

The Importance of Forage Quality for Milk Production and Health

Sandra Stokes

Texas A&M University, TAMU Research & Extension Center, 1229 North Hwy 281,
Stephenville, TX 76401
Email: sr-stokes@tamu.edu

■ Take Home Messages

- Forages are the foundation behind dairy rations and forage quality affects herd health and production performance.
- Quality forage supplies on the dairy don't just happen. They are the result of a planned and executed forage management program.

■ Introduction

The predominant foundation behind rations for lactating dairy cows is to provide a highly fermentable diet that supports high intakes and promotes consistent ruminal fermentation. Dairy cows require fiber for long-term health and productivity. If these requirements are not met, metabolic upsets occur that result in both short-term (milk production, treatment) and long-term (culling) economic losses to the producer.

Forage quality has significant impacts on diet digestibility and feed intake. Perkins (2001) suggested many of the weekly variations observed in high producing dairies are related to minor changes in forage quality and that high producing cows are more sensitive to changes in NDF digestibility than are lower producers. Approximately 40 percent of the dairy ration needs to be forage. Whether this is filled with poor quality or high quality forage will have a huge impact on milk production, feed costs, and herd health.

Considerations in designing a high quality forage management program include: identifying the purpose of forage in the ration; defining forage quality as it pertains to the operation; and managing the ration program to protect forage effectiveness.

■ **Developing a Forage Quality Program**

Defining the Purpose of Forage in the Ration

The purpose of forage in the diet may differ, depending on the type of dairy system. Grazing operations optimize milk production from grass production; however, confined operations tend to focus on maximizing milk production. With respect to this paper, the focus will be on the confined animal operation.

Formulating diets to contain adequate energy for high milk production often requires high levels of rapidly digestible carbohydrate. Lactation diets often have limited space for fiber and must be closely managed to avoid creating adverse health situations. These often occur from the combined effects of intakes in transition, early lactation, hospital cows, or during periods of environmental stress, and the increased risk of health problems (acidosis, displaced abomasum).

Increase in level of processed forages and by-products in the diet, may alter the physical nature of the fiber. Small particle size may reduce rumination and saliva flow. The effects of inadequate fiber in lactation rations can be noticed through erratic feed intake, decreased milk yield, lowered milk fat production, and increased health problems (laminitis, ketosis, displaced abomasums). The importance of adequate fiber in the ration to maintain rumen health is typically recognized by the dairy producer. Subacute acidosis can cause significant losses to the dairy producer (lowered production, health problems, higher culling rates) and effects may be long-term. Laminitis is acknowledged as the primary contributor to lameness in dairy cattle and can cost the dairy producer as much as \$144 per cow per year based on an incidence rate of 30%. The economic impact of lameness is due to decreased milk yield, discarded milk due to treatment, delayed reproduction, increased involuntary culling, and additional management time. The incidence of laminitis in the United States confinement operations is thought to average 35% and while, the causes of laminitis are several, lactic acidosis appears the primary culprit (Shearer, 1996 and personal communication).

With the health implications of forage requirements in mind, consider the economic purpose of forage in the dairy ration. Table 1 compares prices of ingredients (Stephenville, TX; December, 2001) by nutrient. Looking at ingredients this way helps to identify their position in the diet. Why do we feed forage...for protein? Probably not, as soybean meal is much more economical per kilogram of protein supplied. Along those same lines, it is clear we are not feeding it for energy either as corn is a much more economical source of energy in the diet. Specifically, forage's position is to supply fiber. While there is a basic requirement for forage in the diet to maintain healthy rumen function, forages can also deliver other nutrients as well. This is what drives the need for

forage quality in dairy rations. Forages differ significantly in their ability to deliver nutrients. Whether purchased or grown, there needs to be a forage quality plan on every dairy to support profitable milk production levels. Rule of thumb: it costs as much to transport and store poor forage as it does good forage.

Table 1. Ingredient and nutrient prices^a of common feedstuffs.

