (2001c) fed lactating two-year-olds medium quality hay (9.5% CP) and supplemented them to either meet DIP or MP requirements. Supplementing UIP to meet metabolizable protein requirements decreased cow weight loss during the 64 days of the study, but there was no improvement in postpartum interval by UIP supplementation.

In Montana, Wiley et al. (1991) supplemented both thin and moderate condition two-year-old cows during early lactation with either 250 grams of DIP/day or 250 grams of DIP plus and additional 250 grams of UIP/day. Supplementation with UIP increased postpartum weight change and the percentage of heifers bred in 21 days (65.5 versus 43.3% for UIP and no UIP, respectively). The authors hypothesized that increased insulin stimulated by UIP partitioned nutrients towards growth and potentially increased ovarian sensitivity to luteinizing hormone.

Other studies have suggested repartitioning of nutrients associated with UIP supplementation. In New Mexico, Appeddu et al. (1996) supplemented lactating two-year-olds with fat, UIP, or UIP plus fat. Supplementation with UIP increased BCS change between calving and breeding. Fat supplementation decreased weight gain from calving to breeding and increased milk production, but the addition of UIP to the fat supplemented diet reversed that trend. Work in Nebraska with mature cows on brome grass showed that 230 grams/day UIP supplementation increased milk production over cows not supplemented with UIP, but supplementation with 340 grams of UIP/day decreased milk production (Blasi et al., 1991). It is possible that moderate levels of UIP filled a deficiency in MP, while high levels stimulated endocrine responses that repartitioned nutrients away from milk production.

The effects of UIP supplementation to young cows during lactation are not consistent. Without question, MP requirements of young, lactating cows are high. Low to moderate quality forages will not supply enough MP to meet requirements, and supplemental UIP may improve reproductive performance. Feeding programs during lactation that are high in energy and protein, such as alfalfa hay and corn, may supply enough MP to meet the requirements of young cattle. High levels of UIP supplementation may stimulate insulin release, which can have positive impacts on growth and reproduction in some situations (i.e. thin cows). The effects of UIP on endocrine/reproductive system relationships are not clearly defined and likely involve multiple hormones and (or) systems. Certain amino acids may be involved, which would make the “quality” of UIP important. Few data have been published showing a clear relationship between UIP supplementation and reproductive performance in young, lactating cows.

SUMMARY AND CONCLUSIONS

It is important to supply adequate nutrition to young beef females. Use of the metabolizable protein system allows for a distinction between the protein requirements of the rumen microbes and the requirements of the animal at the tissue level. There are many situations where the microbial protein production of a young female does not supply enough protein for the animal; thus supplemental UIP may be needed to meet MP requirements. Use of the software with the 1996 NRC can help define MP requirements and determine if there is a need for supplemental UIP. Extension personnel associated with the institutions sponsoring the Range Beef Cow Symposium, as well as other institutions, can help with use of the NRC software and with determining the degradability of protein in feeds and forages. Research is ongoing as to the appropriate microbial efficiency factor to use in Level 1 of the NRC model (at this time, I use 8% for diets less than 50% TDN, 9% for diets 50-55%, 10.5% for diets 56-60%, and the default 13% for diets greater than 60% TDN).

The requirements for MP increase exponentially as heifers near calving, and supplementation to meet MP requirements can improve two-year-old pregnancy rates. This is especially true if the animals are somewhat nutritionally stressed or in thin to moderate condition at calving. Another way to look at this is to evaluate current pregnancy rates. If two-year-olds currently have high pregnancy rates, spending additional money on supplement may not pay for itself. If two-year-olds have moderate to low pregnancy rates, small input costs associated with UIP supplementation may yield substantial returns. In addition, use of the MP system may be useful to finish developing heifers during the winter that were “under-developed” prior to breeding. This may offer opportunity to reduce costs in heifer development. Supplementation with UIP may be a valuable tool in managing the nutrition program of pregnant two-year-old cows (coming three-year-olds) in the winter as well, especially if the cows are thin or light.

Supplementation of UIP to young females after calving may improve performance and reproduction. Formulating rations to meet MP requirements is advised. Supplemental UIP above that required to meet MP requirements may elicit some reproductive response due to effects on the endocrine system. However, benefits of supplementing with high levels of UIP have not been clearly documented.

It is important to remember that protein and energy are not mutually exclusive. In the rumen, energy is needed for microbial growth for feed fermentation and microbial crude protein production. Protein and energy interact at the tissue level as well. Supplementation with UIP will not reverse performance associated with gross deficiencies in energy intake by cattle. In addition, supplemental UIP is not a cure for other nutritional deficiencies or lack of management. A primary use of UIP supplementation to young females is in alleviating deficiencies in metabolizable protein. Supplemental UIP may be a useful tool in managing young cows that are light or thin before or after calving. Providing the proper nutrition to young beef females is important to ranch profitability, but producers should always be aware of input costs relative to expected returns.

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