How do We Make Better Decisions in Dairy Cattle Diets and Management with Forages and Nitrogen

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Outline

- New approaches to describing NDF
  - aNDFom – why and what it means
  - aNDFom digestibility
  - uNDF – definition
  - uNDF and NDF pools
  - Implications of using this information
- Updates to the CNCPS related to N efficiency
- Summary

High Forage Diets: Cows Can Do It

- **Two case studies in New York**
  - **<u>Herd 1 – entire herd</u>**
    - **73-75% forage (includes corn silage)**
    - **80-85 lb/d milk (2x), 3.7% fat, 2.9% protein**
    - **NE_L=0.76 Mcal/lb**
  - **<u>Herd 2: high pen</u>**
    - **82% forage (includes corn silage)**
    - **100 lb/d milk (3x), 3.6% fat, 3.0% protein**
    - **NE_L=0.77 Mcal/lb**

(Chase, 2012)

NDF analyses

- Nutrition models/software have an input for NDF that is used primarily to calculate energy from available carbohydrates and effective fiber
- Mertens (2002) published the NDF method and gained AOAC approval – there are many approaches to measure NDF
- We want everyone to use of aNDFom – NDF with amylase, sodium sulfite and ash correction – we are working to move labs in that direction
- Sniffen et al. 1992…

Why aNDFom?

- Hay in a hurry – wide swathing picks up dirt
- 600-800 hp choppers and big equipment that move fast make dust and dirt fly
- Flood irrigation moves soil
- Dirt/soil does not solubilize in NDF solution, thus if not corrected will inflate the NDF content
- Inflation of the NDF content means the diet as formulated is lower in actual NDF – intake and rumen health can be compromised (e.g. SARA)

27 FIELD 316 SORGHUM X SUDAN

FIBER	% NDF	% DM
ADF	56.5	34.0
aNDF		60.2
aNDFom		55.4
NDR (NDF w/o sulfite)		
peNDF		
Crude Fiber		
Lignin	4.95	2.98
NDF Digestibility (12 hr)		
NDF Digestibility (24 hr)		
NDF Digestibility (30 hr)	60.2	36.3
NDF Digestibility (48 hr)		
NDF Digestibility (240 hr)	74.9	45.1
uNDF (30 hr)	39.8	24.0
uNDF (240 hr)	25.1	15.1

~ 5 units

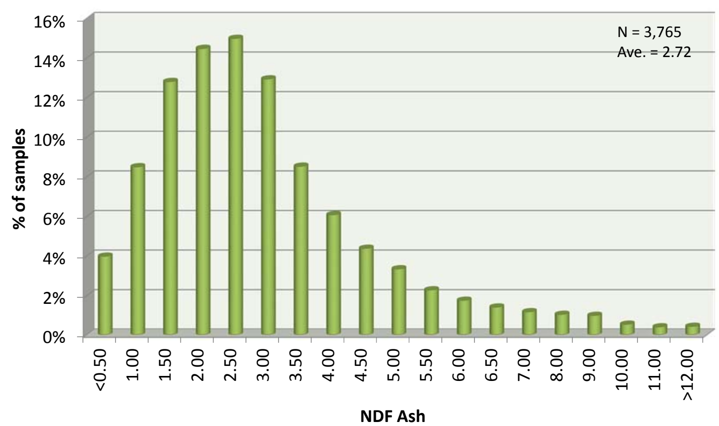
26 FIELD 308 TEST 2 SORGHUM X SUDAN

FIBER	% NDF	% DM
ADF	57.6	36.8
aNDF		63.9
aNDFom		53.7
NDR (NDF w/o sulfite)		
peNDF		
Crude Fiber		
Lignin	4.86	3.11
NDF Digestibility (12 hr)		
NDF Digestibility (24 hr)		
NDF Digestibility (30 hr)	49.3	31.5
NDF Digestibility (48 hr)		
NDF Digestibility (240 hr)	77.0	49.2
uNDF (30 hr)	50.7	32.4
uNDF (240 hr)	23.0	14.7

