MARKETING OF CONSERVED FORAGES BASED UPON QUALITY ATTRIBUTES

Daniel H. Putnam[1]

ABSTRACT

The quality of Forages is one of the key ingredients for top animal performance, whether for milk or meat production. Unfortunately, forages are typically much more variable in quality than grains or concentrated feeds. Forages also contribute multiple quality attributes to an animal diet (energy, protein, minerals, functional fiber). This creates challenges for the industry to fix an economic value on a variable but important product. Marketing of hay has been historically based upon subjective factors (e.g. leafiness, leaf attachment, stem coarseness, color, weeds, molds, and odor) and more recently analytical laboratory values (CP, ADF, NDF, NDFD). Various indices or calculated values (RFV, TDN, RFQ, NEL) have been used based upon measured lab values. While corn silage is seldom marketed, the marketing categories of Supreme, Premium, Good, Fair, and Low (or utility) grade of alfalfa and grass hay are recognized by marketers, based upon both visual and lab analyses. Each of these forage types has a role in animal feeding, but prices are typically dictated by the value of high quality forage for high-producing dairy cows – other classes are secondary. The importance of forage quality changes in the market based upon the supply-demand situation in any given year, with quality being most important in 'low price' years. Marketing of forages requires a uniform description of quality characteristics ("guidelines") and an understanding of the value and limitations of laboratory measurements. Reliable, repeatable lab measurements greatly facilitate marketing of hay and silage, with fewer measurements required for marketing than for ration balancing. There is a very low percentage of corn silage that is marketed, but it is anticipated a greater amount may be marketed in the future. A 'hierarchical' approach to marketing of forages is suggested, with multiple measurements (particularly NDF, CP, NDFD and ASH, and starch in the case of

[1] D. Putnam, UC Cooperative Extension Specialist, Alfalfa & Forage Crops, Department of Plant Science, University of California, Davis, CA 95616. Email: dhputnam@ucdavis.edu. IN Proceedings, International Symposium on Forage Quality and Conservation. November, 2011, Sao Pedro/SP, Brazil.

silage) playing important roles, depending upon class of animal, ration approach, and production system.

INTRODUCTION

The marketing of forage crops (hay, silage, or green forage) has a relatively recent history, since traditionally forages have been mostly fed 'on-farm' without a point of sale. However, in recent years, and in some regions, forages have fully entered regional and even world trade. Only a small minority of corn (*Zea mays*) silage or other silage crops are marketed, but a greater amount of alfalfa and grass hays are marketed; thus the evolution of quality-market relationship for forages have concerned primarily hay, and predominately alfalfa (*Medicago sativa*) hay.

In the western United States, it is likely that >80% of the alfalfa and grass hay is marketed either domestically or in world trade. This is less common in eastern United State, where a vast majority of hay is fed on-farm, but marketing is becoming more common in those regions as well. Exports and dairy purchases in particular have expanded greatly in recent years, necessitating quality-defined price discovery. In this paper, I explore the current methods for defining quality in forage crops for markets, and speculate on how this might change in the future.

Table 1. The first Hay Quality Standards for alfalfa & alfalfa/mixed hay (USDA,1949) were based mostly upon visual designations. Over the past 60 years, these subjective standards have largely been replaced by lab values combined with observational qualities. Color is now generally believed to not have an effect on animal performance.

US Grade (1949):

US No.1. 40% leafiness, 60% green color, 5% foreign material (must have at least one-fifth of the leaves clinging to the stem, and shall not include hay in which a majority of the alfalfa stalks bear brown and/or black seed pods)
US No.2. 25% leafiness, 35% green color, 10% foreign material
US No.3. 10% leafiness, 10% green color, 15% foreign material
Sample Grade: Hay which contains more than a trace of injurious foreign material, or which has any objectionable odor, or which is undercured, heating, hot, wet, musty, moldy, caked, badly broken, badly weathered, badly frosted, badly overripe, or very dusty, or which is otherwise of distinctly low quality.

Additional designations:

Extra Leafy hay –"The leafiness of the alfalfa is 50% or more with most of the leaves clinging to the stems
Leafy Hay –"The leafiness of the alfalfa is 40% or more with at least one-fifth of the leaves clinging to the stem.
Extra Green Hay—"Hay which has 75% or more green color.
(These designations shall not include hay in which a majority of the alfalfa stalks bear brown and/or black seed pods)

--Handbook of Official Hay and Straw Standards effective July 1, 1949. USDA Production and Marketing Administration, Washington, DC.

HISTORY OF HAY MARKETING STANDARDS & GUIDELINES

Hay market standards or guidelines have evolved considerably since the USDA first described hay quality standards (most recently in the

1950s-Table 1). These were based primarily upon leafiness, color and foreign material. It is striking that the quality hay that was fed in the 1950s were likely genuinely much lower quality than the alfalfa hay fed today; the highest quality designation (US No. 1 Extra Leafy) would still tolerate up to 49% of the stalks having seed pods!! (Table 1). There is virtually no high quality hays fed today which have seed pods, suggesting that demands for quality have changed considerably since that time.

Over time, laboratory measurements in particular have played a much more important role, as dairy farmers and nutritionists took a more scientific approach to animal feeding. The system for trading hay today is based upon laboratory analysis, particularly fiber and protein, and more recently, fiber digestibility, but subjective evaluation of quality (including the long-recognized attributes of leafiness, leaf attachment and weeds).

CURRENT PRACTICE IN THE UNITED STATES

Currently, USDA recognizes five categories of hay (Table 2), which are tracked for price and volume (USDA-Market News Service, Table 2). It should be emphasized that these are guidelines, not standards, and that industry participants are generally free to modify these designations to a considerable degree. For example some hay may meet the 'Supreme' quality designation based upon RFV (greater than 180 RFV), but contain, for example, 20% CP – but a marketer may still designate the hay 'Supreme' due to its high TDN, high leafiness, softness, but communicate with the buyer that it is somewhat lower in protein. {See box on the following page for listing of abbreviations}. It's important to realize the differences between **guidelines** (which are approximations of quality) vs. **standards**, (which require minimum quality values). Guidelines are more appropriate for forages, given their variability.

