THE FUTURE OF ALFALFA FORAGE QUALITY TESTING IN HAY MARKETS

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ABSTRACT

Forage quality testing defines the language of value between the dairy and forage sector. 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. Currently, most trading systems for alfalfa hay are 'fiber-based' marketing systems, since they depend solely upon the concentrations of ADF and NDF in the forage, even though RFV and TDN are calculated. This '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. 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. NDFD is becoming increasingly important to dairy nutritionists. 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..

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

INTRODUCTION

Most current marketing indices are fiber based. This is due to the fact that most nutritionists want high energy and protein in their forages which are generally found in low-fiber hay products. Historically, fiber content has been used to estimate total feed intake. Since intake is usually the first limiting factor in dairy rations most, but not all, dairy rations call for low fiber forages. Low fiber in forages comes from early harvest, unfortunately with a yield sacrifice. Therefore both buyer and seller have a stake in the drive to produce low-fiber hay products.

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
NFTA = National Forage Testing Assoc.

Nutritionists use many analyses to derive the most cost effective dairy ration. The analyte

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of most importance may vary depending on the particular mixture of components in a ration. Therefore the individual buyer, while generally looking for low fiber forage will often look at other components of the analysis when making a decision. Thus, there are needs for marketing methods that allow both price comparison (price discovery) among hay lots and for specific price adjustment based on the individual dairyman's other ration components.

FORAGE TESTING AND HAY PRICE

While 50 years ago, most alfalfa hay was evaluated on the basis of color (a minor predictor of quality), today most alfalfa hay entering commerce for the dairy industry is evaluated via laboratory testing. In 1972, about 15% of the California's hay was tested, but today this figure is likely over 70%. The trend for hay testing has occurred with the dairy industry all across the United States. Purchasing on forage quality is common even for dairymen establishing long-term contracts with neighbors to provide forages.

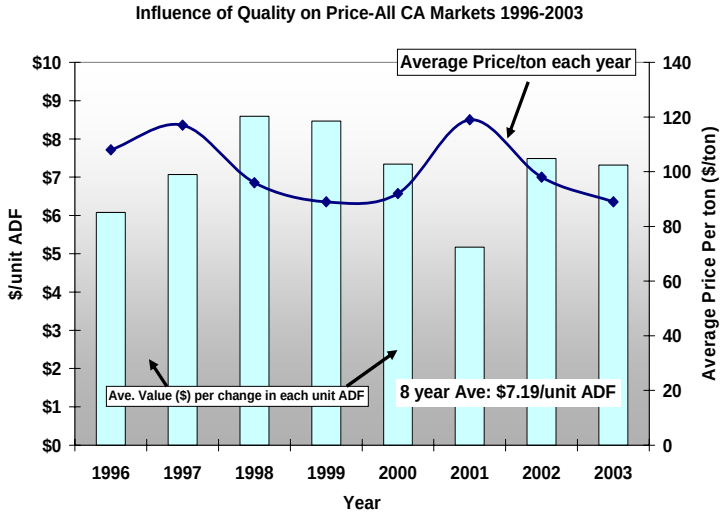
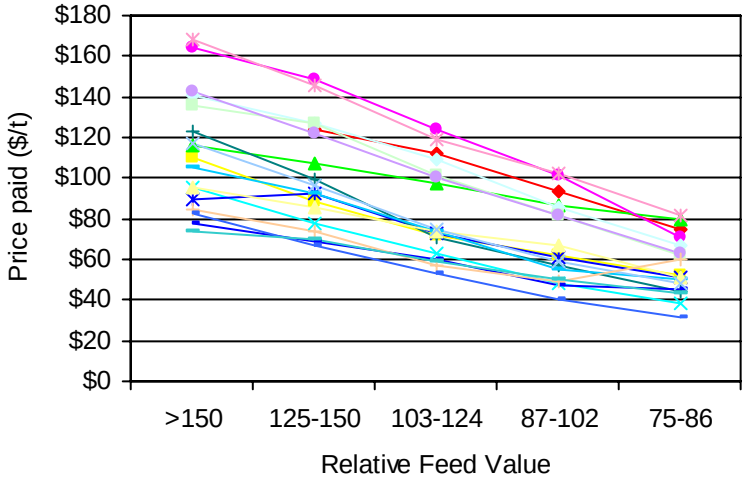


Figure 1. Value of each unit of ADF, average of all California Markets, 1996-2003 (USDA Market

The average change in California markets over 8 years was slightly over $7.00 per unit percentage ADF (over $10.50/unit TDN – Figure 1). The average change in Midwest markets has been about $0.85 per point of RFV (see Figure 2) which $7.44 per point of ADF. The premium per point of RFV has remained fairly constant (slope of line) while the base price of hay has changed based on hay supply. In California markets, the price premium is greater in a low-priced market year (Figure 1). It is interesting that the average price per unit of fiber value has been remarkably similar in both Wisconsin-Minnesota markets and California markets.

