What MUN Tells Us About Protein Nutrition of the Dairy Cow

World Dairy Expo
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Crude Protein (N) Utilization is the Net Result of:

1. How Much Protein the Cow Eats, &
2. How Much Protein the Cow Secretes in Milk.
3. The Rest of the N is Excreted in Manure.

How Can We Use Milk Urea Nitrogen (MUN) to Make Better Use of Protein?

MUN & Protein Utilization

1. N-Metabolism in the Cow.
2. MUN Reflects Blood Urea N & Wastage of Protein.
3. Relationships of MUN to Protein Utilization.
4. Factors Affecting MUN Values.
5. Testing & Using the MUN Predictions.
6. Optimum MUN (?); Bulk Tank MUN.
7. MUN Thumb Rules.
8. The Future of MUN.

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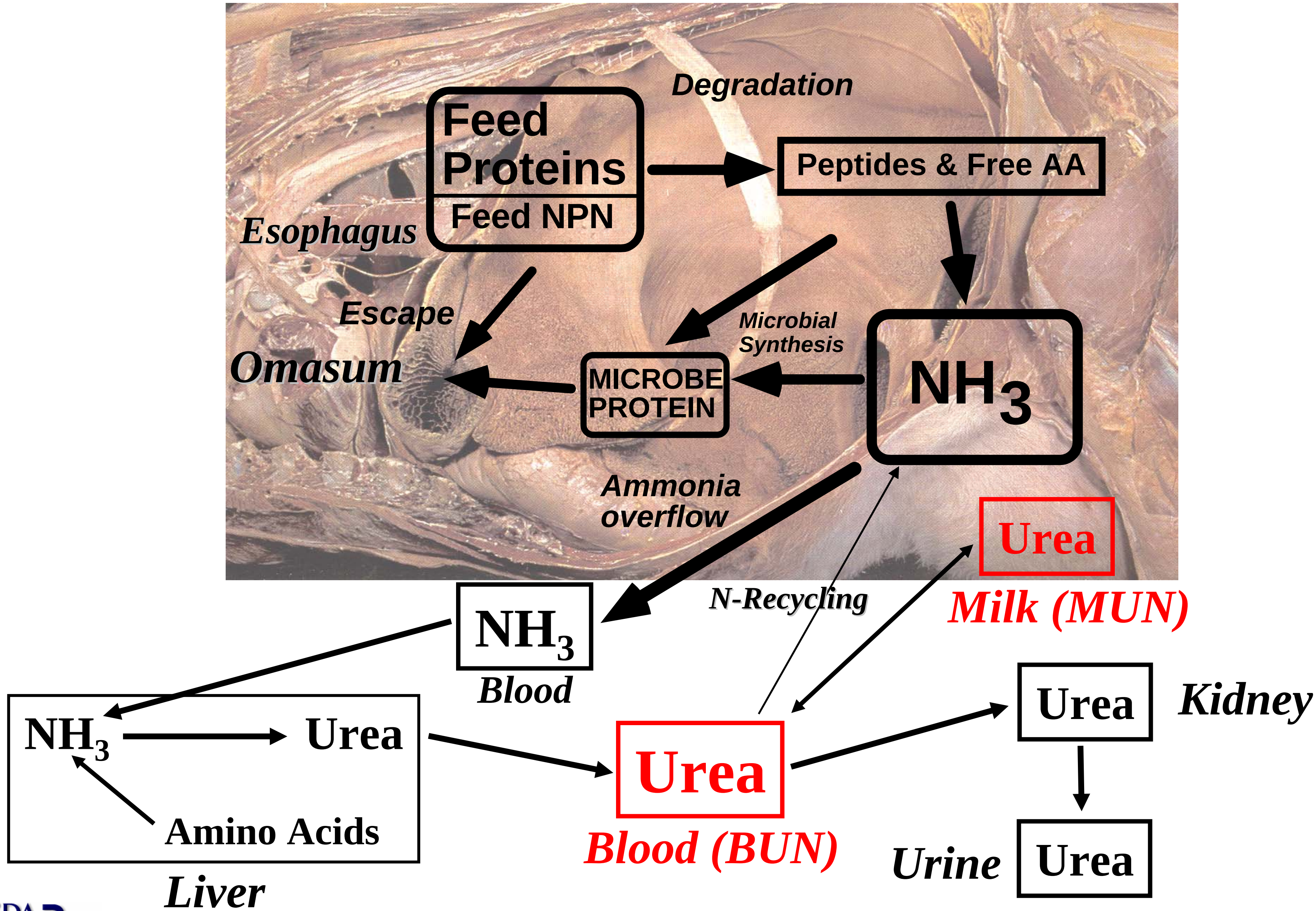
Urea Metabolism in the Cow



