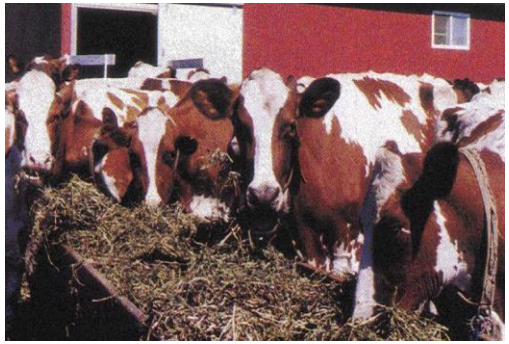
Using NorFor to Balance for Amino Acids in Lactating Cows

Projektet har fået tilskud fra "Grønt Udviklings- og Demonstrations Program, GUDP under Fødevareministeriet".



Glen Broderick

Univ. of Wisconsin & USDA-ARS, Madison, Wisconsin, USA

Maria Åkerlind

Växa, Stockholm

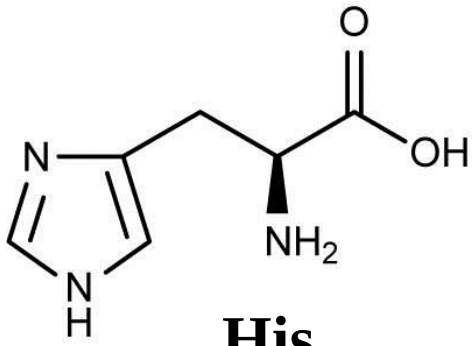
&

Nicolaj Nielsen

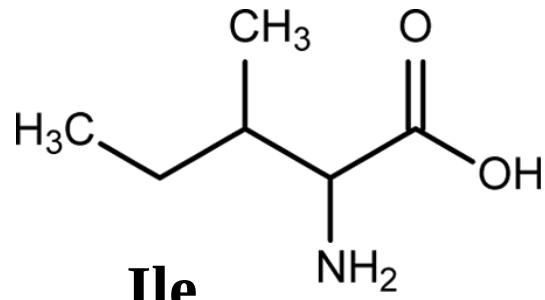
AgroTech A/S, Aarhus, Denmark

Temadag om Aktuelle Fodringsspørgsmål 2013

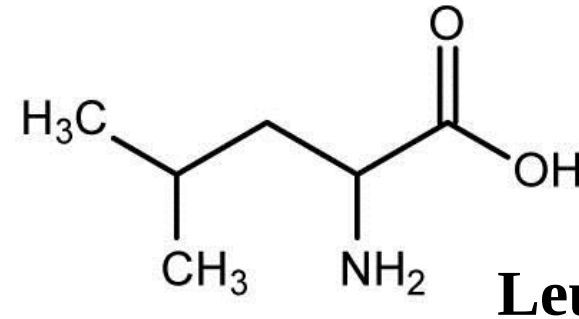
