FORAGE QUALITY AND UTILIZATION: TOTAL TRACT NDF DIGESTIBILITY

Dr. Dave Combs[1]

ABSTRACT

A new in vitro lab assay has been developed by UW-Madison Dairy Scientists that predicts total tract NDF digestion in ruminants. The in vitro TTNDFD assay predicts NDF digestion of alfalfa, corn silage, grass forages and byproduct feeds. UW-Madison researchers have validated the accuracy of the in vitro TTNDFD test against directly measured NDF digestibility lactating dairy cattle. The University of Wisconsin recently was awarded a patent for the test and Rock River Labs in Watertown, Wisconsin is a licensed provider of the TTNDFD assay.

Key words: Alfalfa, NDF digestibility, Dairy

INTRODUCTION

Fiber is an essential component of diets for dairy cattle. In high producing dairy cows, about 20 to 25% of the energy for milk production comes from digested fiber. Neutral detergent fiber (NDF) is a forage test that measures the total amount of fiber in a feed. NDF represents a 'bulky', slow to digest feed component, which can restrict feed intake and milk production. Forages are tested for NDF and lactating dairy cow diets are typically formulated to contain 28-35% NDF.

The digestibility of NDF also profoundly affects intake and milk production. Fiber digestibility can have a much greater impact on milk production than the digestibility of any other feed component. The fiber digestibility of 38% NDF alfalfa can vary from 30% to over 60%. In a dairy ration containing about 15 lbs of this alfalfa, a doubling of fiber digestibility (30 % TTNDFD to 60% TTNDFD) would increase the digestible energy enough to support up to 8-10 pounds more milk per day.

HOW IS TTNDFD DIFFERENT FROM OTHER LAB TESTS?

The TTNDFD assay is different from other fiber quality measures because it is a direct quantitative predictor of fiber digestion. Other tests such as NDFD30, relative feed value (RFV) relative forage quality (RFQ), milk per acre or milk per ton (Milk 2006) are used to compare the relative differences in forage quality among alfalfa varieties or corn silage hybrids. These indexes can't be used to compare forages across types however, which limits their value as decision-making tools for optimizing the combination of corn silage, alfalfa and grass in dairy forage systems. These indexes also cannot be used in ration balancing.

[1] Dr. David Combs (dkcombs@wisc.edu) is a Professor in the Department of Dairy Science at the University of Wisconsin-Madison. **In**: Proceedings, 2015 Western States Alfalfa and Forage Symposium, Reno, NV, 2-4 December, 2015. UC Cooperative Extension, Plant Sciences Department, University of California, Davis, CA 95616. (See http://alfalfa.ucdavis.edu for this and other alfalfa conference Proceedings.)

Most forage testing labs offer in vitro and in situ NDFD assays to estimate and compare fiber digestibility among forages. *In vitro* NDF digestibility measured after 30 hours (NDFD30) or 48 hours (NDFD48) are widely used to index forage fiber digestibility. These tests have limited value because they measure relative, not absolute fiber digestion. Oba and Allen (1999) reviewed several feeding studies with dairy cattle and concluded that a 1 % change in vitro or in situ NDF digestibility was correlated with a 0.4 lb increase in voluntary dry matter intake, and 0.5 lb increase in 4% fat corrected milk yield. The change in situ or in vitro fiber digestibility within a study was correlated with intake and milk production, but there was no significant correlation between the absolute measures of fiber digestion and intake or milk yield across studies. One reason why absolute NDFD values across labs are poorly correlated to intake or milk production is because the procedures for running these tests differ by lab. In addition, surprisingly little work has been published to validate laboratory measures of rumen fiber digestion to observed fiber digestion in cattle. The TTNDFD assay specifically measures and accounts for several factors that influence NDF digestion. The estimates of NDF digestibility derived from the TTNDFD test have been confirmed by feeding trials.

HOW DOES TTNDFD WORK?

The TTNDFD test is designed to predict how the process of forage fiber digestion is expected to occur in high producing dairy cows. There are at least four critical factors that affect fiber digestion and the TTNDFD test accounts for each factor:

1. *The proportion of feed fiber that is potentially digestible.* Forage NDF consists of two components, a potentially digestible (pdNDF) component and an indigestible NDF (iNDF) component. The proportion of NDF that can potentially digest varies due to feed type and growing environment. On average, about 60 to 65% the NDF in alfalfa is potentially digestible. The proportion of potentially digestible fiber in corn silage is typically greater than in alfalfa NDF: 75 to 85% of corn silage NDF is potentially digestible. The proportion of NDF that is indigestible is typically estimated from long term incubations of fiber in the rumens of cattle or long term *in vitro* digestions. The NDF residue remaining after 240h of incubation ($uNDF_{240}$), for example is often used as an estimate of iNDF. The potentially digestible proportion of NDF determined by subtracting the uNDF fraction from total NDF.