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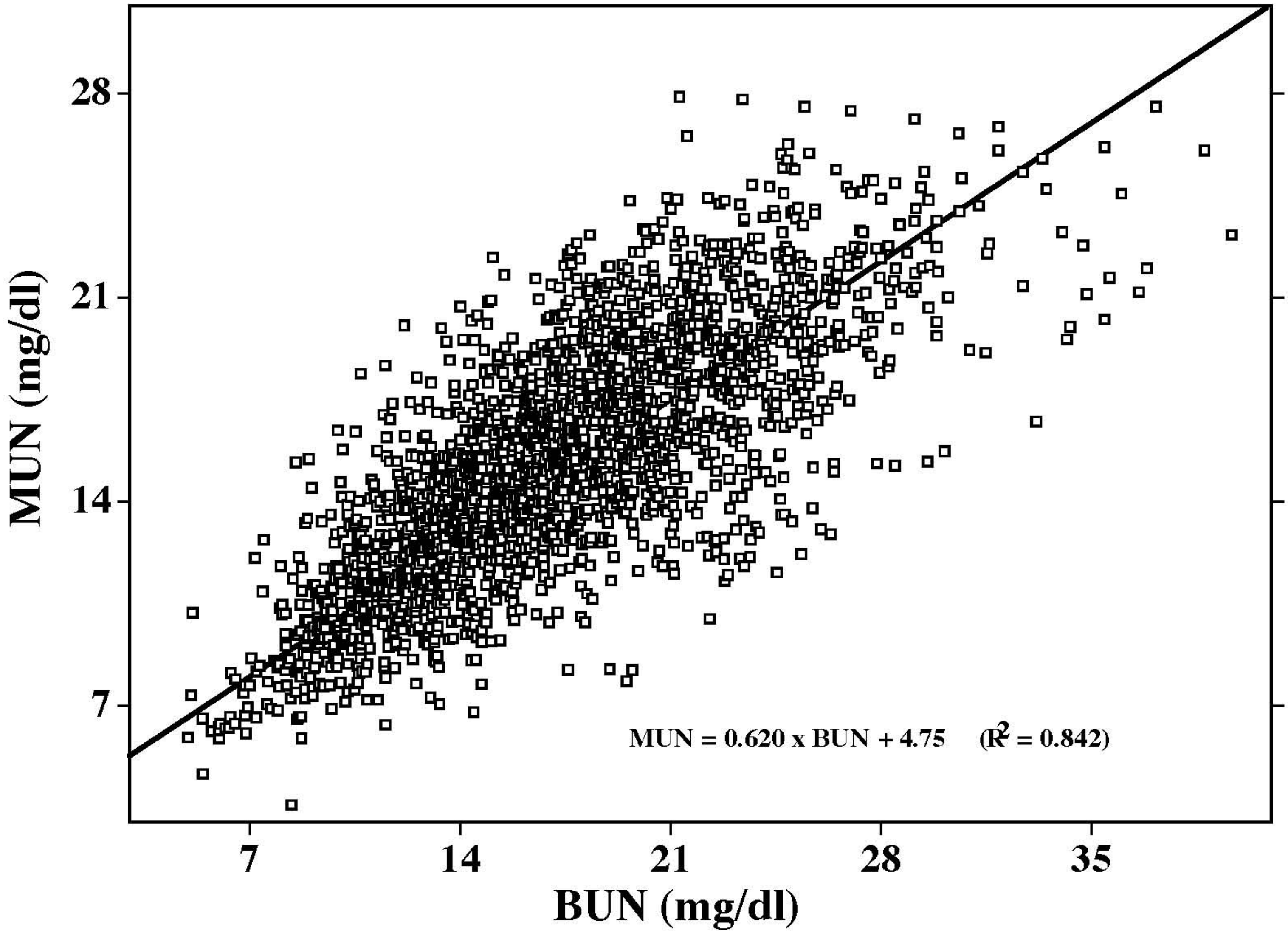
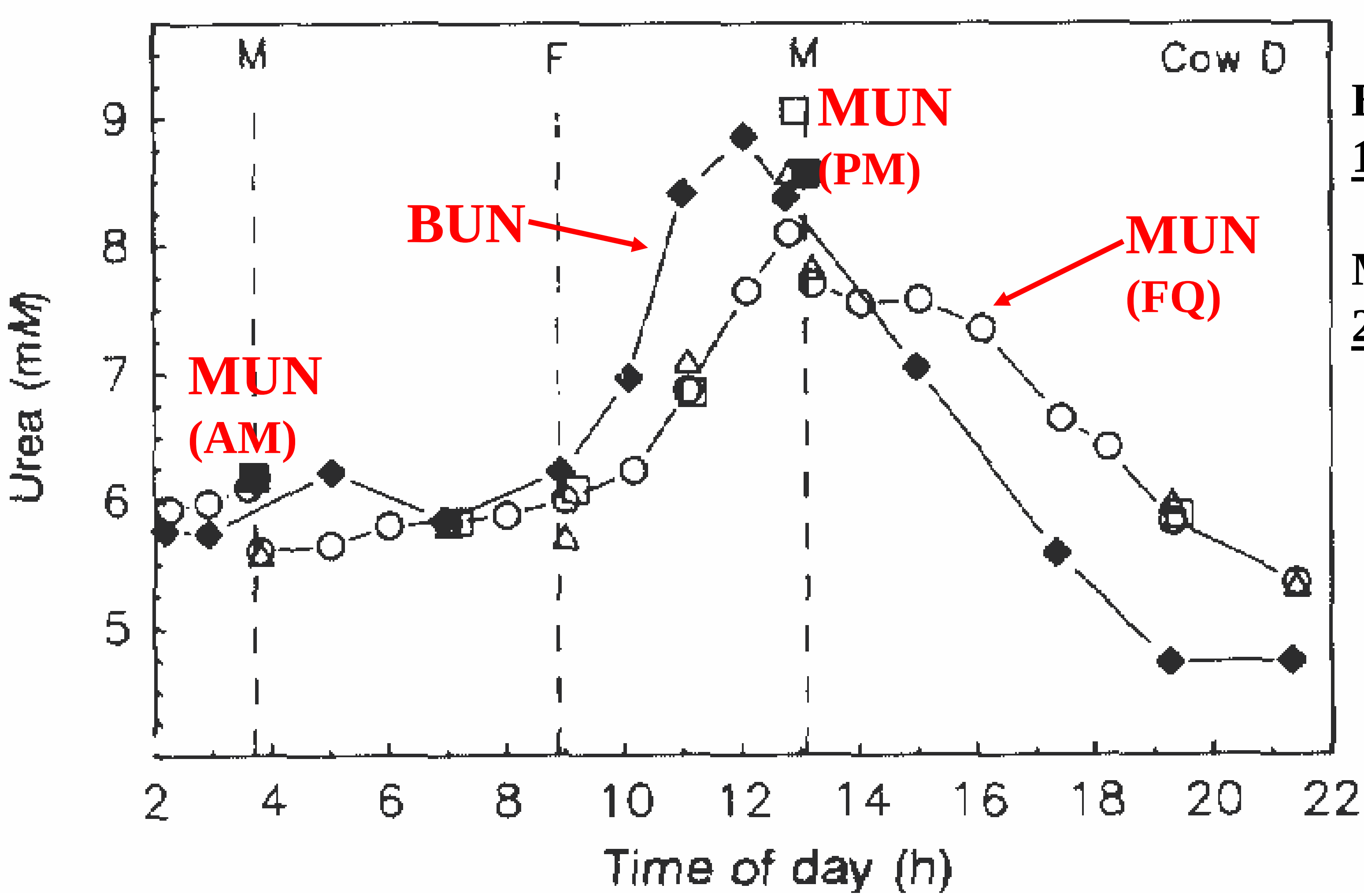
Relationship of Blood & Milk Urea



MUN Mirrors BUN

(Gustafsson & Palmquist, 1993)



BUN (Weighted avg.) =
<u>17.0 mg/dl</u>

MUN (AM/PM avg.) =
<u>20.7 mg/dl</u>

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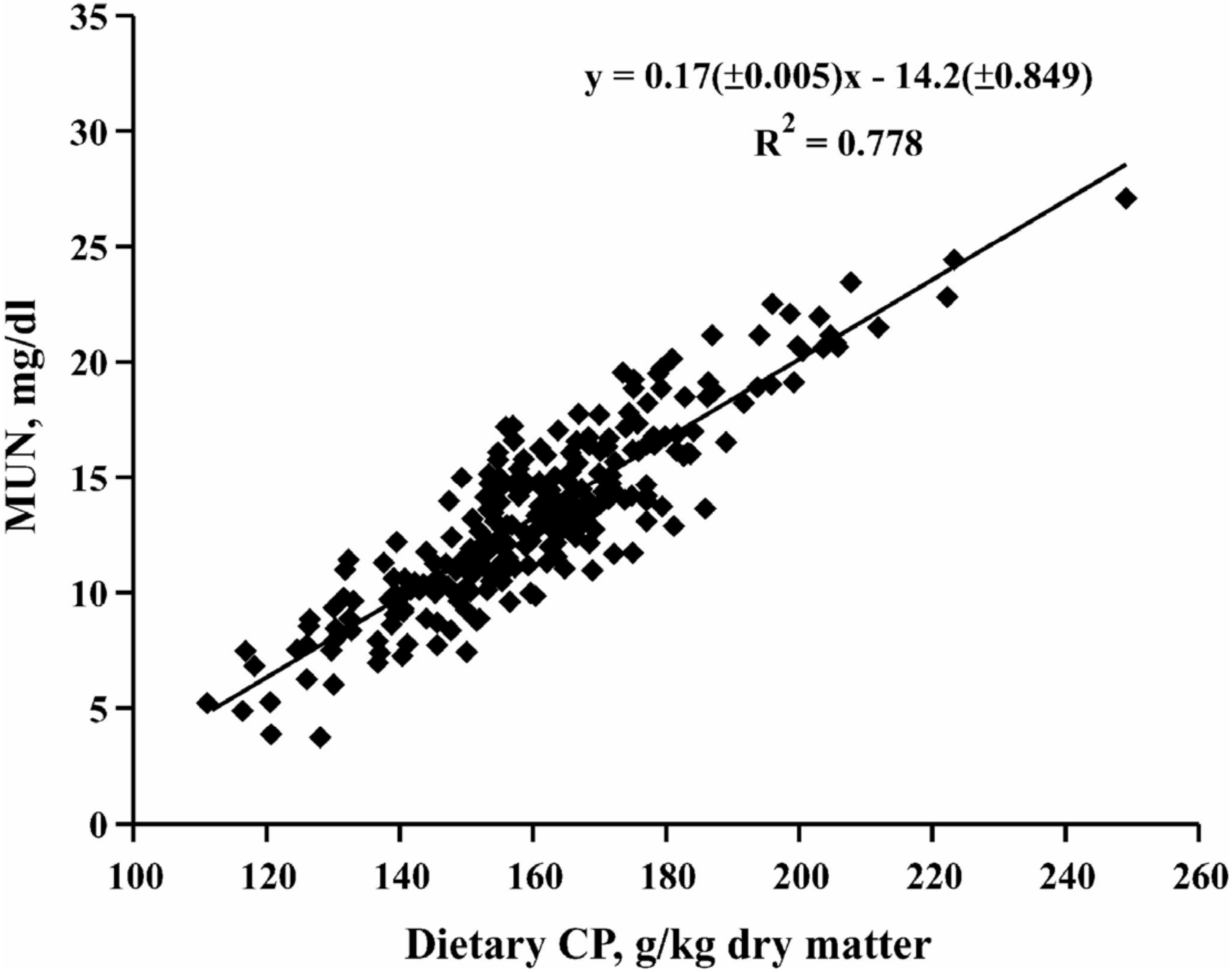
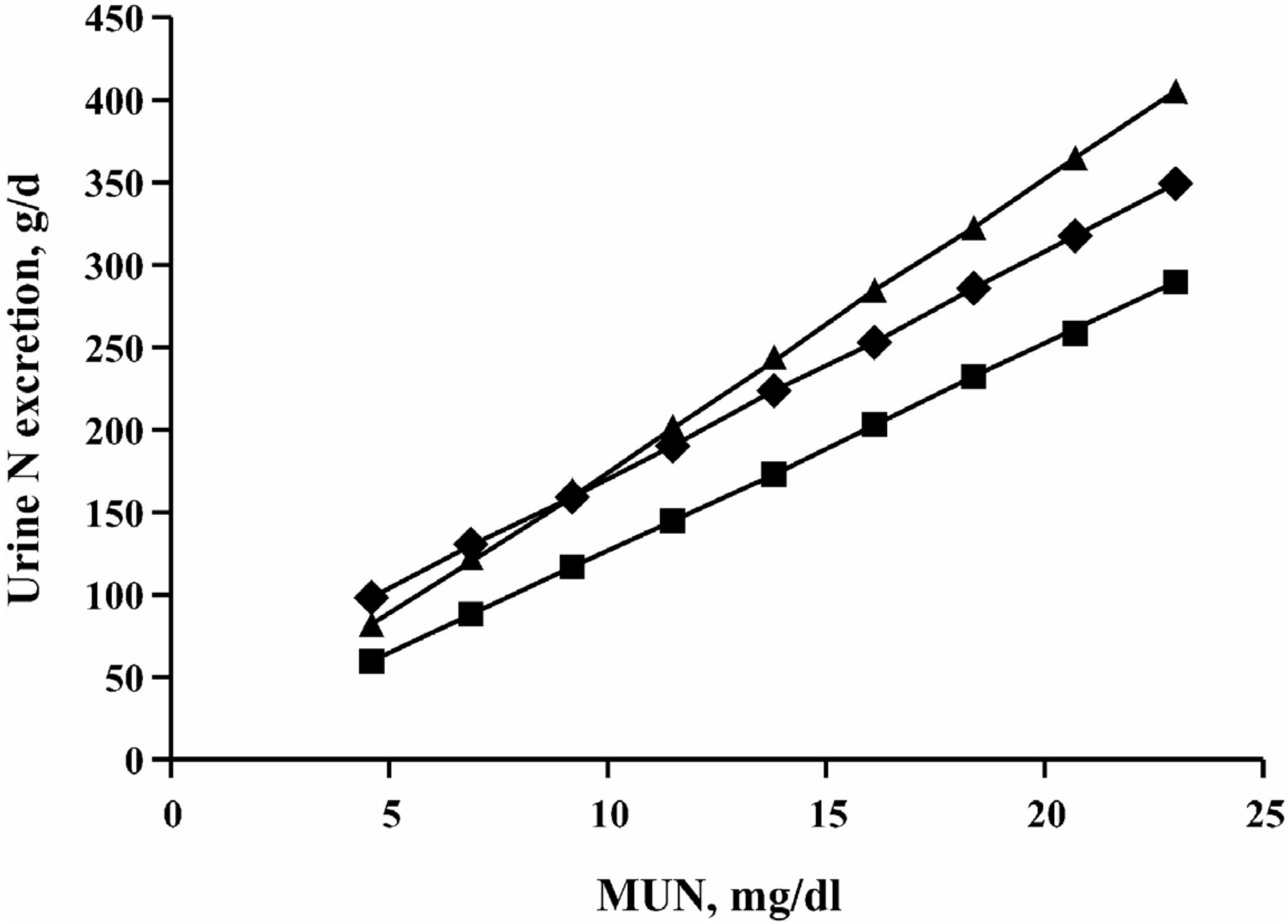
Relationship of MUN to Dietary CP

