Researching the Forage-Cow Interface at Miner Institute

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Chazy, NY

UVM Extension Meeting

Jan 21, 2014

Forage research areas at Miner Institute …

- NDF digestibility, fragility, chewing
- Lignin – phenolics
- Forage physical characteristics
- Fiber passage and digestion dynamics
- Undegradable NDF and DMI
- BMR corn hybrids
- Leafy-floury corn hybrids
- Inoculant evaluation (mini- and midi-silos)

Let’s focus on two areas…

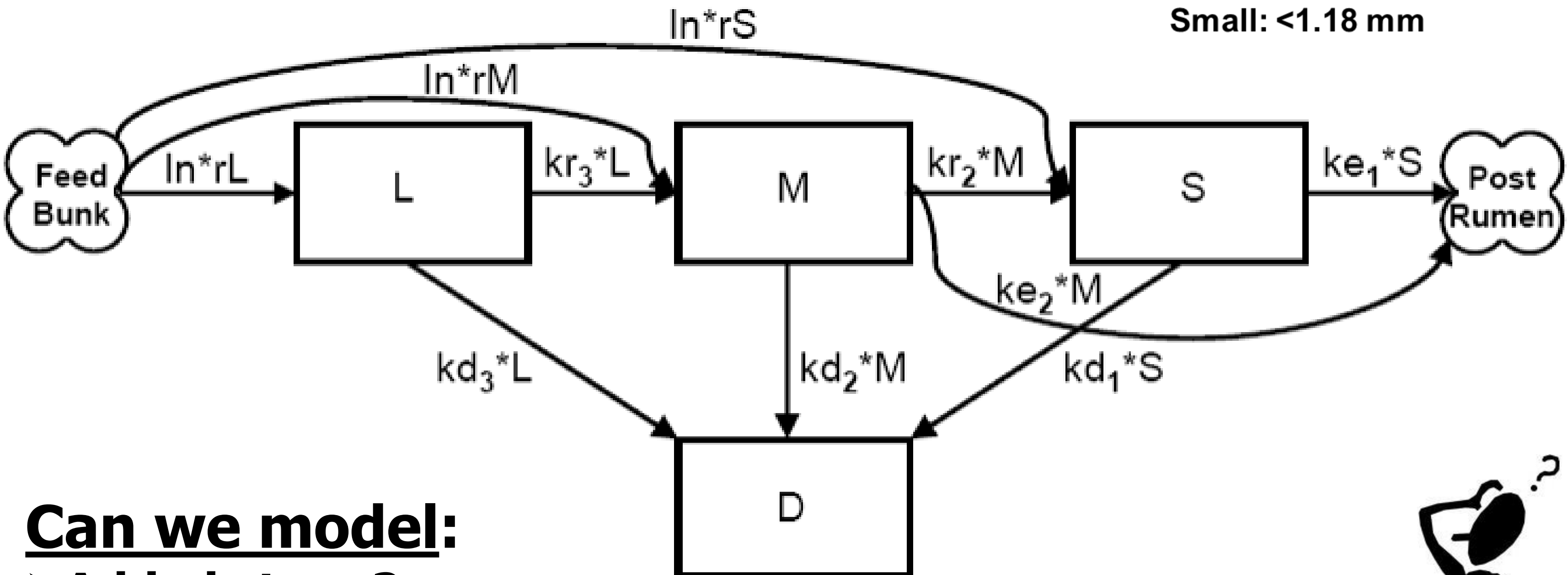
- Higher forage diets and ability to model cow responses
  - CNCPS nutrition model
  - “Fiber Group” collaboration

- Physical and chemical assessment of forage-fiber
  - peNDF

Higher forage diets: Focus on forage dynamics

(Mertens, 2011)

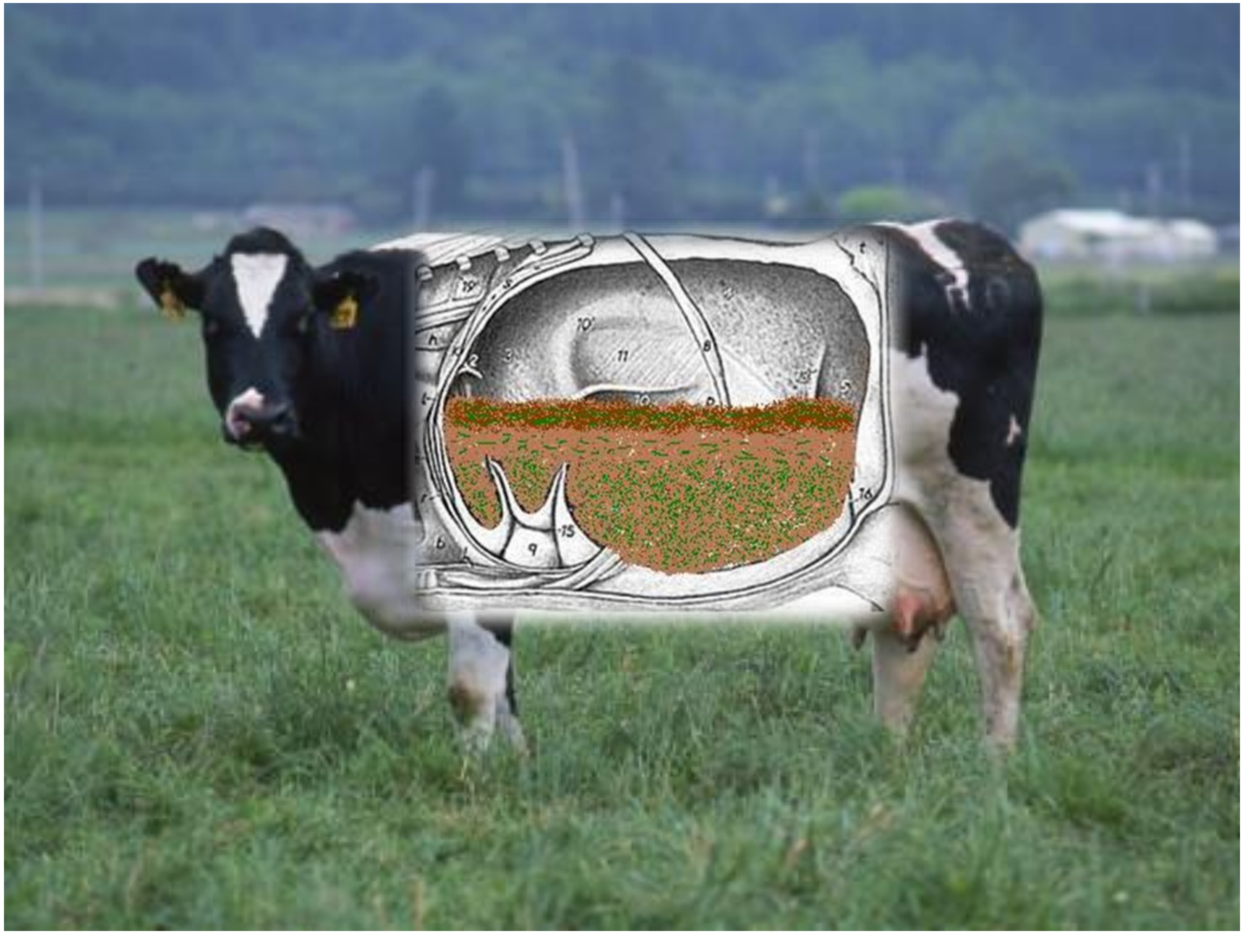
Large: >4.75 mm
Medium: 1.18-4.74 mm
Small: <1.18 mm



<u>Can we model</u>:

- **Added straw?**
- **Haycrop differing in NDFD?**
- **Corn silage BMR/Conventional?**
- **High/low forage diets?**

Rumen Fill Dynamics



TIJ-1
Objective

To determine the effect of level and digestibility of NDF from CS or BMR on rumen retention time of large, medium, small and indigestible forage particles and liquid

Material and Methods

Experimental Design

- 4 x 4 Latin square (21-d periods)
- 8 ruminally cannulated, multiparous lactating Holstein cows (88 DIM, 685 kg BW)

Diets

- 2 levels of forage – High (H) and Low (L)
- 2 sources of CS - Conventional (CCS) and BMR (BMR)
- Within forage level, diets were balanced on NDF basis with similar %NDF from CS
  - **LCCS** – Low forage conventional corn silage
  - **HCCS** – High forage conventional corn silage
  - **LBMR** – Low forage BMR corn silage
  - **HBMR** – High forage BMR corn silage

