Have You Kept Pace With Forage Testing Options?

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Dairy Forage Seminars

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Talking points . . .

- **Forage Tests 30 Years Ago**
- **Standardize fiber analyses**
- **Addition of *in vitro* NDF digestibility**
- **Add ash to testing package**
- **Evolution of RFV and RFQ index**
- **New Tests – Diagnostic tools**

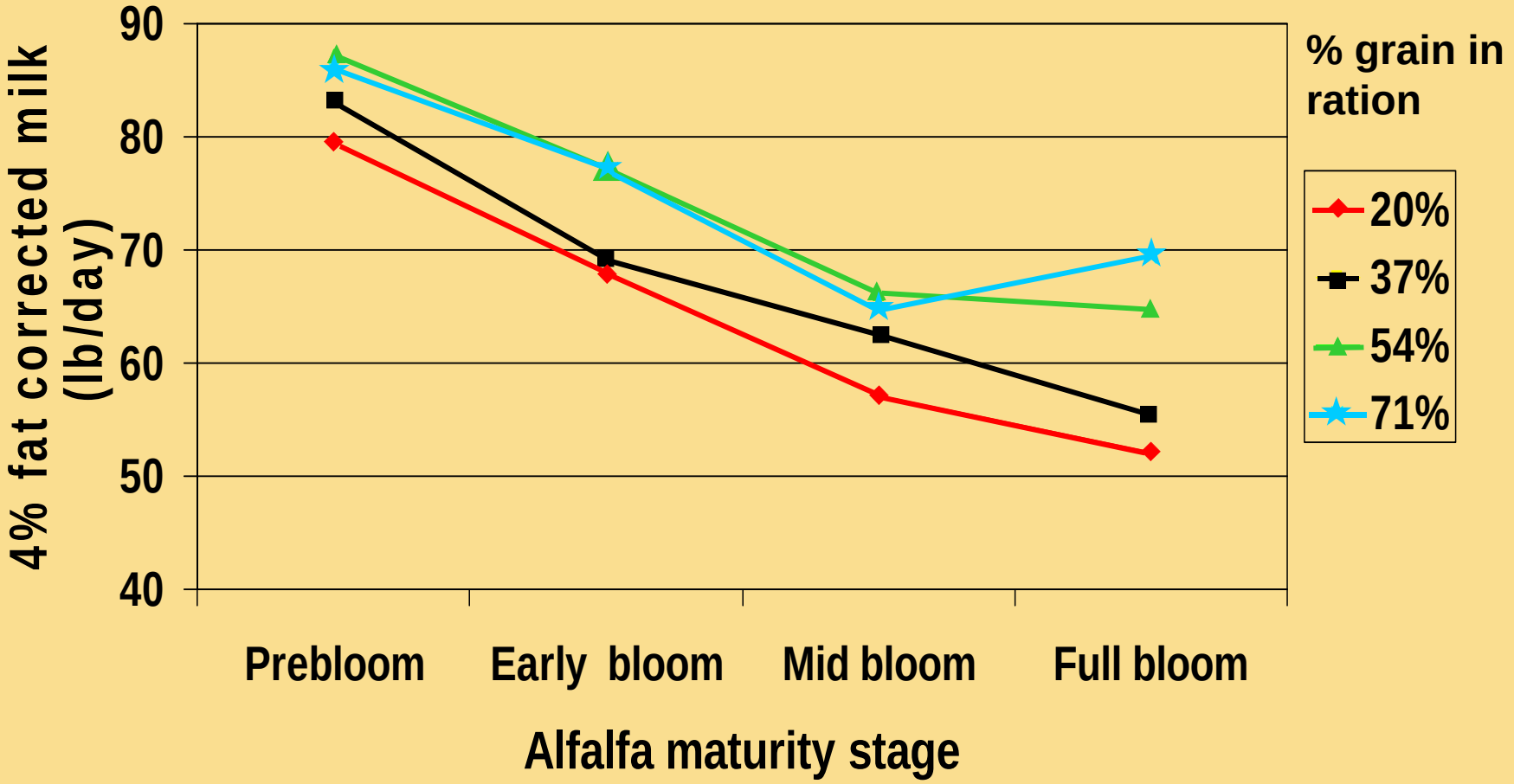
Forage Tests 30 Years Ago

- **Routine tests: Crude protein and crude fiber**
- **Crude fiber under estimated high quality forage and over estimated low quality forage**
- **New test - fiber analyses system (ADF, NDF & ADL)**

