Factors Affecting Forage Quality[1]

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What Is Forage Quality?

Forage quality, the degree to which a forage meets animal nutritional needs, is expressed in terms of animal production, such as growth, milk, or wool production. Forage quality is affected by forage nutritive value(i.e., chemical composition and digestibility) and intake, and it can be estimated when forage is the sole source of nutrients to the animal and offered without quantity restrictions (*ad libitum*). It is also dependent on animal species and class, in the sense that the same forage can have higher value for one type of herbivore than to another. Animal performance, whether growth or milk production, depends upon the animal's potential for production, as well as on how much dry matter (DM) the animal eats and the nutritive value of the DM the animal consumes. Therefore, the two forage-related factors that determine animal performance are (1) forage intake and (2) forage nutritive value. Collectively, these factors determine the quality of the forage.

Figure 1. Over-mature bermudagrass hay field. Both an increase in fiber and senescent material decrease the forage quality.
Credits: Marcelo Wallau

Factors Affecting Forage Intake

Forage intake is affected by a range of pasture, animal, environmental and management factors. Herbage allowance (amount of forage available per animal) and canopy structure, composition and arrangement are primary plant determinants of intake. Nutritive value, especially crude protein and digestibility are associated with the passage rate of the forage through the gastrointestinal tract. Forages of low digestibility and protein have slower passage rate, physically limiting intake (gut fill). Intake is also affected by animal body size, performance level, health, genotype, and social hierarchy. Environmental aspects that affect intake

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include temperature, humidity, and rainfall. Animals out of their comfort zone tend to reduce time grazing. Management factors — such as stocking rate, type, and level of supplementation, feeding frequency, and availability of water and feed — also affect forage intake. Additionally, for stored forage intake is affected by the type of conservation process (i.e., hay or silage), particle size and nutritive value (e.g., fiber, protein, digestibility) and mold contamination, poor fermentation, or any substances that make the forage less acceptable.

"Voluntary forage intake" is used to describe how much forage DM an animal will consume when adequate amounts of forage are available, when no supplements of protein and energy are fed to the animal, and when adequate minerals are available —either in the forage or as supplements. Energy and protein supplements may either increase or decrease livestock forage intake, depending upon the composition of the forage and the composition and amount of supplement being fed to the livestock.

Factors Affecting Forage Nutritive Value

Forage nutritive value is primarily determined by concentrations of crude protein (CP) and "available" energy in the forage. For many years, total digestible nutrients (TDN) has been used as an overall measure of available energy in forages. In the past 20 years, however, measurements of digestible energy, metabolizable energy, and net energy of forage have increasingly been used, especially for more fine-tuned diets. However, TDN is still an acceptable and easily understood measure of nutritive value, particularly for beef cattle. Forage nutritive value is affected most by variations in forage genotype, maturity, season, and management, and presence of "anti-quality" factors.

1. Genotype

Legumes generally have a higher nutritive value than grasses because of higher CP and TDN concentrations at a given age of regrowth. This results in greater intake by livestock, particularly when compared with warm-season (C4) grasses. The TDN concentrations of legumes and cool-season grasses are similar because legumes typically have higher lignin and cool-season grasses are generally low in fiber and high non-structural carbohydrates. Generalizations about the nutritive value of grasses are risky, but temperate or cool-season grasses, such as rye and ryegrass, are nearly always higher in nutritive value than tropical or warm-season grasses such as bermudagrass and bahiagrass. However, there is much variation in forage nutritive value within and among grass genera, and between varieties of the same species.

2. Maturity

The stage of forage regrowth at the time of utilization—whether as hay, haylage, or grazed forage—has a major influence on forage nutritive value. Forage-regrowth stage is determined by the number of days between harvests for hay or haylage and by the rest period in rotational grazing.

There is always a compromise between forage quantity and nutritive value. Forage nutritive value begins to decline during the regrowth period due to the accumulation of stems and deposition of poorly digested lignin in both leaves and stems.

Maturity of legumes and cool-season grasses can be assessed by determining the physiological stage of growth. For warm-season grasses, however, weeks of regrowth are a better indicator of maturity because flowering may begin shortly after regrowth begins. Table 1 shows a decline in the digestibility and crude protein of Coastal bermudagrass after week five (day 35) of regrowth. The information in this table indicates that harvesting Coastal bermudagrass at intervals greater than five weeks will reduce the nutritive value of this forage. Table 2 provides examples of the effects of forage genotype and maturity on the nutritive value of typical forage grasses in Florida. Each value represents several cuttings made from different varieties in different years. These values are a general reference point. These data suggest that digitgrass and limpograss tend to have higher nutritive value than bahiagrass, bermudagrass, and stargrass, especially at later stages of maturity. These differences often affect voluntary intake as well.