Characterization of forages

Forage	DM	NDF	ADL	Starch	$NDFD_{24}$
CCS	37.1	36.6	3.0	36.0	39.0
BMR	36.4	38.3	2.4	34.5	50.8
HCS	36.5	48.1	5.1	1.3	56.5

Formulated rations

	LCCS	HCCS	LBMR	HBMR
TMR NDF, %DM	29.1	33.7	30.0	34.5
NDF from CS, %DM	14.8	20.7	14.6	20.4
% NDF from CS	50.8	61.6	48.7	58.9

Characteristics of marked particles

Particle	Size, mm	Marker	Dose Amount, g
Liquid	--	Co-EDTA	20
Fine fecal	< 2.36	Cr	45
Medium HCS	1.18 – 4.75	La	280
Small CCS/BMR	0.30 – 1.18	Sm	25 / 60
Medium CCS/BMR	1.18 – 4.75	Yb	310
Large CCS/BMR	> 4.75	Pr	310

BMR/conventional corn silage at higher and lower dietary forage

Feed ingredient (% of DM)	Lower forage		Higher forage	
	Conv	BMR	Conv	BMR
CS BMR	---	36.1	---	50.2
CS Conv	39.3	---	55.0	---
Haycrop silage	13.4	13.3	13.4	13.3
Corn meal	17.3	20.4	1.6	6.3
Concentrate	30.0	30.2	30.0	30.2
TMR NDF, %	29.1	30.0	33.7	34.5
%NDF from CS	50.8	49.0	61.6	59.0
peNDF, %	17.5	18.5	23.1	22.0
Starch, %	28.0	27.8	21.2	22.3

Results

Intake

Item	Treatment				SE	*P*-value
	Low CCS	High CCS	Low BMR	High BMR		Treatment
DMI, kg/d	29.0[a]	26.5[b]	29.3[a]	29.2[a]	0.7	<0.01
DMI, % of BW/d	4.31[a]	3.96[b]	4.37[a]	4.36[a]	0.12	<0.01
NDF intake , kg/d	9.36[b]	9.47[b]	9.32[b]	10.25[a]	0.22	<0.01
NDF intake, % of BW/d	1.39[b]	1.41[b]	1.39[b]	1.53[a]	0.04	<0.01

[ab] Least squares means within a row without a common superscript differ ($P \leq 0.05$).

Milk Yield, Milk Composition, & Efficiency

	Treatment					*P*-value
Item	Low CCS	High CCS	Low BMR	High BMR	SE	Treatment
Milk, kg/d	47.0[a]	43.1[b]	48.6[a]	47.2[a]	1.6	<0.01
3.5% Fat-corrected milk (FCM), kg/d	49.3[xy]	46.5[y]	50.3[x]	50.2[x]	1.2	0.06
Solids-corrected milk (SCM), kg/d	45.2[ab]	41.8[b]	46.4[a]	45.7[a]	1.2	0.02
Milk composition						
Fat, %	3.82[ab]	4.02[a]	3.76[b]	3.94[ab]	0.14	0.04
Fat, kg/d	1.83	1.71	1.87	1.85	0.05	0.12
True protein, %	3.06[ab]	2.92[c]	3.10[a]	3.02[b]	0.05	<0.01
True protein, kg/d	1.48[ab]	1.25[c]	1.55[a]	1.43[b]	0.04	<0.01
Efficiency, kg/kg						
Milk/DMI	1.62	1.62	1.66	1.61	0.04	0.46
3.5% FCM/DMI	1.70	1.76	1.72	1.72	0.03	0.28

[ab] Least squares means within a row without a common superscript differ ($P \leq 0.05$).

[xy] Least squares means within a row without a common superscript differ ($P \leq 0.10$).

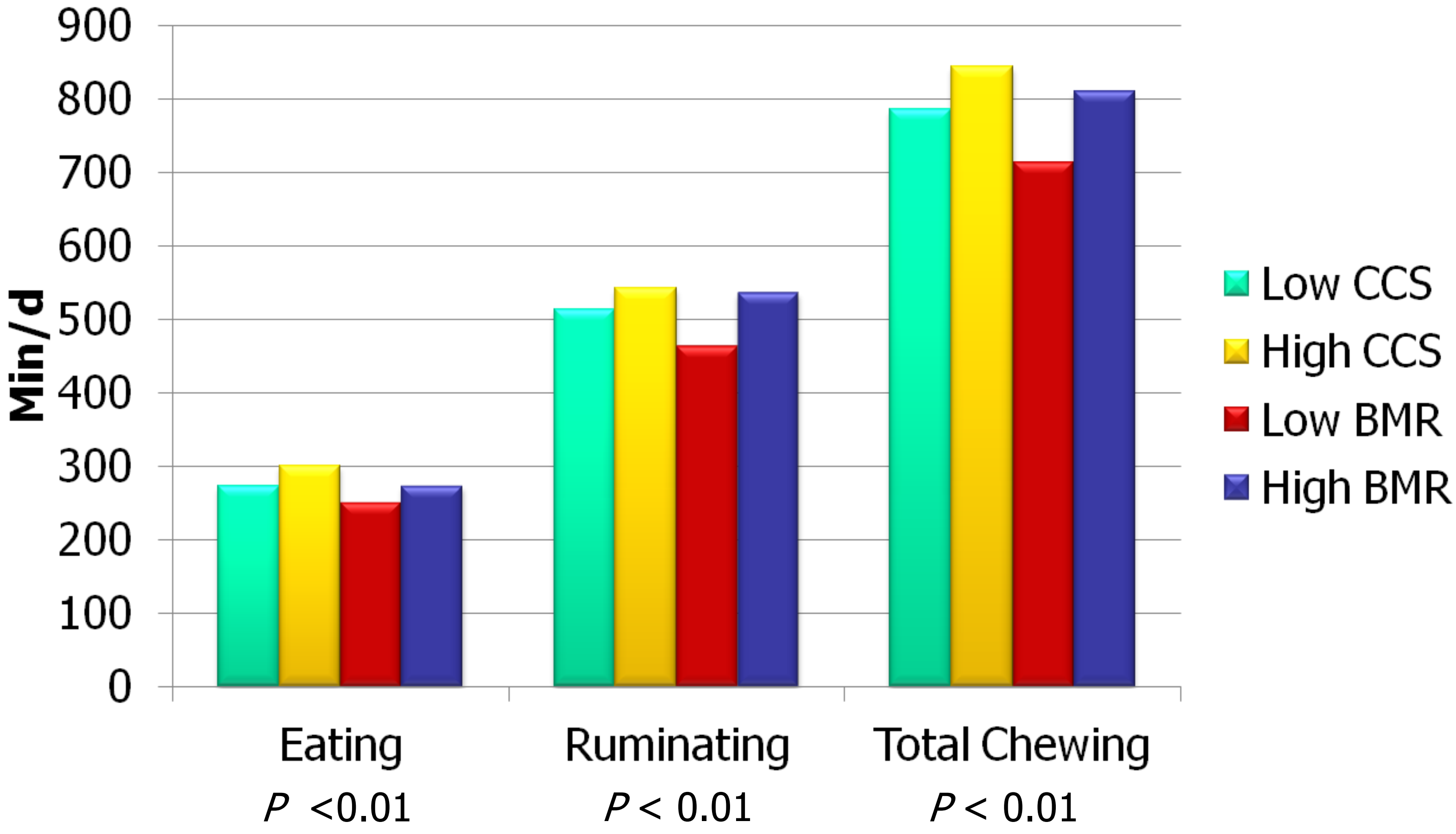
Chewing behavior

	Treatment					P-value
Item	Low CCS	High CCS	Low BMR	High BMR	SE	Treatment
Eating Behavior						
Eating, min/d	273[ab]	301[a]	250[b]	273[ab]	14	<0.01
Eating, min/kg NDF	29.3[ab]	31.7[a]	27.3[b]	27.1[b]	1.6	<0.01
Ruminating Behavior						
Ruminating, min/d	514[ab]	543[a]	463[b]	536[a]	17	<0.01
Ruminating, min/NDF	55.3[xy]	57.0[x]	50.6[y]	53.4[xy]	2.4	0.09
Total Chewing[2]						
Total chewing, min/d	786[a]	844[a]	713[b]	809[a]	24	<0.01
Total chewing, min/kg NDF	84.6[ab]	88.7[a]	77.9[b]	80.5[b]	3.6	<0.01