Forage Tests 30 Years Ago

- **Forage quality of alfalfa hay – too low to support high milk production**
- **Routine use of forage testing limited**

Effect of forage quality on 4% fat-corrected milk production at four concentrate levels

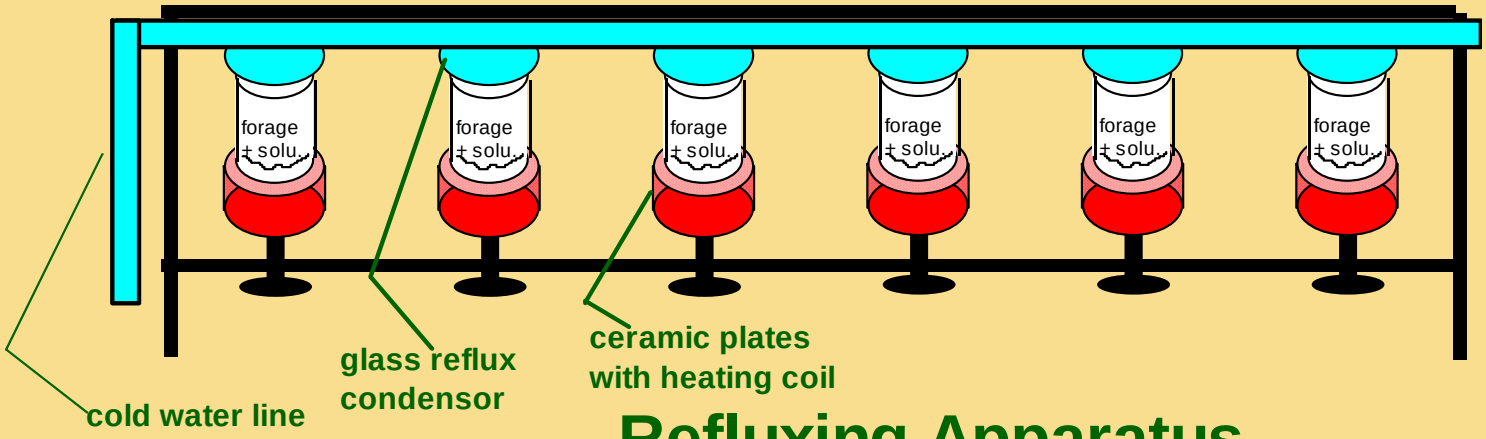


Source: Kawas et al., 1989

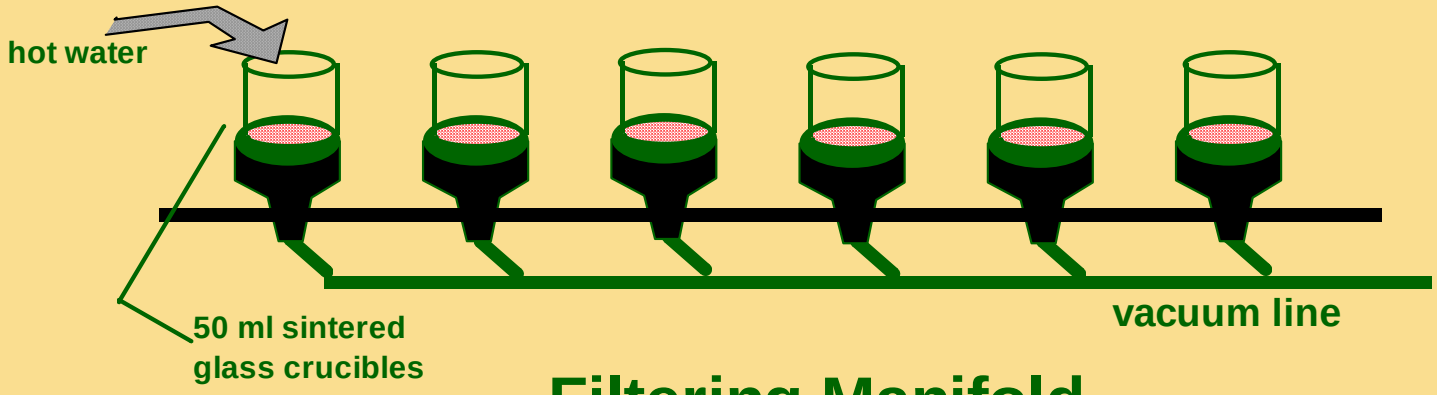
Standardize fiber analyses

- **Mertens obtained AOAC approved method *a*NDF**
- **National Forage Testing Association established proficiency testing program (DM, CP, ADF, aNDF)**
- **Implementation of Near Infrared Reflectance Spectroscopy (NIRS)**