Table 2. Current USDA Quality Guidelines for reporting economic data of alfalfa hay (not more than 10% grass) adapted in 2002 (2003 USDA Livestock, Hay & Grain Market News, Moses Lake, WA). Guidelines are used along with visual appearance to determine quality. It should be pointed out that these guidelines also differ somewhat within the United States, due to regional differences in available hay and attitudes. All figures are expressed on 100% DM

except as noted.

<u>Physical Descriptions of Hay Quality</u> to be used in combination with lab tests for alfalfa hay quality categories (USDA-Market News):

- **Supreme:** Very early maturity, pre bloom, soft fine stemmed, extra leafy. Factors indicative of very high nutritive content. Hay is excellent color and free of damage.
- **Premium**: Early maturity, i.e., pre-bloom in legumes and pre head in grass hays, extra leafy and fine stemmed-factors indicative of a high nutritive content. Hay is green and free of damage.
- **Good:** Early to average maturity, i.e., early to mid-bloom in legumes and early head in grass hays, leafy, fine to medium stemmed, free of damage other than slight discoloration.
- **Fair**: Late maturity, i.e., mid to late-bloom in legumes, head-in grass hays, moderate or below leaf content, and generally coarse stemmed. Hay may show light damage.
- **Utility**: Hay in very late maturity, such as mature seed pods in legumes or mature head in grass hays, coarse stemmed. This category could include hay discounted due to excessive damage and heavy weed content or mold. Defects will be identified in market reports when using this category.

<u>Chemical Descriptions of Hay Quality Guidelines</u> to be used in combination with Physical Descriptions for alfalfa hay quality categories (USDA-Market News):

Category	**ADF**	**NDF**	***RFV**	***TDN**	***TDN** (90% DM)	**CP**
	----------%----------					
Supreme	<27	<34	>180	>62	>55.9	>22
Premium	27-29	34-36	150-180	60.5-62	54.5-55.9	20-22
Good	29-32	36-40	125-150	58-60	52.5-54.5	18-20
Fair	32-35	40-44	100-125	56-58	50.5-52.5	16-18
Utility	>35	>44	< 100	<56	<50.5	<16

RFV is calculated from ADF and NDF: RFV = (88.9-(.779x%ADF)) x ((120/%NDF)/1.29)

TDN = {82.38 – (0.7515 x ADF)} according to Bath & Marble, 1989.

TDN (90% DM) = TDN X 0.9.

WHAT IS QUALITY?

What does a nutritionist want in a forage?

Before discussing markets, it's important to ask 'what is quality?'. Forage quality is broadly defined as the potential to produce a desired animal response from a given intake of forage. Forage quality is always a complex mix of nutritional traits. In a discussion with animal nutritionists, several key qualities emerge as important requirements from forages. These are:

Attribute I. High Quantity of Digestible Energy.

In many cases, the primary consideration for forage quality is the total potential digestible energy per dry matter weight unit (lb, kg, or ton) of forage. This is often the most important forage quality factor, since biological energy drives the animal functions of maintenance, growth, and milk production. Unfortunately, the total potential biological energy in feeds cannot be measured directly but is predicted with equations derived from several laboratory analyses.

Abbreviations:
ADF = Acid Detergent Fiber
NDF = Neutral Detergent Fiber
NDFD = NDF digestibility
NFC-Non Fiber Carbohydrates
CP = Crude Protein
DCAD=Dietary Cation-Anion Difference
EE = Ether Extract (fat)
TDN = Total Digestible Nutrients
IVDDM = In Vitro Digestible Dry Matter
RFV = Relative Feed Value Index
RFQ = Relative Forage Quality Index
RUP = Rumen Undegradable Protein
ME = Metabolizable Energy
NE = Net Energy
NEL = Net Energy for Lactation
NFTA = National Forage Testing Assoc.

Digestible energy primarily comes from rapidly-available forms are compounds such as sugars, starches, and pectins, but also from the fiber fraction, fats, and protein. Considerable energy in forages is contained in the cell wall portion (particularly cellulose, hemicellulose and lignin), which may be 35-55% of the plant, but the cell wall may be only 30 to 70% percent digestible.

In general, as NDF goes up, potential energy often goes down. Energy (TDN, NE, NE_l, or ME) has been predicted from a linear relationship to a fiber measurement (ADF or NDF) in alfalfa, or summative equations that use NDF, NDFd, ash, EE, CP, and other factors to predict energy.

NDF and ADF and NDFD are often considered important measurements for energy estimations, but soluble carbohydrates and NFC (non fiber carbohydrates) are a key calculation

(subtracting NDF, ash, protein and EE from the total dry matter. Carbohydrates can be directly measured, but are not often measured in hay. Estimation of digestible energy is typically the most important factor for predicting quality of forages, although intake is often considered a close second.

Attribute II. High Intake Potential

High quality forages have high intake potential—this is an important attribute of high quality. Intake is critical for high producing dairy cows – but unfortunately, once again, it's difficult to measure and must be predicted. Some forages (such as legumes) are digested very rapidly in the rumen, while other feeds (such as warm season grasses) typically require extended periods for complete digestion. This might be affected by the nature of the forage particle (the physical disintegration of the fiber or ability of the cow to masticate), and by the rate of fiber digestibility by rumen microbes. Additionally, there are factors that cause animals to consume more or less of a forage, often termed "palatability," that are affected by species, taste, condition of the hay, odor, weed content, stem quality, and plant maturity.

