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Adapting the 2016 National Academies of Sciences, Engineering and Medicine—Nutrient Requirements of Beef Cattle to BRaNDS Software—Considering Metabolizable Protein

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Adapting the 2016 National Academies of Sciences, Engineering and Medicine - Nutrient Requirements of Beef Cattle to BRaNDS Software – Considering Metabolizable Protein

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Summary and Implications

The National Academies of Sciences, Engineering and Medicine - Nutrient Requirements of Beef Cattle (NASEM), formally referred to as the National Research Council (NRC), has long been the standard of formulation for beef cattle rations. However, the changes presented in the 8th Edition (2016) regarding the empirical method of formulation appear to only work well with cows and more mature stocker cattle consuming medium- to high-quality forage (51.5-64% TDN) when the microbial efficiency of converting diet TDN to microbial protein are adjusted from the current recommendation back to previously published efficiencies.

Introduction

The NASEM, formally referred to as the National Research Council (NRC), has been and remains the standard of formulation in beef cattle rations. As developments in research-based knowledge occur, this publication is updated. The recently-released 2016 text, now in the 8th edition, has continued to carry this torch regarding beef nutrition insight. We have developed some suggested modifications required with the current model contained in this publication to improve its effectiveness in its use for the formulation of the dietary protein component in mature cattle consuming forage rations. The first motive for this discussion was an apparent inconsistency between the existing model outputs and the observed practical result of aforementioned classes of cattle nutritionally supported on solely medium- to high-quality forages (51.5-64% TDN).; the second motive was the necessity to allow a smooth transition in formulation software as diet ingredients are added using the nutrient specifications recorded on the individual feedstuffs.

The primary points of discussion will concern:

1. Adjusting the efficiency value of converting TDN to microbial protein or MCPtdn
2. Modifying the MPfeed conversion factor of the rumen undegradable protein (RUP) intestinal digestibility from a strict 60% for all forage and 80% for diets containing any amount of concentrate, to develop some degree of a sliding scale based on dietary composition
3. Consideration of nitrogen recycling in rations of fairly low crude protein, but containing adequate TDN

Existing and Proposed Calculations

The 2016 Model is as follows:

1. MTP
MTP = MCP x .8 x .8
MCP = (42.73 + 0.87 x TDN x DMI) / 1000 if EE < 3.9%
MCP = (53.33 + 0.96 x FFTDN x DMI) / 1000 if EE >= 3.9%
FFTDN = TDN – 2.25 x EE

2. MPfeed
MPfeed = RUP x 0.8 if the ration is < 100% forage
MPfeed = RUP x 0.6 if the ration is 100% forage

3. Recycled N (RN)
RN =(-0.1113 + 0.996 x 2.71828182845904^(-0.0616 x CP)) x(0.745 x ((CP x 0.01 x DMI) / 6.25) x 1000 - 11.98)

The proposed adjustment to the model is:

1. MTP (for cows, gestating heifers, and potentially larger stocker cattle outside of a feedyard)
MTP = MCP x .8 x .8
The microbial efficiency is the point of interest in the calculation of the MCP value. This efficiency can be influenced by a number of items such as pH, maturity of the animal, fat levels in the ration and digestibility of the diet. These points have been reflected in the use of TDN, eNDF and now FFTDN in the calculation of the MCP fraction. The adjustment in the current NASEM publication seems to work well for growing cattle in a feedyard or supplemented generously, but in initial uses, does not appear to work well for grazing cattle or those fed medium- to high-quality forage. To maintain credibility of the NASEM work it is proposed that in situations where cattle with a fully functional rumen (a liberty taken and determined to be 50% of mature weight for programming), provided good to medium quality forage and not supplemented to the point where low rumen pH will influence microbial activity to a noticeable extent, the earlier published (NRC 1996, 2000) microbial efficiencies be utilized with the gradual reduction of efficiency to the currently proposed calculation. This

addresses the range of possible diets observed for a given animal outside of the feedyard. If these same animals are placed into the feedyard, it appears that the 2016 proposed MCP equations work fine. On paper and in practice this seems to work out reasonably well. Thus, it is proposed that the following “triggers” be used in the model to differentially calculate MTP based on forage TDN:

IF TDN >=64 then MCP = (0.13 x TDN x DMI) / 1000
IF TDN <= 51.5 then MCP = (42.73 + 0.87 x TDN x DMI) / 1000
IF TDN is between 51.5 and 64 then MCP = (MEF x TDN x DMI) / 1000
MEF = (0.29 x TDN - 5.9)*0.01

