LINKING ALFALFA FORAGE QUALITY AND MARKETS

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ABSTRACT

Forage quality and laboratory testing determines a very significant amount of the farm-gate agricultural value of the United States, since ruminant food production linked to forages is the largest single agricultural system. Forage quality and its measurement impacts farm economics in at least two ways: 1) impacts on animal productivity and 2) price of marketed hay. Forage quality can confer large losses or gains in economic return if inaccurately measured. Current hay quality categories in markets range from Supreme to Premium, Good, Fair and Utility (Low), and are based primarily on fiber (NDF or ADF) concentration, secondarily by CP (see box for abbreviations), as well as visual attributes such as condition and weed presence. This has been a generally effective marketing system, but its limitations must be recognized, particularly if only fiber concentrations are used. Standardizing hay market categories is a challenge given the highly variable nature of forages and the complexity of value to ruminants. Digestibility and other measurements are likely to play a more important role impacting markets the future.

Keywords: ADF, NDF, RFQ, TDN, NDFD, Economics, Markets, Forage Quality

INTRODUCTION

Simply put, forage quality and quality testing determines a very large proportion of crop farm value in the United States.

While corn grain is the most important economic crop in the US (above $50 billion/year), followed by soybean (~$40 billion), the value of ruminant food animal production (dairy and beef) exceeds $100 billion in most years (Table 1). Alfalfa and grass hays receive much of their economic value through the ruminant animal sector. However, farm sales of hay alone (alfalfa and grass) is the

Table 1. Value of Production, Top US Crops, and value of the two major livestock sectors, United States 2016-2018 (USDA-NASS data)

Crop/Product	2016	2017	2018	Rank ($)
	(US$ Billion Dollars)			
Corn Grain	51.3	49.5	51.5	1
Cattle and Calves	65.9	69.4	67.1	
Milk and Cream	34.7	38.1	35.4	
Soybean	40.9	40.0	39.1	2
Hay/Forage (all)	15.6	16.1	17.0	3
Hay (alfalfa)	7.5	9.3	8.5	(3-4)
Wheat (all)	9.1	8.1	9.7	4
Cotton (all)	5.6	7.2	6.7	5
Potatoes	3.9	4.6	3.8	6
Rice	2.4	2.2	2.7	7
All Field Crops	142.6	141.4	143.6	
All Fruit and Nuts	28.4	30.0	30.6	

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third most important crop in the US in farm gate value at about $17 billion/year (Table 1). Alfalfa alone is 3rd or 4th. Thus, taken as a whole, the forage-livestock food-producing agricultural system is the most important agricultural sector in the US, far exceeding farm-gate value of all fruits and vegetables and many grains (Note: a very large % of grains and by-products also support this sector).

Abbreviations:
ADF = Acid Detergent Fiber
NDF = Neutral Detergent Fiber
NDFD = NDF digestibility
CP = Crude Protein
TDN = Total Digestible Nutrients
IVDDM = In Vitro Digestible Dry Matter
RFV = Relative Feed Value Index
RFQ = Relative Forage Quality Index
RUP = Rumen Undegradable Protein
NFTA = National Forage Testing Assoc.

The method of translation between these two major agricultural sectors (forages and ruminants) is 'quality', which, broadly defined, is the ability of a forage to produce a desired outcome in an animal. Over the years, forage quality measurement has become more important for hay and livestock farmers.