Essential Amino Acids



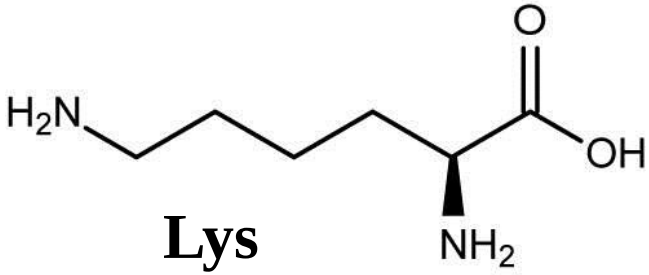
His



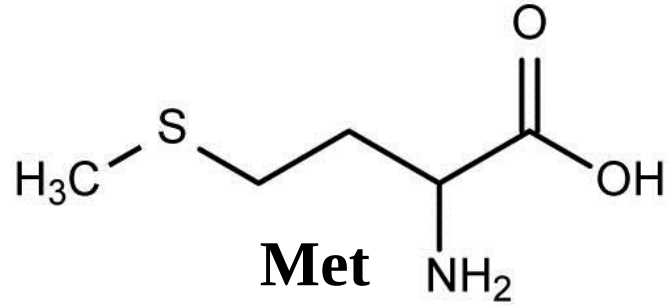
Ile



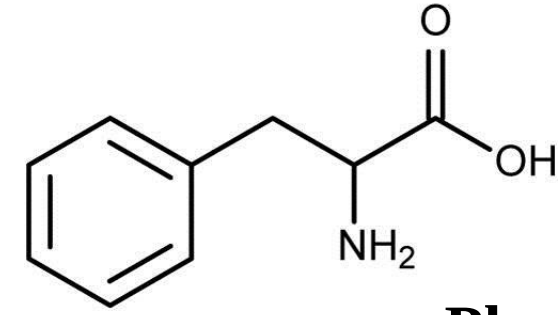
Leu



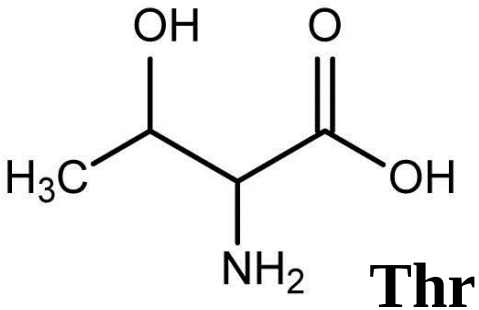
Lys



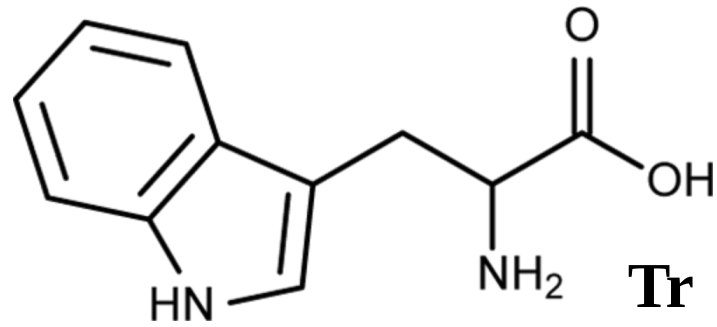
Met



Phe

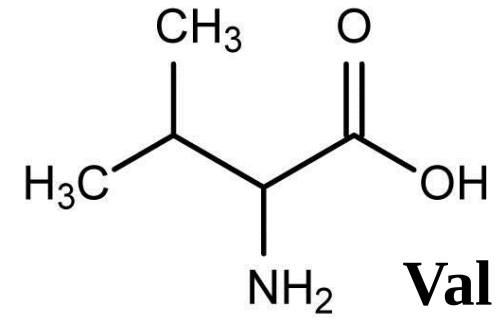


Thr



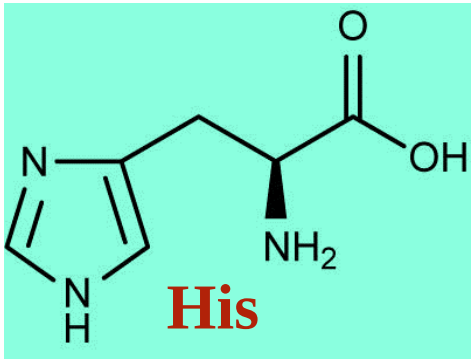
Tr

p

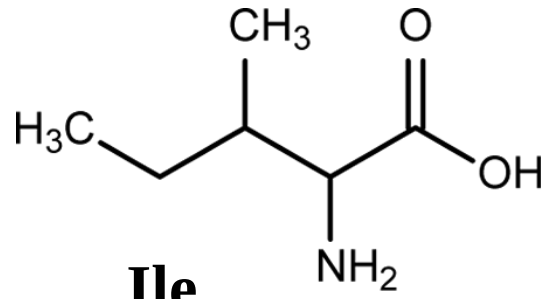


Val

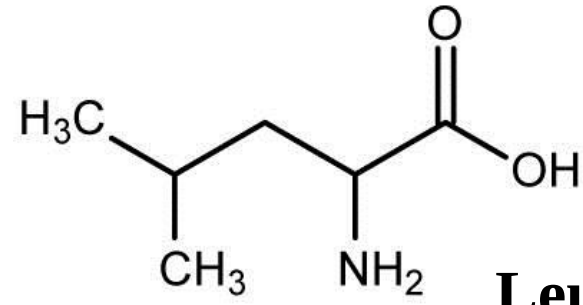
Essential Amino Acids



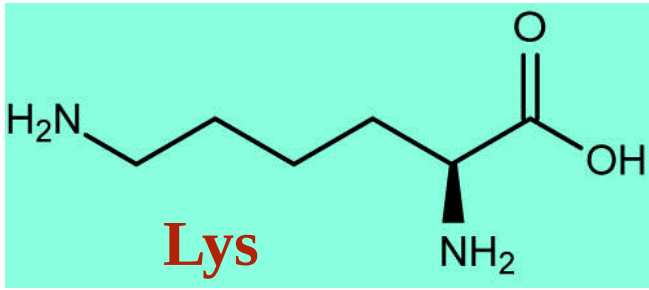
His



