1991

G91-1034 Evaluating the Feeding Value of Fibrous Feeds for Dairy Cattle

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Evaluating the Feeding Value of Fibrous Feeds for Dairy Cattle

This NebGuide describes what makes fiber unique as a nutrient, how it's measured, and the impact different dietary fiber levels have on milk production and feed intake.

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Fiber content of feed or forage affects its feeding value. Understanding fiber and how it is used is necessary to properly feed dairy cows. Each of the following topics will be addressed to better understand fiber nutrition in the dairy cow:

1. What is ***fiber?***
2. How will ***too little or too much*** fiber in the diet affect the cow's metabolism and subsequent production?
3. What are ***optimal*** levels of fiber in the diets of dairy cows at different production levels and stages of their life cycle?

What is Fiber?

Fiber is the slowly digested or indigestible material in feeds. Typically, fiber measures the plant cell wall: the structural portions of the plant that give it support.

Fiber components of the cell wall, including cellulose, hemicellulose, and lignin, as well as pectin, are digested only by the process of microbial fermentation. In the rumen of dairy cows a thriving population of bacteria, protozoa, and fungi produce enzymes that break the very complex components of the cell wall into smaller molecules such as glucose.

Nutritionally, fiber is the portion of feed that: 1) limits digestion; 2) requires chewing for particle size reduction; and 3) occupies space in the rumen because of bulkiness, thus limiting intake.

Fiber contains the less rapidly degraded components of feed such as cellulose and hemicellulose, as well as the indigestible chemical lignin. Fiber limits digestion of feed, and requires cud chewing, or rumination, for particle size reduction.

Maintaining normal rumination by feeding adequate levels of fiber in dairy cows' diets avoids low milk fat test, off-feed problems, acidosis, and sore feet. Fibrous feeds such as forages occupy much more space than grains. This bulkiness can limit the amount of feed an animal consumes when fed high levels of forage.

The capacity of the cow's gut for feed places an obvious limit upon how much she will be able to consume, and the higher the content of forage or other fibrous feeds in the diet, the sooner she will approach this limit.

Measurement of Fiber Level in Feeds

The three methods used for measuring fiber in feeds include:

1. Crude Fiber (CF),
2. Acid Detergent Fiber (ADF),
3. Neutral Detergent Fiber (NDF).

Each of these measurements is found on various feed tags and forage analysis reports. Although they all measure fiber, each method gives different fiber values for one feedstuff. Much confusion can be avoided by realizing exactly which chemical component of the plant cell wall is being measured by each method.

Crude Fiber. This is by far the oldest method of measuring fiber. Basically, a feed or forage sample is boiled for 30 minutes in strong acid and 30 minutes more in a strong alkali.

Crude fiber does not accurately measure cellulose, hemicellulose, or lignin. The acid dissolves hemicellulose, while alkali dissolves lignin. The number obtained for CF will not reflect the actual amount of fiber in the feed.

Acid Detergent Fiber. Acid Detergent Fiber is obtained by boiling a sample of feed or forage for one hour in a detergent-sulfuric acid solution. As stated above, acid dissolves hemicellulose, so ADF is a measure only of cellulose and lignin. Since no alkali is involved in this procedure, in contrast to CF, there is no loss of lignin when the sample is boiled in acid detergent.

As might be expected, ADF values for a given feed tend to be higher than CF values.

Neutral Detergent Fiber. A sample of feed or forage is boiled for one hour in a pH=7 (neutral) detergent solution. One of the primary chemicals in ND solution, sodium lauryl sulfate, is a common detergent found in laundry cleaners and shampoos. Since this solution is neither acidic nor alkaline, there is no loss of either hemicellulose or lignin. Therefore, NDF is a measure of cellulose, hemicellulose, and lignin: the three major structural components of the plant cell wall.

NDF is typically the largest fiber value for a feedstuff, with ADF being next largest and CF the smallest.

