TTNDFD: A NEW APPROACH TO EVALUATE FORAGES

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INTRODUCTION

Fiber is a complex material whose digestibility varies due to forage species, forage variety, plant maturity and growing environment. The NDF fraction represents a 'bulky', slow-to-digest feed component which can restrict feed intake and energy utilization. While this is a critical measure of feed quality, it only reveals part of the story about fiber. In order to optimize the utilization of forages, fiber digestibility (pdNDF) and the rate at which fiber digests (kd) must also be accounted for because both greatly affect feed intake and production. Fiber digestibility is more variable than the digestibility of any other feed component and the NDF fraction accounts for 30 to 40% of the digestible energy (DE) in high quality forages. Apparent total tract NDF digestibility is commonly reported in forage evaluation studies and provides a useful measure of the contribution of fiber to the DE value of feeds. The objective of this paper is to present an approach for measuring and indexing forage digestibility that can be used in the field to formulate diets and evaluate feeds.

QUANTIFYING FIBER DIGESTION

Total tract apparent NDF digestibility values for diets fed to dairy cows are readily available and are a valuable tool for field nutritionists. Goeser (2008) summarized total tract NDF digestibility measurements that were reported 25 corn silage feeding trials (81 treatment comparisons) and in 20 trials in which legumes and grasses (64 treatment comparisons) were the primary forages fed to high producing ruminants (Table 1). Total tract NDF digestibility of legumes and grasses averaged about 7 units higher than in corn silages. In both data sets the variation was normally distributed. Summary statistics from the published studies suggest that in vivo NDF digestibility coefficients can vary by 30 to 35% units among legumes, grasses and corn silages. A more recent survey of corn silage based feeding trials (Ferraretto and Shaver, 2012) reported that the treatment means for total tract NDF digestibility averaged 44.3 ± 2.5 % in 106 treatment observations from 24 dairy feeding trials that were published in peer-reviewed journals between 2001 and 2011. It is apparent that ruminants do not fully compensate for differences rates of fiber digestion (kd) by adjusting their voluntary DMI to alter passage (kp) of potentially digestible fiber. Therefore, an estimate of total tract fiber digestibility can provide useful information about fiber utilization.

Measuring fiber digestion in vivo with the rumen evacuation method.

Measuring ruminal fiber digestion kinetics in vivo is laborious and expensive, but is the 'gold standard' to which other methods should be compared. The kinetic parameters needed to estimate the extent of ruminal fiber digestion include the

proportion of fiber that is potentially digestible (pdNDF), the rate of digestion of the potentially digestible fraction (kd) and the rate of passage of the potentially digestible portion of NDF (kp).

In vivo fiber digestion kinetics is most commonly measured by the 'rumen evacuation' technique (Taylor and Allen, 2005, Huhtanen et al., 2007, Ivan et al., 2005). Rumen pools of digestible and indigestible fiber are measured by total rumen evacuation. Passage rates of pdNDF and indigestible NDF from the rumen are determined by dividing the flow of the fiber component from the rumen by the pool size of the fiber component, and rates of pdNDF digestion are calculated by subtracting the passage rate of pdNDF from turnover rate of pdNDF (Huhtanen et al., 1997).

About 90 to 95% of total tract fiber digestion occurs in the rumen in dairy cattle fed diets based on grasses, legumes and/or corn silage (Huhtanen et al., 2010). The ruminal digestion process can be fit to a simple first-order digestion model with an indigestible fraction (Waldo et al. 1970). Fiber digestibility is ultimately the result of the interaction of Kd and Kp and can be described mathematically as: Proportion of potentially digestible fiber digested =pdNDF x ((Kd)/ (Kd + Kp)) (Mertens, 2002)

Table 1. Total tract NDF digestibility coefficients reported in peer-reviewed feeding studies. (Goeser, 2008)

