

Producing Quality Forages for Cattle and Sheep



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**U.S. Dairy Forage
Research Center
Madison, WI**

**2009 Annual Meeting
Ohio Forage and
Grasslands Council**

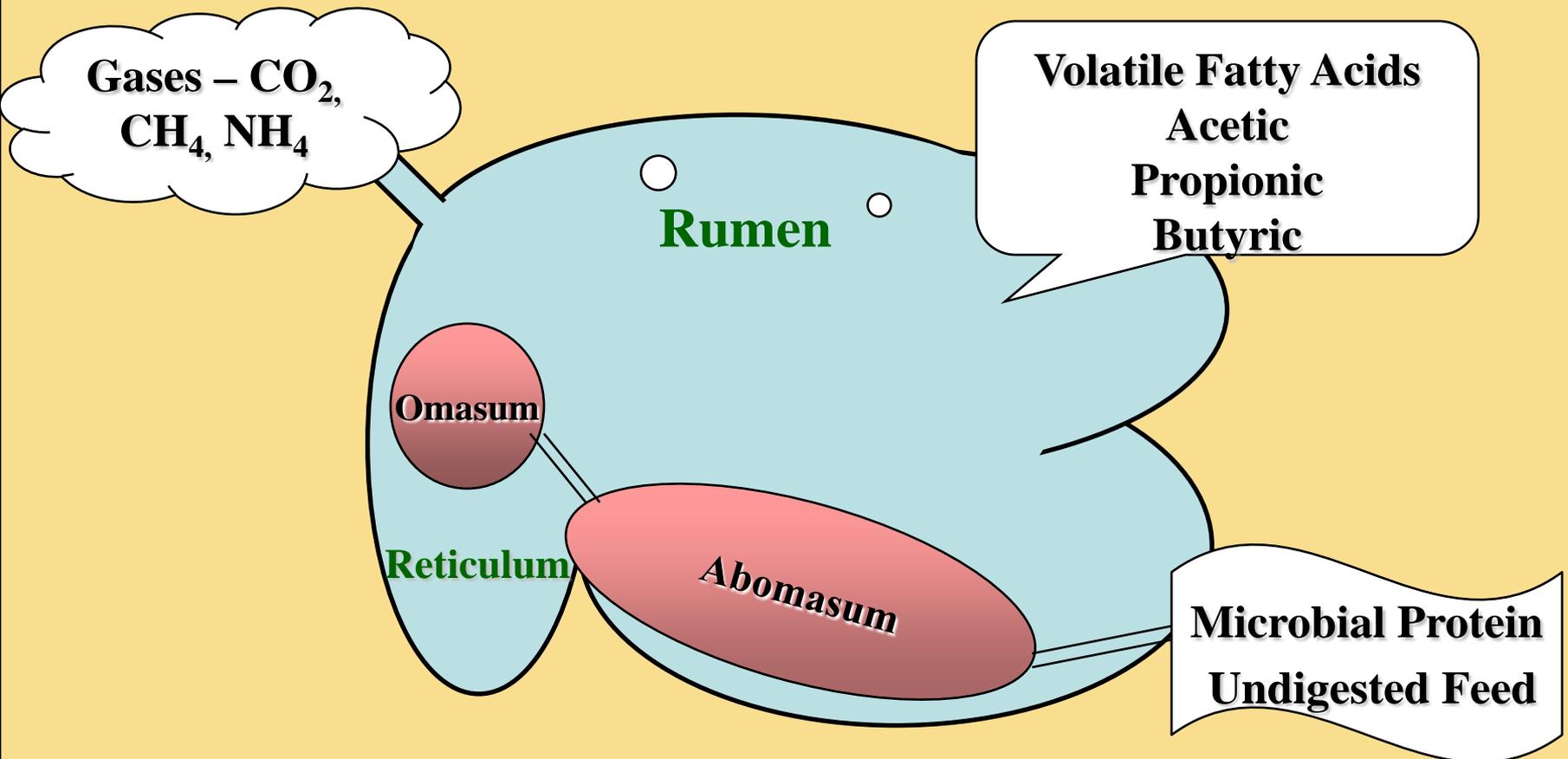
**February 13, 2009
Reynoldsburg, Ohio**

This talk will explore . . .

- Forage quality tests that effectively allocate forages to ruminant livestock
- What tests are needed?
- What do they mean?
- How to use them?



