Optimizing Health and Reproduction Through Amino Acid Balancing in the Transition Period

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Professor

UNIVERSITY OF ILLINOIS URBANA-CHAMPAIGN

Dairy Focus Lab

Displaced Abomasum – a Transition problem

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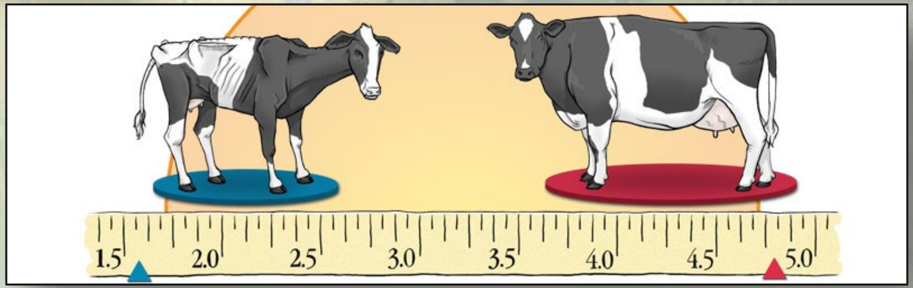
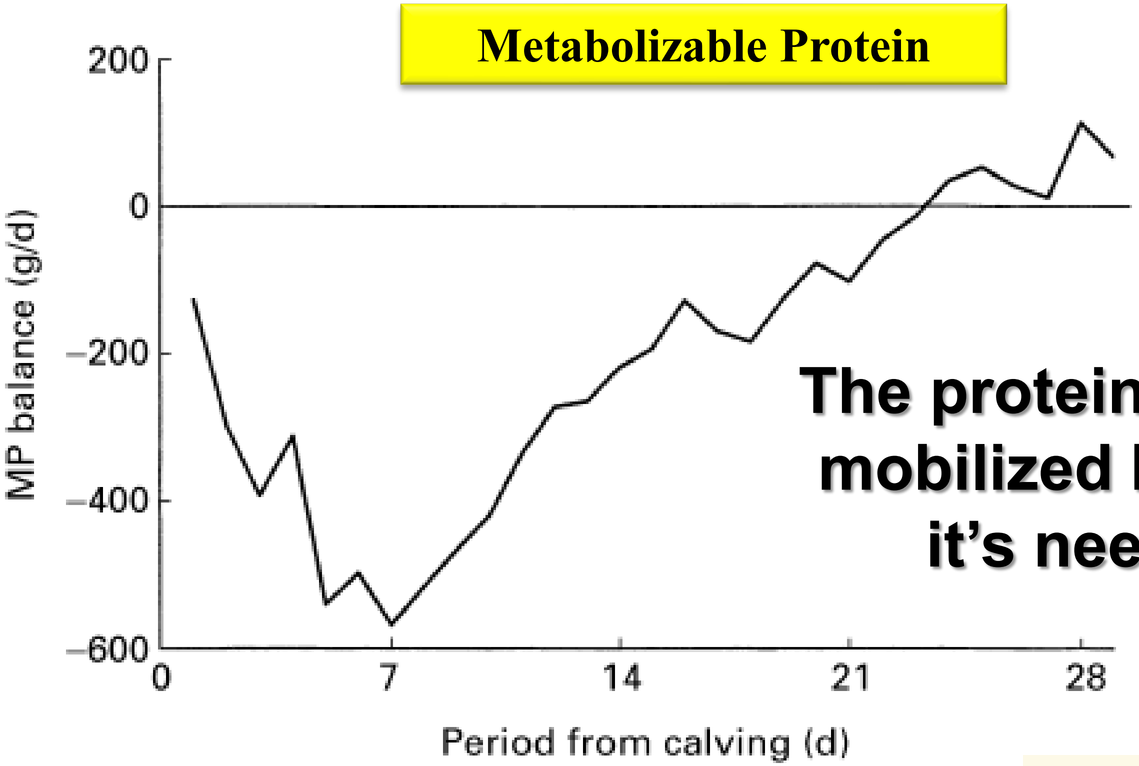
NEB



Negative protein balance is a less talked about phenomena in early postpartum cows…



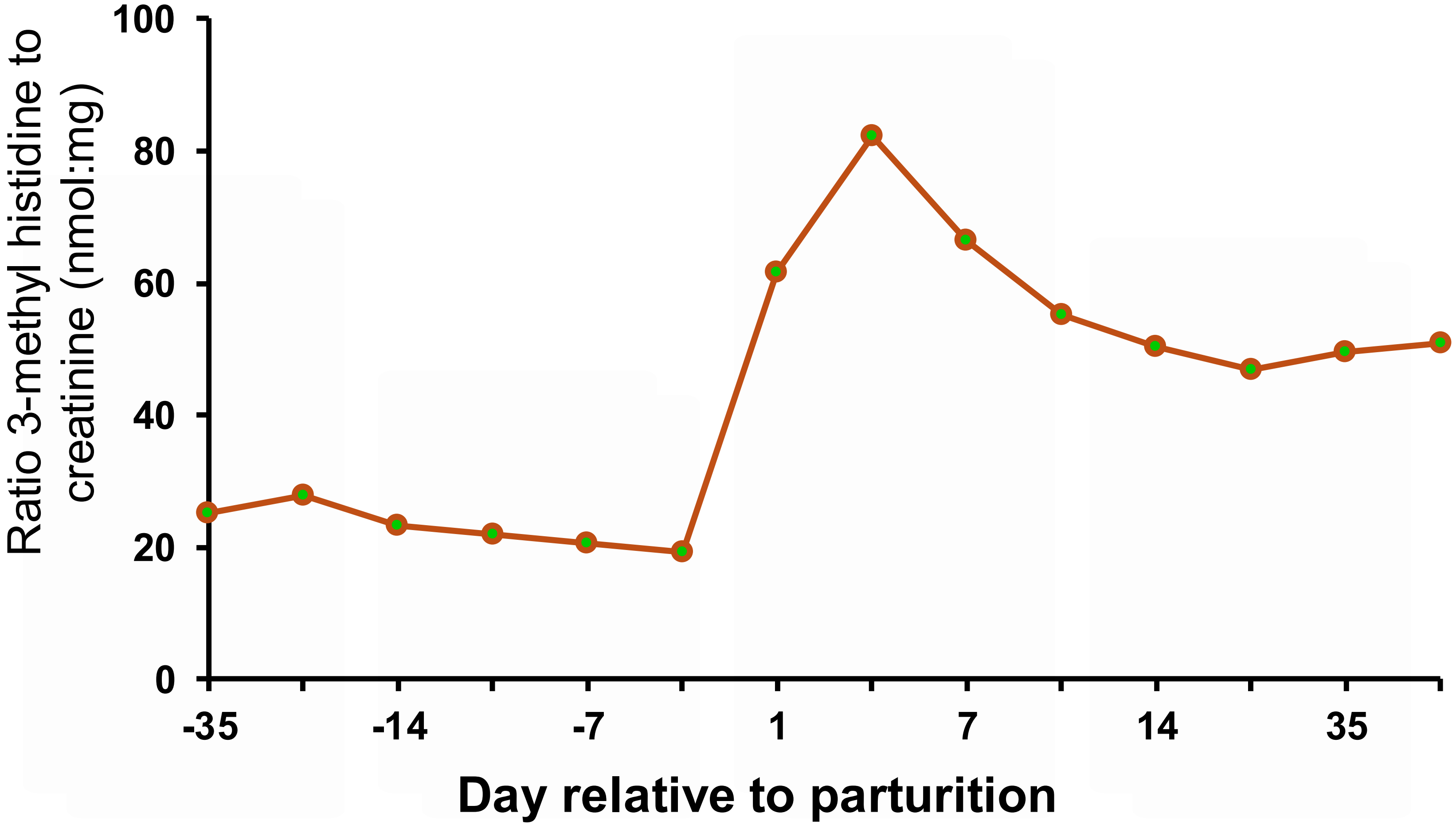
The protein is being mobilized because it's needed!

Average calculated MP balances in postparturient cows (n = 80) fed a ration containing 17.8% CP and 1.7 Mcal/kg of NEL. Individual values were calculated from daily individual measurements of CP intake and milk yield, and weekly measurements of milk composition.

NPB

Bell et al., 2000

Mobilization of skeletal muscle protein increases during early pospartum



Overton et al., 1998

Transition period "best practices"

TRANSITION ILLINOIS

- Improve cow comfort
- Calve cows at ~3.0 BCS
- Do not overfeed energy in the far-off dry period; close-up diet should be intermediate to far-off and fresh
- Meet metabolizable protein (AA) requirements
- Prevent hypocalcemia – use anionic salts or other
- Boost immune system, control inflammation and oxidative stress

Dietary Recommendations for Dry Cows

- **NEL:** Control energy intake at 18 to 20 Mcal daily [diet ~ 1.43 Mcal/kg (0.65 Mcal/lb) DM] for mature cows
- **Crude protein:** 12 – 14% of DM
- **Metabolizable protein (MP):** > 1,200 g/d
- **Starch content:** 12 to 15% of DM (NFC < 26%)
- **NDF from forage:** 40 to 50% of total DM or 4.5 to 6 kg per head daily (~0.7 – 0.8% of BW). Target the high end of the range if more higher-energy fiber sources (like grass hay or low-quality alfalfa) are used, and the low end of the range if straw is used (2-5 kg)
- **Total ration DM content:** <50% (add water if necessary)
- **Minerals and vitamins:** follow guidelines (For close-ups, target values are 0.40% magnesium (minimum), 0.35 – 0.40% sulfur, potassium as low as possible (Mg:K = 1:4), a DCAD of near zero or negative, calcium without anionic supplementation: 0.9 to 1.2% (~125g) calcium with full anion supplementation: 1.5 to 2.0% (~200g), 0.35 – 0.42% phosphorus, at least 1,500 IU of vitamin E, and 25,000 – 30,000 IU of Vitamin D (cholecalciferol)

