FORAGE QUALITY

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Opinions are many and varied when discussing forage quality. The presence of many different terms used in describing forage quality further complicates this
topic. especially when discussing hay. For example. the color of a hay bale is frequently suggested as an
indicator of the quality of the hay as a feedstuff, but hay color has almost no relationship to animal performance. This is the basis of an important fact: the only true measure of forage quality is animal performance. Quality is important because it relates to animal performance.

Plants are made up of cells which are composed of cell walls and the contents within the cell walls. The intracellular contents can be assumed to be near 1000A, digestible, and digestibility does not change as the plant ages or grows. However. the chemical makeup of cell walls changes as the plant grows. With aging. the fiber content increases as a percent of the total plant. One complication is that there are several types of fiber in plants, and they can vary greatly in digestibility. For this leaflet we will use the term increasing fiber to mean decreasing digestibility and will generally be referring to lignin. a fiber which is basically indigestible.

Digestibility and Fiber Analysis

Digestibility can be viewed as a simple balance. If an animal is fed 10 pounds of hay and four pounds of dry manure is produced, then the hay was 60016 digestible. The more digestible the forage. the more energy the animal gets out of the forage.
Currently most laboratories chemically determine the Acid Detergent Fiber (ADF) and/or Neutral Detergent Fiber (NDF) and predict the energy content, Total Digestible Nutrients (TDN), metabolizable energy. and/or net energy from the fiber analysis. NDF is a chemical estimate of the plant cell wall content of a forage. and ADF is the cell wall content minus a cell wall component called hemicellulose. As a plant matures the cell wall content increases as a percent of the total plant cell. Plant cell walls are much less digestible than other parts of the cell (intracellular contents). Therefore. as the cell wall component of the cell increases with maturity. digestibility or quality of the forage decreases.

Therefore. a forage with a low NDF or ADF content is higher in quality than one with a high NDF or ADF content. NDF is closely associated with total potential intake of the forage by an animal while ADF is more closely related to digestibility of the forage. Therefore, both values are used in predicting forage quality.
Generally, most laboratories are using NDF or ADF along with crude protein (CP) content to predict the overall quality of forage samples. (A further quality factor in forages is the mineral content. This aspect of quality is justifiably receiving more attention now than in the past and will be discussed in a forthcoming leaflet.)

Crude protein is relatively easy to measure and, in general, as crude protein increases in a forage, livestock perform better (I.e., gain more weight. produce more milk, etc.). Thus, there is a reasonably good relationship between forage quality and CP content. However, there are several problems with CP as a predictor of animal performance. The first is the concept of first limiting nutrient. Put simply. if an animal is deficient in energy, any amount of protein in excess of requirements will do little to increase performance. The. excess protein can be converted to an energy source by the animal. but this is a very expensive way to meet energy requirements. For example, if an animal has a crude protein requirement of 12%. then a forage with 15% CP will do little to increase performance. However, for almost every generalized statement there are always exceptions. The exceptions here concern some relatively difficult concepts involving amino acid (the building blocks of protein) balance. protein bypass, and the relationship between higher protein and energy in forages. Although protein content of forages is important. energy is often more of a concern.

The information above describes terms relating to forage quality. However, as stated. the quality of a forage is actually based on its feeding value to livestock. Because it is impractical to test all forages with animal feeding studies. due to the immense time and money requirement. many research studies have been conducted that correlate easily measured parameters of forages with animal performance. such as CP, TDN. ADF. NDF. and others.

Forage Quality Components

The next step in understanding forage quality is to achieve a more thorough understanding of where in the plant the quality components of a forage are located. Previously. forage quality was discussed as it related to chemical assays and plant cellular components; but how does this relate to the whole plant and its parts? In general, most usable nutrients in a plant, at least the aboveground parts. are in the leaves rather than in the stem. This is true of grasses. such as bermudagrass and .tall fescue, and the legumes. such as alfalfa and the clovers. Further. the older or more mature the plant. the more it is true. For example. an alfalfa plant may analyze 31 % ADF and 18% CP, but if the leaves and stems were separated and analyzed. the leaves might be 23% ADF and 26% CP, while the stems might be 37% ADF and 11 % CP. This is the basis of the expression "manage for leafmess." Therefore the leaf/stem ratio of a forage is a reasonably good indicator of forage quality. As the leaf/stem ratio increases (Le.. more leaf), the quality of the forage generally increases.

Anti -Quality Components

Another factor involved in the feeding value of forage is the presence of anti-quality components. We deal with many of these factors. The alkaloids produced by the endophytic fungus of tall fescue are an example of one common anti-quality factor. Cattle performance on tall fescue has often been poorer than what was predicted or expected based on CP, TON. etc.. because of these alkaloids. Prussic acid and high nitrates in summer annuals are more examples of anti-quality components, as is tannin content in lespedeza. Therefore, when anti-quality components are present in a forage plant, chemical assays to predict performance will usually be overestimates of the actual performance.

