Hay Testing and Understanding Forage Quality

MISSISSIPPI STATE UNIVERSITY EXTENSION

Do you wonder if your hay is of the highest quality? Forage testing assesses the nutrient composition of forages, allowing ranchers to develop feeding programs and commercial hay producers to develop marketing strategies. Because hay and other stored forages play a major role in winter-feeding programs, testing hay now will provide producers with enough time to design a good feeding program that optimizes hay usefulness and livestock performance. Forage testing provides accurate information about its nutritive value. Testing can tell you how to adjust the amount of protein and energy supplements necessary to meet animal requirements.

Forage quality is defined as the potential of forage to produce a desired animal response. It involves consumption, nutritional value, and the resulting animal performance. Hay quality includes palatability, digestibility, intake, nutrient content, and anti-quality factors. The primary reason for livestock producers to test their hay is to increase their net profit. Not knowing the forage's nutrient composition might cause the producer to underestimate or overestimate nutrient requirements and cut profitability.

How to Collect a Hay Sample

Producers should routinely get a representative sample for hay analysis because forage quality can change based on forage species and mixtures (Table 1), maturity, management, harvest and storage conditions, rain damage, and insect or disease damage. When sampling hay lots, sample each hay lot separately. A hay lot is defined as hay from the same field, same cutting, harvested under the same environmental conditions, and having a uniform forage composition (grass or legume only, or grass/legume mixture).

To determine the quality of the hay accurately, a representative sample must be taken using a hay probe (Table 2). Use a hay probe that is 12 to 24 inches long and 3/8 to 5/8 inches in diameter. Grabbing and pulling hay from different bales is not the correct method, and it will not provide uniform samples for analysis. Producers should sample 15 to 20 round bales depending on the number of bales in the lot, and samples should be taken from the round edge of the bale. For example, if sampling a hay lot that contains 300 bales, sample every fifteenth bale to obtain a representative sample of the entire lot. If the outer layer of the bale has deteriorated, remove the outer layer (usually several inches) before sampling to avoid collecting material that will skew the analysis.

For pastures that will be grazed, samples should be obtained directly from the standing forage in the field. These samples should be taken shortly before the livestock are turned into a pasture. The producers should walk over the entire field and collect 30 to 50 random small grab samples per each 5 acres. Grab samples are taken by reaching down and grabbing a small section of forage between the thumb and forefinger at the same height that the livestock will graze the pasture. Avoid collecting samples in areas that have high weed infestation or areas that have high concentrations of legumes or grass.

Sample at least 10 square bales near the center of their ends to ensure a uniform distribution of leaves and stems in the sample. If square bales have been stacked in an open barn, collect samples in both sides of the barn in a zigzag pattern or at different heights. Once the samples are obtained from each lot, mix the samples thoroughly in a bucket and store in a quart-size, plastic zippered bag. Hay samples are perishable, so it is important to ship or deliver the samples to the lab as soon as possible to prevent moisture loss and microbial deterioration of the sample. Label the bag with all the necessary information using a permanent marker. Include the producer's name, hay lot, forage species, hay cutting, weather conditions, and any other relevant information. Information written on a plastic zippered bag is sometimes erased, so make sure that a label with the same information is placed inside the bag for easy identification. Fill out the information sheet provided by the forage testing lab. If you are working with Extension agents and livestock or forage Extension

Table 1: Forage quality[1] parameters for different forage crops.