Figure 2 Prices paid at MN-WI Tested Auctions, 1884 to 2004



In recent years, growers have had to cut alfalfa at ever-shorter schedules to meet dairy quality expectations. Thus, quality is often attained by reducing fiber (e.g. ADF, NDF) levels and usually also by sacrificing yield and stand persistence in favor of quality. As late as the 1950s, the highest quality hay category described by USDA could contain significant bloom and even up to 49% seed pods—today, most high

quality dairy hay is harvested at pre-bud to bud stages, and little bloom is seen, and never a seed pod. While in 1972, alfalfa below 33% ADF, 100% DM basis) was considered excellent quality dairy hay, today, many nutritionists consider 'high quality dairy hay' to be below 27-29% ADF. It is not surprising that the demands for low-fiber, high quality hay have intensified, given that dairy cows are much more productive, and rations significantly different than in the 1970s. However, this demand for ever-lower fiber hays has an element of irrationality which we should examine carefully.

CURRENT STATUS

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.*

Physical Descriptions of Hay Quality 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.

Marketing Guidelines. In 2002, the USDA Market News developed a set of guidelines for hay quality designation into 5 categories, and attempted to 'harmonize' the various styles of marketing across the US (Table 1). These guidelines have the advantage that the numbers were arrived at through measured relationships between real hay samples from commercial labs. Additionally, subjective hay quality attributes are often included in the hay quality guidelines, since lab measurements do not predict all of the attributes of quality (see text box).

These guidelines have some disadvantages, though. The primary one is that individual hay lots may be categorized in one category by one measurement, but not by another. Additionally, the categories themselves create a problem with those hay lots which are right in between two categories—causing arguments over a few tenths of a percent ADF or TDN, or a few points RFV. While hay test values are 'continuous', these categories imply that forages are 'discrete', with a specific 'cutoff' for quality. A continuous variable is needed to allow differentiation across a wide range of qualities. In addition, reliance primarily upon fiber values has some important limitations.

WHAT'S THE PROBLEM WITH A FIBER-BASED MARKET SYSTEM?

If one carefully examines Table 1, it is apparent that 3 of the columns (RFV, TDN, and TDN 90% DM) are merely calculations from ADF and/or NDF. TDN is 100% explained by ADF, and RFV is 97% explained by NDF alone, even though both ADF and NDF are used (Figure 3). Thus, the current system of hay testing and marketing is essentially a 'fiber-based' market system, with either TDN or RFV used as calculations from fiber lab values. While these two marketing systems appear different, they are both purely a function of the fiber concentration of the hay.

The Problems with TDN and RFV in Markets. Total Digestible Nutrients is an estimate of the energy available to the animal from a feedstuff, and a valuable concept to nutritionists. It is calculated, not measured. However

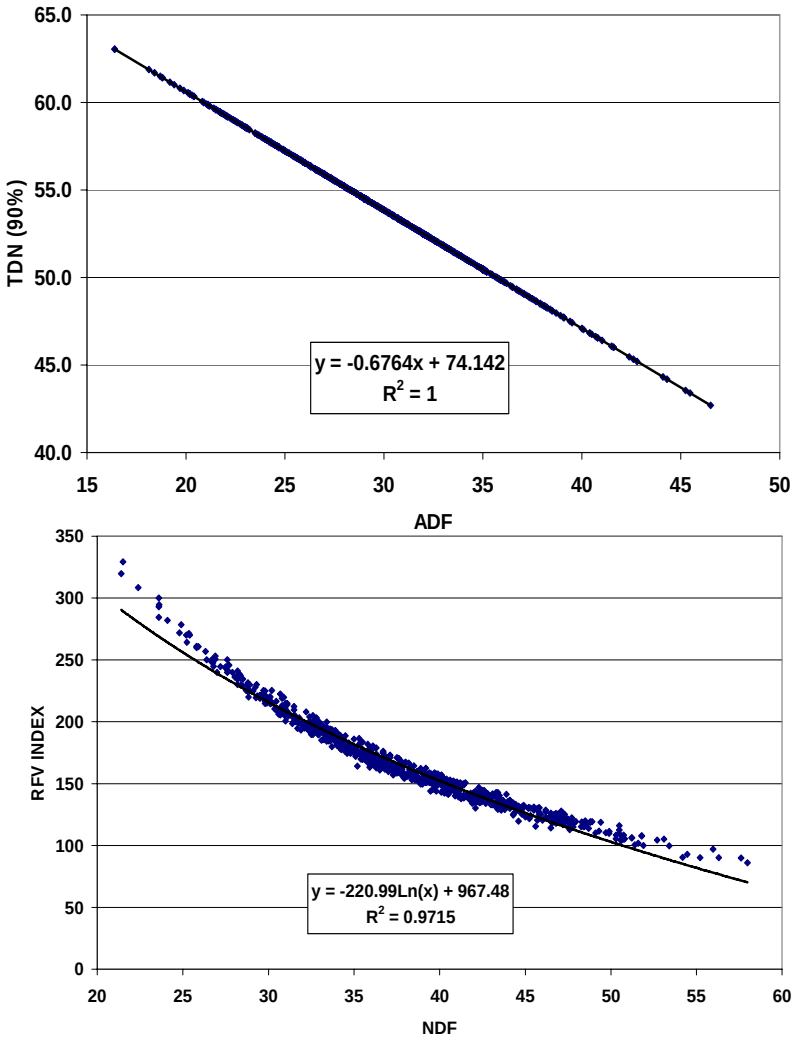


Figure 3. TDN is calculated directly from ADF (top). RFV is calculated from ADF and NDF, but over 97% of RFV is explained by NDF alone (Bottom). Both are 'fiber based' marketing systems.