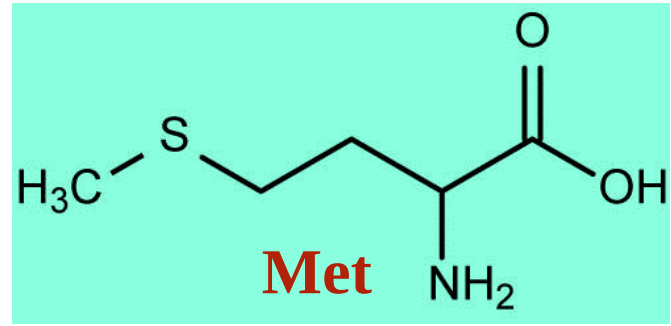
Ile



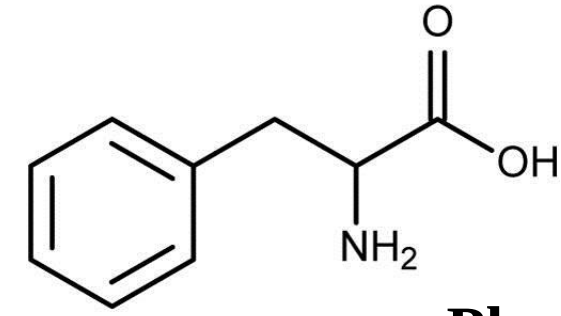
Leu



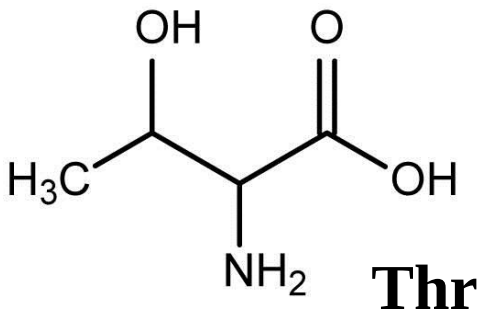
Lys



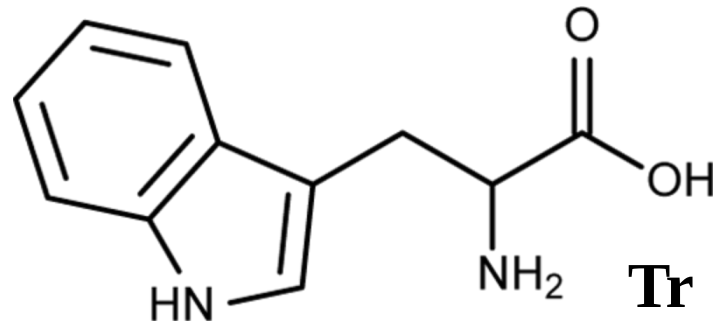
Met



Phe

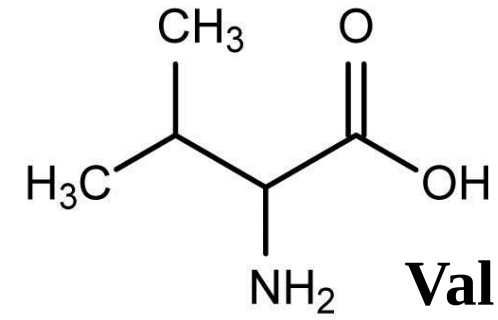


Thr



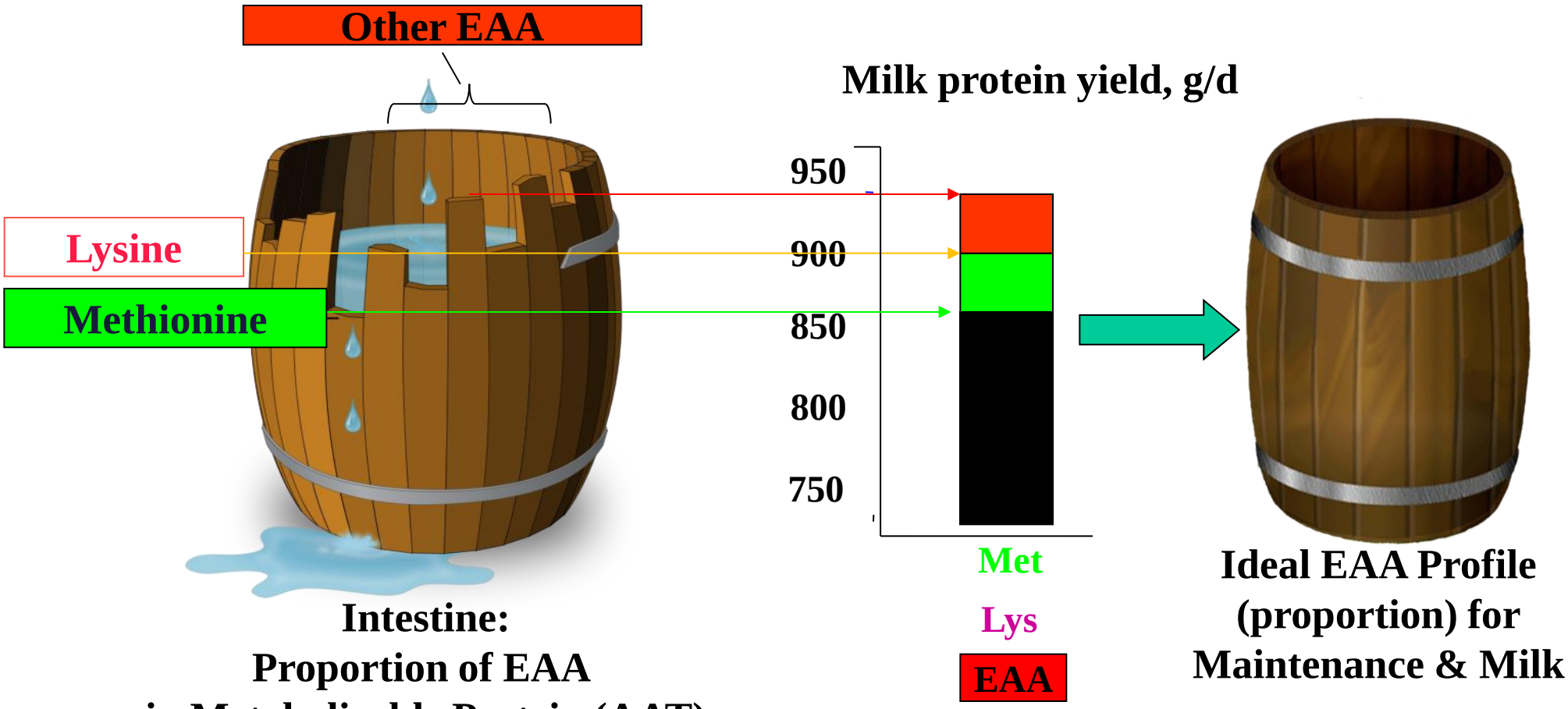
Tr

p

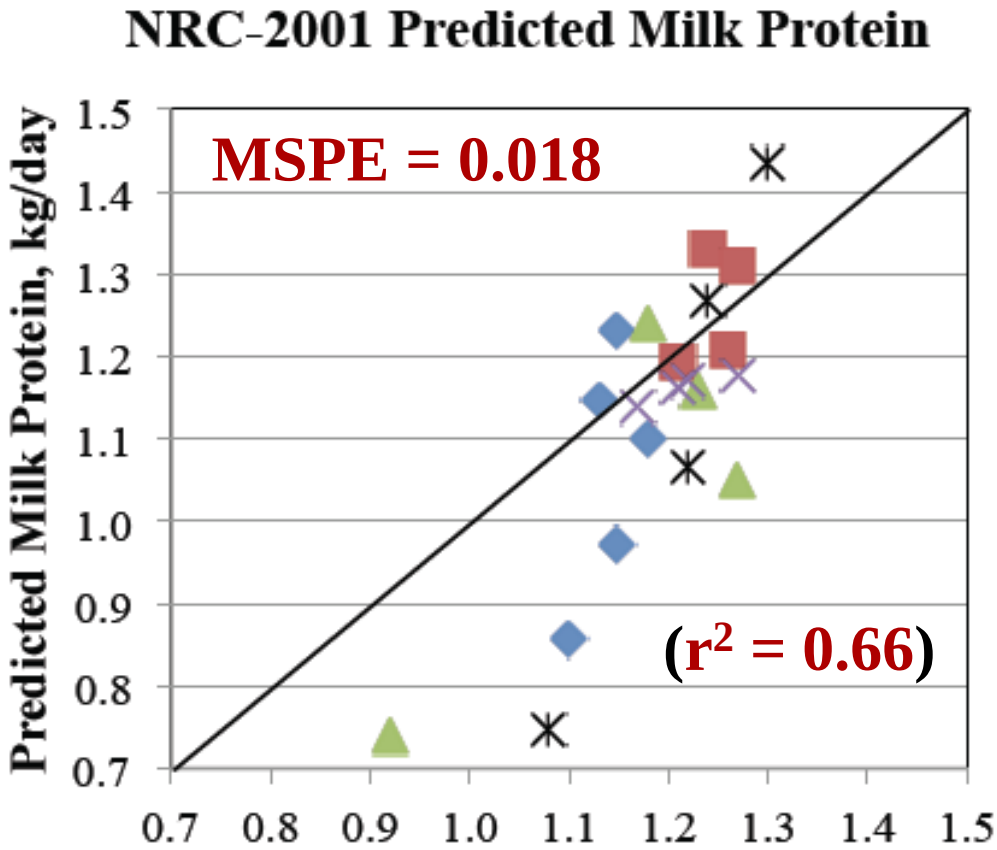


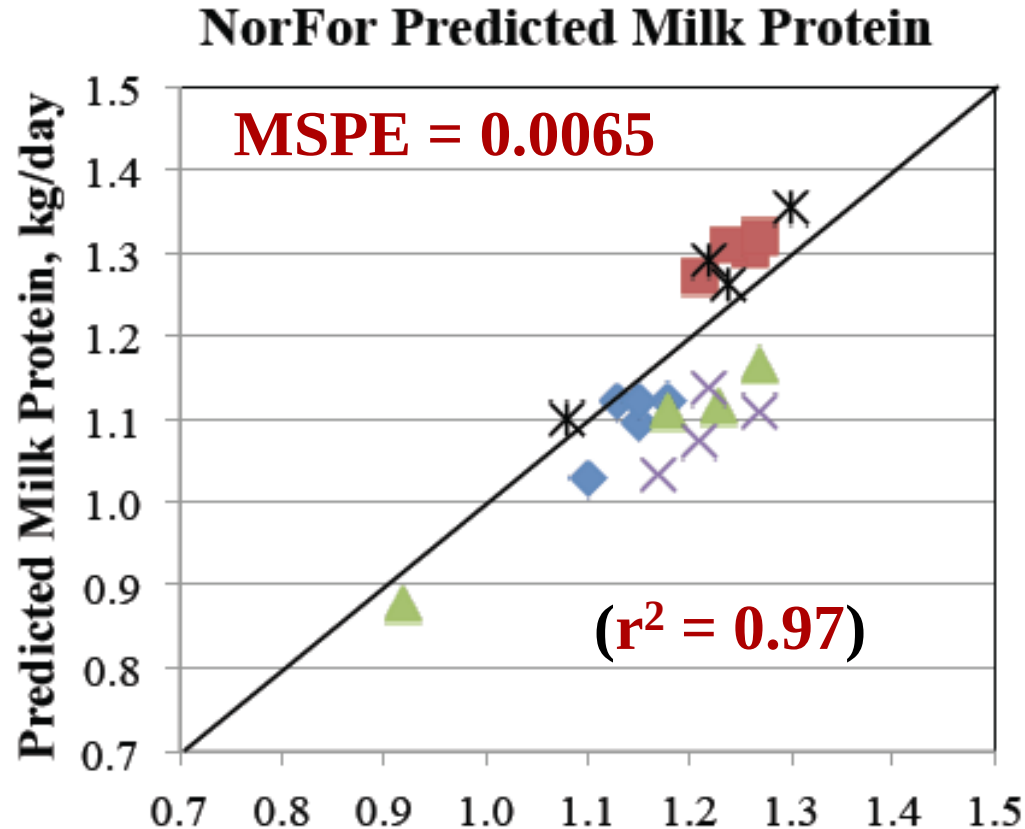
Val

Ideal Essential Amino Acid (EAA) Profile (for Cow): Barrel Stave Analogy



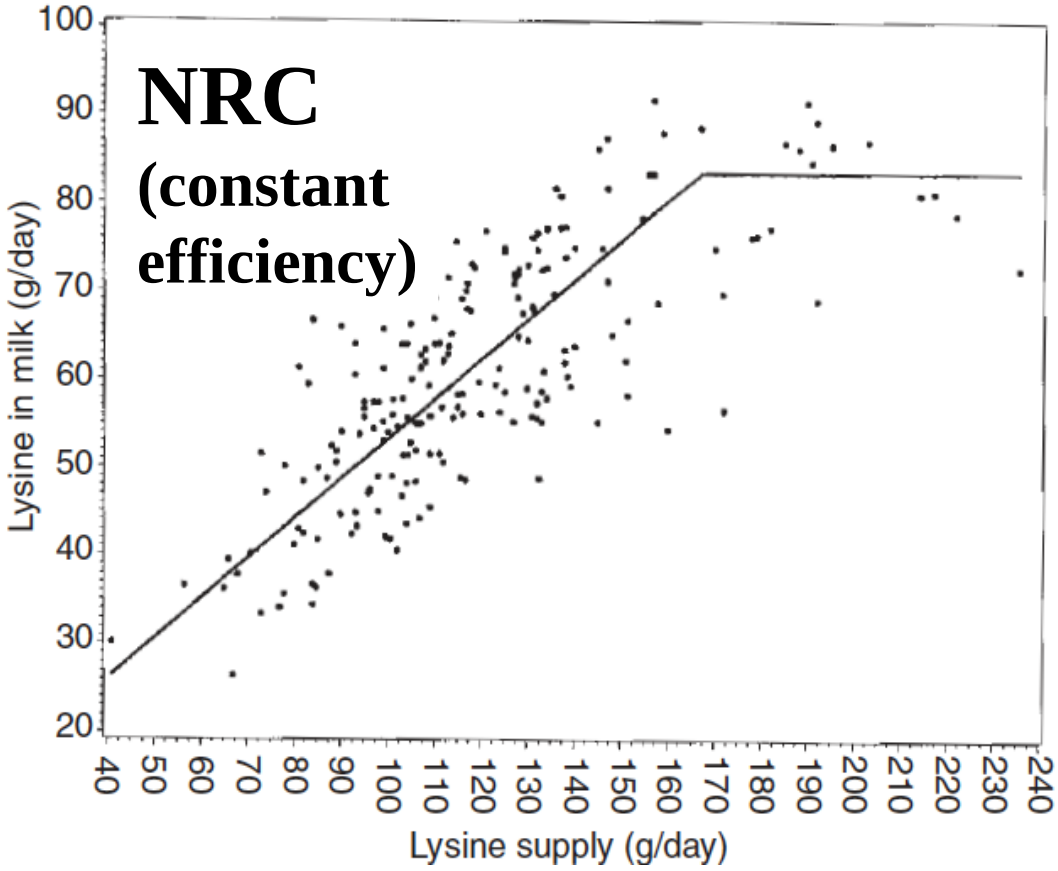
NRC-2001 versus NorFor: Milk Protein Yield