Crop	CP[2]	ADF[2]	NDF[2]	TDN[2]	RFV[2]
Alfalfa	22 – 26	28 – 32	38 – 47	64 – 71	90 – 127
Grass	10 – 18	35 – 48	45 – 65	49 – 62	60 - 111
Grass / Legume Mix	9 – 17	32 – 47	42 – 58	56 – 62	80 – 105
Small Grains[3]	8 – 16	35 – 46	48 - 67	55 – 64	95 – 120
Ryegrass	12 – 16	27 – 33	47 – 53	63 – 68	111 – 134
Corn Silage	7 – 10	24 – 32	48 - 60	64 – 71	105 - 138
Bermudagrass	7 – 16	33 – 38	55 – 68	38 – 54	81 – 93
Bahiagrass	4 - 13	34 – 50	49 – 61	42 – 56	75 - 92
Dallisgrass	5 – 10	38 - 54	55 – 70	38 - 51	65 - 88
Tall Fescue/Orchardgrass	12 – 16	30 – 36	50 – 56	61 – 66	101 - 122
Red Clover	14 – 16	28 – 32	38 – 42	64 – 67	142 – 164
White Clover	18 – 25	24 – 38	30 - 44	55 – 70	115 – 150
Warm-season annual grasses[4]	8 –12	35 – 40	55 – 70	50 – 58	77 – 104
Switchgrass	10 – 14	35 – 40	55 – 60	58 – 62	90 – 104
Crabgrass	12 – 18	32 - 36	43 - 58	59 – 68	80 – 110
Annual Lespedeza	12 – 16	35 – 40	45 – 55	58 – 62	98 – 127
Eastern gamagrass	12 – 20	29 – 40	42 – 61	50 – 57	80 – 95

[1] Forage quality based on cutting at boot stage (grasses) or bud stage (legumes).
[2] Abbreviations over columns are as follows: CP = Crude Protein; ADF = Acid Detergent Fiber; NDF = Neutral Detergent Fiber; TDN = Total Digestible Nutrients; RFV = Relative Feed Value.
[3] Small grains: wheat, oats, rye.
[4] Warm-season annual grasses: pearl millet, sorghum, sorghum-sudangrass.
Source: Ball et al., 2002; Beck et al., 2007.

Table 2. Sampling recommendations for different types of hay.

Type of Bale	Leaf and Stem Distribution	Best Place to Sample
Small squares	Leaves are concentrated in the tight end of the bale.	Take a core sample through the center and the butt end of the bale.
Large squares	Leaf and stem are uniform across the butt, but may vary along the length.	Take a sample at a 45° angle on the side or at a 90° angle at the end of the bale.
Round	Uniform distribution along the circumference.	Take a sample on the curved side of the bale. Remove the outer layer if it is moldy.

Source: Undersander et al., 2005.

specialists, some laboratories will send copies of the report to them as well, so make sure their names and addresses are in the appropriate places on the form.

Depending on where the samples are sent for analysis, time of the year, and the location of the forage lab, results can take up to 3 weeks. Mississippi State Chemical Lab can process forage samples for nutrient analysis, or you may send samples to a private certified forage testing lab of your choice. For more information on how to send samples to Mississippi State, visit http://www.mscl.msstate.edu/ or contact your county Extension office. The cost for analysis of CP, ADF, and NDF ranges from about $15 to $50, depending on the lab. After the results come back, use them to balance the forage-feeding program for the various groups of livestock on your farm.

You can improve livestock's utlization of hay if you know the nutrient composition of the hay--especially crude protein, fiber, and total energy (Table 3 and Table 4). The accuracy of forage analysis depends on the sample that you send to the lab. In many feeding programs, the producer's not knowing the forage content of the hay causes problems. The results of the lab tests will be useful only if the sample accurately represents what the animals will be eating. The forage analysis information could help

Table 3. Forage quality standards for hay production.

Quality	Grass		Legume		Silage[1]	
	Percent (Dry Matter Basis)					
	TDN[2]	CP	TDN[2]	CP	TDN[2]	CP
Excellent	>58	>12	>64	>18	>65	>8
Good	55 – 57	10 – 11	60 – 63	16 – 17	60 – 64	7– 8
Fair	52 – 54	8 – 9	57 – 59	14 – 15	55 – 59	6 – 7
Poor	<52	<8	<57	<14	<55	<6

[1] Silage values are based on moisture different moisture levels. Excellent (<70%), Good (71 – 74%), Fair (75 – 79%) and Poor (>80%).
[2] Determine hay quality by TDN rating. If hay does not meet CP requirements or it is less than 83% dry matter, or if silage does not meet either CP or moisture requirement for quality, lower one grade.

