Relationship Between NDF Digestibility and Animal Performance

David K. Combs

Department of Dairy Science, 1675 Observatory Drive, University of Wisconsin, Madison, WI, 53706
Email: dkcombs@wisc.edu

Take Home Messages

- An accurate laboratory measure of fibre digestibility is essential to optimize the utilization of forages in dairy cattle diets.
- The measure should mimic *in vivo* digestion and should be consistent across forage types.
- A new *in vitro* lab assay has been developed that predicts total tract NDF digestion (TTNDFD) in ruminants. The test is based on a patented and licensed *in vitro* assay and model of fibre digestion.
- The *in vitro* TTNDFD assay is available through commercial labs and has been calibrated to NIR analysis.
- The TTNDFD model predicts fibre digestion of alfalfa, corn silage, and grass forages in cattle and has been validated against directly measured NDF digestibility in lactating dairy cattle.

Introduction

The digestibility of neutral detergent fibre (NDF) is more variable than the digestibility of any other feed component and can profoundly affect intake and milk production. In high producing dairy cows the variation in total tract fibre digestion can account for enough energy to support as much as 4 to 5 liters of potential milk yield. Fibre digestion is affected both by characteristics of the plant material and by the animal consuming the fibre. To accurately predict how fibre will be utilized, laboratory measures that predict the rate of fibre digestion and the proportion of total fibre that is potentially digestible are needed. The rate and potential extent of NDF digestion are heavily influenced by the genetics and growing environment of the forage. Fibre digestion is also affected by the rate of passage of the potentially digestible fibre through the animal's rumen and hindgut and therefore prediction of fibre utilization must also account for animal.

▪ Predicting Fibre Digestion with Laboratory Tests and Modeling

There are at least 4 factors that affect fibre digestion and performance in ruminants:

(a) the proportion of fibre that is potentially digestible

(b) the rate of fibre digestion

(c) the rate of passage of fibre in the animal

(d) the proportion of fibre digestion occurring in the rumen and the hindgut (Figure 1).

The forage and the environment in which the forage was grown have the greatest influence on proportion of fibre that is digestible and the rate of fibre digestion. The animal eating the forage has the greatest influence on rate of passage and rumen/hindgut digestion. Each of these 4 parameters can be estimated with either lab tests or from existing research.

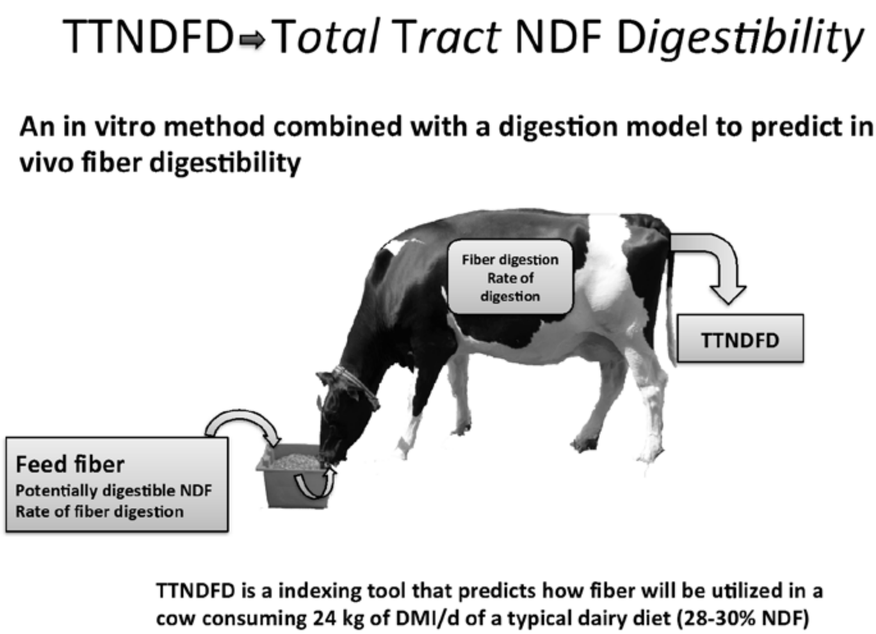

Figure 1. TTNDFD model

a. The proportion of feed fibre that is potentially digestible (pdNDF)