Lower intake levels result in lower energy availability per unit of time, reducing animal performance and lowering the forage quality. Higher-fiber alfalfa or forages with long rumen residence time cause animals to become "filled" and stop eating. This rumen fill limits intake, which ultimately reduces energy intake and animal performance. However, too-rapid rates of degradation result in poor rumen function and negatively affect animal health, causing acidosis and other health problems.

Digestibility of the NDF fiber fraction (NDFd) and other in vitro techniques (IVDDM) are important measurements for predicting intake. Intake potential is one of the most important quality factors for lactating dairy cows.

Attribute III. Good level of Protein, including 'by-pass' protein

Since amino acids from proteins are building blocks for muscle, milk, and animal enzymes, they are important nutritional attributes of forages. Additionally rumen microbes require protein for optimum function. Alfalfa typically contains between 17 and 25% CP and

corn silage from 6-8%. Although the concentration of protein (estimated by CP) is important, many nutritionists may also be interested in the amount of protein that passes undegraded from the rumen and is digested in the small intestine. Rumen degraded protein (RDP) provides an estimate of CP availability in the rumen and Rumen Undegraded Protein (RUP) that which does not degrade in the rumen. Acid detergent insoluble CP (ADICP) estimates the undigestible (typically lignified and heat-damaged) CP. While heat damaged protein is a negative factor, excessive degradation of CP in the rumen is also a negative quality factor if the rumen microbes do not fully utilize the ammonia nitrogen (N) for microbial protein. This excess ammonia N is absorbed through the rumen wall, and must be excreted in the urine. High rumen degradable protein can be a problem with very leafy immature alfalfa.

Crude Protein and RUP and ADIP are typical measurements for protein analysis. Since high CP concentrate feeds are generally available, protein in alfalfa forages are often not as strongly valued compared with its energy content in alfalfa hay markets. As the cost of CP supplements rises, the economic value of protein in forages will become greater, particularly "rumen escape protein" (RUP).

Attribute IV. Ruminally-Effective Digestible Fiber

Although high fiber forages reduce energy and intake, we don't want zero or very low fiber in forage crops. The NDF itself has value in rations in its own right. Many nutritionist highly prize alfalfa & corn silage for its NDF content itself, especially when these feeds are fed at a low % of the ration. The provision of ruminally-effective fiber with a high level of digestibility is a major attribute provided by alfalfa hay to ruminant rations.

Unfortunately, one can immediately see a contradiction between attributes #I , vs. #IV. Markets are faced with a quandary on this issue. Since energy and intake are important, we need to reduce NDF to influence digestibility, and growers are paid extra money to lower their NDF or ADF concentrations. But we don't want to get rid of NDF entirely in forages (even if we could). Reduction of forage fiber to very low levels creates problems in rumen function since dietary fiber stimulates rumination, chewing, and saliva production; the latter helps to stabilize rumen pH, preventing acidosis. High-producing ruminants can suffer physical problems with rumen health when "effective fiber" is too low in their diet. Thus, the fiber in alfalfa provides

positive physical and chemical attributes to ruminant rations, and should be valued in and of itself.

It is clear that both a low concentration of the NDF and the high digestibility of the fiber fraction (NDFD) are important attributes of high forage quality, but the NDF fraction itself is a valuable quality attribute, especially when highly digestible (high NDFD). The value of effective-fiber (vs. low-fiber, high-energy) hay varies, depending on the levels in the diet and class of animals.

V. Low Ash and good Mineral Balance

In general, as ash increases, the level of digestible energy declines, since minerals do not contain energy or protein. Therefore, lower ash levels are generally desirable quality characteristics.

Ash is an estimate of total mineral content in a forage, which could originate from normal mineral uptake by the plant, for example, phosphorus (P), potassium (K), sulfur (S), calcium (Ca), magnesium (Mg), chlorine (Cl), and sodium (Na) from excessive salt accumulation, or contamination with soil (dirt).

Although low ash is generally a good thing, alfalfa provides several essential minerals contained in the ash fraction. The balance (or type) of mineral ions, such as Ca, P, and K in alfalfa may be more important nutritionally than the quantity. For example, high K is a negative attribute for dairy animals just before and just after calving (often termed the “close-up” or “transition” period), since excessive K contributes to an increased incidence of milk fever. In many markets, dairies will pay a premium for ‘low Potassium’ hay for transition animals. Additionally, excessive concentrations of micronutrients (such as selenium [Se] or molybdenum [Mo]) can be toxic when present in high amounts in the diet. Conversely, hays can provide necessary micronutrients that otherwise might be limiting in diets. Nutritionists frequently are most interested in the balance of mineral nutrients in forages (e.g. DCAD).

VI. Other Quality Factors–Weeds, dust, molds, toxic factors, condition, texture and aroma

Animals, like humans, respond to aromas and subtle cues like mouth-feel and dust and molds. Weeds are an obvious negative trait for quality of alfalfa hay, particularly grassy weeds and poisonous weeds, and weeds with spines or thorns. There are other, less-well-defined attributes of quality, such as secondary plant compounds that affect sensory preference by animals, but these may be important primarily as they affect intake (Factor II) and general animal health. Toxic weeds or insects (e.g., blister beetle) can be important anti-nutritional or toxic factors, and important quality factors in hay. Each year, many animals are sickened or die from poisonous weeds, excess nitrate (from weeds), or excess micronutrient concentrations in hay or silage. These are all attributes under the umbrella of "forage quality." Nitrates must be measured, while weeds and condition must be judged via visual inspection, not lab analysis.

EVALUATION OF HAY QUALITY

Table 3. Quality Attributes of Alfalfa Hay and the methods used to evaluate quality. A combination of visual analysis and lab analysis is always recommended. Note that color is not often recommended as a quality indicator.

