

Forage Energy and Digestibility:

TTNDFD

A new (and) better tool for assessing forage
quality

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Balancing rations for carbohydrates (starch and NDF) are critical for health and production in high producing dairy cows.

Milk production is affected by variations in:

Fiber digestibility => 6-7 lbs of milk

Starch digestibility => 3-5 lbs of milk

Assessing fiber digestion is not easy



Poor digestion < 40%



Excellent digestion > 50%

A 2-3 unit change in fiber digestibility corresponds to 1 lb change in milk yield.

Fiber digestibility varies in forages

TTNDFD	Range in % of NDF
Alfalfa hay and silage	25-70
Corn silage	25-80
Grass hay and silage	15-80

Two units increase in diet TTNDFD can potentially increase milk yield by 1 lb

TTNDFD  **T**_{total} **T**_{ract} **NDF** **D**_{igestibility}

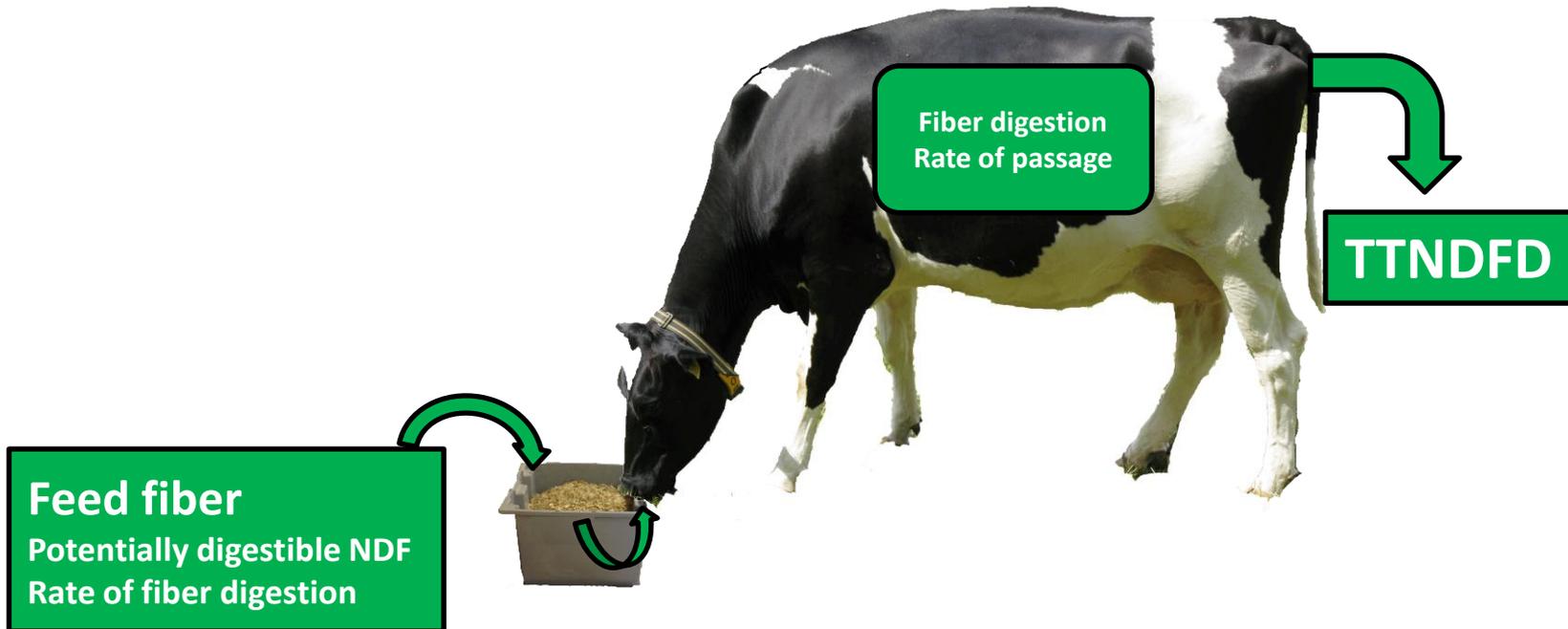
Licensed procedure through the University of WI

>15 years of research, > \$500,000 invested in development

A precise laboratory test that accurately predicts how fiber is utilized by high producing dairy cows

TTNDFD → *Total Tract NDF Digestibility*

Feed and cow factors are combined to measure true fiber digestion



A 2-3 unit change in ration TTNDFD corresponds to 1 pound change in milk yield.

Think of TTNDFD as how far you can travel on a tank of gas:



How far you go depends on:

The size of the tank (pdNDF)
AND

The miles traveled per gallon (kd)

HOW much milk your forage will make depends on the amount of potentially digestible fiber AND the rate of fiber digestion!

How is TTNDFD determined?