Fibre is bulky and one of the slowest digesting components of the diet, and clearance of fibre from the rumen is an important factor limiting feed intake and energy. Neutral detergent fibre consists of 2 components, potentially digestible (pdNDF) and indigestible NDF (iNDF). The proportion of NDF in the pdNDF fraction varies due to feed type and growing environment. On average, the pdNDF fraction of alfalfa is about 60 to 65% of total NDF. The proportion of potentially digestible fibre in corn silage is typically greater (75 to 85%) than in alfalfa NDF.

The iNDF fraction is estimated from long term incubations of fibre in the rumens of cattle or long term *in vitro* digestions. The NDF residue remaining after 240h of incubation ($uNDF_{240}$), is often used as an estimate of iNDF. The pdNDF is determined by subtracting the uNDF fraction from total NDF.

$$pdNDF = NDF - uNDF_{240}$$

The iNDF proportion can only be cleared from the digestive tract by passage whereas the pdNDF fraction disappears by passage and by microbial digestion.

b. The rate of digestion of potentially digestible fibre (kd)

The rate of fibre digestion also differs due to forage type and growing environment. The potentially digestible fibre in alfalfa is digested nearly twice as fast (4–6% per hour) as the potentially digestible NDF in corn silage (2–3% per hour). Even though fibre digestion rates for forages are slow, differences in rate of fibre digestion have a big impact on how much of the potentially digestible fibre will be digested. The total-tract NDF digestibility of alfalfa and corn silage is similar, but the process of NDF digestion is quite different. In corn silage, there is a larger fraction of digestible fibre that is digested slowly. In alfalfa, there is a smaller proportion of digestible fibre, but the faster rate of digestion of the potentially digestible fraction compensates for the bigger pool of iNDF. For the animal, the most important outcome is the total amount of fibre that is digested because digested NDF is a source of digestible energy.

c. 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. Passage of fibre is much slower than the passage of forage dry matter. The passage rates of iNDF and pdNDF are also not the same. Passage of the pdNDF fraction is slower than passage of the iNDF fraction (Lund et al., 2007). As intake goes up, the rate of passage of both fractions also increases, and as a result, NDF digestibility declines.

d. Ruminal and hindgut fibre digestion

Approximately 90–95% of fibre digestion occurs in the rumen (Huhtanen et al., 2010), 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 fibre digestion requires that the 4 factors be integrated into a single measurement.

Total tract NDF digestibility = rumen digested NDF + hindgut digested NDF

The rumen fibre digestion process can be described mathematically as:

Rumen digested NDF = pdNDF x ((kd)/ (kd + kp)

where pdNDF is the fraction or amount of potentially digestible NDF, kd is the rate of digestion of potentially digestible fibre from the rumen, and kp is the rate of passage of potentially digestible NDF from the rumen.

Hindgut digested NDF can be accounted for by dividing the NDF digested in the rumen by the proportion of total fibre digested in the rumen. In the TTNDFD model, it is assumed that 90% of total fibre digestion occurs in the rumen.

▪ Challenges with Assessing Forage Quality with $uNDF_{240}$, $NDFD_{30}$ or $NDFD_{48}$

Nutritionists use many different tests to assess fibre digestibility or to compare forages. The most commonly used assays are $uNDF_{240}$ or $NDFD_{30}$ or $NDFD_{48}$. The numerical subscripts indicate the time of incubation in rumen fluid. Assays that predict iNDF (such as $uNDF_{240}$), or *in vitro* digestion of fibre after a fixed time ($NDFD_{30}$ or $NDFD_{48}$) as stand-alone measures of forage quality have limitations. uNDF240 or NDFD values provide little insight into the energy content of the forage or its intake potential. These assays also cannot be used to compare across forage types or to formulate diets. These assays have value as a simple indexing tool, but they are not very accurate or precise stand-alone measures of forage quality.