		In vivo total tract NDF digestibility
Legume/grass feeding trials (20 trials, 64 treatment observations)	Mean	47.3 % of NDF
	Median	47.5 % of NDF
	Range	31.1-66.2 % of NDF
	St. Dev.	8.1
Corn Silage/Sorghum feeding trials (25 trials, 81 treatment observations)	Mean	40.2 % of NDF
	Median	41.1 % of NDF
	Range	20.1-58.8 % of NDF
	St. Dev.	8.8

Despite the cost and labor, a relatively large number of rumen evacuation studies that have been done in the US and Northern Europe with dairy cattle. The fiber digestion module of the recently published Nordic Feed Evaluation system (NorFor) is based on fiber kinetic parameters estimated by the rumen evacuation technique (NorFor, 2011). Krizsan et al. (2010), compared ruminal passage rates of indigestible NDF as measured by the rumen evacuation technique to empirical estimates of particulate passage rate in cattle. Their database included 49 studies in which 172 treatment means were measured. Huhtanen et al., (2010) also published a meta-analysis of NDF digestion using the rumen evacuation method and omasal sampling. Thirty-two studies and 122 diets were included in this analysis. Most of the published studies are with lactating dairy cattle fed grass, alfalfa or corn silage based diets.

The rates of NDF degradation of diets when measured by the rumen evacuation method typically range from approximately 2% to 6% per hour. Taylor and Allen (2005) reported that the rate of ruminal digestion of potentially digestible NDF from diets formulated with normal and BMR corn silages varied from 2.7 and 3.3% per hour when measured by the rumen evacuation technique. These values are consistent with ruminal digestion rates estimated by Ivan et al. (2005) in corn silage based diets when measured by ruminal evacuation method and by Greenfield et al. (2001) who measured corn silage fiber digestion kinetics in lactating cows that were surgically fitted with rumen and duodenal cannula. Volker Linton and Allen (2008) reported that the ruminal NDF digestion rate of an alfalfa based diet and an orchard grass diet were 7.5% and 5.8% per hour, respectively. Corn silages typically have slower fractional rates of NDF degradation than legumes and temperate grasses are more variable in rates of fiber digestion than corn silages or alfalfa.

It is important to emphasize that the digestion and passage of potentially digestible fiber are measured with the rumen evacuation method. This is not the same as measuring digestibility and passage of intact feed particles with external markers and spot sampling. The dairy NRC (2001) and the Cornell Net Carbohydrate and Protein System (CNCPS) predict particulate passage rates for concentrates and forage feeds and use particle passage rates as the estimate of fiber passage. Fiber is part of the particulate fraction of feeds, but fiber passage rates are significantly lower than feed particle passage (Krizsan et al., 2010). In addition, pdNDF is selectively retained and passes from the rumen at a fractional passage rate approximately .8 of the fractional passage rate of total NDF (Lund et al., 2007).

If the rates of fiber passage are over-estimated, ruminal fiber digestion will be under-estimated relative to the values observed from in vivo feeding studies. The over-estimate of kp appears to be compensated for by what appear to be over-estimates in the rates of NDF degradation in the NRC and CNCPS. Raffrenato and Van Amburgh (2010) reported that the average composite rates of pdNDF degradation for corn silage was approximately 6% per hour for normal corn silage and 7.8% per hour for BMR corn silages, and 11.3% per hour for alfalfas. Results from the meta analysis of Krizsan et al. (2010) found that the fiber degradation rates used in the NRC dairy model and the CNCPS are higher than those measured in vivo. These kd values are one and half to twice as high as digestion rates for similar forages when measured in vivo by rumen evacuation. Fiber digestion rates used in CNCPS model are also significantly higher than the rates for forages of similar composition listed in the NorFor feeding system library, and the empirical prediction equation for forage fiber digestion rates in the NorFor model results in much lower rates of passage than the NRC or CNCPS equations for particulate passage. Allen (2011) also suggests that fiber digestion determined from in vitro methods (traditional in vitro method) over-estimate in vivo fiber digestibility.

