CHANGING FORAGE QUALITY TESTING FOR ALFALFA HAY MARKETS:

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ABSTRACT

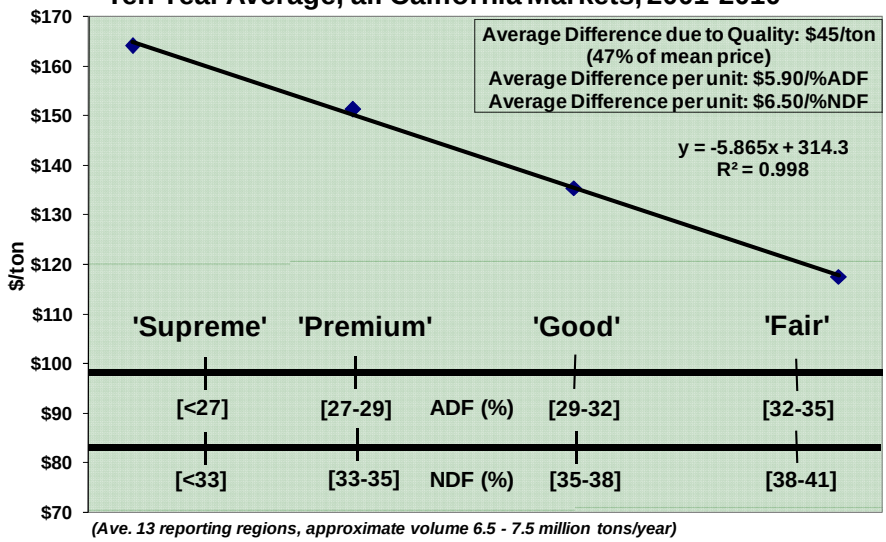
There is ample evidence that our current fiber-based marketing system is inadequate in predicting some of the most important features of alfalfa and other hay products. Worse, our current system has the potential for abuses. Seven of these abuses are described here. One key misuse is the over-emphasis of small differences in fiber concentration (as translated to TDN or RFV), while ignoring important additional quality attributes of hay. While marketing using fiber concentrations has the advantage of being simple and relatively repeatable, it fails to account for differences in fiber digestibility, ash, or other dynamic features of quality that clearly affect animal performance. Since forage quality is innately multi-faceted, and demands by different classes of livestock diverse, it's important to allow markets to recognize these multiple attributes of hay quality. Modest reforms of the hay marketing system to improve predictability, flexibility, and standardization of hay testing are suggested.

Keywords: ADF, NDF, RFV, TDN, NDFD, Quality Analysis, Economics, Markets.

INTRODUCTION

Although some believe that we trade alfalfa hay based upon TDN or RFV, most of the hay trade in the United States is primarily based simply upon a fiber measurement (see end of article for abbreviations). These are ADF and NDF lab measurements, either using NIRS or wet chemistry. TDN is exactly mathematically equivalent to ADF, and RFV is nearly mathematically equivalent to NDF (e.g. 99% in western hays). ADF and NDF, although they differ in lab methods, are very highly correlated in pure alfalfa hays. The influence of ADF and NDF in California markets over the past 10 years is shown in Figure 1. Thus, these two systems (RFV and TDN) may appear to be different, but are quite similar in their use of fiber concentration as the

Figure 1. Influence of Quality on Alfalfa Hay Price - Ten Year Average, all California Markets, 2001-2010



(Ave. 13 reporting regions, approximate volume 6.5 - 7.5 million tons/year)

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benchmark to ascribe quality, and of course, price. This has been a quite useful tool in identifying quality in markets. However, is there a need for change?

The 'fiber based' market system (Table 1 and Figure 1) 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. However, there are major penalties to the hay grower by trying to produce ever-lower ADF or NDF hays in search of 'dairy quality' hay (see article this proceedings on cutting schedules and economics). Additionally, the role of alfalfa 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 to increase energy in forages. If we follow the 'low fiber' price structure (in a linear fashion as per Figure 1) to its logical conclusions, we want zero fiber in forage, with duckweed as our optimum forage! However, nutritionists will rapidly tell you that this is silly – the fiber itself from forages is important to animal health and nutritionally valuable.

Table 1. *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. 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.

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.

Table 2. Seven Common Abuses of Laboratory testing. While some blame labs for difficulties in hay test results, often there are misuses of lab values by those in the industry, especially in relation to hay markets.

