DEFINING AND RE-DEFINING FORAGE QUALITY

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ABSTRACT

Forage quality is primarily a measure of the potential for forage to provide energy to an animal. Forage quality is heavily influenced by the amount of fiber (measured as ADF or NDF) and the digestibility of fiber. Forage labs routinely measure the fiber content of forages. Recent advances in forage testing make it possible to evaluate fiber digestibility more accurately than before. Incorporating measures of fiber digestibility into hay marketing equations and quality indexes like RFV would substantially improve their accuracy as measures of forage quality. This could be especially beneficial to hay growers as new technologies such as reduced lignin alfalfa come into the market.

Key words: Alfalfa, NDF digestibility, Dairy

INTRODUCTION

Reduced-lignin alfalfa varieties have the potential to significantly improve alfalfa quality. Dairy nutritionists expect that feeding reduced lignin alfalfa will make it possible sustain more milk per cow on forages with similar fiber content as conventional varieties of alfalfa. Reduced lignin alfalfas may also allow hay producers to move to longer harvest intervals to improve yields per cutting and reduce cuttings per year (Figure 1). This improved quality is due in part to a slightly slower accumulation of fiber as the alfalfa matures. The other advantage of reduced lignin technology is that fiber digestibility is also significantly higher than in conventional alfalfa. This means that reduced lignin alfalfa varieties could be cut 5 to 7 days later than conventional hays and still have TDN values comparable to earlier cut conventional hays.

The current system for pricing and evaluating forage quality present a challenge for hay growers who are considering whether or not to produce reduced lignin alfalfa. The Western Hay Equation and Relative Feed Value (RFV) are two commonly used tools for pricing hay and evaluating hay quality. Both of these measures only consider the fiber content of forage when evaluating forage quality. Since neither the Western Hay Equation or RFV evaluate fiber digestibility, the added value of a new technology like reduced lignin alfalfa is not fully accounted for.

The objective of this presentation is to propose an adjustment to the current system of forage quality evaluation that would account for fiber digestibility.

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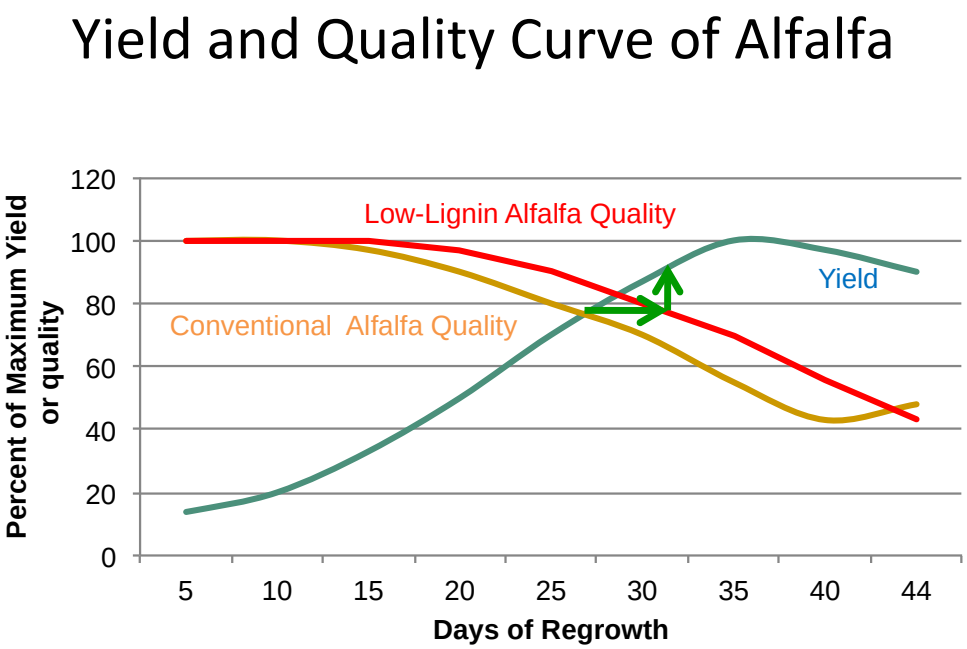
Figure 1. Potential management strategies with reduced lignin alfalfa. Reduced lignin alfalfas appear to decline in quality more slowly than conventional alfalfa varieties. The higher quality of reduced lignin varieties is due to a significantly higher fiber digestibility and a slightly slower rate of increase in fiber as the forage matures.