	Cost per ton	Cost per pound protein	Cost per Mcal NEI	Cost per pound of NDF
Alfalfa hay, Good	\$ 184.00	\$ 0.5110	\$ 0.1509	\$0.0022
Alfalfa hay, Premium	200.00	\$ 0.4347	\$ 0.1470	\$ 0.0026
Corn	155.20	\$ 0.7760	\$ 0.0862	\$ 0.0086
Cottonseed	188.00	\$ 0.4086	\$ 0.0931	\$ 0.0021
Soybean meal, 44%	250.24	\$ 0.2550	\$ 0.1422	\$ 0.0083

^a Prices listed in Canadian dollars; based on delivery to Fort Worth, Texas.

Defining Forage Quality and Assessing It in the Field.

An accurate evaluation of forage quality should consider a number of factors, and include both visual and chemical evaluation. While visual evaluation does not adequately evaluate forage maturity at harvest, chemical analysis may not accurately assess weed or mold content. Table 2 gives several expressions of forage quality, based on nutrient analysis.

Table 2. Expressions of Forage Quality

	By Analysis			By Calculation		
	CP	ADF	NDF	TDN	DDM	RFV
	-----(% of Dry Matter) -----					
Prime	>19	<31	<40	60	>65	<151
1	17-19	31-35	40-46	59-56	62-65	151-125
2	14-16	36-40	47-53	55-52	58-61	124-103
3	11-13	41-42	54-60	52-51	56-57	102-87
4	8-10	43-45	61-65	50-49	53-55	86-75
5	<8	>45	>65	48	<53	<75

Excerpted from Coppock, 1997.

Forages can differ significantly in protein, fiber, and mineral content. Within the fiber portion, there are several components including hemicellulose, cellulose, and lignin. Research over the last decade has broadened our understanding of these components and their effects in the diets. Of the fiber fractions, cellulose is the major fiber fraction digested by the animal. However, lignin can bind the cellulose fraction thus lowering potential forage digestibility. This is a concern with southern-grown forages, as high temperatures during the growing season increases plant lignification. The higher the concentration of lignin, the less digestible the fiber will be. For example, compare two forages having similar ADF contents (30%). Forage A analyzes to be 25% cellulose and 5% lignin; while forage B is only 20% cellulose, but 10% lignin. Forage A, containing the lower percentage of lignin, is more digestible and can support greater milk production. Looking at the effects of NDF digestibility, grasses have higher total NDF digestibilities than legumes but are not preferred for milk production as they digest and move through the gut more slowly. Slower digestion and passage rates limit intake, and thus lower total nutrient intake and digestibility.

There are two methods used to analyze forage samples in a laboratory. These include the traditional wet-chemistry analysis and the newer, near-infrared reflectance spectroscopy (NIRS) analysis. Wet-chemistry analysis, based upon well-established chemical principles, uses chemicals and drying agents to

determine the components of forage. Near-infrared reflectance spectroscopy analysis is a modern computerized method of forage analysis using near-infrared light to determine forage quality. Although NIRS analysis is faster and less costly, there is debate on the complete accuracy and interpretation of the analysis, particularly if a sample contains a mixture of forage species or if the machines are not calibrated with the same species from the same area.

While each component analyzed is used directly in the formulation of dairy rations, comparing forages for quality assessment can be confusing. Several expressions are used in the field to characterize forage quality and commonly these are estimates of forage energy. While measuring energy content of feedstuffs requires sophisticated animal metabolism trials, it has been found that the energy content generally is inversely related to the fiber content. Therefore, many of these expressions predict the energy value of forage based on chemical fiber analysis. Common expressions include Total Digestible Nutrients (TDN), Net Energy for Lactation (NE_l), Digestible Dry Matter (DDM), Dry Matter Intake (DMI), Relative Feed Value (RFV) and Total Forage Index (TFI).