Comparing forages with $uNDF_{240}$ ignores that rates of fibre digestion also vary within and between forages. A simple analogy demonstrates this point. Fibre quality is an estimate of the amount of digestible energy generated from a given quantity of forage NDF and is somewhat analogous to predicting how far you can drive a car before it runs out of fuel. You need to know how much fuel is in the tank and the fuel efficiency of the car to predict the distance that the car will travel. Forage quality is conceptually similar. The amount of digestible energy from fibre (how far you can drive a car) depends on the amount of fibre that is digestible (the amount of fuel) and the rate of fibre digestion (the fuel efficiency). A $uNDF_{240}$ value for forages is analogous to looking at the fuel gauge. Knowing you have half a tank of fuel (iNDF) in the car may be somewhat useful, but you can't accurately determine how far you can go unless you know the amount of fuel and the fuel efficiency of the car. If this particular vehicle had less than half a tank of fuel, it will not travel as far as if the tank was ¾ full, so looking at the gas gauge is a way to index the potential distance that could be traveled in this particular vehicle, but you don't know how many kilometers you can go. The iNDF values of 2 forages may be a tool to compare the relative values of forage fibre quality but it is not an accurate estimate of forage quality. Two different vehicles, each with half a tank of fuel will not necessarily travel the same distance because their fuel tanks may differ in size and the vehicles may differ in fuel efficiency. Knowing the proportions of indigestible NDF and pdNDF is somewhat useful but not a complete picture of fibre quality because both the amount of pdNDF and the rate of fibre digestion differ between different forages. The driver would also have some bearing on the distance traveled. If the driver has a 'lead foot' the distance traveled will be less than for someone who is a more conservative driver. This is a bit like the effect of rate of passage on fibre digestion. A high producing dairy cow is less efficient at digesting fibre because she eats more, which increases rate of passage. To calculate how far you can travel in a specific vehicle, you need to account for the amount of fuel (pdNDF), the fuel efficiency (kd) and the driver (kp). To quantify fibre quality you must integrate pdNDF, kd and kp into a single term.

The iNDF fractions and rates of fibre 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. The TTNDFD *in vitro* assay is a more comprehensive measure of fibre quality than any of the individual terms that are used to determine fibre utilization.

In vitro NDF digestibility measured after 30 hours ($NDFD_{30}$) or 48 hours ($NDFD_{48}$) is widely used to index forage fibre digestibility. Oba and Allen (1999) reviewed several feeding studies with dairy cattle and concluded that a 1% change in *in vitro* or *in situ* NDF digestibility ($NDFD_{30}$ or $NDFD_{48}$) was correlated with a 0.17 kg increase in voluntary dry matter intake, and a 0.25 kg increase in 4% fat corrected milk yield. The change in *in situ* or *in vitro* fibre digestibility within a study was correlated with intake and milk production, but there was no significant correlation between the absolute measures of fibre 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 or to compare NDFD values of alfalfa to NDFD values of corn silage.

There is also another challenge with using values like $NDFD_{30}$ to assess forage quality. The NDF residue remaining after a given time in a flask of rumen fluid is simply undigested NDF. That residue consists of indigestible NDF and the portion of the potentially digestible NDF that has not yet been digested. There is no way of knowing or estimating the rate of fibre digestion or the fraction of indigestible NDF from this measurement alone. In addition, the *in vitro* and *in situ* analyses are closed systems, which means that rate of passage of fibre is not accounted for.

▪ *In vivo* Measurement of Fibre 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 in 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. Summary statistics suggest that *in vivo* NDF digestibility coefficients can vary by 30 to 35% units among legumes, grasses and corn silages. The TTNDFD of corn silage based diets average about 42% of NDF but range from 20% to nearly 60% of NDF. Diets for high producing dairy cows are typically formulated to contain between 28 and 35% total NDF. For cows that are expected to produce over 45 liters per day, a 30-unit change in total tract NDF digestibility with diets that contain similar amounts of NDF is equivalent to the digestible energy needed to support more than 4.5 liters of milk production.