2. *The rate of digestion of potentially digestible fiber (kd).* The rate of fiber digestion also differs due to forage type and growing environment. The potentially digestible fiber in alfalfa digests nearly twice as fast (4-6% per hour) as the potentially digestible NDF in corn silage (2-3% per hour). The TTNDFD values for alfalfa and corn silage are similar, but the process of NDF digestion is quite different between these two forages. In corn silage, there is a larger fraction of digestible fiber that digests slowly. In alfalfa, there is a smaller proportion of digestible fiber, but the digestible fiber in alfalfa digests nearly twice as fast as corn silage fiber.

3. *The rate of passage of potentially digestible NDF through the cow (kp).* Both cow size and feed intake affect the passage rates of pdNDF and iNDF. As intake goes up, the rate of passage of both fractions increase, and as a result NDF digestibility declines. Passage of the pdNDF fraction is also slower than passage of the iNDF fraction. The TTNDFD test specifically accounts for the rate of passage of the potentially digestible NDF.

4. *Ruminal and hindgut fiber digestion.* Approximately 90-95% of fiber digestion occurs in the rumen, but digestion beyond the rumen must be accounted for if one is to accurately predict the amount of energy derived from NDF. When both ruminal and hindgut digestion are accounted for, a total-tract NDF digestion (TTNDFD) measurement can be calculated and this digestion coefficient can be directly validated with dairy cattle.

An accurate assessment of fiber digestion requires that the four factors be integrated into a single measurement. The TTNDFD assay integrates all four of the above factors into a single value. TTNDFD predicts the proportion of the total NDF that will digest between the mouth and feces. The NDF that digests between the mouth and feces is the energy from fiber that can be used to support milk production.

VARIABILITY IN FORAGE TTNDFD VALUES

Typical TTNDFD values for corn silage, alfalfa and grasses are summarized below. The average values represent over 7000 samples each of corn silage or alfalfa and over 1200 grass forage samples. The means, standard deviations (SD) and ranges in TTNDFD values coincide with directly measured values that have been reported in dozens of controlled feeding studies published in scientific journals such as the Journal of Dairy Science.

Table 1. Typical TTNDFD values of corn silage, alfalfa or grass*.

	Mean	SD	Range
	-------TTNDFD©, % of NDF----------		
Corn Silage	42	± 6	20-60
Alfalfa	43	± 7	30-60
Grass	47	± 8	20-80

Samples submitted to Rock River Laboratories, Watertown, WI.

HOW TO USE TTNDFD IN CONSULTING

Our validation studies with corn silages, alfalfa and temperate grasses indicate that TTNDFD values of feeds can be used in ration formulation and evaluation to 'fine-tune' the amount and overall digestibility of NDF in rations of high producing dairy cattle. The average TTNDFD value for most diets formulated with alfalfa and corn silage will be about 42 to 44% and this should be a target for ration formulations.

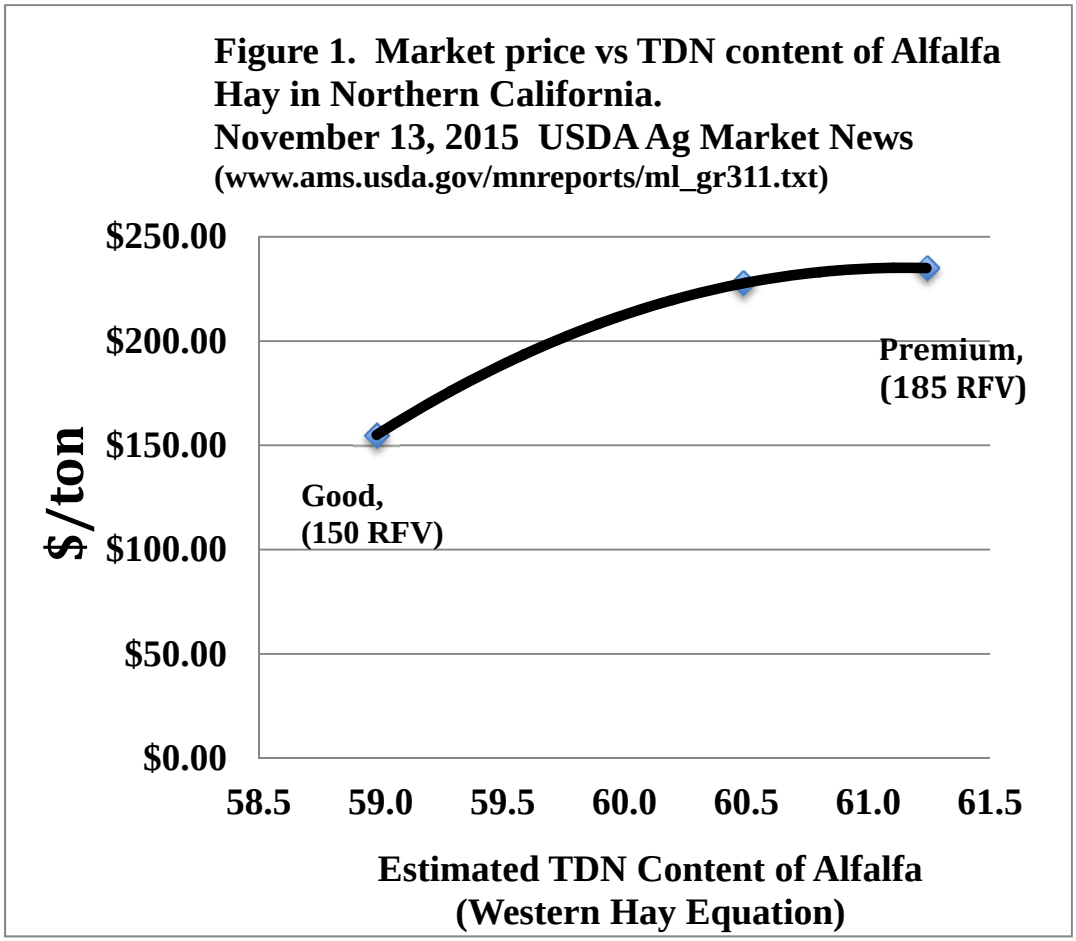
The ability to predict fiber digestibility and incorporate this information into rations could improve our ability to optimize forage utilization and milk production. An alfalfa with a TTNDFD value lower than 42% will not be utilized as well as 'typical' alfalfa hay. Experiences in the field indicate that cows fed low TTNDFD forages produce less milk and have lower feed intake than cows fed diets with that contain forages with more digestible fiber. Likewise, an alfalfa with a TTNDFD value greater than 42% would be expected to feed better than a 'typical' alfalfa.