Forage sample

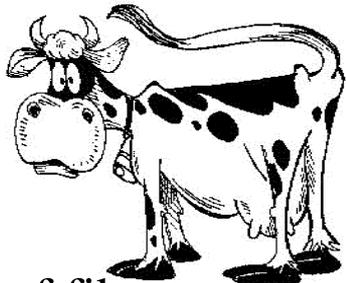


Standardized iv NDFD (24, 30, 48h) and iNDF

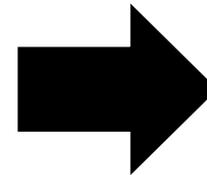
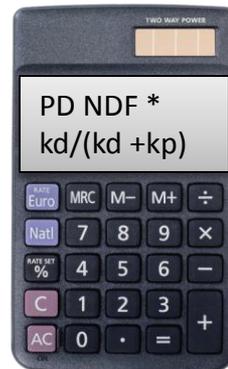
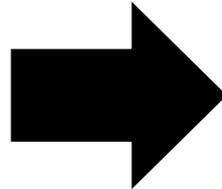


Rate of fiber digestion (**kd**)
Potentially digestible NDF (**pdNDF**)

Rumen and hindgut digestion



Rate of fiber passage, (**kp**)



TTNDFD
(total tract NDF Digestibility)

Feed Analysis Lab Report

Cost of analysis TTNDFD report (NIR) \$26 vs \$22 for a standard analysis w/o TTNDFD



		60 Day Average (DM)
		8.14%
		0.70%
		24.50%
		43.33%
Calcium	0.25%	0.26%
Phosphorus	0.18%	0.20%
Magnesium	0.18%	0.17%
Potassium	0.79%	0.95%
Sulfur	0.11%	0.11%
Fat (EE)	1.91%	2.19%

TTNDFD is a prediction of NDF digestibility for a feed (or diet) in 1400 lb cow consuming 53 lb DM of a 28-30% NDF diet.

Standardized 24HR	23.73%	22.00%
Standardized 30HR	34.57%	33.08%
Standardized 48HR	53.65%	52.75%
Calculations		
TTNDFD	47.98	42.34
N.F.C.	44.48%	4.33
Milk 2006 Energy calculated using avg of 30 & 48h Std NDFD, compared to lab avg = 35.275 (Processed\Un-Processed)		
TDN maintenance	77.08%	75.27%
NEL 3x maintenance Mcal/lb	0.74	0.71
Net energy of gain Mcal/lb	0.62	0.59
Net energy maintenance Mcal/lb	0.91	0.88
Lbs. Milk/Ton	3615	3468

*ND - None Detected

Feed Analysis Lab Report



Lab # Sampled on 1/8/2014 Received on 1/9/2014

Farm

Moisture 54.44% Dry Matter 45.56%

60 Day RRL
Average

Description (%DM unless specified) Dry Matter Basis

Crude Protein 22.55% 21.80%

aNDF 42.6% 43.09%

TTNDFD 51.4 44.70

Relative Forage Quality

Dynamic NDF Kd (using 24,30,48,120 hr) 11.53%/hr

Relative feed value 136

Which is the better Alfalfa?

Both forages have similar RFV

Sample # 1 Haylage

Lab # Sampled on 12/26/2013 Received on 12/27/2013

Farm

Moisture 69.47% Dry Matter 30.53%

60 Day RRL
Average

Description (%DM unless specified) Dry Matter Basis

Crude Protein 20.87% 21.86%

aNDF 42.2% 43.30%

TTNDFD 44.1 44.26

Relative Forage Quality

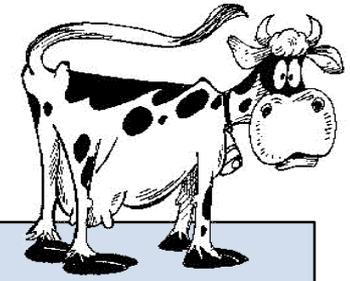
Dynamic NDF Kd (using 24,30,48,120 hr) 7.72%/hr

Relative feed value 138

Validating the TTNDFD model



What do the 'real experts' say?



Legume/grass feeding trials
(20 trials, 64 observations
In vivo NDF diet digestibility)

Mean 47.3 % of NDF
Median 47.5 % of NDF
Range 31.1-66.2 % of NDF
St. Dev 8.1

Cows report that TTNDF digestibility of legume/grasses are higher than TTNDF digestibility of corn silage.