(Nousiainen et al.. 2004)



Relationship of Urinary N to MUN
(Nousiainen et al., 2004)



MUN as Diagnostic Tool for N-Utilization

(Mixed Models)

Factor	Equation	R^2	Ref.
CP, % of DM	= 0.27 x MUN + 13.7	0.84	Broderick & Clayton, 1997
	= 0.45 x MUN + 10.0	0.78	Nousiainen et al., 2004
Urinary N, g/d	= 14.1 x MUN + 26	0.92	Nousiainen et al., 2004
	= 0.01284 x MUN x BW	. . .	Wattiaux & Karg, 2004
Urine, liters/d	= 0.563 x MUN + 17.1	. . .	Nennich et al., 2006
N-Efficiency, %	= – 0.73 x MUN + 38	0.93	Nousiainen et al., 2004
MUN, mg/dl	= 0.22 x PBV (g/d) + 11.8	0.94	Nousiainen et al., 2004
	= 11.8 (Rumen Prot. Balance = 0)		

(MUN = mg/dl; BW = lbs, H = 1400 lbs, J = 1000 lbs)

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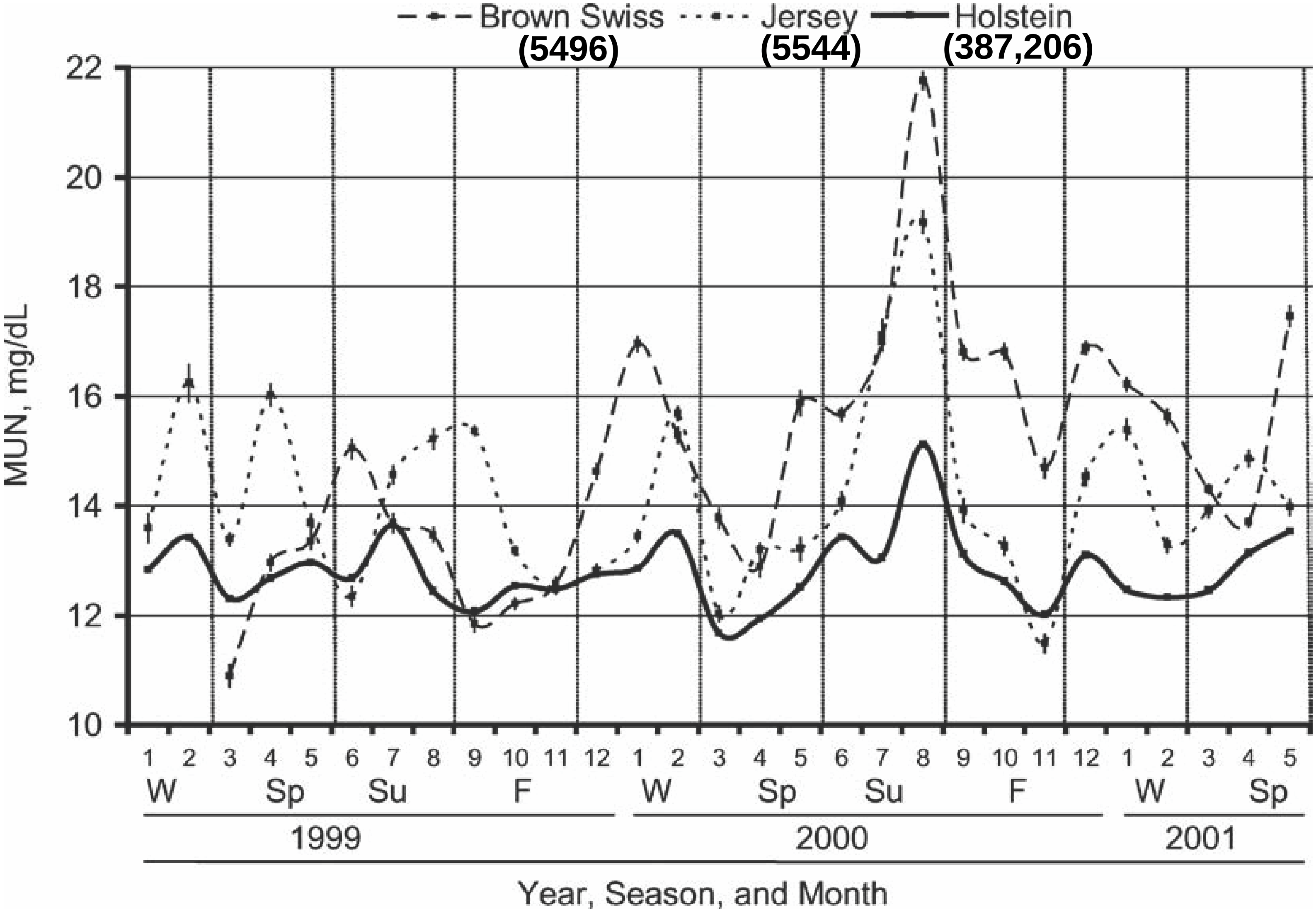
Factors Related to MUN

