Improving the Efficiency of Use of Nitrogen in Lactating Dairy Cattle

Mike Van Amburgh, Erin Recktenwald,
Debbie Ross, Tom Overton, Larry Chase

Outline

- Discuss nitrogen efficiency of lactating dairy cattle
- Discuss opportunities for reducing environmental impact of dairy cows
- Use CNCPS/CPM Dairy/NRC platforms for basis for discussion of protein formulation
- Discuss nitrogen recycling, microbial use and assays
- Describe some current field based diets and cow responses

Improving Nitrogen Efficiency

- Want to reduce N excretion
  - Environmental issues – ammonia volatilization
  - Feed protein is expensive (all feed is now expensive!)
- How do we do this?
  - Increase milk protein output
  - Reduce protein intake
    - Need to maintain milk output

Improving the efficiency of protein and N usage is of practical concern

- Reduced feed costs per unit of lean tissue gain or milk produced
- A desire for greater and more efficient yield of milk protein
- Creation of space in the diet for other nutrients that will enhance production
- Concerns for waste N disposal
- Decreasing ammonia emissions

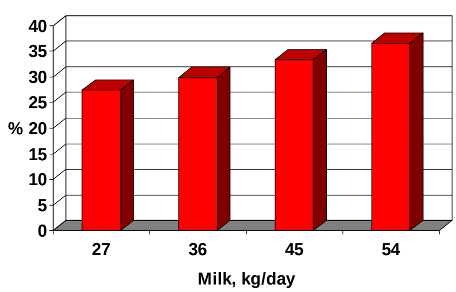
What are the Challenges?

- A dairy farm is a complex, biological system that needs to deal with variation on a daily basis
- Major factors are the daily variation in feed dry matter content, feed nutrient composition and animal dry matter intake

We Are Working to Improve Efficiency of Use on Farm and Reduce N Waste

- Opportunities exist – need refining
- On farm N efficiencies (milk N:feed N)
  25 to 32%
- Theoretical efficiency limit ~ 45% in lactating dairy cattle
- Practical limit is ~ 38%
- Requires refinement of current ration formulation models
- Requires refinement of feeding management – reducing variation

% of Nitrogen Intake Excreted in Milk



Based on a ration meeting daily N requirements

We Are Working to Improve Efficiency of Use on Farm and Reduce N Waste

- Major routes of N excretion:
- Milk (25 to 40%)
- Feces
- Urine

} 75 to 60%

- Feces is relatively fixed ~170 to 250 g per day and is mostly endogenous protein, microbial cell wall and undigested feed

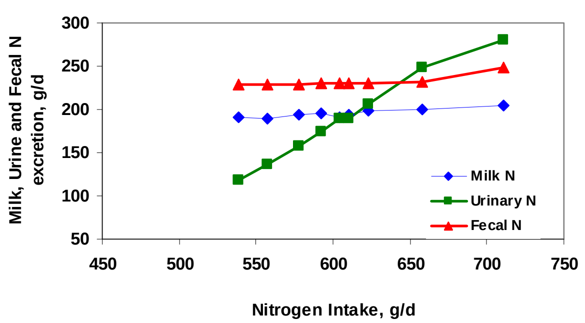
We Are Working to Improve Efficiency of Use on Farm and Reduce N Waste

- Urine N is variable and is a function of excess nitrogen intake and recycling
- Urine N is most volatile form – so reducing it will reduce the environmental impact and improve efficiency
- High levels indicate:
  - Overfeeding total protein
  - High rumen N balance relative to microbial demand
- Can use monitoring tools like milk urea nitrogen to diagnose independent of production responses

Urinary N is main form of excreted N Fecal N is fairly constant

Reference	Intake N (g/d)	Fecal N (g/d)	Urinary N (g/d)
Kauffman and St-Pierre, 2001	429	178	93
	460	184	101
	572	198	190
Hristov and Ropp, 2003	754	176	279
	658	208	233

Nitrogen Excretion in Milk, Feces and Urine Based on N Intake in Lactating Dairy Cattle



CNCPS v6.1 Nutrient Excretion – Manure and Manure Nitrogen

Excretion	
Fecal	44 kg
Urine	23 kg
TotalManure	67 kg
Fecal N	255 g
Urine N	227 g
Total Manure N	482 g
Productive N/Total N	30%
Productive N/Urinary N	0.91:1
Manure N/Total N	70%

CNCPS v6.1 Nutrient Excretion – Manure Phosphorous and Methane Production

Fecal P	70.5 g
Urine P	1.2 g
Total Manure P	71.7 g
Productive P/Total P	33%
Manure P/Total P	67%
CH4 (Mcal)	6.00
CH4 (L)	655.32

Case Farm Example – McMahon Dairy

- 500 cow farm, 33- 34 kg milk/cow/day
- Total animals = 922
- Milking cows = 448
- Dry cows = 100
- Replacements = 374
- Initial P balance = +67%

McMahon's - What Changes Were Made?