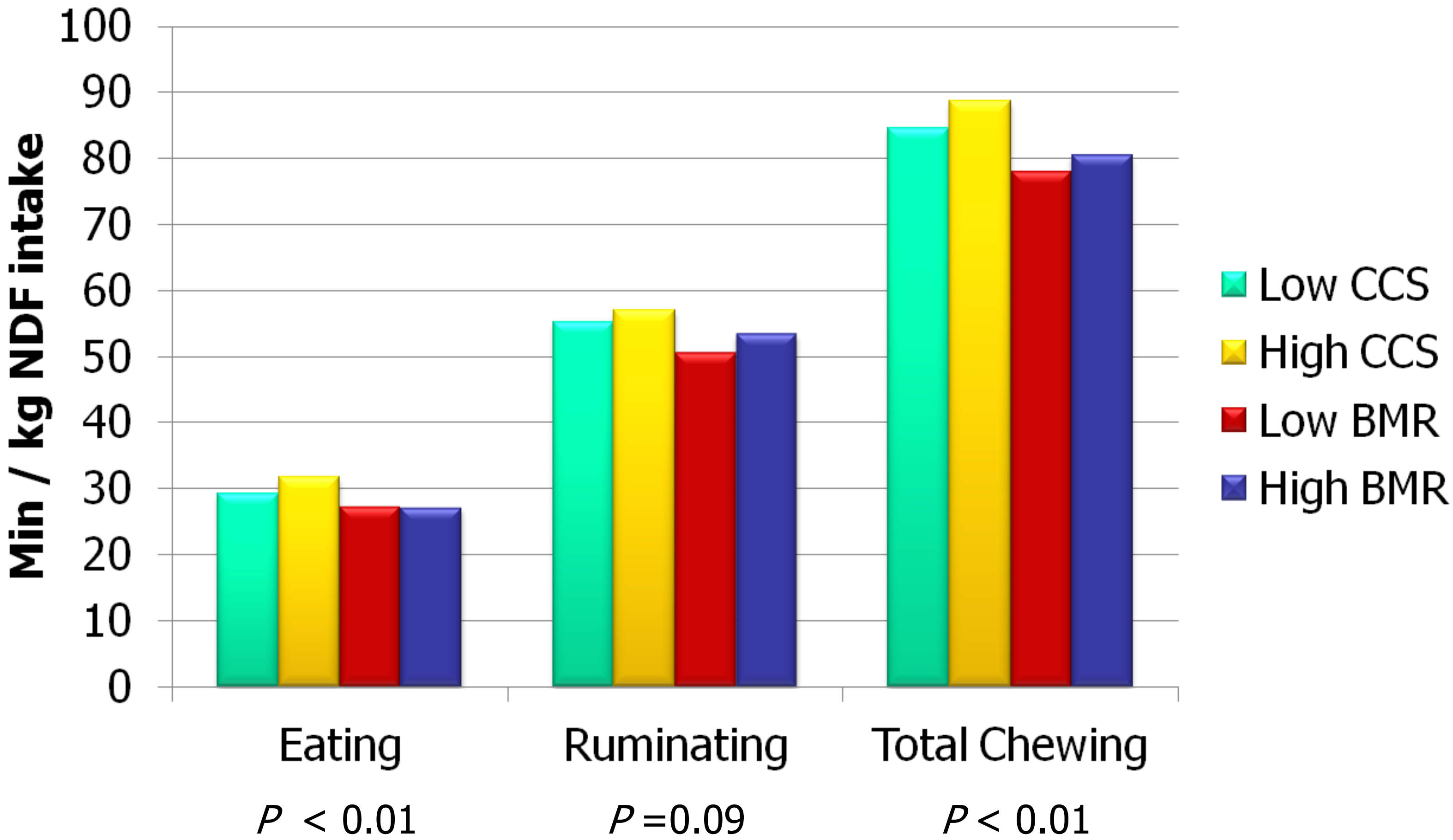
[abc] Least squares means within a row without a common superscript differ ($P \leq 0.05$).

[xy] Least squares means within a row without a common superscript differ ($P \leq 0.10$).

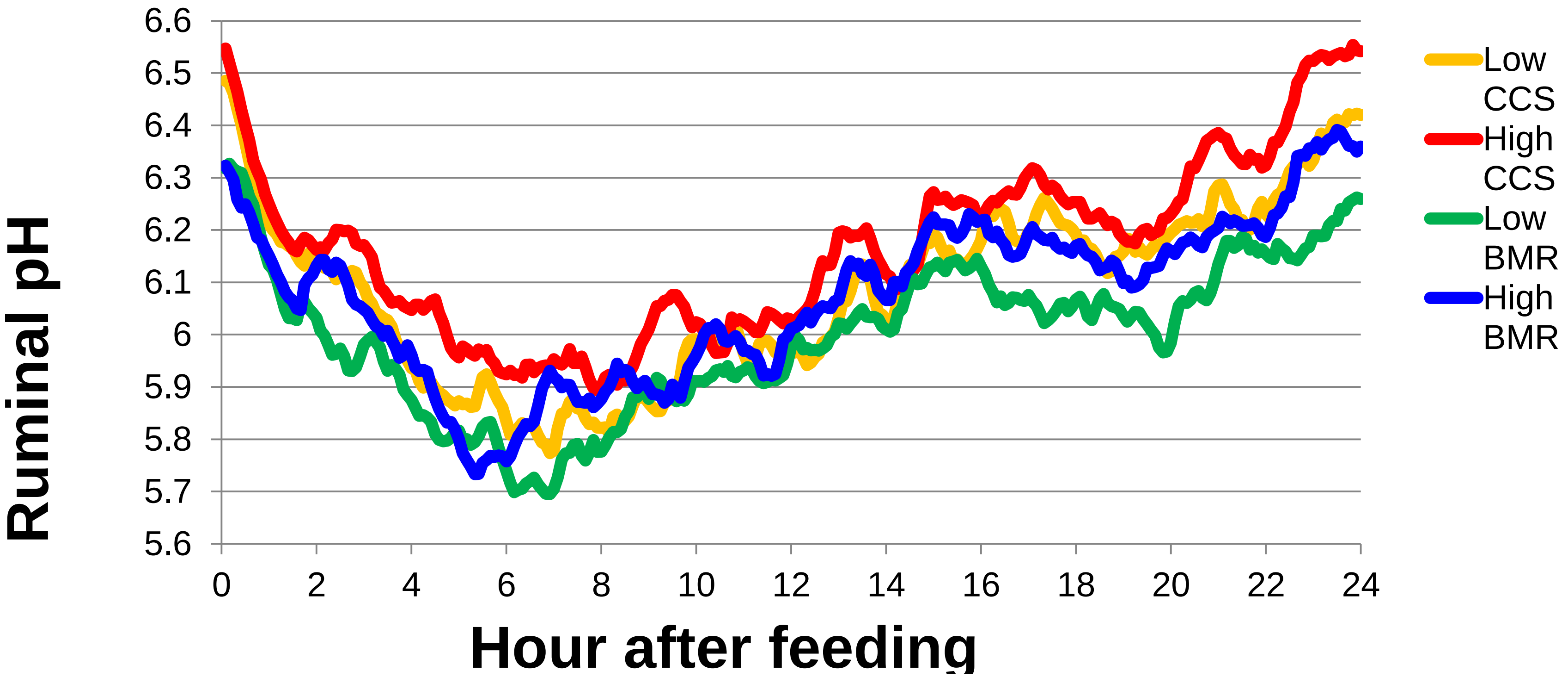
Chewing Activity (min/d)



Chewing Activity (min/kg NDF intake)



Ruminal pH


6.6
6.5
6.4
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6
5.9
5.8
5.7
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2
4
6
8
10
12
14
16
18
20
22
24
Ruminal pH
Hour after feeding
Low CCS
High CCS
Low BMR
High BMR

Lactation response and rumen fiber turnover

Item	Low CS	High CS	Low BMR	High BMR	SEM	*P*
DMI, lb/d	63.9[a]	58.4[b]	64.6[a]	64.3[a]	1.2	0.001
DMI, % of BW	4.31[a]	3.96[b]	4.37[a]	4.36[a]	0.12	<0.001
NDF intake , lb/d	20.6[b]	20.9[b]	20.6[b]	22.6[a]	0.4	<0.01
NDF intake, % of BW	1.39[b]	1.41[b]	1.39[b]	1.53[a]	0.04	<0.01
SCM, lb/d	102.3[a]	91.9[b]	105.4[a]	101.4[a]	2.2	0.002
NDF Pool, kg	8.32[a,b]	8.45[a]	7.64[b]	8.36[a]	0.41	0.02
NDF Turnover, %/h	4.84[b]	4.76[b]	5.12[a,b]	5.52[a]	0.30	0.003
NDF Turnover Time, h	21.1[a]	21.4[a]	20.3[a,b]	19.0[b]	1.1	0.01