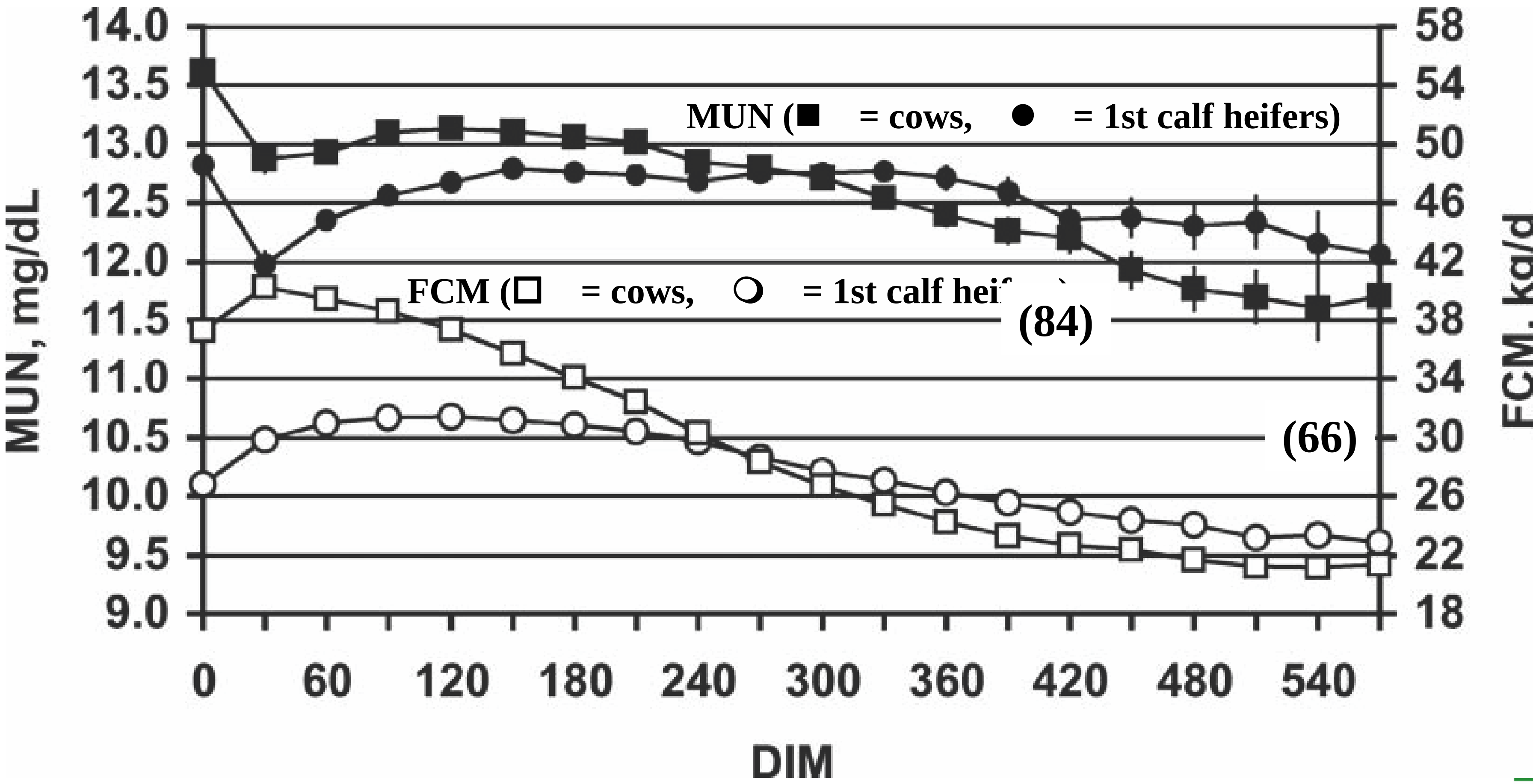
(Broderick & Clayton, 1997)

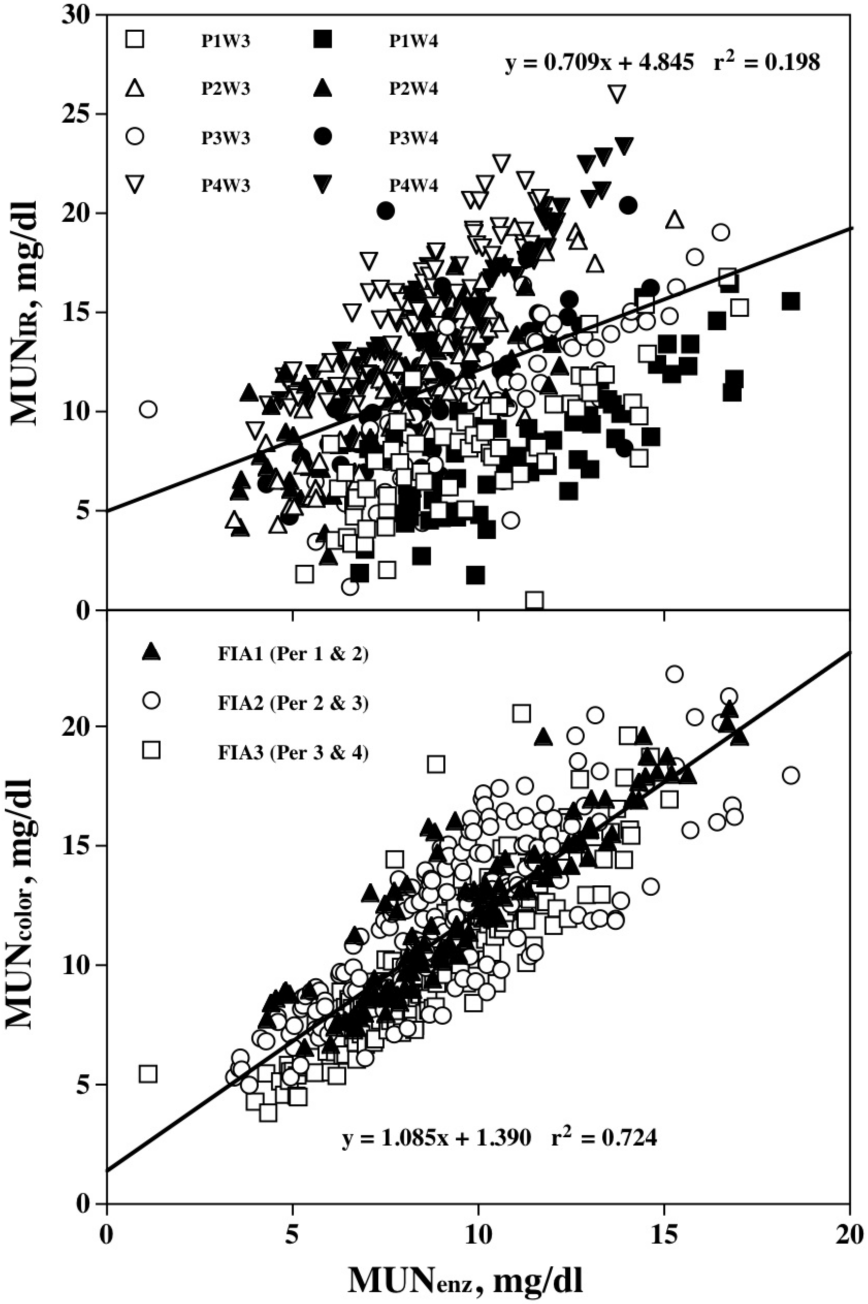
1. Dietary CP (Content; CP/Energy; Intake)
2. N-Efficiency (Nousiainen et al., 2004)
3. **Dry Matter & Energy Intake**
4. **Parity**
5. **Body Weight**
6. **Milk & Fat Yield**
7. **Days-In-Milk**
8. **MUN is Heritable (Mitchell et al., 2005)**

Seasonal Variation in MUN
(Wattiaux et al., 2005)



Variation in MUN Over the Lactation
(Wattiaux et al., 2005)





MUN Varies by Analysis

(GAB53)

R-squares Relating MUN by "Color" & IR to Dietary CP (%) & CP-Intake (lbs/day)

