Virginia Cooperative Extension

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Tests Available for Measuring Forage Quality

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Forage quality has typically been determined by measuring the dry matter, crude protein, fiber, and estimated energy content. Forage testing labs are now able to estimate the actual digestibility of feeds by using newly available tests.

Tables Can Give Average Lab Measurements – Variation Does Exist

Average nutrient content of feeds is just that, average. It does not reflect the range in results that are commonly encountered. In some cases labs publish standard deviations that indicate a range for which a certain proportion of the samples fall. The table on the following page presents results from a fairly typical year in Virginia. Included are dry matter (DM), crude protein, fiber, Total Digestible Nutrients (TDN), and net energy. It shows the standard deviation (SD) for each nutrient. If you take the average, plus and minus the standard deviation, you get the range for which two-thirds of the samples fall. For instance, corn silage has an average dry matter of 38.3% plus or minus 6.1. Therefore, two out of three samples fall between 32.2 and 44.4% dry matter. Samples outside of this would be considered atypical and in most cases undesirable.

The bottom line is forages should be analyzed regularly (every 4 to 6 weeks) for dry matter, protein, fiber, and energy. If regular forage testing cannot be done, the lower end of the range for protein and energy can be used for ration formulation. This would result in less under formulation and result in adequate supplementation under most conditions. Mineral analysis may be needed in some situations.

Relative Feed Value and Relative Forage Quality Index – Indicators of Hay Quality

Relative feed value (RFV) is a term that has been used in evaluating hays. It is a single number that can be calculated for pure grass and legume or mixed hays. To calculate RFV it is necessary to have a forage analysis for acid detergent fiber (ADF) and neutral detergent fiber (NDF). The RFV does not consider protein, but higher RFV values usually would be associated with higher protein. The ADF analysis is used to predict the digestible dry matter = (88.9 – (.779 * % ADF)) and NDF predicts dry matter intake = (120/% NDF). RFV is calculated by multiplying digestible dry matter by dry matter intake and then dividing by 1.29 (the expected digestible dry matter intake as % of body weight for full-bloom alfalfa). The RFV for full-bloom alfalfa would be expected to be 100. For an alfalfa hay containing 29% ADF and 36 % NDF, the RFV = (66.3 * 3.3)/1.29 = 170. Grasses typically have higher ADF and NDF concentrations and consequently have lower RFV. For instance a grass or mixed grass/legume hay having 32% ADF and 50% NDF would have an RFV = (64 * 2.4)/1.29 = 119. Note that grasses and corn silage have a greater NDF:ADF ratio than legumes.

	ADF %	NDF %	NDF:ADF	RFV
Alfalfa A (mature)	40	51	1.28	105
Alfalfa B (immature)	29	36	1.24	170
Grass	32	50	1.56	119

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	Dry matter		Crude protein		A.D.[1] fiber		TDN		Net energy	
	%DM	SD	%DM	SD	%DM	SD	%DM	SD	MCAL	SD
Hays										
Alfalfa	87.0	8.8	18.9	2.8	31.8	6.0	65.4	5.4	.64/lb.	.06
(range)	(78-96)		(16-22)		(26-37)		(60-71)		(.58-.70)	
Mixed	86.7	9.0	12.9	4.4	39.1	7.6	59.1	3.2	.58/lb.	.03
(range)	(78-96)		(9-17)		(32-47)		(56-62)		(.55-.61)	
Grass	81.3	18.2	10.5	2.8	40.4	5.6	55.5	6.8	.54/lb.	.07
(range)	(63-99)		(8-13)		(35-46)		(49-62)		(.47-.61)	
Small grain	87.2	4.9	8.9	3.4	40.6	5.8	59.2	4.6	.58/lb.	.05
(range)	(83-92)		(6-12)		(35-46)		(55-64)		(.53-.63)	
Silages										
Corn	38.3	6.1	7.2	2.9	28.0	4.1	66.9	1.9	.66/lb.	.02
(range)	(32-44)		(4-10)		(24-32)		(65-69)		(.64-.68)	
Alfalfa	49.6	13.3	23.6	3.0	35.8	5.4	62.4	4.5	.61/lb.	.05
(range)	(36-63)		(21-27)		(30-41)		(58-67)		(.56-.66)	
Mixed	34.1	15.6	16.3	4.5	31.8	6.6	66.1	5.0	.65/lb.	.05
(range)	(19-50)		(12-21)		(25-38)		(61-71)		(.60-.70)	
Grass	32.9	11.0	13.6	4.7	35.4	6.2	62.4	7.2	.61/lb.	.08
(range)	(22-44)		(9-18)		(29-42)		(55-70)		(.53-.69)	
Rye	34.4	14.0	14.3	4.0	34.2	5.5	60.9	8.3	.59/lb.	.09
(range)	(20-48)		(10-18)		(29-40)		(53-69)		(.50-.68)	
Small grain	37.8	16.4	10.4	3.7	34.5	5.5	61.5	3.3	.60/lb.	.04
(range)	(21-54)		(7-14)		(29-40)		(58-65)		(.56-.64)	
Sorghum	51.5	20.1	10.6	3.4	39.0	8.2	57.5	2.5	.56/lb.	.02
(range)	(31-72)		(7-14)		(31-47)		(55-60)		(.54-.58)	