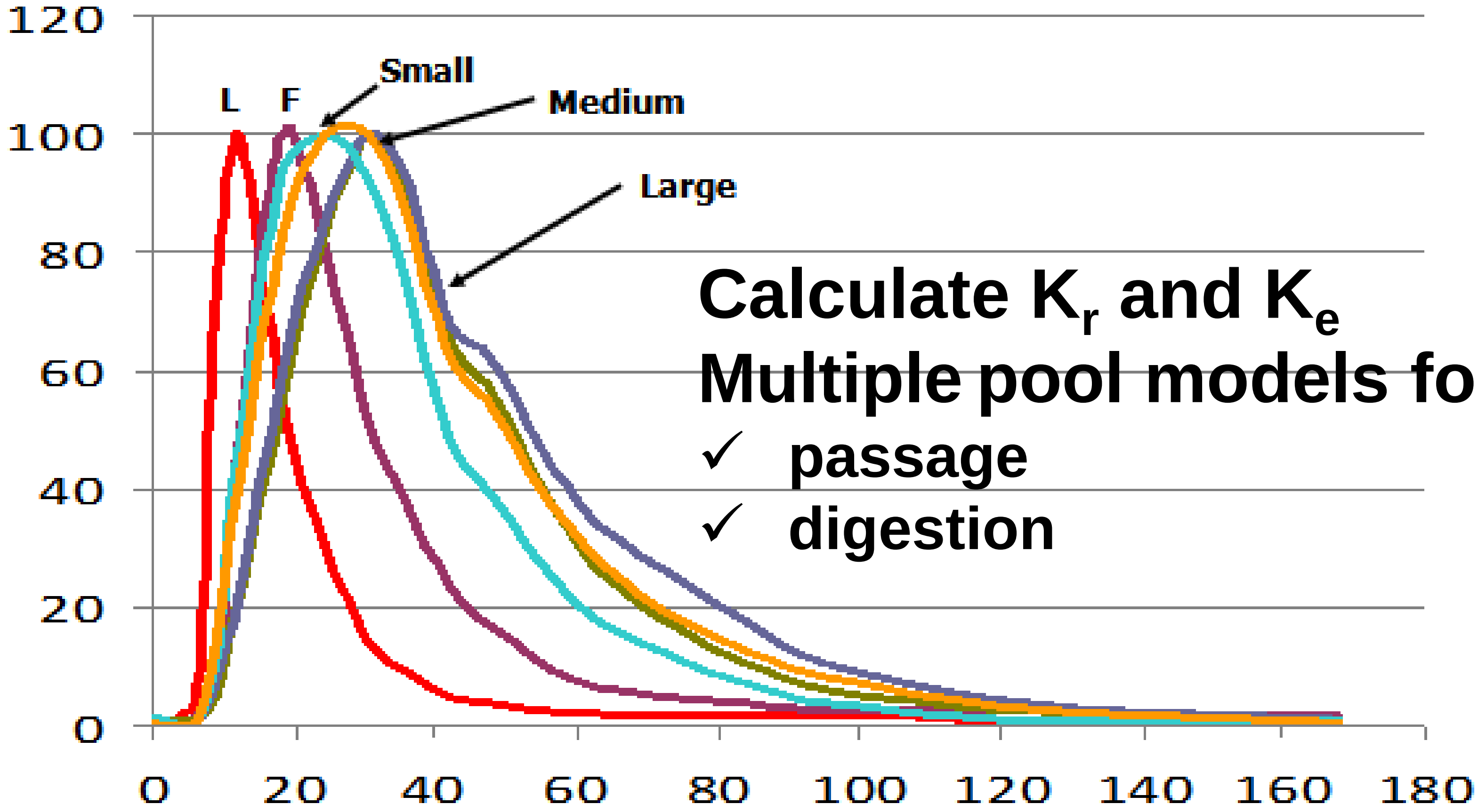
✓ Can our models predict these intake, milk, and rumen responses?

Mean retention time (hours)

Low CS	High CS	Low BMR	High BMR	
47.5	48.8	47.9	46.8	Large
↓	↓	↓	↓	↓ Physical
44.9^{a}	46.0^{a}	43.7^{ab}	42.1^{b}	Medium
↓	↓	↓	↓	↓ Digestion
36.1^{y}	39.8^{x}	37.5^{xy}	36.5^{xy}	Small

<u>NDFD</u> had greater effect on MRT of particles than % forage of diet

Next steps: passage and particle size reduction rates



Calculate K_r and K_e

Multiple pool models for

- ✓ **passage**
- ✓ **digestion**

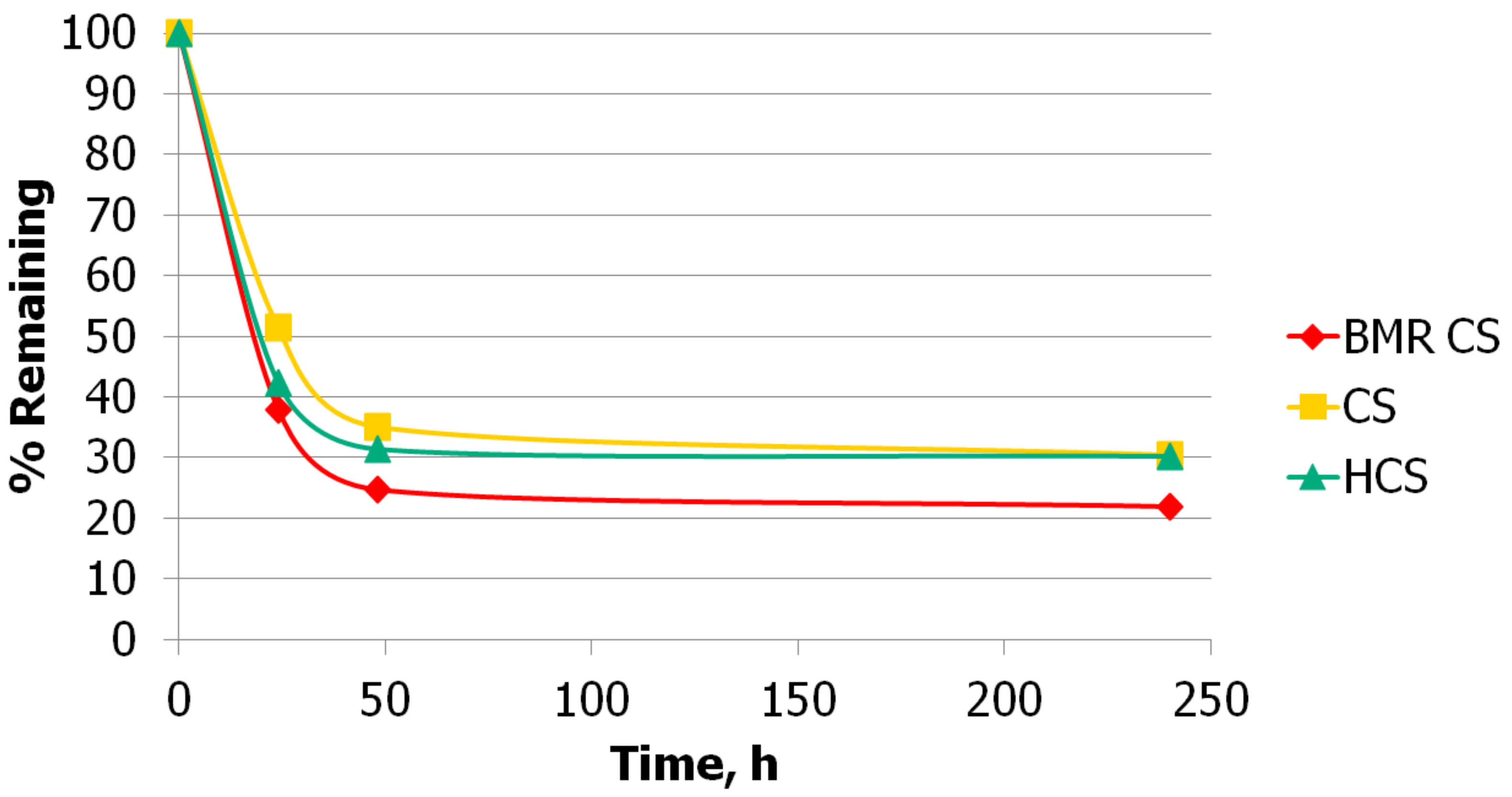
Better estimate of DMI?