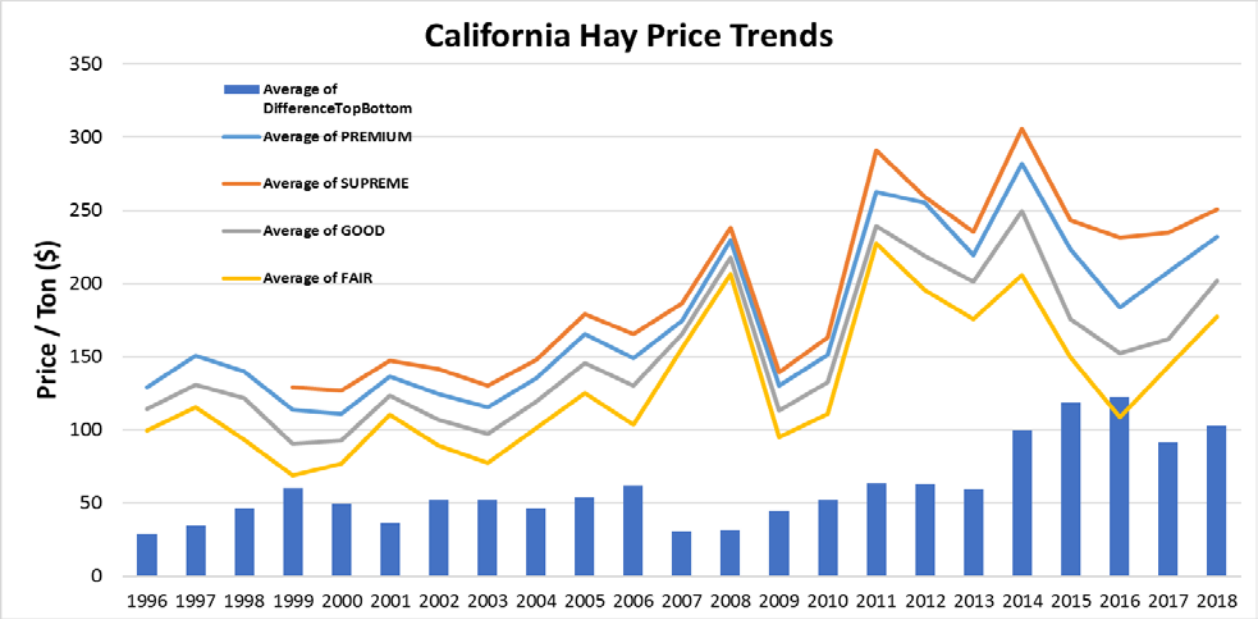


Figure 1. *California alfalfa hay prices influenced by quality, 1996-2018 (USDA-NASS), average of each year by quality. Approximate volume: 4-6 million tons/year.*

How much is forage quality and testing worth in the US? It's difficult to say, but hay quality impacts the economics of the forage-livestock sector in at least two ways: influence on animal productivity and influence on the price of hay. While it is difficult to measure the forage quality impact on animal productivity, even a 5% change in milk production or daily gain due to lack of accurate forage quality measurement or ration balancing could be worth >$5 billion/year in animal productivity losses (or gains) each year. On the hay side, price is highly sensitive to quality. In California where >95% of the alfalfa hay is traded and frequently tested, differences due to hay quality in markets ranged between $50 and $120/ton over the past 10 years (Figure 1) or approximately $250 to $600 million/year in this state alone. Forage quality testing and analysis receives precious little research attention, given the magnitude of impacts on the

economics of both crop and animal production. Forage quality analysis and markets also influences yield and overall profitability of forage production, since growers frequently harvest forages to favor quality while sacrificing yield.

Fiber-Based Marketing. From a nutritionist's viewpoint, forage quality consists of many analyses that, together, provide a prediction of performance in a balanced ration for the dairy cow. Marketing systems, on the other hand, require a few simple criteria that can be related to nutritional value and price discovery. Currently, most trading systems in the US for alfalfa hay are 'fiber-based' marketing systems, with protein occupying a secondary role. RFV and TDN are the most common languages of the hay trade, and these two measurements are 100% derived from a fiber measurement (NDF or ADF or both-Figure 2). NDF and ADF are very highly correlated in pure alfalfa hay. RFQ index incorporates both intake and energy estimates, utilizing NDF, NDFD, ash, and protein.