CURRENT SYSTEM FOR EVALUATING ALFALFA QUALITY

For hay growers in the western US, forage quality is indexed by the Western Hay equation and hay market grades. Hay grades are used to categorize forages based primarily on their Acid Detergent Fiber (ADF) content (Table 1). This system assumes that the hays have less than 10 % grass and normal visual appearance. This system is relatively simple and relies on ADF as the measure of fiber. ADF is routinely measured by virtually all forage testing labs and is a quick, precise lab assay procedure.

Relative Feed Value is a forage quality evaluation tool that indexes forage quality based on intake potential and digestible dry (DDM) content. Intake potential of forages is correlated to the bulkiness or gut fill characteristic of the forage. The intake potential of forage is best predicted from its Neutral Detergent Fiber (NDF) content. The DDM composition of alfalfa can be predicted from its ADF content. (see footnote in Table 1). Finally the RFV indexing system is divided by a constant 1.29 to scale the RFV values such that full bloom mature alfalfa has a RFV value of 100. Dairy quality hay is generally considered to be at least 150-160 RFV in the Midwest, and over 175 in Western hay markets.

Table 1. Alfalfa hay test guidelines, for domestic livestock use and not more than 10% grass.

Hay Grade	ADF	NDF	Relative Feed Value*	TDN** (90% DM)
Supreme	<27	<34	>185	55.9
Premium	27-29	34-36	170-185	54.5-55.9
Good	29-32	36-40	150-170	52.5-54.5
Fair	32-35	40-44	130-150	50.5-52.5
Utility	>35	>44	<130	<50.5

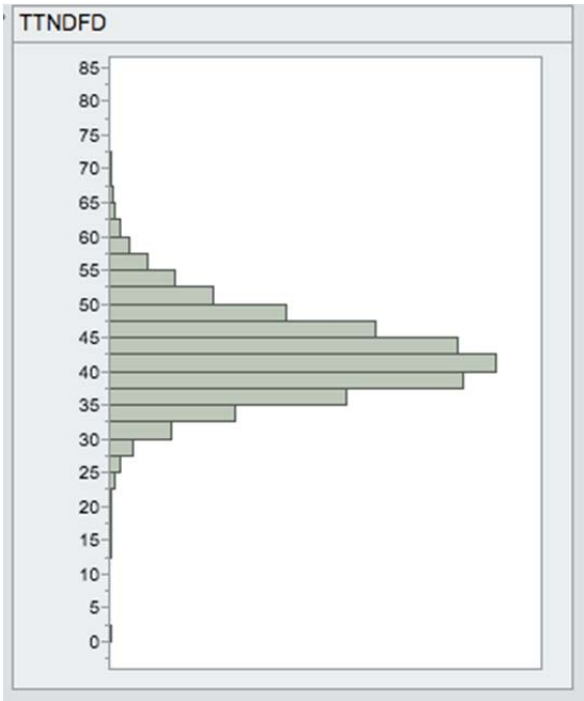
* RFV = [120/NDF x (88.9 – (0.779 x ADF))]/1.29
** Western Hay Equation, TDN (90% DM hay) = 0.9 x [(82.38 – (0.7515 x ADF).