10 units

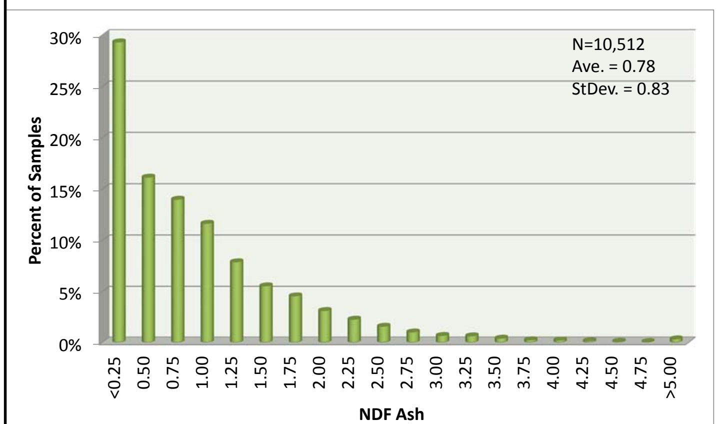
Distribution of NDF Ash in Haycrop Silage

(CVAS, 2013)



Distribution of NDF Ash in Corn Silage

(CVAS, 2012 crop)



Example of the Impact of Ash Contamination on NDF and NDF Digestibility Recovery

Sample	NDF	NDFom	NDFD30	NDFD30om
15081-68	54.6%	**48.3%**	56.3%	**65.9%**
15085-56	60.1%	**50.9%**	49.7%	**61.9%**

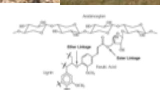
Ralph Ward

The Take Home

- aNDFom is becoming the new standard assay
- Will take time to develop all of the NIR equations, but commercial labs are making great progress (time and $$$)
- Continue to use the “benchmarks” that we have always used just replace NDF with aNDFom (1.1-1.2% BW aNDFom intake, etc.)
- Side benefits are better rumen health through greater rumen fill (using real value) and better predictions of energy and protein supply due to more accurate numbers

aNDFom Digestibility and Implications

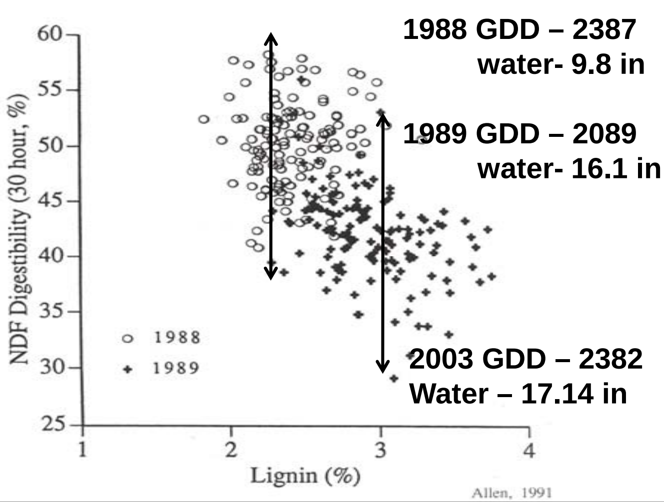
Cows, acres, digestible aNDFom per acre, light, heat and water…



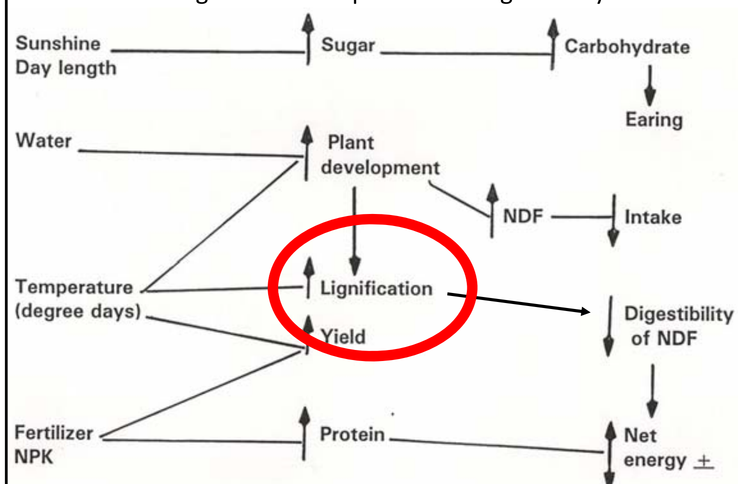
"Lignification" = cross linking between lignin and hemicellulose