	Abuse	Facts	Solution
1	Demanding unrealistic precision in hay tests. Failure to expect a range of variation in lab data.	Markets routinely attempt to demand specific 'dairy quality' numbers (e.g.55% TDN or 165 RFV) and penalize prices if these deviate by a very small amount, even 0.1% or a few points RFV. There is absolutely no way to measure hay to this level of precision, even given optimistic control of sampling and lab variation.	All lab results should be associated with a range of reasonable variation. A' normal range' of variation using the best lab practices is considered might be: • CP— +/-0.5% • ADF— +/-0.7% • NDF— +/-1.0% • TDN— +/-0.5% • RFV— +/-5-8 points This does not include the variation due to sampling.
2	Sole use of a single number that supposedly encompasses all aspects of quality	While it is tempting to try to narrow quality down to a single parameter (such as TDN, RFV or CP), this misrepresents the reality of animal response to forages. Fiber content and its digestibility, Crude Protein and its degradability, ash, carbohydrate content, mineral balance (DCAD), effective NDF or fiber itself, and other measurements may all be important to varying degrees depending upon the class of animal. Additional factors such as poisonous weeds, texture, condition and odor should also be considered when evaluating quality.	Consider a 'hierarchy' of important measurements, from most important to least important, depending upon the class of animal. Typically, energy (as predicted by low fiber and high fiber digestibility) is considered most important, followed by intake potential, protein, effective fiber, and several other factors. However, this will change depending upon class of animal and the ration. For example when alfalfa is at a lower percentage in the ration, it is not as necessary to purchase very high TDN hays, since in this case, alfalfa is primarily providing valuable effective fiber to the ration.
3	Failure to Practice Proper protocols in Hay Sampling	Hay sampling remains the most important source of variation in the hay analysis process. There are many sources of variation in hay, from weeds to soil type, and baling methods. Variation due to sampling is far greater than the 'standard' variation described in #1, for example 3-5 point differences in ADF can be observed from core-to-core samples taken from the same stack. This is why discipline is required to follow proper sampling protocols to control (but not eliminate) this variation, and represent an 'average value' for a stack.	Certify your hay sample! Protocols have been developed to control variation in hay testing—follow them! These include identification of the hay stack, random sampling methods, use of 20 cores, a sharp instrument, 90^{o} angle, protecting the sample, etc. We have published these protocols and you can take an on-line test of your knowledge, and then certify your hay sample. See www.foragetesting.org for protocols and the on-line test. This is helpful in disputes over quality, since sampling has such a large influence on lab results.

Table 1. Seven Common Abuses of Laboratory testing (continued).			
	Abuse	**Facts**	**Solution**
4	Encouraging Lab Bias, Practicing Demand-driven Lab Analysis.	It's commonly known that some labs provide consistently high or low results. Brokers, buyers and sellers sometimes choose labs based upon these biases. This may be due to innate lab practices, or the lab may be responding to clients, who might be either buyers or sellers. This is partly a problem with clients who put pressure on labs to bias results for commercial purposes.	Choose only NFTA-certified labs as a starting point for excellence. This is a voluntary program. Further, ask for their grades on the NFTA sample. Do a blind test of your own using samples that are properly ground and split. Enquire as to whether the lab has Quality Assurance and control programs. Only work with those labs that are fully committed to the scientific accuracy of their lab results.
5	Misinterpreting Calculated Forage Quality predictions	It's common to fail to differentiate between what the lab actually measures, and what they predict using an equation. For example, TDN, RFV, RFQ, NEL and NEL are all predicted or calculated values, generally from ADF or NDF (RFQ also uses NDFd). Sometimes labs fail to tell their customer what is measured vs. what is calculated. Since equations can be confusing, it's important to know the difference between a lab analysis and a calculated value.	Both the calculated and the actual lab value may be important. However, for marketing, it's important to know which is which. Be careful about the calculations used (these should be footnoted). Essentially, a prediction such as TDN, NEL, ME, RFV or RFQ is an interpretation of a lab value, not the lab value itself. If you get confused by all of the calculations, go back to see what the lab actually measures. If they don't offer that, ask them.
6	Misinterpreting Dry Matter Data	Misinterpretation of analysis on different DM bases is a common problem with hay testing. For example, CP on an 'as received' or '90%' DM basis is very different than on 100% DM basis, and some may want to price hay based upon the former vs. the latter. This creates confusion in the marketplace, and is an opportunity for trickery or misunderstanding.	All forage analyses comparisons for marketing purposes should be made on 100% dry matter basis. While it is reasonable to adjust the tonnage purchased based upon the as-received DM (since you are purchasing water), it's not reasonable to adjust quality. (Note: TDN adjusted to 90%, as practiced in CA is actually calculated on a 100% DM basis, then multiplied by 0.9)
7	Failure to Consider additional Forage Quality Attributes	One of the most common abuses of hay testing is to concentrate so intensely on the importance of fiber as the sole determinant of quality (See #2 above). The RFV and TDN systems essentially do exactly that, and arguments over a few percentage points of ADF or NDF (RFV or TDN) can be worth thousands of dollars. It also forces growers to produce ever-lower fiber hays. This is not good for the grower, nor really rational when it comes to ration formulation.	Fiber concentration is useful to generally identify higher quality hays within a reasonable range. However, it is highly questionable to market based upon small differences in ADF or NDF, when factors such as NDF digestibility, Ash, or other measurements may be much more important within that range. Recommend using NDF concentration as the first approximation of value and incorporating NDFd, CP, and ash as additional important attributes of quality.

