



What is Forage Quality and How Does it Effect a Feeding Program?

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Why do camelids require forage and how much forage should I feed? What kind of forage is the best? How do I determine what is good quality forage for my llama or alpaca?

These are only a few of the common questions posed by llama and alpaca owners regarding feeding their animals. As an animal caretaker, you are responsible for providing sufficient feedstuffs to supply an adequate amount of essential nutrients to keep your animals alive and healthy. Most of us want more from our animals than just being alive per se. We would like females to produce a healthy baby every year, for our animals to grow high quality fiber or to be sound, vigorous animals capable of packing. To achieve these desired levels of production, we need to supply a feed that will deliver more than maintenance. Maintenance is the amount of nutrients necessary to keep basic body functions going. Problems like obesity, hepatic lipidosis (fatty liver) and malnutrition can result from an imbalance between forage quality and nutritional needs.

As herbivores, llamas and alpacas are well adapted to consume forages to obtain their daily nutrient needs. Whether or not a given forage, when consumed in reasonable quantities, is capable of supplying sufficient essential nutrients to meet nutritional needs is a way of describing forage quality. Forages fed to camelids might be in the form of hay or pasture and originate from legume (i.e., alfalfa, clover), grass (i.e., timothy, orchardgrass, fescue, ryegrass, bermudagrass) or mixed forage sources. A person does not need to be a nutritional expert to properly feed a

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llama. However, one needs to have some basic understanding of camelid digestive function, forage quality and their interaction to be a good feeding manager. In this column I will introduce the concept of forage quality and relate it to feeding management. Forages are the cornerstone of a feeding program for llamas and alpacas.

What is Forage Quality?

Forage quality is a direct reflection of essential nutrient content and availability to the consuming animal. Three processes define forage quality: an animal's ability to consume (intake), digest (digestibility), and assimilate (availability) essential nutrients contained within the feed. Simply put, forage quality means an animal can obtain a greater portion of their daily nutrient needs from forage alone. Energy, protein, minerals and vitamins are all essential nutrients required by camelids. However, not all forages have the same nutrient content and availability to the animal. Forage can span a wide spectrum of quality within and across legume and grass species. A multitude of factors can influence forage quality. As a result, hay from the same farm and field can vary significantly within a year and between years. It cannot be assumed that hay purchased from the same person year after year that it is the same quality forage each time!

What Influences Forage Quality?

The single most important determinant of forage quality is stage of maturity of the plant when harvested. Plants, like animals, grow and mature over time. The mature plant is one that has developed reproductive components to the point of generating seeds. Immature forage is the lush rapidly growing plant prior to reproductive parts (seeds, flowers) development. Mature plants contain greater amounts of cell wall structural components, as measured by neutral detergent fiber, and lignin for cell wall reinforcement, as reflected in acid detergent fiber amounts. These cell wall components allow the large mature plant to stand upright, rather than to fall over under its own weight. Plant cells, in contrast to animal cells, have a rigid cell wall. This increase in lignin and fiber results in a dilution of energy, protein and other nutrients as well as a decline in nutrient digestibility (Table 1). One must appreciate that forage quality is not to be equated with forage yield. Maximal dry matter yield occurs at greatest plant maturity; however, optimal digestible plant yield occurs significantly before plant maturity and seed production.

A second important factor influencing forage quality is plant species, i.e., legume or grass forages. Legumes are inherently higher in protein and calcium compared to grass forages of similar maturity (see Table 1). Legumes have higher energy at all maturity stages compared to grasses, and have a lesser decline in energy content with maturity. The relationship between leaf and stem in the two different plants accounts for this difference. Alfalfa and other legumes have a distinct leaf and stem, whereas the leaf and stem are intertwined in grasses. Leaves contain more digestible nutrients in contrast to stems, which contain mostly cell wall material and other resistant compounds that help the plant stand and survive in the environment. Cell wall

material is poorly digested and reduces availability of other nutrients, thus reducing feed quality. As a grass plant matures, its nutrient availability is more dramatically reduced compared to legumes. Thus, mature grass hays are more of potential feeding problems as a result of their greatly reduced nutrient availability. Poor quality mature grass forages are more often associated with fatty liver disease in late pregnant and lactating females.

Environmental factors such as rainfall, soil temperature and fertility, cloud cover, location, light and ambient temperature all can influence plant quality via various effects on content of structural or digestible carbohydrates in the plant. Environmental light, temperature and their interaction have the greatest impact on plant growth and quality. Increased temperature stimulates plant cell wall and lignification, thus reducing plant digestibility. Light exposure will increase yields and the plant will be more digestible as a result of the increased sugar content due to stimulated photosynthesis. The interaction between length of daylight and ambient temperature accounts for the within and between year variation in forage quality from a given location. Drought stress may increase forage quality as plant maturity is delayed and production of cell wall components are reduced.