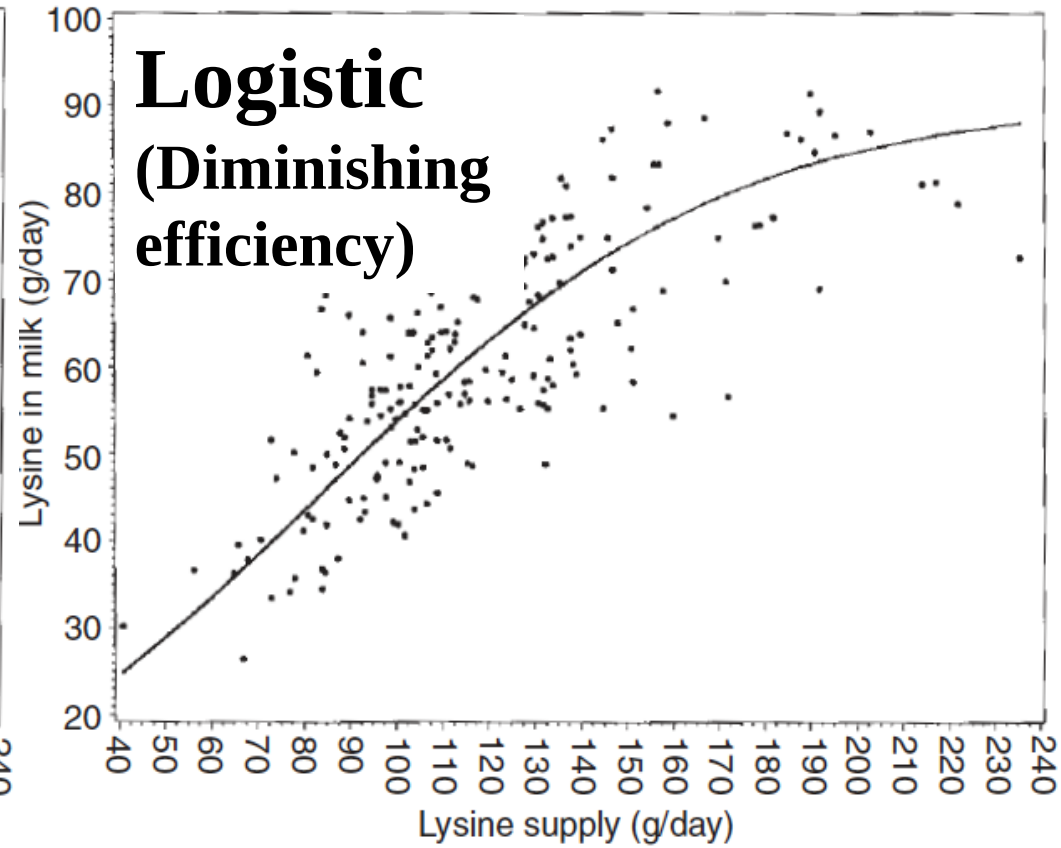




◆Olmos 1 ●Olmos 2 ▲Brito ×Reynal ✳Nursoy & Gonzalez

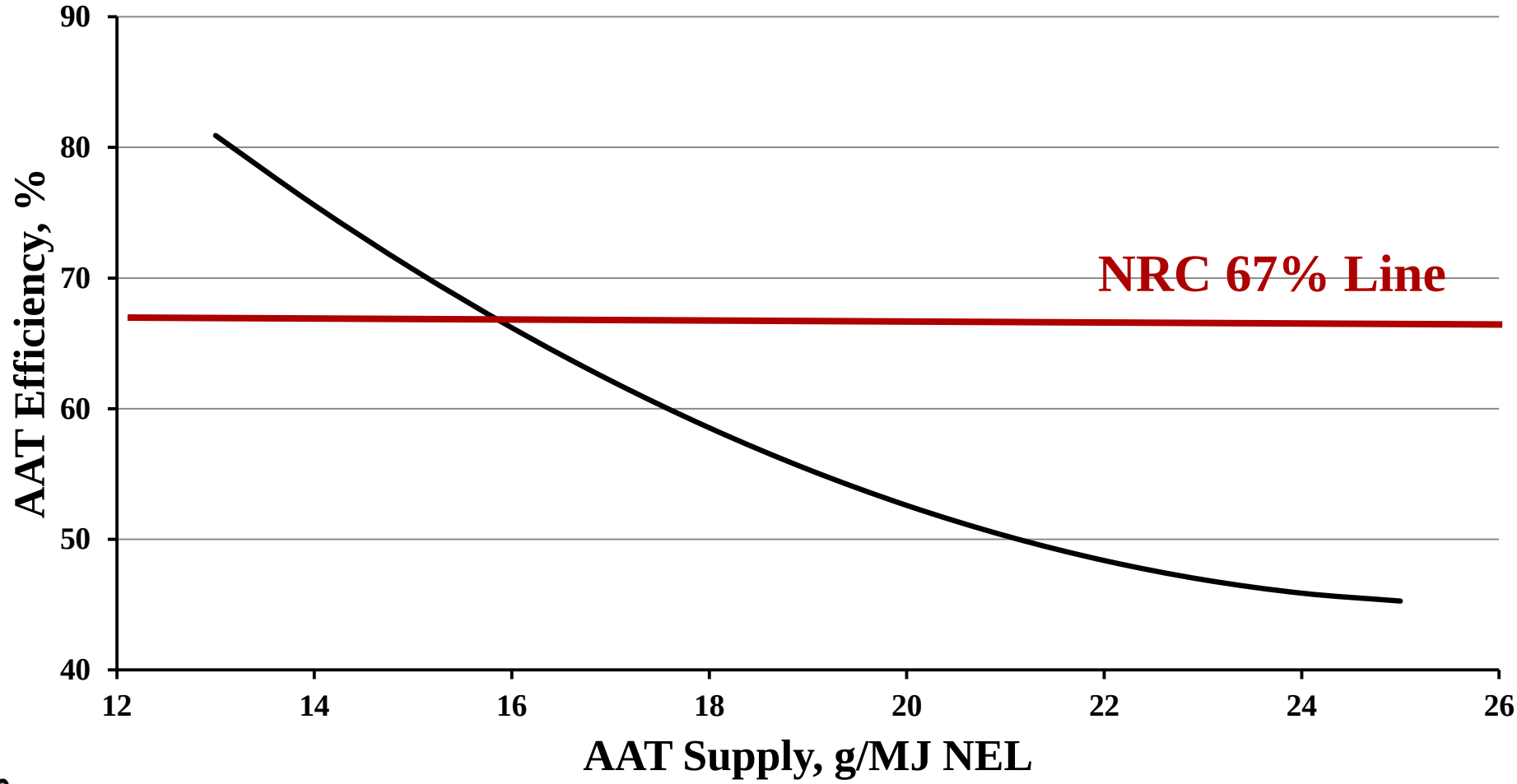
Broken-Stick (NRC) vs. Logistic Model of Protein Utilization



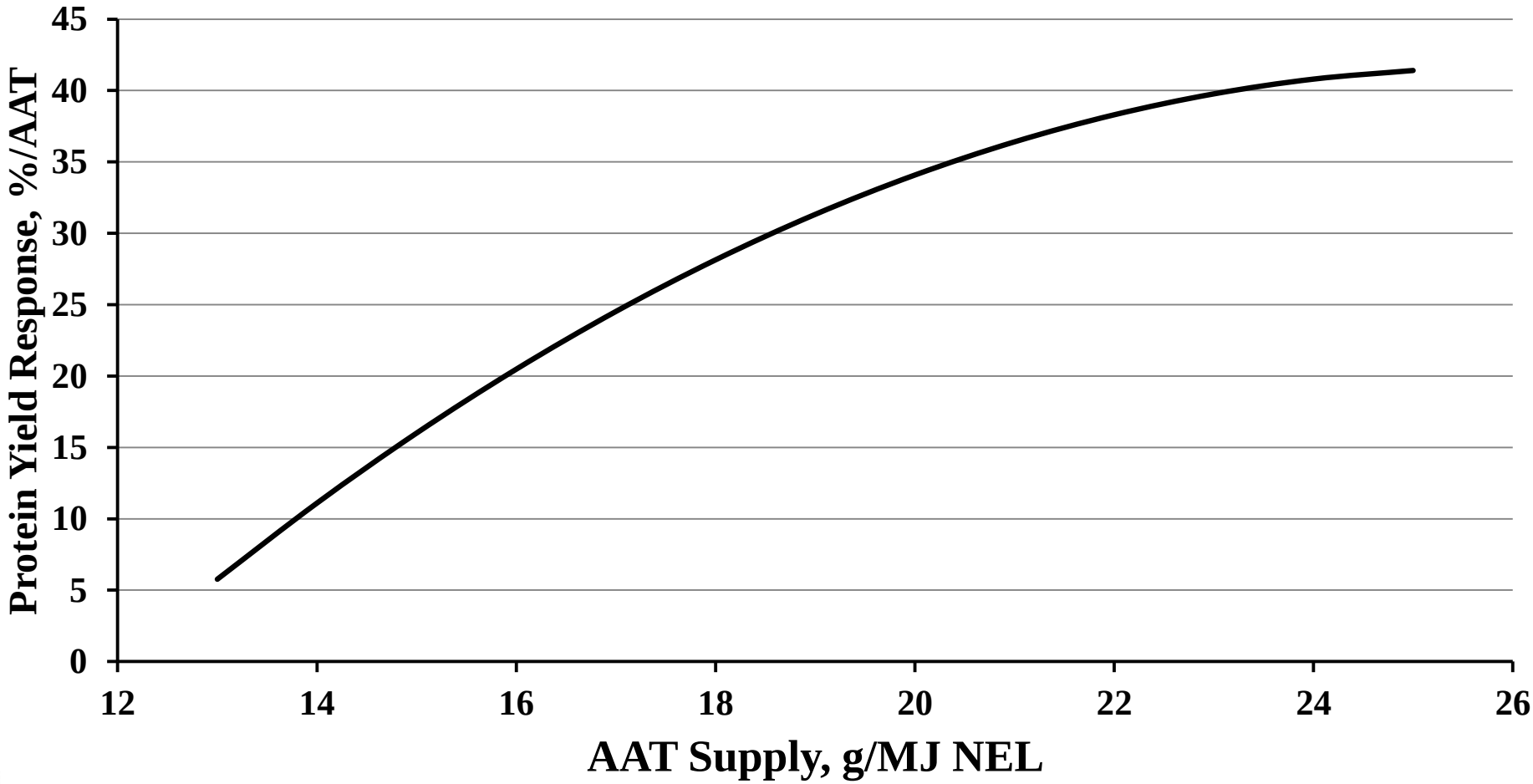


Both Models fit Data Equally Well but Diminishing Efficiency (Logistic Model) Makes more Biological Sense (Lapierre et al., 2005).