Source: http://extension.msstate.edu/

Table 4. Hay quality standards for hay production.

	% DM Analyzed[1]			% DM Calculated[1]			
Quality Standards	**CP[2]**	**ADF**	**NDF**	**TDN**	**DDM**	**DMI[3]**	**RFV**
Prime	>19	<31	<40	>60	>65	>3.0	<151
1	17 – 19	31 – 55	40 – 46	59 – 56	62 – 65	3.0 – 2.6	151 – 125
2	14 – 16	36 – 40	47 – 53	55 – 52	58 – 61	2.5 – 2.3	124 – 103
3	11 – 13	41 – 42	54 – 60	52 – 51	56 – 57	2.2 – 2.0	102 – 87
4	8 – 10	43 – 45	61 – 65	50 – 49	53 – 55	1.9 – 1.8	86 – 75
5	<8	>45	>65	<49	< 53	< 1.8	<75

[1] Values in the columns are expressed in terms of percent dry matter, except for RFV and DMI.
[2] Abbreviatons over columns are: CP = crude protein; ADF = acid detergent fiber; NDF = neutral detergent fiber; TDN = total digestible nutrient; DDM = digestible dry matter; RFV = relative feed value; DMI = dry mater intake.
[3] Based on percent of body weight (% BW).

Source: Coppock, 1997.

you decrease feed cost per animal while maintaining or increasing production. Poor sampling results in misleading values, which can lead to higher feed costs and reduced animal performance. Keep in mind that every field and every cutting will be different. Increasing profitability per animal depends on forage quality and utilization. The results of forage tests may be compared to the requirements for total digestible nutrients (TDN) and protein of different classes of livestock. If you do not know how to use the results, contact your county Extension office or Extension livestock or forage specialists for guidance. It is important to balance hay nutrient composition with the appropriate minerals, vitamins or other supplements to provide adequate nutrition to the livestock.

How to Interpret a Forage Analysis Report as an Indicator of Quality

Knowing information about forage quality allows you to balance rations, which improves the overall nutritional plan and may reduce costs. If present forage is of poor quality, feedback from the forage analysis could improve future crop management. A forage analysis report could also help you make informed decisions about appropriate prices for feed and supplements. Forage quality analysis information varies from laboratory to laboratory but usually contains information related to moisture (%); dry matter (% DM); crude protein (CP, %); acid detergent fiber (ADF, %); neutral detergent fiber (NDF, %); total digestible nutrients (% TDN); net energy calculations for lactation (NEL, mcal/lb), maintenance (NEM, mcal/lb), and gain (NEG, mcal/lb); and relative feed value (RFV).

Dry matter usually refers to the amount of forage that is not water. Acid detergent fiber (ADF) is a measure of the least-digestible plant carbohydrates (cellulose and lignin). Acid detergent fiber is negatively correlated with digestibility, and consequently is often used to estimate energy content of forages. In other words, lower ADF indicates higher digestibility. Neutral detergent fiber (NDF) is a measure of total structural carbohydrates in the plant. Total digestible nutrient is an estimate of all digestible organic nutrients (protein, carbohydrates and fat) in forage that are available to the animal. The NDF is partially digestible. As such, NDF is considered an indicator of forage bulkiness and is related to dry matter intake. Lower NDF indicates more forage intake potential. Forages usually contain more than 30 percent NDF. Neutral detergent fiber and ADF both increase as forages mature, while DMD (or TDN) decreases.

Crude protein is a measure of the amount of nitrogen in the forage. Forages usually vary on their crude protein content depending on forage species, the stage of maturity, and fertilization practices (Table 5). Crude protein content in legumes ranges from 15 to 23 percent, while in grasses, CP levels range from 8 to 18 percent. Other crop residues used in grazing such as straw can have 3 to 4 percent CP. If the analysis report provides the percentage of nitrogen,

Table 5. Changes in botanical composition and forage quality of forage groups at different maturity stages.