Measuring the Fibre Digestion Process *in vivo* with the Rumen Evacuation Method

Measuring the process of ruminal and hindgut fibre digestion *in vivo* is laborious and expensive, but is the ‘gold standard’ to which other estimates of fibre digestion should be compared. Comprehensive evaluations of *in vivo* fibre digestion are most commonly measured by the 'rumen evacuation' technique. With this method, the critical dynamic components that contribute to the digestion of fibre are directly measured in rumen-cannulated animals. Rumen pools of digestible and indigestible fibre are measured by total rumen evacuation. Rates of digestion of potentially digestible NDF and rates of passage of pdNDF and indigestible NDF are also measured as well as total tract NDF digestion.

Despite the cost and labor, a large number of rumen evacuation studies have been published from studies done in the US and Northern Europe with dairy cattle. 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. From this database, they published predictive equations for passage of iNDF in lactating cow fed diets based on corn silage, grass silage, alfalfa and pasture-based grass diets. Huhtanen et al. (2010) also published a meta-analysis of the NDF digestion process using the rumen evacuation method 32 studies and 122 diets were included in this analysis. Most of the published studies are with lactating dairy cows fed grass, alfalfa or corn silage based diets. The fibre digestion module of the recently published Nordic Feed Evaluation system (NorFor) is based on fibre kinetic parameters estimated by the rumen evacuation technique (NorFor, 2011).

The rates of pdNDF degradation of diets when measured by the rumen evacuation method typically range from approximately 2% to 6% per hour. Corn silage based diets typically have slower rates of pdNDF degradation than alfalfa. The NDF in diets based on temperate grasses tends to have a similar proportion of pdNDF as corn silage, but grass fibre degrades faster than corn silage fibre, but slower than alfalfa fibre.

Predicting *in vivo* NDF Digestion with the University of Wisconsin *in vitro* TTNDFD Assay

University of Wisconsin researchers have recently developed an *in vitro* lab assay and model for predicting NDF digestion in dairy cattle that can be used by field nutritionists. The outcome is a total tract digestibility coefficient for NDF (TTNDFD). The TTNDFD value is benchmarked to fibre digestibility values that have been obtained from feeding studies where NDF digestion has been directly measured. Total tract fibre digestibility is reported because this value can be used not only to predict *in vivo* fibre utilization but also to predict forage DE, NE or TDN values.

The TTNDFD assay accounts for pdNDF, kd, kp and hindgut digestion of NDF (Figure 1). Measurement of the pdNDF fraction and the kd of pdNDF are based on a modified Goering and Van Soest (1970) *in vitro* procedure (Goeser and Combs, 2009). The pdNDF fraction is estimated from long term (120 or 240 h) *in vitro* incubations. Multiple measurements of *in vitro* NDF digestibility are used to calculate a rate of ruminal pdNDF digestion. The approach accounts for ruminal and post-ruminal fibre digestion and can be adjusted for changes in fibre passage as size or intake of the animal changes. Rates of fibre passage are estimated from regressions that have been derived from *in vivo* studies (Krizsan et al., 2010, Lund et al., 2007). In this model, the diet TTNDFD can be calculated by summing the amount of digestible fibre provided from each feed. The *in vitro* method has been calibrated to Near Infrared Spectroscopy (NIR) so that kd and iNDF fractions in a feed can be predicted quickly and with little additional cost.

Several feeding studies have been conducted with various forages to test the model and to validate that the estimates of digestion and passage that are used in the model are consistent with what is measured in cattle fed diets containing the test forages (Lopes et al., 2015a,b,c). In addition, our lab group has been monitoring commercial lab-derived TTNDFD for corn silages, alfalfa and grass forages and comparing these values to the digestibility coefficients for the respective forages that have been published in peer-reviewed feeding studies.

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 in Table 1. The average values represent over 7000 samples each of corn silage or alfalfa and over 1200 grass forage samples.

