Hay Quality and How It Affects Your Feeding Program

Forage (pasture or hay) is one of the most important components in the diet of any type of livestock because of its impact on dry matter consumption and its overall effect on digestive health. There are a great variety of forages that are fed to livestock during the winter months in Mississippi, including legumes (alfalfa and clovers), grasses (tall fescue, bermudagrass, bahiagrass, small grains, crabgrass, millets, sudangrass, forage sorghums, annual ryegrass), and mixed forages. Most livestock are well adapted to consume these types of forages and obtain their daily nutrient requirements, but sometimes their potential to meet nutritional needs can be affected by pre-harvest (fertilization and maturity) and post-harvest (moisture content, storage, feeding) management practices.

Forage nutritive value can be defined as the nutrient content of the forage (protein, fiber, energy, minerals, vitamins, etc.) that can be digested by the livestock. Forage quality is a broader term that includes the intake of the forage of certain nutritive value; it can also be defined by four components:

1. **Palatability**: Acceptance of forage by an animal based on texture, aroma, succulence, hairiness, leaf percentage, fertilization, sugar content, alkaloids, maturity, and lignin content.
2. **Intake**: Ability of the animal to consume the forage.
3. **Digestibility**: How much forage can be broken down and digested.
4. **Nutrient availability**: How much of the nutrients can be utilized for the animal's needs.

It is important to understand that not all forages have the same nutritive value and availability to livestock. Forage quality is quite variable in nutrient composition from grasses to legumes, and several factors can influence forage quality. This means that hay produced in the same farm and field can vary significantly from cut to cut and year to year.

The chemical composition of forage can be variable depending on its stage of physiological maturity. As the plant matures, fiber increases, while protein, rate of digestion, and forage digestibility decrease. This causes livestock to ingest fewer nutrients. If digestibility decreases, the energy available also decreases, and the livestock cannot digest the forage; this limits energy intake. A slower passage rate of the forage (during digestion) usually results in a reduction in intake of any supplemental feed. Other factors that can affect forage quality include plant type, variety, soil fertility, weather, harvest methods, and storage conditions. Because of these variables, you should not assume that hay purchased from the same person year after year or produced on your farm is of the same quality each time.

Livestock production during the winter depends largely on the feeding program. The critical issue with forage quality is determining whether the animal's nutrient requirements are met with the forages being fed. When the nutrient content of the forage is limiting, additional supplementation is needed or animal performance will be compromised. The only way to know if the forage will meet the nutrient requirements of the livestock is to get the hay tested. The primary reason for hay testing is to adjust nutrient deficiencies and increase net profit. Knowing the quality of the hay you are feeding, selling, or buying is economically important and should be taken into consideration. The following steps provide guidance to collecting a representative forage sample for analysis. Please contact your local MSU Extension office for assistance.

1. Take a separate sample from each field and cutting (hay lot), especially if hay has been rained on during cutting or baling.
2. To get a representative sample, use a hay probe (bale core) and insert it at least 18 to 24 inches into the bale. For square bales, sample at the end of the bale; for round bales, sample in the round

area of the bale, not from the ends. Avoid taking grab samples from the bale or the windrow because they may cause leaf loss, and the sample will not be a fair representation of the lot.

3. Take at least 20 cores from each lot, mix them in a clean bucket, and place it in a one-fourth to one-half gallon zip-lock bag.
4. Label each bag with your name, location, date, address, type of forage, stage of maturity (days from previous harvest to cutting), and date harvested. Also include the sample information inside the bag if the sample is completely dry.
5. Send samples to your chosen forage testing laboratory. For a detailed list of other laboratories across the United States, visit ***http://bit.ly/NFTAlabs***. Hay submission forms with cost of analysis and information can be obtained directly from the labs since prices are subject to change depending on the type of analysis requested.