Total Digestible Nutrients is a cumulative value of digestible protein, crude fiber, nitrogen free extract, and fat. The latest edition of the NRC (2001) has made substantial changes to this expression of feed energy, in that values are calculated from actual chemical composition data rather than being experimentally determined. For a more complete review of the current energy equations used in the NRC, readers are referred to Weiss (2001).

Net Energy is a more accurate measure of energy than TDN. It is expressed as megacalories (Mcal) per 100 pounds of feed dry matter. Recent changes in this system include calculating values based on actual intake and the digestibility of the entire diet (NRC, 2001).

Digestible Dry Matter stems from the National Alfalfa Hay Quality Committee's equation for prediction based on ADF. The formula is based on ADF analysis and is calculated as follows: $DDM, \% = 88.9 - (0.779 \times ADF\%)$.

Dry Matter Intake is most clearly related to the NDF fraction. The amount of dry matter consumed by the animal is influenced by both rate of digestion and rate of passage through the gut. Research from the University of Wisconsin indicates the maximum forage intake in alfalfa-based dairy rations occurs when NDF is 1.2 pounds per 100 pounds of body weight. Using this factor, the formula is as follows: $Forage\ DMI\ (\% \text{ of body weight}) = 120 / Forage\ NDF\ (\% \text{ of DM})$.

Relative Feed Value is an index (no units attached to values) that combines digestibility and intake potential into one number. While this value is not used

in ration balancing, the intent was to have one number for a quick, easy, and effective method of evaluating feeding value. Digestibility and potential intake values are determined from ADF and NDF analysis. Forages are ranked relative to full bloom alfalfa (RFV = 100). For example, forage with a RFV of 120 contains 20% more energy potential than mature alfalfa. Values for grasses need to be used with caution, as a high RFV does not always equate to high levels of milk production. The calculation of RFV is: $RFV = (DDM \times DMI) / 1.29$.

Total Forage Index is an index built on RFV but adds a protein value and a physical value (Hutjens, 1996). These additions bring a more complete picture of the nutritive value of the forage.

Special-Needs Forages: The Dry Cows.

When planning forage programs, it is important to consider dry cow forage as well. Research advances in dry cow nutrition have clearly demonstrated the value of lowering the potassium intake in cows' pre-partum (Goff, 1999). Reducing ration potassium can present a problem, as most of the potassium in dry cow rations is supplied from the forage portion. All plants require a certain amount of potassium to obtain maximal growth. However, in the presence of high soil potassium, alfalfa and other legumes (and at least some grasses) are known to accumulate potassium within their tissues to concentrations that are well above that required for optimal plant growth. Optimal growth of alfalfa occurs when the plant potassium concentration is between 1.7 and 2.0 percent. Wet chemistry reports seen in the field suggest much commercially grown alfalfa often contains much higher levels. Lanyon (1980) reported that alfalfa samples submitted by Pennsylvania producers' averaged 3.1 percent potassium, with a high of 4.05 percent potassium in one sample. While many growers fertilize alfalfa heavily with potassium to decrease the risk of winterkill, it is unlikely that increasing plant potassium beyond 2.5 percent yields any benefit.

Over-fertilization with potassium results in luxury consumption by the crop and can be detrimental to the health of the periparturient dairy cow. Corn silage tends to analyze between 1.0 and 1.5 percent potassium. It is difficult to find any other forage this low in potassium. Cool season grasses such as Bluegrass, Orchardgrass, and Bromegrass tested lower in potassium than alfalfa did 20 years ago. Since that time, there has been a tremendous increase in the number of cows on each farm and this has not always been accompanied by an increase in the amount of land available for spreading manure. As a result, hayfields that were not fertilized in the past are now being used extensively for manure application fields. Cool season grasses have a fibrous root system that makes them very efficient in utilizing soil potassium. Research has demonstrated that timothy accumulates potassium to a lesser

extent than other grasses and the second cutting of grass hays generally contain less potassium than the first cuttings (Thomas, 1996).

Importance of Forage Sampling.