TDN has historically been predicted only from ADF. Unfortunately, many ADF-TDN equations may be used by different laboratories and sellers, which cause confusion for markets. The different equations produce different TDN numbers when fiber is the same. In addition, differences in reporting of TDN on a 100% DM basis vs. as-received or 90% DM basis causes confusion. TDN is exactly functionally equivalent to ADF from a marketing perspective, so the question arises: why not use the measured value directly?

Relative Feed Value (RFV) Index has some of the same limitations as does TDN when used for marketing. RFV is also a calculated not measured value. Use of two analyses (ADF & NDF) in its calculation may compound errors of the two analyses in lab testing, causing more variation in some cases. RFV is a function of TDN (calculated from ADF as discussed in the previous paragraph) multiplied by an intake function based on NDF. However, RFV is most closely related to NDF (see Figure 3) in pure alfalfa hay, deviating for grasses and other forages. RFV is not used to balance rations, so is generally not used by nutritionists.

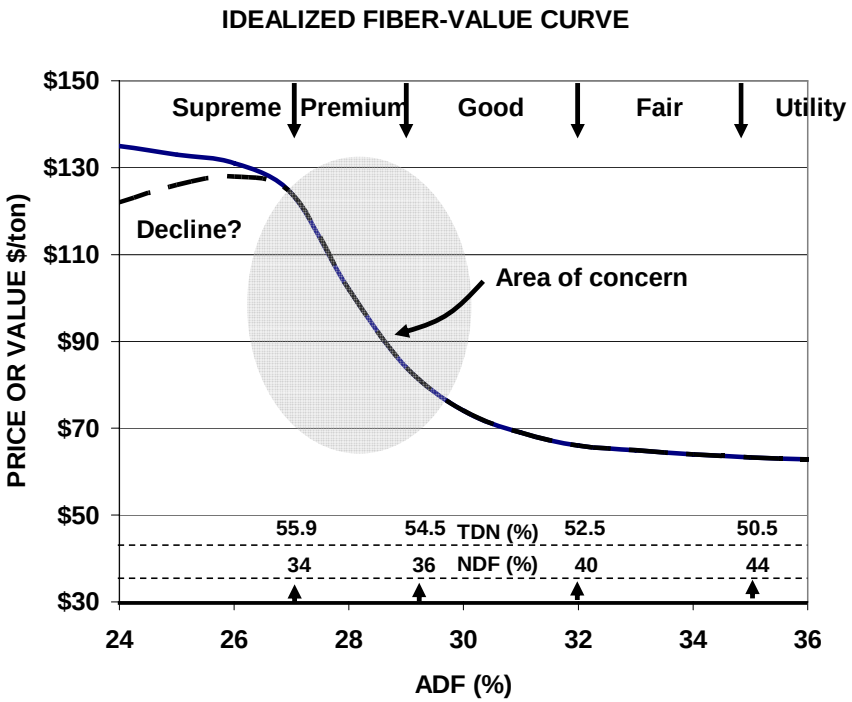
The wrong shape to the Fiber-Value Curve. However, the most important limitation of both the RFV and TDN systems is that they probably give us the wrong relationship between fiber value and potential forage quality. 'TDN' calculated from ADF indicates that the 'value' of hay increases at a fairly constant rate as fiber values become lower (Figure 3). The relationship is similar for RFV, except that the relative value increases at an increasing rate as the fiber values become lower (Figure 3). It is doubtful these curves of fiber-value reflect either the a) true costs of producing high quality hay, b) true behavior of the markets, or c) true economic or nutritional value of forages to milking dairy cows.

The Sacrifice of yield and stand persistence has been a major cost of adhering strictly to a fiber-based marketing system. Since fiber itself has value, the severe penalties placed solely on fiber content are irrational.

Both the TDN and RFV systems predict that the highest 'quality' will be obtained at the lowest possible fiber value (whether ADF or NDF). Is this what nutritionists (or agronomists) wish from their forage crops? A nutritionist would probably answer 'no' since fiber (NDF) itself has a value in spite of its negative relationship with energy and intake. Although they want low-NDF hay for high energy content, NDF itself is necessary for proper rumen function, to prevent acidosis and for animal health. An agronomist would say definitely 'no' since low fiber values are almost always obtained at the expense of yield and persistence. The sacrifice of yield and persistence (as well as weed intrusion due to short cutting schedules) has been a major cost of adhering strictly to the fiber marketing system for alfalfa hay. Since fiber itself has value (especially when alfalfa is a minor component of a ration), the severe penalties placed solely on fiber content are irrational.

What is the True Relationship between Fiber and Value? Figure 4 provides an idealized curve between market value and fiber value, as observed in CA markets. At lower quality categories (higher fiber—Fair, Utility, and some Good), the fiber value tends to be a minor determinant of price. Therefore, little change is seen with one or two points change in NDF or ADF. This type of hay is seldom tested. Weed content or condition (mold, odor) of the hay is a more important determinant of price in this range. In the Good-to-Premium-to-Supreme

Figure 4. Idealized relationship between fiber value and price, observed behavior, California markets. At high fiber values, hay value is not dependent upon lab tests, but other factors (weeds, mold) are more important. At very low fiber values, little gain in value per unit fiber is seen. 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 where additional analyses should assist marketers. The absolute values of price (Y axis) and Fiber (X axis) may shift from year to year or by market.



categories, each change in ADF or NDF results in a dramatic change in price (Figure 4, shaded area). In this range, a few points of ADF or NDF makes a large difference in price. At the left of the curve, at a very low ADF or NDF levels, there is generally no additional premium for lowering the fiber level further. In fact some have suggested that this very low fiber hay should be discounted, since the value of the NDF is lost in the ration. Long hay fiber is essential for healthy rumen function.