Auburn University
ALFA Agricultural Services and Research Building
961 S. Donahue Drive
Auburn University, AL 36849-5411
(334) 844-3958
Services: NIR
http://bit.ly/AuburnForagelab

Mississippi State Chemical Laboratory
310 Presidents Circle 1145 Hand Lab
Mississippi State, MS 39762
(662) 325-3428
Services: Wet chemistry
http://bit.ly/MSChemlab

Oklahoma State University
Soil, Water, and Forage Analytical Laboratory
045 Agriculture Hall
Stillwater, OK 74078
(405) 744-7771
Services: NIR
http://bit.ly/OSUForagelab

Stephen F. Austin State University
SFASU Soil, Plant, and Water Analysis Laboratory
1924 Wilson Drive, Agriculture Bldg. Rm 122
Nacogdoches, TX 75962
(936) 468-4500
Services: Wet chemistry and NIR
http://bit.ly/SFASUForagelab

Texas A&M AgriLife Extension Service
Postal Service
Soil, Water, and Forage Testing Laboratory
2478 TAMU
College Station, TX 77843-2478
Other couriers (FedEx, UPS, etc.)
Soil, Water, and Forage Testing Laboratory
2610 F&B Road
College Station, TX 77845
(979) 845-4816
Services: Wet chemistry and NIR
http://bit.ly/TAMUForagelab

University of Georgia
Feed and Environmental Water Lab (FEW)
2300 College Station Road
Athens, GA 30602-4356
(706) 542-7690
Services: Wet chemistry and NIR
http://bit.ly/UGAForagelab

University of Tennessee
Soil, Plant, and Pest Center
5201 Marchant Drive
Nashville, TN 37211-5112
(615) 832-5850
Services: NIR
http://bit.ly/UTForagelab

Many studies have shown that knowing the quality of your forage can have a significant impact on net profit because knowing the quality will drive supplementation decisions. Despite the benefits of analyzing forages and using that knowledge to make production decisions, there are still many livestock producers in the state who do not recognize the value of forage testing as a management tool. **Tables 1–6** provide a range of forage quality parameters from samples collected at Mississippi State University research and variety trials. The range of nutrients can vary depending on the forage species as well as the level of management, and they should be used for guidance only. Following is a brief explanation of some terms found in the tables:

Dry Matter (DM): Dry matter is the non-moisture portion of the forage sample. Animals consume feeds to meet their dry matter needs; therefore, animals will have to consume more of a fresh forage to receive the same amount of dry matter as they would from a drier forage. It is very important to know the dry matter content of a feed to establish feeding rates and ensure that livestock receive the proper amount of feed to meet their daily needs. For example, for a cow to consume 25 pounds of dry matter, it would require 100 pounds of fresh, lush pasture (25 percent dry matter) or 28 pounds of dry hay (89 percent dry matter).

Crude Protein (CP): Crude protein is the amount of protein concentration in the forage based on the estimated nitrogen from the sample (% N × 6.25). The level of nitrogen fertilization and cutting interval can influence crude protein content. As forages mature, the level of crude protein is diluted by the increase in fiber content.

Acid Detergent Fiber (ADF): Acid detergent fiber contains the poorly digestible cell wall components (cellulose and lignin). It is a good indicator of forage digestibility. Higher values indicate lower digestibility. It can be used to predict energy content in the forage.

Neutral Detergent Fiber (NDF): The insoluble portion of the forage sample that contains the primary components of the plant cell wall (hemicellulose, cellulose, and lignin). It is a good indicator of forage intake by the animal. As plant maturity increases, NDF content will increase, dry matter intake will decrease, and chewing activity will increase.

Water Soluble Carbohydrates (WSC): Carbohydrates that are soluble and extractable in water. Includes monosaccharides, disaccharides, and some polysaccharides.

Total Digestible Nutrients (TDN): A measure of energy in the forage. Energy is the nutrient required in greatest amount. The energy content is not directly measured like other nutrients but derived through regression equations in which ADF is used. TDN varies with forage species, and, as forage matures, TDN value decreases.