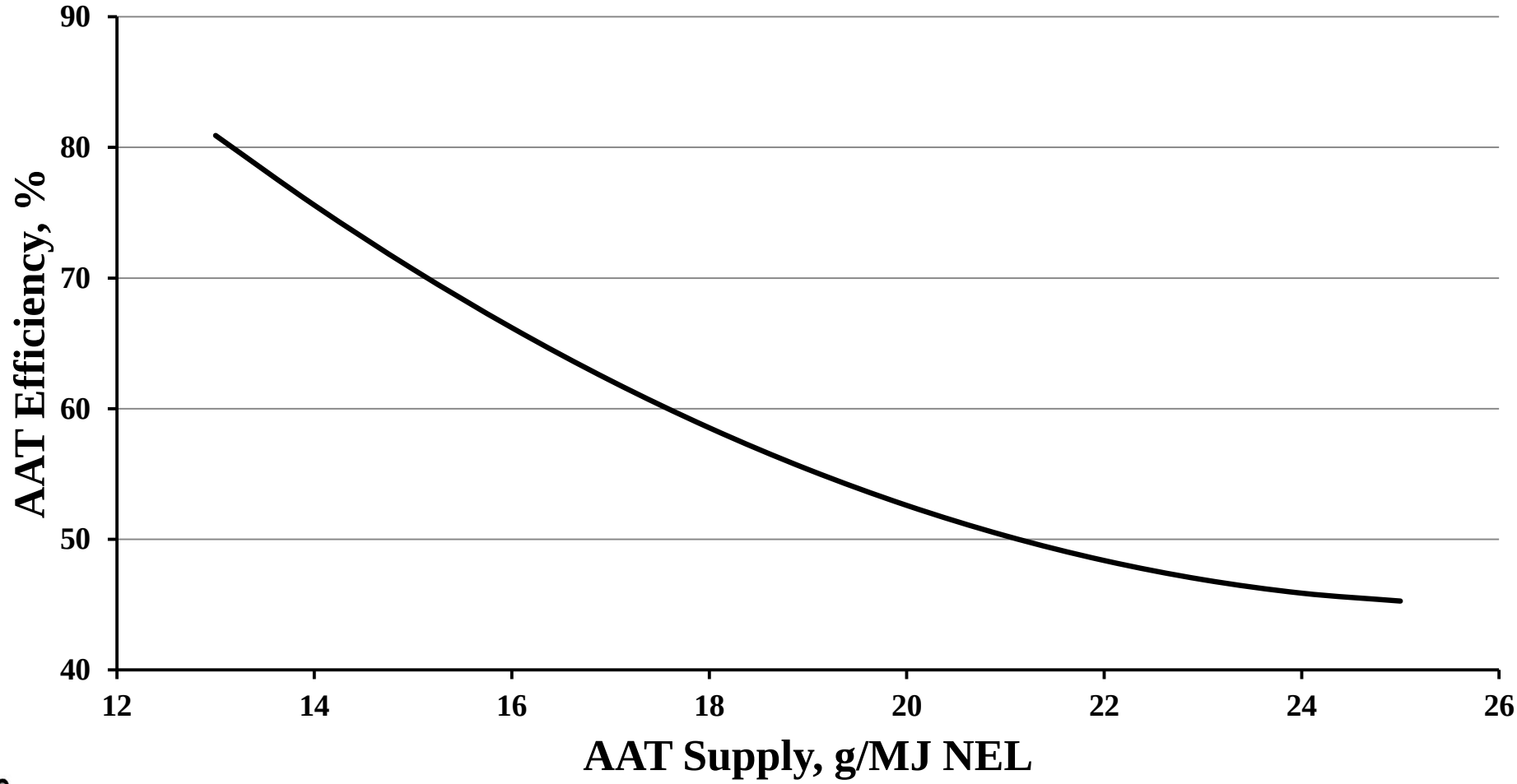
NorFor—Declining AAT (MP) Utilization for Milk Protein with Increasing Supply



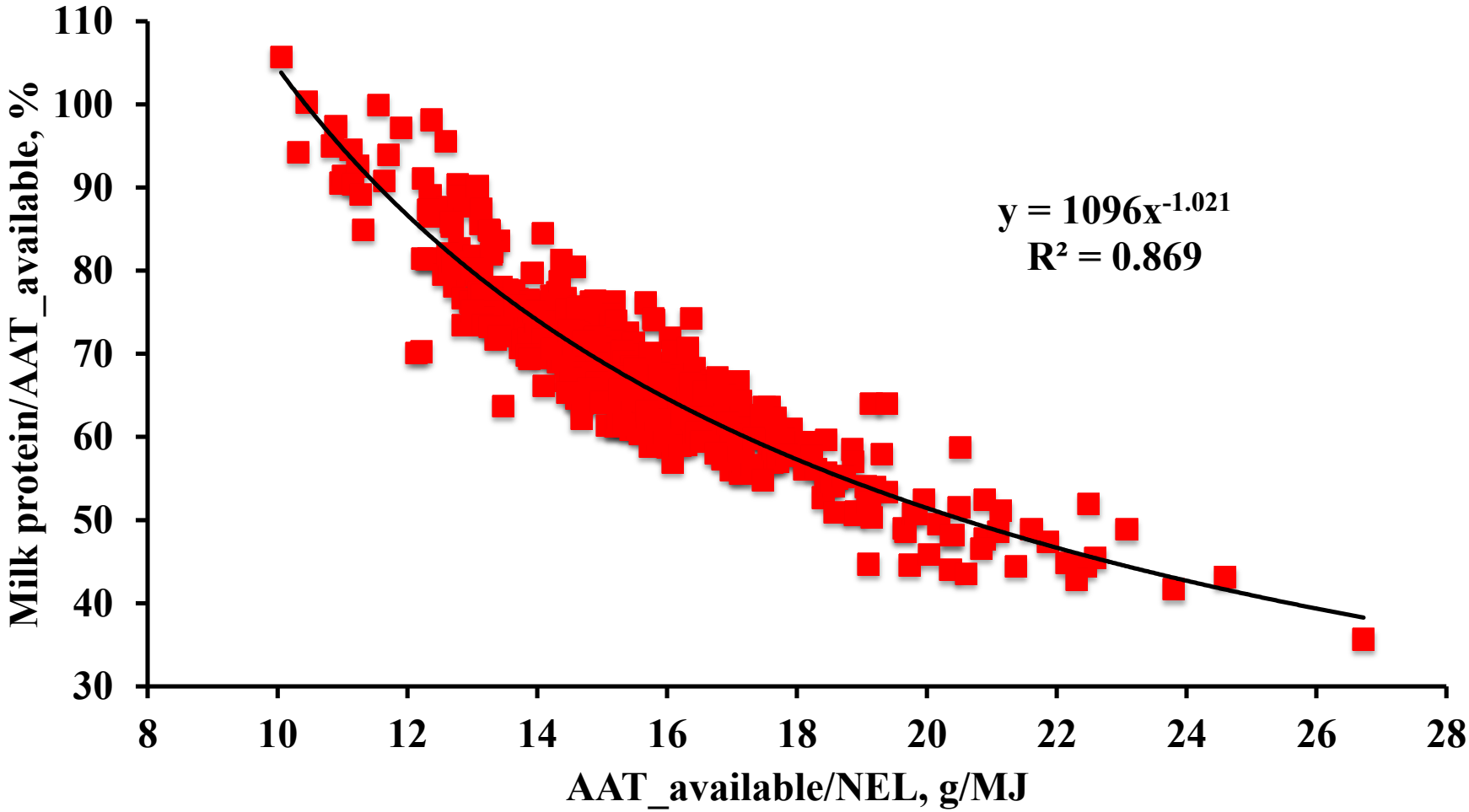
NorFor--Marginal Protein Yield Response with Increasing AAT (MP) Supply