The central portion of this curve (Figure 4) is the area of most concern, since small changes in ADF or NDF result in large changes in price. This is where most of the abuse of the 'fiber-based' market system occurs. It is unreasonable to assign large changes in price to such small changes in fiber, since 1) Analytical and sampling variation alone may account for those differences, and 2) There are clearly other measurements which will help predict feeding value in addition to the NDF or ADF lab value.

Should we measure both ADF & NDF? For marketing purposes for mostly-pure alfalfa, the answer appears to be 'no'. ADF and NDF are very highly correlated, particularly within pure alfalfa hay (Figure 4), and so there is little gain in measuring both ADF and NDF. ADF explained 82% of the variation in NDF in a dataset from the Wisconsin World Dairy Forage Superbowl in 2005 and 2006, and 93% of the variation in NDF in a set of only western alfalfa hays (Figure 4). The difference between ADF & NDF is the hemicellulose content, which is a small portion of the NDF and varies less than total cellulose. The ADF component may contain pectins. This is particularly evident in immature forage and in forage grown in cool conditions. While some nutritionists estimate a 10 point spread between ADF and NDF, this is not always true.

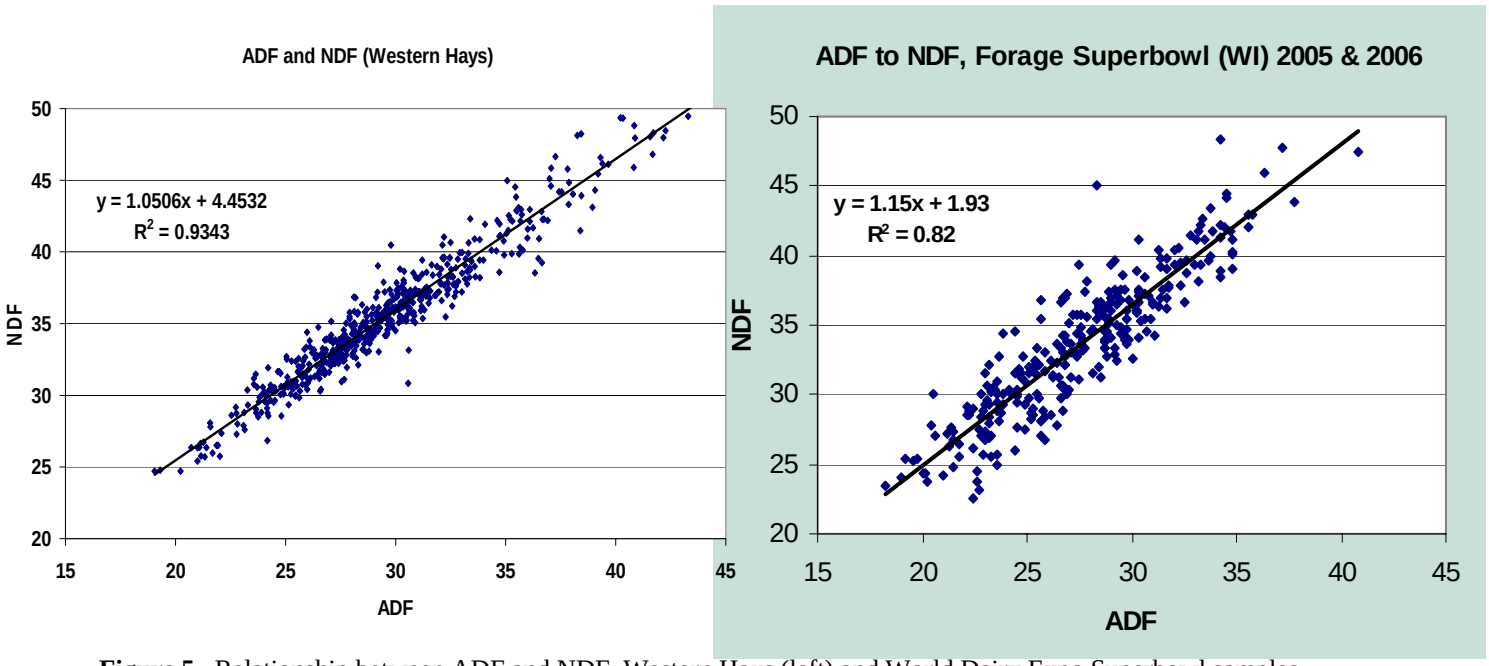


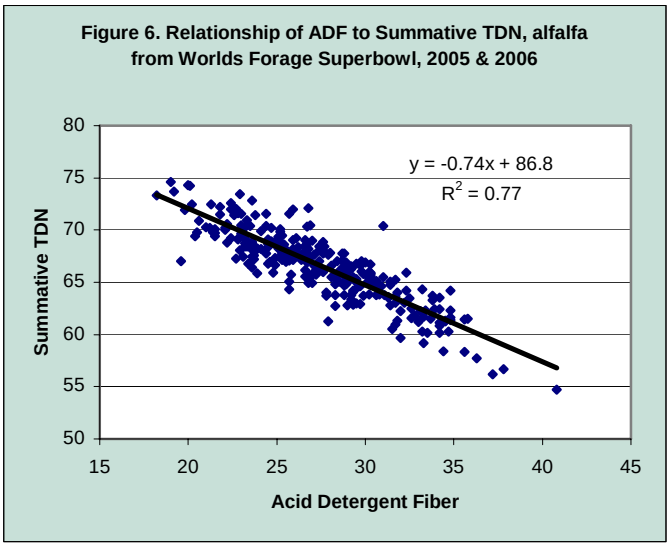
Figure 5. Relationship between ADF and NDF, Western Hays (left) and World Dairy Expo Superbowl samples (right). Both datasets represent multiple states. Western hay sample set courtesy Cumberland Valley Labs.