Relative Forage Quality (RFQ): An index for ranking forages that is based on the same scoring system as relative feed value (RFV). It is a measure of the overall feeding value of the forage and its possible impact on animal performance when forage is fed alone. RFQ could be related to the production level of the livestock to assess forage intake, nutritive value, and efficiency of energy utilization. RFQ can be classified in five categories: (1) **supreme** [>140 (dairy and first trimester dairy calf)], (2) **premium** [125–140 (dairy last 200 days, heifer 3–12 months, and stocker cattle)], (3) **good** [110–125 (heifer 12–18 months and beef cow-calf], (4) **fair** [90–110 (heifer 18–24 months and dry cow)], and (5) **poor** [<90 (utility mulch)]. The higher the RFQ, the better the quality.

Minerals (P, K, Ca, Mg): Minerals in forages are highly variable and can be largely affected by soil fertility and imbalances caused by pH or other mineral interactions. Minerals are of value when there is a good understanding of the complete feeding program for a specific livestock class. Most minerals will require a wet chemical assay, and values determined with near infrared technology can be highly variable. Minerals are not part of a routine forage analysis and should be requested for an additional fee.

Table 1. Forage quality of annual cool-season grasses. Values expressed on percent dry matter basis.

Variable	N[1]	Mean	Maximum	Minimum	Range	Std Dev
	Annual ryegrass					
CP, %	400	17. 89	27. 56	10. 15	17. 41	4. 34
ADF, %	400	31. 32	41. 45	19. 30	22. 15	4. 31
NDF, %	400	49. 60	62. 50	38. 43	24. 07	5. 48
WSC, %	400	7. 67	16. 41	0. 47	15. 94	2. 67
TDN Est., %	400	59. 33	73. 16	47. 68	25. 48	4. 95
RFQ	400	119. 00	185. 70	74. 43	111. 30	21. 95
P, %	400	0. 29	0. 35	0. 22	0. 13	0. 03
K, %	400	2. 23	2. 78	1. 21	1. 57	0. 22
Ca, %	400	0. 64	0. 82	0. 48	0. 34	0. 07
Mg, %	400	0. 38	0. 56	0. 29	0. 27	0. 05
	Small grains[2]					
CP, %	78	16. 71	22. 11	12. 22	9. 89	3. 04
ADF, %	78	25. 44	31. 76	19. 53	12. 23	3. 01
NDF, %	78	44. 40	51. 76	37. 18	14. 58	4. 19
WSC, %	78	14. 66	24. 97	2. 67	22. 30	5. 69
TDN Est., %	78	66. 10	72. 89	58. 82	14. 07	3. 47
RFQ	78	147. 10	182. 20	111. 00	71. 25	20. 68
P, %	78	0. 22	0. 29	0. 15	0. 14	0. 04
K %	78	1. 85	2. 51	1. 28	1. 23	0. 28
Ca, %	78	0. 58	0. 68	0. 47	0. 21	0. 04
Mg, %	78	0. 31	0. 49	0. 18	0. 31	0. 07

[1]N = number of samples analyzed.
[2]Small grains = cereal rye, oats, triticale, and wheat.
TDN = 95.35 - (ADF*1.15); DMI (% BW) = 120/NDF; RFQ = [(DMI, % BW) * TDN (% DM)/1.23]

Table 2. Forage quality of cool-season perennial tall fescue. Values expressed on a percent dry matter basis.						
Variable	**N[1]**	**Mean**	**Maximum**	**Minimum**	**Range**	**Std Dev**
	Tall fescue[2]					
CP, %	686	13. 97	24. 91	7. 16	17. 75	3. 62
ADF, %	686	32. 82	40. 89	25. 36	15. 53	3. 24
NDF, %	686	56. 45	67. 02	45. 14	21. 88	4. 65
WSC, %	676	8. 06	16. 23	0. 27	15. 96	2. 35
TDN Est., %	686	57. 60	66. 18	48. 33	17. 85	3. 73
RFQ	686	100. 70	135. 20	71. 90	63. 32	14. 34
P, %	686	0. 24	0. 32	0. 17	0. 15	0. 03
K, %	686	1. 86	2. 91	0. 86	2. 05	0. 40
Ca, %	686	0. 53	0. 73	0. 27	0. 46	0. 05
Mg, %	686	89. 29	92. 81	12. 03	80. 78	9. 29