Estimating rumen fiber degradation from in vitro NDFD values

Single time point in vitro and in situ analysis are widely used as an alternative to in vivo methods for estimating and comparing rumen fiber digestion. In vitro and in situ analyses measure relative, not absolute fiber digestion. Oba and Allen (1999b) reviewed several feeding studies with dairy cattle and concluded that a 1% change in vitro or in situ NDF digestibility (primarily 30-h or 48-h NDFD) was correlated with a 0.17 kg increase in voluntary dry matter intake, and 0.25 kg 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. For field nutritionists, this suggests that in vitro methods differ enough from lab to lab to make it impractical to compare results between labs. It also is not recommended to compare in vitro digestibility values across forage types.

Another problem with single time point in vitro NDFD assays is that the value doesn't segregate the indigestible NDF from the residual pdNDF nor does it reflect the rate of fiber digestion. A single time point in vitro NDFD assay simply indicates how much residual fiber remains after a specific time period of exposure to rumen fluid. The residue measured includes the indigestible fiber fraction plus the residual potentially digestible fiber remaining. An example can demonstrate the shortfalls of comparing fiber digestibility based on a single time point NDFD assay. In Figure 1 are the in vitro NDFD values of two forages with similar concentrations of NDF (40%). Forage A has higher NDFD values after 24 and 30 hours of in vitro fermentation than forage B but at 48 and 96 hours the NDFD values for forage B are higher.

The fiber digestion kinetic parameters of the two forages are summarized in Table 2. The two forages differ in proportion of NDF that is digestible (pdNDF) and the rates at which the pdNDF digests. These kinetic parameters can be derived by estimating the pdNDF fraction and calculating the rate of digestion by plotting the natural log of the potentially digestible NDF fraction verses time. Forage A has a higher indigestible NDF fraction than forage B, but the rate at which the pdNDF digests is faster in forage A. If the pdNDF in both forages were to pass at the same rate, for example 2.7%/h in a high producing cow, ruminal and total tract digestibility would be similar for the two forages. None of the in vitro single incubation time points accurately reflect how these two forages would be utilized by the animal because the individual NDFD values do not separate the pdNDF and rate of fiber degradation within time point. The values of iNDF, or kd of pdNDF in themselves also do not accurately reflect the NDF digestibility of NDF. To further complicate matters, if the passage rate of pdNDF was different from the example, the fiber digestibilities of the two forages will change. An accurate assessment of fiber utilization can only be made by accounting for the pdNDF fraction, the kd and the kp. The coefficients of ruminal or total tract NDF digestibility, when measured in a specific animal at a specific intake, account all three kinetic parameters and therefore more accurately reflect how forage fiber will be utilized by the animal.

Figure 1. NDFD values for forages with similar NDF (40%) after 24, 30 48 and 96 hours of incubation in buffered rumen fluid.