[1]A.D. = Acid Detergent

Digestibility Is Important – Tests Are Available

What the RFV calculation does not account for is ADF and NDF digestibility. The Rlative Forage Quality (RFQ) Index is similar to RFV except NDF digestibility is used. NDF digestibility allows for a more precise estimate of the energy in the feed. Some laboratories have started offering an in vitro NDF digestibility to account for fiber digestion. Time of incubation of the sample typically ranges from 30 to 48 hours. Grasses typically have fiber digestibilities greater than legumes because legumes have more lignin associated with the fiber. Legumes make up for this by having more cell contents (non-NDF material) that are highly digestible thus elevating energy concentrations to higher levels than in grasses. When using RFV or RFQ, it is best to compare hays that are within a similar classification such as alfalfa, grass, or mixed. RFQ gives more credit for digestible fiber in grasses and grasses will typically have higher RFQ than RFV but still be less than many legumes.

Fiber digestibility in corn silage and other forages is becoming more of a consideration. Since most fiber digestion occurs in the rumen, the main concern is with its digestibility in rumen contents. Typically a 48-hour in vitro NDF digestibility is conducted. Results from variety testing in Virginia indicate there are differences in fiber digestibility in corn varieties. Also year to year variation most likely occurs in fiber digestibility due to more lignification during certain growing seasons. Michigan State University research (Oba and Allen, *Journal of Dairy Science* 82:589, 1999) indicates that a 1% increase in ration-neutral detergent fiber digestibility will result in a 0.37 lb./cow/day increase in dry matter intake (digestibility and intake are related) and 0.64 lb. more 4% fat corrected milk.

If silage is harvested at a mature stage (black layer), the kernels will be hard and difficult for the cow to digest. Corn silages above 45% dry matter many times will have kernels that are hard. Kernel digestibility will be reduced but an analysis on the silage might indicate high energy content because reduced kernel digestibility is not considered. The reason for this is the lab must grind the feed and in doing so the kernel is broken and appears digestible. Therefore, a general lab analysis will not detect reduced digestibility of kernels. It is possible to do an in vitro starch digestibility but the process of sample preparation is still a problem. Corn silage harvested with kernel processing equipment will have greater starch digestion and energy content than unprocessed silages. Some forage testing labs will consider this when calculating energy content.

When there is heating in hay-crop silages and hays during ensiling and storage, the result is protein that is bound in the fiber. This has been termed acid detergent fiber protein or acid detergent insoluble nitrogen. There is a direct relationship between "bound" protein and reduced protein digestibility and this should be accounted for in balancing rations. There also appears to be a reduced amount of energy in heat-damaged forages. Some laboratories estimate protein digestibility based on amount of heat damage measured as acid detergent insoluble nitrogen. Typically, if "bound" nitrogen is less than 12% of total nitrogen, the forage is not considered heat damaged.

Reduced digestibility of forage fiber, silage kernels, or forage protein can result in failure of the ration to meet expectations. Year to year variation in corn silage quality many times can be related to fiber and/or kernel digestibility. Laboratory tests do not always detect these changes but the more refined estimates of dry matter, fiber, or protein digestibility can bring more knowledge of how cows digest feed.

Fermentation Profiles – An Indication of Silage Stability

Typical corn silage will range in protein from 7% to 8% of the dry matter and in net energy from 0.66 to 0.72 Mcal/lb., depending on the lab making the analysis. These measurements do not always give a complete picture of the feeding value of the silage, however. The type and amount of acids produced during storage can give an idea of the adequacy of the fermentation, and ammonia nitrogen content can indicate if excessive protein is broken down during storage. Yeast and molds cause adverse biological processes that can lead to poor-quality silage. Below is a fermentation profile of well-fermented corn silage from *Corn Silage Production Management*, Virginia Cooperative Extension publication 424-015.

pH	3.6-4.0
Lactic acid	4%-6% of dry matter
Acetic acid	less than 2%
Butyric acid	less than .1%
Propionic acid	less than .5%
Ethanol	less than .5%
Ammonia nitrogen	less than 5% of total nitrogen
Yeast and molds	less than 100,000 colony forming units/gram

Note that the pH needs to be below 4.0 for stable corn silage. The dominant acid should be lactic. If other acids such as acetic, butyric, or propionic become predominate, this indicates a shift in the profile that results in poorer quality and may, as a result, not be as palatable to the cows. Ethanol fermentation should be avoided. Also high levels of ammonia are indicative of excessive proteolysis of proteins. These measures can aid in problem-solving situations but are probably not warranted on a routine basis because most silages will have a normal fermentation profile if ensiled under anaerobic conditions with dry matter contents of 30% to 42%.

Summary

It is important to know the nutrient content of forages before feeding, especially dry matter, crude protein, fiber, and estimated energy. Since energy is directly related to digestibility, new laboratory methods have been developed to determine dry matter and fiber digestibility. Also corn-silage kernel digestibility will be impacted by dry matter content at harvest and kernel processing. Some labs will consider these in calculating starch digestibility, which directly affects energy content of corn silage. The results can be used to adjust the energy content of forages. Fermentation profiles are available only after silages have been ensiled and indicate adequacy of storage conditions.