NorFor—Declining AAT (MP) Utilization for Milk Protein with Increasing Supply

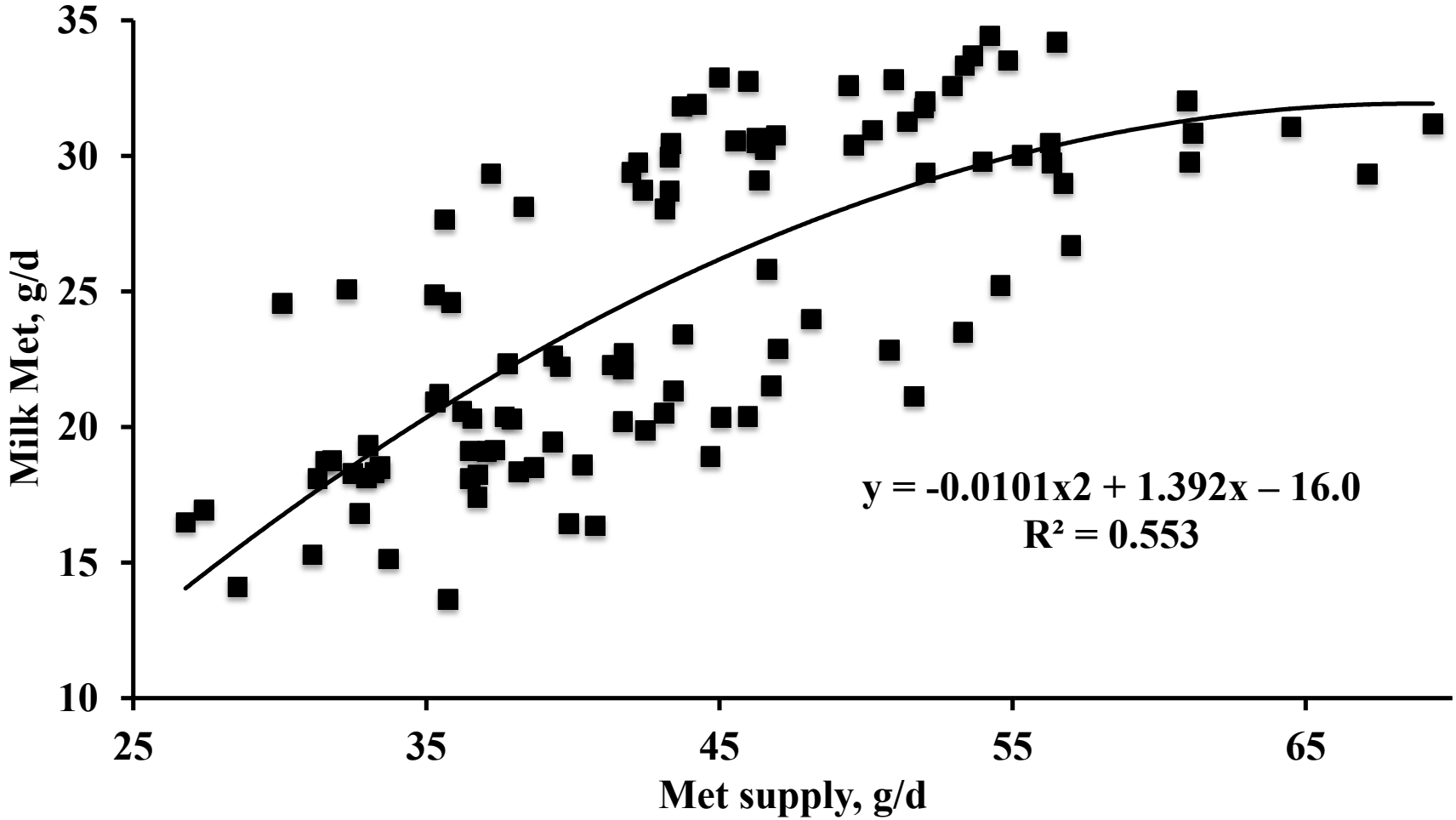


Observed Decline in MP (AAT) Utilization for Milk Protein with Increasing Supply (490 Diets)



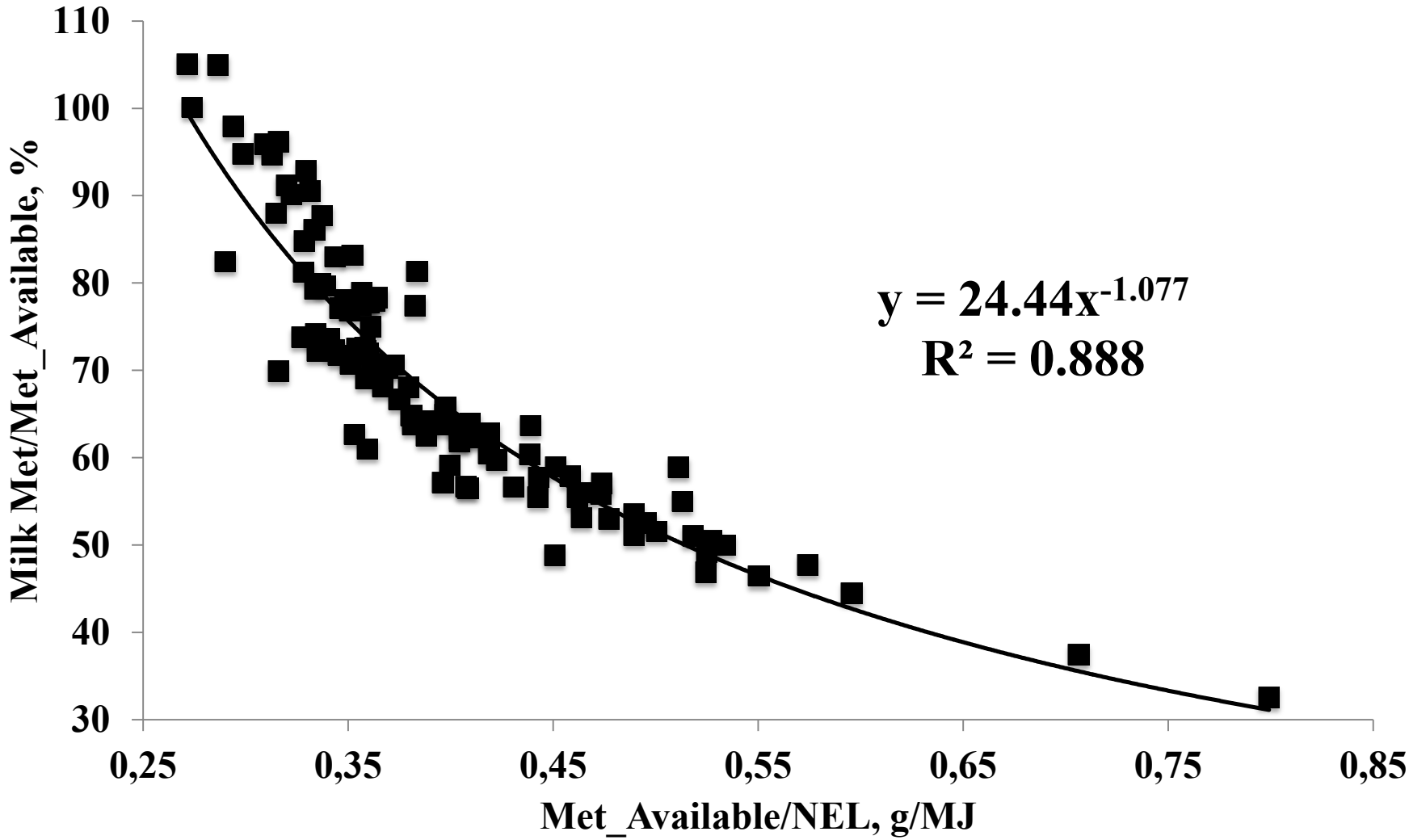
Milk Met Secretion vs. Total Met Supply

(105 Diets)



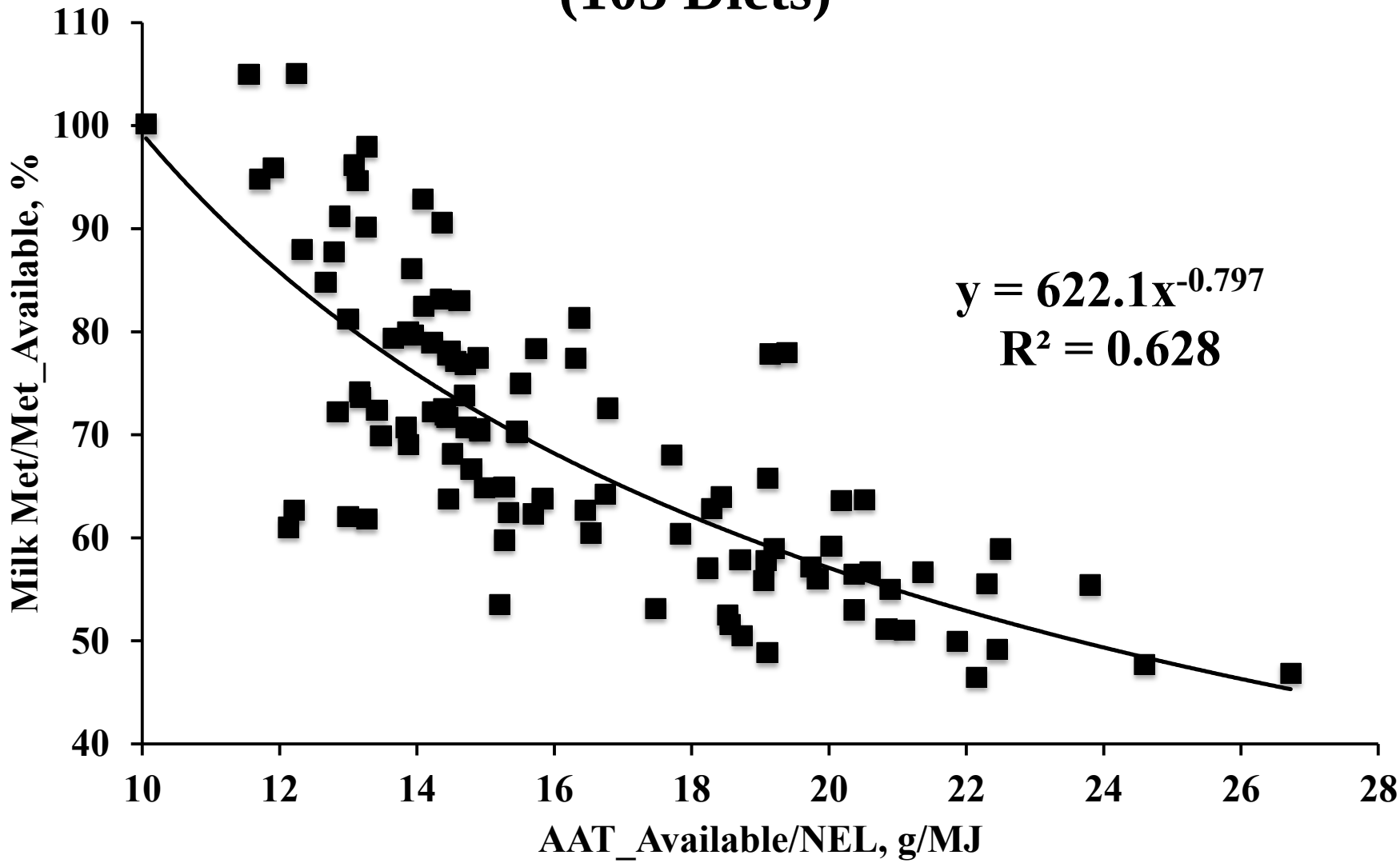
Milk Met/Avail-Met vs. Avail-Met/NE_L

(108 Diets)