Factor	Attributes	Suitability for Prediction: Visual Analysis	Suitability for Prediction: Lab Analysis
Estimated Via Visual Analysis			
Weed Content	Providing weed-free alfalfa is one of the most critical components of high quality hay, especially coarse grasses.	Excellent	Fair – lab analysis can pick up grassy weeds (NDF).
Noxious Weeds	Poisonous or noxious weeds can harm animals and are a major anti-quality factor.	Excellent	Poor
High Leaf Percentage	High alfalfa leaf percentage is one of the strongest predictors of high quality.	Good, but must have trained eye	Good – NDF and CP are good predictors
Leaf-Stem Attachment	Poor attachment leads to loss of quality during feeding.	Excellent	Poor
Molds/Dust	Molds and dust can reduce intake and affect animal health	Excellent	Poor
Texture	Very dry hay causes mouth irritation, softer hays can exhibit better animal acceptance.	Excellent	Poor
Odor	Animals respond to hay with attractive odors and can reduce intake with poor smells	Good to Excellent	Poor
Estimated Via Lab Analysis			

Fiber Concentration	Low, but not too low, fiber concentration (NDF) predicts good energy and intake potential	Poor to Fair – can estimate fiber 'by feel'	Excellent – measure NDF/ADF
Fiber Digestibility	The degradability of the fiber fraction, which makes up 1/3 to ½ the plant, is a critical quality predictor	V. Poor	Excellent- requires invitro methods (NDFd)
Protein Concentration	Supplying sufficient protein is a key quality attribute	Poor to fair- leaf % is OK	Excellent – measure CP
Protein Degradability	'By-pass' protein may improve protein efficiency	V. Poor	Good
Ash	Low ash is important for high quality forages, and can indicate dirt contamination	V. Poor	Excellent – Measure ash
Ash/Mineral Balance	Low potassium is important for some animals, not for others. Look for balance of CA, Mg, and K, Na for some animals – consult nutritionist.	V.Poor	Excellent – measure ash and DCAD

Evaluating Forage Quality

As the above discussion reveals, forage quality is not just one thing, and cannot be reduced to just one number. It's not just the fiber content (the ADF or NDF which determine RFV or TDN) that determines quality, but also the crude protein content, mineral balance, the digestibility of the fiber fraction, functional fiber, and the rumen undegradable protein, but let's not forget the presences of weeds, molds, and foreign materials, and condition of the hay.

We also shouldn't forget that quality is dependent upon type of animal and type of ration. Just as a race-car is not the best for hauling hay to feed your animals, different types of hays are best suitable for different types of animals. A low-fiber, high protein pure alfalfa hay with high digestibility is the most appropriate for a high-producing dairy cow, but a medium-fiber hay with moderate forage grass content is appropriate for many non-lactating horses and beef animals. Additionally, higher fiber in hay is not a bad thing when hay becomes a small part of the diet,

because it provides 'functional fiber' to the animal for good rumen function in TMR rations. There are different qualities for different purposes

Use both Visual and Lab Methods

It is always recommended to utilize multiple methods (visual inspection and lab analysis—Table 3), as well as several lab analyses (Table 2) to evaluate forages.

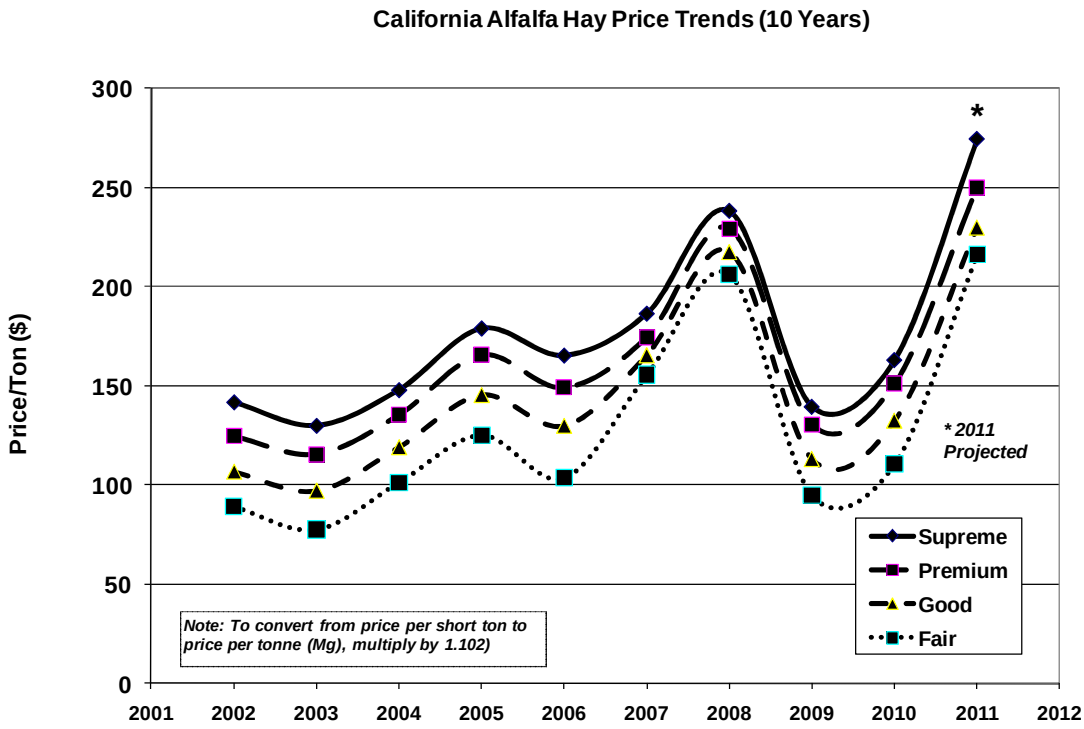


Figure 1. Long term trend of alfalfa hay prices, California, 2002-2011. Source USDA-Haymarket News Service.

