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Terry J. Klopfenstein
University of Nebraska - Lincoln, tklopfenstein1@unl.edu

Mary E. Drewnoski
University of Nebraska, Lincoln, mary.drewnoski@unl.edu

Karla H. Jenkins Jenkins
University of Nebraska, kjenkins2@unl.edu

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Prediction of Energy Value (TDN) in Grazed and Hayed Forages

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Summary with Implications

The goal of producers and nutritionists is to meet the nutritional needs of their cattle. Requirements are well established, but the diets of grazing cattle are difficult to predict. Selection by the animal, sample handling, lab analysis, and relating the lab analysis to the animal are issues that have been researched the last 20 years. Based on that research, data have been compiled to predict the energy and protein values of grazed Sandhills range, meadows, smooth brome, and corn residue. Additionally, equations used by commercial labs to predict the TDN of grass hays based on ADF were compared to TDN estimates based on in vivo digestion. Predictions of TDN values from ADF varied in accuracy and need to be used with caution.

Introduction

The 1996 Nutrient Requirements for Beef Cattle (96 NRC) first recommended metabolizable protein requirements for cattle and included a computer model to predict cattle performance from dietary inputs. After the 96 NRC was released cow performance data from the Gudmundsen Sandhills Laboratory (GSL) was used to evaluate the model (*1996 Nebraska Beef Cattle Report*, pp. 10–13). A series of experiments were used to better define the nutrient values of grazed forages, so as to provide good input values for requirement models. The objective of this report is to describe the necessary adjustments and present the updated nutrient values of grazed forages.

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Table 1. Acid detergent fiber and TDN content of grass hays, baled corn residue and husks used to evaluate prediction equations.

Forage	ADF, % of DM	TDN[1], % of DM
Bromegrass hay	41.0	52.9
Bromegrass hay	45.3	51.1
Prairie Hay	44.5	48.8
Meadow Hay	38.5	55.6
2 Row corn residue (King)	50.4	55.9
8 Row corn residue (King)	54.9	43.8
Conventional corn residue (King)	56.7	46.2
2 Row corn residue (Updike)	54.5	49.7
Husklage (Updike)	54.3	54.9
Husk (Updike)	44.3	65.5

[1] TDN assumed to be equal to digestible organic matter

Procedure

The energy value of the forage samples were predicted using in vitro digestion. However, in vitro digestibility values must be adjusted to obtain TDN values that could be used for diet evaluation in models. A cattle digestion study was conducted to establish actual animal digestion values (in vivo) for forages to act as standards for lab analyses (IVDMD or IVOMD; *2007 Nebraska Beef Cattle Report*, pp. 109–111). Across five different hay sources, IVDMD was 5.4 percentage units higher than in vivo digestibility. Additionally, there is variation from run- to-run within vitro digestibility. Using hay samples with known in vivo digestibility as standards for in vitro analysis allows for adjustment of in vitro values to in vivo values by accounting for both run- to-run variation and adjusting for the difference between in vivo and in vitro digestibility. It is assumed that digestible organic matter (DOM) is equivalent to TDN.

Cattle selectively graze so it is necessary to use diet samples for nutrient evaluation of grazed forages that have been collected with esophageally or ruminally fistulated cattle. Saliva from mastication contaminates the sample, and in the past, the diet samples were squeezed to remove excess moisture. Squeezing removed some highly digestible nutrients (*2013 Nebraska Beef Cattle Report*, pp. 49–50; *2015 Nebraska Beef Cattle Report*, pp. 64–65). Thus when squeezed, the IVDMD should be increased 1.8 percentage points to account for loss of highly digestible nutrients.

Diet samples of cows grazing range were collected over 3 years at GSL (*2008 Nebraska Beef Cattle Report*, pp. 18–19.). Diet samples were collected from steers grazing smooth brome at Eastern Nebraska Research and Extension Center (ENREC) over a 5 year period (*2011 Nebraska Beef Cattle Report*, pp. 24–25). The pastures were rotationally grazed so diet quality may be greater than for continuous grazing. Diet samples were collected by cows grazing wet meadows at GSL (*2010 Beef Cattle Report*, pp. 36–38; *2014 Nebraska Beef Cattle Report*, pp. 50–51). Diet samples were collected by cows or steers grazing corn residue at ENREC, near Mead, or West Central Water Resources Field Laboratory near Brule, NE (*2011 Nebraska Beef Cattle Report*, pp. 33–34; *2017 Nebraska Beef Cattle Report*, pp. 60–61).