Harvesting and storage losses can account for significant declines in forage quality. Losses of highly digestible nutrients occur during forage harvesting and storage. Keeping these losses to a minimum is essential in attaining high quality forages. Improper harvesting techniques can greatly decrease forage quality by loss of leaves. Exposure to air, sunlight, heat and moisture can induce loss of nutrients to various degrees depending upon type and length of storage.

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Dry material usually has more harvesting losses in contrast to wet material, which experiences more storage losses. Leaf shatter and loss during the harvesting process results in lost protein and decreased digestible dry matter. Rainfall on cut forage results in leaching of highly digestible nutrients. Storage conditions allowing for molding and heating can substantially reduce plant nutrient contents and animal acceptability. Moisture content exceeding 15% may promote yeast and mold growth. This can be problematic with large round bales to reduce moisture content sufficiently. Hay stored uncovered and exposed to the elements may result in a 30 to 40% decline in digestible nutrients within 45 to 60 days.

Why is Forage Quality Important?

What's all the fuss about forage quality? After all, forages grown in North America are far better quality compared to those in South America. This statement is not totally true. Forages grown near the equator are exposed to high temperature and long day length resulting in highly lignified fiber, low protein and reduced nutrient availability. However, llamas and alpacas live mostly at higher altitudes where environmental temperature is lower, thus resulting in lower lignification and cell wall content of available forages. Also camelids in South America are not nearly as productive as those in North America and greater nutrient intake and quality is necessary to achieve this level of production. The issue here is not necessarily a direct comparison of nutrient content of forages between North and South America, but adequately providing needed nutrients to maintain high productivity and health of the animals.

The critical issue relative to forage quality is the ability to meet a given animal's

nutrient requirements with the forage. If forage nutrient content is limiting, then additional supplements will be needed, or production and health will be compromised. If forage quality is sufficiently poor relative to animal requirements, the amount of supplements necessary may exceed practical feeding practices. To demonstrate this concept we can use a simple calculation tool called the Pearson Square (Figure 1). The Pearson Square allows one to blend two different feeds to achieve some desired nutrient content. Let's suppose to meet the protein needs for a pregnant alpaca, a diet containing 12% crude protein is desired. In the two situations depicted, the available grass hay contains either (1.) 7 or (2.) 10% crude protein. A 16% supplement is being used to blend with the hay to meet the overall dietary content of 12% crude protein. When the grass hay contains only 7% crude protein, the diet must contain 44.4% hay and 55.6% supplement. If protein content of the hay is 10%, then to meet the same 12% dietary level, one blends 66.7% hay with 33.3% supplement. Most people would not feed more supplement than hay as suggested in the first example, thereby the animal would consume a diet of lower protein content. To feed less supplement with the lower quality hay the supplement protein content would need to be increased. The supplement would need to contain 22% crude protein if one wanted to feed the same proportions of hay (66.7%) and supplement (33.3%) calculated when the hay contained 10% crude protein. Obviously, higher quality forages will reduce your purchased feed costs and provide more essential nutrients to the animal directly. Secondly, higher forage-based diets are more conducive to maintaining good animal health.

Forage Quality and Feeding Behavior

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Selection of feed can provide the animal with a method to overcome poor feed quality. Both the llama and alpaca have a narrow muzzle and prehensile lips that allow them to be extremely discriminatory in selecting feed to be consumed. Given the descriptive difference between alfalfa stem and leaves compared to grasses, one can understand how camelids may preferentially select alfalfa leaves, thus obtaining a much higher quality feed than provided. This may explain the propensity for obesity in feeding alfalfa. In situations where mature alfalfa is being fed, the animal can compensate for the low forage quality by primarily consuming the leaves. The llama or alpaca does not have this luxury with the grass plant. As the grass matures and becomes more lignified, nutrient availability is greatly reduced and the animal can not compensate for low forage quality with selective feeding behaviors if no other forage source is available. Thus the association of more animal health problems with mature grass forages.

Blended forage or providing access to browse and forb plants may allow the animals to use their selective feeding behavior to provide a higher quality diet when grass forage quality is marginal. In Oregon, llamas and alpacas enjoyed browsing blackberry leaves. Out of curiosity, I collected and analyzed blackberry leaves in four seasons. To my surprise, nutritional quality of blackberry leaves throughout the year was better than grass and equal to alfalfa hay (Table 2). Blackberry leaves have less fiber than other forages as would be expected, thus are more digestible. Other data that I could find on nutrient content of various leaves, weeds and browse show similar values. There may be something to not having perfectly manicured “lawn” pastures and allow for some browse to be present.

In my next column I will provide a

discussion of forage testing procedures and interpretation of results relative to forage quality. I look forward to this opportunity to discuss nutritional issues, though the thought of writing an informative column on a regular basis is somewhat daunting. I would like to offer an opportunity to the readers to submit specific nutritional questions or proposed topics for future columns. From the submissions, the editors and I will choose topics we believe to be of interest to the readership. I look forward to this opportunity and hope that I can provide useful and practical information to the readers.

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Table 1. Typical test value of alfalfa and grass hays harvested at various stages of plant maturity (all values on dry matter basis).