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

	TTNDFD, % of NDF	SD	Range
Corn silage	42	± 6	20-60
Alfalfa	42	± 7	25-80
Grass	47	± 8	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. For consultants, we recommend that tested forages be compared with these mean TTNDFD values. When comparing 2 forages with similar total NDF, a forage that is more than 1 SD below the mean TTNDFD value would be among the lowest 15% of forages sampled and a 6 to 7 unit difference from the mean TTNDFD value would indicate that his forage fibre would reduce the DE value of the forage by enough to reduce potential milk yield by 1 to 1.5 liters. A forage which is 1 SD above the mean TTNDFD value would be higher in fibre digestibility than 85% of the forages tested and would contain enough additional DE to potentially support 1 to 1.5 liters more milk production. Experiences with this test in the field suggest that diets that incorporate large amounts of low TTNDFD forage support less milk and cows consume less feed dry matter than expected. Cows fed these types of diets respond well to additions of extra starch, or addition of sources of more highly digestible fibre, such as soy hulls.

Validation with Controlled Feeding Studies

The laboratory prediction of TTNDFD of forages and diets has been validated to fibre digestibility values that have been directly measured in feeding studies. One study (Lopes et al., 2015a) was designed to compare estimates of ruminal fibre digestion predicted from *in vitro* NDFD analysis of feeds to the ruminal fibre digestion measured in cattle fed the same feeds. The feeding study was conducted with lactating dairy cows fed either low fibre digestibility corn silage or to higher fibre digestibility corn silage as the main source of dietary NDF (Table 2).

Table 2. Effects of source of corn silage on total tract NDF digestion (Lopes et al., 2015a)

Feed, % of TMR DM	LFDSCS[1]	HFDCS[2]	SE
Low fibre digestibility corn silage	47	0	
High fibre digestibility corn silage	0	47	
Alfalfa silage	17	13	
Concentrate mix	36	40	
Diet composition			
NDF, % of DM	27.5	28.3	
pdNDF, % of NDF	68.9	75.9	
Results			
DMI, kg/d	25.5	25.6	1.3
4% FCM, kg/d	34.3	34.9	1.0
Observed TTNDFD (in vivo), % of NDF	47	49	2.5
Predicted TTNDFD (in vitro), % of NDF	43	50	0.9

[1, 2]Low fibre digestibility and high fibre digestibility corn silage, respectively.

The fibre characteristics of the low fibre digestibility corn silage (34.4% NDF, pdNDF 58.6% of NDF, kd 3.2%/h) and the higher fibre digestibility corn silage (38.4% NDF, pdNDF 74.3% of NDF, kd 3.3%/h) were determined by our *in vitro* TTNDFD method prior to the feeding experiment. The fibre characteristics of the 2 silages and the other feeds used in the diets were then used to predict total tract NDF digestibility of the treatment rations. The predictions for each diet were then compared to the observed measures of fibre digestion in dairy cows fed the same feeds. The *in vitro* method predicted that the higher fibre digestibility corn silage was higher in TTNDFD than the low fibre digestibility corn silage because it contained a larger proportion of potentially digestible NDF. Rates of pdNDF digestion and passage and the pool of pdNDF in the rumens of cows fed the experimental diets were directly measured in cows and compared to the fibre digestion parameters from the TTNDFD assay and model. It is important to note that the fibre digestion parameters measured directly in the cows are independent of the *in vitro* measurements. Results of the study indicate that the *in vitro* TTNDFD were similar to the directly measured *in vivo* total tract NDF digestibility values and provide evidence that supports the concept that *in vivo* fibre digestion can be predicted from *in vitro* fibre kinetics.

The objective of another *in vivo* experiment (Lopes et al., 2015b) was to compare estimates of total tract fibre 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* fibre digestion parameters for corn silage (NDF = 34.4%, pdNDF kd = 3.2%/h, pdNDF = 58.6% of NDF) and alfalfa silage (NDF = 34.7%, pdNDF kd = 6.1%/h and pdNDF = 51.3% of NDF) indicate that fibre in the corn silage contains more pdNDF than alfalfa, but the rate of digestion of alfalfa fibre is nearly twice as fast as corn silage fibre. The feeding experiment measured how cows use forages that differ in pdNDF and kd (Table 3). The diets contained approximately 55% forage and the dietary NDF concentration was similar across the 4 treatments.