Decline of Forage Quality

There are very few things in nature that do not have an exception. However, one fact that has no exception is directly related to forage quality: as a plant ages or matures, forage quality declines! This principle is illustrated in Figure 1. (Figures 1-3 illustrate typical maturity curves for bermudagrass but. in general, apply to all forages.) When the forage plant is very immature the overall forage quality is quite high (Figure 1, stage 1). Then. as the plant matures, quality begins to decline (somewhat slowly at first) . As the plant starts reproductive growth stages (begins to develop a seedhead), forage quality begins to decline rapidly (Figure 1. stage 2). As the plant approaches full maturity (hard seed). the quality decline is less rapid (Figure 1. stage 3). but the feeding value is already extremely poor.

Leaf/ Stem Ratio

The decline in forage quality with maturity is directly related to the leaf/stem ratio previously discussed. As a plant matures it becomes more "stemmy" (I.e., the

leaf/stem ratio decreases). Therefore, a bale of hay that is referred to as "stemmy" is correctly assumed to be of somewhat lower quality. In the same context, tall. coarse or "rank" plants in a pasture with a low leaf/stem ratio (I.e., more stem than leaf) are also of lower quality. An individual plant leaf does not decline in quality to any great extent until it begins to die. However. stems do decline in quality with increasing maturity.

This process serves an important function in plant reproduction and species survival. As the plant matures and begins reproductive stages. the stem becomes more fibrous or rigid (largely due to lignin) which enables the stem to hold the seedhead upright while the seed are maturing. Therefore, the decline in forage quality with maturity is primarily due to the increasing lignification of the stem and an increasing proportion of stem compared to leaf. To relate this plant physiological process back to the descriptive terms of forage quality, the ADF and NDF values are increasing and the forage quality is decreasing.

The Growth Curve

The other factor involved in forage production can be represented by a growth curve (Figure 2). As shown yield, or quantity, increases (up to a point) with time. The curve can be viewed in four stages. The initial slow growth (stage 1) is a function of limited leaf area or green tissue to intercept sunlight. To review. green plants use sunlight as energy to allow nutrient uptake and carbon to be taken from carbon dioxide in the air; the carbon is used to make all the starch, protein, carbohydrate, etc. In the second stage (2) the plant undergoes rapid groWth (i.e., yield increases rapidly). In the third stage (3), growth slows as the plant shifts its energy to reproduction; nutrients are generally translocated into the seed. just as com does at the time of grain filling.

The fourth stage (4) of the curve is quite important. As you can see, the total yield is decreasing due to a combination of two factors. The fIrst is that a given tiller. or stem. can only produce so many leaves. You can see this readily on bermudagrass. Each stem or tiller will produce only six to eight leaves. then will produce a seedhead and die. The grass. however. continues to produce new tillers; this is how yield increases. But new tillers start at ground level. and when there is a large quantity of standing forage, the new tillers do not get much sunlight and eventually stop developing. This is the second factor relating to the actual decline in total yield. Further. as growth becomes dense. the lower leaves/on the tillers receive less and less sunlight and eventually cease developing. The nutrients in those leaves move out of the leaves to the stem. to new leaves. or often to the roots. So there is actually a decrease in the tonnage of forage present on an acre.

Quality and Quantity

One cannot have both the best quality and the highest yield! The higher quality you want. the lower yield you have to accept. and vice versa. However. the system can be managed for a particular need or class of livestock such as. for example. bermudagrass for hay.

If you have a market for "horse quality" hay that brings a higher price, cutting at close to three weeks of new growth and accepting a lower yield makes sense for those customers that are willing to pay for quality. If you sell on the open market. and you do not get a price incentive for higher quality hay, then cutting at about six to seven weeks for near maximum yield makes sense. If the hay is to be stored for your own use to overwinter a cow herd. then cutting at four to five weeks will produce high yields of hay that are of adequate quality to maintain mature cows. For dry cows, more mature hays may be used. For first-calf heifers, high- quality. immature forages would be ideal. Therefore, harvesting may be manipulated to match nutrient needs of the consuming animals. Also, several factors (weather. labor. breakdowns. other higher priority activities. etc.) may force one to harvest later in the growth curve than originally intended. Unforeseen problems can and do happen during most harvest seasons. However. hay can be stored or grouped according to the quality of a particular cutting and fed to the appropriate class of animals (milking dairy cows, dry cows, lactating beef cows. heifers, first-calf beef cows, etc.). Good management entails feeding with the quality of hay. or pasture, that most nearly matches livestock nutrient need and is generally associated with improved animal performance and enhanced profitability.