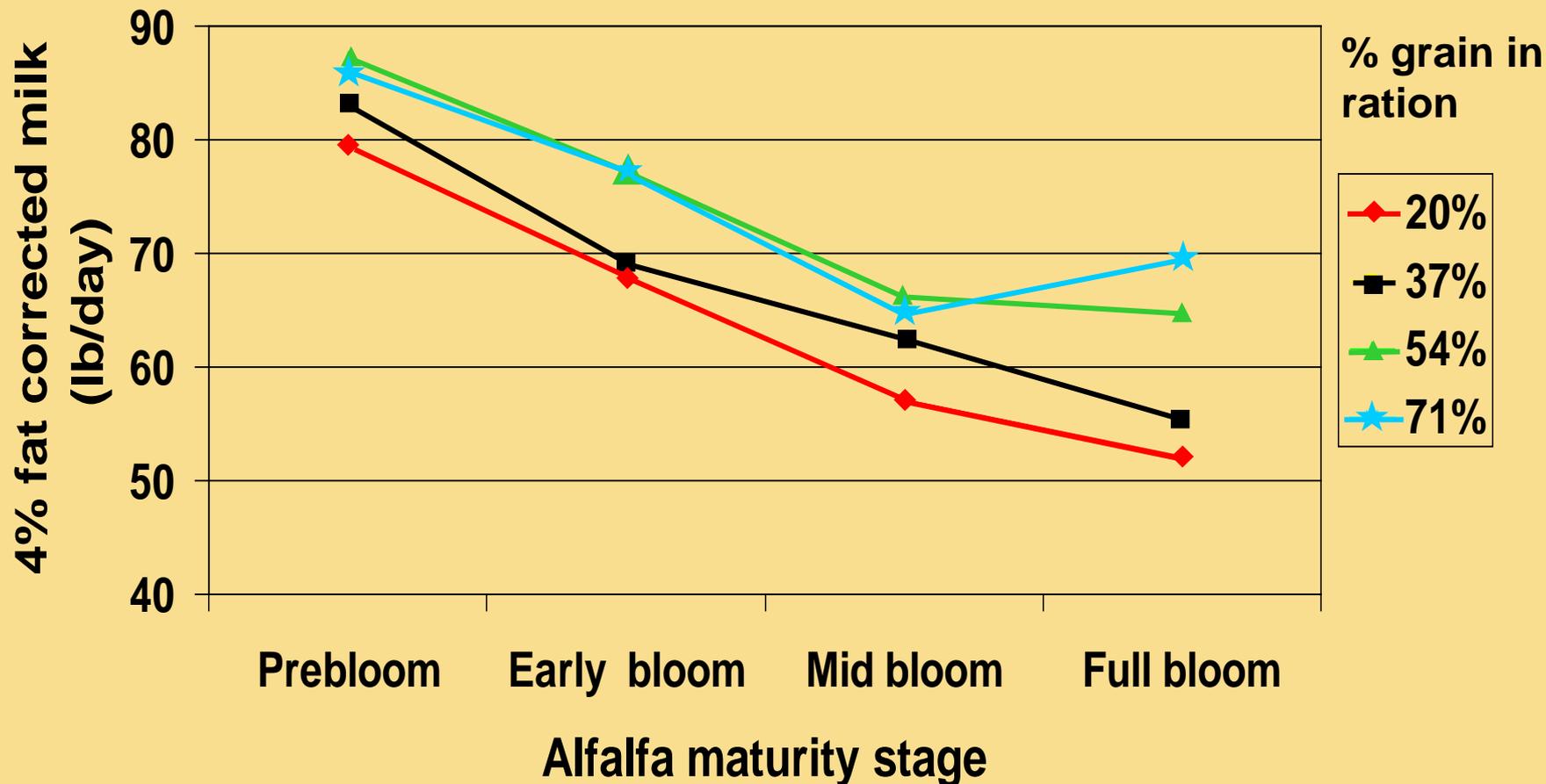
Ruminant Digestion End Products



SOURCE: Linn, James, G.; U of Minnesota



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

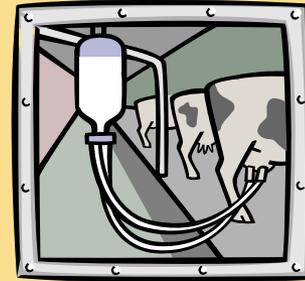


Source: Kawas et al., 1989



Understanding Forage Quality is Needed to:

- Improve profit
- Make improvements in animal performance
- Increase utilization of forage



Analytical Values Needed

- **Dry Matter**
- **Crude Protein**
- **Neutral Detergent Fiber**
- **Acid Detergent Fiber**
- **Acid Detergent Lignin**
- **Neutral Detergent Fiber Digestibility**
- **Ash**



Definition of Forage Quality

Analytical Terms

- Dry matter (DM) is the percentage of feed that is not water.



Definition of Forage Quality

Analytical Terms

- Crude protein (CP) is determined by measuring total nitrogen in a sample and multiplying by 6.25.
- It is a mix of true protein and non-protein nitrogen.

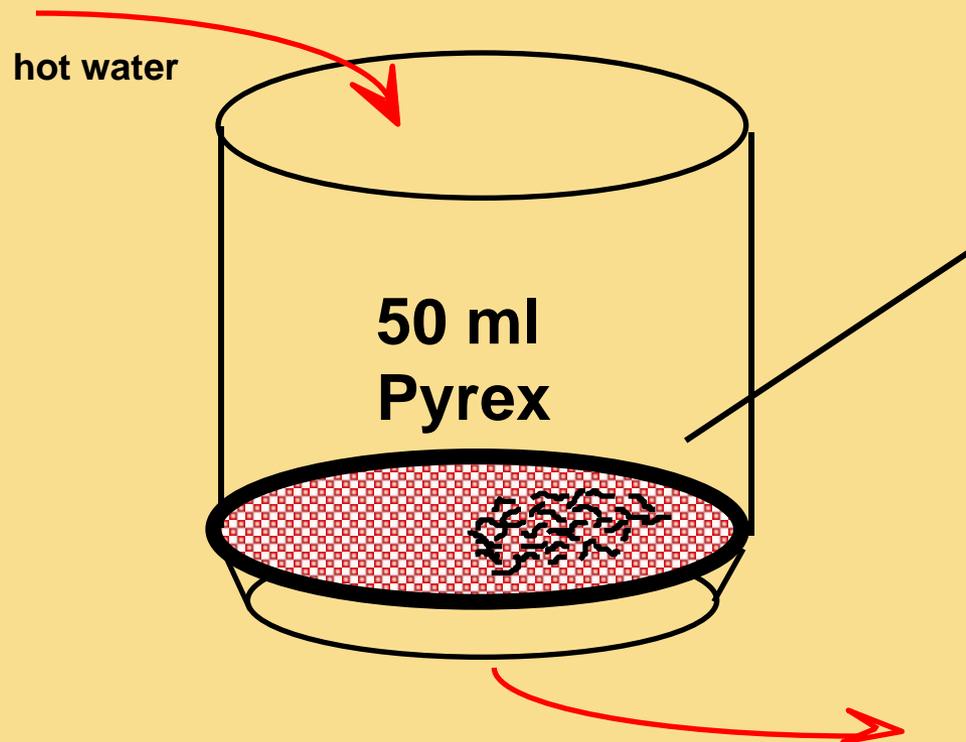


Definition of Forage Quality

Analytical Terms

- Neutral detergent fiber (NDF) is the percentage of fiber in a forage sample which is not soluble in a neutral detergent solution.
 - It is the residue left after boiling in neutral detergent solution.
 - It is called aNDF if amylase and sodium sulfite are used during the extraction.

Neutral detergent fiber analysis



Captures:

- cellulose
- hemicellulose
- lignin
- acid insoluble ash
- cutin

Releases:

- cell solubles

sugars

starch

fat

protein

NPN

pectin

Neutral Detergent Fiber (NDF)

- Represents cell walls
- Partially digestible
- $100 - \text{NDF} = \text{cell solubles}$
- NDF is inversely related to voluntary intake



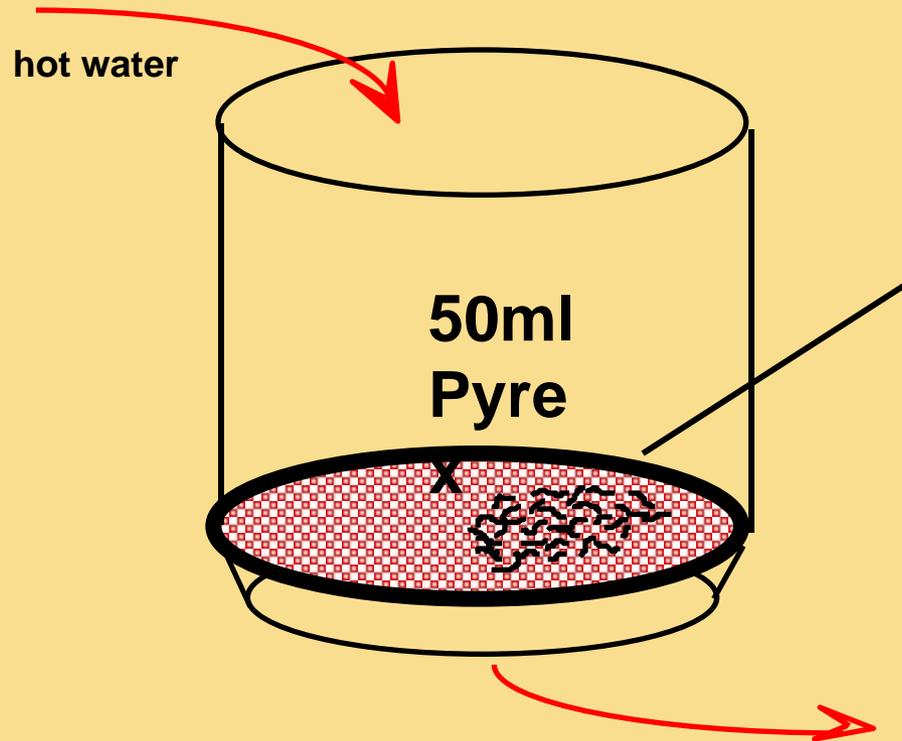
Definition of Forage Quality

Analytical Terms

- Acid detergent fiber (ADF) is the percentage of fiber in a forage sample which is insoluble in a weak acid.
- It is the residue remaining after boiling a forage sample in acid detergent solution.