Table I illustrates this concept for several common grasses and legumes. In all cases the CF value is lowest, the NDF highest, and ADF intermediate. More information concerning forage testing and interpretation of test results can be found in NebGuide *G89-915, Testing Livestock Feeds for Beef Cattle, Dairy Cattle, Sheep and Horses*.

Table I. Typical fiber content of forages as measured by three common techniques

Forage	Crude Fiber (CF)	Acid Detergent Fiber (ADF)	Neutral Detergent Fiber (NDF)
	- - - - - - - - - - - % of dry matter - - - - - - - - - - -		
Alfalfa hay, Alfalfa silage	22	29	40
Ladino clover	21	32	36
Corn silage	24	28	51
Bromegrass hay	30	35	65

Source: National Research Council. Nutrient Requirements of Dairy Cattle. 1989.

Fibrous Feeds and Dairy Cow Performance

Adequate fiber content of proper physical form in the diet of lactating dairy cows assures normal chewing activity and rumen function. All feeds or forages have a certain ***roughage value***.

Roughage value measures a feed's ability to stimulate chewing, specifically chewing during rumination. This concept considers not only the fiber content of the feed, but its texture or particle size, as well.

High-fiber byproduct feeds such as soybean hulls or corn gluten feed may be quite high in fiber level, but the fiber typically has small particle size and low effective fiber level or **roughage value.**

Other feeds with high fiber levels but low effective fiber include: beet pulp, brewers grains, corn gluten feed, soy hulls, wheat bran, corn bran and sunflower meal. **Remember:** both fiber level and fiber coarseness affect the "roughage value" of a feed.

More information concerning feeding recommendations for these byproducts can be found in NebGuide *G90-978, Byproduct Feedstuffs for Beef and Dairy Cattle*.

Unlike many nutrients, the dairy cow requires a fairly narrow range of fiber for maximum milk production response. This reflects the fact that fiber has two distinct effects upon the cow.

First, by increasing the fiber in the diet from none toward the optimal level, the roughage value of the fiber stimulates more rumination and maintains normal rumen function. As more fiber is added to the diet beyond the optimal level for a given production level, fiber begins to assert its second distinctive effect: limiting intake and digestibility of the diet.

Fiber Content of the Total Ration

Too little fiber, fiber texture inadequate. A ration with an NDF level below 26-28 percent for high

producing dairy cows, or a ration containing fiber that has been reduced in particle size too dramatically, can cause a series of metabolic problems.

The first symptom of inadequate roughage value (fiber level x texture)of the diet will be decreased chewing activity. As normal cud-chewing (eight to 10 hours daily) declines, saliva production suffers. Saliva, which contains bicarbonate, acts to buffer the rumen against acids produced due to microbial fermentation of feeds. The pH level of the rumen contents must not fall below 6.0-6.2, or degradation of fiber by microbes will be reduced.

When there is insufficient bicarbonate, rumen acidosis may result. This condition typically is associated with milk fat depression, off-feed problems, sore feet, and other metabolic upsets. *Table II* demonstrates the influence of fiber level and particle size upon rumination activity of dairy cows.

A tremendous reduction in cud-chewing can occur when the effective fiber content of the ration is inadequate *(Table II)*. Cows fed the 31 percent NDF diet ruminated about three hours more per day than did cows fed the 21 percent NDF diet.

Table II. Influence of NDF level and particle size upon chewing activity in dairy cows

	Activity (minutes/day)		
	Eating	**Ruminating**	**Total Chewing**
31% NDF ration[1]	211	534	745
21% NDF ration[2]	175	343	519
31% NDF ration,			
Silage rechopped	220	318	538
21% NDF ration,			
Silage rechopped	153	240	393

[1]Ration contained 55% (dry basis) alfalfa silage containing 48 percent NDF.
[2]Ration contained 55% (dry basis) alfalfa silage containing 31 percent NDF.
Data from Purdue University Dairy Center herd; C.H. Noller, V.F. Colenbrander and R.J. Grant. Purdue University. 1989.