Apparatus for Fiber Analysis



Refluxing Apparatus



Filtering Manifold

Standardize Forage Testing

- National Forage testing Association, www.foragetesting.org
- NIRS Forage and Feed Testing Consortium, www.NIRSconsortium.org

Forage Testing

- **Before 1970 -** protein, crude fiber, and minerals
- **During 1970's –** introduction of detergent fiber system
- **1976 –** Norris et al. USDA-ARS introduced Near Infrared Reflectance Spectroscopy (NIRS)

Near Infrared Reflectance Spectroscopy

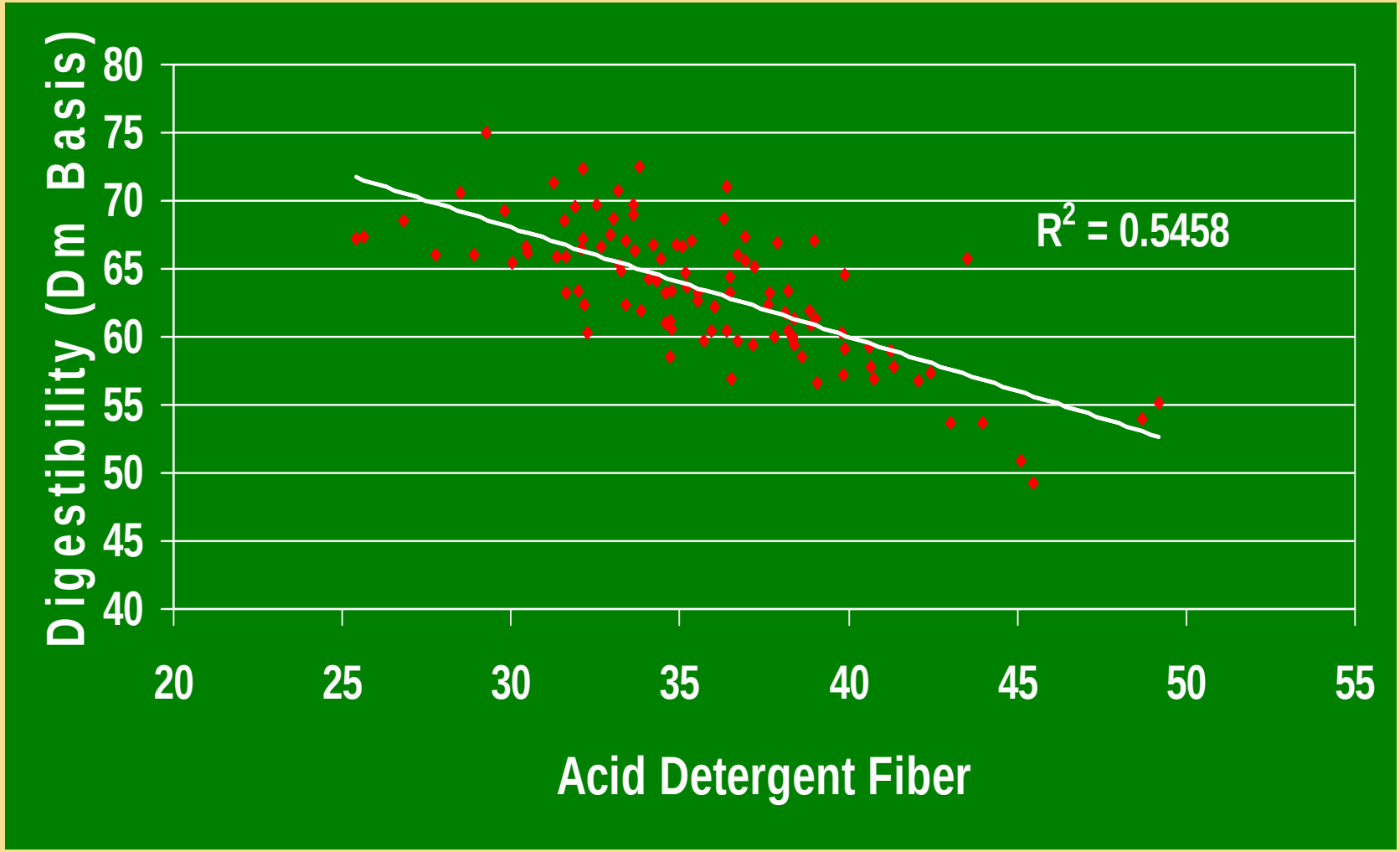
- **USDA-ARS NIRS Network**
  - **1978 - 1989**
- **USDA-CSREES Grants, 1984**

Penn State University
Richard Adams
University of Minn.
Jim Linn and
Neal Martin
University of Wis.
Dwayne Rohweder
and Terry Howard

Talking points . . .