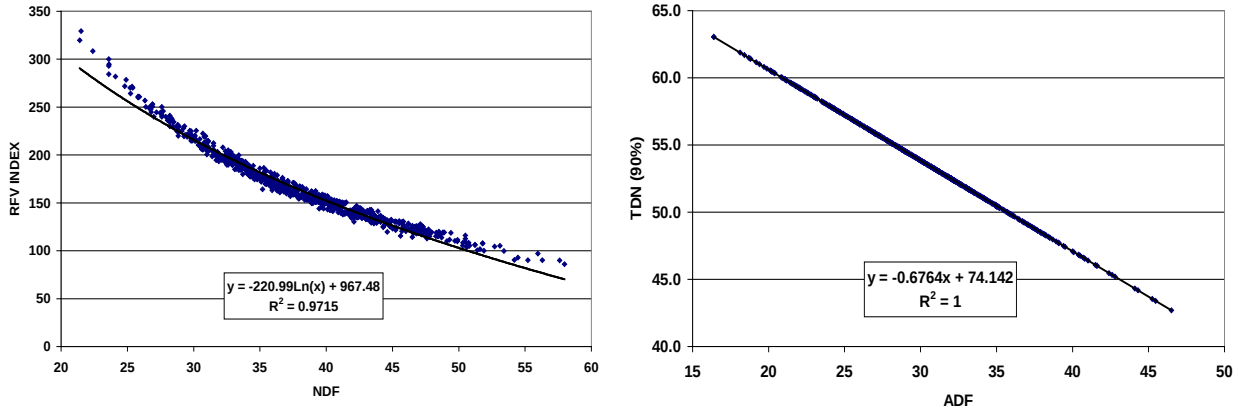
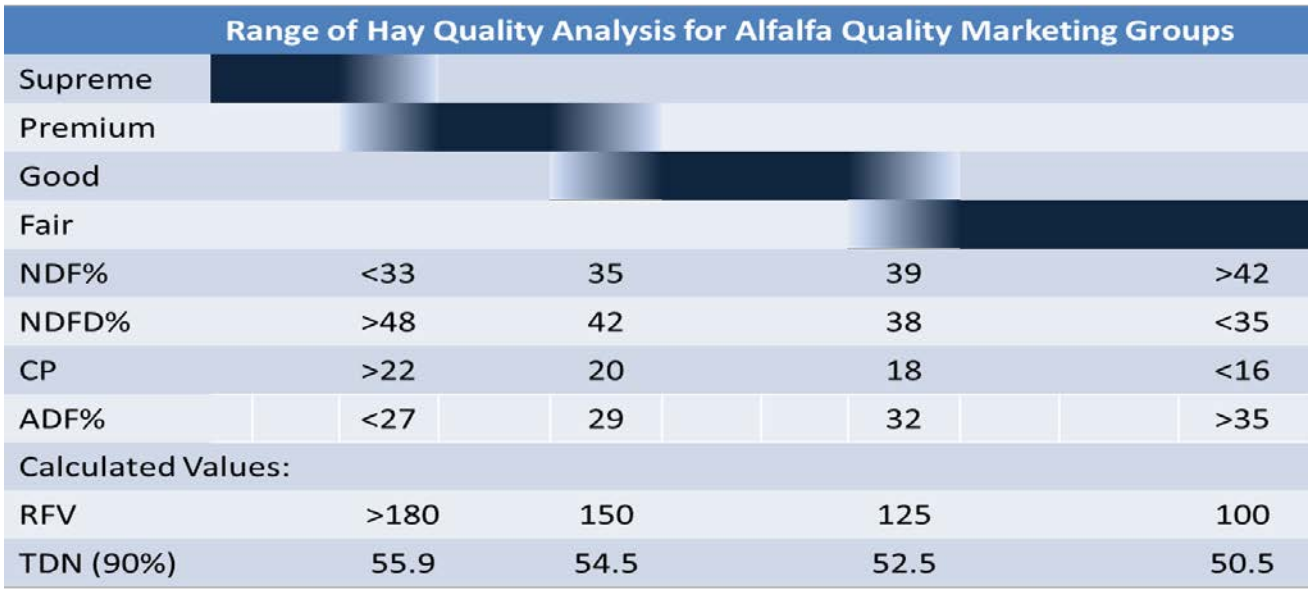


Figure 2. RFV (left) is nearly identical to the NDF measurement, and TDN (right) is 100% calculated directly from ADF. Both are 'fiber based' marketing systems which rewards ever lower fiber hays for high quality and high price. Both marketing systems miss the important role of fiber digestibility, as well as the value of digestible protein, intake, and value of forage fiber for rumen health. Additionally very low fiber levels may reduce some of the nutritional value of forages, since digestible fiber itself confers value.