The protein values used to evaluate the models were calculated using the crude protein values obtained by Geisert et al. (*2008 Nebraska Beef Cattle Report*, pp

18–19) and the degradability reported by Buckner et al. (2013 Journal of Animal Science 91:2812–2822) and Gigax (2011 UNL thesis). Another challenge in determining the nutrient adequacies of grazed forages is estimating animal intake. Data collected by Meyer et al. (*2009 Nebraska Beef Cattle Report*, pp. 13–14) suggest that lactating cows will consume 2.5% of body weight when fed a diet with a digestibility of 52 to 55% TDN. Dry cows consumed 2.1% of body weight while on the same forage. Data supports the use of 2% of body weight for dry cows grazing corn residue or winter range (*2012 Nebraska Beef Cattle Report*, pp. 5–7; *2012 Nebraska Beef Cattle Report*, pp. 15–16).

Most commercial labs use chemical analysis to predict TDN of submitted samples. One commonly used method is to predict the TDN of forages using the acid detergent fiber (ADF) content. While these predictions can be useful, the equation used can have significant impacts on the accuracy. The TDN prediction of six equations commonly used by commercial labs were compared to the TDN measured as DOM of four hays, five baled corn residue samples and husks obtained from hybrid seed production (Table 1). The equations were 1) TDN = 4.898+(89.796*(1.0876–0.0127*ADF)); 2) TDN = 32.4+53.1*(1.044–0.0131*ADF); 3) TDN = 87.1–0.83*ADF; 4) TDN = 97.6–0.974*ADF; 5) TDN =34.9+53.1*(1.085–0.015*ADF); 6) TDN =71.7–0.49*ADF.

Results

The TDN and protein values for Sandhills range are shown in Table 2 by month and by grazing season, summer or winter. These data are consistent with cow performance at GSL (*2010 Nebraska Beef Cattle Report*, pp. 5–7; *2012 Nebraska Beef Cattle Report*, pp. 15–16). Values for smooth brome are in Table 3. Values are available only for summer months. These data are consistent with cow performance when grazing adjacent pastures (*2015 Nebraska Beef Cattle Report*, pp. 14–15). The TDN and protein values for Sandhills meadow forage are in Table 4. Values are only available for the summer months.

Values for corn residue are in Table 5. Corn residue is unique because the plant is dormant and the cattle are selective, grazing grain and husks followed by leaves. The husks are much more digestible than the leaves, so as the grazing season progresses, the TDN declines. The season long TDN value of 51% is based on 5 years of data on cows grazing irrigated corn residue at UNL recommend rates in southeast NE (*2012 Nebraska Beef Cattle Report*, pp. 5–7).

The 1996 NRC was updated in 2016 (2016 NASEM). The energy and protein requirements remained the same as those in the 1996 NRC. The dry matter intake prediction was also maintained, however, it was suggested that the NASEM equation may underestimate dry matter intake by 3–5% for lactating cows and overestimate intake by 3–5% for dry cows. This is consistent with the Meyer et al. data (*2009 Nebraska Beef Cattle Report*, pp. 13–14). Therefore, users of either the 1996 NRC model or the 2016 NASEM model might consider increasing dry matter intake by 3–5% above the model prediction for lactating cows and decreasing it for dry cows.

The 1996 NRC model assumes all ruminally undegradable protein (RUP) is 80% digestible in the intestines. However, the data in the tables illustrate that the assumption of 80% digestibility is incorrect. The 2016 NASEM model accounts for the differences in RUP digestibility and the values in the tables are appropriate for use in that model. The values are not appropriate for the 1996 model. The values in the tables provided in this report can be adjusted by the following equations:

RDP, % DM = CP, % DM x RDP, % CP

RUP, % DM = [(CP–RDP, % DM) x RUP digestibility] ÷ 0.8

Adjusted CP (to be used in 1996 model)= RDP, % DM + RUP, % DM

RDP, % (to be used in 1996 model) = RDP, % DM ÷ adjusted CP

When evaluating the TDN prediction from ADF it appears that most of the equations over-predicted the energy value of the hays and undervalued the corn residue and husks. Corn husks are unique and the values were not included in the prediction equations for the corn residues. Husks are much more digestible than the ADF content would predict. The husks have excellent TDN values when consumed by grazing cattle or when husks are maximized in harvested residue. Laboratory values using ADF to determine energy content will not be accurate and significantly underestimate the TDN. None of the equations accurately predicted the TDN values of either the conventional forages or the corn residues. Three examples are illustrated in Figure 1. In panel A, the equation provided good linear relationships of TDN predicted from ADF to TDN measured in cattle in both the 4 hays and the corn residues (slopes of 1.04 and 0.95). However, the hay TDN values were about 2 percentage units too high and the corn residue values were over 9 percentage units too low.