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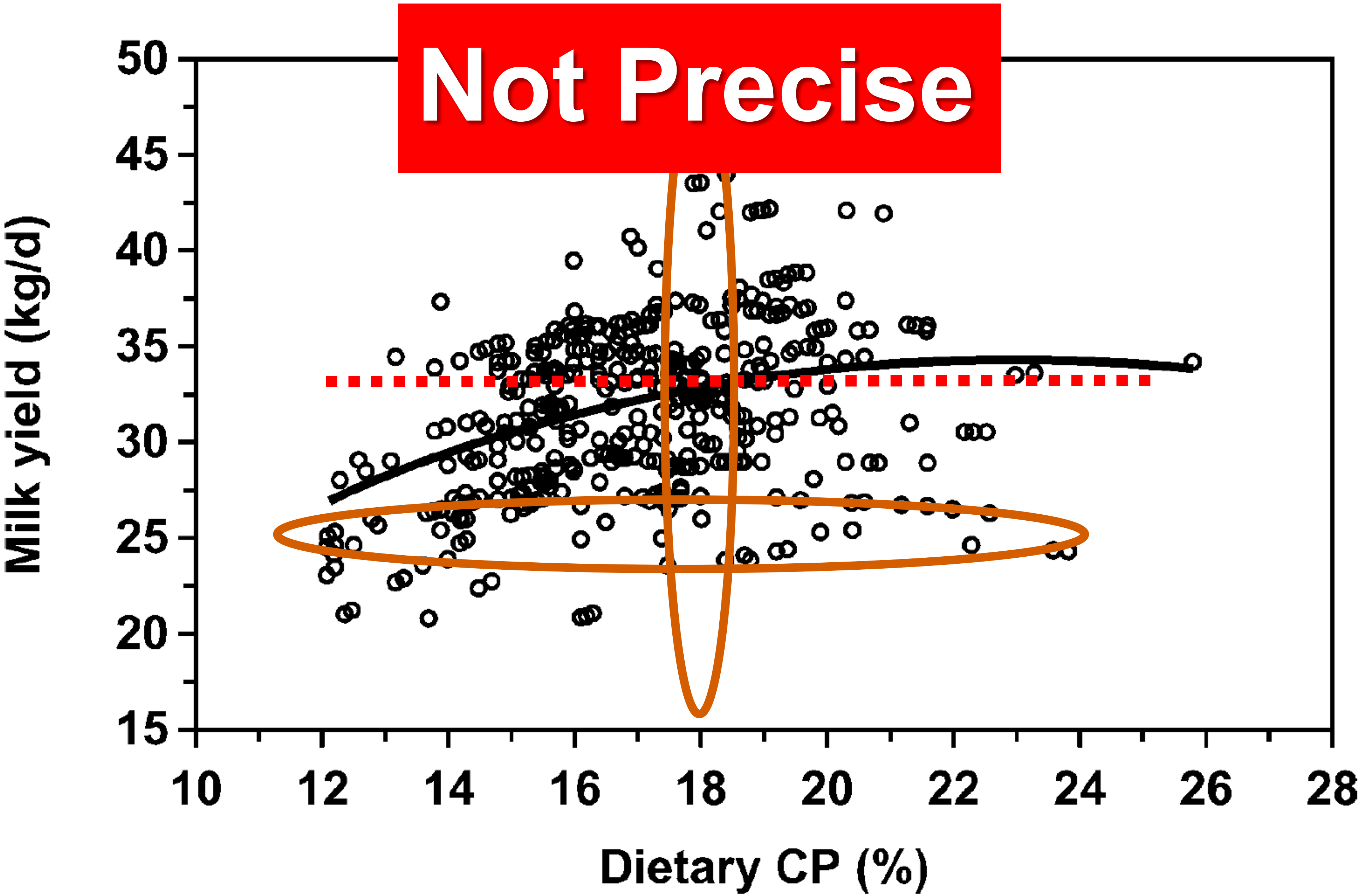
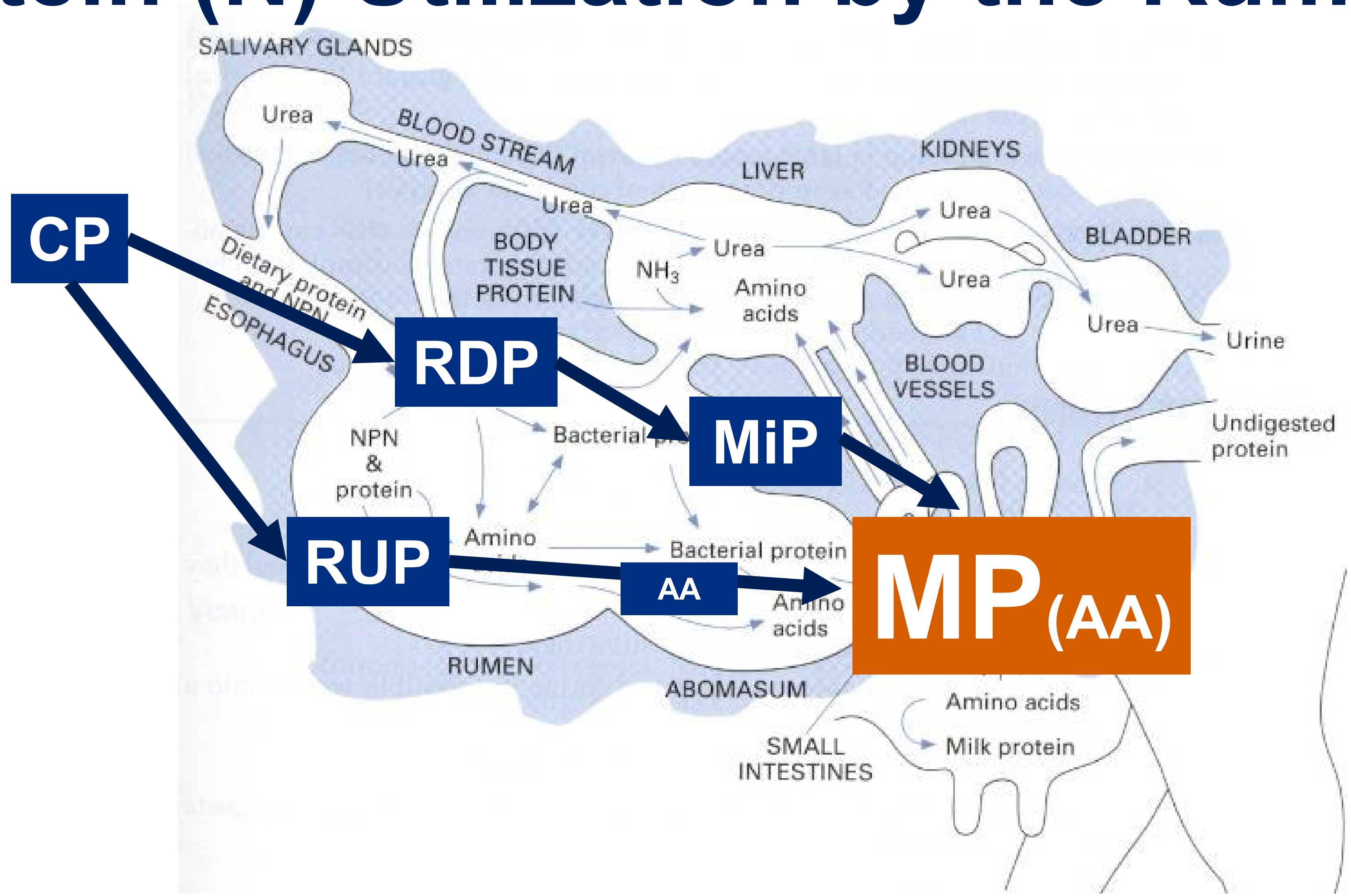
Relationship between milk yield and dietary CP (%) for lactating dairy cows



Ipharraguerre and Clark, 2005

Protein (N) Utilization by the Ruminant



J. Bryant and B. R. Moss, Montana State University

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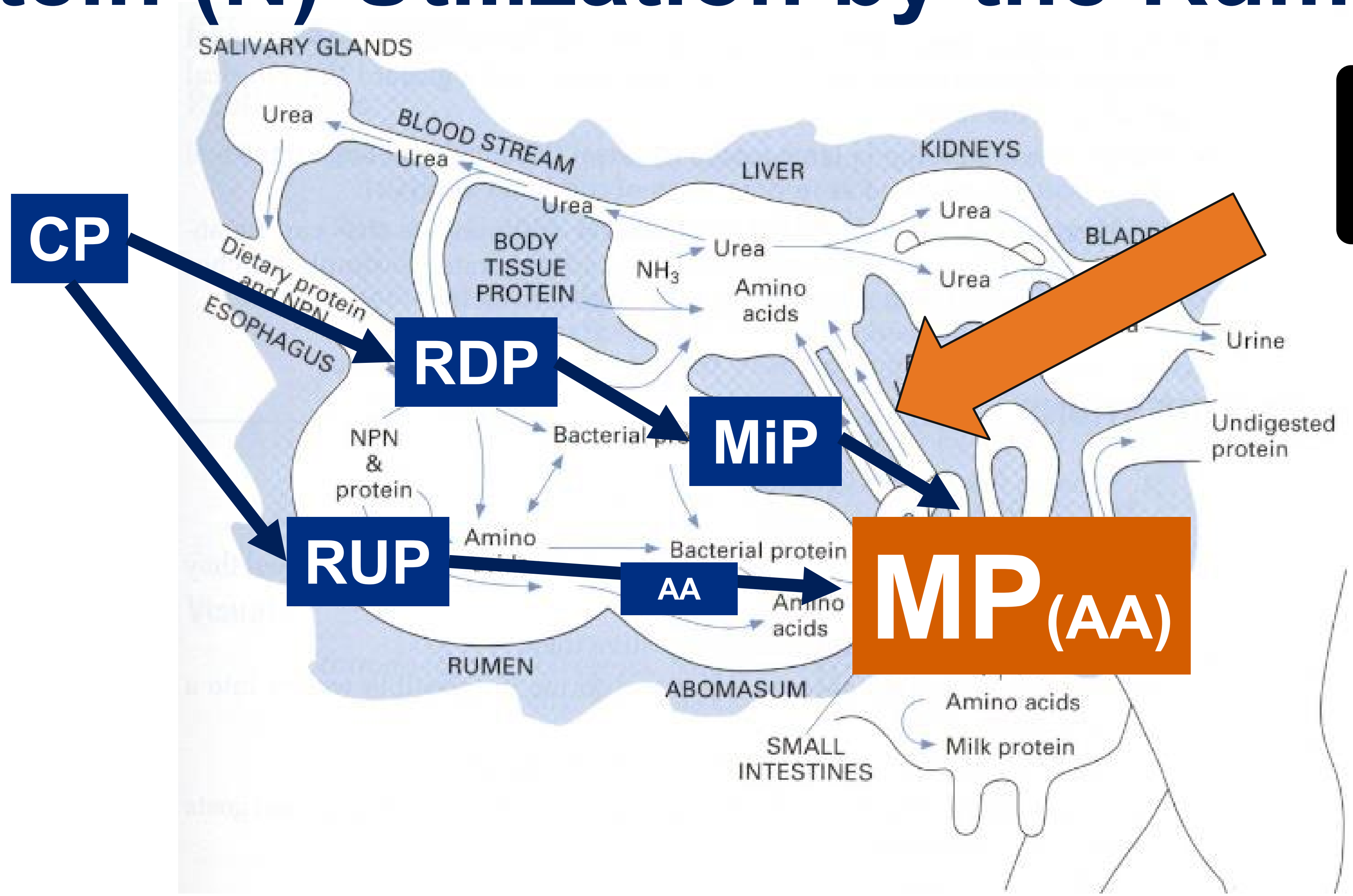

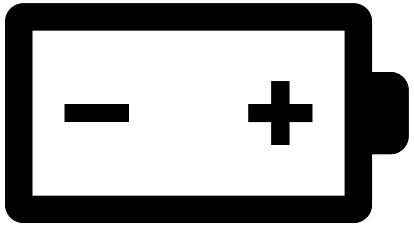

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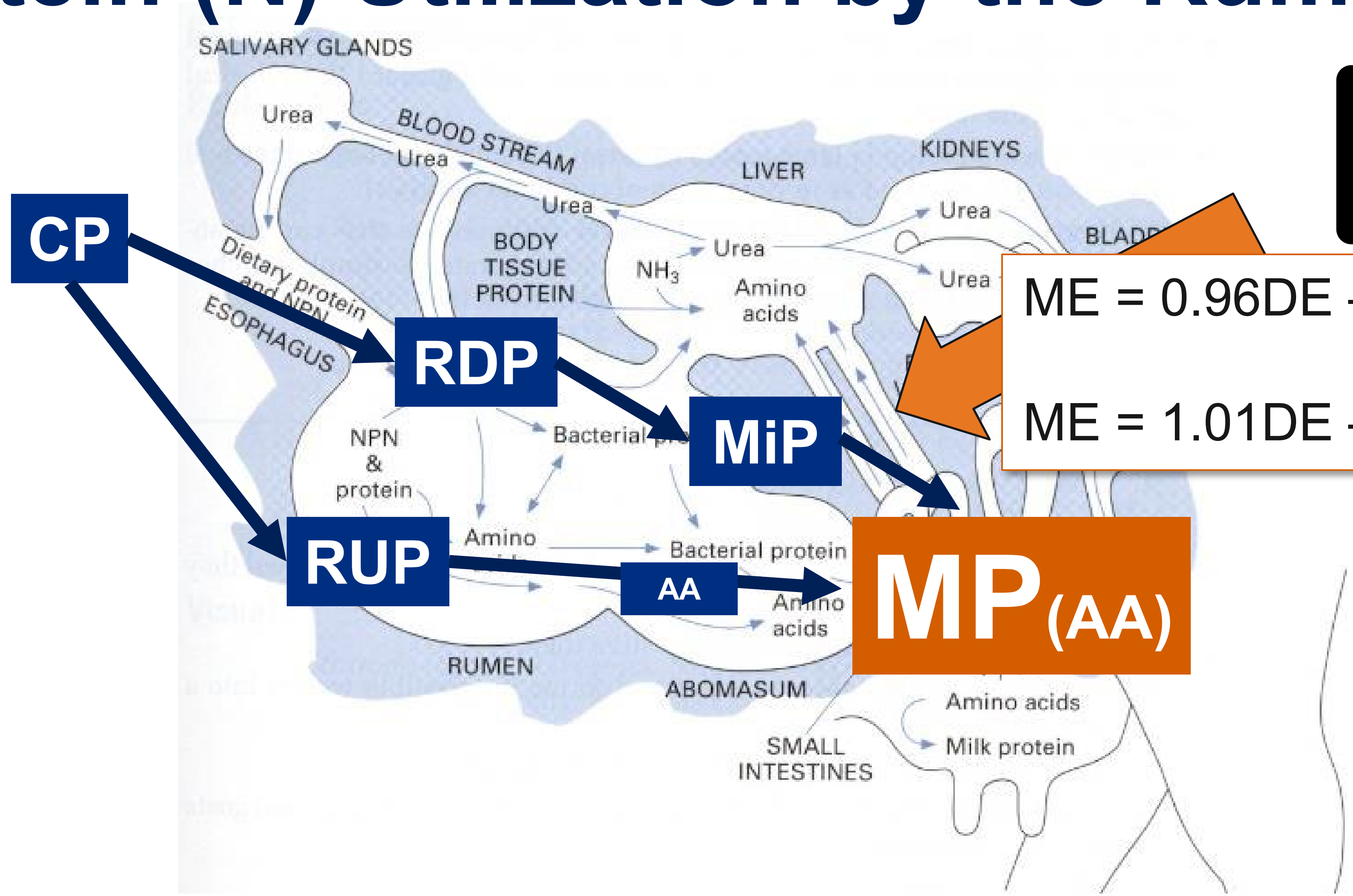

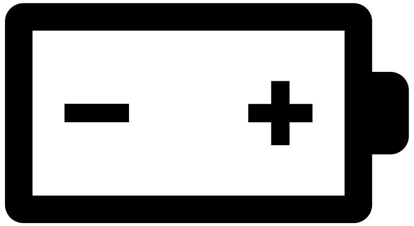

ME = 0.96DE – 0.3 (Galyean et al., 2016)

ME = 1.01DE – 0.45 (NRC, 2001)

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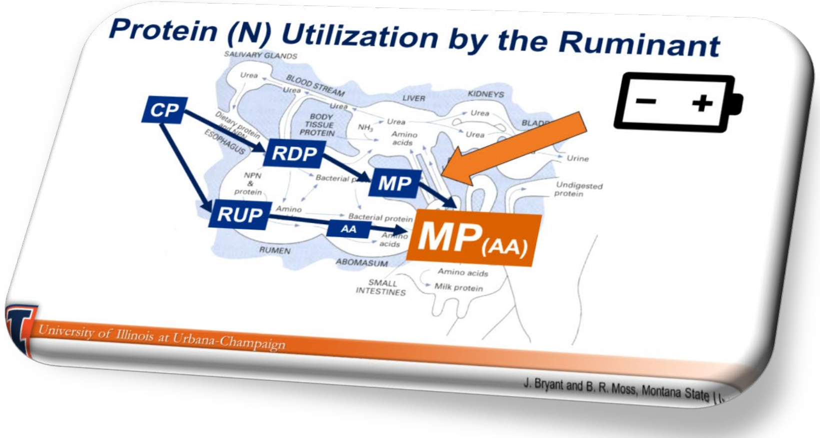
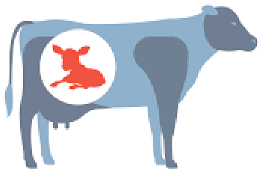
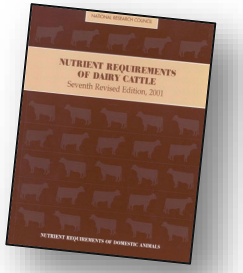
Protein requirements