Milk Met Secretion vs. AAT/NEL

(105 Diets)

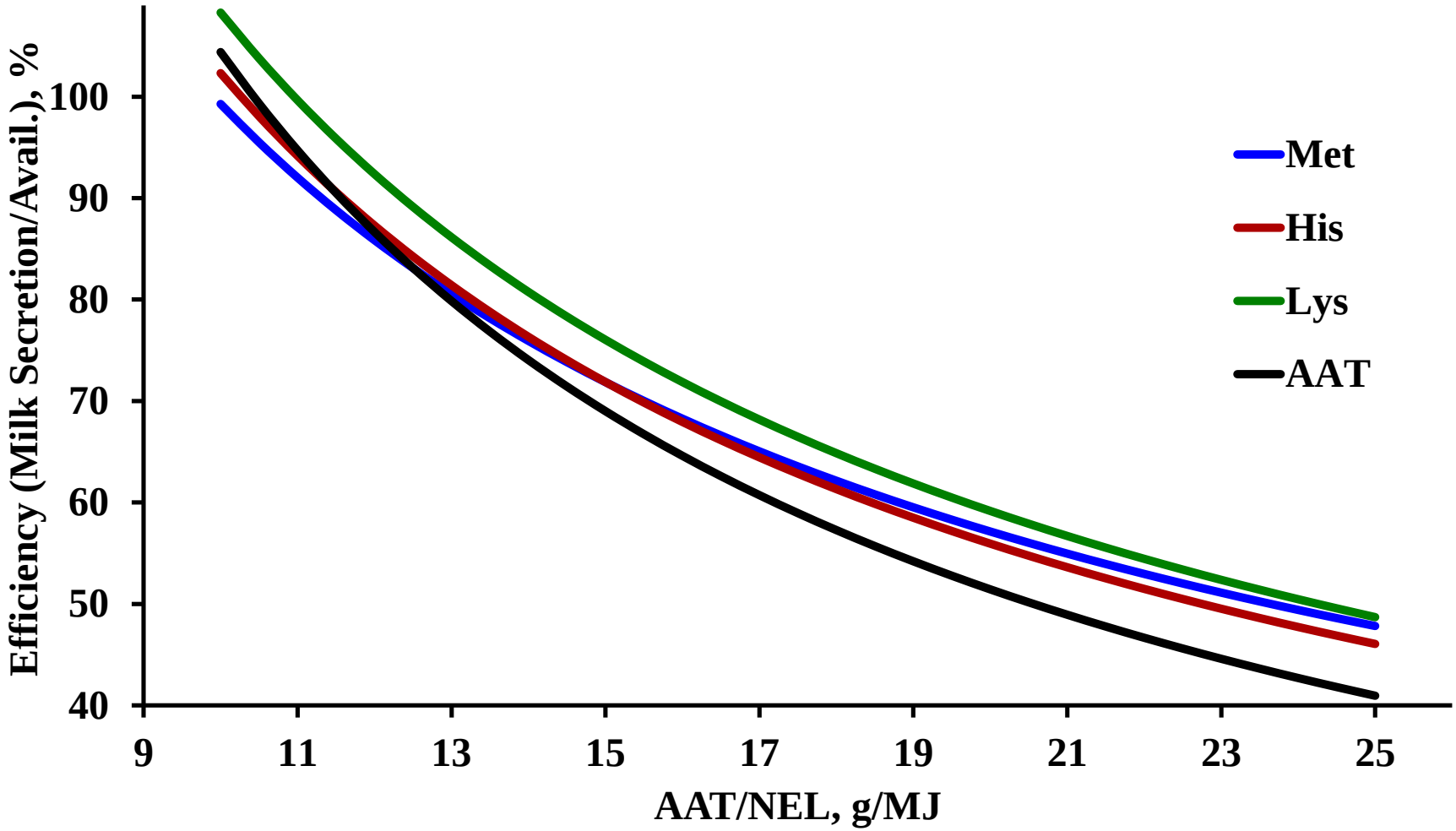


Power Ftns Predicting EAA Efficiency

Y (Milk EAA/EAA_avail, %) = Coef.*X^t (X = EAA_avail/NEL)

	Essential Amino Acid		
Parameter	**Met**	**Lys**	**His**
R^2	**0.888**	**0.894**	**0.852**
Coef. X	**24.4**	**78.2**	**26.4**
t (Exponent)	**-1.08**	**-1.10**	**-1.01**
Points	**108**	**108**	**108**

Milk EAA & Protein Secretion vs. AAT/NEL (490/105 Diets)

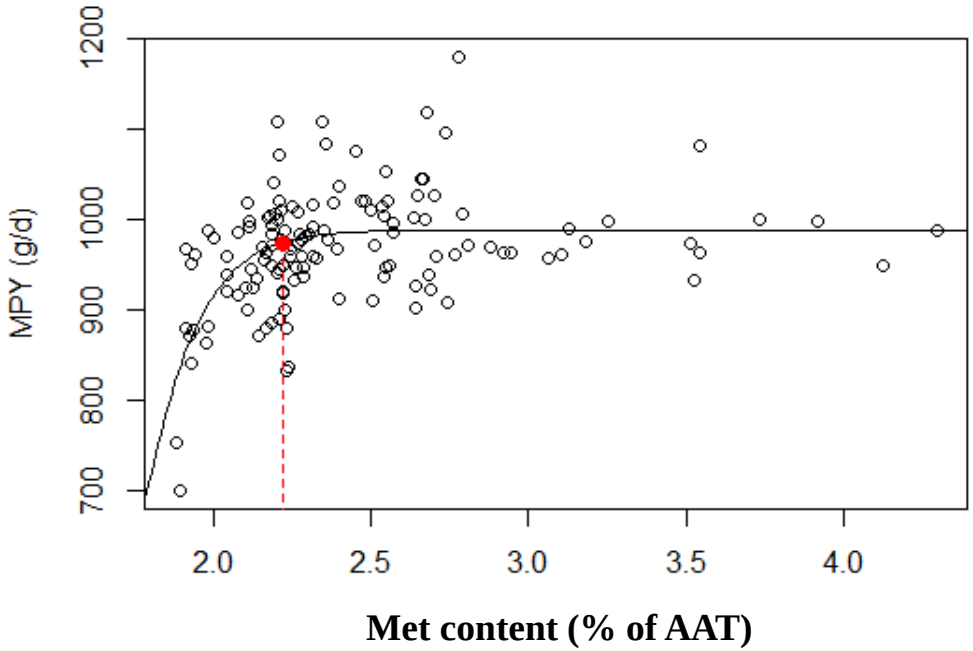


What are EAA Optimums?

Schwab et al. (1992) & NRC (2001):

2.4% Met & 7.2% Lys in Metabolizable Protein

Met & His Both = 2.6% of Milk Protein (= Optimum)



Nicolaj's Fit of Milk Protein Yield (MPY) Responses to Met Supplementation (RP-Met & Abomasal Infused Met): 2.2% Met in AAT

EAA Requirements as % of AAT (MP)

AAT/NEL	AAT eff.	Met eff.	[Met]	[His]	[Lys]	Lys/Met
(g/MJ)	-----(%)-----		----------(% of AAT)----------			
12.0	86.7	89.4	2.40[1]	2.42	6.94	2.9
13.0	79.9	83.4	2.40	2.41	6.95	2.9
14.0	74.0	78.1	2.40	2.40	6.96	2.9
15.0	69.0	73.5	2.40	2.39	6.97	2.9
16.0	64.6	69.3	2.40	2.38	6.97	2.9
17.0	60.7	65.6	2.40	2.37	6.98	2.9
18.0	57.3	62.2	2.40	2.36	6.99	2.9
19.0	54.2	59.2	2.40	2.36	7.00	2.9
20.0	51.4	56.4	2.40	2.35	7.00	2.9
21.0	48.9	53.9	2.40	2.34	7.01	2.9
22.0	46.7	51.6	2.40	2.34	7.02	2.9
23.0	44.6	49.4	2.40	2.33	7.02	2.9

[1]Utilizable Met set = 2.4% of AAT (Schwab, 1992)

EAA Requirements as % of AAT (MP)