Table 3. Comparison of rumen and total tract NDF digestion of diets predicted from TTNDFD model and observed *in vivo* (Lopes et al. 2015b)

Item	Predicted *in vitro*[1]	Observed *in vivo*[2]	SEM	P value
Input				
pdNDF kd, %/h	4.1	4.3	0.5	0.72
pdNDF kp, %/h	2.7	2.8	0.3	0.56
Output				
NDF digested in rumen, kg	2.73	2.63	0.22	0.64
NDF digested in hindgut, kg	0.36	0.64	0.19	0.05
NDF digested in total tract, kg	3.09	3.27	0.22	0.42
Total tract NDF digestibility, % of NDF	46.4	49.5	0.07	0.13

[1] Fibre digestion parameters predicted from *in vitro* analysis of feed components of the diets before cows were fed test diets.

[2] Fibre digestion parameters directly measured in cows fed the test diets.

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. The observed (*in vivo*) total tract NDF digestion 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. Milk and 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 fibre digestibility coefficients suggest that the faster rate of fibre digestion of alfalfa fibre compensates for lower content of pdNDF but as higher proportions of alfalfa forage are fed, the amount of indigestible fibre in the rumen increases and rumen fill becomes a more predominant factor limiting feed intake.

These feeding experiments demonstrate that the *in vitro* TTNDFD analysis can provide important insights into fibre utilization by dairy cattle. The rates of fibre degradation determined from the *in vitro* NDFD assays are consistent with values measured in *in vivo* feeding studies. The kd, kp and pdNDF parameters predicted by the TTNDFD model appear to be consistent with *in vivo* measures and the total tract digestion of NDF as predicted by the TTNDFD model is consistent with observed *in vivo* digestion.

The third study (Lopes et al., 2015c) compared 21 diets from 7 feeding experiments and showed that TTNDFD of total mixed rations analyzed by the *in vitro* TTNDFD method were highly correlated to the directly measured in vivo total tract NDF digestibilities of the same diets in lactating dairy cows.

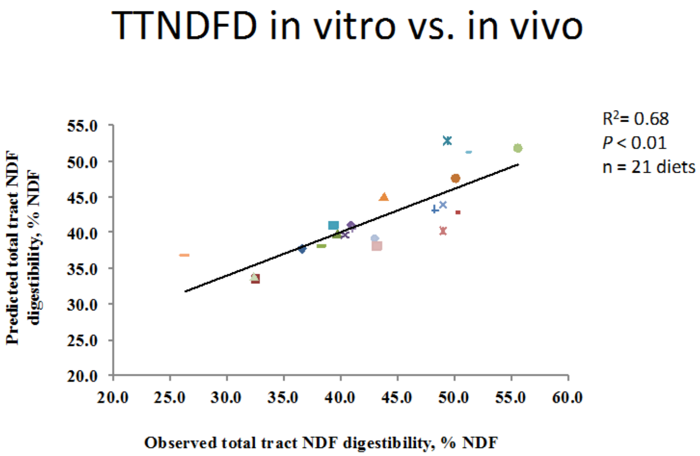

Figure 2. Comparison of observed total tract NDF digestion and NDF predicted by an in vitro TTNDFD assay 21 diets from seven feeding studies. Lopes et al., 2015c.

Conclusions: How to Use the TTNDFD Test

The key to getting the most out of forages is understanding how energy values are affected by NDF and NDF digestibility. This test is intended to be an additional tool to provide a clearer understanding of how forage-fibre is utilized in dairy cattle. It is not intended to be the only tool to be used to evaluate forage quality or fibre utilization by dairy cattle. Table 5 summarizes important limitations to this assay. In top quality forages, NDF accounts for 35-45% of the total dry matter and this fibre is the source of 30 to 40% of the digestible energy. A 30% NDF diet with a TTNDFD of 33% would support 3 to 4.5 liters less milk than a 30% NDF diet with a TTNDFD of 45% assuming no reduction in feed intake. 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.

Table 5. Guidelines for using TTNDFD.