Metabolizable protein (MP)



Gestation





MP Preg (g/d) = (((0.69 × DaysPreg) – 69.2) × (CBW/45))/0.33

CBW: calf birth weight

Protein requirements

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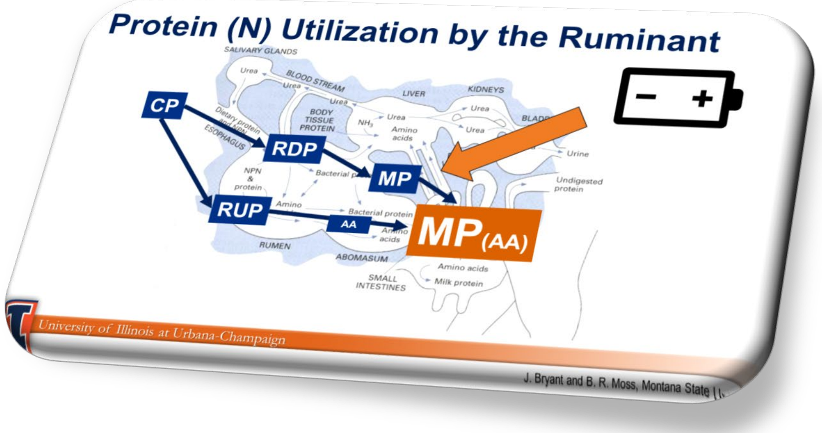

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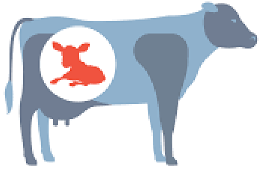

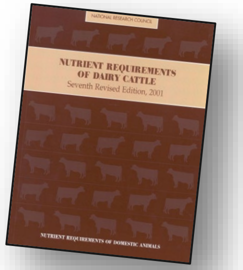

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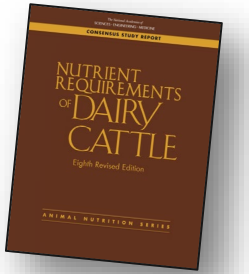
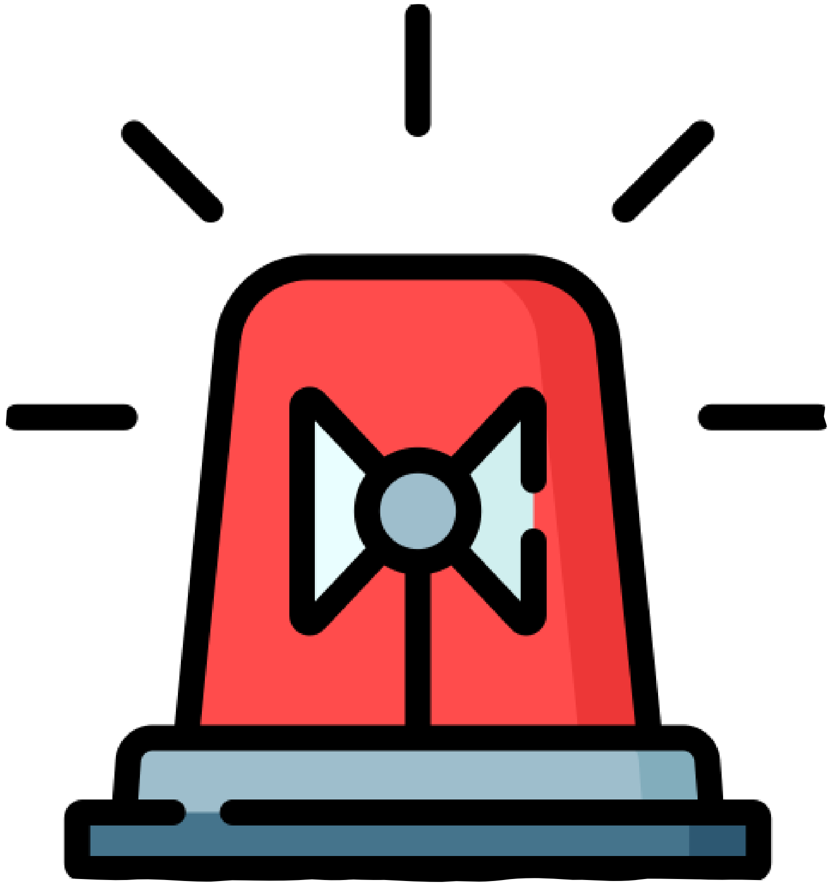


Recommended for individual EAA digestible flow = [(NetAA-scurf + NetAA-MFP) / Target_Eff_AA] + (NetAA-gestation / 0.33) + (NetAA-growth / 0.40) + AA-endogenous urinary

MFP = microbial fecal protein

Protein - NASEM 2021 model



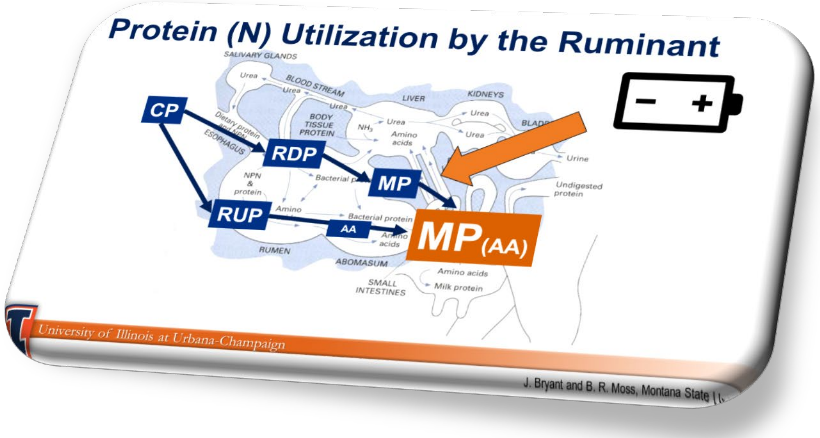
Close-up cow and heifer

- ~13% CP (7.8% MP) will meet requirement
- Translates to 936 g/d (DMI 26.4 lb/d) to 1014 g/d (DMI 28.6 lb/d)
- Might not be optimum for heifers

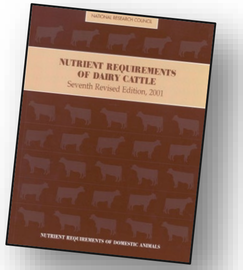
➢ Model ignores MP for colostrum, mammary development, immune function, and restoration of body protein (no data to model)

Protein requirements

Metabolizable protein (MP)



Lactation

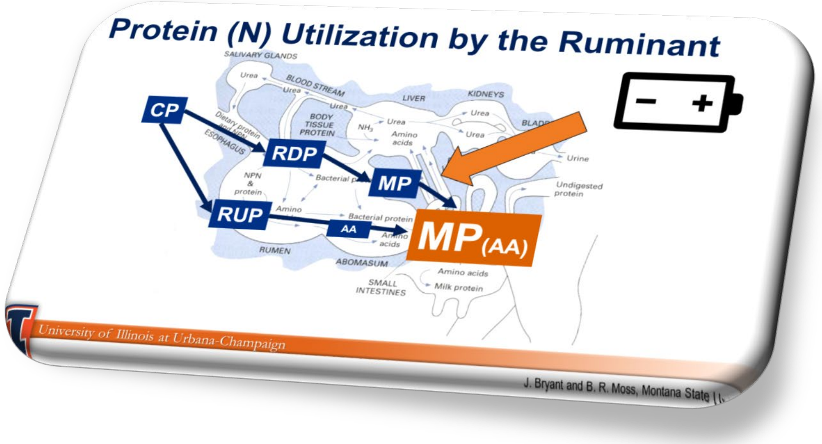


MP Lact (g/d) = (Yprotn/0.67) × 1,000

Yprotn = milk protein yield

Protein requirements

Metabolizable protein (MP)



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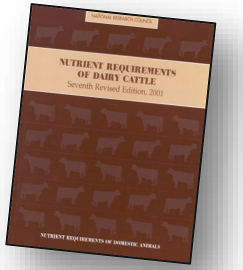

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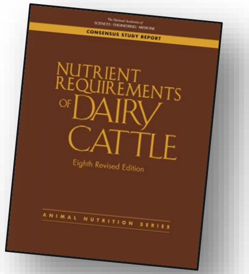

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Diet Formulation – Precision Feeding

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Ration Outputs | AA Supp. Tool | CNCPS | Min & Vit | Additives | Amino Acids | Met E & P | P & E

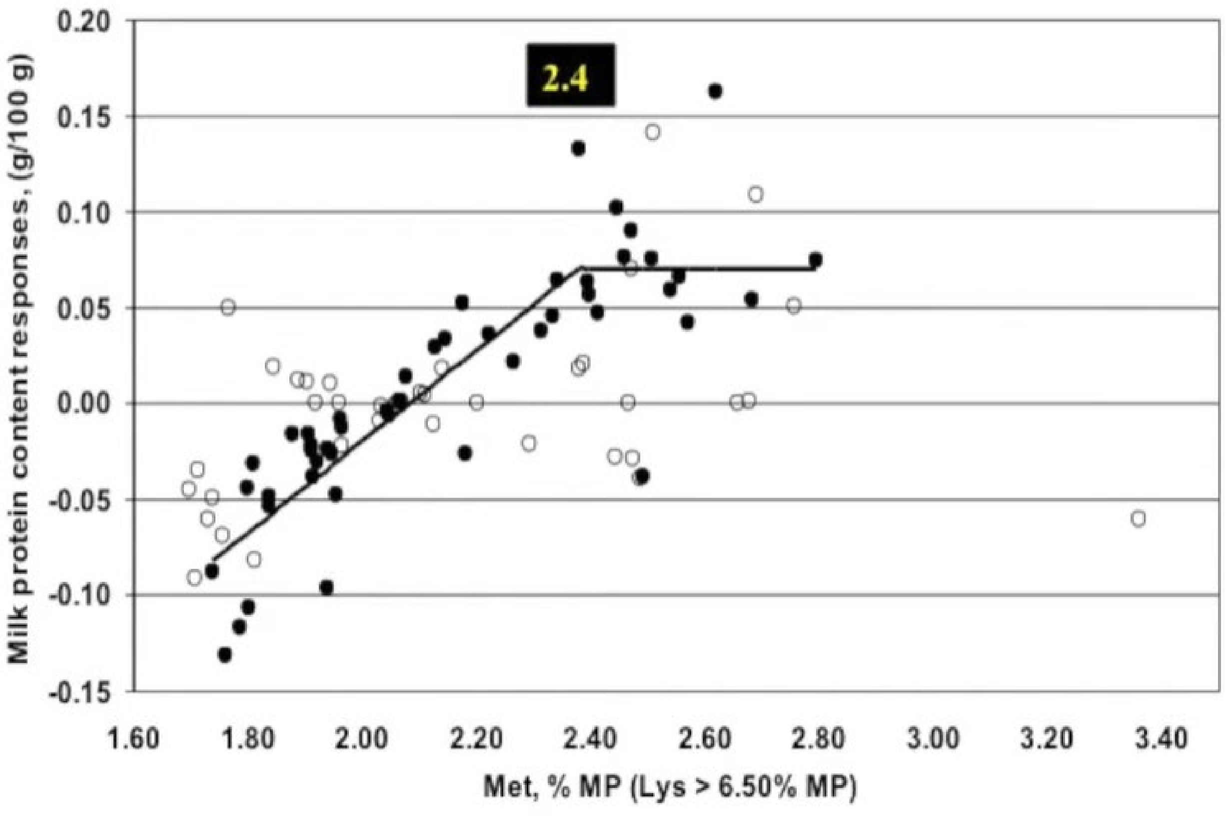
Units			Current	Desired	grams Req.
◉ % MP ○ grams ○ g/Mcal		MET	2.83	0.00	0
		LYS	7.56	0.00	0