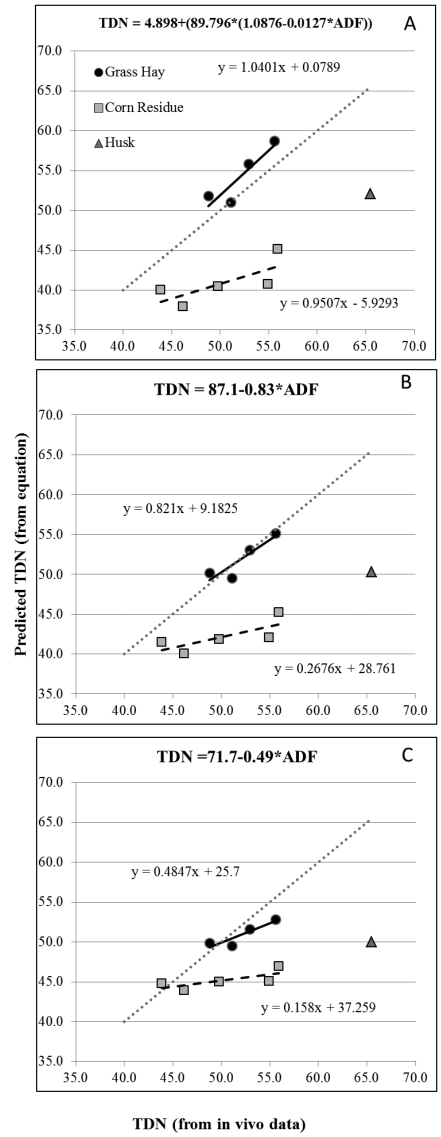

Figure 1. Prediction of TDN in hay or corn residue applying three equations based on ADF that are commonly used by commercial laboratories.

Table 2. Sandhills range

Month	TDN, % of DM	CP, % of DM	RDP, % of CP	RUP digest,[1] %
May	64.8	12.4	84.8	38.6
June	59.9	10.8	81.5	34.6
July	55.8	9.5	83.7	20.0
August	55.2	8.9	64.0	9.5
September	50.7	8.8	70.0	11.7
October	50.3	7.9	68.4	12.0
November	48.7	7.6	67.1	12.0
December	48.6	7.0	64.3	12.0
January	51.5	6.9	63.8	12.0
February	51.9	6.2	60.0	12.0
March	49.9	7.4	66.2	12.0
April	56.8	8.0	68.9	12.0
Season, Summer[2]	57.0	10.1	76.8	22.9
Season, Winter[3]	50.2	7.2	65.0	12.0

[1]RUP digestibility, % of RUP

[2]May thru Sept average

[3]Oct thru March average

Table 3. Brome

Month	TDN, % of DM	CP, % of DM	RDP, % of CP	RUP digest.[1], %
May	68.9	18.6	85.6	50.2
June	61.7	13.7	88.3	48.3
July	58.8	13.7	86.9	46.8
August	56.3	15.3	86.8	41.7
September	52.5	15.5	85.9	39.0
Season	59.6	15.4	86.7	45.2

[1]RUP digestibility, % of RUP

Table 4. Meadow grazing

Month	TDN, % of DM	CP, % of DM	RDP, % of CP	RUP digest.[1], %
May	66.2	14.6	93.2	45.0
June	62.7	11.4	85.3	47.0
July	59.0	8.6	80.8	38.7
August	55.1	8.4	79.6	35.0
September	52.2	8.5	80.0	35.0
Season Average	59.0	10.3	83.8	40.1

[1]RUP digestibility, % of RUP

Table 5. Corn residue grazing

	TDN, % of DM	CP, % of DM	RDP, % of CP	RUP digest.[1], %
Season	51	4.61	74.5	25.6
Initial	58.3			
End	43.7			

[1]RUP digestibility, % of RUP

The equation used in panel B predicts the TDN of the hays fairly accurately within the range of 47 to 57% TDN. Because the slope is less than one (0.76), values outside the above range will not be accurate as it will over predict the digestibility of low quality hays and under predict higher quality hays. Values for the corn residues were 8 percentage units below in vivo values.

Panel C illustrates the values for an equation which was developed for straw and is sometimes used for corn residue. While the predictions for corn residues were closer than some of the others, on average 5% below in-vivo values. However, the equation did not account well for changes in TDN within corn residue (slope 0.16) that was due to differences in harvest methods. For example, conventionally baled corn residue with a 46% TDN is predicted to be 2.2 percentage units less than the in vivo value but residue with low stem content and 55% TDN is predicted to be 8.9 percentage units lower than the in vivo value. Therefore, this suggests that none of the six equations provided accurate prediction of in vivo TDN values.

Conclusions

When using diet samples and adjusting in vitro digestibility estimates, TDN could be predicted adequately. The TDN estimates provided in this report can be used to determine supplementation needs when grazing these forage resources. When ADF was used to predict the TDN of grass hay or corn residue samples, none of the six equations were accurate. Protein values provide information to estimate protein status of the cattle.

Terry Klopfenstein, Professor Emeritus

Mary Drewnoski, Assistant Professor Department of Animal Science, Lincoln

Karla Jenkins, Associate Professor, Panhandle Research and Extension Center, Scottsbluff, NE