CURRENT FIBER-BASED MARKETING SYSTEMS

Nationwide, in the US, alfalfa hay is essentially marketed using 'fiber-based' marketing systems. RFV and TDN are the most common languages of the hay trade, and appear to be superficially different. However, these are simply calculated from ADF and/or NDF lab measurements, so they are essentially similar in approach. They are both 'fiber-based systems'. Higher fiber equals lower price in current markets. TDN is 100% equivalent to ADF alone, and RFV is essentially 99% equivalent to NDF alone in pure alfalfa hays. CP and other factors figure in to some degree, but it's basically driven by fiber. (See NFTA www.foragetesting.org for calculations of RFV and TDN).

The state of California provides an interesting glimpse into the marketing of forages, since >95% of the hay in this state is marketed (compared with probably <10% in most eastern and Midwestern states), it has a long history of marketing, with large volumes. The marketing system in CA is similar to many of the other western states of OR, WA, ID, UT, NV, AZ, and NM, where 35-40% of the US alfalfa is grown. In CA, forage quality designations probably account for between $250-300 million/year in crop value of a $1 billion/year cash crop.

During the past 10-year period, average hay prices in this state varied between about $70/ton to about $280/ton, and were influenced by both supply-demand in any given year, and upon quality factors (Figure 1). On a volume averaging 7.4 million tons (6.7 million Mg), averaged across 13 marketing districts, differences in price changed an average of $6.14 per unit change in % ADF (Figure 2). Differences due to quality were about $45/ton or an average of 45.8% percent of the lowest price value in any given year. (To convert from $/ton to $/Mg, multiply times 1.102).

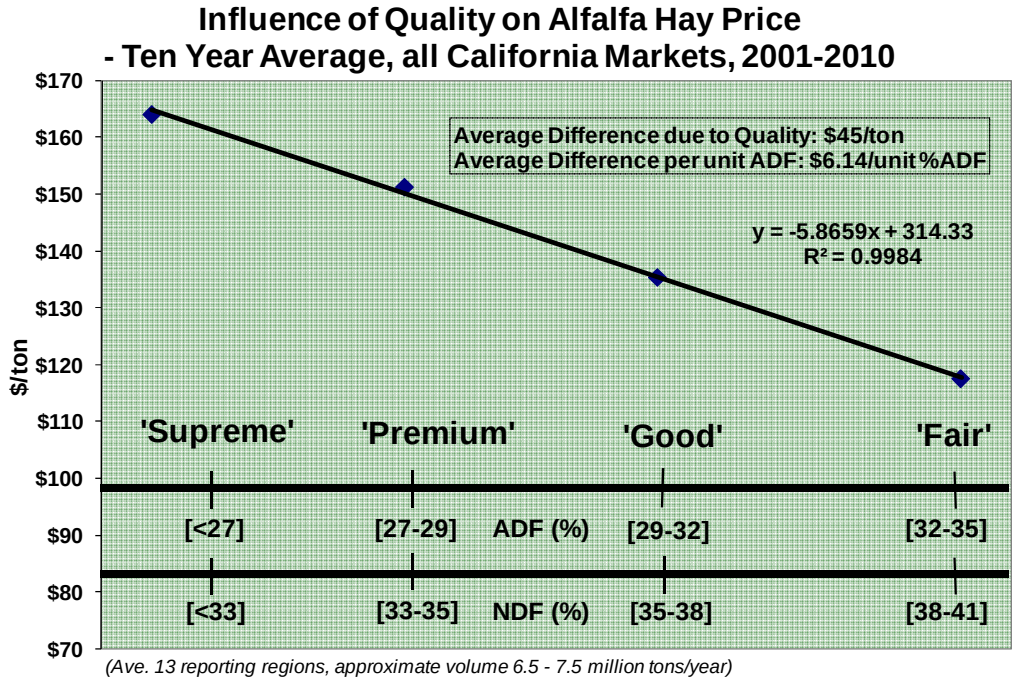


Figure 2. Average Changes in Fiber concentration (ADF & NDF) and its influence on price, 10 years in California markets. This does not account for 'utility' hays or hays sold mostly for horses.

Supply-Demand Influence on Quality-Price Relationship

The influence of quality on hay price is highly dependent upon the supply and demand situation in any given year (Figure 1). It's worth noting that in 'high price years', differences due to quality are smaller than in 'low price years' (Figure 1), both numerically and as a percentage of price. This relationship can be clearly seen in Figure 3. In the lowest priced years, high quality hays were worth up to 90% more than the low quality hays, but in a high priced year, the quality premium was only 20-30% more. This is because buyers can be less choosey in a high-price year, and must accept hays of lower quality. Additionally, hay growers are less-apt to sacrifice yield for quality in high price years, producing less amounts of high-quality forage since it is in their economic interests. Conversely, in low price years with high hay supply, lower quality hay often just simply doesn't sell, so growers must produce high quality in those years just to be able to sell hay.