IMPORTANCE OF SUMMATIVE EQUATIONS

The potential biological energy (e.g. TDN) available from forages, as well as intake potential are perhaps the most important concepts in ruminant nutrition. Unfortunately, these cannot be practically measured, but are always predicted. Many nutritionists no longer derive TDN (and NEL and other energy estimates) from a single fiber value (ADF) but use 'summative equations' which calculate TDN using several measured values (NDF, NDFD, Ash, EE, etc.). An example of a summative equation is as follows:

TDN = (0.93xCP) + (0.98xNFC) + (NDF*NDFD) + (0.97*2.25*FA)-7

In this equation, NFC is calculated directly from NDF (100-%NDF), NDFD is the digestibility of the fiber fraction, and FA is the fatty acid or lipid portion of the feed. Ash can also be included in a summative equation. It is noteworthy that the ADF-TDN linear equation approach is completely absent from dairy nutrition ration balancing recommendations, although it is still used by for marketing purposes.



This 'summative equation' approach is widely considered to be an improvement in energy prediction (2001 NRC Requirements of Dairy Cattle) because it involves all digestible fractions of a feedstuff. Most importantly, it does not assume that all fiber has the same digestibility as equations calculating TDN from ADF or NDF presume. Also, since this equation involves all digestible fractions including the fiber, it can be used across forages. There is no need for different equations with each different forage type as was necessary with TDN calculated from ADF. As figure 6 shows, the overall agreement between the Summative TDN and ADF (or a TDN calculated from it) are good. However, individual values vary considerably. Deviations are due to differences in digestibility of fiber. When dairymen buy hay with above average digestibility (points above line), the cows will milk better than expected and, when dairymen buy forage with below average digestibility (points below line), cows will not milk as expected. This is due to the inclusion of additional analyses, particularly NDFD.

THE NEED FOR CHANGE

Both the Relative Feed Value Index and the TDN method of marketing have been valuable in assisting growers to identify the quality of hay. However, their limitations should be clear. As a practical matter it should be clear that these methods are based solely on fiber content. Nutritionists know full well that there are additional parameters that could predict the value of forage to a milking dairy cow beyond the NDF or ADF concentrations. The fact that a small change in ADF or NDF may result in a large price change reveals two weaknesses to the fiber method of marketing: 1) Sampling variation or differences between labs alone can result in significant price differences and 2) changes in ADF or NDF alone are do not adequately predict the full dimensions of feeding quality to have such a dramatic influence on price.

Simplicity vs. Complexity. Generally, nutritionists use a larger set of analyses to balance rations than what might be required to identify the quality of hay in the marketplace. Hay analyses marketing should have the following characteristics:

- Must be rapid (within a few days or several hours)
- Must be reliable and utilize recognized standardized methods
- Must be repeatable across labs and across time
- Must not change significantly over time or be subject to different interpretations
- Must be a relatively powerful predictive tool for nutritionists

The 'fiber-based' (e.g. ADF or NDF) system generally satisfies most of these requirements, with the exception of the last. There is sufficient anecdotal and experimental evidence to show that ADF or NDF alone, though useful, cannot differentiate some important differences in forage intake and digestibility. Nutritionists in the Midwest report that they were about 60% accurate when balancing rations with dry matter, protein, and fiber. Accuracy improved to 90% when they began including digestible fiber and ash. However, the need for greater predictability must be balanced by the need for reliability, repeatability and speed for marketing purposes.

ARE THERE ADDED DIMENSIONS THAT COULD ASSIST?

ADF, NDF, CP, and DM are the current measurements considered the 'standard hay test' in the US. Nutritionists are using additional tests that pertain to all forages and should be included in marketing systems. In fact, the buyer may be considering these analyses already.