Feed	MET			LYS	
	lbs/day	$/hd		lbs/day	$/hd

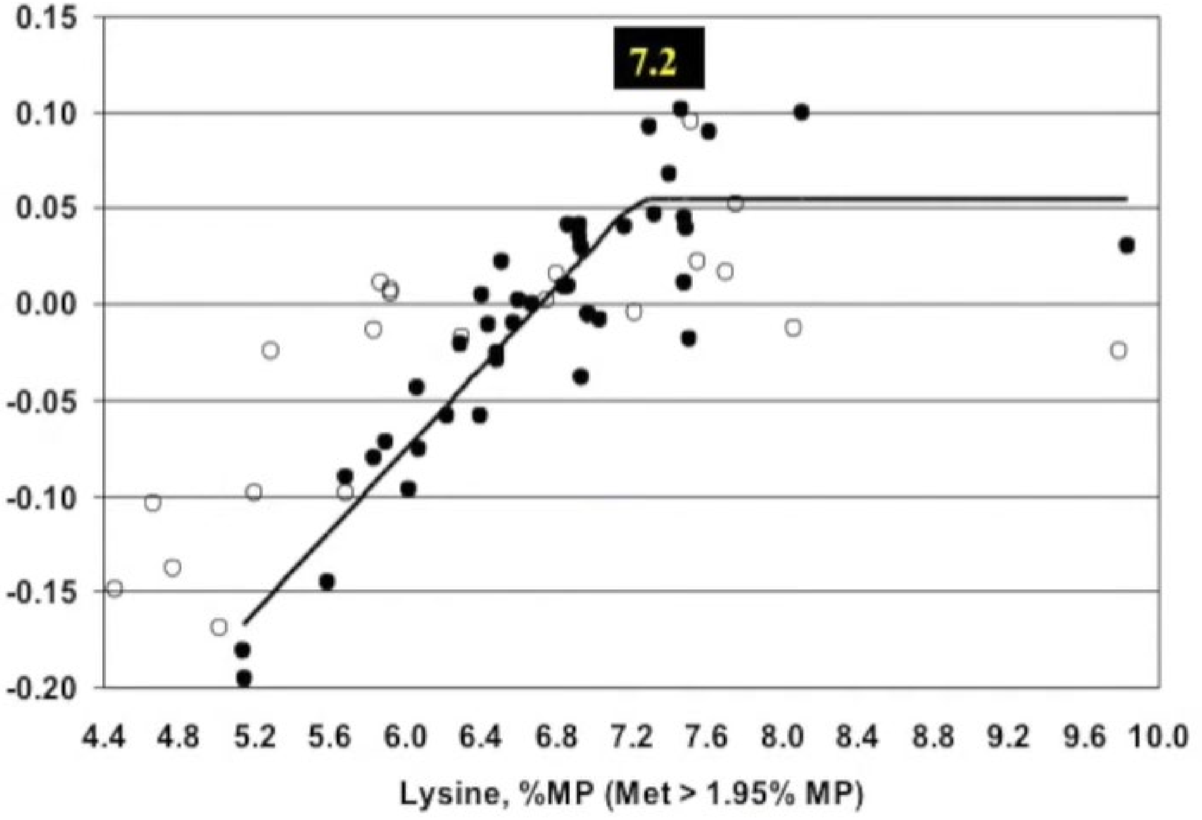
AMTS

Fehlberg et al., 2020

Methionine

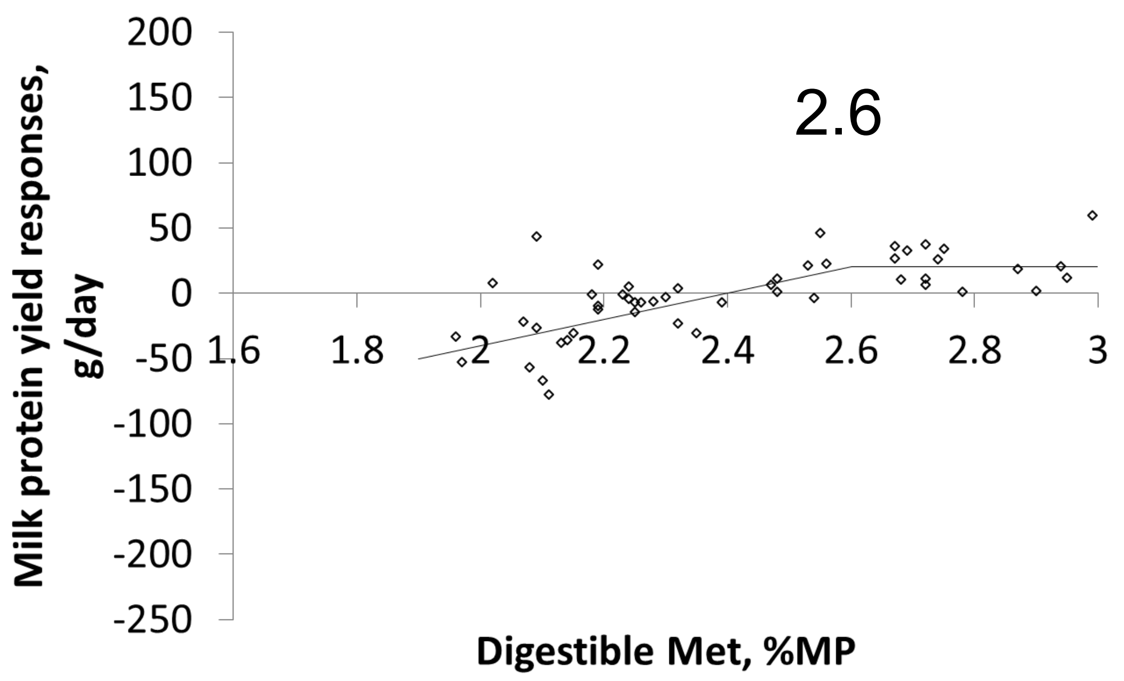


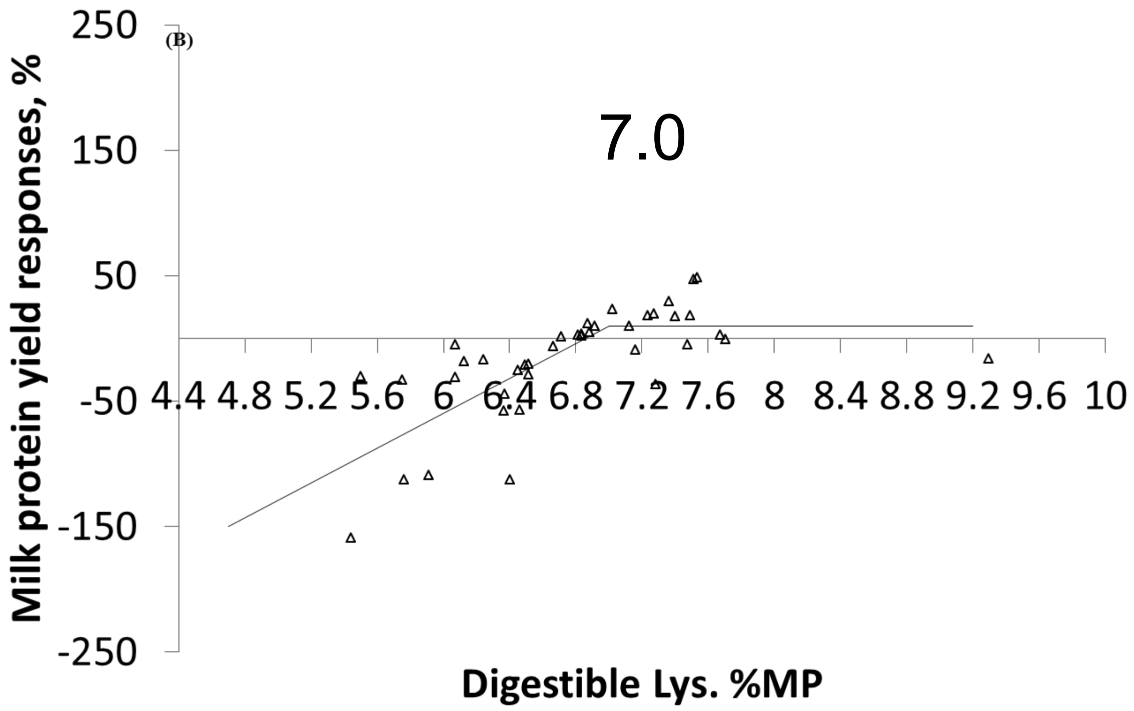
Lysine



NRC, 2001

Optimum Lys and Met (% MP) for the CNCPS V6.5





Practical Lys (%MP) >6.4 – Lys:Met = 2.69:1 – Practical Met (%MP) >2.37

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Units		Current	Desired	grams Req.
( ) % MP (●) grams ( ) g/Mcal	MET	33.38	0.00	0
	LYS	89.28	0.00	0

Feed	MET			LYS	
	lbs/day	$/hd		lbs/day	$/hd

Fehlberg et al., 2020

Diet Formulation – Precision Feeding

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Units		Current	Desired	grams Req.
( ) % MP (●) grams ( ) g/Mcal	MET	33.38	0.00	0
	LYS	89.28	0.00	0

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Units		Current	Desired	grams Req.
( ) % MP ( ) grams (●) g/Mcal	MET	1.18	0.00	0
	LYS	3.16	0.00	0

Feed	MET			LYS	
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AMTS

Fehlberg et al., 2020

Diet Formulation – Precision Feeding

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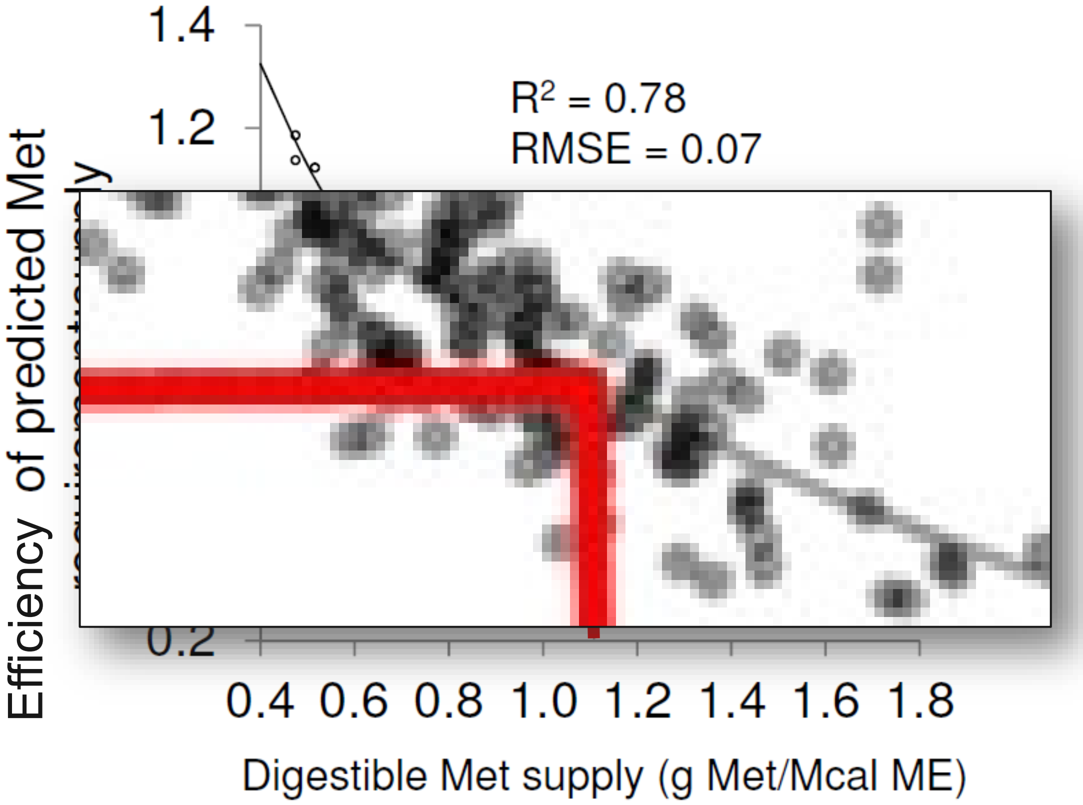

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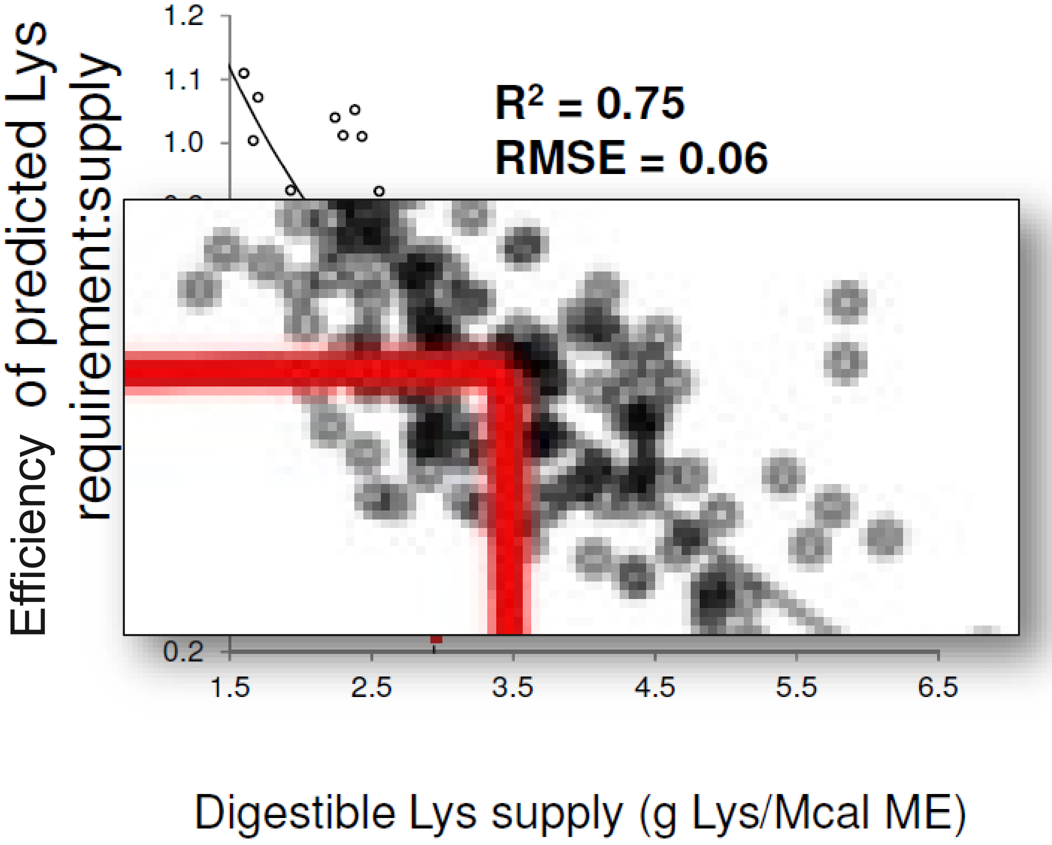

Adapted from Van Amburgh, 2019

Effects of Precision Essential Amino Acid Formulation on a Metabolizable Energy Basis for Lactating Dairy Cows

- One hundred and forty-four (n = 144) Holstein cows [26 primiparous and 118 multiparous; 2.9 ± 1.4 lactations; 92 ± 24 DIM at enrollment] were enrolled in a 114 day longitudinal study.
- Cattle were blocked into 16 cow pens (free stall) and balanced for parity, DIM, previous lactation performance, and current body weight.
- Each pen was fed TMR once daily at approximately 0600 h and pens were targeted for 5% refusal rate. All nine pens were fed the POS diet during a 14 day covariate period and randomly assigned to one of three diets described above for the remaining 100 d.