Corn Silage/Sorghum feeding trials
(25 trials, 81 observations,
In Vivo NDF diet digestibility)

Mean 40.2 % of NDF
Median 41.1 % of NDF
Range 20.1-58.8 % of NDF
St. Dev. 8.8

Validating the TTNDFD model

J. Dairy Sci. 92:3833–3841

doi:10.3168/jds.2008-1136

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An alternative method to assess 24-h ruminal in vitro neutral detergent fiber digestibility¹

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Validating the TTNDFD model

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doi:10.3168/jds.2008-1745

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Modification of a rumen fluid priming technique for measuring in vitro neutral detergent fiber digestibility¹

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Validating the TTNDFD model

Patents

Application

Grant

Find prior art

Discuss this application

Method for measuring fiber digestibility

US 20090272889 A1

ABSTRACT

Described is a method of measuring fiber digestion in ruminants and calibrating spectrophotometers using the measured fiber digestion values. The method includes the steps of harvesting rumen fluid from at least one ruminant animal and combining the rumen fluid with a primer composition comprising a carbohydrate. The rumen fluid and carbohydrate are then incubated in a sealed container until a pre-determined pressure is achieved within the sealed container. A plant matter sample is digested with the rumen fluid so treated. The digested sample is then measured for absorbance or reflectance using a spectrophotometer. The digestion values and the absorbance or reflectance values are then correlated to construct a standard curve for predicting fiber digestion values using spectrophotometric analysis, preferably NIRS analysis.

Publication number	US20090272889 A1
Publication type	Application
Application number	US 12/405,650
Publication date	Nov 5, 2009
Filing date	Mar 17, 2009
Priority date 	Mar 17, 2008

Also published as [US8501493](#)

Inventors [David Kenneth Combs](#), [John Phillip Goeser](#)

Original Assignee [David Kenneth Combs](#), [John Phillip Goeser](#)

Export Citation [BiBTeX](#), [EndNote](#), [RefMan](#)

[Referenced by \(1\)](#), [Classifications \(8\)](#), [Legal Events \(1\)](#)

External Links: [USPTO](#), [USPTO Assignment](#), [Espacenet](#)



Validating the TTNDFD model



J. Dairy Sci. 98:574–585

<http://dx.doi.org/10.3168/jds.2014-8661>

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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 2 levels of dry matter intake

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Validating the TTNDFD model

Article in Press

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

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Validating the TTNDFD model



J. Dairy Sci. TBC:1–13

<http://dx.doi.org/10.3168/jds.2014-8662>

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Effects of varying dietary ratios of corn silage to alfalfa silage on digestion of neutral detergent fiber in lactating dairy cows

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In vivo – pool and flux method

- Omasal digesta and rumen fluid collected
- Fecal samples collected
- Rumen contents were evacuated manually at 1300h (4h after feeding) on d 20 and at 0800 h (1 h before feeding) on d 21

Rumen kinetic and pool size

- Ruminal turnover rate (%/h)
- Ruminal passage rate (%/h)
- Ruminal digestion rate (%/h)



Can the in vitro TTNDFD test detect a difference in fiber digestibility as ratios of corn silage (36% TTNDFD) and alfalfa(42% TTNDFD) change in the ration?

Corn silage:alfalfa ratio	100CS 0AS	67CS 33AS	33CS 67AS	0CS 100AS	
					SE
DMI, kg/d	25.2 ^{ab}	25.3 ^a	24.3 ^b	21.9 ^c	0.8
4% FCM, l/d	36.3	35.4	35.2	36.0	0.9
Observed TTNDFD, in vivo	38.3^a	40.9^{ab}	39.4^{ab}	43.8^a	1.9
Predicted TTNDFD, in vitro*	38	41	41	45	2.1

****In vitro TTNDFD analysis of feeds matched the observed (in vivo) NDF digestibility values***

Fiber digestibility TTNDFD vs. in vivo

	Method			P-value
	<u>TTNDFD</u>	<u>In vivo</u>	<u>SEM</u>	<u>Method</u>
NDF digested in rumen, kg	2.4	2.6	0.2	0.6
NDF digested in hindgut, kg	0.2	0.3	0.1	0.4
NDF digested in total tract, kg	2.7	2.9	0.1	0.7
Total tract NDF digestibility, % of total NDF	41.8	40.6	1.86	0.5