- Took place over a 5 year period
- Changes were made in the cropping program, crop rotations, harvest management, forage storage and the feeding program

Potential for precision feed management[1]

	Purchased feed, $/day	Milk, kg/day	Nitrogen, kg/year	Phosphorus, kg/year
Before	1813	12,532	140,219	19,707
After	1375	18,225	116,311	14,152
% change	-34.2	45	-17.1	-28.2

[1]Tylutki PhD thesis, 2002.

Email Question from Dr. Robert Fry

- "Why does the model not attribute significant MP from alfalfa haylage in this session? You will see that the CP of this diet is ~ 26% with lots of peptides and NH3. Why does the model want so much soybean meal coupled with the alfalfa?"

  "Any idea what I am missing?"

Implication – all of the soluble protein from the alfalfa is all NPN and has no MP value (not true), or it never leaves the rumen (most likely not true either)

CNCPS v6.1

- Several updates to the biology and "fixes"
  - New carbohydrate fractions – volatile fatty acids, lactic acid, organic acids, and sugars (Lanzas et al., 2007)
  - New solid and liquid passage rate equations (Seo et al., 2006)
  - Bacterial ash accounting (Tylutki et al. in press)
  - Updated passage rate assignments
  - Updated rates of protein degradation

CNCPS v 6.1 – Carbohydrate & Fiber Fractionation

- Volatile Fatty Acids (A1)
- Lactic acid (A2)
- Organic acids as a separate pool (A3)
- Sugar as separate pool (A4)
- Starch as a separate pool (B1)
- Soluble Fiber as a separate pool (B2)
- Neutral Detergent Fiber (B3)
- Lignin as % NDF (C)

CNCPS v 6.1 – Carbohydrate & Fiber Fractionation – Rate Changes

	Rates, %/hr
Volatile Fatty Acids (A1)	**0**
Lactic acid (A2)	**7**
Organic acids as a separate pool (A3)	**5**
Sugar as separate pool (A4)	**40 (300)**
Starch as a separate pool (B1)	**10 - 40**
Soluble Fiber as a separate pool (B2)	**20 - 30**
Neutral Detergent Fiber (B3)	**Variable 1 to 12**

CNCPS v6.1- Efficiency of use of Protein for Milk Protein Synthesis

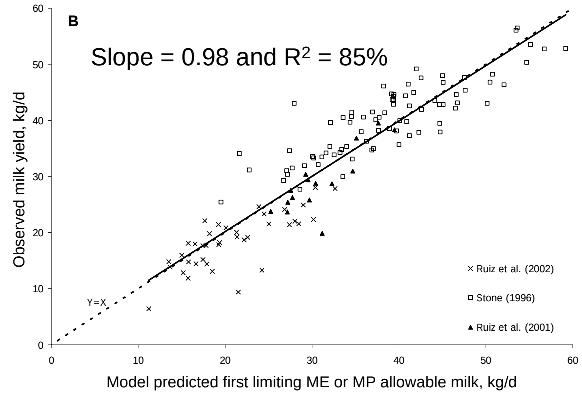
Increased the efficiency of use of absorbed protein for milk protein synthesis from 0.645 to 0.67 based on NRC 2001

$$LE = Milk(0.0929 \times MF) + \left(\frac{0.0547 \times MTP}{0.93}\right) + (0.0395 \times ML) \quad (7)$$

$$LP = Milk\left(\frac{(MTP/100)}{0.67}\right) \times 1000 \quad (8)$$

where LE is net energy for lactation (Mcal/d); Milk the milk production (kg/d); MF the milk fat (g/100 g milk); MTP the milk true protein (g/100 g milk); ML the milk lactose (g/100 g milk); and LP is metabolizable protein for lactation (g/d).