- uNDF vs iNDF
  - uNDF h: 24, 48, 120, 240, 520….
    - Undigested
  - iNDF: theorhetical, timeless/infinite
    - Indigestible

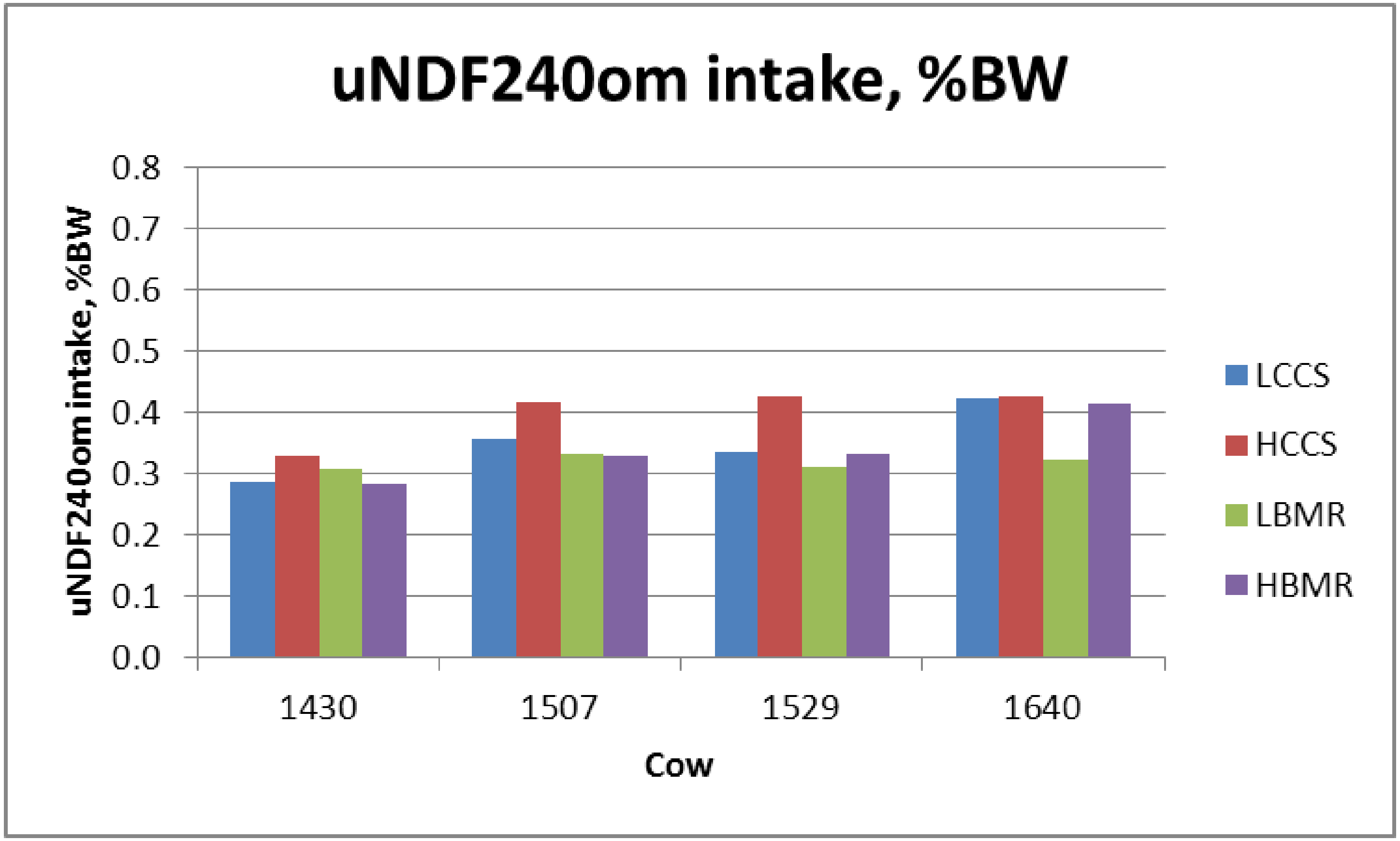
CVAS uNDF 2013

	NDFom, %DM	NDFD24om, %NDF	NDFD48om, %NDF	NDFD240om, %NDF	uNDF240om, %NDF
BMR CS	34.8	62.1	75.3	78.1	21.9
CS	36.1	48.6	64.9	69.5	30.5
HCS	46.2	57.7	68.5	69.7	30.3
TMR A LCCS	30.8	--	--	73.3	26.7
TMR B HCCS	33.7	--	--	71.5	28.5
TMR C LBMR	30.7	--	--	77.5	22.5
TMR D HBMR	33.5	--	--	77.4	22.6