Limitations. However, as has been frequently stated at this symposium and elsewhere, a purely 'fiber-based' marketing system fails to account for important quality factors, especially when severe market penalties are given for small changes in ADF or NDF concentration (e.g. 5-10 points RFV or 1-2 points TDN). The fiber-based marketing system has evolved due to the need for simplicity and rapidity of decision-making to identify classes of hay. While it may be difficult to incorporate additional analyses into marketing, it is important to do so, since critical attributes of forage of often missed. NDFD is becoming increasingly important to dairy nutritionists for high producing dairy cows. Ash content would be helpful, since it contains zero energy and differs widely across samples. Marketing systems based first upon NDF, and then upon NDF digestibility, CP, Ash, or other measurements may assist in differentiating hay products. Continued emphasis on lab consistency is needed as these become more widely used.

Figure 3. Hay Quality Guidelines widely used for marketing of alfalfa and grassy hays.



Range of Hay Quality Analysis for Alfalfa Quality Marketing Groups				
Supreme				
Premium				
Good				
Fair				
NDF%	<33	35	39	>42
NDFD%	>48	42	38	<35
CP	>22	20	18	<16
ADF%	<27	29	32	>35
Calculated Values:				
RFV	>180	150	125	100
TDN (90%)	55.9	54.5	52.5	50.5

Hay Quality Designations

Definitions of Hay Product Categories	
Alfalfa Hay	- Consists of a minimum of 90% alfalfa hay
Mixed Alfalfa Hay	- Consists of greater than 50% and less than 90% alfalfa
Grass Hay	- Consists of a minimum of 90% grass hay, designated by species
Mixed Grass Hay	- Consists of greater than 50% and less than 90% grass
Rained on Hay or hay with faults	- May be any of the categories listed above, but must be designated as such

Hay Quality Descriptions for Alfalfa and Mixed Alfalfa Hay	
Supreme	Vegetative, prebud, or early bud, low in fiber, high in fiber digestibility, soft stems, very high energy and intake potential. High leaf-stem ratio. Very good leaf attachment, free of grasses and weeds, no noxious weeds, no molds, well cured.
Premium	Prebud, bud or early bloom, med-low fiber with soft stems high energy and intake potential, high fiber digestibility, good leaf attachment. Mostly free of weedy grasses and weeds, no noxious weeds, no mold, well cured.
Good	Prebloom to mid-bloom, medium fiber and protein content, fair leaf attachment, can contain some palatable grasses or weeds, no noxious weeds, well cured.
Fair	Mid to late bloom, medium to high fiber with coarse stems, low to medium energy and protein content, fair leaf attachment, may have moderate grass and weed content. No noxious weeds.
Low or Utility	Hay with serious fault or faults. This could be to conditioning problems, rain damage, high or noxious weed content, mold, poor curing, very high fiber, or other serious faults. These hays are generally not described by test.

DISCUSSION

The difficulty in developing highly simplified quality-to-price relationships is a function of the genuine challenges and limitations in forage testing and animal nutrition. First, there is the highly variable nature of forage crops, which range from warm-and cool season grasses to highly palatable legumes such as alfalfa, and dramatic effects of harvest schedule and agronomic practices on quality for every species. Secondly, the nutritional value of forage to ruminants cannot be simplified to a single characteristic, such as energy (TDN or NEL) or protein, since intake, protein availability, digestible energy, and the physiological functions of fiber are all important to varying degrees. Thirdly, different classes of animals (dry cows, high producing milk cows, beef cows, sheep, horses) are all likely require different optimum types of forages for growth, lactation and health, further confusing the quality-price relationship. A top-quality horse hay with palatable medium fiber grass-alfalfa mix may be optimum for that type of animal, but not for a high-producing dairy cow.