CNCPS Observed versus Predicted – Three Data Sets



Passage Rate Assignments

- Soluble pools (CHO A and Protein A and B1) were incorrectly programmed
- They were assigned to the solids (particle) passage rate equation
- This was corrected and they are now assigned to the liquid passage rate equation
- This has profound effects on rumen carbohydrate and protein balance

Protein Fractionation – CNCPS v 6.1

- Pro A - Non-protein Nitrogen
- Pro B1 - Rapidly Degradable Protein
- Pro B2 - Medium Degradable Protein
- Pro B3 - Slowly Degradable Protein
- Pro C - Unavailable Protein (bound)

Amino acids based on the insoluble residue or B2, B3 and C (although we are updating to whole feed amino acids because of the passage rate changes)

Previous Characteristics of Protein Pools

- We have assumed that the rate of degradation of the Protein A pool has been infinite and is all NPN
- Also assumed that most of the feed protein associated with the B pools, especially B1 and B2, that solublizes disappears into bacteria or is converted to ammonia
- NDF digestion rates and the associated Protein rates (B3- NDIP) are independent – for example NDF kd 4%/h with NDIP kd 0.35%/h

Protein A and B1 Rates of Degradation

Data from omasal flow studies: Rate of degradation of the A and B1 pools less than previously characterized (Choi et al., 2002, Volden et al., 2003, and Reynal et al. 2007)

Review of the literature suggests that Protein B1 rates range from 20 to 50%/h (Lanzas et al., 2007)

Broderick et al. (2004) B pool proteins from soybean meal degraded at 9 to 21%/hr – 10 times less than current rates

Rates of degradation (kd) of protein A and B1 pools in CNCPS v5.0 and v6.1.

Feed	**ProtA kd v.5.0**	**ProtA kd v.6.1**	**ProtB1 kd v.5.0**	**ProtB1 kd v.6.1**
Corn Grain Ground	10000	200	135	50
Corn High Moisture 22%	10000	200	135	50
Soybean Meal 44	10000	200	230	46
Soybean Meal 48	10000	200	230	46
Corn Silage	10000	200	300	28
Grass Silage	10000	200	200	49
Alfalfa Silage	10000	200	150	28

From: Broderick, 1989; Volden et al. 2002, Choi et al., 2003; Hequist and Uden, 2006; Lanzas et al., 2007

Precipitable true protein of trypticase with varying PPT agents and pore size

PPT Agent	Filter pore, µm	True protein	Filtrate peptide chain length
Tungstic acid	1	34.4	3.0
	6	23.1	4.3
	20	1.8	4.2
Stabilized TA	1	31.0	3.3
	6	28.5	3.4
	20	4.4	3.6
TCA	1	2.57	3.4
	6	0.78	4.3
	20	0.42	5.0
Perchloric Acid	1	1.36	3.2
	6	1.56	4.1

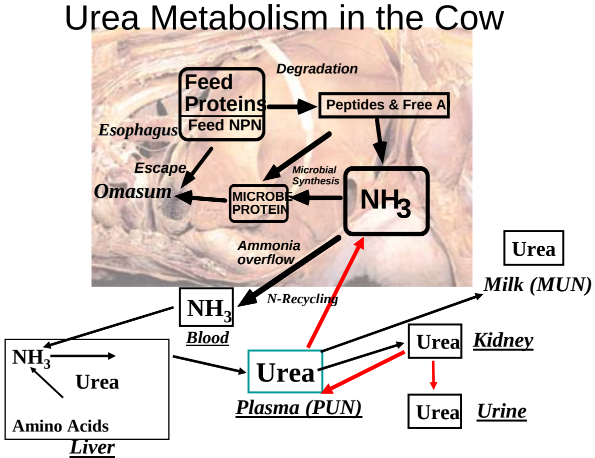
Protein B3 – NDIP Rate

- Rates of protein degradation were assumed to be independent of the carbohydrate and a function of the type of protein (Sniffen et al., 1992)
- For example, NDF kd – 4%/h and NDIP kd of 0.35%/h – implies that as the ND fraction digests, protein accumulates in the residue or in the rumen
- Data from several labs suggest this is incorrect
- Also we have the “Sulfite or no sulfite” in the NDF analyses – The AOAC method uses sulfite
- If the rate of degradation of the B3 pool is similar to the NDF, then the sulfite question is made less relevant

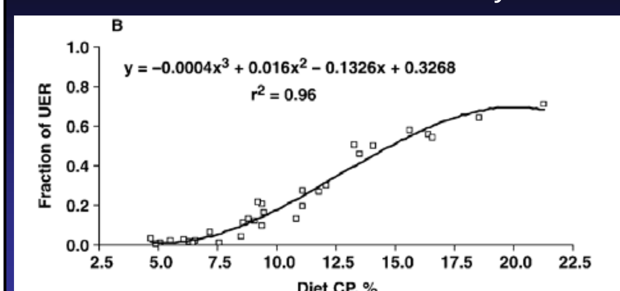
Protein B3 – NDIP Rate

- Data from our lab (Righi, unpublished) and other laboratories demonstrate that the Protein B3 pool digests at the same rate as the NDF – at least for forages
  - Thus, in the latest release of the CNCPS, when you adjust the NDF kd, the Protein B3 pool assumes the same rate
  - This needs to be evaluated for all of the concentrates and byproducts