ABUSES OF HAY TESTING

The hay market Guidelines (Table1) provide a rational way to consider hay quality, but also can create abuses and warping of price in relation to quality. This 'fiber based' market system is prone to a range of abuses – which are described in more detail in Table 2. Some of these abuses may be unavoidable arguments that one might expect between buyers and sellers, but other aspects are conducive to correction, based upon a more scientific approach to forage testing. In addition to lab testing, subjective evaluation (visual, olifactory) remains important in judging the potential feeding value of hay, since detection of weeds, molds, texture, leaf attachment, and other quality attributes remains beyond the reach of laboratory tests.

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 value and price discovery. While it may be difficult to incorporate additional analyses into marketing, it is important to do so, since important attributes of forage of often missed. Figure 2 indicates the precipitous change in forage quality within a narrow range of ADF or NDF values. It is clear that there are large differences in digestibility of NDF WITHIN each these narrow ranges of quality categories (Figure 3). NDFD is becoming increasingly important to dairy nutritionists. Ash content would be helpful, also, 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.

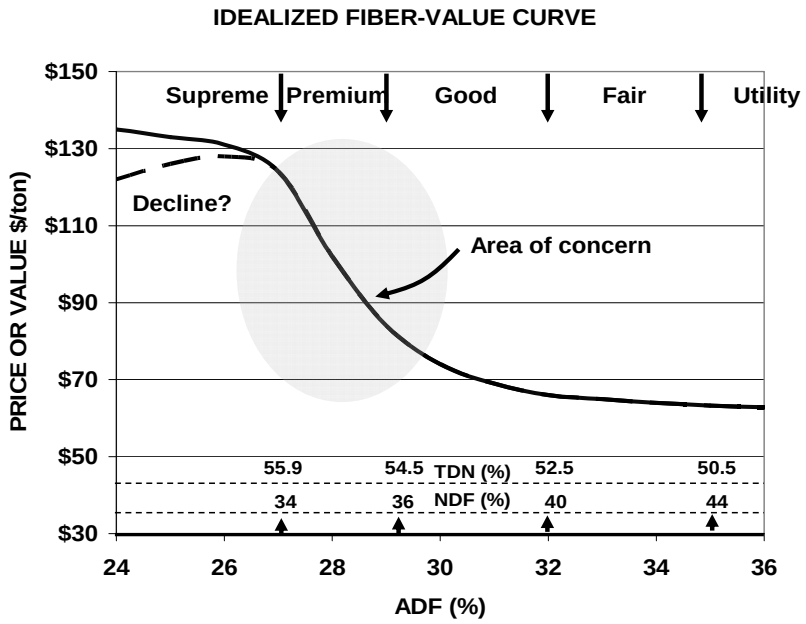
RECOMMENDATIONS FOR MOVING FORWARD

Industries change only slowly, it is clear. The standard hay test (ADF, NDF, CP, and DM) has been a standard for several decades. Growers mostly understand them, although some confusion remains vis-à-vis calculated values (RFV, TDN), and lab-to-lab consistency and sampling problems. 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. A series of recommendations are suggested for the future of forage testing as it relates to marketing of alfalfa hay for dairy production. The predictability of the hay measurement, or series of measurements, must be balanced with the need for the system to be simple and repeatable. The highest priority of these include:

- **Use of NDF** as a starting place, a first approximation of quality. NDF represents a more meaningful dietary measurement for most nutritionists. Low, but not extremely low NDF frequently predicts high quality.
- **Drop ADF.** ADF and NDF are highly correlated in pure alfalfa hays. NFTA labs have shown that NDF can be standardized to minimize lab-lab variation. There remains little incentive for keeping ADF in addition to NDF.
- **Use of NDFD** into routine analysis for marketing. 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.

- **Use of Ash in Marketing.** There remain large differences in ash between different hay types which are currently ignored by markets.
- **Continued use of CP.** Crude protein continues to be useful, and important for ration balancing – often second to NDF in importance.
- **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.

Figure 2. Idealized relationship between fiber value and price, California markets. Contrast this curve with that in Figure 1. 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.



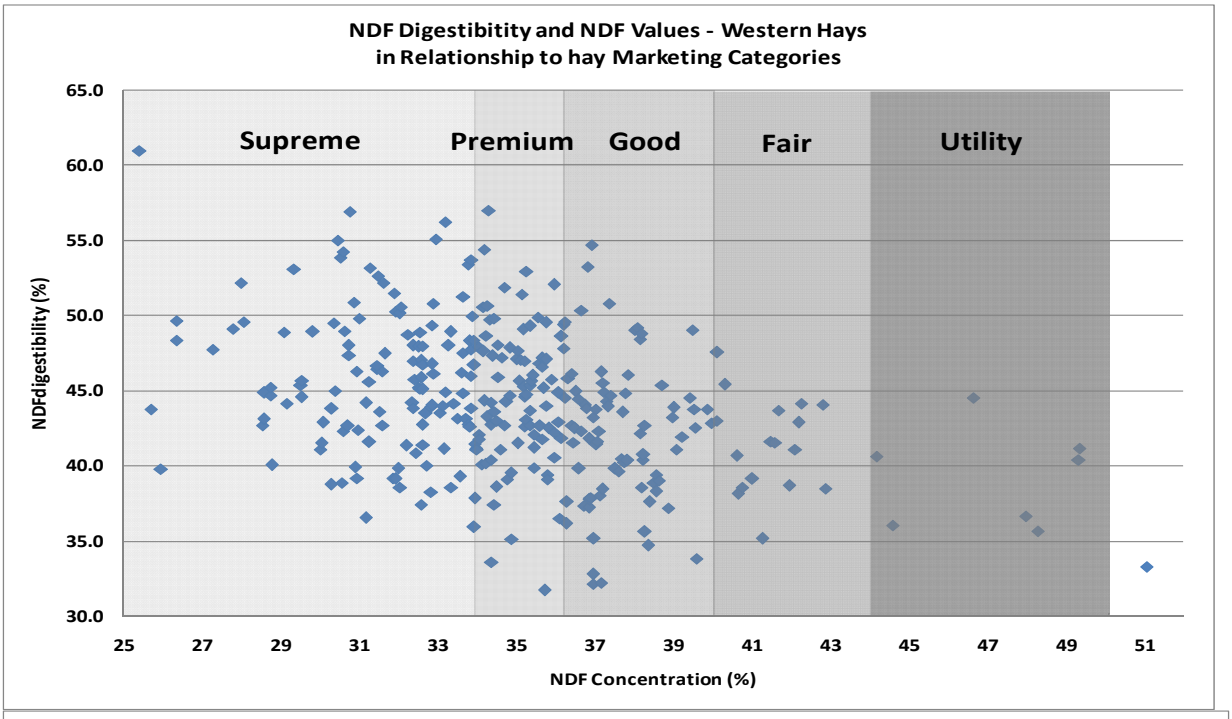
Suggested Direction for a revised standardized hay test. While a wider range of analyses can be used, this represents a smaller sub-set, particularly the first 4 analyses, for ascribing a majority of the value of alfalfa hays. This would replace the current practice of utilizing DM, ADF, NDF, and CP 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