- **Forage Tests 30 Years Ago**
- **Standardize fiber analyses**
- **Addition of *in vitro* NDF digestibility**

Comparison of ADF to *in vitro* digestibility of alfalfa



SOURCE: Undersander, Dan, UW Extension

Definition of Forage Quality

- **Neutral Detergent Fiber Digestibility (NDFD) is the portion of Neutral Detergent Fiber lost during incubation with rumen fluid.**
- **Incubation times may be 24 to 48 hours.**
- **dNDF is expressed as percent of dry matter**
- **NDFD is expressed as percent of NDF**

Add Ash to Test Package

- **Ash (also called total ash) is an estimate of the total mineral content; the residue remaining after burning a sample.**
  - **Values above 6% for grasses or 8% for legumes usually indicate soil contamination of forage.**
  - **Each 1% soil contamination is 1% less TDN of forage.**
  - **Ash, ADF-ash and NDF-ash will be different values because ADF and NDF procedures remove some minerals.**

RFV and RFQ index

- **30 years ago we needed an index that estimated potential dry matter intake of forages fed to high producing dairy cows**
- **AFGC Hay Marketing Task Force proposed Relative Feed Value Index – National Alfalfa Hay Marketing Task Force Adopted RFV index using ADF & NDF to predict digestibility and intake**

Change from RFV to RFQ

- **Fiber digestibility varies**
- **Prediction of *in vivo* digestibility from linear regression equation does not fit samples outside data set**
- **Need to use summative equation to predict energy to improve accuracy of prediction**

Summative Approach to Predicting TDN of Forages

- **Uniform feed fractions will have predictable digestion coefficients**

$$TDN_{1\text{-}X} = tdCP + (tdFA \times 2.25) + tdNDF + tdNFC - 7$$

+ **A more accurate and robust way to estimate TDN of forages than ADF**
- **TDN values estimated by NRC(2001) are different than what we are used to.**

Definition of Forage Quality

- **Relative Feed Value (RFV) is an index which ranks legume and legume-grass forages by digestible dry matter intake potential.**

Definition of Forage Quality

- **Relative Forage Quality (RFQ) is an index which ranks legume, grass and legume-grass forages by digestible dry matter intake potential.**

Definition of Forage Quality

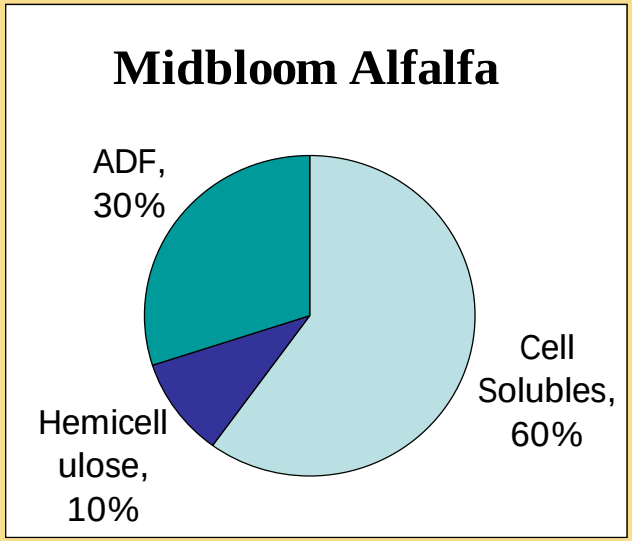
Relative Forage Quality (RFQ) =

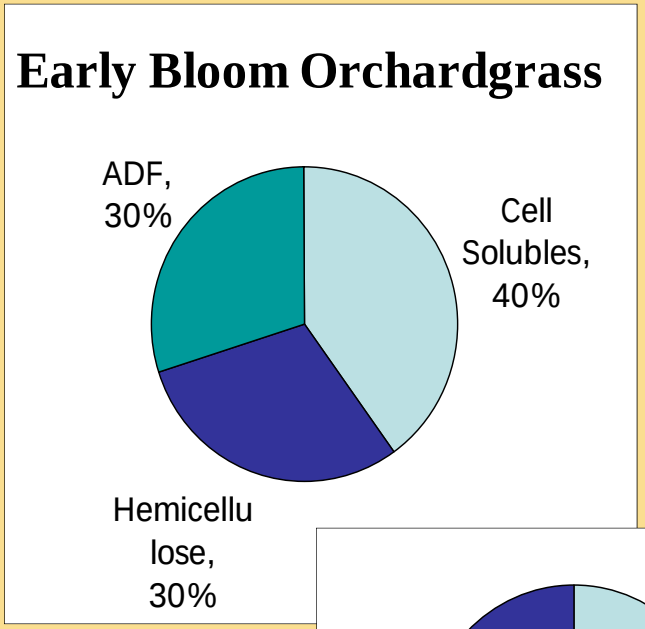
$$\frac{\text{(dIntake Potential * dTDN)}}{\text{Constant}}$$