Whether growing or buying forage, nutrient analysis is important for accurate and cost-effective supplementation. A ration having a high inclusion of corn silage will be supplemented quite differently than a ration based predominantly on alfalfa. Most analyses (CP, ADF, NDF) use a 1-gram sample. Considering this size of sample against what is represented (silage pit, truckload of hay, etc.), most producers will quickly grasp the significance of accurate forage sampling. Sampling is often the largest source of error in an analysis. In general, the more cores taken throughout a stack or bunk face incorporated into the final sample, the more accurate representation of the entire lot. General recommendations for sampling procedures in common sites on the dairy are listed below.

Upright Silos. Fill a feed cart and take 10 to 15 grab samples. Combine samples in a large tub and blend well. Subsample from several spots in the tub for the final sample. Place the sample in a plastic bag and remove as much air as possible. Seal the bag tightly and freeze. Some double-bag their silage samples for better storage.

Bunker Silos. Mentally divide the face in thirds and then in half. Sample from each section, blend and take final sample. A corer may be used to facilitate sampling more accurately by getting 8 to 12 inches into the face. Sample storage in the plastic bag is the same as in upright silos.

Hay. Divide the barn or stack into sections that can be tracked for ration balancing. This is especially important if different deliveries are stored together. The use of a forage sample probe is recommended to physically reduce the bulkiness of the sample and to allow for increased sampling representation. Decide on a routine and follow it: some use every other bale (large bales) or every 10 bales (smaller bales). Following a set routine helps eliminate the tendency to select only better bales and increases accuracy of analysis. Again, place the sample in a plastic bag and seal well.

A second, but possibly equally, important consideration to the procedure used by the producer is the procedure used by the laboratory to subsample the sample submitted for analysis. Whenever possible, the entire sample should be ground for analysis. When not possible, strict protocols for reducing sample size should be observed.

Managing Forage Effectiveness in The Ration.

Physical limitations may be caused by rumen distension with high forage diets. With the advent of mixer wagons that can handle large amounts of forage, many of today's lactation rations have limited, if any, long-stem hay fed outside the total mixed ration (TMR). Additionally, much of the fiber fraction fed to cows in early lactation includes high quality forages, byproducts, or a combination of both. Thus, a concern with these diets is the effectiveness of the fiber. Feeding management can override or mask the true potential of the ration. Considerations should include accurate dry matter values of feeds and accurate mixer management. If mixer wagons are not managed correctly, extensive reduction of forage particle size may alter its ability to stimulate cud-chewing and saliva flow which is necessary for adequate rumen buffering.

Cow response to effective fiber (particle size, forage level) led to development of particle size separators as a diagnostic tool to evaluate effective fiber on-farm. These tools consist of a series of stacked screens designed to separate a ration into various particle sizes. Particle size evaluation is an attempt to have a visual, quantitative assessment of the ration components that are rapidly digestible, moderately digestible, and effective in stimulating cud chewing and buffer production. Some commercial laboratories offer particle size separation analysis as part of their service. There are also separators available for on-farm demonstration analysis, such as the Penn State Particle Size Separator (Heinrichs, 1996). This tool separates the particles into three groups: particles greater than .75", between .75" and .31", and those smaller than .31". The top screen (retaining particles greater than .75") identifies those particles that will form the rumen mat and will stimulate cud chewing and saliva production; the middle screen (particles between .75" and .31") represents the portion of the TMR that is moderately digestible; while the bottom pan (particles smaller than .31") represents particles that are rapidly digestible and/or may be removed from the rumen in the fluid outflow (Lammers et al., 1996). Use of the separator is fairly simple and can be used on-farm to monitor changes in forage harvesting procedures or feed mixing schemes.

■ Summary

Forage selection and management is the base of every dairy ration program. It constitutes approximately 40 percent of the dairy ration and what goes into this portion will have a huge impact on milk production, feed costs, and herd health. Quality forage programs don't just happen: they take design, planning and continual management. Don't let the tail wag the dog.

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