MUN Assay	CP	CP-Intake
IR	79%	84%
Color	79%	85%

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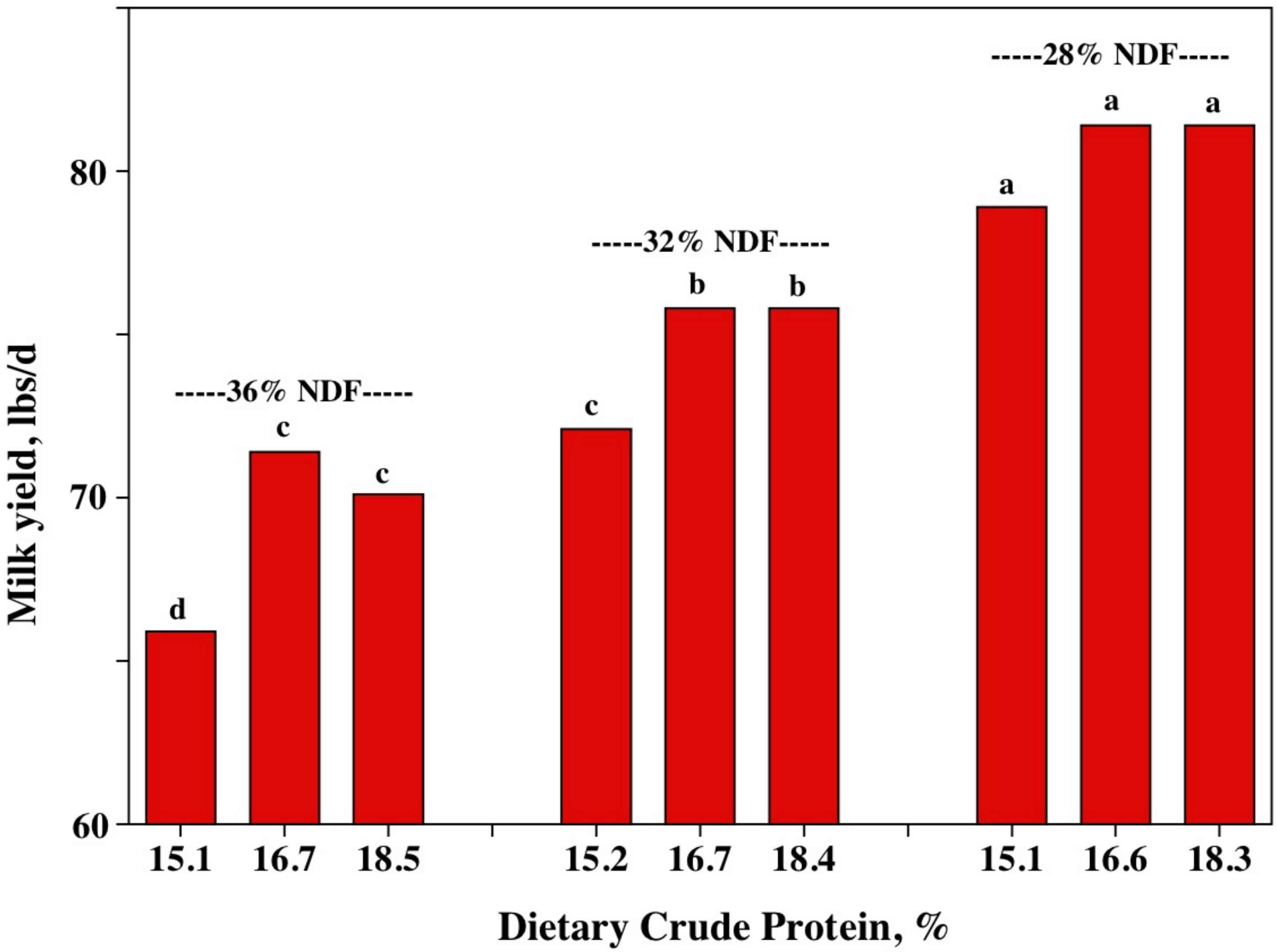
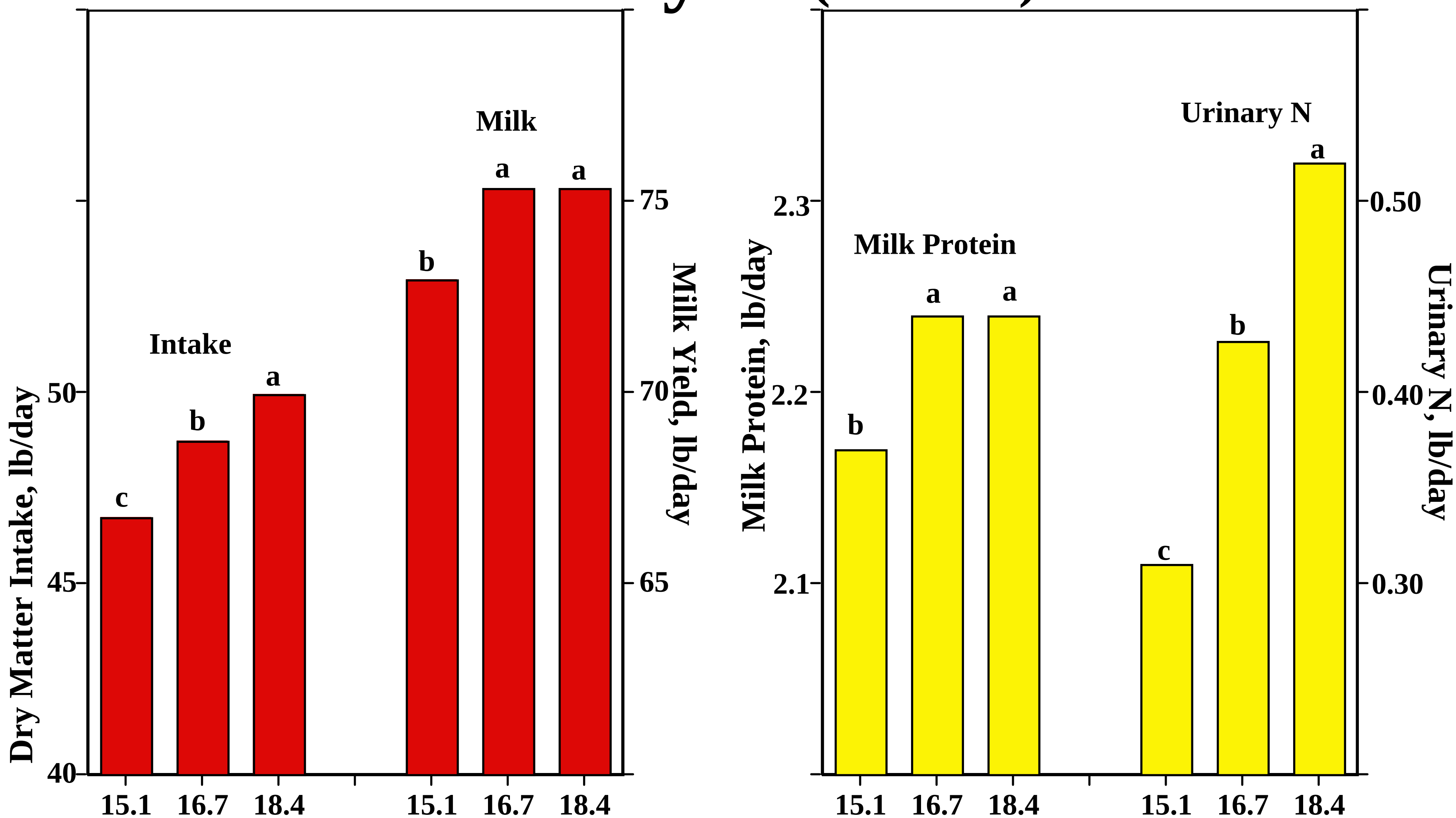
Effect of Dietary CP or Energy on Milk Yield

(GAB53)