[1]N = number of samples analyzed.
[2]Tall fescue = endophyte infected, endophyte free, and novel endophyte.
TDN = 95.35 - (ADF*1.15); DMI (% BW) = 120/NDF; RFQ = [(DMI, % BW) * TDN (% DM)/1.23]

Table 3. Forage quality of warm-season perennial grasses. Values expressed on a percent dry matter basis.						
Variable	**N[1]**	**Mean**	**Maximum**	**Minimum**	**Range**	**Std Dev**
	Bahiagrass					
CP, %	333	10. 95	17. 79	5. 45	12. 34	1. 67
ADF, %	334	38. 83	46. 71	33. 27	13. 44	2. 02
NDF, %	334	63. 75	69. 63	57. 09	12. 54	2. 35
WSC, %	328	4. 79	8. 28	1. 11	7. 17	1. 40
TDN Est., %	334	50. 70	57. 09	41. 63	15. 46	2. 32
RFQ	334	77. 81	97. 57	58. 33	39. 24	6. 38
P, %	334	0. 21	0. 25	0. 11	0. 14	0. 02
K, %	334	1. 51	2. 00	0. 35	1. 65	0. 21
Ca, %	334	0. 56	0. 71	0. 44	0. 27	0. 04
Mg, %	333	0. 56	17. 77	0. 28	17. 49	1. 45
	Bermudagrass					
CP, %	1316	13. 49	20. 36	6. 91	13. 45	2. 40
ADF, %	1317	33. 96	43. 60	26. 47	17. 13	2. 73
NDF, %	1317	63. 63	75. 58	52. 24	23. 34	3. 44
WSC, %	1285	5. 20	11. 83	0. 13	11. 70	2. 05
TDN Est., %	1317	56. 29	64. 91	45. 21	19. 70	3. 14
RFQ	1317	86. 78	120. 30	59. 61	60. 66	9. 21
P, %	1316	0. 22	0. 34	0. 05	0. 29	0. 03
K, %	1317	1. 72	11. 67	0. 11	11. 56	0. 45
Ca, %	1317	0. 45	37. 63	0. 19	37. 44	1. 03
Mg, %	1316	0. 68	66. 79	0. 17	66. 62	2. 54

[1]N = number of samples analyzed.
TDN = 95.35 - (ADF*1.15); DMI (% BW) = 120/NDF; RFQ = [(DMI, % BW) * TDN (% DM)/1.23]

Table 4. Forage quality of warm-season annual grasses. Values expressed on a percent dry matter basis.

Variable	N[1]	Mean	Maximum	Minimum	Range	Std Dev
	Crabgrass/Teffgrass					
CP, %	134	14. 93	19. 64	9. 51	10. 13	2. 06
ADF, %	134	35. 24	39. 59	30. 95	8. 64	1. 89
NDF, %	134	59. 46	65. 98	51. 38	14. 60	2. 88
WSC, %	133	4. 39	10. 57	0. 14	10. 43	2. 04
TDN Est., %	134	54. 83	59. 76	49. 83	9. 93	2. 18
RFQ	134	90. 29	113. 50	74. 56	38. 92	7. 44
P, %	134	0. 22	0. 28	0. 13	0. 15	0. 03
K, %	134	1. 60	2. 38	0. 44	1. 94	0. 29
Ca, %	134	0. 64	0. 89	0. 45	0. 44	0. 09
Mg, %	134	0. 60	17. 65	0. 31	17. 34	1. 49
	Sorghum, sudangrass, millets					
CP, %	266	13. 76	22. 56	7. 82	14. 74	3. 52
ADF, %	266	35. 74	43. 42	28. 28	15. 14	3. 08
NDF, %	266	62. 02	71. 18	50. 94	20. 24	4. 06
FAT, %	260	6. 05	13. 87	0. 22	13. 65	2. 82
TDN Est., %	266	54. 25	62. 83	45. 42	17. 41	3. 54
RFQ	266	86. 07	118. 40	62. 25	56. 16	11. 34
P, %	266	0. 25	0. 31	0. 19	0. 12	0. 02
K, %	266	1. 77	3. 00	0. 87	2. 13	0. 33
Ca, %	266	0. 48	0. 75	0. 10	0. 65	0. 09
Mg, %	266	0. 66	14. 42	0. 15	14. 27	1. 58