Acid detergent fiber analysis



Captures:

- cellulose
- lignin
- silica (insoluble ash)
- cutin

Releases:

- cell solubles
- hemicellulose

Acid Detergent Fiber (ADF)

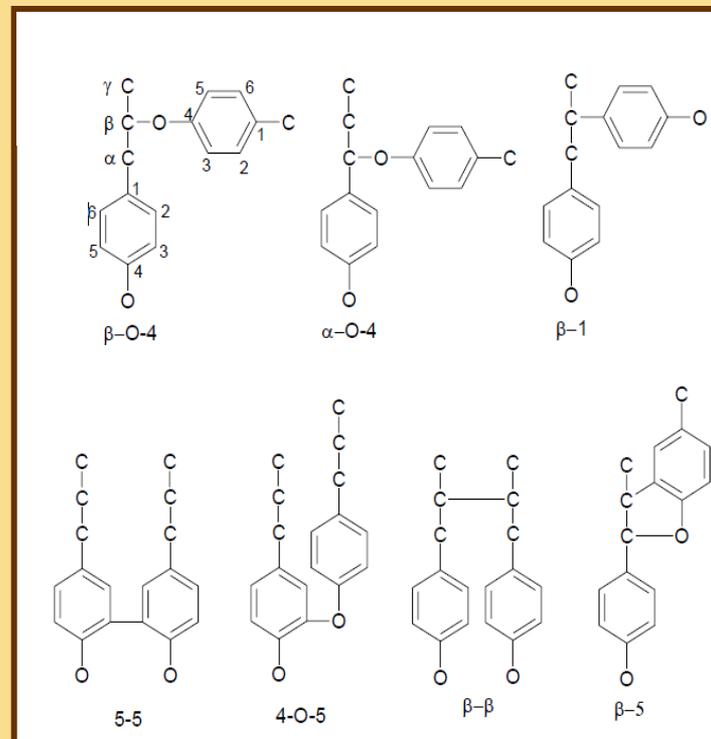
- Represents cell wall minus hemicellulose
- Is inversely related to digestibility



Definition of Forage Quality

Analytical Terms

- **Lignin** – polymer of phenyl propane units
 - Gives strength to plant
 - Undigestible
 - Reduces digestion of fiber



Definition of Forage Quality

Analytical Terms

- **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.

Definition of Forage Quality

Analytical Terms

- 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.



Influence of NDF digestibility on forage digestibility

$$\text{TDN} = \text{tdCP} + (\text{tdFA} \times 2.25) + (.75 \times \text{NDFD}_{48} \times \text{NDF}) + \text{tdNFC} - 7$$

	NDF	ADF	NDFD ₄₈	TDN	DDM*
Forage A:	40	30	58	61.6	65.5
Forage B:	40	30	36	53.6	65.5

$$*\text{DDM} = 88.9 - 0.779(\text{ADF})$$

Influence of NDF digestibility on dry matter intake

$$\begin{aligned} \text{dIntake} &= \text{base intake plus adjustment for dNDF} \\ &= \text{base intake} + [(\text{NDFD-average NDFD}) * .374] \end{aligned}$$

Source: Oba and Allen, 1999. *J. Dairy Sci.* 82:589-596

	NDF	ADF	NDFD	dIntake	DMI*
Forage A	40	30	58	31.0	2.78% of BW
Forage B	40	30	36	22.8	2.78% of BW

*DMI = 120/NDF

Adjusting DMI , Base TMR

	<u>lb DM</u>
Alfalfa 20-30-40-58	25
Corn silage	6
HMC	20
Protein/mineral/vitamins	7
DMI	58
NRC 2001 ration evaluation (110 lb milk)	
NE allowable milk, lb	93
MP allowable milk, lb	110
NEI balance, Mcal	- 5.6
TMR Nel, Mcal/lb	.70

Adjusting DMI , Base TMR

Suppose alfalfa
composition changed
to 20-30-40-36:

	<u>lb DM</u>	Impact:	
Alfalfa 20-30-40-58	25	TDN	61.6 -> 53.6
Corn silage	6		
HMC	20	dIntake	31.0 ->22.8
Protein/mineral/vitamins	7		
DMI	58	Action steps	
NRC 2001 ration evaluation (110 lb milk)		•Change alfalfa TDN in	
NE allowable milk, lb	93	ration program	
MP allowable milk, lb	110		
NEI balance, Mcal	- 5.6	•Discount TMR intake	
TMR Nel, Mcal/lb	.70	.374(58-36) = 8 lb	

Adjusting DMI and TDN

	Base TMR <u>20-30-40-58</u>	Adjusted TMR <u>20-30-40-36</u>
Alfalfa	25	22
Corn silage	6	5
HMC	20	17
Protein/mineral/vitamins	7	6
DMI	58	50
NRC 2001 ration evaluation		
NE allowable milk, lb	93	83
MP allowable milk, lb	110	91
NE _l balance, Mcal	- 5.6	-8.7
TMR Ne _l , Mcal/lb	.70	.73



Calculated Terms Needed

- **Digestible Dry Matter**
- **Dry Matter Intake**
- **Relative Feed Value**
- **Relative Forage Quality**