Neither the Western Hay equation nor RFV account for variation in forage fiber digestibility. Fiber digestibility varies considerably in forages (Figure 2). This variation in fiber digestibility can have a significant impact on the forage TDN value. The mean NDF digestibility in alfalfa is 42% of NDF. This means that for every pound of NDF consumed, 0.42 lb of NDF is digested and utilized as a source of energy by a ruminant. The Standard Deviation (SD) of NDF digestibility in alfalfa is approximately 7% units, which means that 2/3 of all alfalfa samples will range in fiber digestibility from 35 to 49%. A one standard deviation difference from the mean in fiber digestibility (42% to 49% fiber digestibility) will change the energy value of forage by approximately 2 TDN units. In the current hay quality system a two-unit change in TDN could increase or decrease the alfalfa quality by one hay-grade.

Fiber digestibility is influenced by plant genetics and by the environment. Plant geneticists are developing reduced lignin (high fiber digestibility) alfalfa by natural plant selection techniques or by developing GMO lines of alfalfa. Plant breeders have been successful in improving alfalfa fiber digestibility by both methods. The fiber digestibility of conventional and reduced lignin alfalfa also is affected by growing environment. Alfalfa grown in cooler climates with high sun intensity will have higher fiber digestibility than the same variety grown in hot environments with less sun intensity.

Laboratory methods are now available to detect differences in fiber digestibility and we propose that Hay Market Equations and indexing tools like RFV could be adjusted to reflect the impact of forage fiber digestibility on forage quality.

Figure 2. Variation in total tract NDF digestibility (TTNDFD) of alfalfa NDF. Higher than average fiber digestibility (> 42% of NDF) increases the TDN content and lower than average TTNDFD (< 42% of NDF) decreases TDN content. Data provided by Rock River Labs Inc., Watertown, WI.



A PROPSOSAL FOR ADJUSTING HAY MARKET GRADES AND RFV FOR FIBER DIGESTIBILITY

The Western Hay Market equation and RFV are widely used and hay growers and hay buyers are familiar with the values of TDN and RFV. I recognize that growers and buyers may be reluctant to adapt a totally new system of forage quality evaluation, so rather than introduce a new forage evaluation system with its own metric of describing forage quality, an adjustment of TDN and RFV is proposed. This would mean that 'typical' forages would continue to have TDN and RFV values that match the current hay market system. The TDN value of alfalfa samples with higher of lower than average NDF digestibility, however, would be adjusted to reflect the gain or loss in digestible energy from fiber. The lab measure of fiber digestibility could be TTNDFD or $NDFD_{48}$. Both tests are in vitro lab tests that have been calibrated to NIR and are or could be adapted by any forage-testing lab.

An example of how the proposed system could work is shown in Table 2. The 'baseline' RFV and TDN would be determined as they are now. TDN determined by the Western Hay equation assumes that average TTNDFD of the forage is 42% of NDF. If the in vitro TTNDFD or $NDFD_{48}$ lab assays indicate that the forage has 'normal' fiber digestibility, no adjustment of TDN or RFV would be done. If however, the TTNDFD assay or $NDFD_{48}$ assay indicates that

the fiber is lower or higher in digestibility than normal, the TDN values would be adjusted.

A scenario for a forage with a fiber digestibility that is one standard deviation higher than the average TTNDFD is shown in Table 2. An alfalfa with a TTNDFD value one standard deviation higher than average would provide enough additional energy to raise the TDN content of this alfalfa by approximately 2 units. (Preliminary data with reduced lignin alfalfas have shown that the in vitro NDF digestibility has been increased by about one standard deviation from the mean of conventional alfalfas across several cuttings). The deviation in TDN from average would be added to the base TDN as calculated by the Western Hay equation. In the case of the Supreme Grade alfalfa, this would adjust the TDN value of this hay from 55.8% TDN to 57.8 % TDN.

Table 2. A possible approach to adjusting TDN and RFV to account for changes in fiber digestibility in alfalfa.