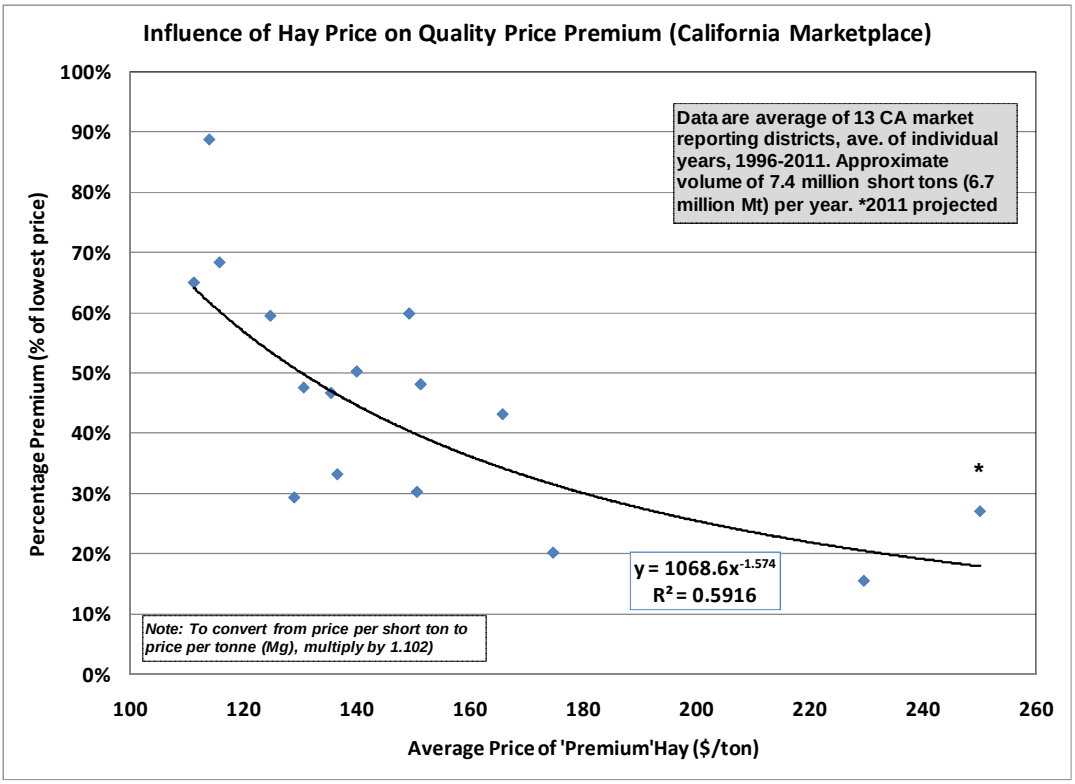
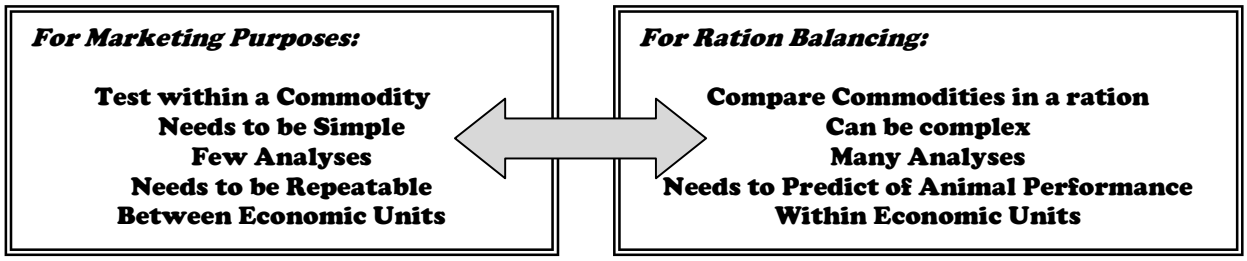


Figure 3. Price premium due to quality as a function of hay price (top vs. bottom), California markets.

LIMITATIONS OF A FIBER-BASED MARKETING SYSTEM

TDN and RFV systems (which are calculated from the fiber analyses of ADF and NDF) have been very useful in enabling hay markets to develop, and have enabled dairy producers to increase animal output substantially. The 'fiber based' market system is not unreasonable, due to the fact that most nutritionists want high energy and protein in their forages, which are generally found in low-fiber hay products. It is important to realize that the analyses required for marketing may be different from the analyses required for ration balancing (Figure 4). While we need to have simple, dependable systems and test WITHIN a commodity for marketing, we need to COMPARE commodities when balancing rations. Marketing measurements need to be simple, whereas lab values used for ration balancing can be more complex (Figure 4).

Figure 4. The important attributes of forage testing changes for marketing purposes vs. ration balancing. Repeatability and simplicity are critical for marketing purposes, while a high degree of predictability and relationship with other feeds are important for ration balancing.



However, the 'fiber-based' marketing system creates some warping of the quality-value relationship that must be addressed. There are major yield penalties to the hay grower by trying to produce ever-lower ADF or NDF hays in search of 'dairy quality' hay-the farmer suffers yield losses and stand losses as a result. But there are nutritional problems as well.

Valuing forage simply targeting 'low fiber' makes no sense from a nutritional viewpoint. The role of forage fiber in dairy rations is changing. With all the concentrates currently fed, digestible effective fiber (NDF) has played a much more important role in rumen function and animal health, as compared with the need to lower fiber itself to increase energy in forages. Marketing based upon fiber values has the advantage of simplicity, but may fail to differentiate important differences in forage quality within a critical range where the change in price due to fiber value is dramatic (Figure 5).

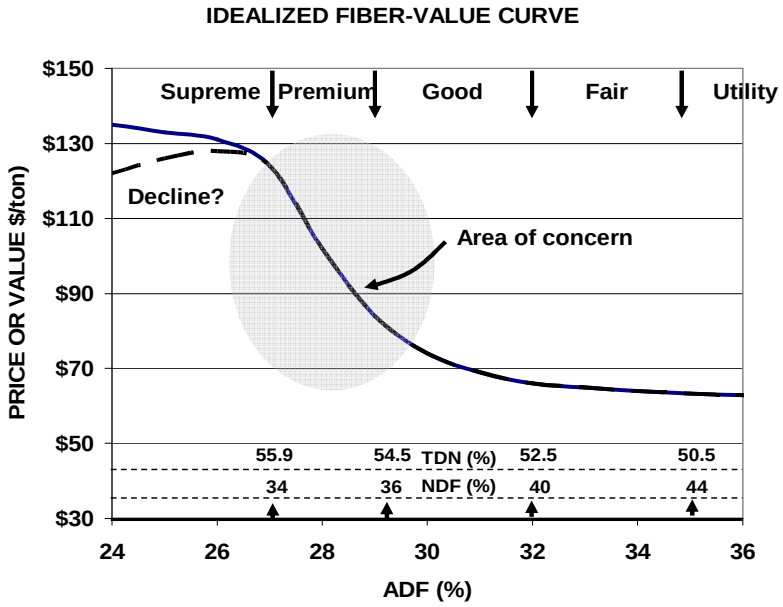


Figure 5. Idealized relationship between fiber value and price. While portions of this curve are linear others are not. A critical area of concern is the 'cutoff' between dairy quality and non-dairy hay (linear portion), where small differences in fiber result in large price differences and where there is the most abuse of the fiber-marketing system. This is the region prone to the most misuse, and where additional analyses should assist marketers.