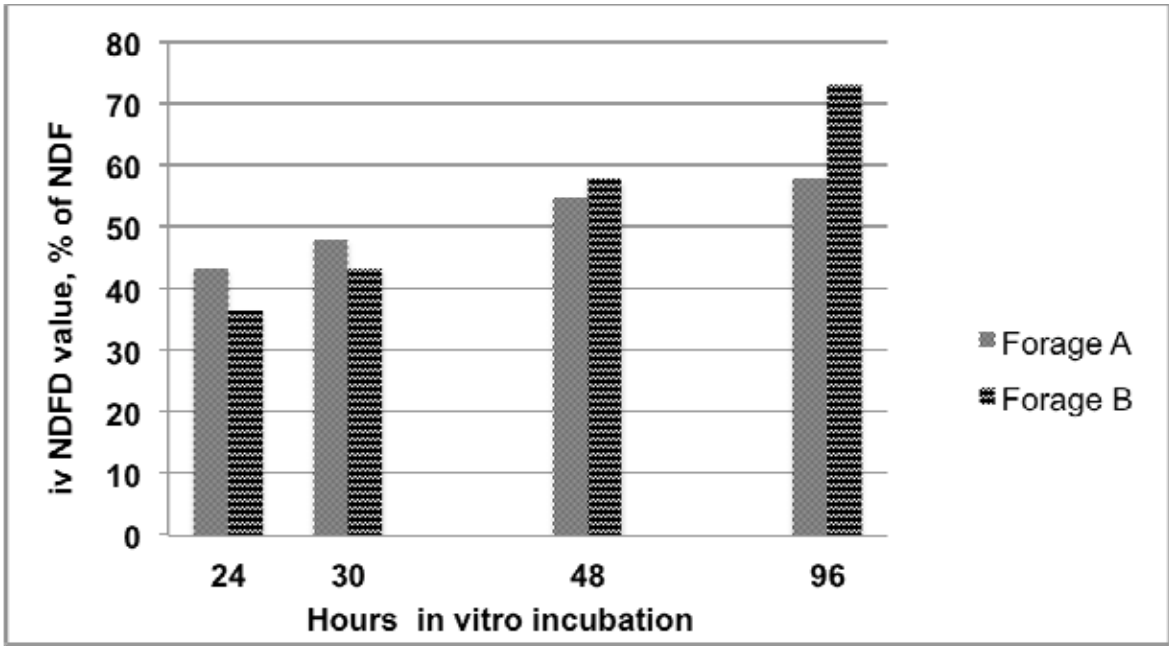

Table 2. Predicted in vivo digestion of fiber from two forages with different pool sizes and rates of pdNDF degradation when rate of passage (kp) is assumed to be .0267/h.

Item	Forage A	Forage B
iNDF, iv 240 h,% of NDF	42	22
kd pdNDF, %/h	6.5	3.0
kp pdNDF, %/h	2.7	2.7
Rumen digestion*		
NDFD, % of NDF	41	41
Total tract digestion**		
NDFD, % of NDF	46	46

*Calculated as pdNDF x kd/(kd +kp)

** Assumes 10% of NDF digestion occurs in the hindgut

Single time point NDFD values are sometimes used to compare fiber quality within forage types. These comparisons are also suspect because iNDF fractions and rates of fiber degradation can vary considerably within forage type. In forages measured in our lab, the iNDF fractions in alfalfa and grasses vary from less than 5% to over 55% of

NDF, while corn silage iNDF values range from less than 10% to over 40% of NDF (unpublished data). Krizsan et al. (2010) reported that iNDF values in a database of 172 feeds ranged from 2.4 to 17.4% of feed dry matter. In addition the estimated rates of degradation of pdNDF vary from about 1% per hour to over 10% per hour when measured by using multiple incubation time points and fitting the disappearance of pdNDF to first order kinetics. These data suggest that a single NDFD30 or NDFD48 hour value, as commonly reported on forage test reports provide little useful information regarding fiber digestibility.

TTNDFD

University of Wisconsin researchers have recently proposed a more direct model of fiber degradation that could be used by field nutritionists. The outcome is a total tract digestibility coefficient for NDF (TTNDFD). The TTNDFD value is benchmarked to fiber digestibility values that have been obtained from feeding studies where NDF digestion has been directly measured. Total tract fiber digestibility is reported because this value can be used in equations to predict forage DE, NE or TDN values. The approach accounts for ruminal and post-ruminal fiber digestion and can be adjusted for changes in fiber passage as size or intake of the animal changes. Multiple measurements of in vitro NDF digestibility are used to calculate a rate of ruminal NDF digestion for a feed (Goeser and Combs, 2009). The NDFD measurements can be done with in vitro analysis or by near infrared spectroscopy (NIR). The ability to rapidly predict TTNDFD of forages from NIR is critical to field nutritionists.

Field observations with TTNDFD

We have been monitoring the TTNDFD values of corn silages, alfalfa and grasses that have been submitted to a commercial forage testing lab for routine analysis. The 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.

Table 3. Typical TTNDFD values of corn silage, alfalfa or grass*.