- Light, heat and water interact at various stages of development to affect digestibility
- For example, water stress causes ~ 7x greater cross-linking between lignin and hemicellulose
- Similar to the effect of building a very tall building – to keep it standing, the building needs crossbeams to provide rigidity

NDF Digestibility as Affected by Lignin (GDD and Water)



Factors Affecting Plant Development and Digestibility



From Van Soest, 1996

Estimating iNDF … Measuring uNDF

- ADL x 2.4/NDF (Chandler et al., 1980)
- ADL/NDF$^{0.67}$ (Weiss et al., 1992)
- 288-h in situ (Huhtanen et al., 2007)
- 240-h in vitro fermentation (Raffrenato and Van Amburgh, 2010)

Van Soest and Lane Moore, 1963
USDA, Beltsville, MD right after
Pete characterized NDF

NDF Digestibility/Indigestibility

- Nousiainen et al. (2003; 2004)
  demonstrated in grasses that the relationship between lignin and digestibility was highly variable
- This was confirmed by Rinne et al. 2006 on legumes
  – methods used to determine this included 288 hr in situ (in a bag in the rumen) fermentations
- We were/are doing similar work at Cornell
  - Working to develop a procedure that could be used in a commercial lab
  Ph.D. work of Raffrenato (2011)

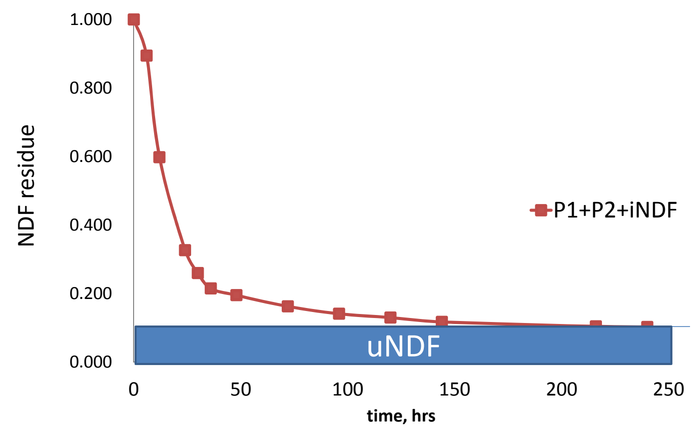
uNFD – Another New Term

- Unavailable NDF
- Determined after a 10 day (240 hr) in vitro incubation under specific conditions and proper filtration
- Commercial labs are providing this value now via NIR analysis, so you don't need to wait 10 days

?

It doesn't stay in the cow that long, does it?

Corn silage example: $NDF_{digestibility}$



Corn silage example for uNDF 240 vs lignin*2.4 – 2013 corn silages

	CS 1	CS 2	CS 3	CS 4
NDF, %DM	45.4	44.5	40.3	50.2
aNDFom, %DM	44.4	43.8	38.8	49.3
Lignin, %DM	3.40	3.43	2.87	4.26
Lignin*2.4/NDF	18.4	18.7	17.9	20.7
uNDF, %NDF	11.8	10.7	10.9	14.2

Corn silage chemistry and uNDF by three methods, 240 hr uNDF, Chandler et al. (1980) and Conrad et al., 1984 equations

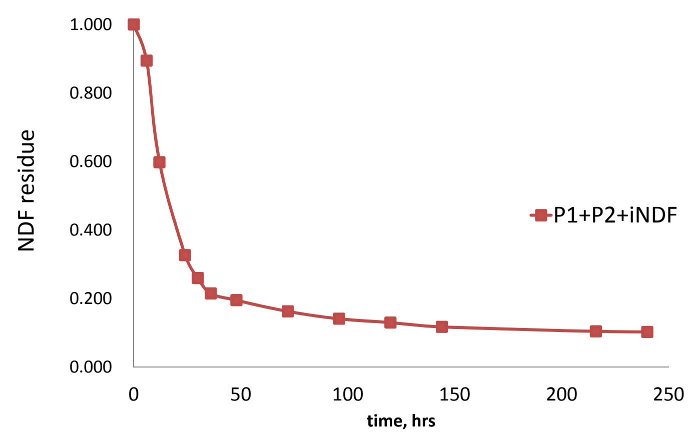
Corn silage	aNDF, %DM	aNDFom, %DM	uNDF, %NDF	Chandler et al. 1980	Conrad et al., 1984
1	38.1	37.5	23.6	42.3	16.4
2	39.5	38.9	25.6	39.2	16.9
3	41.5	40.9	27.3	43.4	17.7
4	43.7	41.9	22.8	42.8	31.8