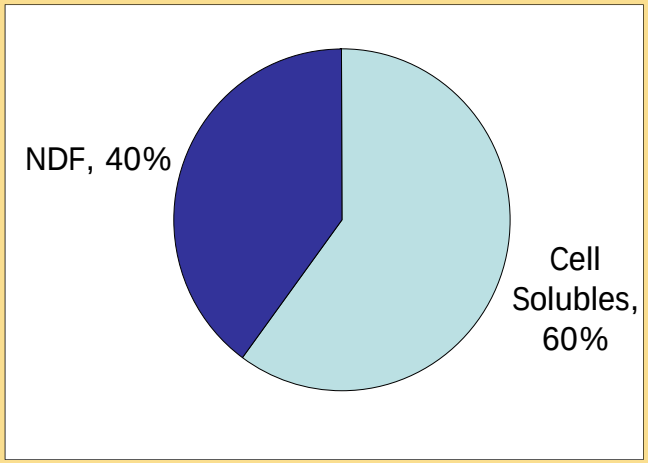
Same concept as RFV

- ✓ **using NDF as in RFV**
- ✓ **but in vitro fiber digestibility test**

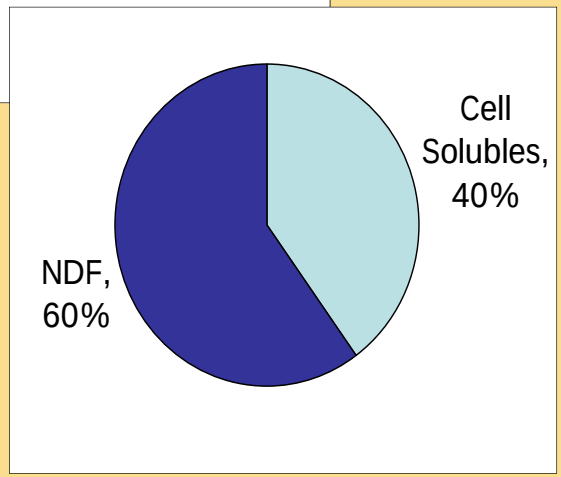
Forage Composition- Alfalfa vs. Grass





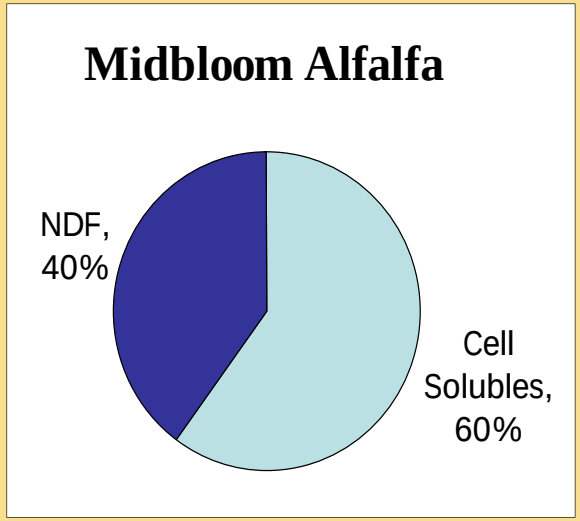


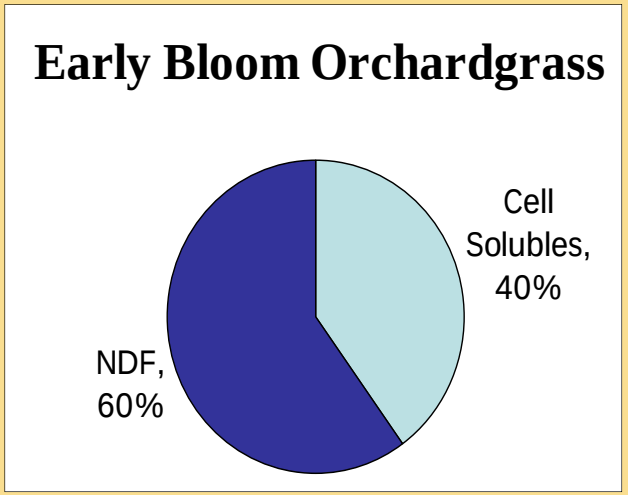
RFV 152



RFV 102

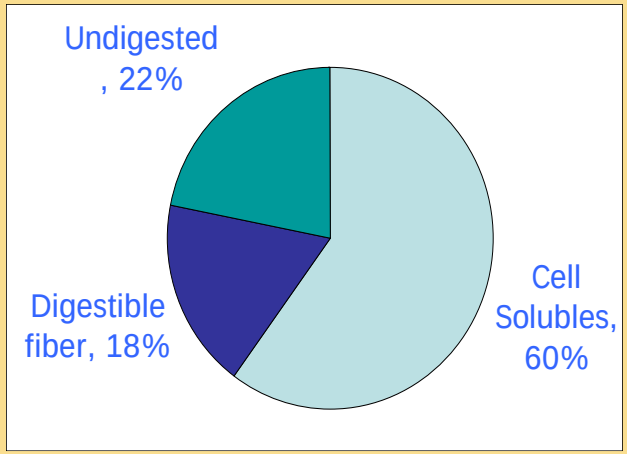
Forage Composition- Alfalfa vs. Grass





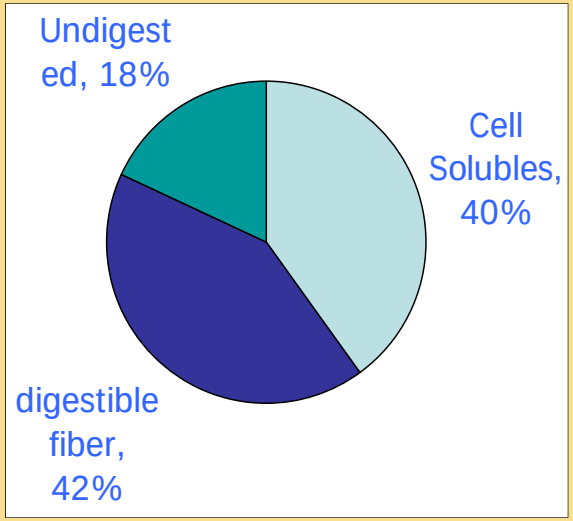
RFV 152

RFQ 145



RFV 102

RFQ 141



Relative Forage Quality

Intake potential

= base intake plus adjustment for dNDF

= base intake + [(dNDF-average dNDF) *.374]

=(0.012/NDF) + (NDFD-45)*0.374*1350/100

From Oba and Allen, 1999, J Dairy Sci

Relative Forage Quality for Grasses

$$TDN_{grass} = (NFC*.98) + (CP*.87) + (FA*.97*2.25) + (NDFn*NDFDp/100) - 10$$

Where NDFDp = 22.7 + .664*NDFD

$$DMI_{Grass} = -2.318 + 0.442*CP - 0.0100*CP2 - 0.0638*TDN + 0.000922*TDN2 + 0.180*ADF - 0.00196*ADF2 - 0.00529*CP*ADF$$