	Mean	SD	Mean - 1SD	Mean+1SD	Range
	----------TTNDFD©,		% of NDF ----------		
Corn Silage	42	±6	36	48	20-60
Alfalfa	43	±7	36	50	25-80
Grass	47	±8	39	55	6-80

Samples submitted to Rock River Laboratories, Watertown, WI

The means, standard deviations (SD) and ranges in TTNDFD values coincide with in vivo measures of total tract NDF digestibility that have been reported in dozens of controlled feeding studies published in peer reviewed journals.

BMR corn silages and TTNDFD

BMR-corn silages have more highly digestible fiber than conventional corn silages. Corn hybrids with the BM3 mutant have lower lignin and a lower proportion of iNDF than isogenic normal corn silages. Oba and Allen, (1999a) reported that the in 30h IVNDFD for a BM3 corn silage was 9.5% units higher than its isogenic control but when the BMR corn and its isogenic control were fed to lactating cows the diets differed in total tract digestibility by approximately 2% units. Data from our lab (unpublished) indicates that on average, BMR corn silages are approximately 5 units higher in TTNDFD than conventional corn silages if they are compared at equal feed intakes and 2-3 units higher in NDF digestibility if DMI intake (and subsequently kp of pdNDF) is increased by 5 to 7 %. A 5 to 7% increase in intake is consistent with the change in intake observed in feeding studies summarized by Oba and Allen (1999b).

Allen and Oba (2009a) suggest that the improvement in fiber digestibility with BMR lines is largely due to the reduction in the proportion of indigestible fiber. The TTNDFD test indicates that improved fiber digestion in BMR hybrids is the result of a lower proportion of iNDF but that the rate of fiber digestion is also improved. The TTNDFD test also reveals that there is considerable overlap in fiber digestibility between conventional and BMR corn silages, which suggests that growing conditions, time of harvest and other factors beyond plant genetics also affect plant fiber digestibility. These observations are also consistent with what has been directly measured in feeding experiments (Allen and Oba, 1999b, Ivan et al., 2005).

VALIDATING THE TTNDFD APPROACH

We recently completed a series of feeding trials to test and validate the TTNDFD approach. The objective of the first study (Verbeten et al., 2011) was to test the concept that forages with more highly digestible fiber could effectively replace fiber from corn silage and alfalfa. A control diet was formulated with excellent quality corn silage (30.5% DM, 37.5% NDF) and alfalfa silage (44% DM, 36.5% NDF) as the only sources of forage (Table 4). Grass silages were used in test diets to replace one third of the corn silage and alfalfa. One diet was formulated with tall fescue silage (51% DM, 50.1% NDF) and another diet was formulated with meadow fescue silage (38.5% DM, 50.1% NDF). Another diet was formulated with wheat straw (92.1% DM, 79.9% NDF). Wheat straw replaced an equivalent amount of NDF as the diets with the grass silages. Replacement of one third of the corn silage and alfalfa mix with the grass silages raised the diet NDF content, and increased the total tract NDF digestibility. Cows fed the diets including grass silages produced similar levels of milk as compared to the control diet. Adding wheat straw increased the NDF content compared to control, but did not alter total tract fiber digestibility. The additional fiber improved milk fat percentage for all three test diets, but it appeared that fat test was improved more when the fiber was from the more highly digestible fescues than from wheat straw. Partial replacement of corn silage and alfalfa fiber with more digestible fiber from grasses increased total tract digestibility of NDF and improved milk fat test without reducing milk production. This

trial demonstrates that diets can be formulated to improve fiber utilization if fiber digestibility could be measured.

A second study (Lopes et al., 2013a) was designed to compare estimates of ruminal fiber digestion predicted from in vitro NDFD analysis of feeds to the ruminal fiber digestion measured in cattle fed the same feeds. The in vitro TTNDFD model predicts rumen fiber digestibility from the rate of pdNDF degradation (kd), the rate of passage of pdNDF (kp) and the proportion of total NDF that is potentially digestible. The kd is calculated from in vitro NDFD measurements taken at 24, 30 and 48 h of incubation using first order kinetics model with an indigestible fraction (Mertens, 1993). Passage of potentially digestible fiber is predicted from a regression model (Krizsan et al., 2010) for iNDF which is adjusted to account for the selective retention of pdNDF (Lund et al., 2006). The pool of indigestible fiber was estimated from 288 h in situ NDF residues. In this model, the NDF and the TTNDFD value for each feed used is calculated and the NDF and TTNDFD content of the diet is calculated from the values for each feed.