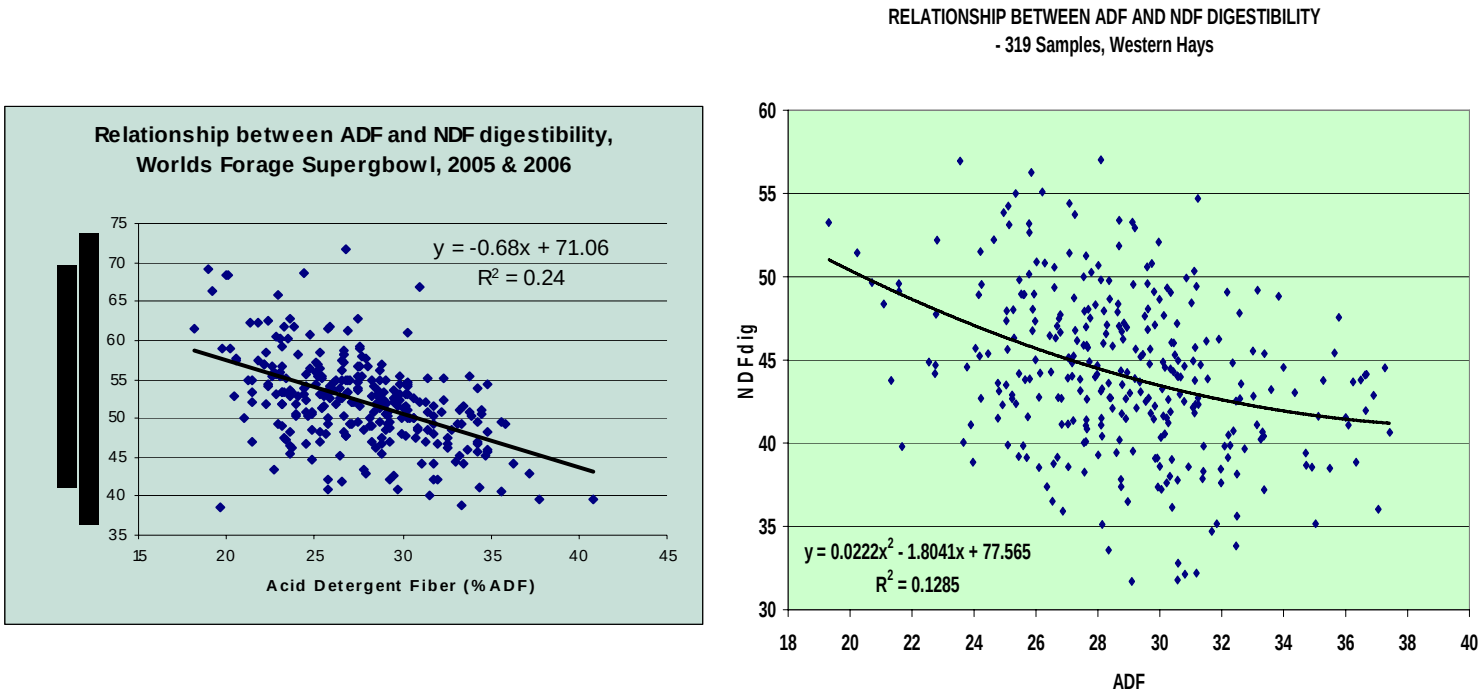


Figure 7. Relationship between ADF and NDF digestibility. NDF digestibility (48 hr, left 30 hr, right) is the percentage of the NDF fiber fraction which digested in rumen fluid, expressed as a percentage of NDF.

Fiber digestibility (NDF digestibility) is the fraction of the NDF content which breaks down in rumen fluid in 24 to 48 hours hours. The relationship between fiber digestibility and the ADF or NDF measurement itself is weak (Figure 7). At a given ADF level, fiber digestibility percentage of alfalfa ranges about 30 points. This indicates that NDFD provides more information than is provided by the simple NDF or ADF measurement. From a nutritional perspective, NDF digestibility are thought to aid in prediction of the 'residence time' in the rumen and intake factors for forage crops, as well and energy content and this can be used in ration balancing programs. Rapid NDF digestibility in rumen fluid may indicate the potential for a forage to either limit intake (with low NDFD) or to enhance rate of passage and feed intake (high NDFD). Some nutritionists and laboratories use the National Research Council recommendation of 48 hours and some have reduced the incubation times for in vitro digestion from 48 hr to 30 or 24 hr. The rational for shorter incubation times is that feed is not retained in the rumen of a high producing dairy cow for 48 hr. The recommendation of a 48 hr digestion by the NRC (2001) is to facilitate calculating summative TDN content of forages at maintenance intake which can then be adjusted for intake as a level of maintenance. As fermentation time is shortened below 48 hours, the error of estimating NDFD increases dramatically. Further, the real value of NDFD is to identify forages where digestible fiber differs significantly from average. The ranking of

forages is generally about the same regardless of forage digestion time (correlation usually above 90%). Shorter digestion times do have lower mean digestion times, so the important consideration when comparing digestible fiber of alfalfa hay is to only compare those run with the same rumen digestion time.

Gas Production Method. When samples are placed in rumen fluid, gas is evolved from fermentation. Measurement of gasses (timing and volumes) may enable more dynamic