[1]N = number of samples analyzed.
TDN = 95.35 - (ADF*1.15); DMI (% BW) = 120/NDF; RFQ = [(DMI, % BW) * TDN (% DM)/1.23]

Table 5. Forage quality of cool-season legumes. Values expressed on a percent dry matter basis.						
Variable	N[1]	Mean	Maximum	Minimum	Range	Std Dev
	Alfalfa, conventional					
CP, %	348	22. 77	27. 36	19. 48	7. 88	1. 43
ADF, %	348	31. 23	40. 70	21. 98	18. 72	4. 05
NDF, %	348	41. 20	56. 03	29. 87	26. 16	5. 43
FAT, %	348	2. 57	3. 28	1. 92	1. 36	0. 23
TDN Est., %	348	59. 43	70. 07	48. 54	21. 53	4. 66
RFQ	348	144. 70	225. 70	85. 56	140. 10	30. 35
P, %	348	0. 35	0. 45	0. 29	0. 16	0. 03
K, %	348	2. 31	3. 37	1. 24	2. 13	0. 38
Ca, %	348	1. 60	2. 34	1. 29	1. 05	0. 21
Mg, %	348	0. 36	0. 54	0. 29	0. 25	0. 05
	Cool-season annual[2] & perennial clovers[3]					
CP, %	157	25. 27	28. 32	19. 09	9. 23	1. 79
ADF, %	157	28. 35	34. 15	23. 02	11. 13	2. 86
NDF, %	157	37. 51	46. 71	28. 30	18. 41	4. 74
FAT, %	157	2. 56	3. 14	1. 84	1. 30	0. 29
TDN Est., %	157	62. 75	68. 88	56. 08	12. 80	3. 29
RFQ	157	167. 00	236. 20	119. 80	116. 40	30. 58
P, %	157	0. 39	0. 46	0. 30	0. 16	0. 04
K, %	157	2. 54	3. 55	1. 30	2. 25	0. 51
Ca, %	157	1. 69	2. 02	1. 29	0. 73	0. 15
Mg, %	157	0. 45	0. 52	0. 37	0. 15	0. 03

[1]N = number of samples analyzed.
[2]Annual clovers = arrow leaf, crimson, ball, and berseem.
[3]Perennial clovers = white and red.
TDN = 95.35 - (ADF*1.15); DMI (% BW) = 120/NDF; RFQ = [(DMI, % BW) * TDN (% DM)/1.23]

Table 6. Forage quality of warm-season legumes. Values expressed on a percent dry matter basis.						
Variable	N[1]	Mean	Maximum	Minimum	Range	Std Dev
	Warm-season legumes[2]					
CP, %	308	17. 94	27. 68	12. 56	15. 12	2. 83
ADF, %	308	32. 10	49. 91	16. 73	33. 18	7. 38
NDF, %	308	38. 35	59. 70	16. 74	42. 96	9. 02
FAT, %	308	3. 44	7. 30	1. 78	5. 52	1. 30
TDN Est., %	308	58. 44	76. 11	37. 95	38. 16	8. 49
P, %	308	0. 36	0. 55	0. 26	0. 29	0. 06
K, %	308	2. 37	3. 61	1. 03	2. 58	0. 51
Ca, %	308	1. 74	3. 09	0. 84	2. 25	0. 50
Mg, %	308	0. 41	0. 62	0. 20	0. 42	0. 07

[1]N = number of samples analyzed.
[2]Warm-season legumes = alyce clover, aeschynomene (deer vetch or joint vetch), cowpeas, forage soybeans, and lablab.
TDN = 95.35 - (ADF*1.15)

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