Table 4. Partial replacement of corn silage and alfalfa with grass silage or wheat straw. Verbeten et al., 2011)

	CS/ALF	Tall Fescue	Meadow Fescue	Wheat Straw	
Diet component*, % of DM					
Corn silage	26	17	17	20	
Alfalfa silage	26	17	17	20	
Tall fescue silage	0	17	0	0	
Meadow fescue silage	0	0	17	0	
Wheat straw	0	0	0	8	
High moisture corn	26	25	26	24	
Protein/minerals	22	24	23	28	
Diet composition					
NDF, % of DM	24.2	27.1	27.3	27.6	SE
Results					
DM Digestibility	62.6^{b}	64.9^{ab}	67.4^{a}	62.2^{b}	1.1
NDF digestibility*	25.2^{b}	40.5^{a}	41.1^{a}	29.1^{b}	2.2
DMI, lb/d	58^{ab}	54^{b}	59^{a}	58^{ab}	1.1
Milk fat, %	2.9^{a}	3.4^{b}	3.4^{b}	3.2^{ab}	0.1
3.5% FCM, lb/d	91	92	95	92	2.1

The feeding study was conducted with lactating dairy cows fed either normal corn silage or BMR corn silage as the main source of dietary NDF at ad libitum or restricted (90% of ad libitum) intake (Table 5). The fiber characteristics of the normal corn silage (34.4% NDF, iNDF 41.4% of NDF, kd 3.2%/h) and the BMR corn silage (38.4% NDF, iNDF 25.7% of NDF, kd 3.3%/h) were determined prior to the feeding experiment. The fiber characteristics of the two silages were then used to predict ruminal NDF digestibility of the treatment rations. The predictions for each diet were then compared

to the observed measures of fiber digestion. The in vitro method predicted that the BMR corn silage was higher in NDFD than the normal corn silage because it contains a smaller proportion of indigestible NDF. The observed rumen NDFD values were calculated from the observed rates of pdNDF digestion and passage and the measured pool of pdNDF in the rumens of cows fed the experimental diets. It is important to note that the fiber digestion parameters measured directly in the cows are independent of the in vitro measurements. Results of the study indicate that the predicted values of rumen NDFD were similar to the directly measured rumen NDFD values and provide evidence that supports the concept that in vivo fiber digestion can be predicted from in vitro fiber kinetics.

Table 5. Effects of intake and source of corn silage on ruminal fiber digestion. (Lopes et al., 2013a)

Corn silage source	Normal		BMR		
Intake level	Restricted	Ad Lib	Restricted	Ad Lib	
Normal corn silage, % of TMR	47	47			
BMR corn silage, % of TMR			47	47	
Alfalfa silage, % of TMR	17	17	13	13	
Concentrate, % of TMR	36	36	40	40	
Diet composition					
NDF, % of diet DM	26.1	27.5	26.9	28.3	
iNDF, % of NDF	31.5	31.1	25.9	24.1	
Results					SE
DMI, lb/d	50.8	56.1	49.3	56.3	2.9
4% FCM, lb/d	78.1	75.5	79.0	77.0	2.4
Observed rumen NDFD, % of NDF	35.1	40.5	43.1	41.5	2.5
Predicted rumen NDFD, % of NDF	39.0[c]	38.4[c]	47.5[a]	42.8[b]	0.9