Urea Metabolism in the Cow



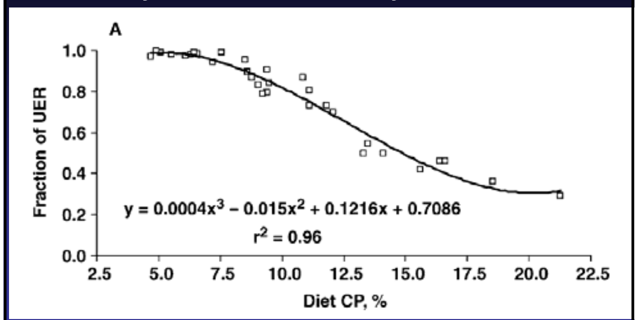
Fraction of Urea Production the is Excreted in the Urine and Milk by CP%



Archibeque et al., 2001, 2002; Ruiz et al., 2002; Marini and Van Amburgh, 2003; and Wickersham, 2006

Reynolds and Kristensen, 2007

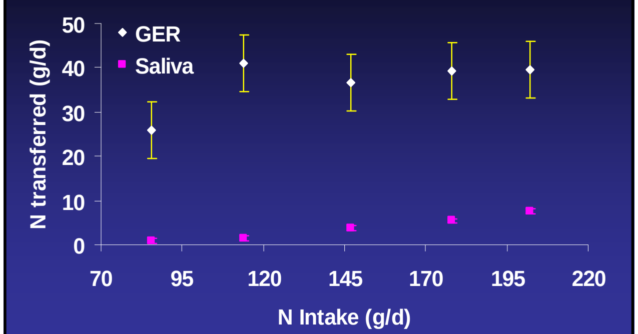
Fraction of Liver Urea Production Recycled to the GIT by Diet CP%



Archibeque et al., 2001, 2002; Ruiz et al., 2002; Marini and Van Amburgh, 2003; and Wickersham, 2006

Reynolds and Kristensen, 2007

Effect of Nitrogen Intake on Urea Recycled to the GIT tract



Marini and Van Amburgh, 2003

Recycled N and Bacterial MP supply

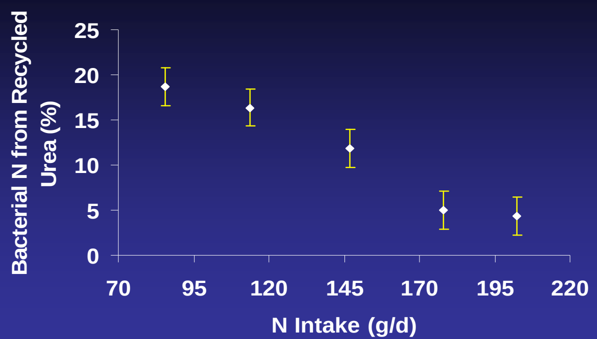
- NFC and FC bacteria utilize ammonia for microbial protein synthesis
  - Inflow of recycled N makes more ammonia available
  - Ammonia supply above requirement does not improve growth
  - Rumen ammonia absorption more correlated to MP excess than N intake (0.6 vs. 0.2) – Lapierre et al., 2005.

Bacterial Utilization of Recycled Urea

- Function of nitrogen intake and number of times N molecule recycles
- Current carbohydrate status
  - N utilization dependent on microbial capacity in particular environment
    - May lead to wide ranges in efficiency of use
  - Varying forage and grain in diets resulted in contributions of recycled urea N to bacterial N of 13-38%

Lapierre and Lobley, 2001

Effect of Nitrogen Intake on the Origin of the Bacterial N



Marini and Van Amburgh, 2003

Effect of Barley Processing and Fat on N Metabolism and Urea Recycling

Item	Canola		Flax	
	Dry rolled barley	Pelleted barley	Dry rolled barley	Pelleted barley
Actual milk yield, kg/d	32.3	32.4	33.1	28.1
ECM yield, kg/d	31.4 †	30.1	29.8	27.6 †
Fat yield, kg/d	1.10	0.80	1.15	0.72
Protein yield, kg/d	0.96†	1.00	1.03	0.89†