LaPierre et al., 2019

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	-1 SD		+1 SD
Item	Negative	Neutral	Positive
CP, % of DM	14.04	14.75	15.95
Soluble fiber, % of DM	6.01	5.55	5.05
ADF, % of DM	20.79	19.96	19.77
NDF, % of DM	32.39	31.03	31.39
uNDF240, % of NDF	25.5	29.09	28.73
Lignin, % of NDF	8.06	9.65	8.73
Starch, % of DM	29.82	29.31	29.30
Sugar. % of DM	3.95	4.06	3.9
Ether extract, % of DM	3.49	3.61	3.78
Ash, % of DM	6.60	6.92	6.57
Metabolizable Energy, Mcal/kg of DM	2.58	2.60	2.61
Methionine, g	71.44	78.30	92.67
Methionine, g AA/Mcal ME[1]	1.01	1.09	1.29
Lysine, g	201.70	222.12	250.07
Lysine, g AA/Mcal ME[1]	2.84	3.00	3.49
Histidine, g	62.78	70.42	83.81
Histidine, g AA/Mcal ME[1]	0.88	0.98	1.17

[1] formulated

LaPierre et al., 2019

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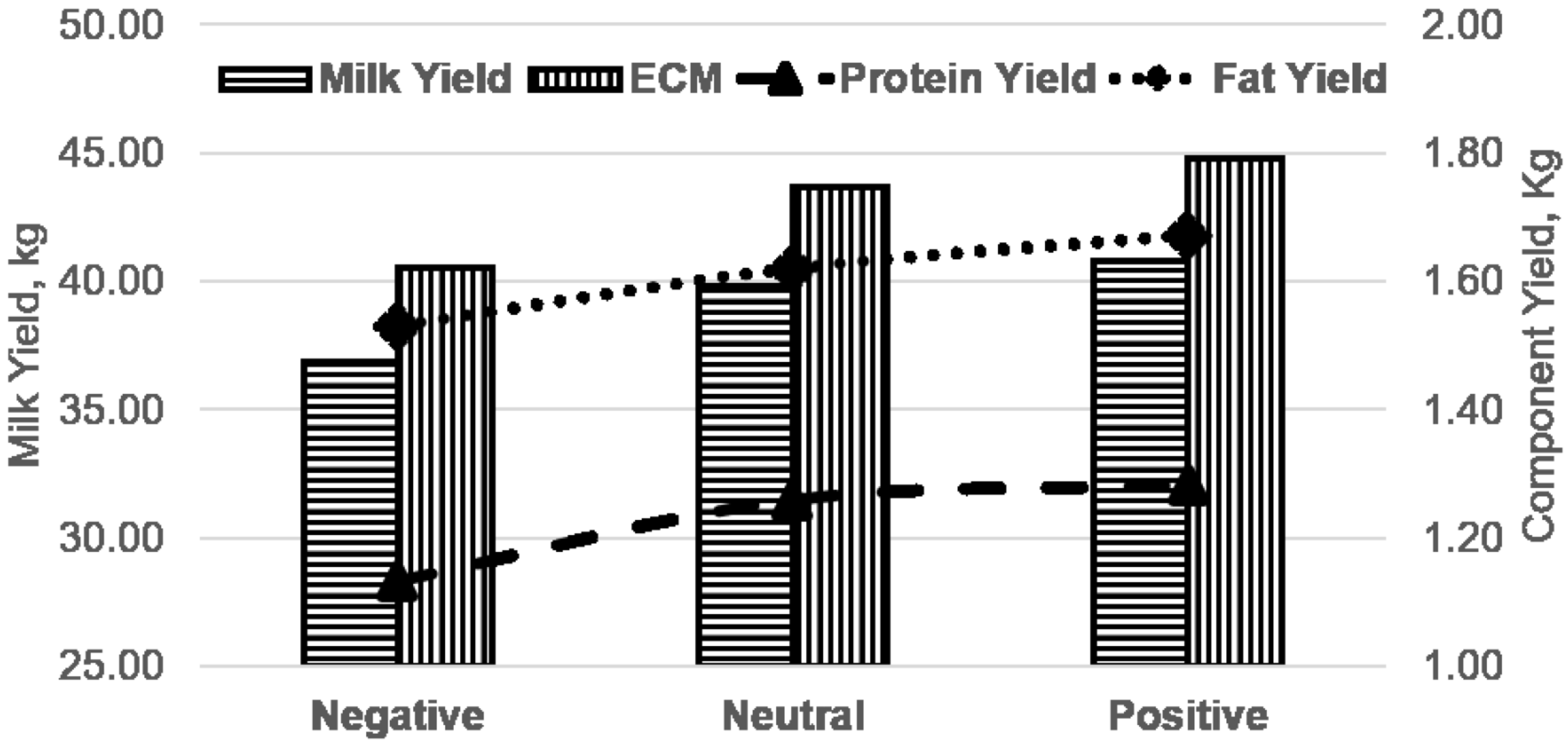
Cows fed ***Neutral*** produced similar levels of energy corrected milk and yield similar production of fat components when compared to cows fed the ***Positive*** treatment



No difference in dry matter intake (~28 kg/d)

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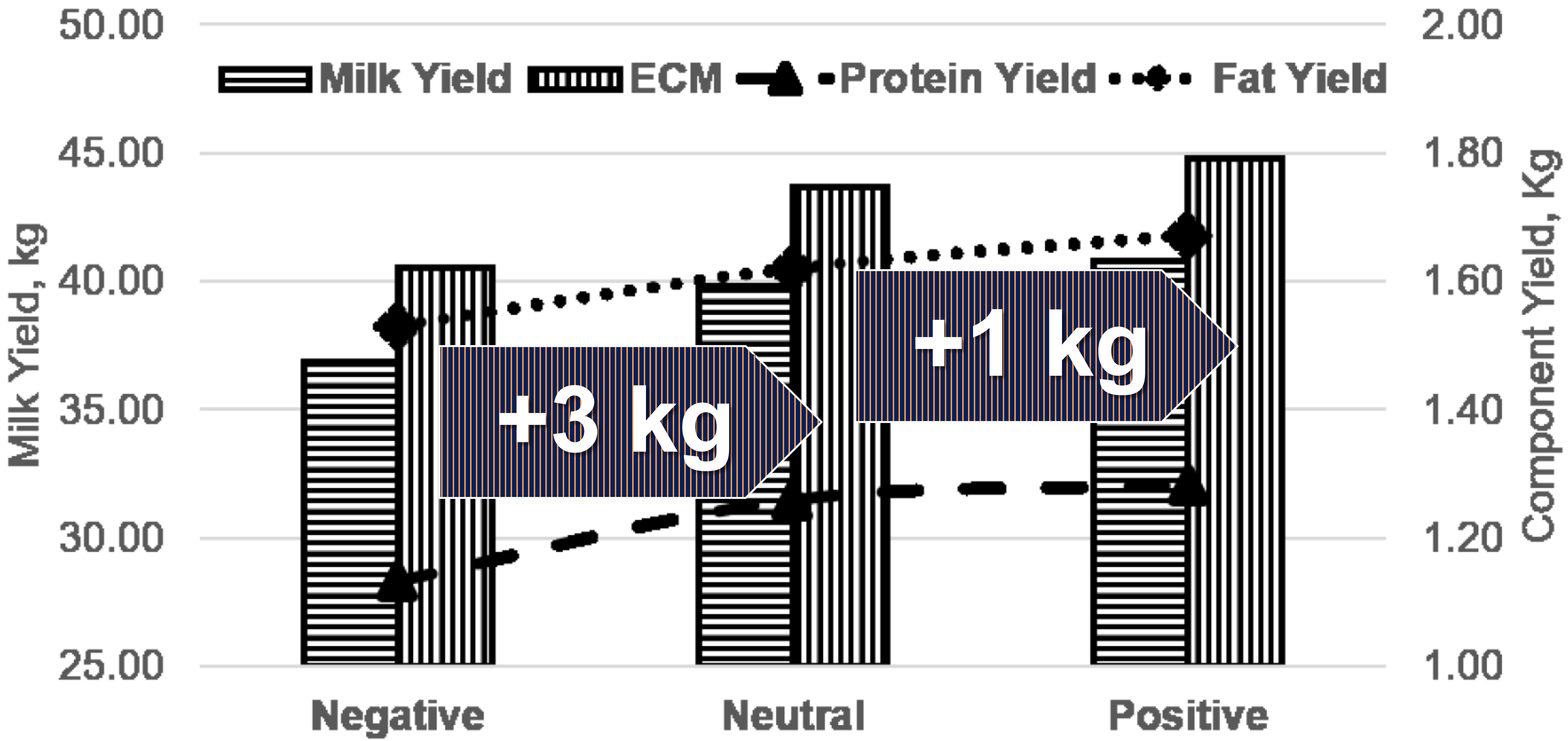

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- **Metabolizable protein (MP):** > 1,200 g/d → Met Lys
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CNCPS v6.55

1.17 g Met / Mcal of ME (1.05 – 1.10)

2.7:1 Lys:Met

2.9 – 3.20 g Lys / Mcal of ME

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CNCPS v6.55 — Lactation

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2.7:1 Lys:Met

2.9 – 3.20 g Lys / Mcal of ME

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- **NDF from forage:** 40 to 50% of total DM or 4.5 to 6 kg per head daily (~0.7 – 0.8% of BW). Target the high end of the range if more higher-energy fiber sources (like grass hay or low-quality alfalfa) are used, and the low end of the range if straw is used (2-5 kg)
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- **Minerals and vitamins:** follow guidelines (For close-ups, target values are 0.40% magnesium (minimum), 0.35 – 0.40% sulfur, potassium as low as possible (Mg:K = 1:4), a DCAD of near zero or negative, calcium without anionic supplementation: 0.9 to 1.2% (~125g) calcium with full anion supplementation: 1.5 to 2.0% (~200g), 0.35 – 0.42% phosphorus, at least 1,500 IU of vitamin E, and 25,000 – 30,000 IU of Vitamin D (cholecalciferol)

Dietary Recommendations for Dry Cows

- **NEL:** Control energy intake at 18 to 20 Mcal daily [diet ~ 1.43 Mcal/kg (0.65 Mcal/lb) DM] for mature cows
- **…ude…tei…** – 1… of D…
- **Metabolizable protein (MP):** > 1,200 g/d

Met
Lys

CNCPS v6.55	Dry
~ 35g Met	
2.65:1 Lys:Met (92g Lys)	

- **Starch content:** 12 to 15% of DM (NFC < 26%)
- **NDF from forage:** 40 to 50% of total DM or 4.5 to 6 kg per head daily (~0.7 – 0.8% of BW). Target the high end of the range if more higher-energy fiber sources (like grass hay or low-quality alfalfa) are used, and the low end of the range if straw is used (2-5 kg)
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9502

Evaluation of rumen-protected amino acids (RPAA; methionine and Lysine) supplementation in a close-up diet with <u>two energy levels</u> on performance, health, and fertility of Holstein cows during the transition period and early lactation

O’Meara et al., 2025

From – 21 through 70 days in milk

	Prepartum			Postpartum
Composition of MP[1]	HEAA[2] NE_L 1.71 Mcal/kg of DM	CEAA[3] NE_L 1.45 Mcal/kg of DM	CENAA[3] NE_L 1.45 Mcal/kg of DM	Fresh[4] NE_L 1.73 Mcal/kg of DM
Metabolizable protein, g/d	1372	1200	1186	2262
Lys, % of MP	7.30	7.34	6.82	7.26
Met, % of MP	2.76	2.77	2.23	2.73
Lys:Met	2.64	2.65	3.06	2.66
Lys, g/d	99.53	88.15	81.02	164.32
Met, g/d	37.63	33.24	26.4	61.71
Lys, g/Mcal	3.21	3.21	2.94	3.21
Met, g/Mcal	1.21	1.21	0.96	1.21

