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Using NDF and ADF To Balance Diets

Ron L. Belyea, Barry Steevens, George Garner, Jack C. Whittier and Homer Sewell
Department of Animal Sciences

In MU publications G3150, *Forages for Cattle: New Methods of Determining Energy Content and Evaluating Heat* we explained how detergent solutions are used to measure forage fiber. These publications show how neutral detergent solution can be used to measure neutral detergent fiber (NDF). NDF represents the total plant fiber or cell wall including hemicellulose, cellulose and lignin.

These publications also show how acid detergent solution can be used to measure acid detergent fiber (ADF), which contains cellulose and lignin. Both ADF and NDF data help to more accurately estimate feed intake, energy values and animal performance.

Using NDF to predict forage intake

NDF reflects the bulkiness of a forage. Because forage fiber is bulky, there is a limit to the amount of NDF that will fit into a cow's rumen (first stomach). When that limit is reached, she will stop eating. There is no more room until a significant portion of the fiber in the rumen is digested and/or passes on to the lower gut.

We have measured the amount of NDF in the rumens of fistulated cows fed various forage diets. A typical 1,300-pound Holstein will contain 14 to 16 pounds of forage NDF (on a dry matter basis) in her rumen. Thus, she can hold a maximum of 1 to 1.2 percent of her body weight (BW) as NDF. Other researchers have reported NDF intakes of 1.1 to 1.2 percent of body weight for typical forages, although it appears that very high-quality forages and certain byproducts may be associated with 1.5 percent or more.

The proportion of NDF to body weight is an important fundamental relationship. If we know the percent of NDF in the forage and the cow's body weight, we can estimate maximum forage dry matter intake (DMI). A 1,000-pound cow eating hay with an NDF of 65 percent on dry-matter basis and a dry matter of 90 percent would be expected to consume a maximum forage intake of 18.8 pounds (on as fed basis):

1,000-pound cow x 0.011 = 11.0 pounds NDF Intake (NDFI)

$$\frac{\text{11.0 pounds NDFI}}{\text{0.65 NDF in forage}} = \text{16.9 pounds forage DMI}$$

or more simply:

$$\text{DMI} = \frac{\text{1.1 x body weight}}{\text{NDF percent}} = \frac{\text{1,000 x 1.1}}{65} = \text{16.9 pounds DMI}$$

$$\frac{\text{16.9 pounds forage DMI}}{\text{0.90 DM}} = \text{18.8 pounds on as fed basis}$$

These assumptions are for dairy cows. Beef cows appear to eat about 10 percent less forage than dairy cows and estimates of forage intake are set at 90 percent that of dairy cows.

Expected forage DMI for various body weights and forage NDF percents are in Table 1. These numbers should be considered maximums for cows eating diets containing 50 percent or more forage. If forage quality is very high, or if the animal is a very high-producing dairy cow or rapidly growing beef cow or if it is very cold, NDFI and feed intake could increase 10 to 20 percent.

Table 1
Expected cell wall and forage dry matter intake

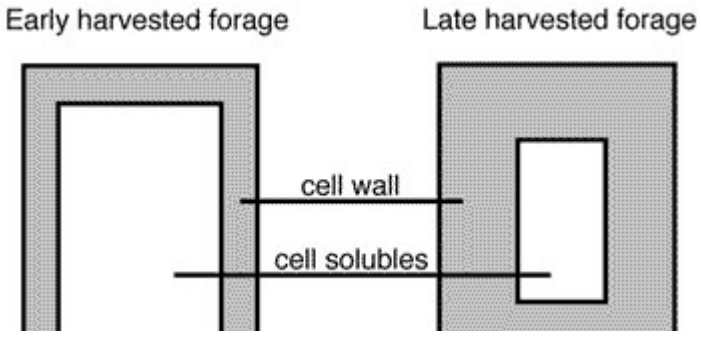
		NDF intake		Forage dry matter intake	
Body weight	**Forage NDF**	**Dairy cow**	**Beef cow**	**Dairy cow**	**Beef cow**
1,000 pounds	40	11.0 pounds	9.9 pounds	27.5 pounds	24.8 pounds
	50	11.0 pounds	9.9 pounds	22.0 pounds	19.8 pounds
	60	11.0 pounds	9.9 pounds	18.3 pounds	16.5 pounds
1,200 pounds	40	13.2 pounds	11.9 pounds	33.0 pounds	29.7 pounds
	50	13.2 pounds	11.9 pounds	26.4 pounds	23.8 pounds
	60	13.2 pounds	11.9 pounds	22.0 pounds	19.8 pounds
1,400 pounds	40	15.4 pounds	13.9 pounds	38.5 pounds	34.7 pounds
	50	5.4 pounds	13.9 pounds	30.8 pounds	27.7 pounds
	60	15.4 pounds	13.9 pounds	25.7 pounds	23.1 pounds

On the other hand, if cows are eating large amounts of grain or if the environment is very hot, intake could be depressed 10 percent or more. Byproduct feeds, such as corn gluten feed and soybean hulls, and very high-quality (very immature) forages also are exceptions, since 2.0 percent of body weight as NDFI are possible. However, for most forages and quality stages, 1.1 to 1.2 percent body weight appears reasonable.

Using ADF to estimate NEL or TDN

Energy content of a forage often is estimated from ADF content. Energy can be expressed as total digestible nutrients (TDN), digestible energy (DE), metabolizable energy (ME), net energy of lactation (NEL), net energy of maintenance (NEM) or net energy of gain (NEG).

TDN is expressed in percent, while DE and ME are expressed in energy units (i.e., Mcal per pound); these usually are used to formulate swine, sheep and horse diets. For this discussion we will use NEM, NEL, NEG and TDN to formulate diets for cattle. There are separate equations for estimating these four energy values; they all are based on ADF percent. The basic assumption is that high-quality forage has low ADF and NDF compared to low-quality forage. High-quality forage digests more completely and has higher energy values (Figure 1).