Gozho et al., 2008

Effect of Barley Processing and Fat on N Metabolism and Urea Recycling

Item	Canola		Flax	
	Dry rolled barley	Pelleted barley	Dry rolled barley	Pelleted barley
N intake, g/d	623	583	653	539
Fecal N, g/d	160	132	196	116 †
Urine N, g/d	291	261	267	243
Milk N, g/d	151	159	162	137

Gozho et al., 2008

Effect of Barley Processing and Fat on N Metabolism and Urea Recycling

Item	Canola		Flax	
	Dry rolled barley	Pelleted barley	Dry rolled barley	Pelleted barley
Production UER, g/d	401	364	483	304
GIT entry GER, g/d	248	234	298	170
Return to cycle ROC, g/d	183	181	225	138
Reuse, UUA g/d	57	45	63	25

Gozho et al., 2008

Effect of Forage Harvest Management on Urea Metabolism – Ouellet et al., 2004

Type	N intake, g	Urea prod., g N/d	Urea entry rate, g N/d
Hay	295	172.3 (58%)	123.4 (42%)
Formic silage	341	170.6 (50%)	121.6 (36%)
Inoculant silage	351	200.0 (57%)	140.6 (40%)

Relationship between dietary CP and percentage of urea recycled into the rumen based on NRC, 1985 and used in CNCPS and CPM Dairy

% CP in diet	% recycled (%N intake)
6	61
8	46
10	34
12	24
14	17
16	12
18	10

% recycled = 121.7 – 12.01 x CP% + 0.3235 x $\%CP^2$

Effect of Forage Harvest Management on Urea Metabolism – Ouellet et al., 2004

Type	N intake, g	Urea entry rate, g N/d	Pred. urea N recycled, g
Hay	295	123.4	70.4
Formic silage	341	121.6	69.7
Inoculant silage	351	140.6	68.0

What we know about recycling in lactating cows

- On average 65% of the N intake is converted to urea in the liver
- From the liver urea production approximately 60% returns to the rumen and large bowel
- Thus, 39% of the intake N is recycled to the GIT and approximately 20% of it is captured by bacteria – however this is highly variable and the focus of some of our current work

Calculated ammonia N requirement: ~364 g

Current balance: 409 g

Current balance + recalculated recycled urea N (35% of Intake N – 228 g): 606 g (167%)

DMI Predicted	54.4 lb/d	Pept & NH3 Bal	45 g/d	111 %
DMI Actual	54.2 lb/d	Pept Bal	29 g/d	113 %
Predicted Ruminal pH	6.46	Urea Cost	0.058 mCal/d	
Target Growth	0.06 lb/d	Target Milk	100.0 lb/d	
Input Growth	0.12 lb/d			
ME Allowed Growth	0.12 lb/d	ME Allowed Milk	100.8 lb/d	
MP Allowed Growth	0.34 lb/d	MP Allowed Milk	102.4 lb/d	
AA Allowed Growth (Isoleucine)	-1.15 lb/d	AA Allowed Milk (Isoleucine)	94.1 lb/d	

Potential Limitations of Recycled N

Fiber digesting bacteria require branched chain VFA's

- source is BCAA
- potentially reduce fiber digestion and microbial yield

Rate of urea entry might create competition among bacteria:

- NSC bacteria faster metabolism
- Can out-compete the SC bacteria for available N under low N conditions

Effect of Urea Addition to Alfalfa Based Diets in Beef Steers

Item	Diet: Alfalfa	Diet: Alfalfa + urea	grams Change
N intake	153	209	56
PDV[2] NH_3-N release	85	134	49
Liver urea N release	122	180	58
Urine N excretion	81	140	59
PDV urea N removal	32	45	13
Saliva urea N entry	28	22	–6
Total gut urea entry	60	67	7

[1]From Maltby et al. (2005).
[2]PDV = portal-drained viscera.

Lapierre did a similar study in lactating cattle – same response – all the urea exited in the urine

What About Protozoa?

- CNCPS/CPM Dairy: microbial yield reduced by 20% based on concept of protozoal predation.
- Protozoa are not accounted for in CNCPS/CPM Dairy or NRC
- Estimates of protozoa range from 20 to 50% of total microbial mass in rumen

Does protozoal death contribute to rumen microbial peptide pool?

What are the N requirements of protozoa and how do they affect predictions of rumen N balance?

Protozoal Protein: Neglect or Acknowledge?