The objective of another in vivo experiment (Lopes et al., 2013b) was to compare estimates of total tract fiber digestion as predicted by the in vitro TTNDFD model to in vivo measurements in lactating dairy cows. Cows were fed diets that varied in proportions of corn silage and alfalfa. The in vitro fiber digestion parameters for corn silage (NDF =34.4%, NDF kd =3.2%/h, iNDF=41.4% of NDF) and alfalfa silage (NDF=34.7, NDF kd =6.1 and iNDF=48.7) indicate that fiber in the corn silage contains less indigestible NDF than alfalfa, but the rate of digestion of alfalfa fiber is faster than corn silage fiber. The feeding experiment measured how cows utilize forages that differ in iNDF and kd (Table 6). The diets contained approximately 55% forage and the dietary NDF concentration was similar across the four treatments.

Feed intake was lower when cows consumed the diets that contained 100% of forage as alfalfa silage than it was when cows were fed diets containing corn silage. Milk yields were similar amongst diets. The observed (in vivo) TTNDFD values were calculated from feed and fecal samples. Cows consuming the diet with alfalfa as the

only forage had higher NDF digestibility than cows on the diets that contained corn silage. Fat corrected milk yield did not differ due to treatment. The NDF digestibility coefficients predicted by the in vitro TTNDFD method were similar to the in vivo values. The fiber digestibility coefficients suggest that the faster rate of fiber digestion of alfalfa fiber compensates for its lower fiber digestibility but as higher proportions of alfalfa forage are fed, the amount of indigestible fiber in the rumen increases and rumen fill becomes a more predominant factor limiting feed intake.

Table 6. Effect of changing ratios of corn silage to alfalfa on intake, production and fiber digestion in dairy cows (Lopes et al., 2013b).

Corn silage:alfalfa ratio	100CS 0AS	67CS 33AS	33CS 67AS	0CS 100AS	
Corn silage, % of TMR	56	37	18	0	
Alfalfa silage, % of TMR	0	19	37	55	
Concentrate mix, % of TMR	44	44	45	45	
Diet composition					
NDF, % of DM	24.9	25.5	24.6	25.5	
iNDF, % of NDF	31.1	31.6	31.8	32.3	
Results					SE
DMI, lb/d	55.4^{ab}	55.7^{a}	53.5^{b}	48.1^{c}	1.8
4% FCM, lb/d	79.6	77.9	77.4	78.3	1.9
Observed TTNDFD, in vivo	38.3^{a}	40.9^{ab}	39.4^{ab}	43.8^{c}	1.9
Predicted TTNDFD, in vitro	38.0	41.0	41.0	45.0	2.1

The three feeding experiments demonstrate that the TTNDFD analysis can provide important insights into fiber utilization by dairy cattle. The rates of fiber degradation determined from the in vitro NDFD assays appear to be consistent with what has been measured in vivo feeding studies. The kd, kp and iNDF parameters predicted by the TTNDFD model appear to be consistent with in vivo measures.

SUMMARY : USING TTNDFD VALUES IN THE FIELD

The key to getting the most out of forages is understanding how energy values are affected by NDF and NDF digestibility. The TTNDFD test is intended to be a tool to more accurately evaluate forage fiber digestibility. In top shelf 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. A 30% NDF diet with a TTNDFD of 33% would support 7 lbs less milk than a 30% NDF diet with a TTNDFD of 45% assuming no reduction in feed intake.

The TTNDFD value can also be used as a stand-alone value to index forages. As discussed earlier, Table 3 summarizes the typical TTNDFD values for forages submitted to a commercial lab for routine testing. A consultant could compare values from their

forage test to these values. For example, note in the table that an average corn silage will have a TTNDFD value of 42%. A corn silage sample with a TTNDFD value one standard deviation below average (less than 36%), would be among the bottom 15% of the corn silages tested. A corn silage sample with low TTNDFD likely will not be utilized as well as 'typical' corn silage. 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, a corn silage with a TTNDFD value greater than 48% is in the top 15% of the corn silage population tested and would be expected to feed better than a 'typical' corn silage. The ability to predict fiber digestibility and incorporate this information into rations could improve our ability to optimize forage utilization and milk production.

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