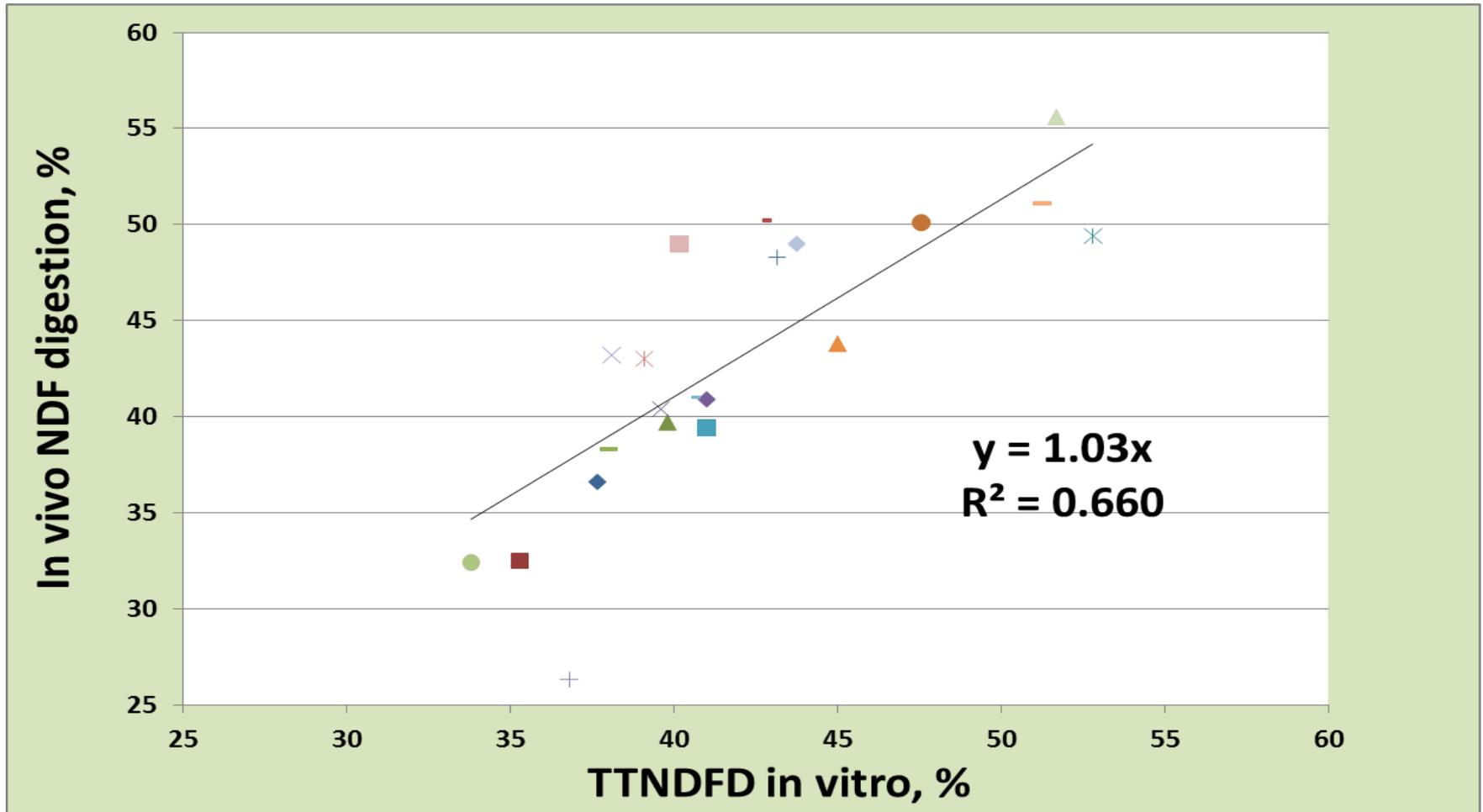
Lopes et al, 2105

TTNDFD validation: Comparing lab prediction to results from feeding studies

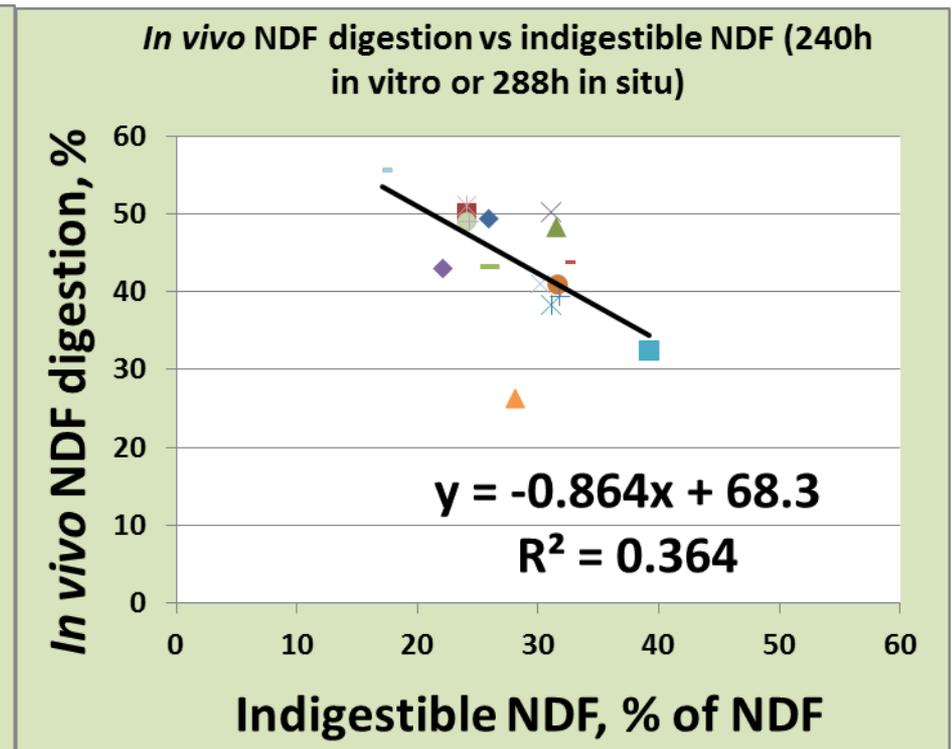
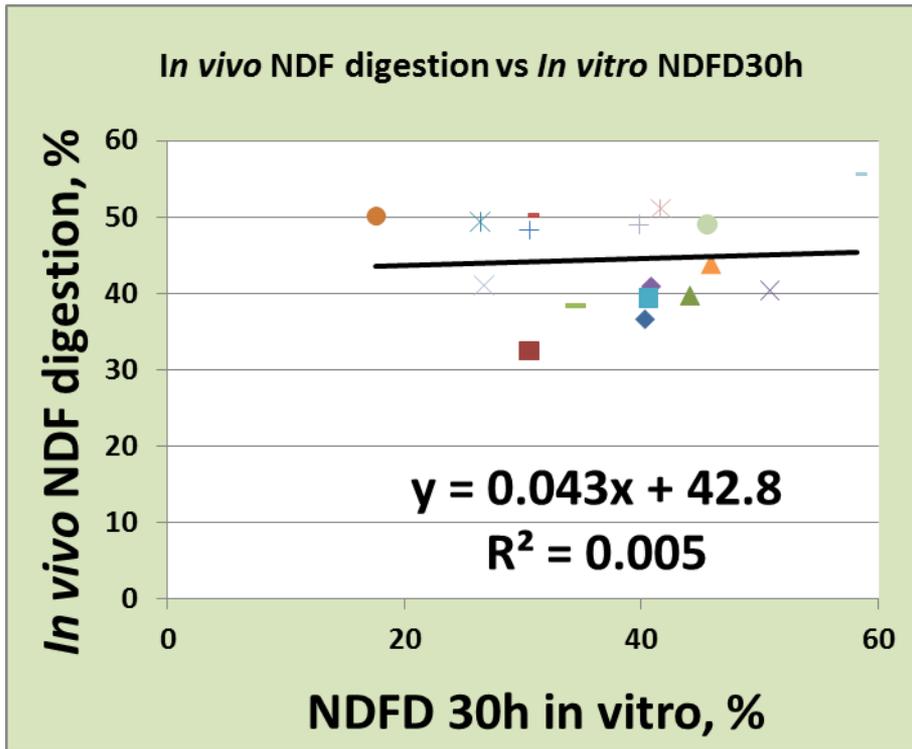
- **Total tract NDF digestibility in vivo studies**
 - Seven studies (total of 21 diets) conducted at UW-Madison
- **Total tract NDF digestibility in vitro evaluation of diets**
 - 21 diets
 - TTNDFD predicted from TMR samples



TTNDFD combines *in vitro* rate of NDF digestion with *iNDF* to improve the prediction of *in vivo* fiber digestion



Stand-alone *in vitro* NDFD30 or iNDF values are poor predictors of *in vivo* fiber digestion



