A Comparison of TDN and Net Energy Calculations for Estimating Empty Body Weight Change for Beef Cows Using ADF, NRC-01 Lignin and TTNDFd Methodology

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Total tract neutral detergent fiber digestibility is a relatively new system for feed fiber quality evaluation and subsequent feed energy determination. This system has been proven to work in dairy cattle and also seems to work considerably better than the acid detergent fiber (ADF) system for feed energy estimation in beef cattle diets, even at low feed intakes per unit of body weight.

The evaluation of a feedstuff in terms of the energy that is available to the animal that consumes it becomes somewhat elusive, since the digestibility of the fiber fraction is quite variable due to the plant's environment during growth (heat units and moisture), along with the plant's maturity at harvest and plant genetic variation. The ADF content, lignin and total tract neutral detergent fiber digestibility (TTNDFD) have been used to compare which system provides the most reliable method of assessment of the energy content of the feedstuff in terms of its digestibility and subsequent utilization by Angus, late summer calving cows.

The ADF method does not measure digestibility, but rather the concentration of ADF in the feed. A higher concentration assumes a reduction in digestibility. Generally this works in terms of relative maturity since as a forage becomes more mature, the ADF fraction increases and the digestibility is reduced. This does not address the situation where ADF fractions are the same, but digestibility still is different between samples. The lignin content, which can be measured, is part of the ADF fraction and is not digestible, was used as outlined by the Ohio Agricultural Research and Development Center (OADRC) method and used in the National Research Council (NRC) Dairy 2001 publication. Here a higher concentration of lignin correctly implies a reduced digestibility. The remaining fraction of the plant fiber is assumed to follow some level of constant digestibility, which may or may not occur. Finally, the TTNDFD is used and provides a measure of total neutral detergent fiber (NDF) disappearance by using four fiber digestion time points, giving both the digestibility and the rate at which this NDF is digested. This value is used in the National Academies of Science, Engineering and Medicine (NASEM) 2016 Beef publication's total digestibility nutrients (TDN) equation to arrive at the digestible energy and subsequent ME and NE equations.

Materials and Methods

Multiparous Angus cows, due to calve in September at the Iowa State University McNay Memorial Research and Demonstration Farm, were randomly separated into four diet treatments. Within these four groups, cows were grouped into one of four pens based on body weight, placing cows of similar weights together to negate bunk competition. Average empty cow weights per cow per pen ranged from 1040 lbs. to over 1400. lbs. All cows were starting the eighth month of pregnancy. Cows were weighed and had their 12th rib fat and ribeye areas measured by ultrasound image on and off test to determine body condition score.

The four treatment diets were based on typical dry lot cow rations used in the Midwest (Table 1). These rations were fed at constant levels throughout the eight-week trial with the same amount given to each pen of cows with the realization these may be inadequate from a caloric intake standpoint. The hay was a mixed grass hay (primarily fescue), the corn was dry whole shell corn. The dry distillers grain (DDG) was dry and derived from corn. Feeds were sampled every two weeks while cows were on test. Feed nutrient and digestibility evaluation, including TTNDFD, was performed by Rock River Laboratory, Inc. Cow weight change performance was measured and projected using the NASEM 2016 Beef Cattle publication methodology, with the energy values provided by the Rock River Laboratory reports generated from these feedstuffs. A two sample T test assuming equal variance then was performed to determine if the equation projected weight change and the actual weight change was different.

Results and Discussion

Test results of the hay can be observed in Table 2. The values were quite close among samples and this was expected since the feedstuffs were from a similar source and harvested at the same time point. The TDN also are provided in Table 3. Although the feedstuff is the same, the estimated energy these calculations arrive at are quite different. Table 4a settles the issue, however, in the comparison between actual and projected weight change after accounting for fill and fetal calf weight change.