	Composition	**Quality**	
Forage Group	**Leaves**	**CP**	**NDF**
	% DM		
Grasses			
Vegetative	>50	>18	<55
Boot	40 – 50	13 – 18	55 – 60
Head	30 – 40	8 – 12	61 – 65
Mature	20 – 30	<8	>65
Legumes			
Vegetative	40 – 50	>19	<40
Bud	35 – 45	17 – 19	40 – 46
Early Flower	25 – 40	13 – 16	47 – 51
Late Flower	<30	<13	>51

Source: Schroeder, 1996.

then the crude protein can be calculated by multiplying the total N concentration (%) by a constant, 6.25. The formula for CP is as follows: CP = % N x 6.25.

The relative feed value (RFV) is an index used to rank forages based on forage digestibility (ADF) and forage intake potential (NDF). RFV is not a percentage; it measures the overall feed value of forage. The original RFV was developed for alfalfa but can be use to rank different grasses and legumes. Grasses typically have higher ADF and NDF concentrations and consequently have lower RFV's. Grasses and corn silage also have a greater NDF to ADF ratio than legumes. Higher RFV values indicate higher forage quality. Because the RFV system was developed using legume forages, the relative forage quality (RFQ) index is more useful with warm-season forages. The RFQ uses fiber digestibility to estimate intake as well as the total digestible nutrients (energy) of the forage. In the calculation of RFQ values, total digestible nutrients (TDN) substitutes for DDM intake. TDN are calculated from fiber digestibility obtained in the laboratory. The RFQ is a better index than RFV for those who buy and sell forages, and it better reflects the performance that can be expected from cattle fed those forages.

The forage quality report also gives a value for net energy (NE). Net energy refers to the energy concentration in a feed. It can be measured directly only by expensive, laborious animal trials. However, it can be predicted using either NDF or ADF. Forages cut at different stages of maturity have different levels of fiber and energy (Table 6). Older, more mature forages have higher fiber and less energy than younger, succulent forages. Net energy is calculated in megacalories (Mcal) per lb (hundredweight). This NE shows that 0.5 Mcal/lb is the same as 50 Mcal/100 lbs. Both NDF and DMD (as TDN) are needed in the equation because as a plant matures, the increase in NDF is large, while the decrease in DMD is not so great. Using both NDF and DMD increases accuracy of the net energy value.

Summary

Forage testing goes beyond balancing the nutritional requirement of the animals. Forage testing can also help you detect forage management problems in your livestock operation. Forages may be sampled as hay or as standing pasture. The objective of sampling forages is to obtain "representative samples" for laboratory analysis to estimate the value of feed for livestock. Sampling technique is a significant aspect of standardized hay testing, because the analysis is valid only to the extent that the sample represents the lot of hay. It is important to identify the sample by date, cutting, forage or pasture location, and owner before shipping the sample to the lab.

Forage quality refers to forage's potential to meet the nutritional needs of a particular animal. Many livestock species use forages as their primary source of nutrition. Therefore, it is important to provide animals with the best quality forage available. Using the results from a forage test to create a balanced ration is a critical component of nutritional management for any livestock species. Paying close attention to the quality of forages will positively impact the health of your animals and minimize the costs of purchasing concentrated feeds. You can use the information reported on a forage test to improve forage quality. The first question to address is: Do I need to change my management? Make sure you keep in mind the nutritional needs of the animals when reviewing your forage program.

Table 6. Changes in digestibility and energy levels of hay at four maturity stages.

Maturity Stage	Digestibility	Gross Energy	Digestible Energy	Net Energy
	(% DM)	(Mcal/lb)		
Vegetative	67	1.92	1.28	0.73
Boot	61	1.90	1.16	0.65
Head	51	1.92	0.98	0.49
Senescence	47	1.93	0.91	0.41

Source: McCullough, 1989.

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