1. The TTNDFD assay is intended to evaluate the digestibility of NDF of feeds and rations in animals fed a balanced diet. Inadequacies of other nutrients (protein, amino acids, minerals) or excesses of dietary components other than fibre (e.g., mycotoxins) are not accounted for in this assay.

2. The TTNDFD can be used to compare fibre utilization across forage or fibre sources. For example, fibre digestibility of corn silage can be compared to fibre digestibility of alfalfa, grass or co-product feed.

3. TTNDFD does not account for differences in physical form (effective fibre) of forages.

4. TTNDFD estimates total tract digestibility of fibre for a dairy cow consuming about 24.5 kg of DM.

5. *In vitro* NDFD values (NDFD24, NDFD30 or NDFD48) should not be used as a single indicator to compare fibre digestibility of forages. These values do not factor in indigestible fibre, or NDF concentration of forages. Single time NDFD values are poorly correlated to total tract fibre digestibility

6. Total NDF <u>and</u> TTNDFD must be considered when comparing forages for quality.

The TTNDFD value can also be used as a stand-alone value to index forages. A consultant could compare values from their forage test to the values in

Table 1. For example, note in the Table 1 that an average alfalfa will have a TTNDFD value of 42%. An alfalfa with a TTNDFD value one standard deviation below average (less than 36%), would be among the bottom 15% of the alfalfas tested. A sample with low TTNDFD likely will not be utilized as well as ‘typical’ alfalfa containing similar amounts of total NDF. 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 ability to predict fibre digestibility and incorporate this information into rations could improve our ability to optimize forage utilization and milk production.

References

Goering, H.K. and P.J. Van Soest. 1970. Forage fiber analyses (apparatus, reagents, procedures, and some applications). Agric. Handbook no 379. ARS-USDA, Washington, DC.

Goeser, J.P. 2008. Improvement of rumen in vitro NDF digestibility techniques and data analysis. Ph.D Thesis. University of Wisconsin-Madison.

Goeser, J.P. and D.K. Combs. 2009. An alternative method to assess 24-h ruminal in vitro neutral detergent fiber digestibility. J. Dairy Sci. 92:3833-3841.

Huhtanen, P., S. Ahvenjarvi, G.A. Broderick, S.M. Reynal, and K.J. Shingfield. 2010. Quantifying ruminal digestion of organic matter and neutral detergent fiber using the omasal sampling technique in cattle – a meta analysis. J. Dairy Sci. 93:3203-3215.

Krizsan, S.J., S. Ahvenjarvi and P. Huhtanen. 2010. A meta-analysis of passage rate estimated by rumen evacuation with cattle and evaluation of passage rate prediction models. J. Dairy Sci. 93:5890-5901.

Lopes, F., D.E. Cook, and D.K. Combs. 2015a. Validation of an in vitro model for predicting rumen and total-tract fiber digestibility in dairy cows fed corn silages with different in vitro neutral detergent fiber digestibilities at two levels of dry matter intake. J. Dairy Sci. 98: 574-585.

Lopes F., D E. Cook and D.K. Combs. 2015b. Effects of varying dietary ratios of corn silage to alfalfa silage on NDF digestion in lactating dairy cows. J. Dairy Sci. 98:6291-6301.

Lopes, F., K. Ruh and D.K. Combs. 2015c. Validation of an approach to predict total tract fiber digestibility using a standardized in vitro technique for different diets fed to high producing dairy cows. J. Dairy Sci. 98 (Accepted in press, published on-line 1/30/2015).

Lund, P., M.R. Weisbjerg, and T. Hvelplund. 2007. Digestible NDF is selectively retained in the rumen of dairy cows compared to indigestible NDF. Anim. Feed Sci. Tech. 134:1-17.

NorFor-The Nordic Feed Evaluation System. 2011. H.Volden ed. EAAP publication no. 130. ISBN 978-90-8686-162-0. Wageningen Acad. Publ., The Netherlands

Oba, M. and M.S. Allen. 1999. Evaluation of importance of digestibility of neutral detergent fiber from forage: effects on dry matter intake and milk yield of dairy cows. J Dairy Sci. 82:589-596.