Type of Hay and Stage	CP %	ADF %	NDF %	TDN %
Alfalfa				
Pre-bloom	> 19	< 30	< 35	> 62
Early bloom	17-19	30-35	35-39	57 - 62
Mid bloom	13-16	36-41	41-47	51 - 56
Late bloom	< 13	> 41	> 48	< 51
Grass				
Prehead	17	< 29	< 55	> 54
Early head	12-17	30-35	56-61	47 - 54
Head	8-12	36-44	60-65	44 - 46
Post-head	< 8	> 45	> 65	< 44

Abbreviations: CP = crude protein; ADF = acid detergent fiber; NDF = neutral detergent fiber; TDN = total digestible nutrients.

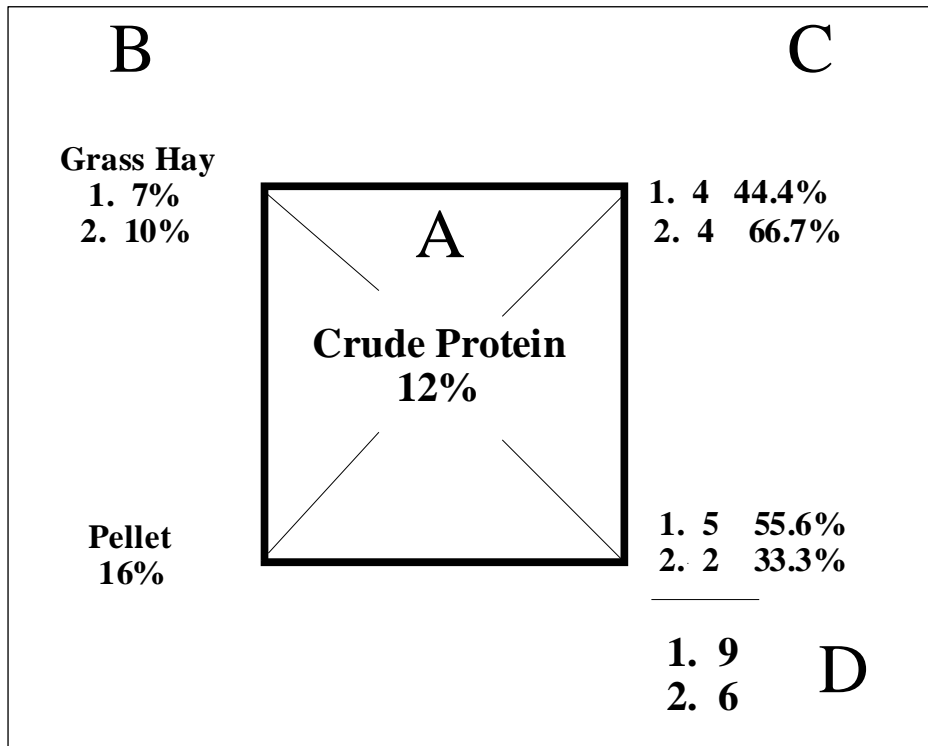


Figure 1. Nutritional evaluation of supplements using a Pearson square. Box center (A) contains desired nutrient content of diet. Left side of box (B) has nutrient content of two different feeds to be blended together to meet requirement. Values on right side of box (C) represent differences across diagonal lines (absolute values). These values are summed (D) and percent contribution for each feed calculated.

Table 2. Comparison of nutrient content of legume and grass hays, pasture and blackberry leaves to suggested nutrient requirements for camelids.¹

Nutrient	Estimated Requirement	Mean (Range) Nutrient Content			
		Mixed Mostly Legume Hay	Mixed Mostly Grass Hay	Mixed Grass Pasture	Blackberry Leaves
		----- % of dry matter -----			
Crude Protein	8 - 14	17.0 (13.6-20.4)	12.0 (8.3-15.7)	20.2 (14.0-26.3)	13.6 (12.5-15.2)
TDN ²	55 - 65	57.2 (53.9-60.4)	56.0 (52.6-59.4)	62.4 (56.8-67.9)	64.25 (63-65)
NDF ²	> 30	49.7 (41.9-57.6)	60.8 (53.7-68.0)	51.9 (41.9-61.9)	34.9 (31.1-39.2)
ADF ²	> 20	35.3 (30.4-40.2)	38.8 (34.2-43.5)	30.8 (24.7-36.9)	26.6 (24.4-30.6)
Calcium	0.3 - 0.75	1.2 (0.88-1.52)	0.71 (0.43-0.99)	0.66 (0.40-0.92)	1.2 (0.84 - 1.62)
Phosphorus	0.16 - 0.40	0.29 (0.23-0.35)	0.27 (0.19-0.34)	0.36 (0.25-0.47)	0.25 (0.16 - 0.36)

¹Forage analysis data from Dairy One Forage Laboratory, Ithaca, NY (www.dairyone.com)

²TDN = total digestible nutrients (a measure of energy content); ME = metabolizable energy; NDF = neutral detergent fiber (a measure of total fiber); ADF = acid detergent fiber (a measure of indigestible fiber).