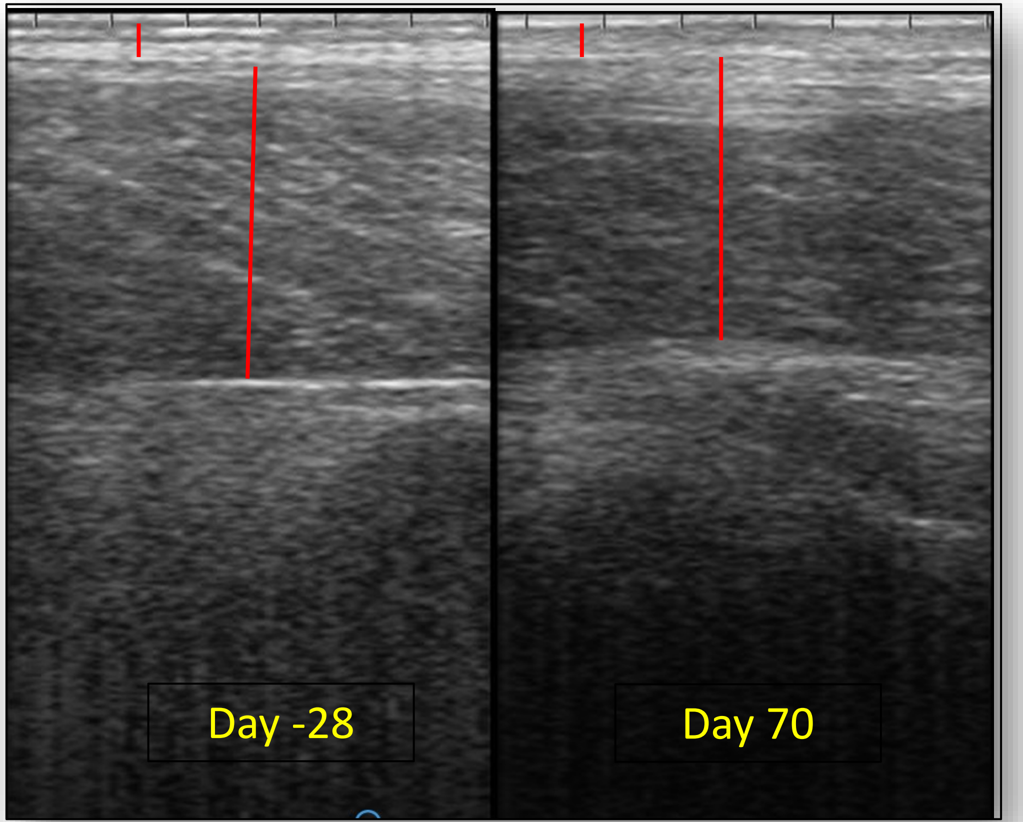
Rumen-protected Met top-dressed
0.093% of DMI prepartum; CE
0.115% of DMI prepartum; HE
0.150% of DMI postpartum

Rumen-protected Lys top-dressed
0.150% of DMI prepartum; CE
0.214% of DMI prepartum; HE
0.375% of DMI postpartum

[1]Metabolizable protein and AA predicted by AMTS
[2]Formulated for a dry cow at 1562 lb BW and 28.07 lb/d
[3]Formulated for a dry cow at 1562 lb BW and 29.13 lb/d
[4]Formulated for a cow at 14 days in milk, 1649 lb BW, producing 88.2 lb/d of milk

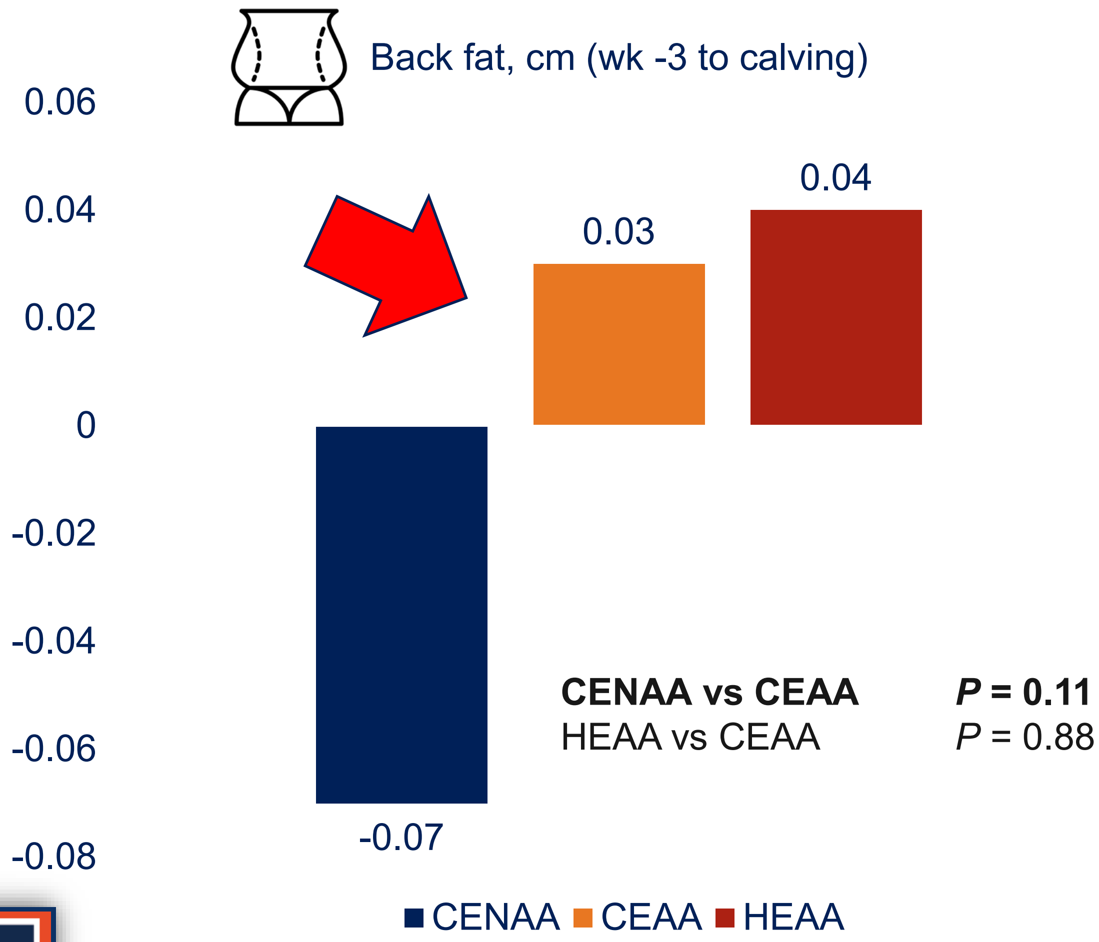
O'Meara et al., 2025

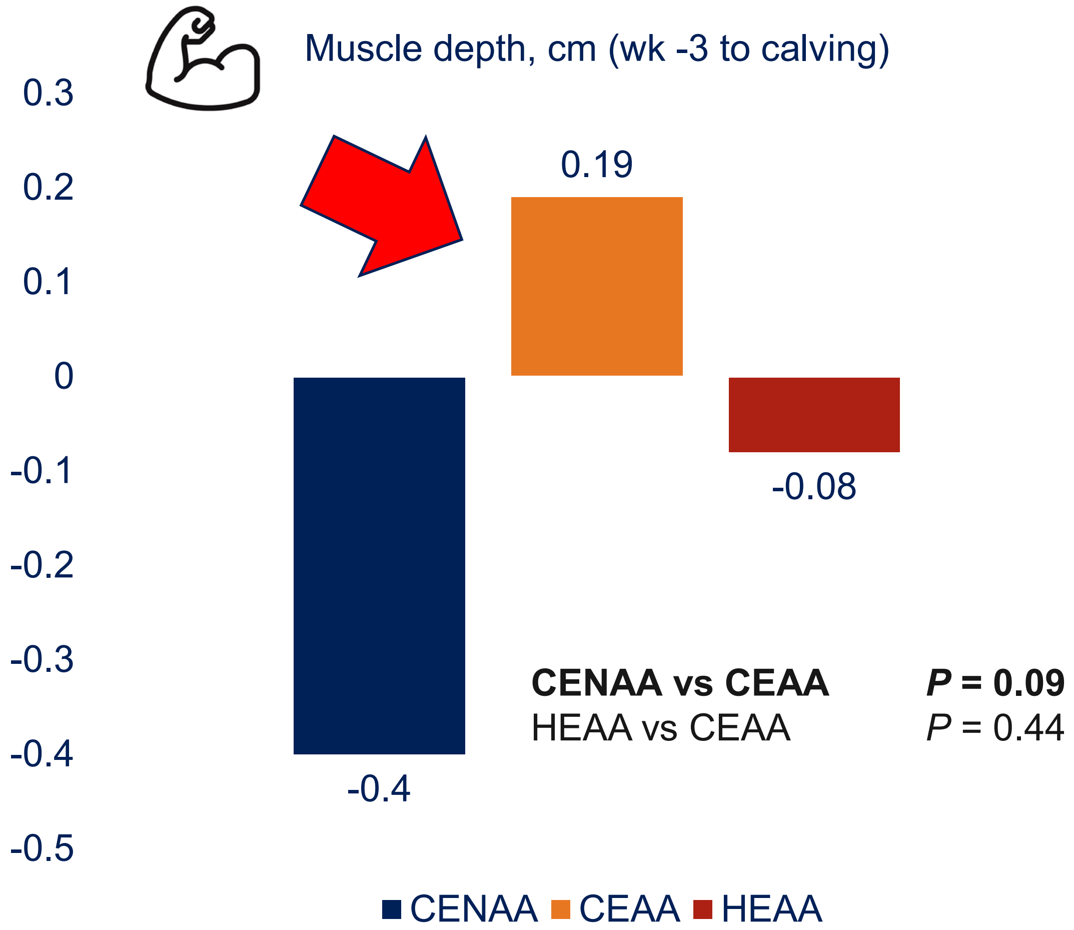
Ultrasound measurement of backfat thickness and muscle depth in Holstein cows



O’Meara et al., *unpublished*

Cows that consumed RPAA prepartum had reduced *muscle* depth and *back fat* change



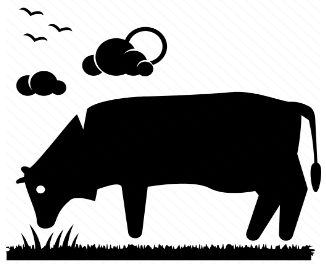


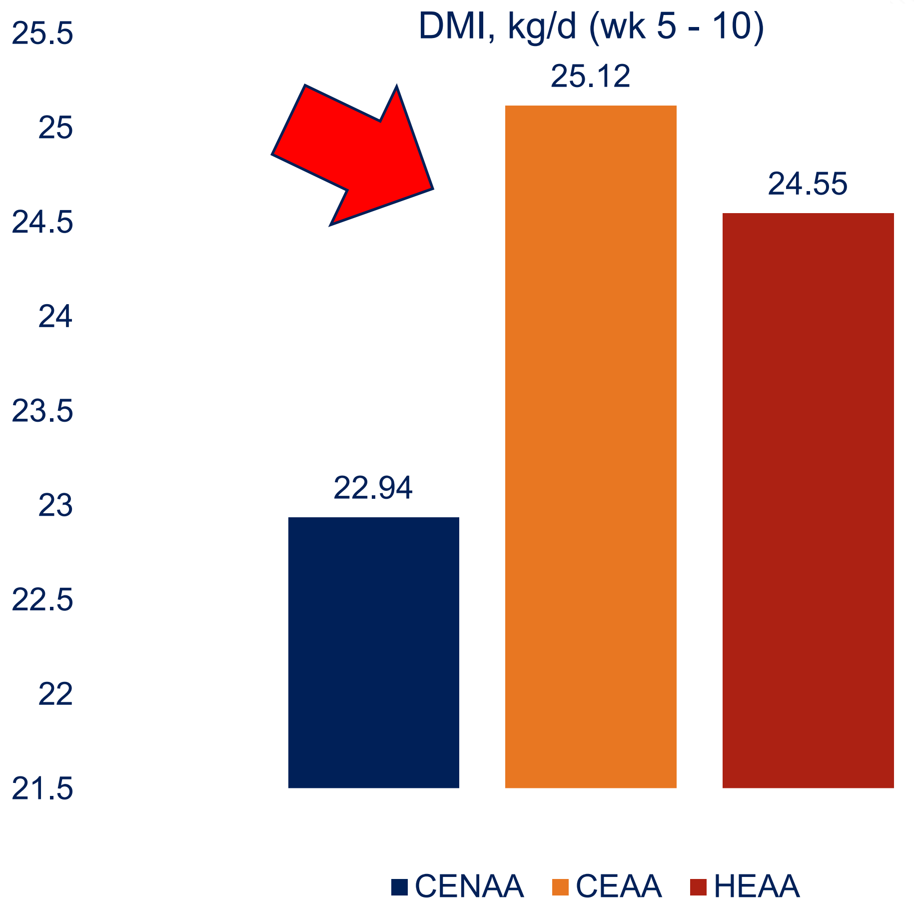
Data was collected at days -28, -14, -7, and 0

O'Meara et al., *unpublished*

Cows that consumed rumen-protected AA had higher DMI than cows that did not receive RPAA from WK 5 – 10

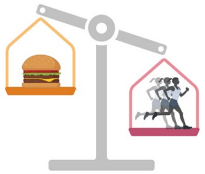
CENAA vs CEAA ***P* = 0.02**
HEAA vs CEAA *P* = 0.53