From Table 4a, which includes all treatment rations, using the NASEM Beef 2016 energy calculations adapted to incorporate TTNDFD resulted in the bias between projected weight and actual weights being the least. The calculation using ADF generated the greatest bias, overestimating the digestibility of the hay and subsequent weight change in the cows. This can be interpreted to mean the NASEM Beef 2016 energy calculations, adapted to include TTNDFD, offered an improved prediction for weight change relative to the ADF calculations. Likewise, the TTNDFD calculation provided the best correlation between the two measures and the T test showed the least difference between actual and estimated weight change. The T test would indicate in Table 4a there was a difference between the actual and the projected performance across all systems, thus no system is statistically adequate. However, when just the hay only ration treatments were observed, out of all the treatments, the T values all were greater than 0.05, thus allowing one to think the systems all can work, and the NRC 2001 Dairy methodology gave a better fit in this situation. In reality, though, usually more than one ingredient is fed, but the TTNDFD calculation was only determined on the hay from the lab

Table 1. Treatment rations.

Treatment	Ingredients	Pounds dry matter, daily allowance	Ration NDF%
Hay	Hay	18.1	59.9
Hay+Corn	Hay Whole Corn	19.2 6.5	46.7
Hay+Corn+Dry Distillers Grain	Hay Whole Corn Distillers Grain	19 2.9 0.9	54.4
Hay+ Dry Distillers Grain	Hay Distillers Grain	21.7 5.6	55.1

Table 2. Hay test results.

ADF%	Range	Lingin %	Range	TTNDFD % NDF	Range
43.2	41.5-45.1	9.0	8.3-9.7	32.5	28.7-34.8

Table 3. Hay test calculated TDN energy results.

ADF to TDN	Range	Lingin to TDN	Range	TTNDFD % TDN	Range
58.1	56.6-59.5	49.8	47.6-50.8	42.3	40.9-44.2

Table 4a. *Actual weight change and calculated weight change, over all diets.

	ADF Methodology	NRC Dairy 2001 (lignin)	NASEM Beet 2016+TTNDFD
Bias (in pounds) (Actual-Projected)	65.7	37.9	17.3
Correlation	0.64	0.66	.078
P (T < = t)	4.59 x 10 10^{-7}	0.0001	0.003

Table 4b. *Actual weight change and calculated weight change, hay diet only.

	ADF Methodology	NRC Dairy 2001 (lignin)	NASEM Beet 2016+TTNDFD
Bias (in pounds) (Actual-Projected)	17.0	0.8	8.3
Correlation	0.99	0.99	1.00
P (T < = t)	0.06	0.92	0.19

analysis, and with this, using a constant Kp and Kd value in the determination. The other ingredients were valued in terms of energy from some other method, rather than TTNDFD by the lab.

In Table 5, the TTNDFD was used in a more proper context where the Kp* and Kd* values were calculated on each of the pens prior to applying the TTNDFD/ NASEM equation. In this situation, TTNDFD becomes even more powerful in providing an estimation of performance and relative value of the feedstuff at hand. This is an example of how TTNDFD could be incorporated within diet formulations, where animal inputs are known.

The ADF based TDN energy calculations over estimated weight change by approximately 66 lbs. per cow, whereas the NASEM Beef 2016 +TTNDFD equations reduced this error to roughly 17 lbs. per cow over the trial. In commercial cow/calf nutrition, using the ADF based calculations can result in energy deficiencies in situations as this experiment. The NASEM Beef 2016 + TTNDFD equations appear more appropriate, and will allow more suitable diets formulated to avoid such deficits during high energy requirement feeding months over winter. Example feed library values for forages and corn grain are presented in Table 6. For more accurate weight predictions in beef nutrition, feed samples should be analyzed by a commercial laboratory capable of reporting NASEM Beef 2016 energy calculations, adapted to include TTNDFD.

*Kp and Kd are rate of passage and rate of digestion

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Table 5. TTNDFD with Kp and Kd calculated prior to determining bias.

	Over all Diets	Hay diets only
Bias (in pounds) (Actual-Projected)	15.8	1.5
Correlation	0.71	0.99
P (T < = t)	0.012	0.82

Table 6: Typical feed library values for hundreds of thousands of samples analyzed by Rock River Laboratory, Inc. between 2014 and 2019 across the United States.