- Can be a contributor to rumen N and duodenal N flow
- In cows fed 46 to 60% forage:
  - 4.8 to 12.7% of ruminal microbial N was protozoal (low to high forage)
  - 5.9 to 11.9% of duodenal N flow was protozoal (low to high forage)

Sylvester et al. 2005

Protozoa most likely contribute substantial amino acids and peptides to rumen & animal

Microbial Turnover – More Peptides

Firkins et al., 1992 suggested that microbial turnover would produce peptides and amino acids in the rumen

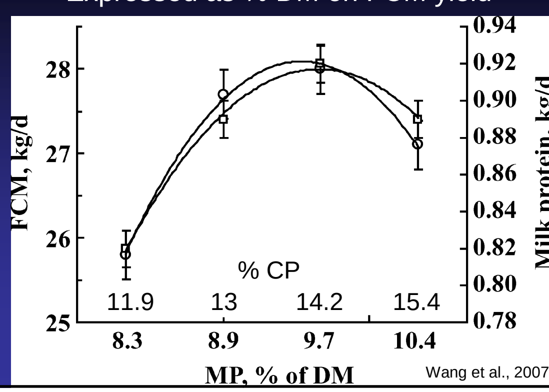
- estimated that turnover ranged from 20 to 90%

Wells and Russell (1996) calculated microbial yields and demonstrated that bacterial turnover could not exceed 50% (20 – 30%)

- but would provide peptides and amino acids

AA	Maintenance efficiency of use	Lactation (mammary gland utilization) Efficiency of use	Std Dev.	CV
Met	0.85	1.00	0.10	10%
Lys	0.85	0.86	0.13	16%
His	0.85	0.94	0.13	14%
Phe	0.85	0.98	0.08	8%
Thr	0.85	0.79	0.14	18%
Leu	0.66	0.71	0.07	10%
Ile	0.66	0.66	0.07	11%
Val	0.66	0.62	0.09	14%
Arg	0.85	0.34	0.06	17%

Effect of Metabolizable Protein Level Expressed as % DM on FCM yield



If we take some of this into account, how low can we drop CP level and still make milk?

Experiment Description

- Conducted at Cornell T&R
- 93 early lactation (70 DIM) multiparous lactating dairy cows in randomized complete block design
- Cows given bST per label and fed monensin
  ~ 300 mg/cow/d
  - Individual DM intakes and milk yields recorded daily
  - Plasma samples taken via tail vein weekly
  - Milk samples taken weekly; analyzed at Dairy One, Ithaca, NY
  - Body weights recorded biweekly; BCS weekly
    - Five cows dropped due to non-study issues

Ingredient (% of DM)	Diet N	Diet P	Diet T
Corn silage	45.24	46.14	45.34
Wheat straw	2.05	2.10	2.06
Ground corn	11.31	11.11	10.92
Cottonseed	8.23	8.39	8.45
Citrus pulp	9.25	5.24	9.27
Ground barley	8.23	4.19	6.18
Confectioners sugar	0.82	2.62	3.09
Soybean hulls	4.11	4.19	4.12
Soybean meal, 47.5 solv.	7.81	5.77	0
SoyPLUS	0	6.29	5.15
Mepron	0	0.05	0.05
ProvAAl	0	1.05	2.27
Nitroshure	0.41	0.38	0.35
Vitamin and mineral mix	2.53	2.47	2.76

Diet composition	Diet N	Diet P	Diet T
Dry matter, %	48.83	48.43	48.80
Crude protein, % DM	14.30	16.30	14.20
Soluble protein, %CP	35.47	29.80	30.29
RDP, %DM	9.43	9.52	7.70
NDF, % DM	34.67	34.50	34.81
peNDF, % NDF	23.16	23.31	23.20
Starch, % DM	26.13	24.64	25.37
Sugar, % DM	5.01	5.50	6.18
Silage acids, % DM	2.18	2.22	2.18
Soluble fiber, % DM	8.79	7.81	8.27
Ether extract, %DM	4.37	4.61	4.54
Calcium, % DM	0.75	0.75	0.72
Phosphorus, % DM	0.34	0.33	0.33

CPM Dairy Predictions at 50 lb/d Formulated Dry Matter Intake

	Diet N	Diet P	Diet T
ME allowable milk, lb/d	89.9	89.5	89.0
MP allowable milk, lb/d	77.4	95.9	88.0
CP, % DM	14.2	16.6	14.2
RDP, % DM	9.6	9.9	7.7
Ruminal:			
Peptide balance, g/d	14(103%)	24(106%)	-50(88%)
Peptide and NH3, g/d	0(100%)	10(105%)	-52(77%)
MP bacteria, g/d	1494	1529	1345
MP feed, g/d	848	824	1207