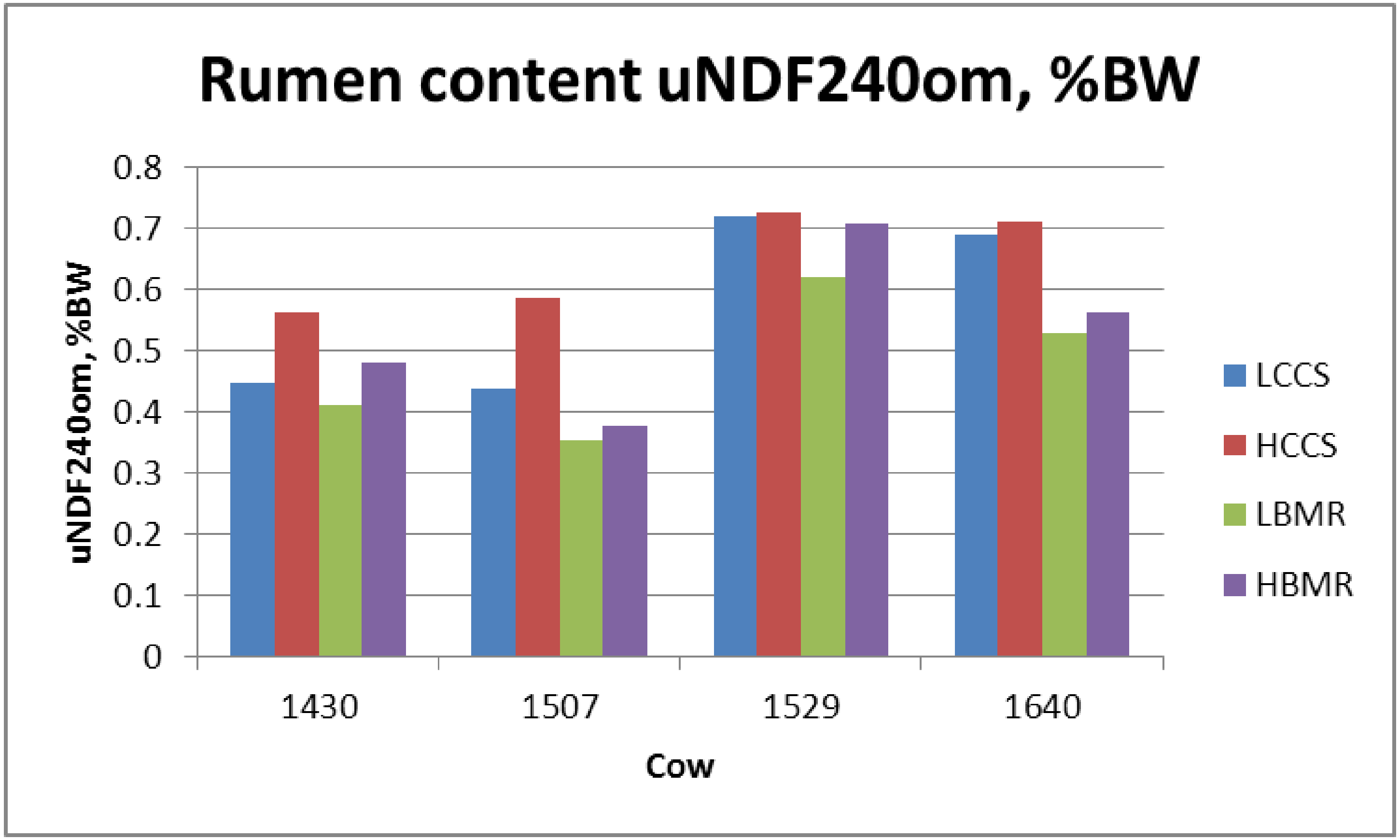
uNDF Residue Remaining



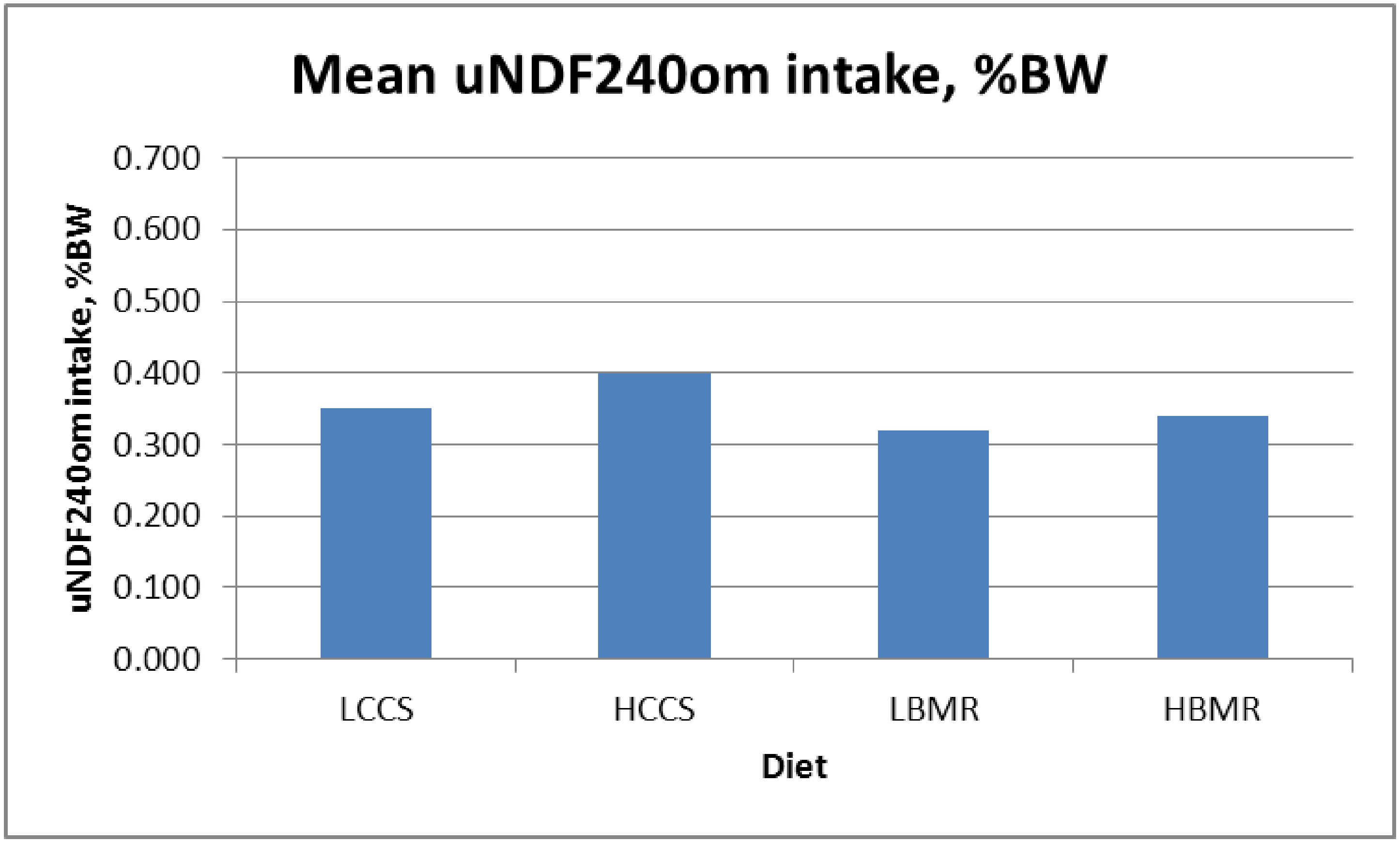
uNDF240om Intake, %BW



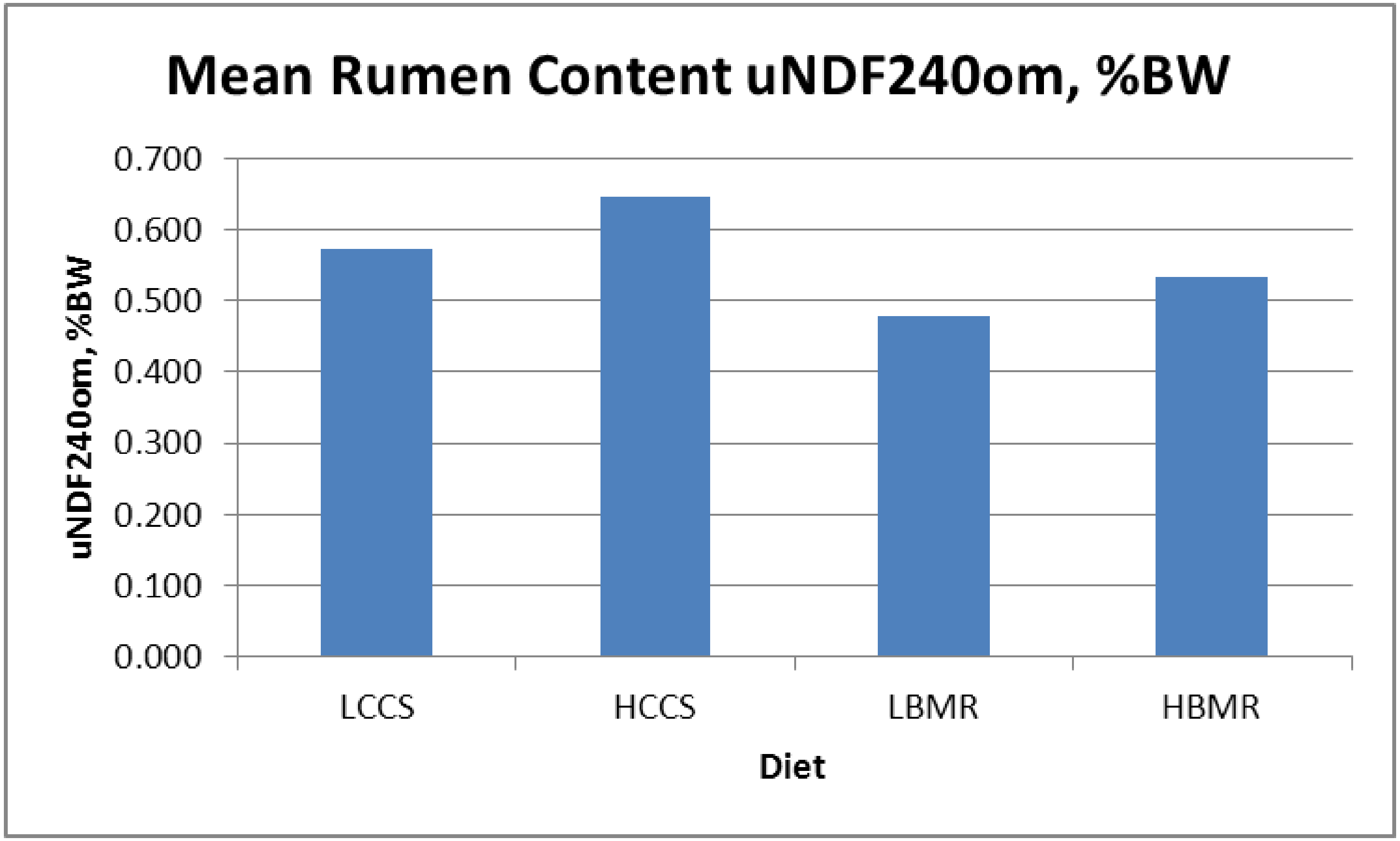
Rumen Content uNDF240om, %BW



Mean uNDF240om Intake, %BW



Mean Rumen Content uNDF240om, %BW



CVAS uNDF240om intake, rumen, fecal output

Treatment	Cow	uNDF240om intake, kg DM	Rumen Content uNDF240om, kg DM	Fecal uNDF240om output, kg DM
A – LCCS	1529	2.13	4.56	2.31
	1640	2.58	4.24	2.49
B – HCCS	1529	2.69	4.59	2.74
	1640	2.50	4.21	2.36
C – LBMR	1529	2.01	4.03	2.04
	1640	1.87	3.05	1.81
D – HBMR	1529	2.12	4.50	2.18
	1640	2.42	3.29	2.32