Definition of Forage Quality

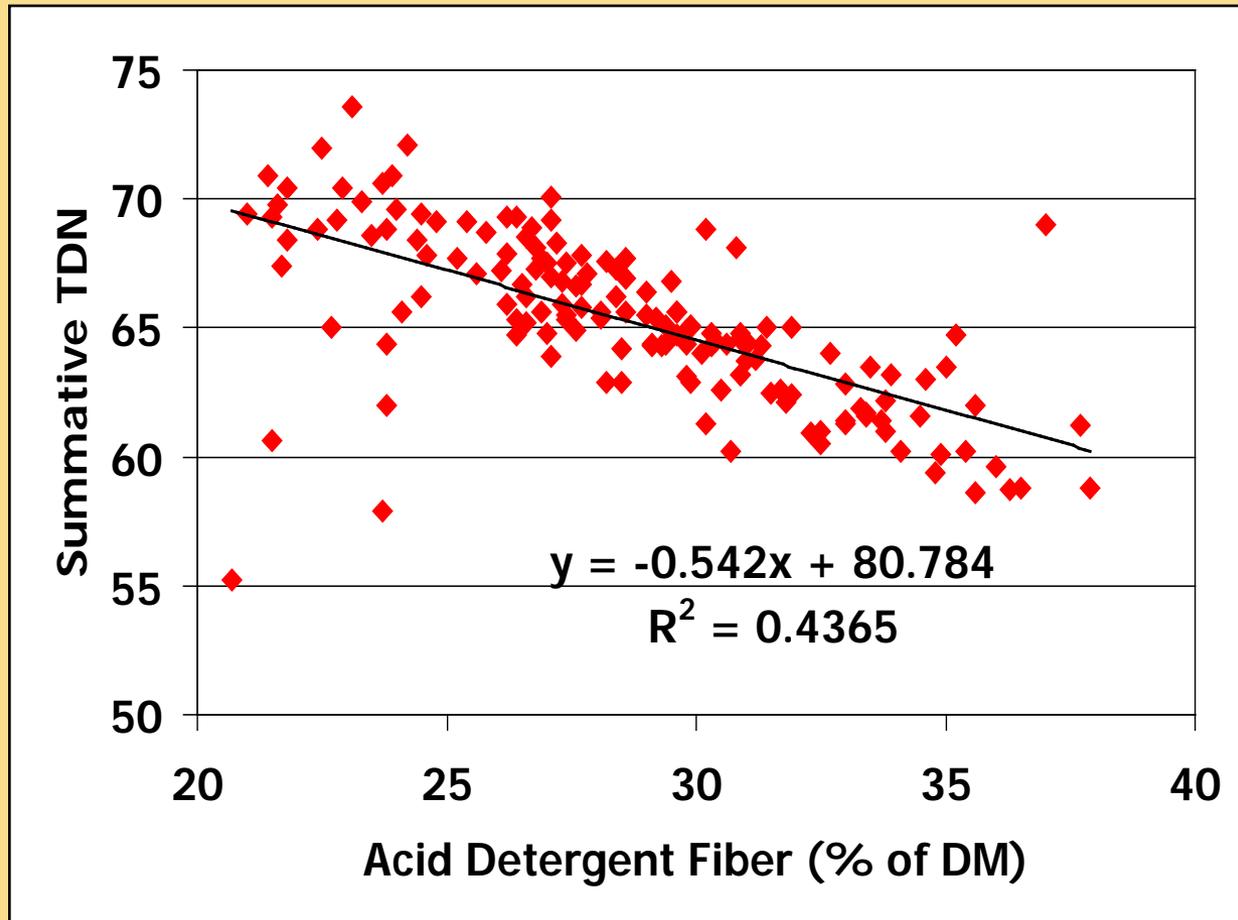
Calculated Terms

- Digestible Dry Matter (DDM) is the portion in a forage that is digested by animals at a specified level of intake.
 - Estimated by:
 - measuring in vitro or in situ digestibility,
 - near infrared reflectance spectroscopy
 - calculated from % ADF (most common but not recommended).

~~$$\% \text{ DDM} = 88.9 - (\% \text{ ADF} \times 0.779)$$~~

~~$$\% \text{ DDM} = \% \text{ TDN}$$~~

Comparison of ADF to TDN for Alfalfa, 2003 Forage Superbowl



Producing Quality Forages for Cattle and Sheep



Definition of Forage Quality

Calculated Terms

- Dry matter intake (DMI) is an estimate of the relative amount of forage an animal will eat when only forage is fed.

$$\text{DMI as a percent of body weight} = \frac{120}{\text{Forage NDF (\% of DM)}}$$

Definition of Forage Quality

Calculated Terms

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

Use of the RFV index

- Allocate forages to livestock
- Purchase hay
- Forage management evaluation

$$\text{RFV index} = \frac{\% \text{ DDM} \times \text{DMI}}{1.29}$$

Relative Feed Value (Current)

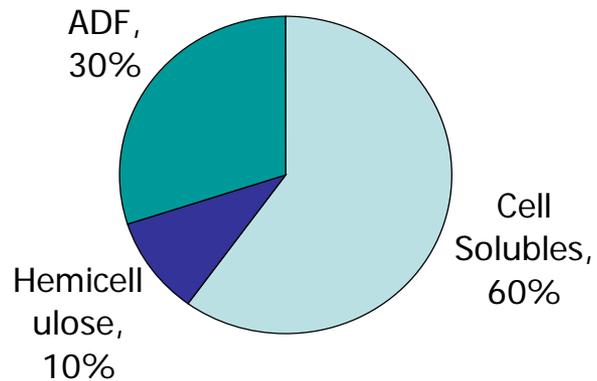
Intake Potential = 120/NDF

Digestible DM = 88.9 - (0.779 * ADF)

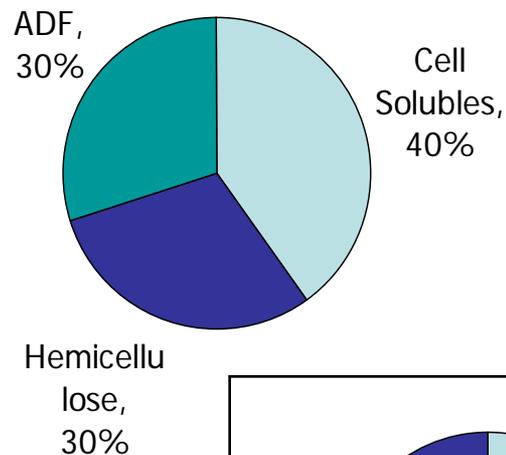
Constant = 1.29

Forage Composition- Alfalfa vs. Grass

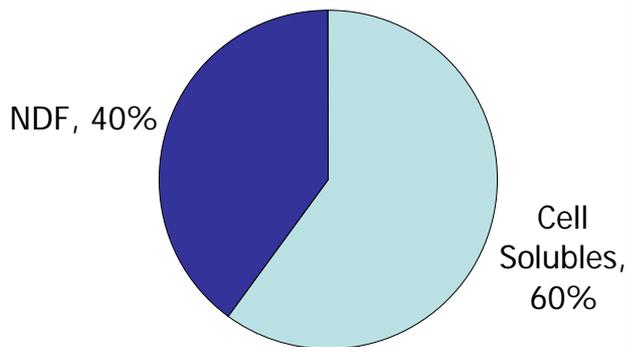
Midbloom Alfalfa



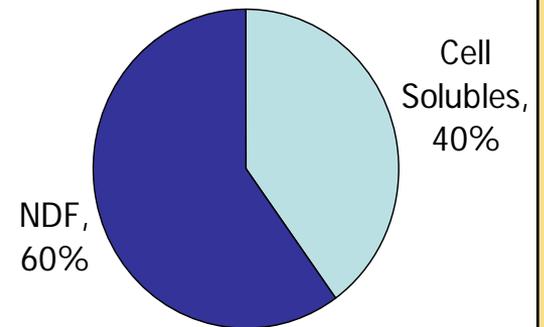
Early Bloom Orchardgrass



RFV 152



RFV 102



Definition of Forage Quality

Calculated Terms

- 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) =

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

Same concept as RFV

- ✓ using NDF as in RFV
- ✓ but adding fiber digestibility



Summative Approach to Predicting TDN of Forages

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

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

- + **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.**



Relative Forage Quality

Intake potential

= base intake plus adjustment for dNDF

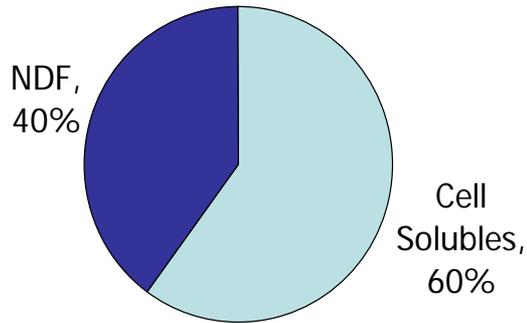
= base intake + [(dNDF-average dNDF) * .374]