Assuming a cow produces one-half pint (one elementary school milk carton) of saliva during each minute she ruminates, this means the cow consuming the higher NDF ration will produce about 10-11 gallons of saliva per day more than a herdmate eating the low NDF ration. Based upon the composition of saliva, about one-half pound of bicarbonate will be available to this cow beyond that amount available to the cow consuming the low NDF diet. It will be delivered to the rumen naturally and when the cow needs it.

Table III further illustrates some of the effects that diet fiber level has on the cow's metabolism and production. As the NDF content of the diet decreases, levels of rumen acetate decrease and propionate increases. These volatile fatty acids (VFA) are major products of microbial fermentation of feeds in the rumen.

Table III. Typical effect of fiber content of the ration upon metabolic state of the dairy cow				
	Long Roughage in the Ration			
Measurement	**100%**	**60%**	**40%**	**0%**
NDF %	70	48	36	14
Chewing (minutes/day)	960	900	820	340
Saliva (gallons/day)	50	47	45	33
Rumen acetate %	70	61	55	40
Rumen propionate %	15	22	27	40
Milk fat %	3.7	3.5	3.4	1.0
Source of data: Dr. D.R. Mertens, U.S. Dairy Forage Research Center, Madison. WI.				

Acetate is a precursor for milk fat synthesis, while propionate predisposes the cow toward body fat production. A low fiber diet makes a cow more efficient at body fat synthesis and less efficient at milk fat synthesis. Ultimately, milk fat depression results.

Too much fiber in the total ration. Although too little fiber in the ration can adversely affect milk production and milk fat synthesis, as well as cause digestive problems, too much fiber also can reduce milk production.

High fiber decreases the energy concentration of the diet because fibrous feeds are less energy-dense than grains. As the cow approaches her fill capacity for feed, a high fiber diet decreases feed intake. These two effects of high fiber diets result in decreased milk production, a situation dairy producers want to avoid.

Optimal NDF Levels for Dairy Cows

The optimal level of fiber in the diet is a function of the cow's production level. The higher the milk production, the lower the optimal fiber level for maximum feed intake.

As milk production increases, the optimal NDF level in the ration decreases. For very high levels of milk production, the NDF level in the ration drops to 26 percent NDF. This value should be viewed as a **minimum**. Generally, any time the NDF content of the ration falls below 26-27 percent, there is a good chance the cow can go off feed, become acidotic, develop sore feet, or suffer from milk fat depression.

All these recommendations for minimum fiber levels in the ration are based on the assumption that 75 percent of the fiber comes from coarse roughage.

The high NDF value recommended for dry cows reflects the recommendation to maintain well-conditioned dry cows on high roughage diets. As heifers approach first-calving the NDF percent needed in the ration increases.

Table IV. Estimated NDF content of optimal rations for dairy cows	
Lactating Cows	**NDF (% of Dry Matter)**
Very high production, 100+ lb/day	26
High production, 70-100 lb/day	28
Medium production, 45-70 lb/day	32-33
Low production, <45 lb/day	39
Fresh cow (3-4 wk of lactation)	36
Dry Cows	50
Heifers	
Less than 400 lb	34
From 400 to 800 lb	42
Bred 800 to 1200 lb	50
Sources: National Research Council, 1989. Nutrient Requirements of Dairy Cattle, and Purdue University Dairy Ration Analyzer.	

Conclusions

Fiber level in the ration plays a key role in regulating feed intake and milk production. To formulate a diet that provides adequate effective fiber, a dairy producer must understand what fiber is, what measurements of fiber are used, and what role physical fiber plays in maintaining normal rumen function. Formulating diets for optimal levels of NDF should provide maximum forage intake and maximum milk production.

File G1034 under: DAIRY
A-28, Feeding and Nutrition
Issued June 1991; 6,000, printed.

Issued in furtherance of Cooperative Extension work, Acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture. Elbert C. Dickey, Director of Cooperative Extension, University of Nebraska, Institute of Agriculture and Natural Resources.