Thank You

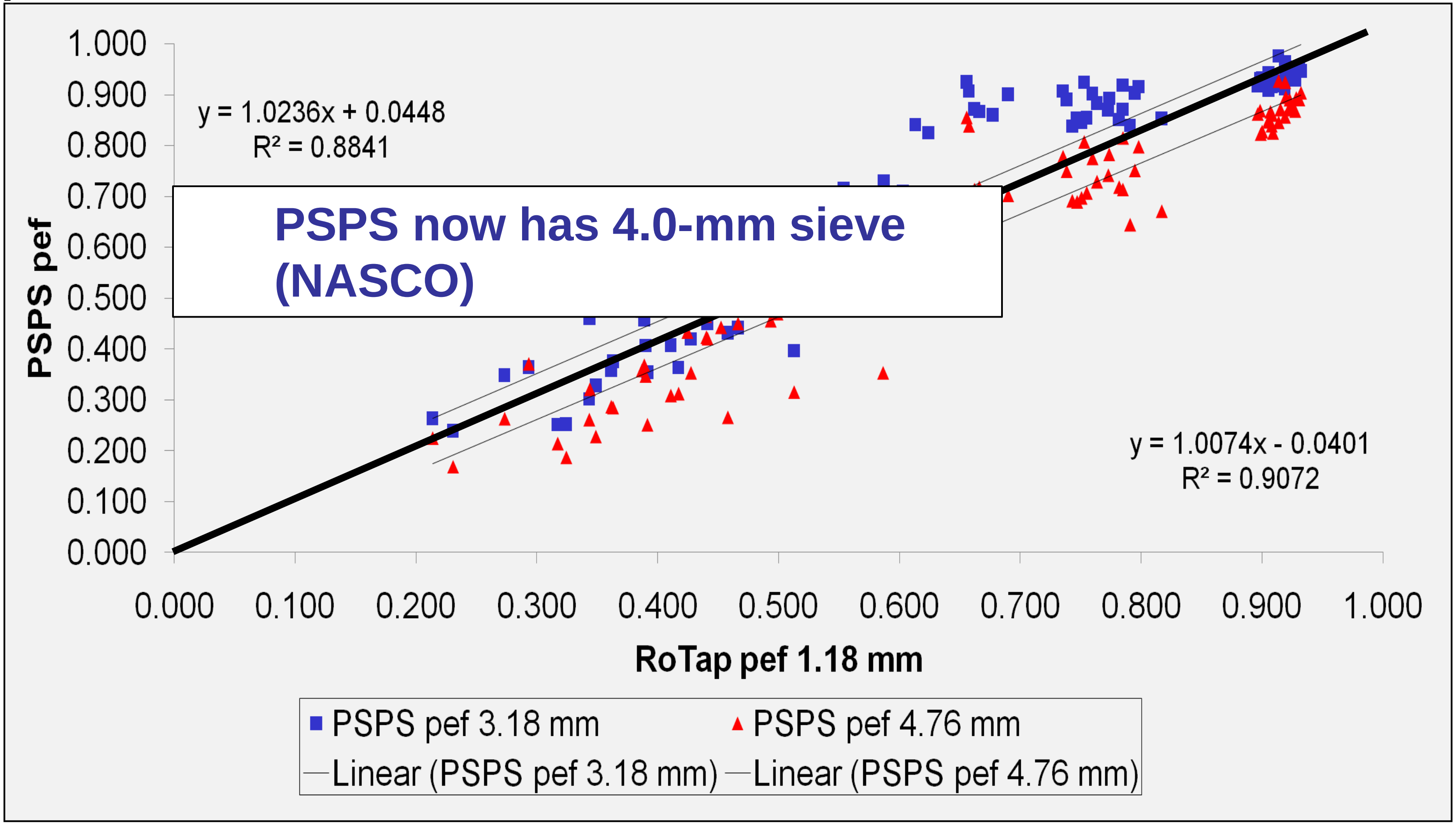
Physical effectiveness factor (pef) and peNDF

- pef = physical effectiveness factor
  - 1.18-mm screen with dry sieving (Ro-tap)
  - 3.18- or 4.76-mm sieve on farm (Z-Box)
  - Ranges from 0 to 1.0

- peNDF = pef x NDF%

Physical effectiveness factor: Ro-Tap vs PSPS

(Cotanch et al., 2010)



PSPS now has 4.0-mm sieve (NASCO)

Not all NDF stimulates the same chewing response
(Mertens, 1997)

	NDF	Total Chewing Activity	
Feed	% of DM	(min/kg of DM)	(min/kg of NDF)
Alfalfa	49	61	125
Grass	65	103	158
Ryegrass	68	104	152
Oat straw 1	78	163	209
Oat straw 2	84	164	195

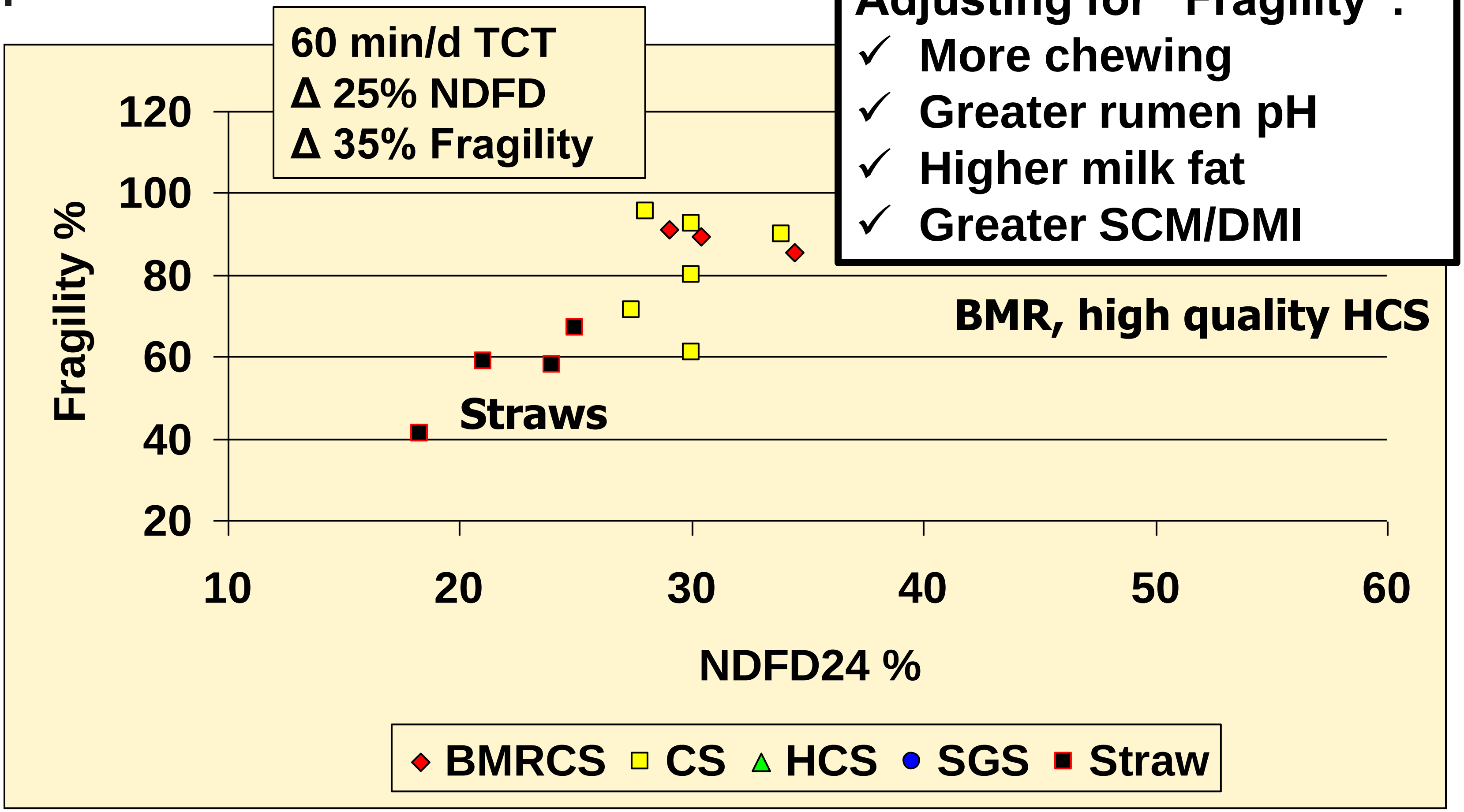
- peNDF explains 44 to 75% of variation in chewing response
- Can’t rely only on particle size measurement