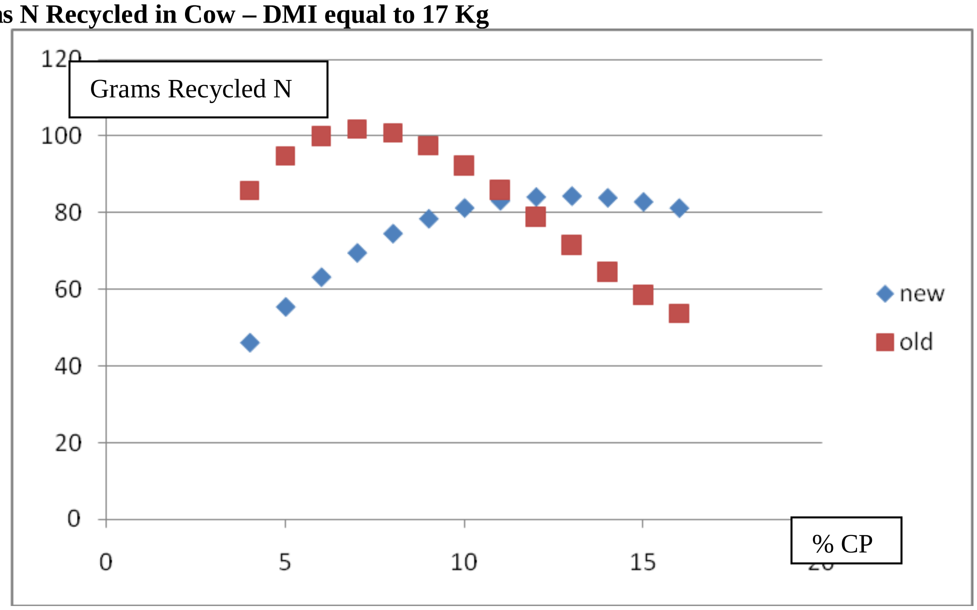
2. MPfeed
The multipliers of 0.6 and 0.8 for 100% forage and all other diets, respectively, in the current model indicate digestibility differences in rumen undegradable crude protein (RUP) from grain and forage sources. Two problems occur when used in practice. (A) There could be questions in terms of what may or may not be a forage when a nontraditional feedstuff is used. (B) The possibility of minimal concentrate supplementation to an overwhelmingly forage-based diet, yielding a ration that is less than 100% forage and using the multiplier of 0.8 instead of 0.6; a seemingly slight difference which can lead to a large change in formulation results.

To solve problem “A”, ADF content is used since this component generally increases as digestibility decreases, and is commonly reported in a feed analysis generated from a commercial feed testing lab. For the purpose here an ADF content of 25% or less would be considered a supplemented ration while a ration of 45% or higher would be unsupplemented. Addressing item “B” then, a smooth transition is created between these two points in order to address the situation where only minimal or high quality forage is provided. The proposed formula is as follows:

IF ADF% <= 25 then 0.8,
IF ADF% >= 45 then 0.6
Otherwise, (45-ADF%)*0.01+0.6

3. Recycled N (RN)
RNnew (NASEM, 2016)=(-0.1113 + 0.996 x 2.71828182845904^(-0.0616 x CP)) x(0.745 x ((CP x 0.01 x DMI) / 6.25) x 1000 - 11.98)
Vs
RNold (NRC, 1985)=((121.7 - 12.01 x CP + (0.3235x CP x CP)) / 100) x CP x .01 x DMI / 6.25 x 1000

Figure 1. Grams N Recycled in Cow – DMI equal to 17 Kg



When RDP is less than MCPtdn, the RN value is added to the RDP value and the lower value of MCPtdn or (RDP+RN) is used to calculate the final MCP value. The response of the 1985 RN (old) and NASEM value (new) at a fixed DMI are shown in Figure 1. In the previous version of the BRaNDS software the old RN was used and done so seemingly successfully. Use of the RN will have a particularly large impact in cows eating corn silage-, range- and warm season annual grass-based rations since these are forages that generally have limiting RDP relative to TDN. The concept of recycling seems better represented by the old RN equation since it shows more recycling at low crude protein intakes as one would expect. The range of data over which new and old were developed is not known by this author so where the curves illustrated begin to misrepresent reality is unknown, but for now it seems that retaining the old RN for cow diets as being discussed here is satisfactory.

Allowable Weight Gain from MP

The rest of the protein calculations are as presented in the NASEM text. To wrap up this discussion the above items are then used as follows to determine allowable tissue growth from MP. Total MP Intake is determined by adding MTP with MPfeed. From this value the requirements for maintenance, pregnancy, lactation are subtracted. This remaining fraction can be used for weight gain. Referring to the NASEM text the calculation for shrunk body weight gain allowed by MP (MPg) intake is:

$$SWG = (29.4 \times RE + NPg) / 268$$

The NPg is calculated as:

$$NPg = MPg \times Max[0.492 \text{ or } (0.834 - 0.00114 \times EQSBW)]$$

$$EQSBW = SBW \times (SRW / MSBW)$$

If MP Intake is too low and Nitrogen recycling in inadequate tissue is used to supply MP for maintenance, lactation and pregnancy (MPdef). Using the current body condition score, the MP (MPbcs) available in this weight from the current score to the next lower score is calculated. Total tissue yield is calculated and a weight loss can be determined from the MP demand.