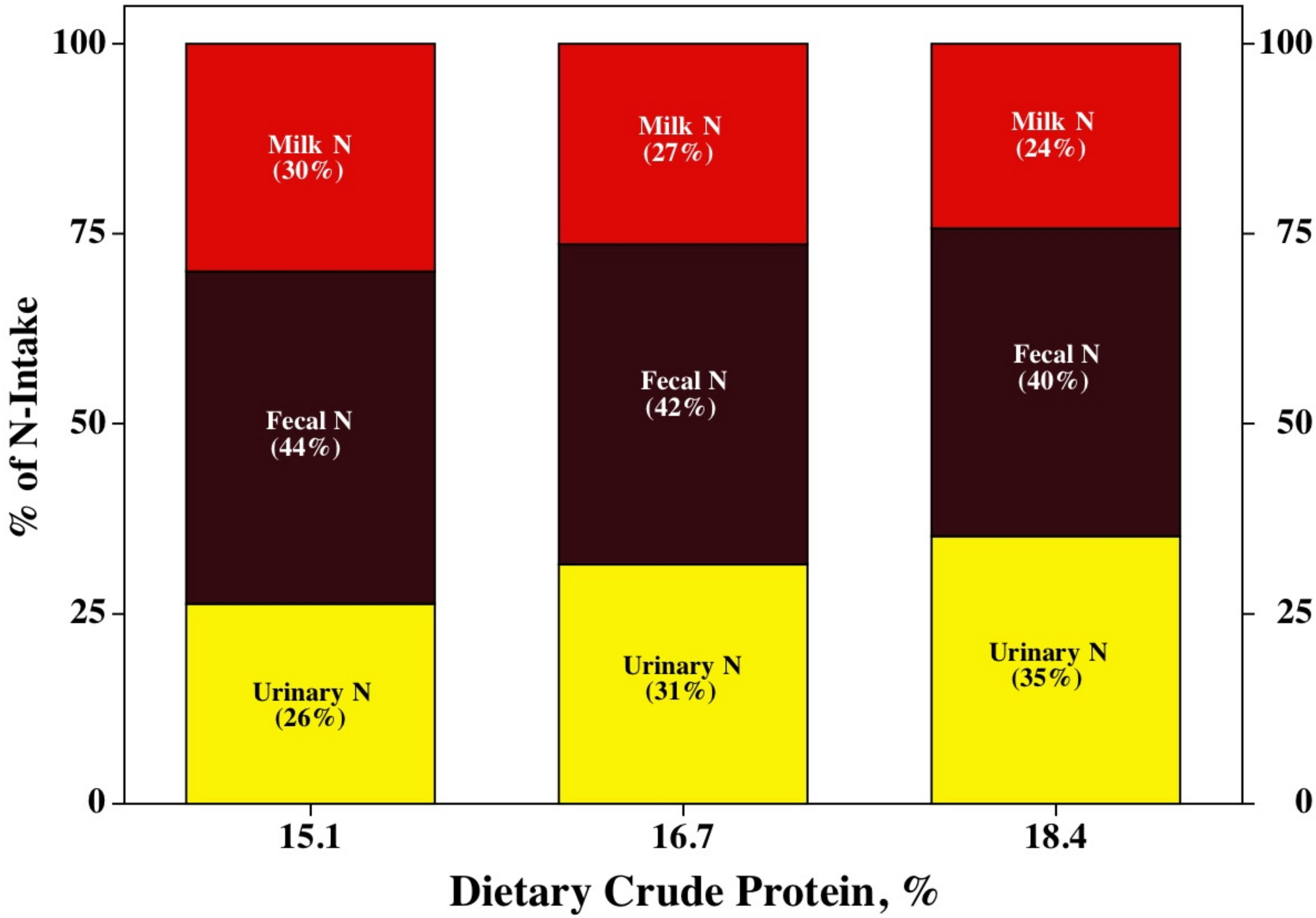
Effect of Dietary CP on Intake, Yield & Urinary N (GAB53)



Dietary Crude Protein, % of DM

N-Utilization Falls when CP Increases

(GAB53)



Dietary CP & Production, N-Excretion

(GAB53)

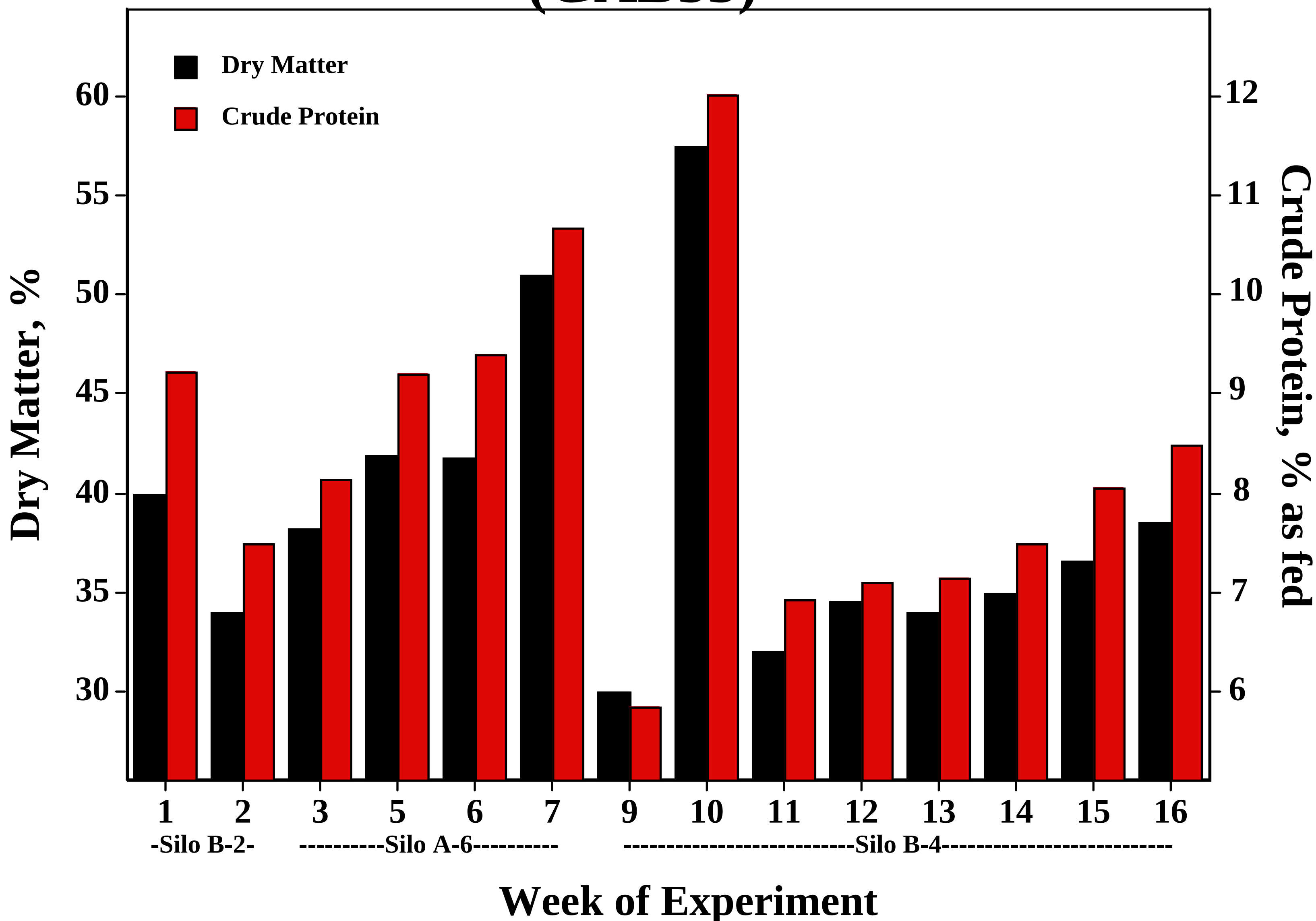
Variable	15.1% CP	16.7% CP	18.4% CP	*Prob.*
Milk, lbs/d	73.2[b]	75.2[a]	75.4[a]	< 0.01
Protein, lbs/d	2.18[b]	2.25[a]	2.25[a]	0.04
Milk-N/NI, %	30[a]	27[b]	24[c]	< 0.01
Fecal-N, g/d	236[c]	264[b]	273[a]	0.01
Urine-N, g/d	141[c]	192[b]	236[a]	< 0.01
MUN, mg/dl	9.2[c]	12.4[b]	15.9[a]	< 0.01

Changes in CP Over a 17-Week Trial
(GAB53)

QuickTime™ and a
decompressor
are needed to see this picture.