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

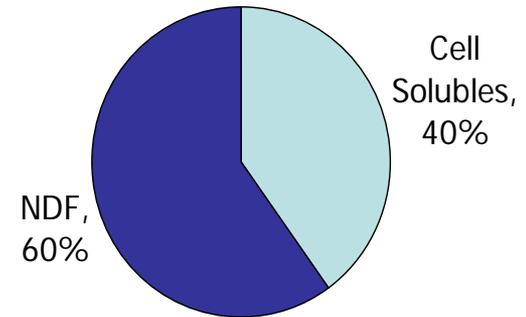
From Oba and Allen, 1999, J Dairy Sci

Forage Composition- Alfalfa vs. Grass

Midbloom Alfalfa



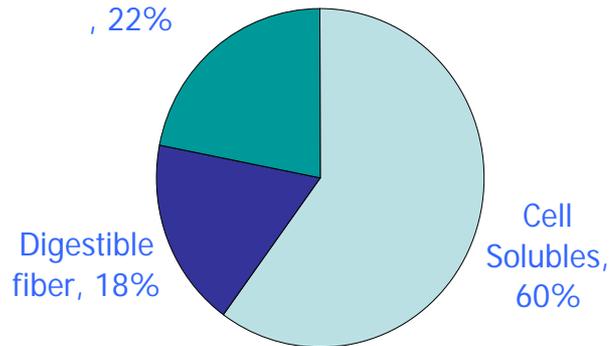
Early Bloom Orchardgrass



RFV 152

RFQ 145

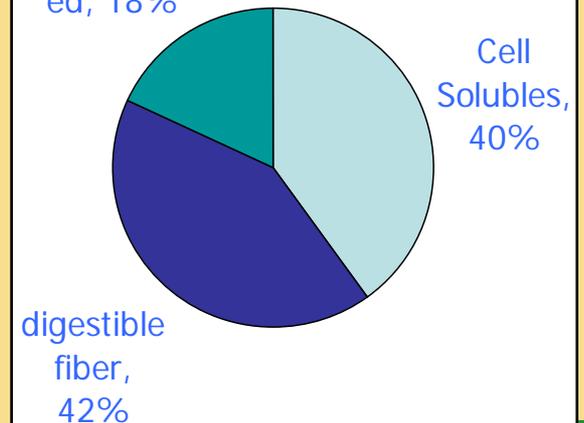
Undigested
, 22%



RFV 102

RFQ 141

Undigest
ed, 18%



Relative Forage Quality for Grasses

$$\text{TDN}_{\text{grass}} = (\text{NFC} \cdot .98) + (\text{CP} \cdot .87) + (\text{FA} \cdot .97 \cdot 2.25) + (\text{NDFn} \cdot \text{NDFDp} / 100) - 10$$

$$\text{Where NDFDp} = 22.7 + .664 \cdot \text{NDFD}$$

$$\text{DMI}_{\text{Grass}} = -2.318 + 0.442 \cdot \text{CP} - 0.0100 \cdot \text{CP}^2 - 0.0638 \cdot \text{TDN} + 0.000922 \cdot \text{TDN}^2 \\ + 0.180 \cdot \text{ADF} - 0.00196 \cdot \text{ADF}^2 - 0.00529 \cdot \text{CP} \cdot \text{ADF}$$