Hay Grade	RFV[a]	Western hay TDN value [b] (90% DM)	Adjusted TDN value if fiber digestibility is 1 SD higher than average[c]	Change in TDN	Adjusted RFV
Supreme	185	55.8	57.8	2.0	205
Premium	170	54.5	56.6	2.1	191
Good	150	52.5	54.8	2.3	175
Fair	130	50.5	53.3	2.8	159

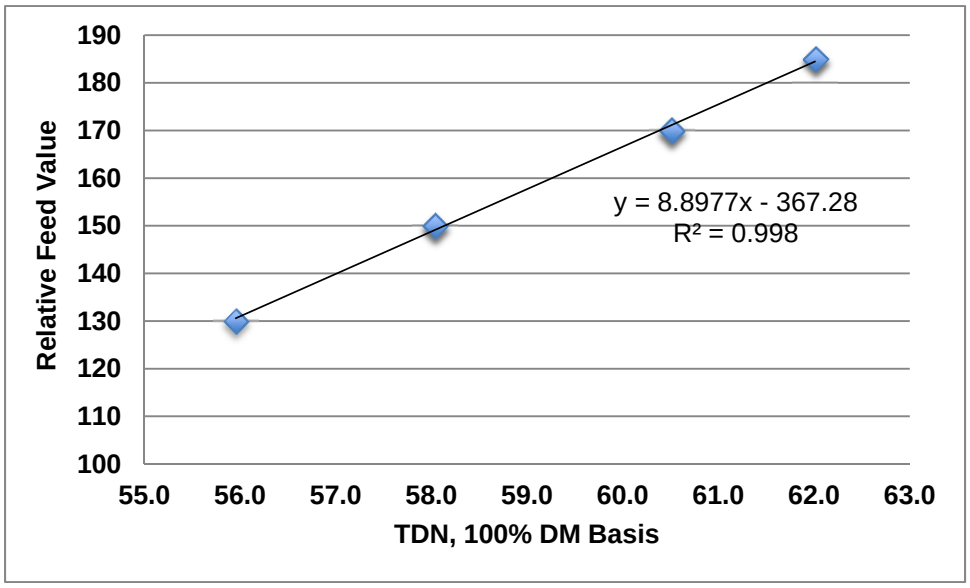
[a] Relative feed value (RFV) also does not account for variation in fiber digestibility.

[b] TDN values are determined by the Western Hay Equation (TDN, % of DM = 82.38-(0.7515 x ADF(%of DM). The Western hay equation does not adjust for variation in fiber digestibility.

[c] Adjustment in the Western Hay TDN value made by adding change in TDN value to base Western Hay TDN value.

The adjusted RFV value is determined from the relationship of RFV and Western hay market estimates of TDN (Figure 3). This regression indicates that for every unit increase in TDN on a DM basis, the RFV will increase by 8.9 units. The 'Adjusted RFV' accounts for the improved fiber digestibility.

Figure 3. Relationship of Relative Feed Value and TDN as measured by the Western Hay equation. A one-unit change in TDN raises the RFV value by 8.9 units.