Feed Evaluation

- All ingredients analyzed for CNCPS/CPM Dairy fractions
- NDF rates determined on 6 and 24 hr in vitro digestions (Van Amburgh et al., 2003)
- Starch rates determined by in vitro digestion (6, 9, 12 and 24 hr) using a single pool model with discrete lag
- Remaining rates per model library

Dry Matter and Nitrogen Intake, Milk Yield and Components

Variable	Diet N	Diet P	Diet T
n	29	29	30
DMI, lb/d	56.1^{a}	56.7^{a}	53.4^{b}
N intake, g/d	582^{b}	669^{a}	550^{b}
Milk, lb/d	93.1^{b}	100.7^{a}	95.0^{b}
Fat %	2.67^{a}	2.63^{a}	2.54^{b}
Fat yield, lb/d	2.45^{b}	2.58^{a}	2.40^{b}
Protein %	2.92^{a}	2.93^{a}	2.88^{b}
Protein yield, lb/d	2.69^{b}	2.91^{a}	2.73^{b}

^{a,b,c}Different subscript within each row indicates significant different ($P < 0.05$)

Production Characteristics and Efficiencies

Animal production	Diet N	Diet P	Diet T
Milk energy† (Mcal/d)	25.13^{b}	26.82^{a}	25.02^{b}
3.5% FCM†, lb/d	79.9	85.3	80.1
Milk yield:DMI, lb/lb	1.67^{a}	1.75^{b}	1.80^{b}
3.5% FCM:DMI, lb/lb	1.42	1.51	1.50
Milk N:Intake N g/g	0.35	0.33	0.38

†Calculated by 2001 Dairy NRC energy equations

Ration Costs – Actual intake and milk yield

- Diet costs include forage costs (corn silage @ $30/ton)

	Diet N	Diet P	Diet T
Cost, $/d	4.21	4.32	4.60
Cost, $/cwt milk	4.57	4.30	4.84

Milk and Plasma Urea N and Ruminal pH

	Diet N	Diet P	Diet T
MUN, mg/dl	8.75[b]	10.98[a]	8.50[c]
PUN, mg/dl	8.25[b]	11.22[a]	6.87[c]
Ruminal pH	6.00	5.95	5.94

pH from 12 fistulated cows (4/trt) monitored over the study period

Study Period BW, BW Gain and BCS Changes

	Diet N	Diet P	Diet T
n	29	29	30
Initial BW (lb)	1,382	1,444	1,455
Final BW (lb)	1,457	1,525	1,512
Change in BW (lb/week)	5.4	5.8	4.2
Initial BCS	2.77	2.75	2.76
Final BCS	2.82	2.86	2.85

Reproduction Information

	Diet N	Diet P	Diet T
Days in milk @ confirmed pregnant	156	148	148
Times bred	2.96	2.84	2.96

Urinary N excretion

- The average high producing cow excretes 200 to 250 g/d urinary N (Davidson et al., 2003; Wattiaux and Karg, 2004; Brito and Broderick, 2006)
- Cows on this study demonstrated a 27 to 67% lower predicted urinary N excretion
- These excretion predictions were checked against other equations published by Nennich et al., 2006 (±15% of CPM predictions)

Model predictions based on milk yield and components after Rumensin removed from diet

		Diet N	Diet P	Diet T
Actual milk, lb/d		93.0	100.7	95.0
CPM	ME milk, lb/d	96.8	98.5	92.3
	MP milk, lb/d	77.7	98.1	89.3
NRC	NEl milk, lb/d	97.0	98.5	93.9
	MP milk, lb/d	77.6	96.5	69.4
	NEl balance, Mcal/d	1.4	-0.8	-0.4
	MP balance, g/d	-290	-89	-499

Nitrogen Utilization and Efficiency Study – Recktenwald et al., 2007

	Diet P	Diet N	Diet T
CP, % DM	16.2	14.1	14.0
Soluble protein, % CP	29.9	35.6	30.4
PUN, mg/dl	11.31[a]	8.40[b]	7.13[c]
Ruminal NH_3, mg/dl	6.58[a]	8.32[a]	5.84[a]
Milk yield, kg/d	45.0	42.6	43.3

Nitrogen Utilization and Efficiency Study – Recktenwald et al.