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

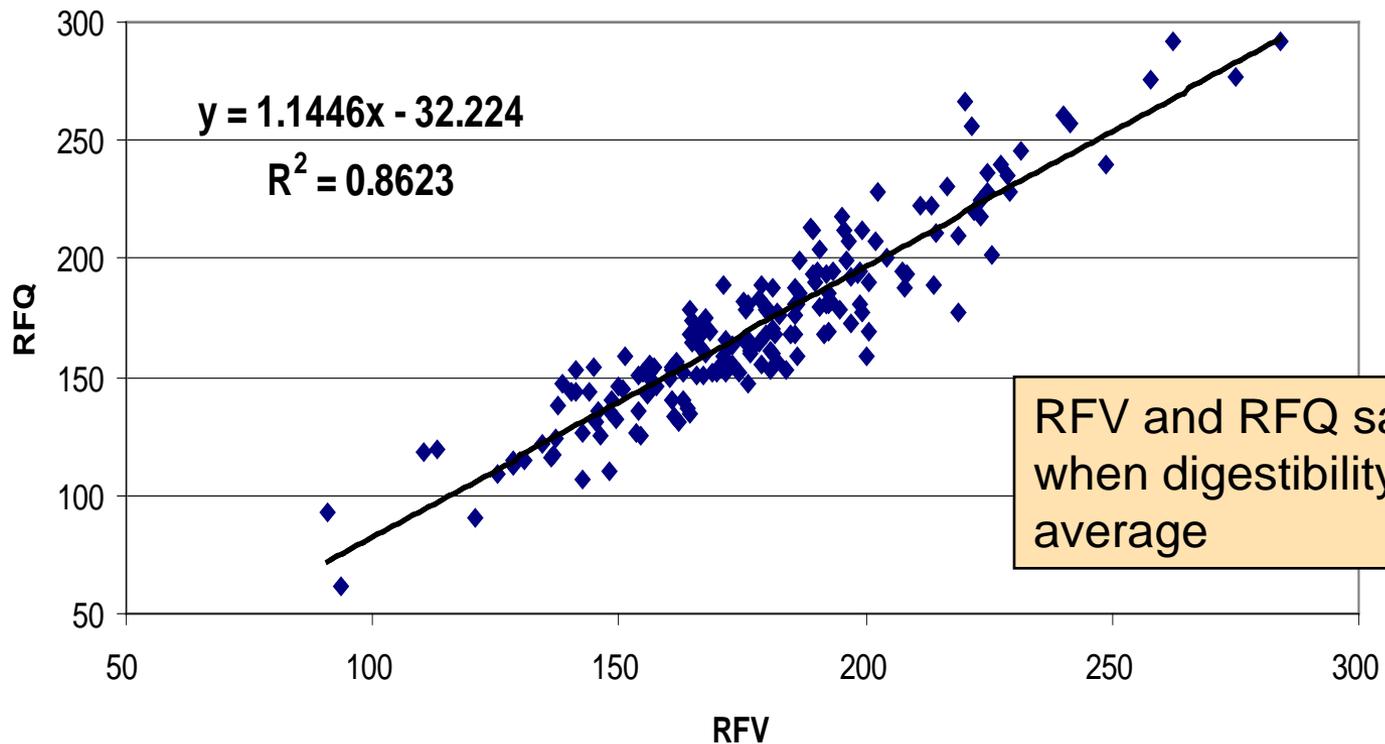


Uses of Relative Forage Quality

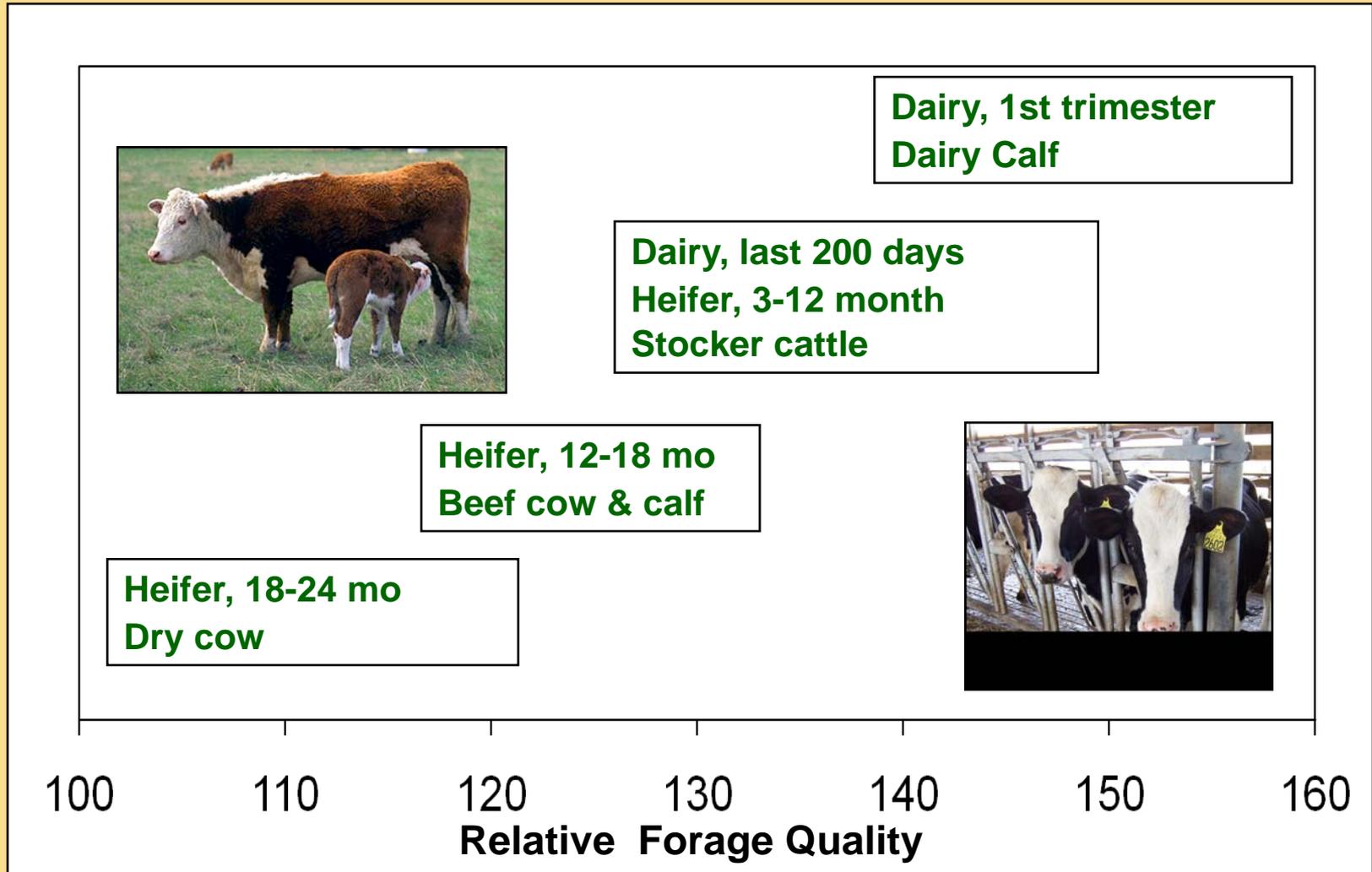
- **When to harvest**
- **Allocation of hay to animals**
- **Buying/selling hay**
- **Contracting for harvest with quality incentive**



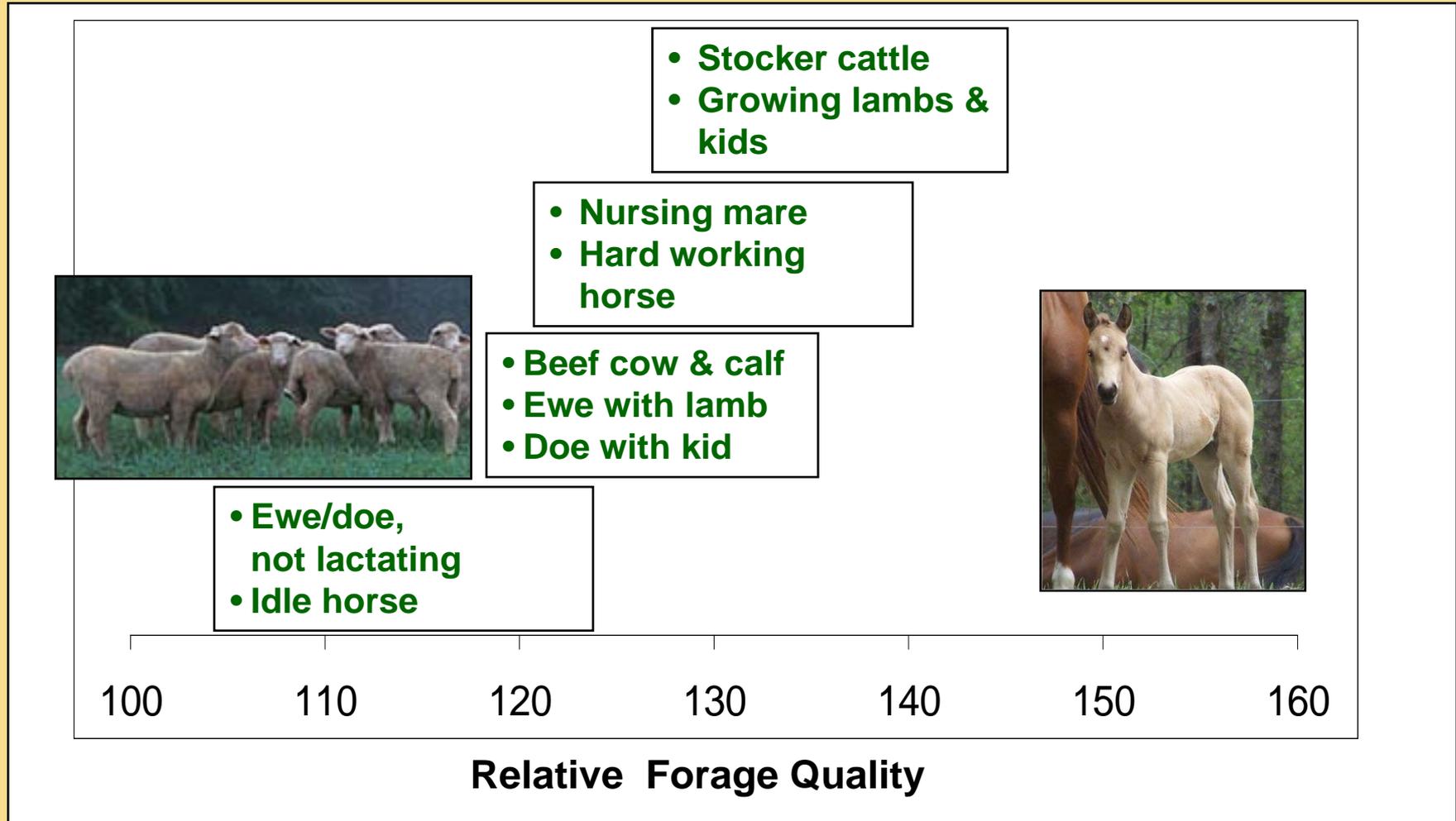
Comparison of RFV and RFQ for Hay, Haylage, and Baleage, 2002 Worlds Forage Superbowl



Forage Quality Needs of Animals



Forage Quality Needs of Animals



Protein Content of Forage

Analytical Results of Four Hay Samples on a 100 % Dry Matter Basis

Component	158 Alfalfa/ Orchard Grass	173 Alfalfa/ Grass	225 Orchard Grass	178 Alfalfa/ Grass
Percent				
Dry Matter (DM)	83.3	88.1	88.6	88.6
Crude Protein (CP)	16.9	8.4	7.9	9.6
ADF	45.5	40.7	44.4	41.2
NDF	56.0	58.7	68.4	57.9
NDFD	68.3	54.6	55.4	43.8
Phosphorus (P)	0.34	0.26	0.29	0.19
Potassium (K)	3.37	2.26	2.28	1.80
Calcium (Ca)	1.39	0.50	0.29	0.55
Magnesium (Mg)	0.33	0.22	0.23	0.22

Crude protein needs range from approximately 7% for mid-gestation mature dry cows to approximately 13% for beef cows nursing calves.