Measuring "fragility" by ball milling forages (Cotanch et al., 2009)

- Ball mill with ceramic balls mimics chewing action (Jim Welch, unpublished data)

Greater fiber digestibility enhances forage fragility
(Cotanch et al., 2010)

Adjusting for "Fragility":
- ✓ More chewing
- ✓ Greater rumen pH
- ✓ Higher milk fat
- ✓ Greater SCM/DMI

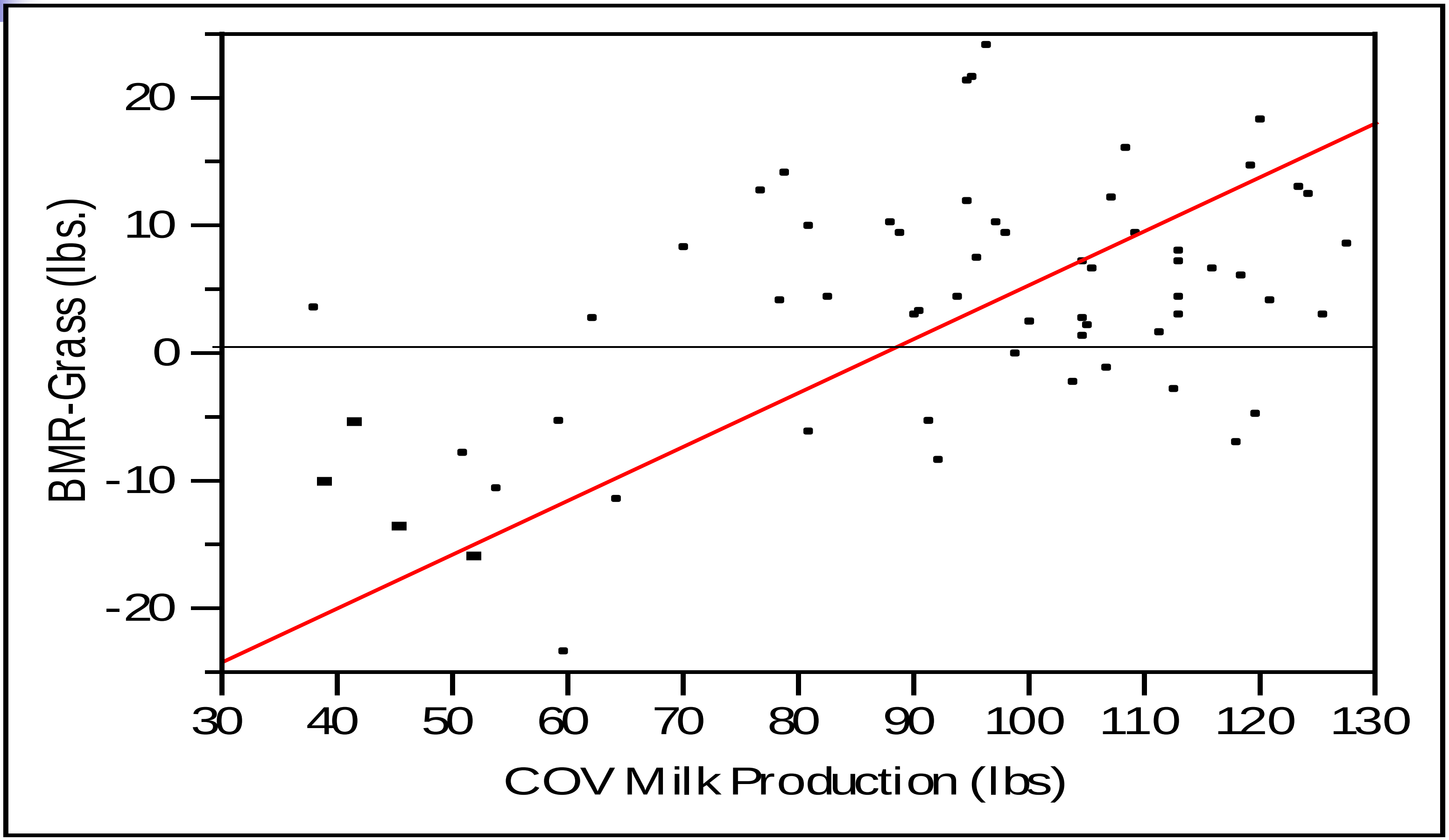


pef adjustment factor: corn silage

24-h NDFD	Fragility	Adjustment factor	Example pef=0.85
30	65	0	0.85
40	75	-0.07	0.78
50	85	-0.13	0.72
60	95	-0.20	0.65

- ✓ Adjustment factors also for:
  - ✓ Legumes
  - ✓ Grasses

Milk production level and response to bmr (24-h NDFD 56%) vs grass (24-h NDFD 53%; Miner Inst., unpublished)



➢ **Mycogen F2F444 and 1st cut grass silage (ADF=32.5, NDF=51.1, CP=17.6%)**


Cow Management
Environment?

“Center for Forage Research Excellence”

Lallemand – Miner Institute collaboration

- **Two scientists**
- **Technical Committee comprised of Miner Institute and Lallemand scientists**
  - **Prioritize research objectives**

Research objectives…

Focus on improving silage quality

- Preserving nutritional value
- Enhancing palatability
- Improving digestibility
- Linking forage quality with dairy cow response

Development and testing of products in mini-silos and farm-scale research

Where to from here?

Strengthen the Center for Forage Research and Lallemand collaboration

Component of our overall strategy to enhance the forage focus at Miner Institute

Center for Forage Research will be important for feeding forage profitably

Goals of presentation

- What is Miner Institute?
- Forage research focus
- Forage research highlights
- Forage Research Center of Excellence

Where is Miner Institute?


New York State Map
CHAZY
MILES
0 20 40 60 80
Albers equal area projection
CANADA
QUÉBEC
VERMONT
NEW HAMPSHIR
MASSACHUSETTS
CONNECTICUT
NEW JERSEY
LONG ISLAN
Lake Ontario
Lake Erie
Lake Champlain
Long Island Sound
Oneida Lake
Cayuga Lake
Seneca Lake
Lake George
ADIRONDACK MTS
Catskill Mts
Slide Mtn+ 4180
Mt Marcy 5344
Black R
Hudson R
Susquehanna River
Delaware R
Massena
Malone
Plattsburgh
Potsdam
Ogdensburg
Saranac Lake
Lake Placid
Tupper Lake
Watertown
Long Lake
Oswego
Fulton
Rome
Utica
Oneida
Ilion
Gloversville
Johnstown
Amsterdam
Schenectady
Saratoga Springs
Glens Falls
Troy
Albany
Lockport
Niagara Falls
North Tonawanda
Cheektowaga
Buffalo
Irondequoit
Rochester
Newark
Seneca Falls
Geneva
Auburn
Syracuse
Geneseo
Cortland
Norwich
Oneonta
Sidney
Ithaca
Dansville
Hornell
Bath
Dunkirk
Fredonia
Jamestown
Olean
Wellsville
Corning
Elmira
Binghamton
Endicott
Hudson
Catskill
Kingston
Poughkeepsie
Monticello
Newburgh
Middletown
Peekskill
White Plains
Yonkers
New York
Levittown
Hempstead
Montauk
washingtonstatesearch.com
TRANSPORTATION
Interstate; limited access highway
Other principal highway
Railroad
Ferry
POPULATED PLACES
1,000,000 and over New York
100,000 – 499,999 Syracuse
25,000 – 99,999 Binghamton
24,999 and less Saranac Lake
PHYSICAL FEATURES
Streams
Lakes
Highest elevation in state (feet) +5344
Other elevations (feet) +4180

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Investment in forage research capability …

- Agronomist position
- Forage/soil labs
- Long-term improvement fund: forage focus
- Exploring linkages
- 340-cow research complex
- 40-acre crop plots

Agronomy plot research
(Young et al., 2013)

- ✓ 320 corn silage hybrid plots
  - ✓ Conventional, BMR
  - ✓ Leafy, floury
- ✓ 200 triticale plots; winter rye cover crops

Item	bmr 1	bmr 2
DM, %	30.1	30.7
aNDF, %	35.9	41.0
ADL, %	2.1	2.0
L/NDF, %	5.8	4.9
NDFD, 24-h	55.2	55.1