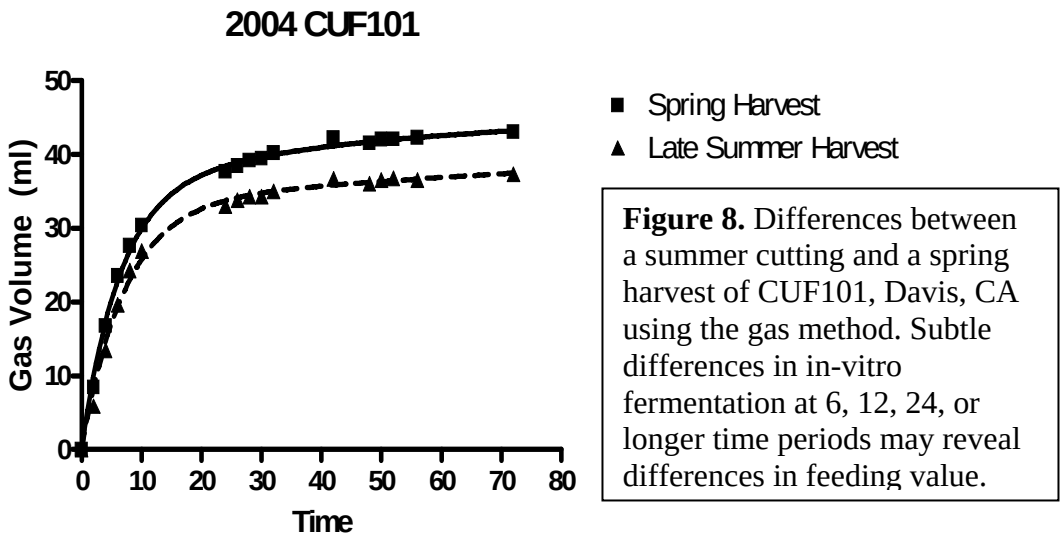


Figure 8. Differences between a summer cutting and a spring harvest of CUF101, Davis, CA using the gas method. Subtle differences in in-vitro fermentation at 6, 12, 24, or longer time periods may reveal differences in feeding value.

measurements of forage quality, since timing of digestion is nearly as important as extent of digestion for many classes of animals. This has advantages over the NDFd method, in that multiple times of digestion can be estimated on a single sample. Figure 8 shows the difference between CUF 101 alfalfa grown in the spring vs. summer harvest at Davis, CA. However, the gas method is currently not widely used in the US.

Ash is a measurement of the non-organic, mineral component of hay. All plants naturally contains a certain amount of mineral (usually 6 to 8%). Ash analysis identifies hay lots which have a significant soil contamination, or hays which have an above-normal mineral concentration due to salt accumulation or another factor. Figure 7 shows the range of ash values at different ADF levels for western hays. ADF and NDF do not estimate ash value (nor TDN calculated from ADF). Each 1% ash is about 1% less energy for the cow (this is reflected in TDN

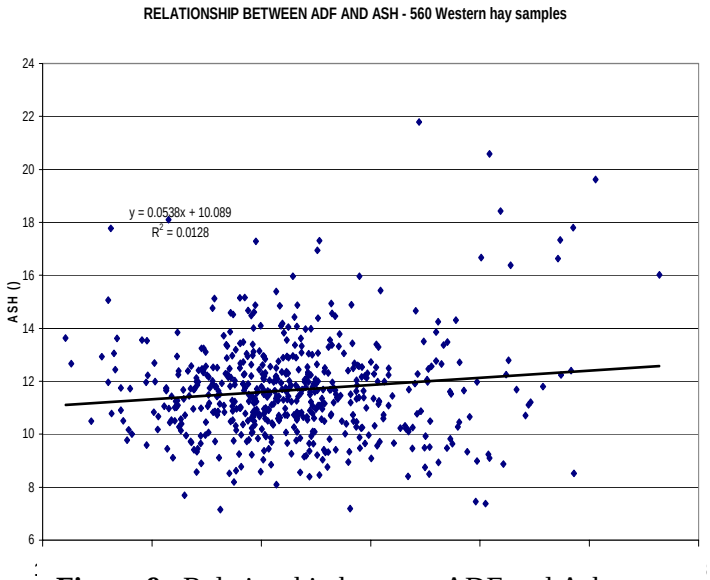


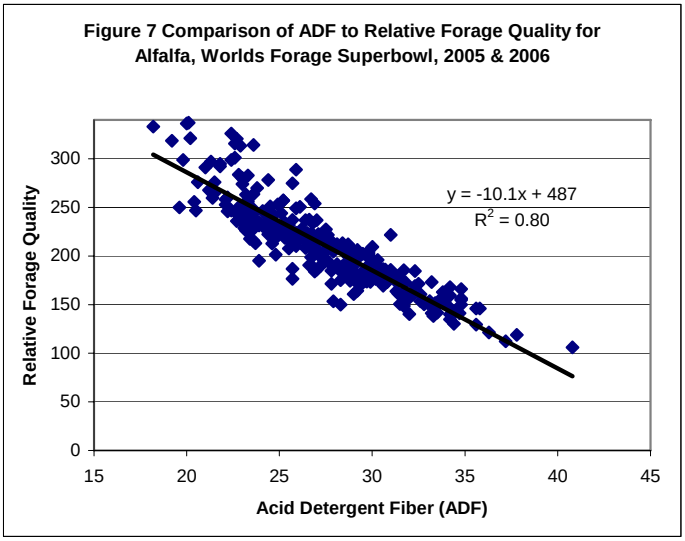
Figure 9. Relationship between ADF and Ash Percentage, Western Hays. Data from Cumberland Valley Labs, Maryland.

calculated from the summative equation).

One has to wonder why buyers and sellers argue over 0.5 or even 0.1 of a point TDN or ADF, when, at a given ADF and TDN level, a hay could vary as much as 20 percentage points in the digestibility of the fiber fraction, and 10 points in the ash content.

Protein relationship with fiber (either ADF or NDF) and CP is relatively weak (data not shown). Although fiber and protein are negatively correlated for alfalfa (higher fiber indicates generally lower protein), they are not so highly correlated that measurement of one could adequately predict the other. Therefore, both a fiber and a protein measurement appear necessary. Note that we do not actually measure protein in forage. We normally measure total nitrogen and multiply it by 6.25 to get and estimate of total protein (Crude Protein). We do this because animals can use non-protein nitrogen (actually, the rumen microbes can take non-protein nitrogen and make bacterial protein with the cow digesting the bacterial protein.) However, most nutritionists are also interested in the degradability of the protein fraction, and it's availability in the rumen vs. the lower gut. Rumen undegradable protein for the ration is often calculated and a by-pass protein source added to the diet if insufficient protein will by-pass (not degrade in) the rumen.