Figure 5 shows an idealized quality-value curve – this is a reflection of the general reality of fiber-vs.-value in most alfalfa hay markets (the numbers are examples only). When %NDF or %ADF are high, markets do not distinguish much due to changes in lab values (these are mostly considered low quality hays fed to dry cows or low producers). But between about 34 and 40% NDF, small changes (e.g. 0.3%) in NDF or ADF result in a large change in price. Additionally, markets do not necessarily reward very low NDF or ADF values at the other extreme.

The influence of such small changes in NDF on price ('area of concern', Figure 5) does not make sense, since 1) Lab measurements themselves have a greater degree of variation than would be justified by this practice, and 2) it is unlikely that the true feeding value varies that tightly with small changes in fiber content. A better approach would be to define a range of acceptably low fiber levels (e.g. 33-36 NDF) for high energy forages, and add the different dimensions (such as NDFD, Ash, CP) which would assist in the price identification.

If we follow the 'low fiber' price structure to its logical conclusions, we would want zero fiber in forage, with duckweed or algae as our optimum forage! However, nutritionists will rapidly tell you that this is silly – the fiber itself from alfalfa and corn silage forages is important to animal health and are nutritionally valuable.

Greater use of NDF, NDF digestibility, ash, protein and its derivatives, or other measurements may assist buyers and sellers in differentiating hay products and improve prediction of the feeding value, especially if those measurements can be shown to be rapid and repeatable. Buyers can then take a 'heirarchical approach' to valuation, emphasizing some analyses more for some classes of animals, and other analyses for other situations. For example, if protein becomes expensive, dairy managers may be much more interested in the protein levels vs. energy or intake.

RECOMMENDATIONS FOR IMPROVEMENTS

The standard forage test consisting of ADF, NDF, CP, and DM has been a standard hay test for several decades. Growers mostly understand them, although some confusion remains vis-à-vis lab-to-lab consistency and sampling standardization (See www.foragetesting.org for standardized hay sampling techniques and lab methods). Calculations of RFV, TDN are

somewhat confusing, but these are simply derived from analyzed lab values. There is a need to seek ways of improving this system, in particular to prioritize what we measure, and what weight is given to each measurement. The predictability of the hay measurement, or series of measurements, must be balanced with the need for the system to be simple and repeatable. This may result in a revised 'standard hay test' (Table 4). The highest priority of these include:

- **Use of NDF** as a starting place, a first approximation of quality for markets. NDF represents a more meaningful dietary measurement for most nutritionists. Low, but not extremely low NDF frequently predicts high quality. For alfalfa hays there is no need to measure both ADF and NDF. Some nutritionist value lignin measurements as well.
- **Continued use of CP.** Crude protein continues to be useful and important for ration balancing – often second to NDF in importance.
- **Use of NDFD** into routine analysis for marketing and hay evaluation. The digestibility of the NDF fraction is clearly needed to differentiate hays which are genuinely different in feeding value but have the same fiber value. NDFD provides clearly different information about forages compared with NDF or ADF (Figure 6). However, repeatability of NDFD needs further evaluation and testing.
- **Use of Ash in Marketing.** There remain large differences in ash between different hay types which are currently ignored by markets.
- **Expression of lab values on 100% DM basis** (including ADF, NDF, CP as well as TDN). Confusion arises when other forms of expression are used.
- **Clear separation between analyzed and calculated values** on lab tests to reduce confusion in the marketplace.
- **Continued attention to the importance of hay sampling and lab standardization,** via voluntary effects such as NFTA.

Table 4. Suggested direction for a revised standardized hay test. While a wider range of analyses can be used, this represents a smaller sub-set for ascribing a majority of the value of alfalfa hays. This would replace the

current practice of utilizing DM, ADF, NDF, and CP in standard hay tests.
Analytical Determinations
Dry Matter (DM) (as received)
Neutral Detergent Fiber (aNDF) (100% DM)
NDF Digestibility (NDFD) (100% DM)
Crude Protein CP (100% DM)
Ash (100% DM)
Calculated Values (100% DM) as Needed
TDN
NEL
ME
RFV
RFQ

COMMENTS ON CORN SILAGE

It is likely that a small minority of the corn silage in the US is marketed between farmers, and even less is marketed based upon quality traits. Thus the experience of the industry of marketing corn silage based upon quality is still in its infancy. The majority of corn silage is grown by dairies and fed on-farm-but this is changing as farm units increase in size; more corn silage is likely to be marketed in the future.

Currently, growers of corn silage who sell to neighbors typically prioritize yield factors over quality, and will often compare grain yields with potential silage yields economically. But from the feeding perspective, there is quite a bit of interest in improved genetics (such as the BMR trait, leafy corn varieties, low lignin, and high oil silage types) and how these will affect animal importance. This begs the question of how to value these traits in exchanges between farmers. This problem is complicated by the fact that 'quality' in silages is influenced to a high degree by management factors during ensiling, such as particle size, moisture, inoculation, compaction, spoilage and containment (ability to exclude air). So the question as to whether silage is marketed BEFORE ensiling or AFTER is important. Wisconsin and California (he two

largest dairy states) are also the largest corn silage producing states in the US. In CA, quite a bit of the corn is grown by neighbors, but the ensiling is accomplished by contracted operators or by the dairies themselves. Thus yield and DM content are typically the only considerations setting price in this market—quality is primarily determined within a dairy after ensiling.

