Factors Affecting Forage Quality[1]

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What Is Forage Quality?

Forage quality is quantified in terms of animal production, such as beef, milk, or wool production. Forage quality is affected by forage nutritive value 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*). 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.

Factors Affecting Forage Intake

Forage intake is affected by a range of factors, including the amount of forage available and characteristics of the forage consumed, as well as the animal's intake capacity, performance level, health, genotype, and social hierarchy. Environmental factors also affect forage intake, including prevailing temperature and humidity. Management factors—such as stocking rate, type, and level of supplementation, feeding frequency, and availability of water and feed—also affect forage intake.

Figure 1. Bahiagrass field in Florida
Credits: Y. C. Newman

Additionally, forage intake is affected by forage quantity and by many characteristics of forages, such as particle size of stored forages and amounts of fiber, protein, and minerals in the DM. How fast undigested DM passes through the animal affects an animal's forage intake. Mold contamination, poor fermentation, and any substances that make the forage less acceptable also affect livestock intake of stored forages. Intake of pasture forage is affected by the nature of the sward. Accumulations of dead forage or manure on pasture could decrease intake, and a dense, leafy canopy will increase forage intake.

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"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 forage, metabolizable forage, and net energy of forage have increasingly been used. However, TDN is still an acceptable and easily understood measure of nutritive value, particularly for beef cattle.

Forage quality is affected most by variations in forage genotype, maturity, season, and management. Other "anti-quality" factors may be encountered occasionally; these factors are described below, under heading 5, "Anti-Quality Factors Affecting Forage."

1. Genotype

Legumes generally have a higher quality than grasses. Legumes have higher CP concentrations and a higher intake by livestock due to a higher percentage of rapidly digestible leaves. However, the TDN concentrations of legumes and cool-season grasses are similar because legumes typically have more poorly digested lignin than grasses. Generalizations about the quality of grasses are risky, but temperate or cool-season grasses, such as rye and ryegrass, often are of higher quality than tropical or warm-season grasses such as bermudagrass and bahiagrass. However, there is much variation in forage quality within and among grass genera.

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 quality. Forage-regrowth stage is determined by the number of days between harvests for hay or haylage and by the rest period in rotational grazing.

Forage quality begins to decline during the regrowth period due to the accumulation of stems and deposition of poorly digested lignin in both leaves and stems. Therefore, forage quality generally declines with increasing length of the interval between harvests of stored forages or with longer rest periods in rotational grazing.

Maturity of legumes and cool-season grasses can be assessed by determining the reproductive 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 quality of this forage.

Table 2 provides examples of the effects of forage genotype and maturity on the quality of typical forage grasses in Florida. Each value represents several cuttings made from different cultivars in different years. These values are a general reference point. These data suggest that digitgrass and limpograss tend to have higher quality 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 quality 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, mature limpograss and digitgrass often are low in CP and require protein supplementation for optimum utilization.

3. Season

Seasonal effects on forage quality 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, and this problem is called the "summer slump." A direct comparison of bahiagrass with dwarf elephantgrass suggested that this summer slump in cattle weight gain is due to the effect of the environment on forages rather than the effect of the environment on animals. The summer slump was dramatic with bahiagrass, but not apparent with elephantgrass, even though similar cattle grazed adjacent paddocks of the two grasses. Summer slumps in quality 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 quality 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 quality 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 quality of bermudagrass hay is highest when harvested in the spring or early summer.

4. Management

Pre-Harvest Management

Pre-harvest management for maximum quality 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 silage, depending on rainfall.

Post-Harvest Management

The quality of hay or silage is hardly ever better than 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).

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's 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 overly mature herbage to optimize forage quality. There is much controversy about how to achieve this target. Proper stocking rate is the most important factor to match forage quantity and animal requirements. Fertilizer application may affect forage quality, particularly the CP concentration, which may be increased for a period of time following N fertilization. If forage CP is low in unfertilized grass, then N fertilizer application will often increase forage CP and 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, insect infestation, and unusually wet growing areas.

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 common in corn, rye, sorghum, sudangrass, and alfalfa, and prussic acid accumulates in sorghum and sudangrass. 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 to livestock. 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 generally reduces concentrations of these compounds to safe levels, but volatile toxic gases are 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.

In some cases, insects can defoliate forages, thus decreasing forage quality. Additionally, cattle grazing forages grown under very wet conditions (i.e., standing water) may have low rates of performance for reasons that are not well understood.

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

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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 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.