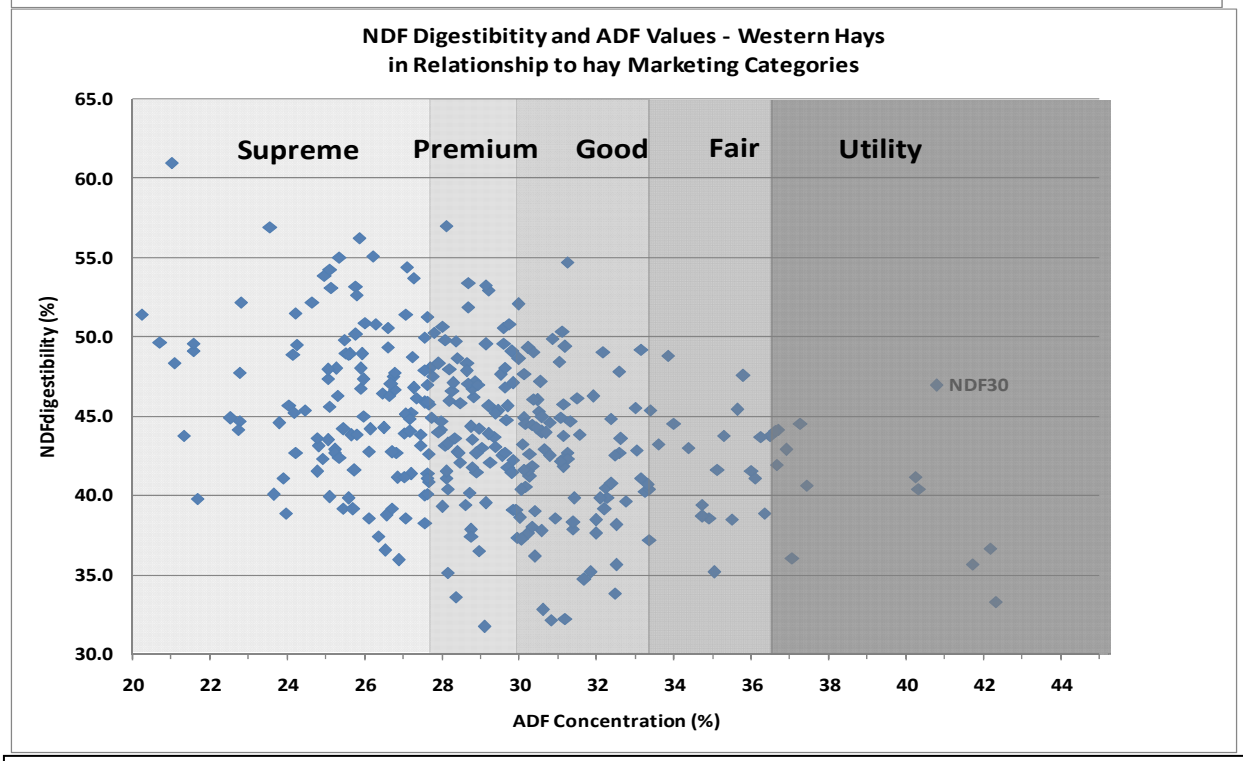


Figure 3. Relationship of NDF digestibility to currently-used hay market categories of Supreme, Premium, Good, Fair, and Utility, as defined by USDA-Market News (NDF above, ADF below). ADF or NDF concentration, though important, fail to predict digestibility of the fiber fraction, of major importance to nutritionists. Although NDFd is sometimes difficult to measure, nutritionists widely believe that differences from 30% to 60% digestibility, as in this dataset, should be significant in impacting animal performance. (Dataset from grower-submitted western states alfalfa hays, Cumberland Valley Labs, Cumberland MD).

CONCLUSIONS

Greater use of NDF, NDF digestibility, Ash, or other measurements should assist in differentiating hay products and improve prediction of the feeding value. Current marketing systems based upon ADF or NDF (the 'fiber-based' marketing system) have the advantage of simplicity, and can successfully differentiate major differences between hay lots. However, they are prone to a range of abuses, particularly the too-intensive use of small differences in ADF or NDF (TDN or RFV), which can't be realistically measured, nor do they necessarily fully predict animal performance. Simply using ADF or NDF is likely fail to differentiate important differences in forage quality within a critical range of interest where changes in price are dramatic.

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
NEL = Net Energy for Lactation
DCAD = Dietary Cation-Anion difference
NFTA = National Forage Testing Assoc.