Arndt C, Armentano LE, Hall MB. *J. Dairy Sci.* 2009;92 (E-Suppl. 1):94.

Ferraretto L. F., A. C. Fonseca, C. J. Sniffen, A. Formigoni, and R. D. Shaver. 2014. Submitted to ADSA meeting 2014.

Fredin SM, Bertics SJ, Shaver RD. 2013 *J. Dairy Sci.* 2013;96(E-Suppl. 1):149.

Fredin SM, Ferraretto LF, Akins MS, Shaver RD. 2013 *J. Dairy Sci.* 2013;96(E-Suppl. 1):34.

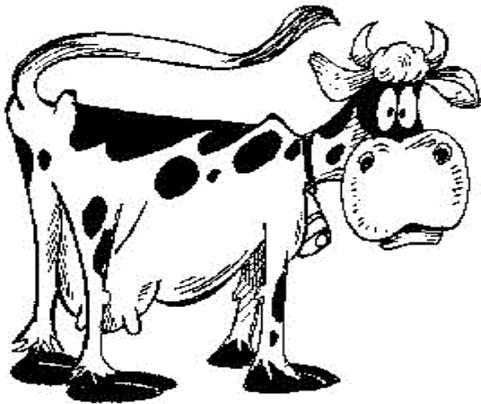
Lopes, F., D. E. Cook, R. W. Bender and D. K. Combs. 2013a. *J. Dairy Sci.* 96 (E-Suppl 1): 523..

Lopes. F., D. E. Cook and R. W. Bender and D. K. Combs. 2013b.. *J. Dairy Sci.* 96(E-Suppl 1): 16..

Verbeten, W. D., D. K. Combs and D. J. Undersander. 2011. *J. Dairy Sci.* 94 (E-Suppl 1): 556.