With respect to maturity effects on perennial grasses, the most dramatic difference is the decrease in voluntary intake between six and eight weeks. These data and others show that after eight weeks of regrowth, forage nutritive value will generally be less than needed for livestock maintenance. Exceptions are digitgrass and limpograss, which maintain a somewhat higher TDN when mature than do the other grasses. Consequently, limpograss and digitgrass are excellent forages for fall stockpiling. However, those are often are low in CP when mature, and require protein supplementation for optimum utilization.

3. Season

Seasonal effects on forage nutritive value have been noted in grazing trials in Florida where forage regrowth intervals were kept constant. Gains of grazing cattle have been less during the summer than in spring and fall. This problem is called the "summer slump." This summer slump in cattle weight gain is due at least in part to the effect of the environment on forages. Summer slumps in nutritive value of warm-season grasses have been observed with hay harvested after similar regrowth intervals on different dates throughout the growing season (Table 3). Summer regrowth may have lower nutritive value because high temperature increases lignin deposition, and high rainfall increases growth rates and maturation of the forage.

In the case of hay made in Florida, the negative effects of season and maturity on forage nutritive value may be additive. Spring harvests are made generally after short regrowth periods, while summer harvests are made after long regrowth periods because of heavy summer rainfall that delays harvests. Therefore, the nutritive value of bermudagrass hay is greatest when harvested in the spring or early summer.

4. Management

Pre-Harvest Management: Pre-harvest management for maximum nutritive value of hay or silage involves weed control and frequent cutting. (See discussion above under heading 2, Maturity.) Some producers harvest every four or five weeks throughout the season, making either hay or haylage, depending on rainfall.

Post-Harvest Management: The nutritive value of hay or silage can only be as good as the forage from which it was made. However, post-harvest decreases in hay or silage quality can be minimized by careful management. Post-harvest management of hay requires avoiding rain damage and proper curing of hay to less than 15% moisture. Leaching of nutrients from weathering decreases forage nutritive value. Therefore, hay bales should be stored under a barn or a tarp whenever possible. Post-harvest management of silage involves avoiding rain damage, wilting to 60%–70% moisture when necessary, packing to a density of about 40 lb/cubic feet (as fed), promptly sealing silos (or wrapping haylage bales) on the day the forage is harvested, and feeding out the silage at a rate that prevents heating (over 12 inches per day). For more information, check EDIS publication AN266: Comparison of Hay or Round Bale Silage as a Means to Conserve Forage (http://edis.ifas.ufl.edu/an266).

Growth of yeasts and molds may also decrease forage nutritive value and acceptability, and therefore reduce forage intake by livestock. Additionally, molds may produce mycotoxins, which can reduce animal performance and cause diseases in livestock and people. To avoid mold growth, silages should be harvested and stored at the recommended moisture concentration. In addition, silage or haylage plastic should be maintained properly; any holes should be promptly sealed with silage tape. Silage density and feed out rate should follow the guidelines above to prevent mold growth and heating. Application of additives containing propionic acid or *Lactobacillus buchneri* inoculants can also prevent the growth of molds.

Management of Grazed Pastures: Pastures should be managed to maintain a leafy canopy that is free of weeds and not overly mature to optimize forage nutritive value. Proper stocking rate is the most important factor to match forage quantity and animal requirements (see EDIS publication SS-AGR-92: Grazing management Concepts and Practices–http://edis.ifas.ufl.edu/ag160). If forage CP is low in unfertilized grass, then N fertilizer application will increase forage CP and may also contribute to improved forage intake and animal performance.