Ratio of lignin to uNDF

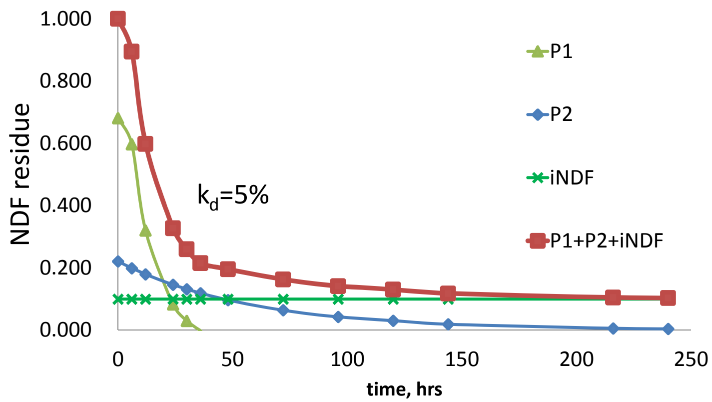
Group	n	NDF	ADL	uNDF	Ratio (range)
		%DM	g/kg NDF		uNDF/ADL (%NDF)
Conventional C.S.	30	42.7	72.4	316.8	4.72 (1.73-7.59)
BMR C.S.	15	39.1	43.6	171.7	4.01 (3.14-5.45)
Grasses	15	47.2	62.1	222.8	3.63 (2.51-4.73)
Mature grasses	11	64.5	84.4	313.8	3.89 (2.60-5.64)
Immature grasses	13	44.1	59.3	232.2	4.16 (2.59-7.40)
Alfalfas	18	36.6	172.6	461.4	2.70 (2.43-2.95)

Raffrenato 2011

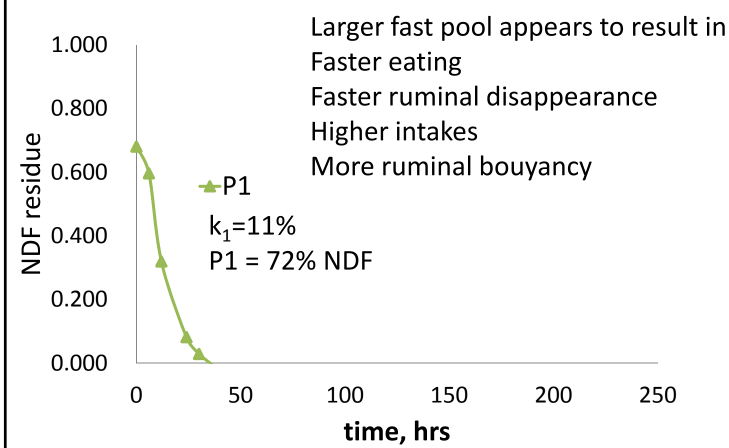
Corn silage example: $NDF_{digestibility}$