Actual Milk Yields and Predictions	**Diet P**	**Diet N**	**Diet T**
Actual milk yield, kg/d	45.00	42.62	43.29
CPM Model Prediction			
Actual BW changes included			
ME allowable milk, kg/d	48.9	49.2	47
ME balance, Mcal/d	3.7	6.2	3.4
MP allowable milk, kg/d	43.3	34.6	40.0
MP balance, g/d	-71	-362	-146
Peptide and NH_3 balance, g/d	56	48	-22
Peptide and NH_3 balance, % requirement	113	111	95
Peptide balance, g/d	17	-3	-51
Peptide balance, % requirement	107	99	77

CNCPS v6.1 predicted vs observed after updates

Observed versus Predicted ME and MP Allowable Milk, And Statistics (Six studies, 22 treatments)

prediction	CNCPS status	Obs. mean, kg	Predicted mean, kg	slope	y intercept	r^2
MP	Initial	39.62	37.04	0.73	12.63	0.75
MP	Post	39.62	43.75	0.71	8.55	0.64
ME	Initial	39.62	44.97	0.66	9.91	0.70
ME	Post	39.62	44.69	0.67	9.63	0.69

Observed versus Predicted ME and MP Allowable Milk and Statistics

prediction	CNCPS status	Obs., kg	Predicted mean, kg	slope	y intercept	r^2
Most limiting	Initial	39.62	36.91	0.74	12.48	0.76
Most limiting	Post	39.62	42.09	0.76	7.63	0.70
Most limiting, no negative rumen N balance	Initial	38.65	35.37	0.76	11.79	0.76
Most limiting, no negative rumen N balance	Post	38.65	41.58	0.77	6.80	0.71

Data of Recktenwald, 2007

Diet	P		N		T	
	Prior	After	Prior	After	Prior	After
Actual milk, kg	45.0		42.6		43.1	
MP allowable, kg	43.3	46.7	34.6	40.0	40.0	42.2
Rumen NH3 balance, % reqd	145	110	137	119	114	82

Field Application of the CNCPS V6.1 Updates

- Currently being applied in several herds
- Each herd/group balanced for ME and MP allowable milk and producing at approximately 89 to 92 lb/d
- Diets are 14.4 and 15.5% CP and positive for Rumen NH3 balance respectively.

Example Herd Ingredients – 54 lb DMI, 92 lb Milk

Ingredient	DM amount, lb
Corn silage	17
Grass haylage	12
Dry hay	3
Ground corn	13.3
Soybean Meal	4.0
Roasted soybean	1.6
Cane molasses	0.46
Sugar	0.70
Provaal	0.44
Urea	0.097
Meta smart	0.012
Min. & Vitamins	1.59
Total	54.2

Example Herd – 54 lb DMI, 90 lb Milk

% DM basis	CNCPS v6.1 output
CP	14.4
RDP	8.6
Sol CP	4.9 (34)
Rumen NH3, % req	134
Rumen peptides, % req	143
NDF	31.6
Lys:Met	3.29
ME allowable, lb	99
MP allowable, lb	90

CNCPS v6.1

- Effects of updates

- With increased passage rate of soluble pools, the RDP drops
- With decreased kd of Protein B1 pool the RDP decreases
- With decreased CHO A4 kd's (sugar pool rates) rumen NH3 demand decreases
- With increased rate of passage of soluble pools, CHO A4 (sugar) a very small percentage of the sugar can pass out of the rumen

Example herd B - 53 lb DMI, 89 lb milk

Ingredient	DM amount, lb
Corn silage	19.5
Alfalfa hay	9.8
Wheat straw	1.0
Flaked corn	6.2
Ground corn	6.2
Soybean Meal	1.9
Amino Plus	2.9
Wheat midds	2.0
Citrus pulp	2.0
Sugar	0.50
Provaal	0.23
Energy Booster	0.35
Urea	0.13
Smartamine and Alimet	0.03
Min. & Vitamins	1.3

Example herd B - 53 lb DMI, 89 lb milk

% DM basis	CNCPS v6.1 output
CP	15.0
RDP	8.1
Sol CP	4.9 (30)
Rumen NH3, % req	104
Rumen peptides, % req	110
NDF	31.5
Lys:Met	2.8
ME allowable, lb	94
MP allowable, lb	98

Conclusions:

With changes – model is much more sensitive to protein supply

We have the opportunity to lower protein intakes to reduce the environmental impact of dairy farms

Any effort to do this will require greater intensity of management and adherence to SOP's

We still have work to do to adequately capture the biology of the cow for ration formulation development – but are making progress