Producing Quality Forages for Cattle and Sheep



NDF Content of Forage

Analytical Results of Four Hay Samples on a 100 % Dry Matter Basis

Component	158 Alfalfa/ Orchard Grass	173 Alfalfa/ Grass	225 Orchard Grass	178 Alfalfa/ Grass
Percent				
Dry Matter (DM)	83.3	88.1	88.6	88.6
Crude Protein (CP)	16.9	8.4	7.9	9.6
ADF	45.5	40.7	44.4	41.2
NDF	56.0	58.7	68.4	57.9
NDFD	68.3	54.6	55.4	43.8
Phosphorus (P)	0.34	0.26	0.29	0.19
Potassium (K)	3.37	2.26	2.28	1.80
Calcium (Ca)	1.39	0.50	0.29	0.55
Magnesium (Mg)	0.33	0.22	0.23	0.22

- Range from 40% on early bloom legume hay to 72% on late cut grass hay
- Maximum NDF DM content of the daily ration should be from 1.2 to 1.5 % of the cow's body weight.
- Higher quality forage results in more forage consumed.
- As NDF values increase, forage intake will decrease.

Forage test

UW Soil & Forage Analysis Laboratory

2611 East 29th Street
 Marshfield, WI 54449
 Phone 715-387-2523 Fax 715-387-1723

Bucky Badger
 2611 East 29th Street
 Marshfield, WI 54449

Account: 555901
 Date received: 2/1/2006
 Date processed: 2/17/2006

Results also available on-line at <http://uwlab.soils.wisc.edu/reports>
 lab number: 12346 access code: qsnm

COOPERATIVE EXTENSION
 University of Wisconsin-Extension
 University of Wisconsin-Madison
 Soils Department, Madison, WI



PROUDLY USING
 NIRSC EQUATIONS

Corn Silage Report - UW Recommended

Report Number: 12346 Lab Number: 2 Sample Description: CS sample
 Material: Corn Silage
 Harvest date: 4/7/2008

Item	Abbreviation	Unit	Unprocessed	Processed	Method ¹
Dry Matter	DM	% as fed	35.84	35.84	WC
Moisture		% as fed	64.16	64.16	C
Protein Fractions					
Crude Protein	CP	% DM	8.09	8.09	NIR
Soluble Crude Protein	SCP	% CP			NR
Acid Detergent Fiber Crude Protein	ADF-CP	% DM	0.50	0.50	NIR
Neutral Detergent Fiber Crude Protein	NDF-CP	% DM	1.30	1.30	NIR
Heat Damaged Protein-Estimated		% DM	0.50	0.50	C
Adjusted Crude Protein		% DM	8.09	8.09	C
Fiber Fractions					
Acid Detergent Fiber	ADF	% DM	23.34	23.34	NIR
Neutral Detergent Fiber, with Na ₂ SO ₄	aNDF	% DM	39.54	39.54	WC
Lignin, Acid Detergent	ADL	% DM	4.46	4.46	NIR
Lignin, Acid Detergent	ADL	% NDF	11.28	11.28	C
Neutral Detergent Fiber Digestibility, 48 h, 1mmNDFD		% NDF	67.45	67.45	WC
Carbohydrates and Fats					
Non Fiber Carbohydrate	NFC	% DM	45.48	45.48	C
Starch		% DM	26.80	26.80	NIR
Starch Digestibility, Predicted		% Starch	84.93	90.23	C
Non Starch NFC, Sugars + VFAs		% DM	15.00	15.00	C
Fat		% DM	2.63	2.63	NIR
pH					NA

Energy Calculations: Schwab/Shaver					
Total Digestible Nutrients, 1X	TDN	% DM	67.34	68.76	C
Net Energy, Lactation, 3X	NEl	Mcal/lb	0.63	0.65	C
Net Energy, Maintenance	NEm	Mcal/lb	0.75	0.77	C
Net Energy, Gain	NEg	Mcal/lb	0.47	0.49	C
Metabolizable Energy	ME	Mcal/lb	1.16	1.18	C
Milk/Ton		lbs	2,904	3,019	C

Macro Minerals				Micro Minerals					
Phosphorus	P	0.20	% DM	NIR	Iron	Fe	ppm	NR	
Calcium	Ca	0.43	% DM	NIR	Manganese	Mn	ppm	NR	
Potassium	K	1.55	% DM	NIR	Zinc	Zn	ppm	NR	
Magnesium	Mg	0.23	% DM	NIR	Copper	Cu	ppm	NR	
Sodium	Na		% DM	NR					
Chloride	Cl		% DM	NR	Ash		5.56	% DM	WC
Sulfur	S		% DM	NR					