$$MPdef / MPbcs \times WTBCS \times -1$$

$$MPbcs = (0.200886 - 0.0066762 \times BCS) \times WTBCS$$

ADF = acid detergent fiber –measured as a percent
CP = crude protein –measured as percent
DMI = dry matter intake –measured in Kg
EE = ether extract –measured as %
EQSBW = equivalent shrunk body weight –measured in Kg
FFTDN = fat free TDN = TDN – 2.25 x EE
MCP = microbial crude protein – measured in grams
MCPtdn = microbial crude protein from TDN intake – measured in grams
MEF = microbial efficiency calculation based on year 2000 update NRC Beef publication.
MP = metabolizable protein –measured in grams
MPbcs = grams of metabolizable protein in 1 body condition score worth of weight in current state
MPdef = gram deficient of MP
MPfeed = metabolizable protein from rumen undegraded protein intake –measured in grams
MPg = metabolizable protein available for gain –measured in grams
MSBW = mature shrunk body weight = mature weight x .96 (Kg)
MTP = microbial true protein – measured in grams
NPg = net protein for gain –measured in grams
RDP = rumen degraded protein –measured in grams
RUP = rumen undegraded protein –measured in grams
SRW = standard reference weight –set to 478kg for cows and stocker cattle
TDN = total digestible nutrients (%)
WTBCS = MSBW x 0.071 (Kg)

Results and Discussion

The table that follows provides results from running the 2016 NASEM model, the proposed model and, for reference, the 1996/2000 NRC model compared with some actual trial data.

Table 1. Open mature cows (≥ 3 yrs of age), Mixed ration of baled cornstalks, corn gluten feed, corn silage, corn grain
TDN = 46.9, CP = 6.5
Energy-limited gain modeled as 0.53 lbs per head per day,
Actual gain was 0.44 lbs per head per day

	Proposed Model	2016 NASEM Model	1996/2000 Model
% of MP Supplied	122	135	123
MTP (grams)	364	353	297
MPfeed (grams)	211	281	281
ADG allowed by MP (lbs)	0.74	0.99	0.76

Comment: Differences in MTP across models are from MEF, RN, and digestion coefficients on RUP

Table 2. Mid-lactation mature cows, Legume + grass pasture, Spring-Summer
TDN = 57.5, CP = 14
Energy-limited gain modeled to 1.07 lbs per head per day,
Actual gain was unknown, but cows seemed to maintain or gain in body condition score

	Proposed Model	2016 NASEM Model	1996/2000 Model
% of MP Supplied	103	88	107
MTP (grams)	555	475	555
MPfeed (grams)	205	179	239
ADG allowed by MP (lbs)	0.69	-1.35	0.83

Comment: Differences in MTP across models are from MEF, RN, and digestion coefficients on RUP

Table 3. Mid-lactation mature cows, grazing Stockpiled tall-fescue and orchardgrass
TDN = 58.5, CP = 16.1
Energy-limited gain modeled to 0.87 lbs per head per day,
Actual gain was -0.22 lbs per day

	Proposed Model	2016 NASEM Model	1996/2000 Model
% of MP Supplied	97	83	102
MTP (grams)	539	451	539
MPfeed (grams)	225	200	267
ADG allowed by MP (lbs)	-0.33	-2.18	0.42

Comment: Differences in MTP across models are from MEF, RN, and digestion coefficients on RUP

Table 4. Third trimester mature cows, Silage + urea in dry lot
TDN = 62, CP = 8.1
Energy-limited gain on paper to 0.39 lbs per head per day,
Actual gain was not known other than cows maintained body condition

	Proposed Model	2016 NASEM Model	1996/2000 Model
% of MP Supplied	99	102	107
MTP (grams)	414	387	414
MPfeed (grams)	176	220	220
ADG allowed by MP (lbs)	-0.02	0.29	0.40

Comment: Differences in MTP across models are from MEF, RN, and digestion coefficients on RUP

Table 5. First trimester heifer, Grass pasture
TDN = 64, CP = 10.4
Target Gain = 1.00 lbs per day.
Energy-limited gain modeled to 1.47 lbs per head per day,
Actual gain was not known other than heifers grew and maintained body condition

	Proposed Model	2016 NASEM Model	1996/2000 Model
% of MP Supplied	110	91	114
MTP (grams)	420	343	419
MPfeed (grams)	107	95	127
ADG allowed by MP (lbs)	1.44	0.71	1.52

Comment: Differences in MTP across models are from MEF, RN, and digestion coefficients on RUP

Table 6. Third Trimester Heifer, Silage + Urea in Dry Lot
TDN = 60, CP = 8.1
Target Gain = 1.00 lbs per day.
Energy-limited gain modeled to 0.7 lbs per head per day,
Actual gain was 0.71 lbs. per day

	Proposed Model	2016 NASEM Model	1996/2000 Model
% of MP Supplied	101	104	105
MTP (grams)	453	445	453
MPfeed (grams)	224	254	254
ADG allowed by MP (lbs)	0.75	0.77	0.78

Comment: Differences in MTP across models are from MEF, RN, and digestion coefficients on RUP