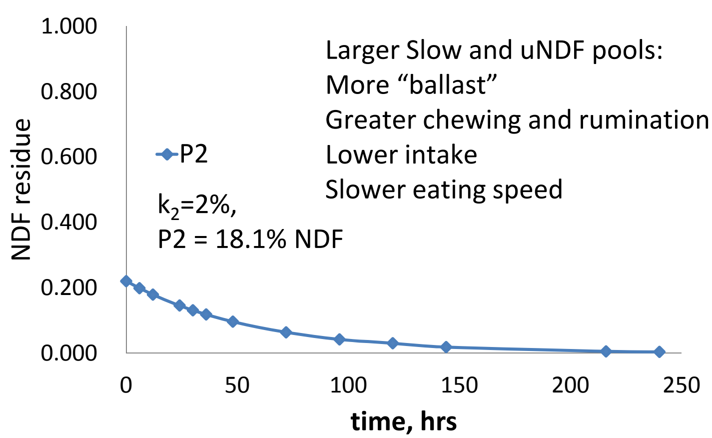
Corn silage example: P1+P2+iNDF



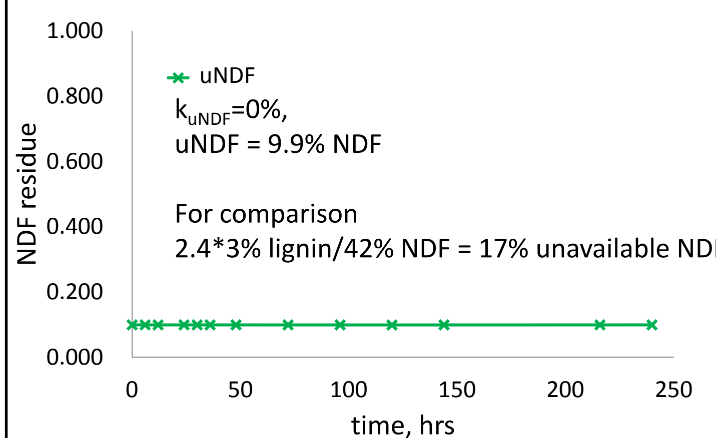
Corn silage example: fast pool



Corn silage example: slow pool



Corn silage example: uNDF



uNDF Study @ Miner Institute

- What does it mean and how do we take advantage of the information?

Composition of diets used in uNDF study at Miner Institute.

	Diet			
Ingredient % of ration DM	LF-LD (Low CS)	HF-LD (High CS)	LF-HD (Low BMR)	HF-HD (High BMR)
Conventional corn silage	39.2	54.9	---	---
Brown midrib corn silage	---	---	36.1	50.2
Hay crop silage	13.4	13.4	13.3	13.3
Corn meal	17.3	1.6	20.4	6.3
Grain mix	30.1	30.1	30.2	30.2
Chemical composition				
Crude protein, % of DM	17.0	17.0	16.7	16.7
NDF,% of DM	32.1	35.6	31.5	35.1
Starch, % of DM	28.0	21.2	27.8	23.8
24-h NDF digestibility, %	56.3	54.0	62.0	60.3
peNDF, % of DM	17.3	23.1	18.5	21.5

uNDF study – Miner Inst.

	High CCS	Low CCS	High BMR	Low BMR
DMI lb/d	58.43	63.95	64.39	64.61
SCM lb/d	92.17	99.67	100.77	102.31
Efficiency	1.58	1.56	1.57	1.58

uNDF Intake, Rumen content and Fecal excretion

	High CCS	Low CCS	High BMR	Low BMR
uNDF Intake lb/d	5.80	5.27	4.87	4.48
uNDF Rumen lb	9.17	8.42	7.63	7.06
uNDF Fecal lb /d	5.80	5.27	4.87	4.48

Can we use this to better predict DMI and adjust diets to allocate forages better?

	High CCS	Low CCS	High BMR	Low BMR
uNDF, %DM	9.92%	8.24%	7.57%	6.93%
uNDFi:uNDFf	1.00	1.00	1.00	1.00
uNDFi: NDFr	0.63	0.63	0.64	0.63
uNDFr:uNDFi	1.58	1.60	1.57	1.58

uNDFi, uNDF Intake
uNDFf, uNDF Fecal
uNDFr, uNDF Rumen content

Interpretation

- Need to understand what changes uNDF Rumen content
  - 4.48 – 5.80 lbs. or 7% - 10% DMI is significant
  - Rumen content appears to determine intake and fecal output of uNDF
  - What causes variation of uNDF Rumen content?
- "Working hypothesis": the disappearance of the fast and slow pools of pdNDF determines volume of uNDF Rumen content and capacity along with the "ballast and rumen fill of the slow and uNDF fractions.

Perspective

	High CCS	Low CCS	High BMR	Low BMR	Median
uNDF, %DM	9.92%	8.24%	7.57%	6.93%	**7.90%**
uNDF Intake lb	5.80	5.27	4.87	4.48	**5.07**
uNDF Rumen, lb	9.17	8.42	7.63	7.06	**8.03**
uNDF Fecal/d	5.80	5.27	4.87	4.48	**5.07**
uNDFi:uNDFf	1.00	1.00	1.00	1.00	**1.00**
uNDFi:uNDFr	0.63	0.63	0.64	0.63	**0.63**

Take into account current uNDF% and intake while rebalancing diet. If you know current capacity based on current feeds you should be able to optimize better diet.