Research Update on Grass Feeding

(Could a little grass in the ration be a good thing?)



Grass feeding: Perceptions

- Confinement dairies:
 - Grass perceived to be too high in fiber/too low in quality for high producing dairy cows
 - Corn silage a higher yielding alternative to perennial or annual grasses
 - Pure alfalfa stands easier to manage
- Pasture based dairies:
 - Have challenged perceptions about grass
 - Have created research opportunities

Perception vs Reality:

- High quality grasses can be an integral part of rations for high producing cows
- Excellent source of highly digestible fiber
- Fit well into cropping systems

- *TTNDFD is the TOOL that can optimize grass utilization*

NDF AND TTNDFD OF ALFALFA, CORN AND SORGHUM/SUDAN SILAGES ANALYZED BY RRL: 2014 GROWING SEASON

	COUNT	NDF, % OF DM	TTNDFD, % OF NDF
ALFALFA SILAGE	10252	42	39
CORN SILAGE	15883	44	42
"BMR" CS	363	47	48
SORGHUM /SUDAN SILAGE	1145	57	44
"BMR" S/S SILAGE	231	57	50

Alforex Introduces Hi-Gest 360

Alfalfa with Improved TTNDFD

28 Day Cut System (5 cuts)*

Alfalfa Variety	pdNDF	Dyn Kd	TTNDFD
Hi-Gest 360	73.3	7.2	55.1
Conventional Check	68.2	6.6	48.2
% Difference:	7%	10%	14%

35 day Cut System (3 cuts)*

Alfalfa Variety	pdNDF	Dyn Kd	TTNDFD
Hi-Gest 360	59.1	5.9	39.3
Conventional Check	54.8	5.4	35.6
% Difference:	8%	8%	10%

Low lignin: higher fiber digestibility

TTNDFD: Tells you how fiber digestibility was improved

The logo for NutriFiber is presented within a rectangular frame with a black border. The background of the frame is a gradient of yellow and green, with a field of green grass blades at the bottom. The word "NutriFiber" is written in a bold, white, sans-serif font with a thick black outline. The letters are slightly shadowed to give a 3D effect.

NutriFiber

NDF AND TTNDFD OF GRASSES ANALYZED BY RRL: 2014 GROWING SEASON

	COUNT	NDF, % OF DM	TTNDFD, % OF NDF
ALL GRASSES	4000	59	41
"ORCHARD"	34	56	44
"TIMOTHY"	40	63	38
"BROME"	13	63	37
"REED"	6	63	39
"FESCUE"	78	55	48
"RYE"	34	54	51



Fiber digestibility varies in forages

NutriFiber Grasses are higher in fiber digestibility than other grasses with similar NDF Content*

Item	N	NDF range % of DM	TTNDFD % of NDF
Green Spirit [®]	13	46 to 56	59.5
Other Grass Forage	448	46 to 56	48.3

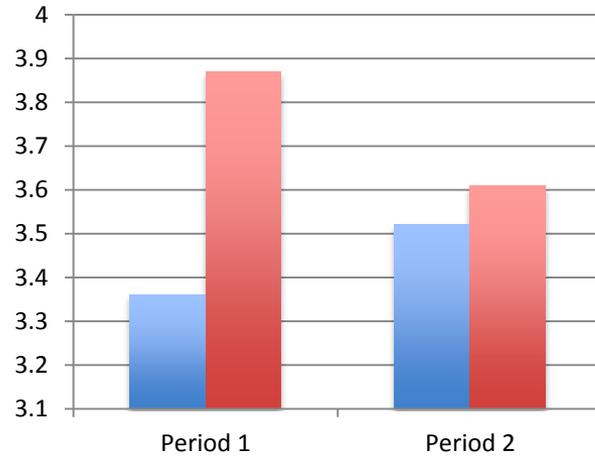
* Forage samples submitted to Rock River Labs, Watertown, WI in 2012



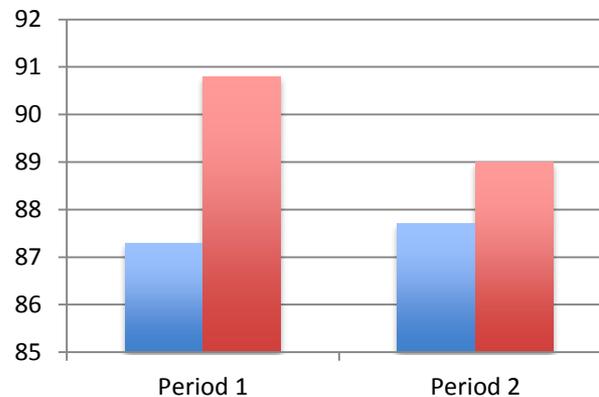
Green Spirit Italian Ryegrass* Silage in TMR for High Producing Dairy Cows. (UW-Madison, 2009)