Variation of DM & CP in Alfalfa Silage

(GAB53)



Effect of Forage Source & CP on Production (Wattiaux & Karg, 2004)

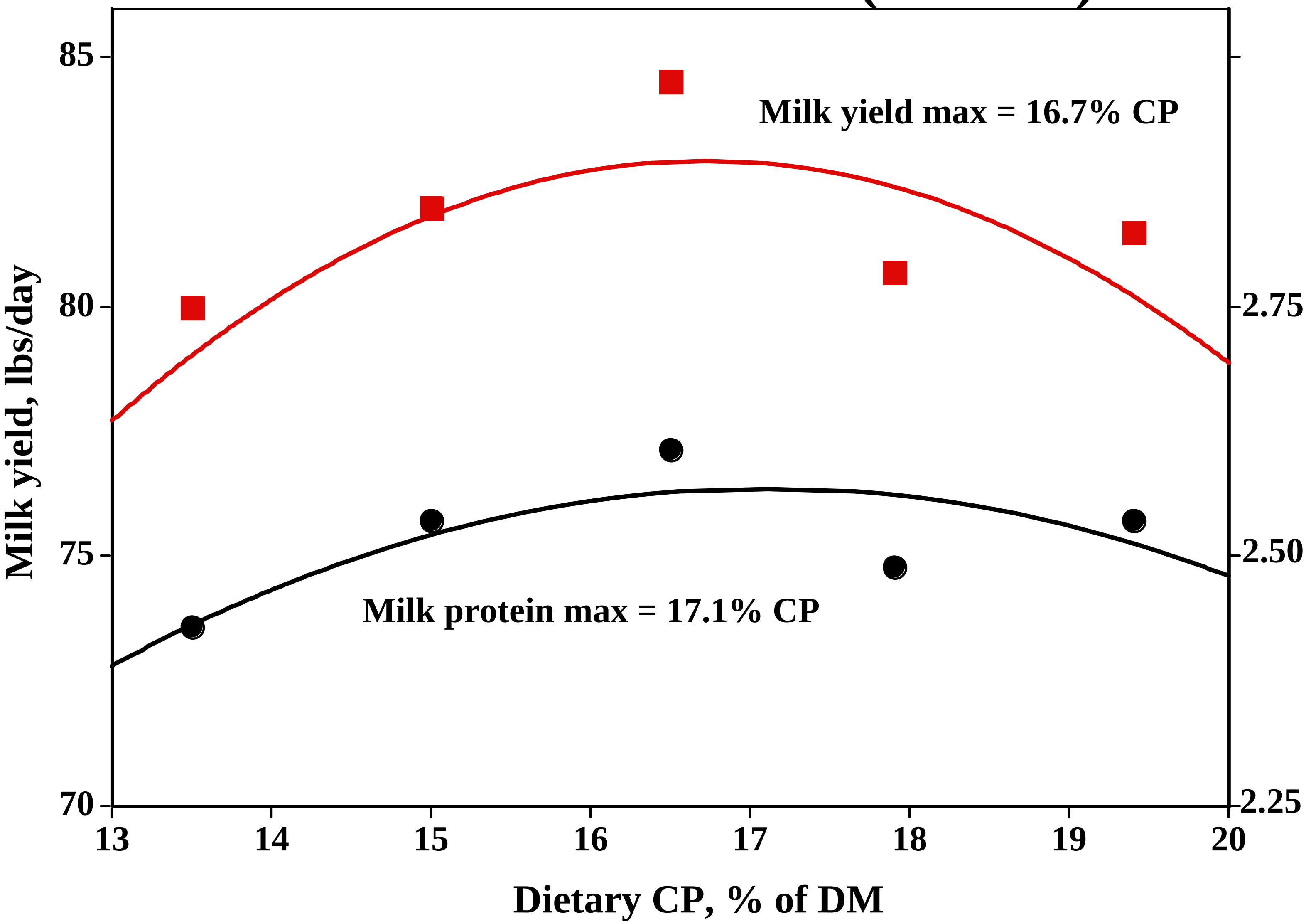
	Forage/CP (%)				Prob.[1]	
	Alfalfa silage		Corn silage			
Item	16.5	18.0	16.2	17.1	*For.*	*Prot.*
DMI, lb/d	54	56	53	54	0.41	0.30
Milk, lb/d	102	103	109	107	0.03	0.97
3.5% FCM, lb/d	102	102	101	101	0.84	0.95
Fat, lb/d	3.8	3.5	3.4	3.3	0.08	0.35
True protein, lb/d	2.8	2.8	2.9	2.9	0.20	0.88
MUN, mg/dl	11.7	12.2	11.5	12.8	0.35	< 0.01

[1]No Forage*Protein interactions were observed (P > 0.60).
Alfalfa Silage Diets = 41% AS + 14% CS; Corn Silage Diets = 41% CS + 14% AS

Diet Composition (GAB59)

Ingredient	Dietary CP 13.5	15.0	16.5	17.9	19.4
			(% of DM)		
Alfalfa Silage	25	25	25	25	25
Corn Silage	25	25	25	25	25
Rolled HMSC	44	41	37	34	30
48% SBM	2.4	5.8	9.2	12.6	16.0
Roasted Soybeans	2.5	2.5	2.5	2.5	2.5
Bicarb	0.6	0.6	0.6	0.6	0.6
Dical/Salt/TM/Vit	0.5	0.5	0.5	0.5	0.5
Analysis					
Crude protein	13.5	15.0	16.5	17.9	19.4
NDF	25	25	25	25	25

Effect of CP (Solvent SBM) on Milk & Protein Yield (GAB59)



Effect of CP on Production (GAB59)

	Diet					
Trait	13.5	15.0	16.5	17.9	19.4	*prob.*
Milk, lbs/d	80	82	84	81	82	0.10
Protein, lbs/d	2.4	2.5	2.6	2.5	2.5	0.09
MUN_{IR}, mg/dL	7.7[d]	8.5[d]	11.2[c]	13.0[b]	15.6[a]	< 0.01
MUN_{color}, mg/dL	7.5[e]	9.8[d]	13.6[c]	16.7[b]	19.6[a]	< 0.01
<u>Urinary excretion</u>						
Urine volume, L/d	17.3[bc]	15.4[c]	17.9[b]	19.4[ab]	21.7[a]	< 0.01
Urine-N, g/d	113[e]	140[d]	180[c]	213[b]	257[a]	< 0.01
Calc. volume[1], L/d	21.4	21.9	23.4	24.4	25.9	
Calc. Urine-N[2], g/d	129	142	187	217	260	

[a-e](P < 0.05)

[1]Equation of Nennich et al. (2006) & MUN_{IR}.

[2]Equation of Wattiaux & Karg (2004) & MUN_{IR}.

CHO Source--Diet Composition
(Charbonneau et al., 2006)

	Diet			
Ingredient	**Control**	**GC**	**GC+S**	**GC+W**
	(% of DM)			
Alfalfa Silage	45	45	45	45
Cracked corn	47	—	—	—
Ground Corn	—	47	35	35
Wheat Starch	—	—	11	—
Dried Whey	—	—	—	11
Treated SBM	7.4	7.4	8.4	8.4
Vit-Min.	1.0	1.0	1.0	1.0
Analysis				
Crude protein	18.7	17.9	17.4	18.0
RDP	13.7	12.8	12.7	13.0
NDF	28	27	25	25

CHO Source--Production

(Charbonneau et al., 2006)

Ingredient	Diet: Control	GC	GC+S	GC+W	*Prob.*
DMI	50[a]	54[b]	54[b]	57[a]	< 0.01
Milk	75.0[c]	82.5[ab]	82.9[a]	78.9[b]	< 0.01
Protein	2.4[c]	2.7[a]	2.7[a]	2.6[b]	< 0.01
Fat	2.8	2.9	2.8	3.0	0.45
MUN, mg/dl	13.4[a]	10.7[b]	9.9[b]	9.8[b]	< 0.01
Milk-N/N-I, %	24.8[b]	27.9[a]	28.4[a]	24.9[b]	< 0.01
Calc. Milk-N/N-I, %	28	30	31	31	

(Nousiainen et al., 2004)

Supplementing Rumen Protected-Met While Decreasing CP (GAB67)

Item	CP, %	18.6	17.3	16.1	14.8	P > F
	RP-Met, g/d	0	8	17	25	
Milk, lbs/d		88^{b}	92^{a}	92^{a}	88^{b}	0.05
Milk/DMI		1.72^{ab}	1.80^{a}	1.77^{ab}	1.69^{b}	0.06
Protein, lbs/d		2.54	2.71	2.71	2.65	0.19
Milk-N/NI, %		26^{c}	30^{b}	32^{b}	34^{a}	< 0.01
MUN, mg/dl		14.5^{a}	11.8^{b}	9.4^{c}	7.9^{d}	< 0.01
Calc. Urine-N, g/d (Wattiaux & Karg, 2004)		245	200	159	137	
Urine-N, lbs/300 d			30	57	74	