Summary of 2008 and 2011 studies: uNDF240om rumen fill relative to intake

- 7 of 8 rations show similar ratio of rumen fill:intake of uNDF240om
  - 1.6x
- Suggests uNDF240om as viable predictor of DMI across various diets
- Considering 2008 and 2011 data; suggests
  - 0.40% BW as possible fill max, DMI max
  - 0.30% BW as possible fill minimum for rumen health and functioning.

Digestible aNDFom per Acre

- Cost effective, high quality land availability is tight
- Growth of the business is paramount to future success – so more cows
- Cows run on forage and high quality forage is the key to high milk yield, lower income over purchased feed costs and reduced environmental impact
- Question: How much digestible aNDFom do you yield per acre with your current forage program?
  - for corn silage have to recognize starch contribution for energy and purchased grain, but forage digestibility is still key

Forage Rotation and Selection to Optimize Digestible aNDFom per Acre

- Alfalfa is good example – traditional forage for lactating dairy cattle
- Drought resistant due to root structure and capability
- High nitrogen content for a forage
- Good digestibility?

Forage Rotation and Selection to Optimize Digestible aNDFom per Acre

- uNDF content of alfalfa ranges from 43% to 53% depending on cutting and leaf to stem ratio
- 2012 Large Herd DFBS data – Haycrop yields 3 to 3.3 tons DM/acre
- Assume this is alfalfa at 40% NDF and 47% uNDF, that means tons digestible aNDFom per acre on average is 0.7 tons per acre

Forage Rotation and Selection to Optimize Digestible aNDFom per Acre

- Corn silage by comparison can range from 9 to 17% uNDF and will yield ~7.5 DM ton per acre.
- At 42% NDF, that is 3.2 tons aNDFom/acre and ~2.3 tons of digestible aNDFom per acre

Predicting AA Balance and Protein Supply – Four Pieces To The Nitrogen/AA Part of the Puzzle

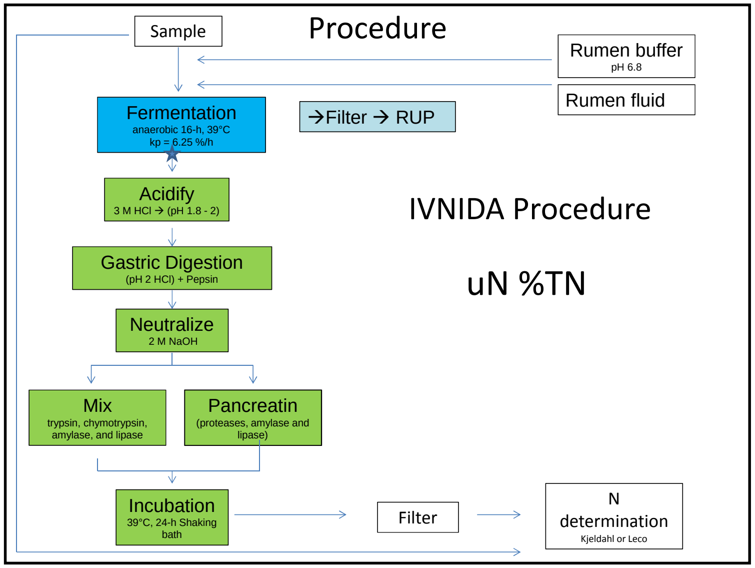
Nitrogen components at the duodenum

What is most limiting?

Total amino acid requirements

Amino acid profile of each component

Digestibility in the small intestine



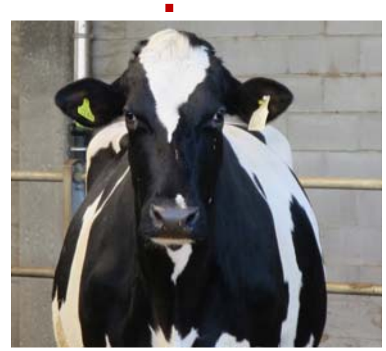
Comparison of ADIN and Ross in-vitro indigestible N

	Feed N (% DM)	ADIN (%N)	Ross In-vitro indigestible N (% N)
Regular blood meal	16.2	4.7	16
Heat damaged blood meal	16.1	1.8	93
Soybean meal solvent extracted	7.6	6.7	8
Soybean meal heat treated	7.3	7.9	11

Source: Ross, 2013

Does The Cow Care?