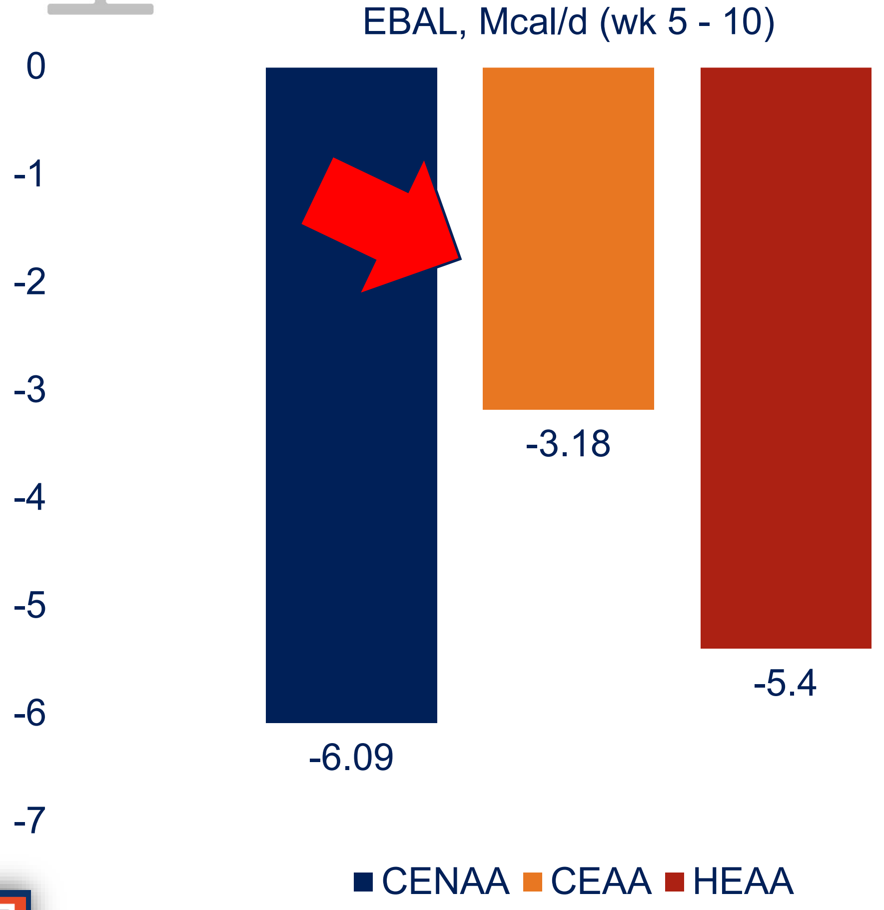


O'Meara et al., 2025

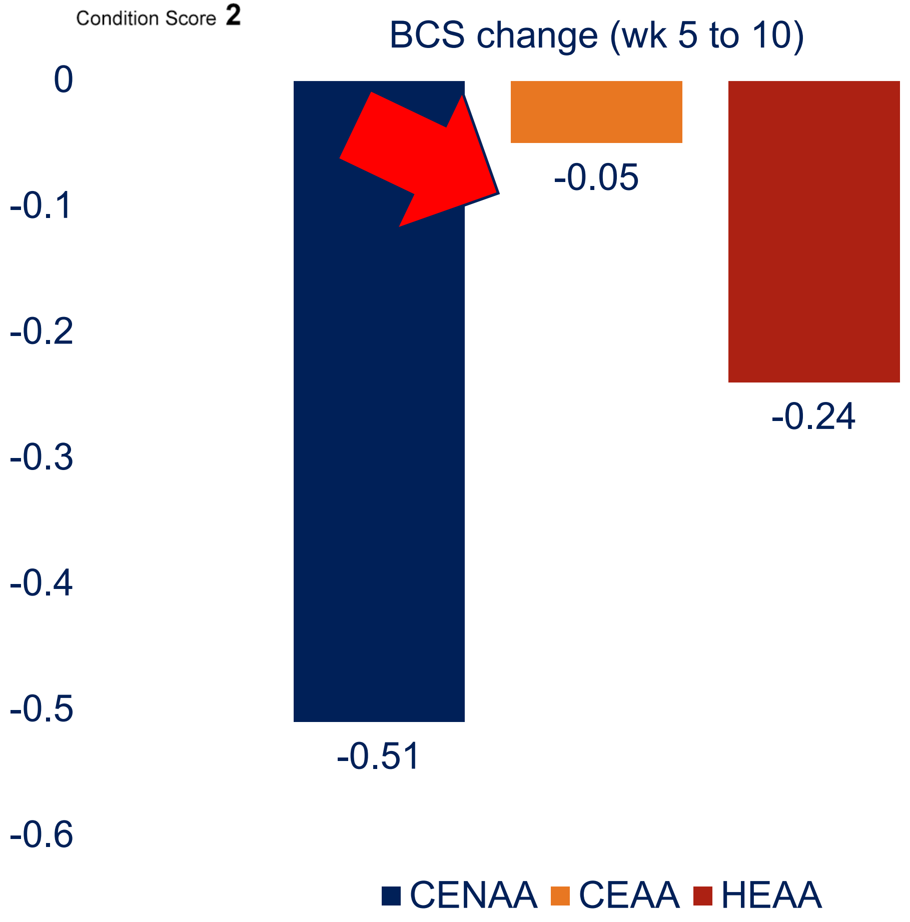
Cows in CEAA had improved energy balance from WK 5 – 10



CENAA vs CEAA ***P* = 0.01**
HEAA vs CEAA ***P* = 0.06**



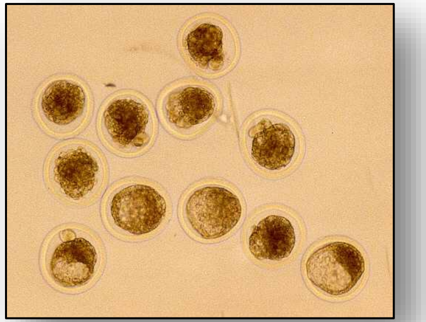
CENAA vs CEAA ***P* = 0.01**
HEAA vs CEAA *P* = 0.24



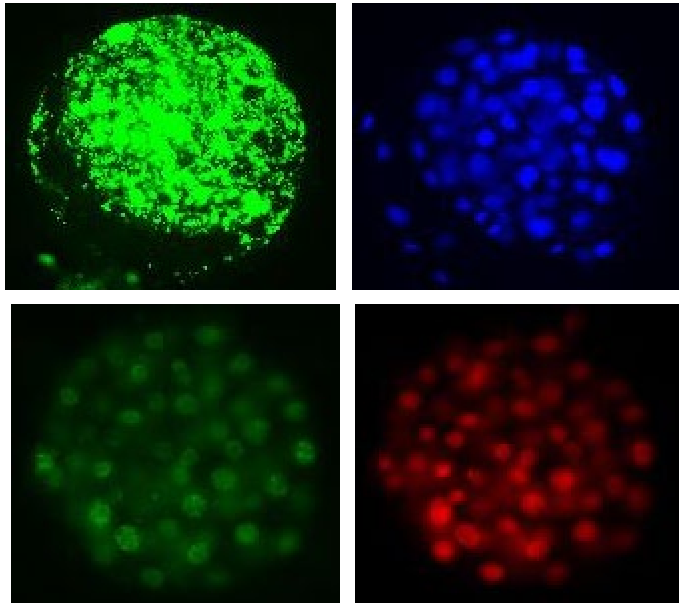
O’Meara et al., 2025

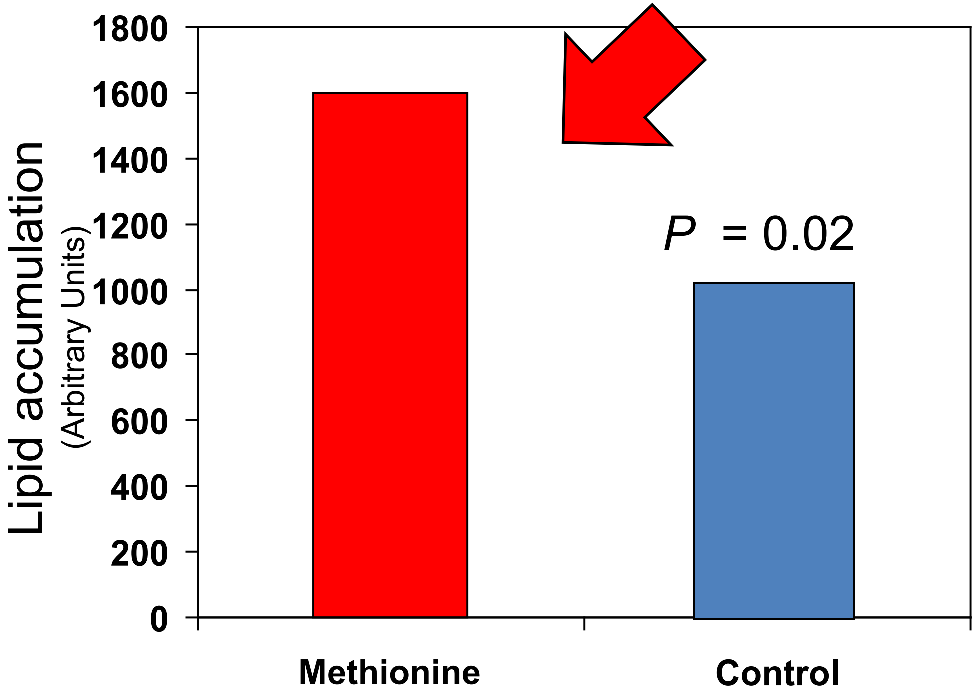

9357
9358

Effect of Methionine Supplementation from -21 to 72 Days relative to calving on Lipid Accumulation of Preimplantation Embryos



Embryos (n = 37) harvested 7 d after timed AI at 63 DIM from cows fed a control diet or the control diet enriched with rumen-protected methionine.

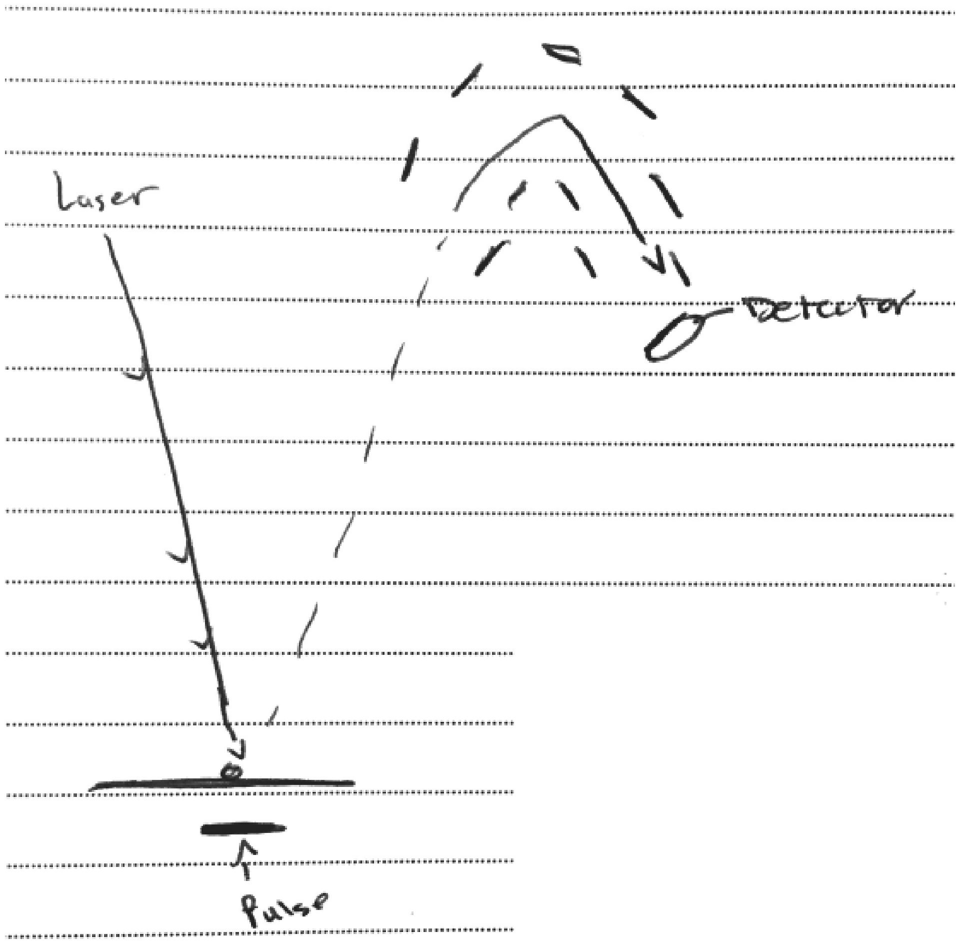




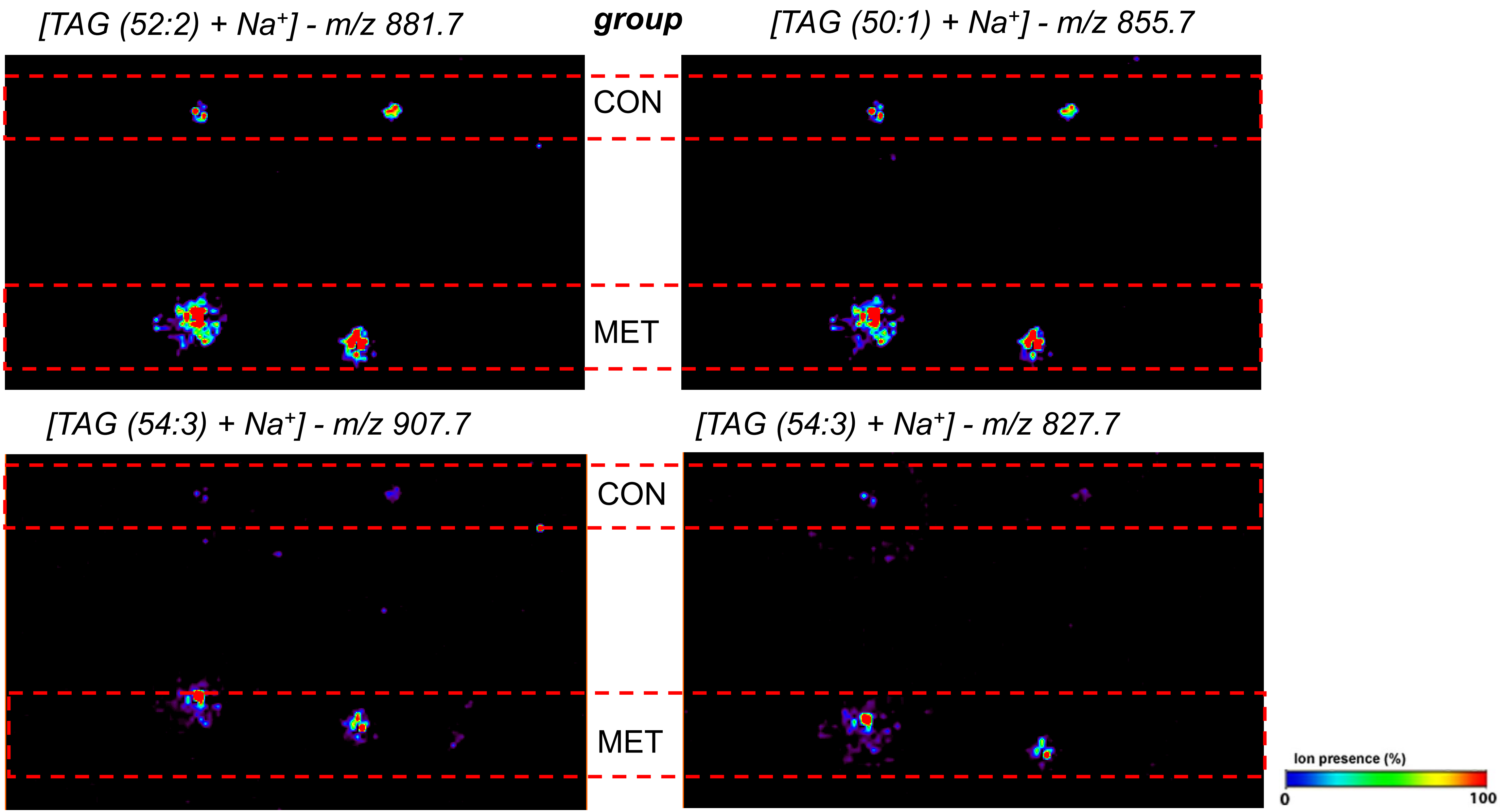
Fluorescence intensity of Nike Red staining