UW-researchers have also shown that replacing low TTNDFD forages with alternative forages that have higher TTNDFD values increase milk yield and/or improve feed efficiency. In several cases, we have been able to increase milk yield while actually increasing the total NDF level of the diet by using forages with more highly digestible NDF.

The TTNDFD value can be used as a stand-alone value to compare fiber digestibility of forages. In top quality forages, NDF accounts for 35-45% of the total dry matter and this fiber is the source of 30 to 40% of the digestible energy of the forage. A consultant could compare values from their forage test to the values in Table 1. A forage with lower than average TTNDFD likely will not be utilized as well as 'typical' forage containing similar amounts of total NDF.

POTENTIAL TO USE TTNDFD TO ADJUST MARKET VALUE OF ALFALFA

The estimated TDN of alfalfa hay heavily influences its market value. The market value of alfalfa hay sold in Northern California in mid November, 2015 ranged from $155/ton for Good Quality (RFV about 150, 29% ADF) to $235/ton for Premium Quality alfalfa (185 RFV, 27%



ADF) (Figure 1). The graph also shows that the price of alfalfa decline quickly when TDN values drop below 60%. The 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. Relative feed value (RFV) also does not account for variation in fiber digestibility.

Forages with higher than average NDF digestibility will have greater TDN values than forages with typical NDF digestibility values. Table 2 shows how the market values of forages potentially could be affected if they were adjusted to account for fiber digestion. In this table, I have assumed that the NDF digestibility of the typical alfalfa is 42%. I then attempt to show how the TDN values would change if the TTNDFD values were actually 48%. For each of the three forages, an increase in TTNDFD by 6% units increased the TDN values from 2 to 2.5% units. In this hypothetical scenario, the improvement in TDN in the Premium hay (NDF, 35%, RFV 178) would increase the market value minimally because market values of hays with greater than 62% TDN don't tend increase as TDN values increase. The Good grade of hay however would theoretically be valued at nearly $70/ton more if its TTNDFD value was 48% instead of 42%.

Table 2. Potential increase in market value of alfalfa hay that contains higher than average NDF digestibility (48 TTNDFD vs 42 TTNDFD).

NDF	TTNDFD	RFV	TDN (western equation)	Market value $/ton *	Increase in TDN due to higher NDF digestibility	Revised market value	Increase in market value
35	42	178	61.2	235			
35	48	178	61.2		2.1	> $235	minimal
38	42	162	60.5	228			
38	48	162	60.5		2.3	> $ 235	$ 7/ton
41	42	147	59.0	155			
41	48	147	59.0		2.5	$235	$ 70/ton

* Based on market price of afalfa hay in northern California. November 13, 2015. USDA Ag Market News (www.ams.usda.gov/mnreports/ml_gr311.txt)

SUMMARY

The key to getting the most out of forages is understanding how forage energy values are affected by NDF and NDF digestibility. The TTNDFD test is intended to be an additional tool to provide a clearer understanding of how forage fiber is utilized by dairy cattle. It is not intended to be the only tool to use to evaluate forage quality or fiber utilization by dairy cattle. But it can provide valuable insights into evaluating forages and predicting animal performance.