?



Objectives

- To evaluate the performance of lactating dairy cattle fed two different levels of uN as determined by the IVNIDA
- To compare MP allowable milk predictions of the CNCPS using the detergent system or uN IVNIDA with the study data
- Economic evaluation of the outcome

Unavailable N in Excellent and Average Blood Meal Estimated by the Detergent System or by the uN assay

Ingredient, % N	NDIN	ADIN	uN det.	uN IVNIDA
LOW uN Blood Meal	0.0	0.0 →	0.0	9.0
HIGH uN Blood Meal	0.0	0.0 →	0.0	33.8

Diet Formulation

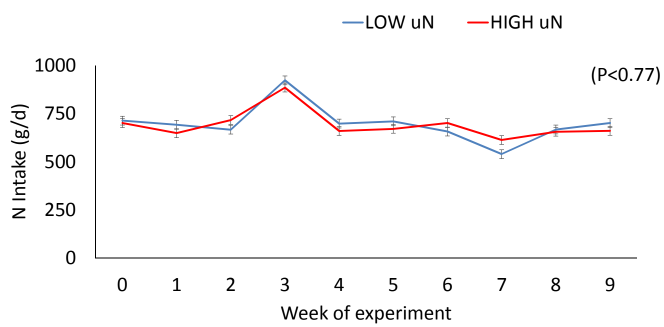
	Treatment	
Ingredient, % DM	LOW uN	HIGH uN
Alfalfa haylage	11.5	11.5
BMR corn silage	49.3	49.3
Bakery byproduct	1.8	1.8
Blood meal (9% uN)	3.7	---
Blood meal (34% uN)	---	4.0
Canola meal	3.0	3.0
Corn grain	16.1	16.1
Energy Booster 100	1.8	1.8
Molasses	1.8	1.8
Smartamine M	0.1	0.1
Sodium bicarbonate	0.6	0.5
Soybean hulls	4.6	4.5
Urea	0.2	0.2
Wheat midds	4.6	4.5
Min/vit mix	1.0	1.0

Chemical Composition of Initial Diets Fed

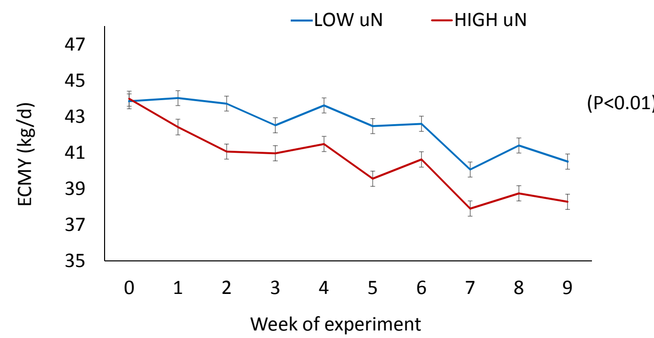
	Treatment	
Item	LOW uN	HIGH uN
DM, % as fed	50.0	50.5
CP, % DM	15.2	15.2
NDF, % DM	31.9	32.3
ADF, % DM	21.3	20.5
Fat, % DM	4.3	3.9
Starch, % DM	30.4	31.2
Sugar, % DM	3.6	3.3
Ca, % DM	0.65	0.60
P, % DM	0.43	0.43
ME*, Mcal/kg DM	1.8	1.7
Lys:Met*, % MP	3.21	2.89

* calculated CNCPS

Nitrogen Intake



Energy Corrected Milk



Results

	Treatment			
Item[1]	LOW uN	HIGH uN	SEM	P-value
DMI, lb	60	60	1.34	0.75
N Intake, g	671	664	14.8	0.77
Milk production				
Milk, lb	93	89	0.68	<0.01
ECM, lb	92	88	0.71	<0.01
Fat, lb	3.33	3.13	0.04	<0.01
Protein, lb	2.78	2.71	0.02	0.03
Milk composition				
Fat, %	3.6	3.5	0.03	<0.03
Protein, %	3.03	3.06	0.02	0.20
Lactose, %	4.9	4.86	0.02	0.18
MUN, mg/dl	9.4	8	0.18	<0.01

[1] DMI: dry matter intake, ECM: energy corrected milk (Tyrrell and Reid, 1965), MUN: milk urea nitrogen