5. Anti-Quality Factors

Examples of anti-quality factors in commonly grazed or fed Florida forages are noxious weeds, nitrates, prussic acid, ergot alkaloids, and insect infestation

Nitrate or prussic acid accumulation can occur in certain forages after stressful periods, such as drought, frost, hail, and herbicide or fertilizer injury. Nitrate accumulation is most common in drought-stressed grasses including corn, rye, sorghum, sudangrass, and others. Prussic acid accumulates in members of the sorghum family, including sorghum, sudangrass, and the weed johnsongrass. It is very common immediately after a frost event and can be associated with new growth after drought stress. Both of these compounds—nitrate and prussic acid—can limit oxygen transfer in the blood of livestock. Therefore, the accumulation of these compounds in forage is dangerous. If forages have undergone a stressful period as described above, forage samples should be sent for nitrate or prussic-acid testing before the forage is fed to livestock. Proper ensiling may reduce concentrations of these compounds to safe levels, but testing to ensure safe levels is recommended. Volatile toxic gases can be released during the ensiling process, therefore, workers should be careful when handling ensiled forages, particularly within the first month of ensiling.

Ergot alkaloids have also been observed in a few cases on bermudagrass in Florida, as in Mexico, Texas, and Oklahoma. Problems such as tremors associated with ingestion of ergot alkaloids can be avoided by maintaining a 4- to

5-week cutting interval for bermudagrass, interseeding with legumes or other grasses, and diluting the toxin with nontoxic forages and supplements.Ergot alkaloids from *Claviceps* species can also be a problem affecting seed heads of grasses such as rye, ryegrass, *Phalaris spp*., *Sorghum spp*., and some *Paspalum spp* (e.g., bahiagrass), causing reproductive problems in livestock. In some cases, insects can defoliate the leaves of forages, thus decreasing forage quality.

Implications

Forage quality varies widely due to variations in forage genotype, maturity, season, management, and anti-quality components. Because of all these factors and their interactions, tables of forage quality and nutritive value are unlikely—by themselves—to provide useful information about a particular forage. Therefore, be sure to test forages frequently, using forage samples that are taken carefully to ensure that the samples are representative of the forage that will be consumed by livestock.

Additional Information

Vendramini, J. M., M. S. Silveira, J. D. Arthington, and A. R. Blount. 2015. *Forage Testing*. SS-AGR-63. Gainesville: University of Florida Institute of Food and Agricultural Sciences. http://edis.ifas.ufl.edu/aa192.

Table 1. Nutrient Composition of Coastal Bermudagrass as Affected by Maturity.

	Digestibility	Crude Protein	ADF	Lignin
Maturity (Weeks)	--------------------------%---------------------------			
4	60	18	29	4
5	59	18	30	4
6	56	16	31	5
7	53	13	33	6
Source: Adapted from Mandevbu et al. (1999)				

Table 2. Effects of Grass and Maturity on Forage Nutritive Value and Quality.

Grass	TDN[a]			Voluntary Intake[b]		
	4 weeks	6 weeks	8 weeks	4 weeks	6 weeks	8 weeks
Bahia	56	55	54	2.3	2.1	1.7
Bermuda	57	52	44	2.3	2.2	1.8
Star	60	53	49	2.4	2.5	2.1
Digit	60	58	57	2.5	2.7	2.2
Limpo	63	63	56	2.5	2.3	2.2

Source: Adapted from W. F. Brown and R. S. Kalmbacher (May 1998), "Nutritional Value of Native Range and Improved Forages: A Perspective from Central and South Florida," in *47th Annual Florida Beef Cattle Short Course*, 79–87.
[a] Total Digestible Nutrients, percentage by dry matter.
[b] Intake of dry matter expressed as percentage of body weight.

Table 3. Quality of Coastal Bermudagrass Hay Harvested at Different Maturities and Seasons.

Item	Weeks of Regrowth	Harvest Date				
		June 14	July 12	August 9	Septmeber 6	October 4
TDN %[a]	4	55	57	52	53	46
	6	52	51	47	49	48
	8	52	51	46	47	44
QI[b]	4	1.4	1.4	1.3	1.3	1.1
	6	1.3	1.4	1.0	1.2	1.2
	8	1.3	1.1	0.9	1.1	0.8
ADG, lb[c]	4	0.57	0.78	0.72	0.63	0.28
	6	0.34	0.48	-0.04	0.42	0.22
	8	0.16	0.07	-0.39	0.07	-0.39

Source: Adapted from Nelson et al. (October 1980), Louisiana Agr. Exp. Stat. Bull. 730.
[a] Total Digestible Nutrients, percentage of dry matter.
[b] Quality index.
[c] Average daily gain, in pounds/day; feeding trial conducted with steers from December through February for all hays.