Nutrient, Digestibility or NASEM Beef 2016 +TTNDFD Energy calculations	Feed	15th Percentile	Median	85th Percentile	Standard Deviation
Beef per ton, lbs.	Corn Grain	383.08	398.99	417.00	20.39
CP, % DM	Corn Grain	7.43	8.22	9.04	0.92
aNDF, % DM	Corn Grain	7.22	9.14	15.05	4.50
NEg, mcal / lb.	Corn Grain	0.63	0.65	0.68	0.03
NEm, mcal / lb.	Corn Grain	0.92	0.95	0.98	0.03
TDN, %	Corn Grain	83.17	85.20	87.55	2.58
Beef per ton, lbs.	Corn Silage	184.98	230.24	266.78	45.29
CP, % DM	Corn Silage	6.86	7.67	8.55	0.94
aNDF, % DM	Corn Silage	34.06	38.98	45.24	6.07
NDFD30, % aNDF	Corn Silage	22.08	28.22	34.72	6.55
NEg, mcal / lb.	Corn Silage	0.35	0.41	0.46	0.06
NEm, mcal / lb.	Corn Silage	0.61	0.68	0.73	0.07
TDN, %	Corn Silage	61.23	65.63	69.53	4.46
TTNDFD, % aNDF	Corn Silage	35.92	41.12	46.40	6.38
Beef per ton, lbs.	Hay	70.85	160.39	208.38	73.56
CP, % DM	Hay	12.07	20.16	23.43	5.20
aNDF, % DM	Hay	35.86	41.99	58.17	10.13
NDFD30, % aNDF	Hay	28.78	37.50	45.60	8.97
NEg, mcal / lb.	Hay	0.20	0.31	0.38	0.10
NEm, mcal / lb.	Hay	0.45	0.57	0.64	0.11
TDN, %	Hay	50.56	58.59	63.35	6.85
TTNDFD, % aNDF	Hay	37.28	44.32	51.88	8.31
Beef per ton, lbs.	Haylage	93.45	163.90	218.70	64.94
CP, % DM	Haylage	15.12	19.72	22.84	3.88
aNDF, % DM	Haylage	38.69	44.23	52.78	7.31
NDFD30, % aNDF	Haylage	28.62	36.29	43.92	8.13
NEg, mcal / lb.	Haylage	0.24	0.33	0.40	0.09
NEm, mcal / lb.	Haylage	0.49	0.58	0.66	0.09
TDN, %	Haylage	53.26	59.39	64.63	6.16
TTNDFD, % aNDF	Haylage	38.46	45.17	53.21	7.83
Beef per ton, lbs.	Small Grain Silage	34.37	96.01	167.38	79.84
CP, % DM	Small Grain Silage	8.95	12.02	16.26	3.69
aNDF, % DM	Small Grain Silage	46.63	53.59	61.18	7.61
NDFD30, % aNDF	Small Grain Silage	20.30	28.96	38.35	9.82
NEg, mcal / lb.	Small Grain Silage	0.13	0.25	0.34	0.11
NEm, mcal / lb.	Small Grain Silage	0.38	0.50	0.60	0.12
TDN, %	Small Grain Silage	46.12	53.82	60.25	7.49
TTNDFD, % aNDF	Small Grain Silage	35.55	42.49	51.38	9.06
Beef per ton, lbs.	Stover	0.00	41.19	215.31	518.86
CP, % DM	Stover	3.76	5.79	9.25	3.05
aNDF, % DM	Stover	58.63	74.06	80.38	12.34
NEg, mcal / lb.	Stover	10.58	22.34	37.49	14.88
NEg, mcal / lb.	Stover	0.00	0.02	0.36	0.22
NEm, mcal / lb.	Stover	0.09	0.26	0.62	0.23
TDN, %	Stover	29.57	39.34	61.98	14.27
TTNDFD, % aNDF	Stover	20.20	33.28	51.02	16.64