Fat Test, %

	CON	TRT
	(DM % of Diet)	
NDF	24.8	26.9
NFC	48.5	46.5
Corn Silage	24.65	16.58
Alf. Silage	25.49	16.03
Rye Silage	0	17.53
HMSC	29.5	29.5
Conc.	20.36	20.36



4% FCM, Lb

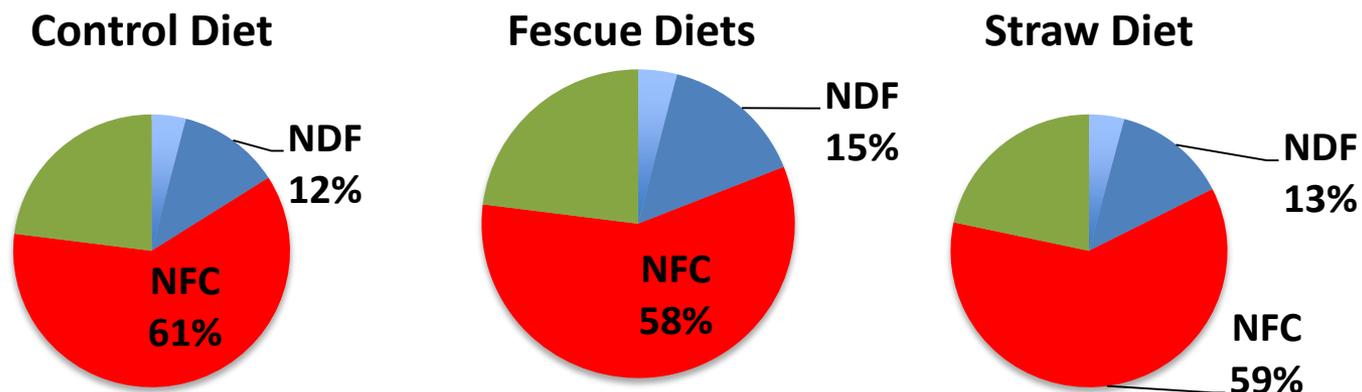


Control
Green Spirit Italian Rye

Partial replacement of Corn and Alfalfa Silages with Tall Fescue, Meadow Fescue or Wheat Straw (Verbetin and Combs, 2012)

	HOT	Tall Fescue	Meadow Fescue	Straw
	-----% of Diet DM-----			
Corn silage	26	17	17	20
Alfalfa silage	26	17	17	20
Bariane Tall Fescue*		17		
Pradel Meadow Fescue*			17	
Wheat Straw				8
High Moisture Corn	26	25	26	24
Protein/minerals	22	24	23	28
	100	100	100	100

Partial replacement of Corn and Alfalfa Silages with Tall Fescue, Meadow Fescue or Wheat Straw (Verbetin and Combs, 2012)



	HOT	Tall Fescue	Meadow Fescue	Straw
Intake, lb/d	58^{ab}	54^b	59^a	58^{ab}
Fat, %	2.9^a	3.4^b	3.4^b	3.2^{ab}
3.5% FCM, lb	91	92	95	92

UW-Madison Study 2014: Feeding Mature (64%NDF, 42% TTNDFD) Bariane Tall Fescue to Lactating Dairy Cows:
Diet Formulations

Ingredients	33% ALF & 67% CS (lb/d)	60% TF & 40% ALF (lb/d)	60% TF & 40% CS (lb/d)	33%TF & 67% CS (lb/d)
Alfalfa silage	10	10	0	0
Corn silage	20	0	10	18
Tall Fescue hay	0	15	15	9
H.M.C, protein, min	22	27	22	24.5

Alfalfa silage, 45% NDF, 43% TTNDFD

Corn Silage, 36% NDF, 38% TTNDFD

Tall Fescue Hay, 64% NDF, 42% TTNDFD

UW-Madison Study 2014: Feeding Mature (63%NDF, 42% TTNDFD) Bariane Tall Fescue to Lactating Dairy Cows: Intake and Production

Item	33% ALF & 67% CS	60% TF & 40% ALF	60% TF & 40% CS	33%TF & 67% CS	P Value
Intake, lb DM/d	53 ^a	52 ^{ab}	50 ^b	52 ^{ab}	<.01
4 % FCM	91	88	84	90	<.10
% Fat	3.9	3.9	3.8	4.1	<.001
TTNDFD, in vivo vs (predicted)	38 (42)	44 (44)	42 (42)	45 (42)	<.001