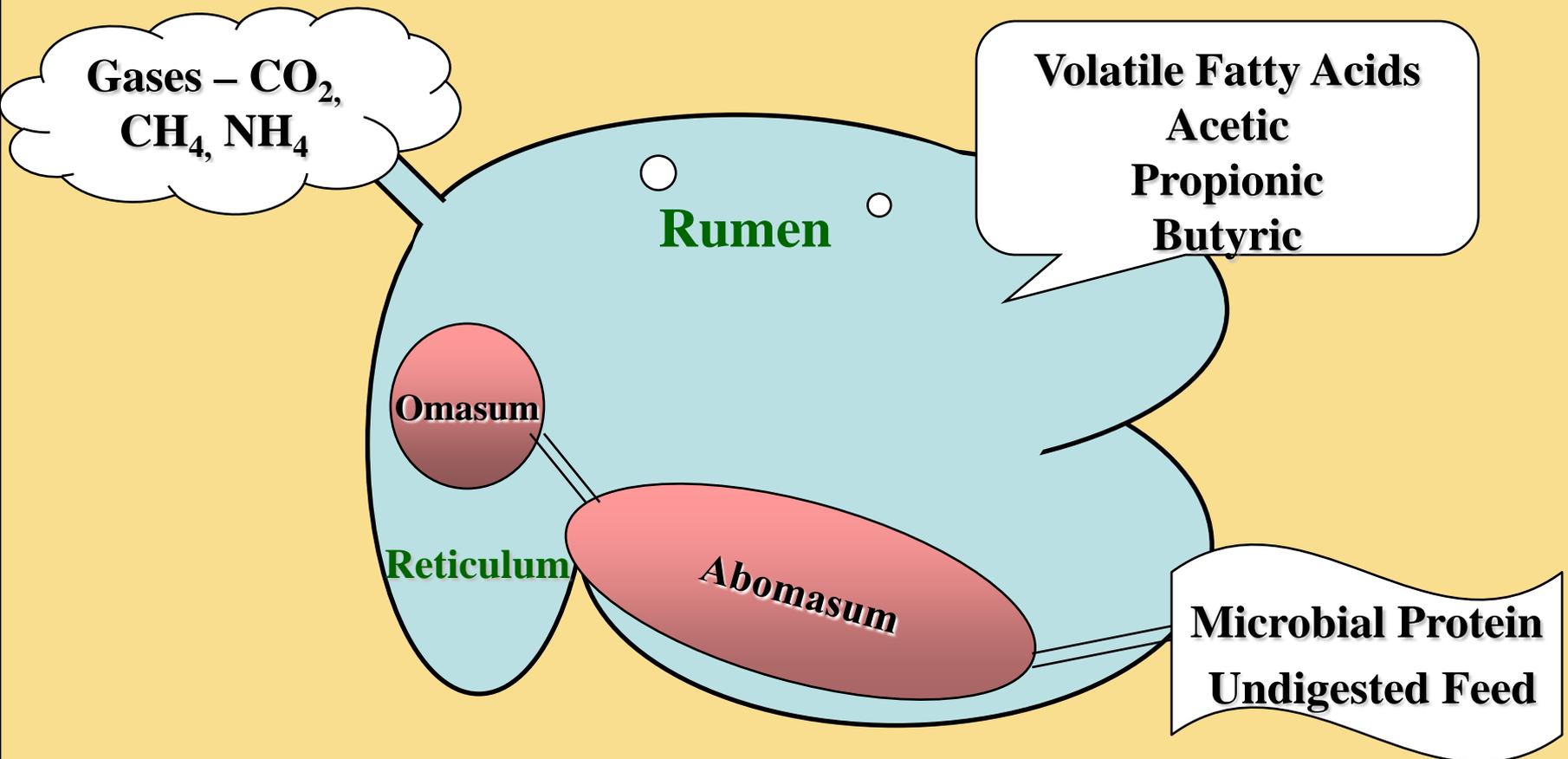
¹ WC = wet chemistry NIR = near infrared spectroscopy NR = not requested NA = not available C = calculated T = tabular value

Methods used for these analyses can be found at <http://uwlab.soils.wisc.edu/procedures.htm>

CLIENT COPY



Ruminant Digestion End Products



SOURCE: Linn, James, G.; U of Minnesota



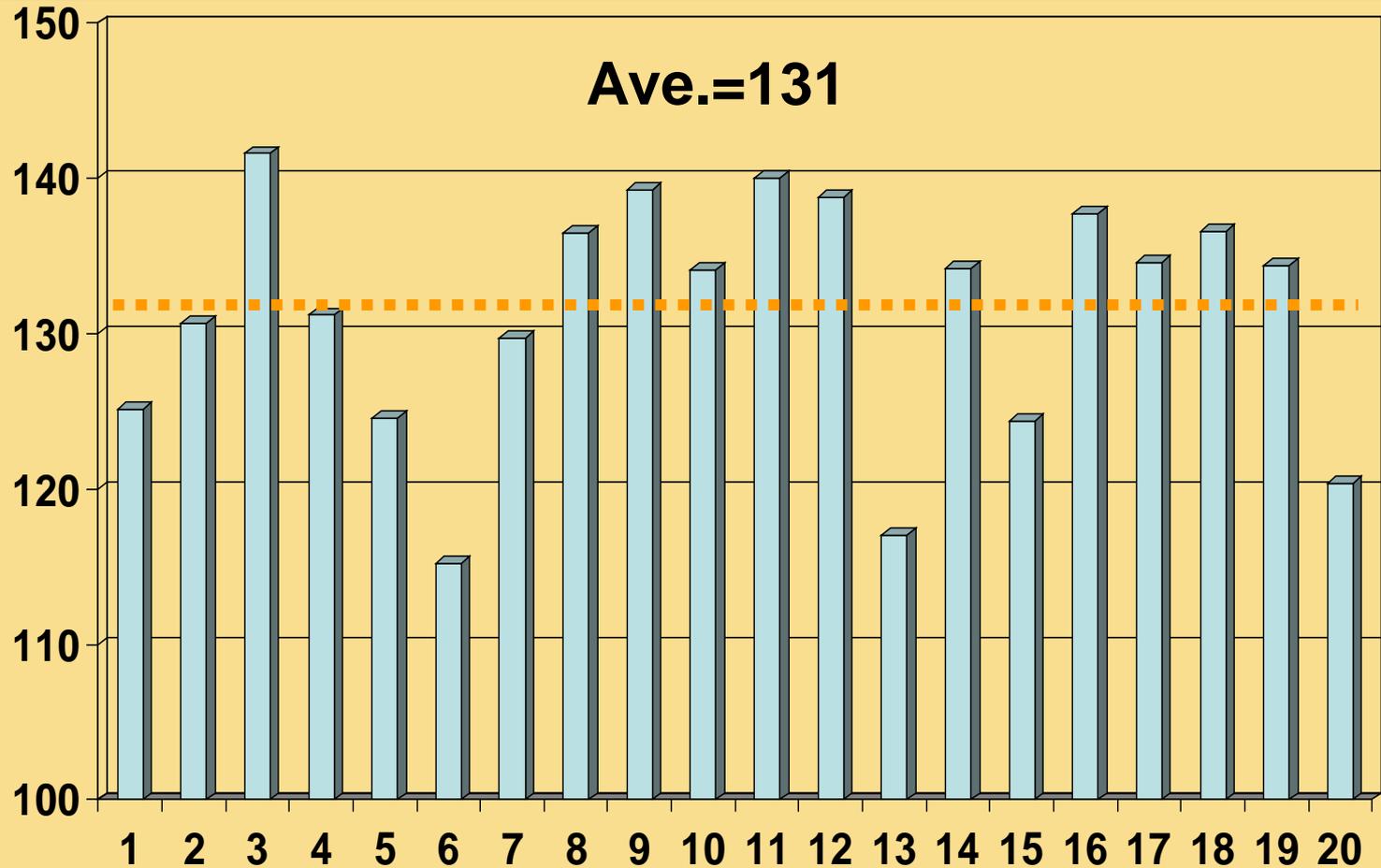
The Sampling Dilemma



Producing Quality Forages for Cattle and Sheep



Variation in RFV--Lot 6



Producing Quality Forages for Cattle and Sheep



Standardized Sampling Guidelines For Small Bales:

- Identify a single lot of hay (<200 tons)
- Choose an appropriate, sharp coring device (3/8" - 3/4")
- Sample at random (don't avoid bales)
- Take enough cores to represent a lot (>20)
- Use proper technique (90° angle, 18"-24")
- Handle samples correctly (plastic bags, heat)
- Appropriate size: not too big, not too small (1/2 lb)
- Only split samples after grinding to test labs

Reducing Analysis Error

- Only send results to National Forage Testing Association certified laboratories

<http://www.foragetesting.org>



Questions ?



Producing Quality Forages for Cattle and Sheep