There are traditional 'rules of thumb for marketing corn silage: e.g. multiplying the price of a bushel of corn by 10 times to equal the price of a ton corn silage at 35%DM. The price of corn grain has frequently been used, and is a reasonable approach from a grower's point of view, since they can always choose to harvest the crop as a grain, with well-understood price structures. Alternatively, some may multiply the going price for top-quality alfalfa hay by 50-66%.

However, methods that link silage price to the price of the grain do not value the forage stover portion of the crop, and the potential differences in feeding value. Jim Linn at University of Minnesota has developed an adjustment method which starts with a base price per ton of DM based upon the planting and harvest costs, and then adds a starch adjustment of a dollar amount per unit corn grain, and an NDF digestibility adjustment based upon a milk price (http://www.ansci.umn.edu/dairy/topics/high_corn_silage_diets.pdf).

It is obvious that improved marketing methods for corn silage will need to be divided into marketing of the 'Crop in the Field' vs. marketing 'Corn Silage Delivered'. The requirements for these are likely to be different. It appears that widely used measurements of DM, NDF, Starch, CP and NDFD are likely to play important roles for both types. For 'Corn Silage Delivered', additional factors such as 'success in fermentation' – particle size, presence of mycotoxins or spoilage, nitrates are likely to play a more important role.

Moisture content is a critical value, since 'true tonnage sold' can only be determined by accurate moisture percentages. This is sometimes done sloppily. The same, unfortunately, is true of the hay markets, but with less impact, since DM doesn't vary as much. DM should primarily determine tonnage, not quality, although very high or very low moistures are an indicator of the possibility of quality problems, especially with silages, but also with hays.

It is painfully obvious that there is a need for improved incorporation of quality measurements in the marketing of corn (and other) silages to take advantage of the improved feeding value of improved corn silage hybrids and better methods of ensiling. Utilizing corn grain values alone ignores the significant differences in fiber digestibility that are known to exist

between hybrids and growing conditions. DM, NDF, Starch, CP and NDFD are all likely to play an important role, with physical can chemical considerations also coming into play.

In my view, a 'hierarchical' approach here again makes sense, since these different analyses may be more valuable in some rations and markets vs. others.

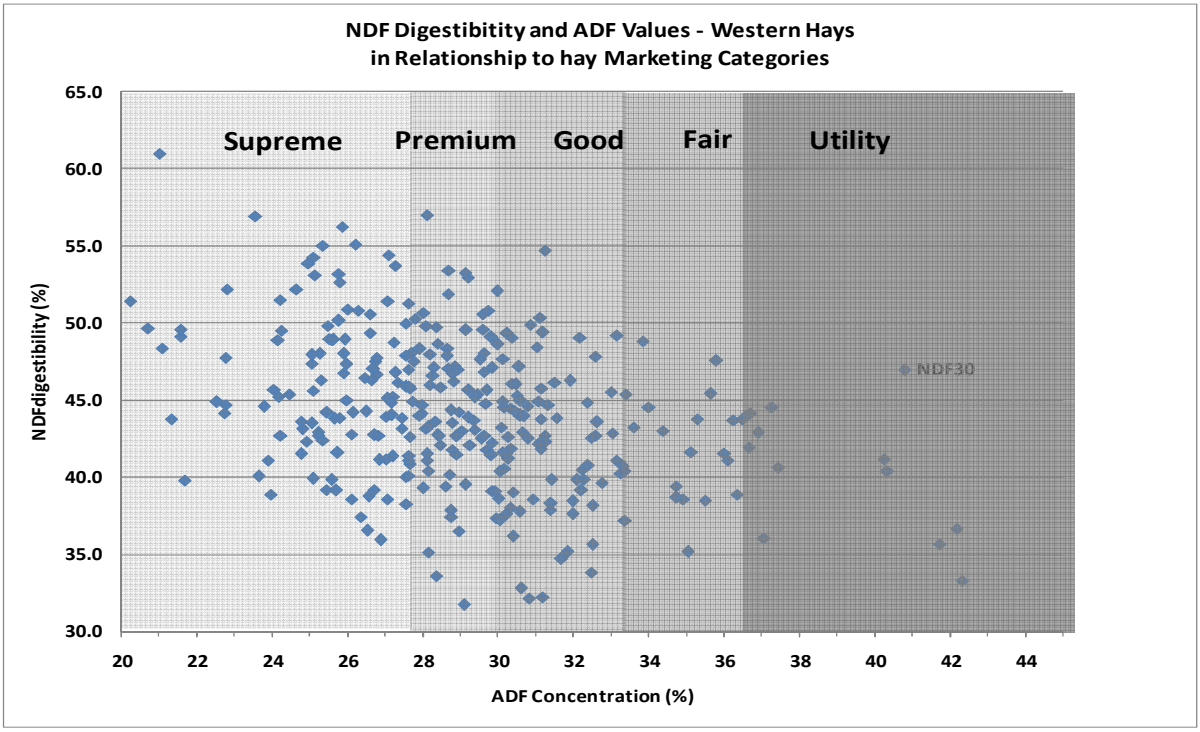


Figure 6. Relationship of NDF digestibility to currently-used hay market categories of Supreme, Premium, Good, Fair, and Utility, as defined by USDA-Market News (using ADF). ADF or NDF concentration, though important, fail to predict digestibility of the fiber fraction, of major importance to nutritionists. (Dataset from grower-submitted western states alfalfa hays, Cumberland Valley Labs, Cumberland MD).