Furthermore, populations of hay or forage crops genuinely differ by region – for example there is a low amount alfalfa hays produced in SE states due to the low acreage, so markets must reflect the availability of forages in a region. In addition to these challenges, the limitations of sampling and lab variation come into play, as well as varied nutritional philosophies and preferences practiced by nutritionists which are not uniform across the US. The seemingly confusing array of equations and approaches to forage testing and its relation to markets is a reflection of the true complexity of ruminant systems and forage production.

The yield penalty of our marketing system. From an agronomic perspective, especially for cash hay crops, yields nearly always trump quality economically under most market conditions for the grower. However, many growers routinely harvest very early to meet the demands for ever-lower fiber content, since lower quality hay often simply does not sell. Unfortunately early harvests significantly penalizes yield as well as stand persistence. The sacrifice of yield and stand persistence has been a major cost of adhering strictly to a fiber-based marketing system. Since digestible fiber itself has nutritional value (and is uniquely supplied by forages), the severe penalties paced solely on fiber content are irrational. This is especially true in situations where alfalfa occupies a much smaller percentage of the ration. Additionally, innovative genetics (e.g. reduced lignin lines) is likely to change emphasis on fiber alone as an index of quality.

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Figure 3 illustrates hay quality categories and guidelines for hay testing commonly used in many parts of the US. The standard techniques (ADF, NDF, CP, and DM) is largely considered a 'standard' hay test are now fairly well adapted across the US. The RFV system and TDN index systems, although superficially different, are both fiber-based systems that are not that different, and both have the same limitations. It should be pointed out that any guideline or classification is likely to require visual/subjective evaluation such as those in Figure 3, since some important aspects of quality such as weed presence, mold or lack of good conditioning cannot be evaluated

via lab analysis. Likewise, visual observation alone is inadequate to predict quality features, since protein and fiber and digestibility are poorly predicted just by looking at a hay bale.

Given the limitations of a fiber-based marketing system, there are several changes in approaches to forage testing that would likely be helpful in moving forward on linking forage quality with markets:

- **Use of a single fiber value** as a starting place (NDF). There appears to be no compelling reason to continue to measure both ADF and NDF for marketing of alfalfa hay since they are so highly correlated.
- **Incorporation of NDFD, and Ash** into routine analysis for marketing. These analyses have the potential to improve differentiation between hays which are genuinely different in feeding value but have the same fiber value. The standardization of the NDFD method, however, is a challenge.
- **Incorporation of Protein and Measurements of Protein Degradability.** There is a clear need to evaluate the quantity, degradability and availability of the protein fraction of forages since protein clearly has an economic value in rations.
- **Expression of lab values on 100% DM basis.** This has been the source of confusion in some markets. Forage quality measurements should be compared at a 100% DM basis.
- **Clear separation between analyzed and calculated values** on lab tests to reduce confusion in the marketplace. Prediction equations such as TDN, indexes such as RFV and RFQ, and calculations of various types are should not be mixed with actual measured analyses. RFQ is clearly a better index than RFV, but neither is used by nutritionists.
- **There is a need for innovative methods for economic analysis of multiple lab values** (e.g. NDF, NDFD, CP, Ash) for marketing purposes to account for the differences between animal groups, economics of ration balancing, and other factors.
- **Continued attention to the importance of hay sampling and lab standardization,** and choosing labs certified by the National Forage Testing Association (see www.foragetesting.org for listing of certified labs and for sampling certification). It is impossible to overemphasize the influence of sampling on hay testing, as well as the importance of lab standardization.

CONCLUSIONS

The current dominant marketing system in the US is based upon ADF or NDF (fiber-based' marketing system) and has the advantage of simplicity, and can successfully differentiate large differences between hay lots. However, they likely fail to differentiate important differences in forage quality within a critical range of interest where changes in price are dramatic. Greater use of NDF, NDF digestibility, analysis of protein, ash, or other measurements may assist in differentiating these hay products and improve prediction of feeding value, if those measurements can be shown to be rapid and repeatable. Calculated indexes may be useful, but attention to the underlying analyses and their repeatability is critical. It's important to take a 'consensus' or at least a 'majoritarian' view of the most important measurements to link quality to markets, since views of nutritionists can vary widely. More sophisticated methods are needed to provide greater flexibility given the varied demands for animal nutrition.