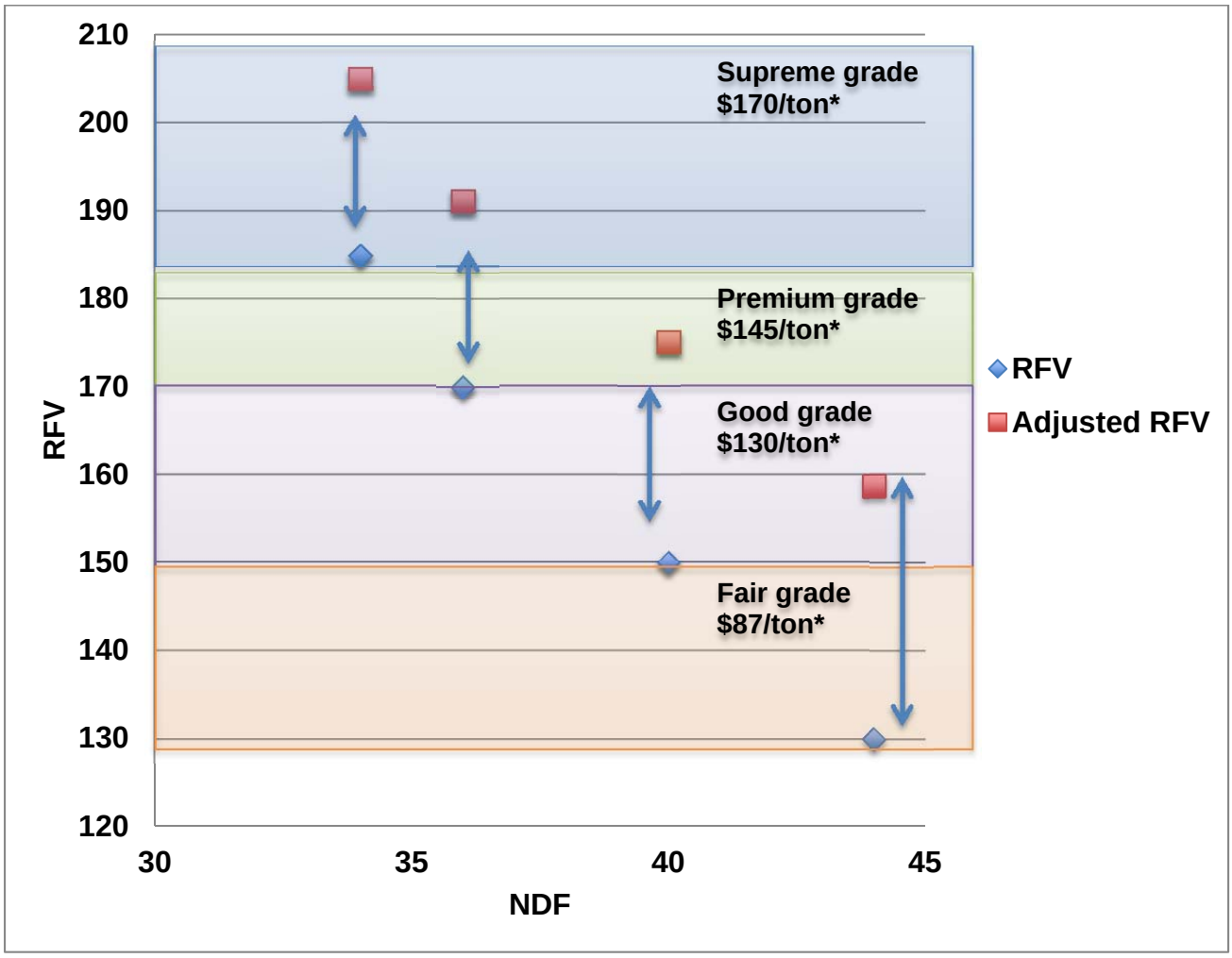


The potential impact of adjusting the RFV of alfalfa forages that are one standard deviation higher in fiber digestibility than average are shown in figure 4. In this example, a Supreme, Premium, Good, Fair and Utility forage that each grade on the low end of the hay grade range is adjusted for RFV to account for higher than average fiber digestibility. For each of the four example alfalfa forages shown, a one standard deviation increase in fiber digestibility would increase the forage by one hay-grade. The value of the hays that were originally graded premium, good or fair would increase in value by $25, $15 and $43/ton, respectively.

Implications

The current hay market and RFV system does not account for variation in fiber digestibility. Reduced lignin alfalfa is an example of new forage technologies that we expect will consistently improve fiber digestibility. Reduced lignin alfalfa with the same fiber content as a conventional alfalfa could be as much a 2 units higher in TDN than the conventional alfalfa. Costs associated with new innovations in forage production, such as technology fees or higher seed costs, must eventually be covered by those that benefit from the technology. Hay producers will find it more attractive to adopt technologies like reduced lignin alfalfa if they can be fairly compensated for the higher quality associated with these new forage products.

Figure 4. Example of how a one standard deviation increase in fiber digestibility could influence Hay Market Grades if RFV and TDN were adjusted to reflect the increase in fiber digestibility.



* Based on market price of alfalfa hay in northern California, November 4, 2016. USDA Ag Market News (www.ams.usda.gov)