Source: Moore and Undersander, 2002
Moore and Kunkle, 1999

Uses of Relative Forage Quality

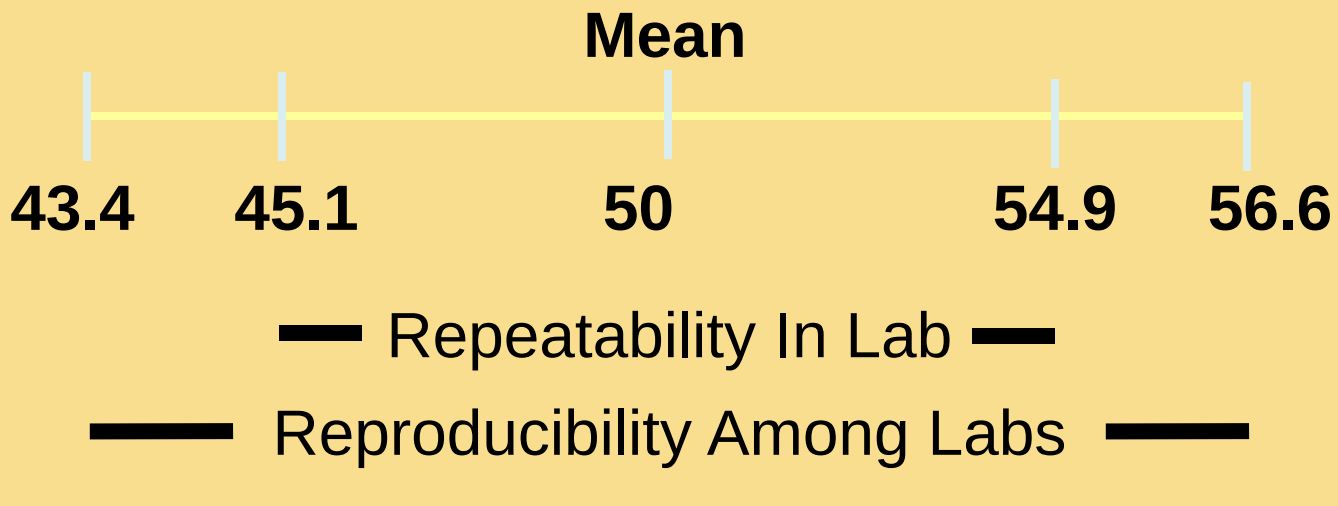
- When to harvest
- Allocation of hay to animals
- Buying/selling hay
- Contracting for harvest with quality incentive

New Tests – Diagnostic Tools

- Improved NDFD methods
- Protein and starch analyses
- Fermentation profiles
- Gas fermentation techniques in rumen-fluid to estimate rates of fermentation of carbohydrate pools

Repeatability & Reproducibility

Sample	Grand Mean 30 h NDFD Range	95% Probability Limits Repeatability	Reproducibility
Alfalfa	39.1 - 58.5	9.5	10.2
Corn Silage	43.8 - 62.6	10.7	15.6
Grass	33.4 - 73.9	8.7	14.6



Hall and Mertens, 2012

New Tests – Diagnostic Tools

Dr. David Combs and Rock River Lab presents:

A New Analysis for Total Tract NDFD and Use in a Ration Evaluator

Have You Kept Pace…

New Tests – Diagnostic Tools

	TTNDFD, %
Legumes	
In vivo lit review (Goeser's Ph.D) n=20 studies, 64 treatments	47.3
TTNDFD predicted with Standardized In vitro NDFD method (n=978 samples)	46.7
Corn silage	
In vivo lit review (Goeser's Ph.D) n=25 studies, 81 treatments	40.2
TTNDFD predicted with Standardized In vitro NDFD method (n=996 samples)	40.0

New Tests – Diagnostic Tools

Observed in vivo TTNDFD vs Lab-Predicted TTNDFD

	Legumes			Corn Silage	
	In vivo studies	TTNDFD model		In vivo studies	TTNDFD model
Mean	47.3	46.7		40.2	40.0
Median	47.5	46.2		41.1	40.3
Range	31-66	24-79		20-59	19-56
St. Deviation	8.1	5.9		8.8	4.1
N	64 treatment averages 20 trials	982 NIR scanned samples		81 treatment averages 25 trials	996 NIR scanned samples

New Tests – Diagnostic Tools

TTNDFD

Total tract *in vivo* NDF digestibility predicted from the *in vitro* values

TTNDFD integrates:

Amount of diet fiber…
Rate of ruminal fiber digestion… and
Rate of Passage of fiber…

Allow comparisons across forage types and rations
Can be verified with direct measurements of digestibility

Silage Fermentation Analysis…

Crop factors

- Moisture content
- Buffering capacity
- Sugar content

Management factors

- Packing speed
- Silage pack density
- Type of additive used
- Chop length
- Silo management during storage
- Silo management during feedout

Use FA to quantitatively explain poor silage nutritive value or low intakes *not to balance diets for cattle*

Fermentation End Products

End Product	Legume silage (30-40 %)[1]	Legume silage (45-55 %)[1]	Grass silage (30-35 %)[1]
pH	4.3-4.7	4.7-5.0	4.3-4.7
Lactic acid, %	7-8	2-4	6-10
Acetic acid, %	2-3	0.5-2.0	1-3
Propionic acid, %	<0.5	<0.1	<0.1
Butyric acid, %	<0.5	0	0.5-1.0
Ethanol, %	0.2-1.0	0.5	0.5-1.0
Ammonia-N, %	10-15	<12	8-12

1 Percent of dry weight

SOURCE: Kung, Limin and Randy Shaver. 2003. 3(13). Focus on Forage.
Wisconsin Team Forage. UW Extension.