Results

	Treatment			
Item[1]	LOW uN	HIGH uN	SEM	P-value
BW and BCS				
BW initial, lb	1508	1525	22.26	0.58
BW change, lb	76	65	4.96	0.12
BCS change	0.44	0.35	0.07	0.29
Efficiency				
Gross feed efficiency[2]	1.56	1.50	0.03	0.34
Milk N efficiency[3]	30.0	29.7	0.70	0.76

[1] BW: body weight ; BCS: body condition score
[2] calculated as kg milk / kg DMI
[3] calculated as milk N / N intake *100

CNCPS Prediction Evaluation

- Full chemical composition in all feeds
- Inputted all environmental, barn and animal characteristics from experiment
  - BCS change was inputted as measured
  - Target ADG was allowed to estimate nutrient requirements for growth based on mature size
- The uN values from the blood meals were the only values changed and were used in place of ADIN

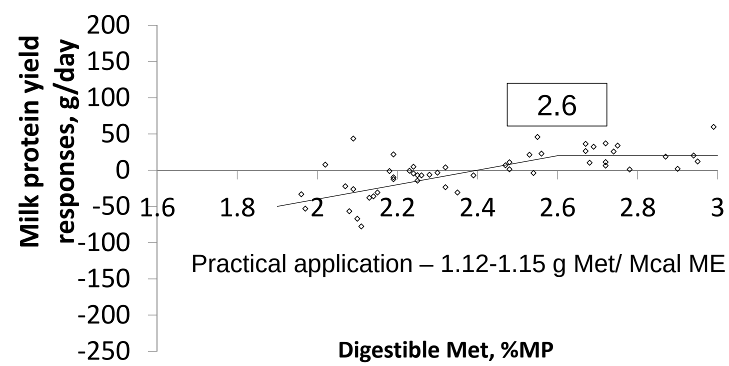
CNCPS v6.5 predictions for ME and MP allowable milk

Item	Treatment LOW uN	Treatment HIGH uN
Energy corrected milk, lb	92	88
Predicted ME allowable milk, lb	102	101
Using ADIN and NDIN		
Predicted MP allowable milk, lb	99	99
Predicted MP supply, g	3,105	3,144
Using uN assay data		
Predicted MP allowable milk, lb	94	87
Predicted MP Supply, g	3,036	2,835

N indigestibility study

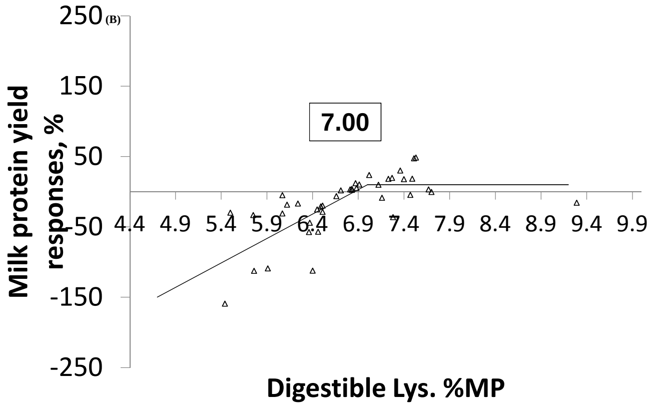
- Final difference in predicted N supply was 32 g or 4.8% of N intake.
- Suggests that with adequate and correct N digestibility information, we can refine diet formulations to a small margin
- Challenge is getting variation in feed and management accounted for properly
- Understanding what is first or most limiting is important as we refine our formulation strategies

BALANCING FOR MET – UPDATED AA PROFILES – MILK PROTEIN YIELD v6.5



Source: Van Amburgh et al., JDS 2015

BALANCING FOR LYS – UPDATED AA PROFILES – MILK PROTEIN YIELD V6.5



Van Amburgh et al., JDS 2015

Methionine and Lysine and Relative to Energy

If 60 Mcals ME, then (60 mcal*1.12 g/Mcal) 67.2 g Met

The lysine requirement should be (7/2.6 =2.69)

Therefore 2.7 (Lys:Met) *67.2g = 181.4 g Lys

Always calculated Met first – what the gram/energy relationship was derived from

Then calculate lysine otherwise the ratio will provide incorrect values

Thank you for your attention.

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