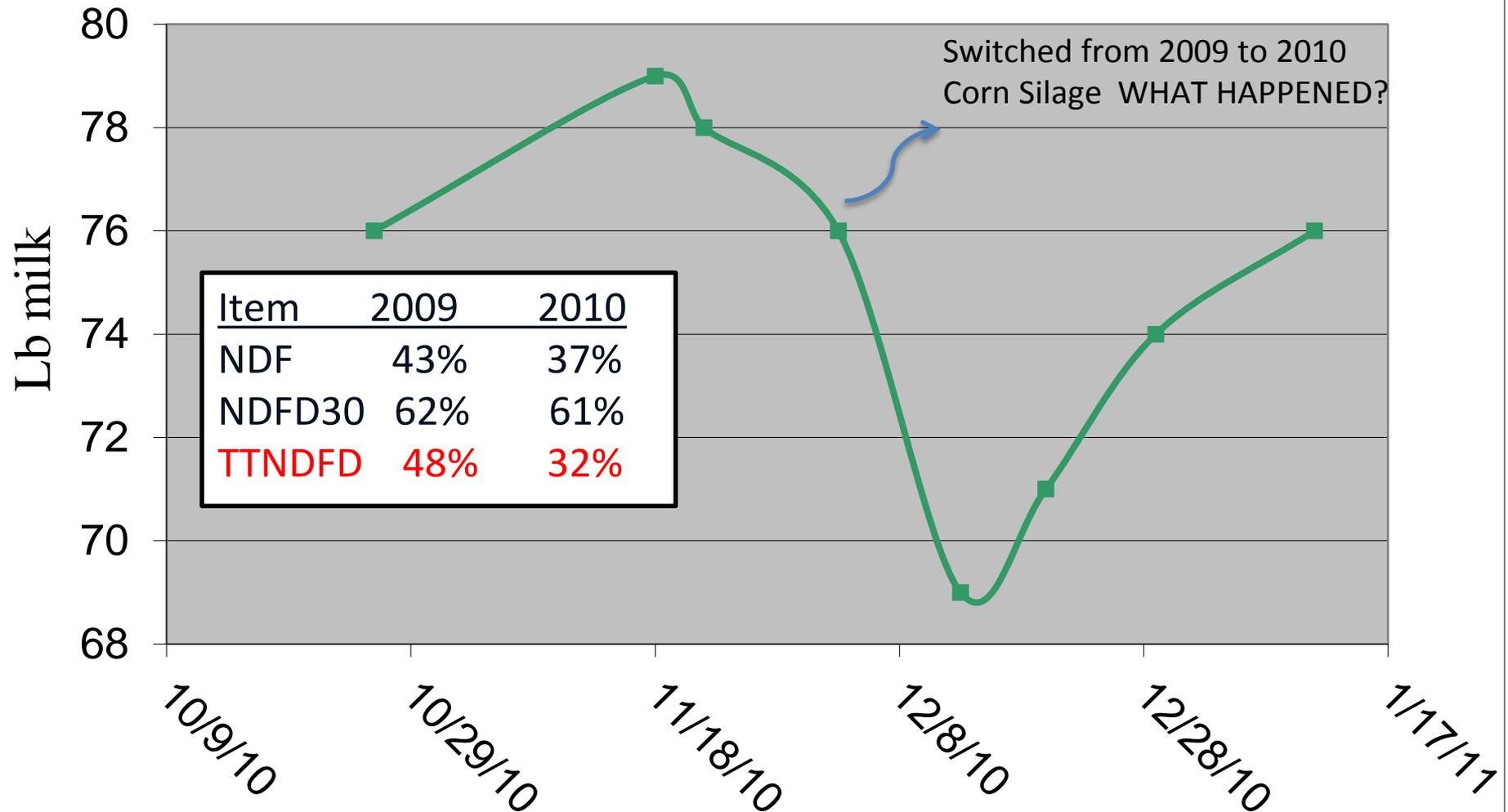
Alfalfa silage, 45% NDF, 43 % TTNDFD

Corn Silage, 36% NDF, 36% TTNDFD

Tall Fescue Hay, 63% NDF, 42% TTNDFD



Troubleshooting with TTNDFD



Ration Balancing With TTNDFD

- TTNDFD values are consistent across feed types
- Target rations for >42% TTNDFD
- 'Dynamic kd' and iNDF are compatible with AMTS and CNPCS ration software
- Co-product feed tables available

TTNDFD Guidelines

- Remember 42% TTNDFD
 - Corn silage and haylage average!
- Goal = 48+%



TTNDFD: The Take Home Message

1. Fiber digestibility has a big impact on milk yield.

A 2-3 unit change in ration TTNDFD corresponds to a 1 pound change in milk yield.

2. The TTNDFD test was developed to predict fiber digestibility in high producing dairy cattle

Can be used across forage types and byproduct feeds

Can be used in ration balancing and evaluation

Is a more accurate measure of forage quality than

RFV or RFO



The Wisconsin Idea is a philosophy embraced by the University of Wisconsin System, which holds that research conducted at the University of Wisconsin System should be applied to solve problems and improve health, quality of life, the environment and agriculture for all citizens of the state.

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