New Tests – Diagnostic Tools

Feedstuffs, December 13, 2010 **Feedstuffs** Reprint

Gas fermentation: A promising diagnostic tool

ADJUSTING rations to account for digestibility differences among new-crop forages can be a humbling experience. Single-time-point neutral detergent fiber (NDF) digestibility (NDFD) values (e.g., 24-hour NDFD, % of NDF) can provide some comparative direction for nutritionists but have limited value in modern ration-balancing software that require digestion rates (Kd) rather than NDFD as feed library inputs.

A series of seminars delivered at the October World Dairy Expo unveiled a new laboratory method called the Fermentrics

Bottom Line

with
BILL MAHANNA*

disappearance at set time points. Thus, an incorrect choice of time points can lead to incorrect data interpretation, conclusions and decisions. In addition, even if the choice of time points is correct, what happens between the points — or the kinetic aspects of

fermentation products (carbon dioxide and methane) of microbial metabolism and the additional carbon dioxide produced upon buffering microbial-produced short-chain fatty acids (SCFA) — primarily acetate and butyrate.

Its application to the estimation of various organic matter fractions (NDF, starch, soluble carbohydrates) does have limitations. However, forage NDF research (Doane et al., 1997) exemplifies the strong correlation between gas production and NDF digested (gas yield = 0.35 mL/mg of NDF digested; R^2 = 0.92; Johnston and

Have You Kept Pace…

New Tests – Diagnostic Tools

Fermentrics™ Interpretation and Guidelines

September 2013

Fermentrics™ is a novel laboratory method utilizing a batch-culture, rumen-fluid, gas-fermentation system combined with mathematical curve-peeling techniques allowing for the differentiation of rapid and slowly-fermenting carbohydrate pools in individual feedstuffs or TMR samples. The rate and extent of organic matter degradation, employing hundreds of data points, can be determined with Fermentrics™ by monitoring gaseous fermentation products (CO_2, methane) of microbial metabolism in addition to CO_2 produced by the buffering of microbial produced short-chained fatty acids (SCFA, primarily propionate, acetate and butyrate). This allows for a direct approach to determining carbohydrate pool (B_1, B_2, B_3) digestion rates to more accurately populate feed libraries in newer ration-balancing software. Fermentrics™ reports incorporate traditional nutritional parameters with unique analytes such as direct measurement of microbial biomass production and a microbial approach to measuring soluble protein.

SOURCE: Dairyland Laboratories, Inc.

New Tests – Diagnostic Tools

While gas-fermentation systems are quite popular among European researchers there are only a few research labs in North America with gas-fermentation capabilities and they are not capable of processing and handling the sample volume needed in a commercial offering. The desire to provide more dynamic and diagnostic nutritional tools led to an August, 2010 joint initiative between Dairyland Laboratories, Inc. and RFS Technologies to commercialize Fermentrics™ and make this cutting-edge analysis widely available to North American livestock producers and their nutritionists.

RFS Technologies™ is a full service agricultural testing and research laboratory located Ottawa, Canada who have spent decades researching and field-testing Fermentrics™ out of the frustration of not being able to use current analytical techniques to understand and manipulate the biological potential of the rumen. This is not to diminish the value of wet chemistry or NIR analyses, but rather to point out their static nature which does not provide the dynamic or diagnostic approach needed to generate both qualitative and quantitative information on the rate and extent of digestion in a practical and inexpensive manner. Fermentrics™ is based on research conducted at Cornell University, University of Kentucky, the University of California, the Rowett Research Institute, the University of Hohenheim and the DLO Institute for Animal Science and Health.

SOURCE: Dairyland Laboratories, Inc.

Forage Testing – Keeping Pace

- **Rapid tests are available using standard protocols for accuracy**
- **Efforts to standardize tests and protocols have been driven by research and extension**
- **Standardization of fiber digestibility, protein and starch tests across forage and grain products is needed**

Quality terms - Needed

Have You Kept Pace…

Recommended Reading

- **Forage sampling frequency…**

http://www.uwex.edu/ces/crops/uwforage/ForageSamplingFrequency-FOF.pdf

- **In vitro NDF digestibility…**

http://www.uwex.edu/ces/crops/uwforage/30vs48-FOF.htm

- **Relative forage quality…**

http://www.uwex.edu/ces/crops/uwforage/RFQ-FOF.pdf

- **Heat damaged forages….**

http://www.uwex.edu/ces/crops/uwforage/HeatDamForageEnergy-FOF.pdf