Relative Forage Quality (RFQ) has been introduced as an index to replace RFV, addressing some of the criticisms presented above. RFQ uses summative TDN (NRC, 2001) which uses digestible fiber and subtracts ash content as part of the calculation. RFQ also adjusts intake for digestibility. Some hay marketers (and hay buyers) are using RFQ to index hay for sale. This is of particular importance to hay sellers when the hay may have above average digestibility. As figure 10 indicates, RFQ is highly correlated with ADF (and TDN calculated from ADF).



The agreement is good when ash and digestibility are average, but, about 40% of the time, values are not average and numbers differ significantly. When numbers differ, standard fiber measurements will not provide adequate information to accurately balance rations. The potential uses of RFQ include all the current uses of RFV. RFQ could be translated into energy requirements for maintenance and production. Multiplying RFQ by 1.23 gives an estimate of TDN intake (% of BW). TDN concentration may be converted to NE concentration and Voluntary Feed Intake (VFI) and used for several nutritional models, if desired.

Impact of biotechnology must be considered when thinking about the long-term future of forage testing. Improvements in alfalfa need to be able to be quantified so they can provide value to both the grower and the dairyman. Development is underway for low lignin alfalfa. This will be more digestible than standard alfalfa varieties but such differences will not likely be marketable or able to be involved in dairy ration balancing unless digestible fiber is measured. Work is also under way to develop alfalfa that will have elevated levels of rumen undegraded protein. This

will increase the level of bypass protein and reduced the need for supplement. However, again, this will not be marketable unless there is an analysis tool that can report differences between the new varieties and standard varieties.

FOCUS ON THE MEASURED VALUES

Calculated values such as TDN, RFV, RFQ, or summative equations may be useful as interpretations of data. However, they are not lab data itself. After all, calculated values are only as good as the lab analyses from which they are derived.

Furthermore, the usefulness of different lab analyses is likely to change depending upon the class of animals and market conditions. For example, a 30 hour or digestibility value may be more important for a high producing dairy cow than for other classes of animals. The protein content in alfalfa hay will likely be worth more when protein supplements are expensive and far less when they are cheap. Protein or Rumen Undegradable Protein may be more important for some groups of animals than another. The NDF content of alfalfa hay may be more valuable than the energy or protein content when the rate of inclusion of forages in the ration is low, and thus medium to high fiber hays may be more desirable. Low potassium hay is important for 'close up' pregnant cows nearing calving, and therefore has 'value'. Thus, markets may wish to place different economic values on specific analyses. For marketing, it is important to emphasize what is actually measured, and the reliability of that measurement. At a minimum, calculated values should be separated from analyzed values on lab reports, and both buyers and sellers should understand how they are derived.

FUTURE TRENDS

A casual conversation with 10 ruminant nutritionists will likely reveal at least 11 philosophies of ruminant nutrition, ration balancing, and forage testing. This fact is frustrating to those interested in standardizing forage testing and understanding the use of forage testing in markets, but also reveals a dynamic and changing field. The seemingly confusing array of equations and approaches to forage testing is a reflection of the true complexity of ruminant systems and forages quality. There are genuine conceptual problems in providing a comprehensive approach to forage testing that can handle <u>all</u> forages from <u>all</u> regions for <u>all</u> classes of animals.

Over time, a system of 'fiber-based' marketing methods have evolved, and these standard techniques (ADF, NDF, CP, and DM) are now fairly well adapted across the US. However, there is a need to seek ways of improving this system. A series of recommendations are suggested for the future of forage testing as it relates to marketing of alfalfa hay for dairy production:

- **Use of a single fiber value** as a starting place. We recommend using NDF as a starting (minimum) value for marketing as a simplification of the TDN or RFV systems. The TDN and RFV systems in reality consist of a 'fiber-based' system anyway, so such a move would remove some of the confusion and negative aspects of calculating TDN and RFV. Furthermore, standardization on a <u>measured value</u> would enable more consistent reporting across marketing regions. NDF is the obvious candidate.

- **Drop ADF-based tools.** We should move from ADF to NDF as a primary tool for a fiber-based marketing system, since NDF is of stronger interest to nutritionists. ADF and NDF are highly correlated in pure alfalfa hays. NFTA labs have shown that NDF can be standardized to minimize lab-lab variation.
- **Expression of lab values on 100% DM basis** (including ADF, NDF, CP as well as TDN). It should be understood that forage quality measurements in the marketplace should be compared at a 100% DM basis. Confusion arises when other forms of expression are used.
- **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, needs some attention.
- **Measurements of Protein Degradability.** There is a clear need to evaluate the degradability of the protein fraction of forages—particularly as biotechnology and other genetic innovations come on the scene.
- **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.
- **There is a need for improved 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. None of these analyses are worth their while if widely-accepted protocols for sampling and lab analyses are not followed.

CONCLUSIONS

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 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, Ash, or other measurements may assist in differentiating these hay products and improve prediction of the feeding value, if those measurements can be shown to be rapid and repeatable. More sophisticated methods to incorporate additional measurements into the marketplace are needed.

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