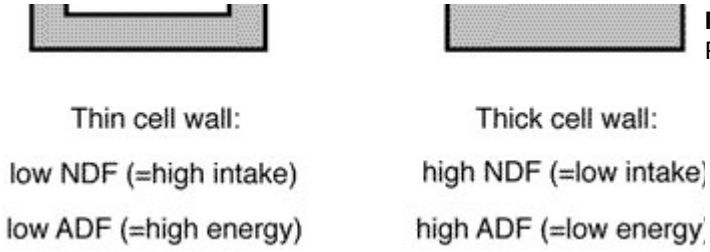


Figure 1
Relationship between harvest stage and fiber content.

The relationships among TDN, NEL, NEM and NEG for high-quality alfalfa (ADF = 30 percent) and two low-quality alfalfas (ADF = 40 percent) are illustrated in Table 2. Although each forage species (i.e., legumes, grasses, Sudan-sorghums, corn silage, etc.) has its own separate equations for predicting energy values, all equations are based on a negative correlation with ADF. Most testing laboratories use computer programs containing these equations to estimate the appropriate value. However, not all labs use the same equations for a particular forage species. Thus, if you sent the same forage sample to several different testing labs, the results may not agree.

Table 2
Relationships between energy values for alfalfa

Term	ADF (percent)	
	30.00	40.00
NEL	0.66	0.54
NEM	0.66	0.54
NEG	0.40	0.23
TDN	65	55

An example follows:

For legumes:

- NEL = 1.037 - 0.0124 x ADF
- NEM = 1.037 - 0.0124 x ADF
- NEG = [2.54 - (2.42/(NEM x 2.2))]/2.2
- TDN = 8 + 86 x NEL

For alfalfa with an ADF of 34 percent, then;

- NEL = 0.62
- NEM = 0.62
- NEG = 0.35
- TDN = 61

Balancing diets using NDF and ADF

Using the previous information, we can balance diets maximizing forage intake. Table 3 provides data on low-quality forages:

Table 3
Concentrate supplementation needed by a dairy and beef cow fed low-quality forage

Dairy cow		Beef cow	
Use	**NEL needed**	**Use**	**NEM needed**
Maintenance	10.0 Mcal	Maintenance	9.0 Mcal
Milk (60 pounds)	21.0 Mcal	Milk	6.0 Mcal
Total	31.0 Mcal	Total	15.0 Mcal
Forage DMI	16.7 pounds	Forage DMI	15.2 pounds
Forage NEL	8.7 Mcal	Forage NEM	7.9 Mcal
Energy needed from grain	22.3 Mcal (31.0-8.7)	Energy needed from grain	7.1 Mcal (15.2-7.9)
Amount grain	26.2 pounds (DM)	Amount grain	8.4 pounds(DM)
(22.3 ÷ 0.85 Mcal per pound)		(7.1 ÷ 0.85 Mcal per pound)	
29.1 pounds (as fed) = 26.2 ÷ 0.90		9.3 pounds (as fed) = 8.4 + 0.90	

Assume a 1,000-pound dairy cow producing 60 pounds of milk or a 1,000-pound beef cow of superior milking ability in early lactation eating low-quality legume forage (NDF = 65 percent and ADF = 42 percent of DM):

- Cell wall intake = 1,000 x 0.011 - 11.0 pounds
- Forage DMI = 11.0 pounds/0.65 NDF = 16.7 pounds DM (18.8 pounds as fed)
- Forage NEL or NEM = 0.52 Mcal per pound (based on ADF)
- Forage NEL or NEM intake = 0.52 x 16.7 pounds = 8.7 Mcal
- Concentrate NEL or NEM = 0.85 Mcal per pound
- Concentrate needed for dairy cow = 29.1 pounds (as fed)
- Concentrate needed for beef cow = 9.3 pounds (as fed)

This is relatively high-concentrate ration. We can increase forage intake if we feed a high-quality legume forage (NDF = 45 percent and ADF = 30 percent) Table 4 provides high-quality forage data; an example follows:

Table 4
Concentrate supplementation needed by a dairy and beef cow fed a high-quality forage

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Dairy cow		Beef cow	
Use	NEL needed	Use	NEM needed
maintenance	10.0 Mcal	maintenance	9.0 Mcal
milk (60 pounds)	21.0 Mcal	milk	6.0 Mcal
Total	31.0 Mcal	Total	15.0 Mcal
Forage DMI	24.4 pounds	Forage DMI	22.0 pounds
Forage NEL	16.1 Mcal (24.4 x 0.66)	Forage NEM	14.5 Mcal
Energy needed from grain	14.9 Mcal (31.0-16.1)	Energy needed from grain	0.5 Mcal
Amount grain	17.5 pounds (DM)	Amount of grain	0.6 pounds (DM)
	19.4 pounds (as fed)		0.7 pounds (as fed)

- Cell wall intake = 1,000 x 0.011 = 11.0 pounds
- Forage DMI = 11.0 pounds/0.45 = 24.4 pounds DM (27.1 pounds as fed)
- Forage NEL = 0.66 Mcal per pound
- Forage NEL intake = 0.66 x 24.4 = 16.1 Mcal
- Concentrate needed for dairy cow = 19.4 pounds (as fed)
- Concentrate needed for beef cow = 0 pounds

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Related MU Extension publications

- G3150, Forages for Cattle: New Methods of Determining Energy Content and Evaluating Heat Damage http://extension.missouri.edu/p/G3150

Order publications online at http://extension.missouri.edu/explore/shop/ or call toll-free 800-292-0969.

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