$^{a-d}(P < 0.05)$

CP Supplements & Production

(Brito & Broderick, 2007)

Item	Protein Supplement: Urea	SSBM	CSM	CM	*P* > F
	--------------------(lbs/d)			--------------------	
DM intake	49[c]	53[b]	55[ab]	55[a]	< 0.01
Milk yield	73[b]	88[a]	89[a]	91[a]	< 0.01
Protein yield	2.0[c]	2.7[ab]	2.6[b]	2.8[a]	< 0.01
Fat yield	2.2[c]	2.7[ab]	2.6[b]	2.8[a]	< 0.01
MUN, mg/dl	16.9[a]	12.0[b]	10.0[c]	11.6[b]	< 0.01
Calc. Urine-N, g/d	286	203	169	196	

SSBM = Solvent Soybean Meal; CSM = Cottonseed Meal; CM = Canola Meal

Diets Formulated from AS, CS & HMSC & had 16.5% CP

[a-c](P < 0.05)

Supplementing RUP or CP on Intake & Yield

(Olmos & Broderick, 2006)

Item	15.6%$_{RUP}$	16.6%	16.6%$_{RUP}$	17.6%	Stats
Solvent SBM, % DM	3.6	9.6	4.6	11.7	
Expeller SBM, % DM	4.5	0.0	5.9	0.0	
DMI, lb/d	56	56	56	58	B vs. D
Milk, lb/d	85	88	89	88	A vs. B
Protein, lb/d	2.7	2.8	2.8	2.8	A vs. B(.11)
MUN_{IR}, mg/dl	11.0	11.5	12.1	13.5	B vs. D
Milk N/NI, %	30	29	29	27	B vs. D

(Diets Contained 20% Alfalfa Silage, 35% Corn Silage & 29-33% High Moisture Corn)

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What is the "Optimum"MUN?

Source	Optimum (mg/dl)	Criteria
AgSource	10-14	Safety margin
GAB53	12.4	Yield & N-eff.
Wattiaux & Karg (2004)	11.6	Yield
GAB59	11.2	Yield & Urine N
Charbonneau et al. (2006)	10.3	Yield & N-eff.
Mepron study (GAB67)	10.6	Yield & N-eff.
Olmos (2006)	11.8	Yield & N-eff.
Brito (2007)	11.8	Yield & Urine N
Kohn (2002)	10-12 (12-14=Jerseys)	Field Study
Nousiainen et al. (2004)	11.8	Rumen N-Equil.
Overall	**11.3**	**Average**

What About Bulk Tank MUN?

(USDFRC, March 1 - 25, 2006)

Source	Mean	CV	Range low	Range high
Fat, %	3.77	2.1%	3.53	3.90
Protein, %	2.93	2.3%	2.85	3.20
SCC, thousand	370	8.7%	309	453
MUN, mg/dl	10.5	11.2%	8.8	12.7
	(MUN rose 9.5 to 12.7 in 1-day)			

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MUN Thumb Rules for the Farm

(AgSource)

1. Establish Your MUN Baseline.
2. Get Your MUN's Under Standard Conditions (Same Milking; Group Means; etc.).
3. Exclude Cows with Mastitis & < 30 DIM.
4. Number of Cows to Test for MUN:
   a. > 50% of Each Group or Herd (AgSource)
   b. 4 Cows, ± 2 Units; 16 Cows, ± 1 Unit (B & C, 1997)
5. Follow MUN Trends in Archived Data.

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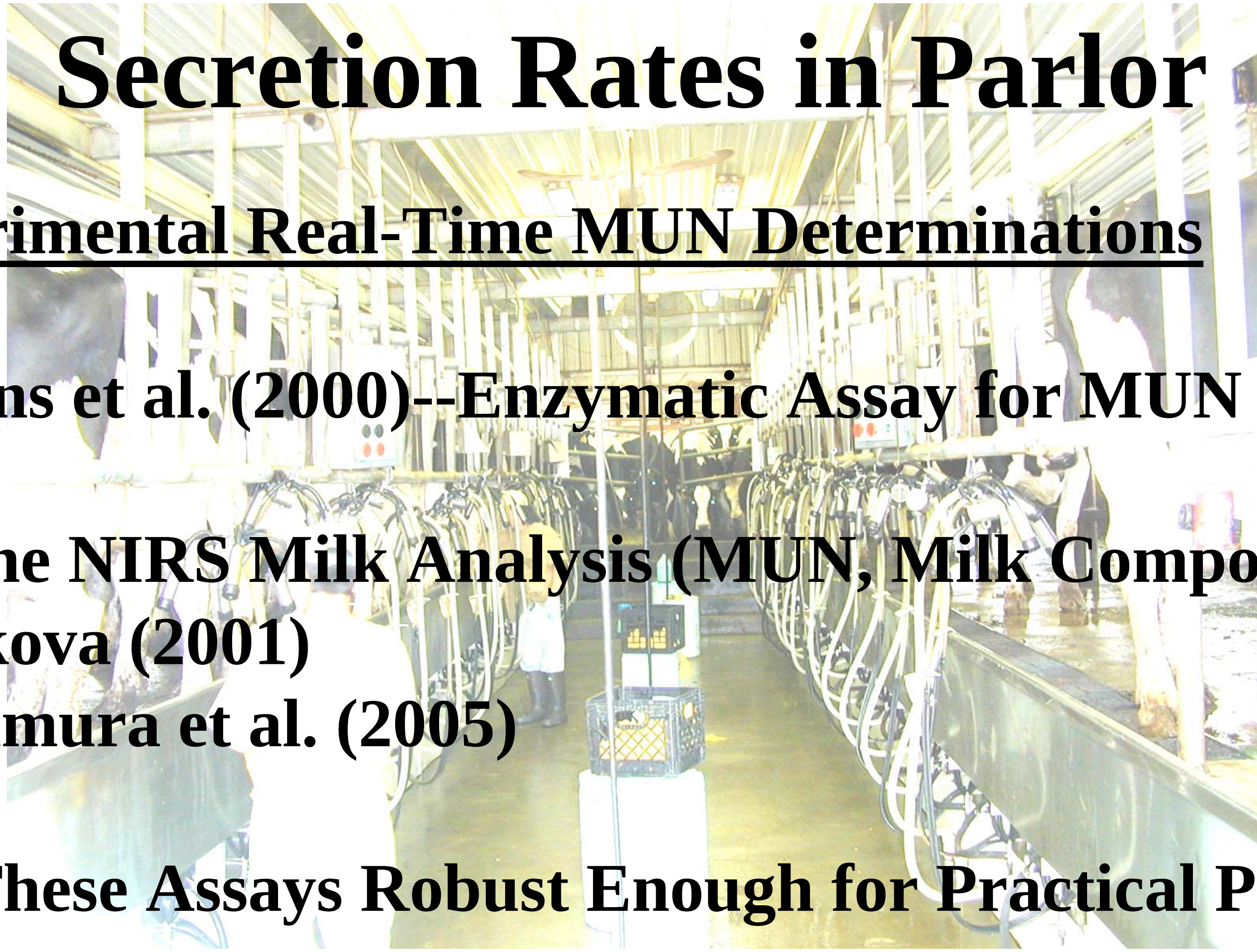
Current Limitations of MUN

1. Timeliness--Data Can Come Too Late to be Useful (DHIC = 3-5 d).
2. Accuracy & Standardization.
3. Integration with Other Information.

Measurement of MUN Concentrations & Secretion Rates in Parlor



<u>**Experimental Real-Time MUN Determinations**</u>

Jenkins et al. (2000)--Enzymatic Assay for MUN

In-Line NIRS Milk Analysis (MUN, Milk Composition):
Tsenkova (2001)
Kawamura et al. (2005)

Are These Assays Robust Enough for Practical Parlors?

Summary

1. MUN Tells Us About N Inefficiency.
2. Timely MUN Values Useful for:
   a. Detecting Diet Problems.
   b. Estimating Urine N & N Efficiency.
3. Standardize MUN Values.
4. Optimum (?) MUN Range:
   a. 10 to 14 mg/dl (AgSource)
   b. 10 to 12 mg/dl (Broderick; + 2 = Jerseys)