AAT/NEL	AAT eff.	Met eff.	[Met]	[His]	[Lys]	Lys/Met
(g/MJ)	-----(%)-----		----------(% of AAT)----------			
12.0	86.7	89.4	2.40[1]	2.42	6.94	2.9
13.0	79.9	83.4	2.40	2.41	6.95	2.9
14.0	74.0	78.1	2.40	2.40	6.96	2.9
15.0	69.0	73.5	2.40	2.39	6.97	2.9
16.0	64.6	69.3	2.40	2.38	6.97	2.9
17.0	60.7	65.6	2.40	2.37	6.98	2.9
18.0	57.3	62.2	2.40	2.36	6.99	2.9
19.0	54.2	59.2	2.40	2.36	7.00	2.9
20.0	51.4	56.4	2.40	2.35	7.00	2.9
21.0	48.9	53.9	2.40	2.34	7.01	2.9
22.0	46.7	51.6	2.40	2.34	7.02	2.9
23.0	44.6	49.4	2.40	2.33	7.02	2.9

[1]Utilizable Met set = 2.4% of AAT (Schwab, 1992)

Prediction of Response to RP-Met & Lys

Reference	Met	Lys	RP-Met		RP-Met+Lys		RP-Lys	Comment
	Supply - Req, g/d		MPY response (supp - control), g/d					
Robinson et al., 1998	-6.1	-9.7			19		-10	
	-2.6	-1.1			54			
Piepenbrink et al. 1996	-6.2	-4.6			-17	(3)		
Armentano et al. 1997	-3.5	-6.5	36	(2)	62			
Bremmer et al. 1997	-3.7	-9.6			10			
Bateman et al. 1999	-6.5	-14.0			-13			
	-5.3	-15.4			47			
Blum et al. 1999	-4.1	-9.8	-24					44 g Met/d
Overton et al. 1998	-2.5	-3.3	54					
	0.8	9.8	-21					
Soder & Holden, 1999	-7.5	-4.6	-25	(2)				
Samuelson et al. 2001	-6.4	-10.5	53	(3)				
	-8	-21.7	-36	(3)				
Nichols et al. 2000	12.6	46.4			15			Excess Met & Lys?
	23.9	-0.5			64			
Rulquin et al. 1997	1.4	7.5	17					
Casper et al. 1988	-0.6	-1.2	22					
Pisulewski & Kowalski 1999	0.6	5.2	-9	(4)				
Leonardi et al. 2003	-8.2	-12.8	-26					
	-8.7	-24.2	62					
Ordway et al. 2009	4.2	12.3	34	(2)				
Means	-3.3	-4.6	10.5					
	-4.8	-8.7			23.1			

Prediction of Response to RP-Met & Lys (Means)

Met Supply - Req, g/d	Lys	RP-Met MPY response (supp - control), g/d		RP-Met+Lys	
-3	-5	11	(23)		
-5	-9			23	(9)

Supplementing Low CP Diets with Rumen-Protected Met, Lys & His (Lee et al., 2012)

Item	Metabolizable Protein				Prob.
	Adequate	Deficient	Def+ML	Def+MLH	
CP, %	15.7	13.6	13.6	13.6	
MP (NRC), kg/d	2.66	2.08	2.15	2.20	
Production					
DMI, kg/d	24.5	23.0	23.7	24.3	0.06
Milk, kg/d	38.8^{a}	35.2^{b}	36.9^{ab}	38.5^{a}	<0.01
True prot., kg/d	1.13^{a}	1.01^{b}	1.10^{a}	1.14^{a}	<0.01
MUN, mg/dL	13.0^{a}	10.3^{b}	10.1^{b}	11.1^{ab}	<0.01
MN/NI, %	29^{b}	34^{a}	34^{a}	34^{a}	<0.01
Urinary N, g/d	143^{a}	92^{b}	87^{b}	97^{b}	<0.01

Supplemented 18, 24 & 12 g/d of Rumen-Protected Met, Lys & His

^{a,b}($P < 0.05$)

Supplementing Low CP Diets with Rumen-Protected Met, Lys & His (Lee et al., 2012)

	Dietary Metabolizable Protein				
Item	Adequate	Deficient	Def+ML	Def+MLH	
CP, %	15.7	13.6	13.6	13.6	
AAT, kg/d	2.50	2.12	2.25	2.33	
[EAAi] in AAT					Optimum
Met, %	2.1	2.2	2.9	2.8	2.4
Lys, %	6.7	6.6	7.4	7.4	7.0
His, %	2.5	2.5	2.5	2.8	2.4

Supplemented 18, 24 & 12 g/d of Rumen-Protected Met, Lys & His

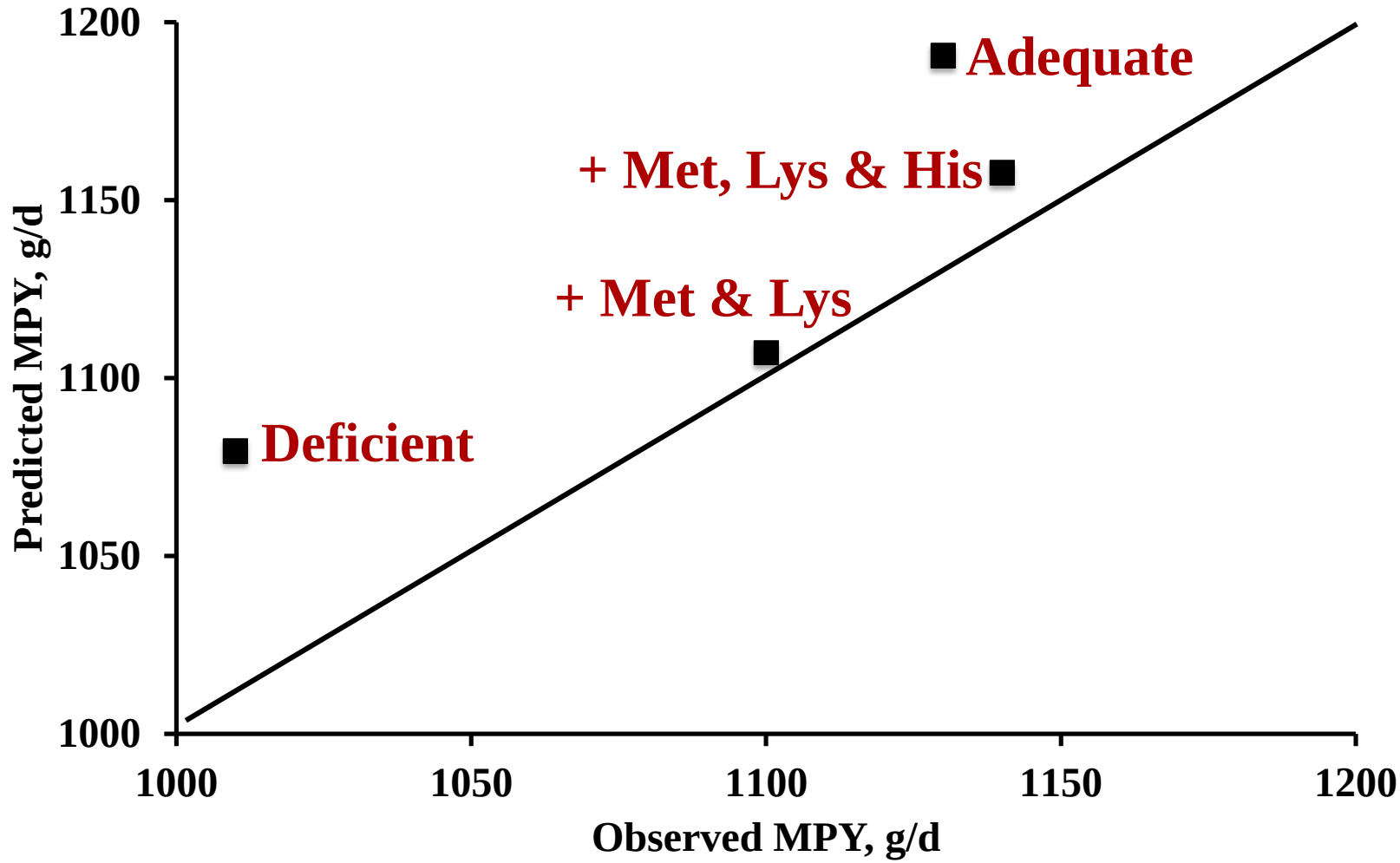
Supplementing Low CP Diets with Rumen-Protected Met, Lys & His (Lee et al., 2012)

	Dietary Metabolizable Protein				
Item	Adequate	Deficient	Def+ML	Def+MLH	
CP, %	15.7	13.6	13.6	13.6	
AAT, g/d	2.50	2.12	2.25	2.33	
[EAAi] in AAT					Optimum
Met, %	2.1	2.2	2.9	2.8	2.4
Lys, %	6.7	6.6	7.4	7.4	7.0
His, %	2.5	2.5	2.5	2.8	2.4

Supplemented 18, 24 & 12 g/d of Rumen-Protected Met, Lys & His

Prediction of Milk Protein Yield by NorFor

(Lee et al., 2012)



Summary & Conclusions

1. **Met, Lys & His Are Most Limiting EAA**
2. **NorFor Applies Variable, Diminishing Efficiencies of AAT Utilization**
3. **Power Functions Developed for Met, Lys & His Efficiency**
4. **Further Development of EAA Approach is Needed**
5. **Supplying Limiting EAA Will Lower Required Dietary CP & Reduce Environmental Footprint**