Acosta et al., 2016

Matrix-assisted laser desorption/ionization mass spectrometry imaging (MALDI-MSI)

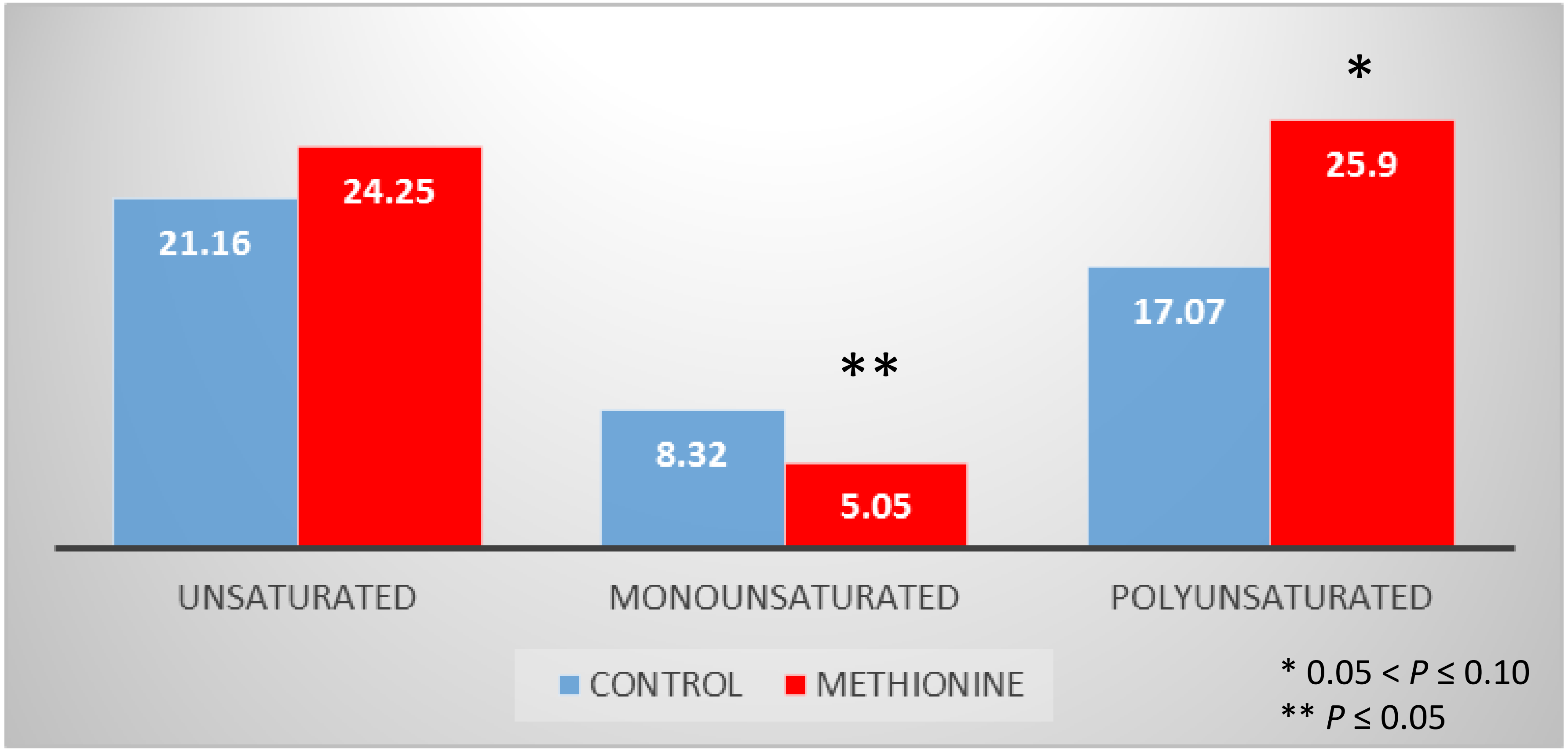


Stella et al., 2023



Stella et al., 2023

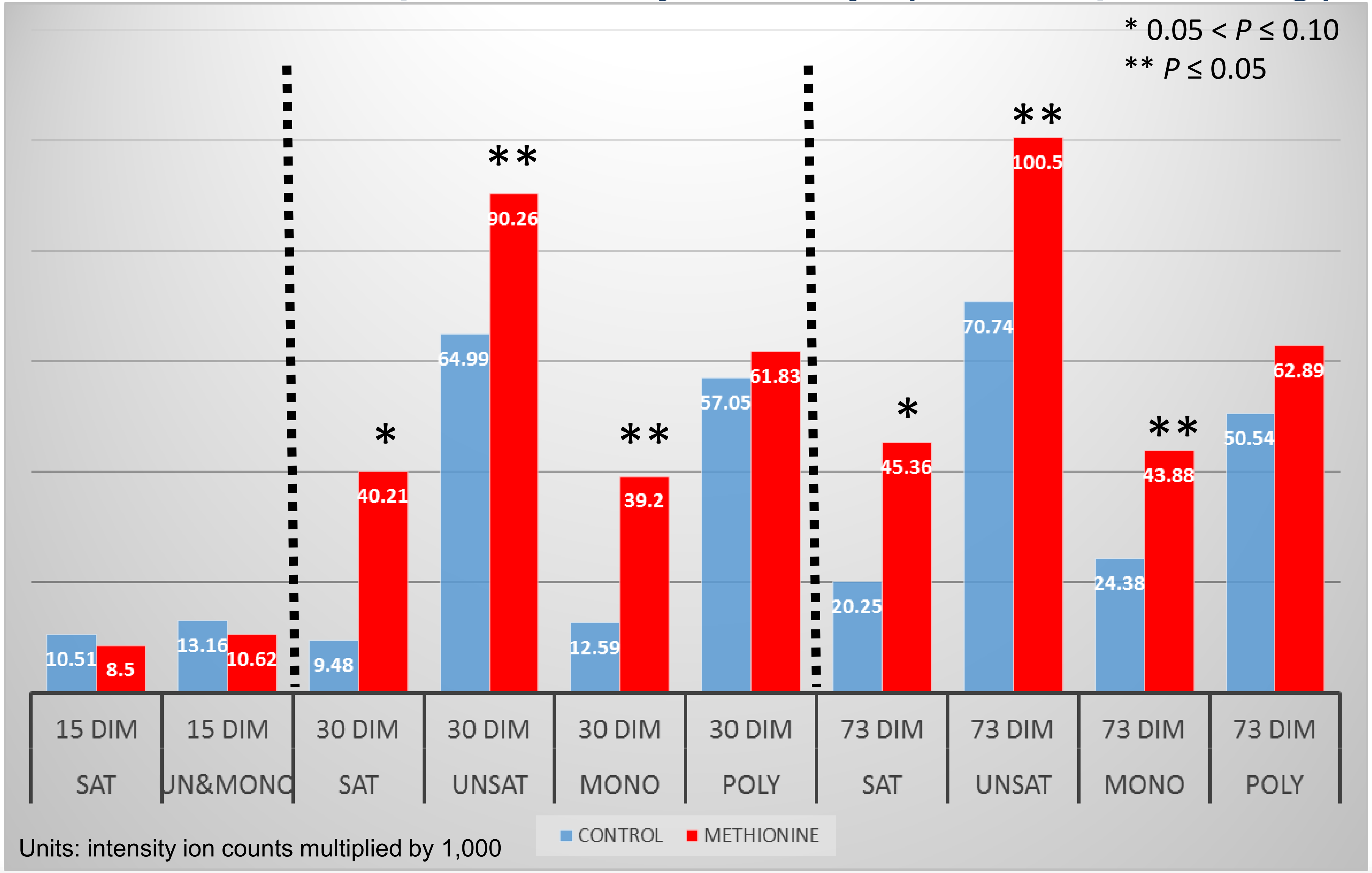
Embryo samples analyzed by (MALDI-MSI)



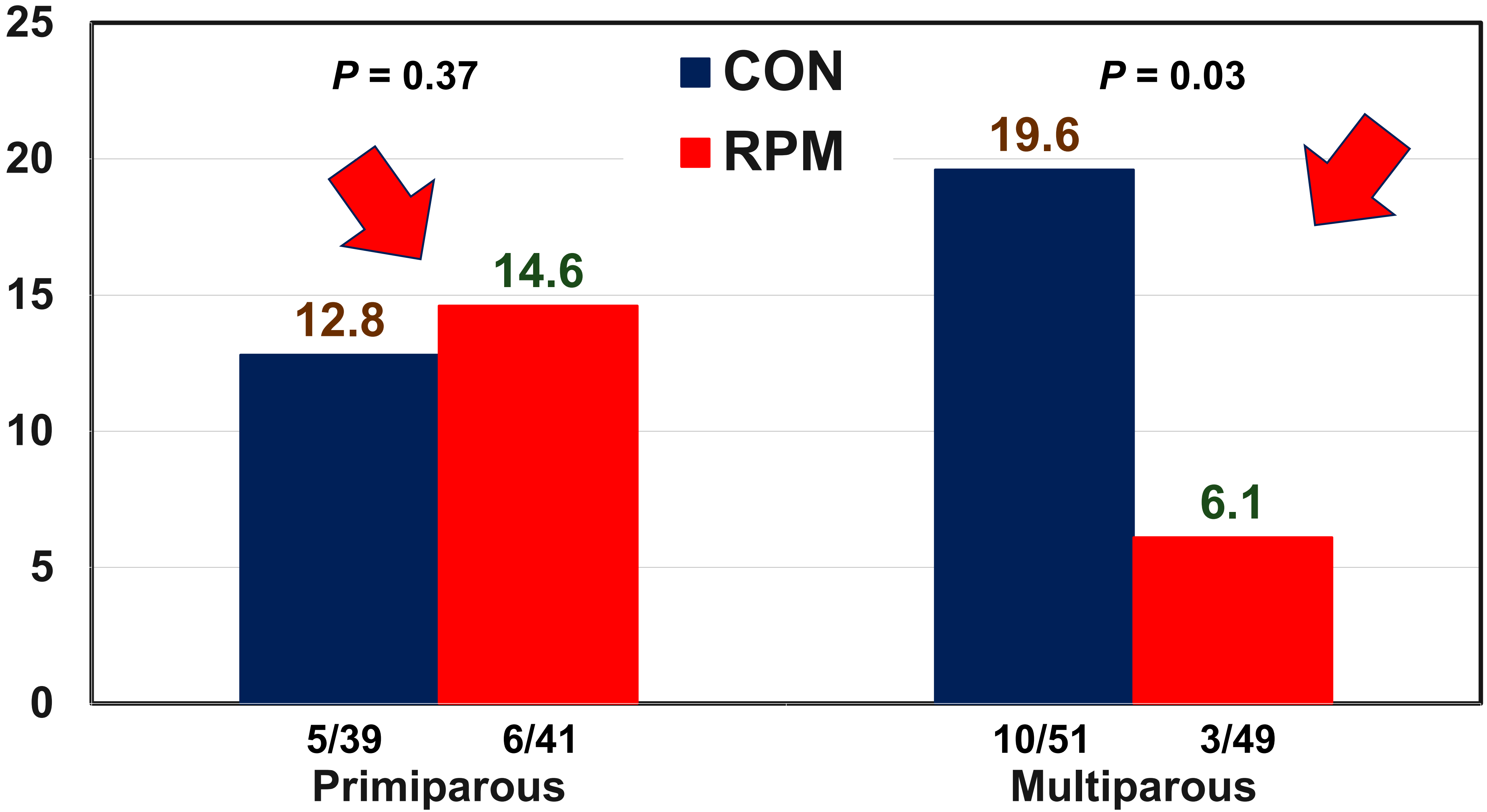
Units: intensity ion counts multiplied by 1,000

Stella et al., 2023

Uterine samples analyzed by (MRM-profiling)

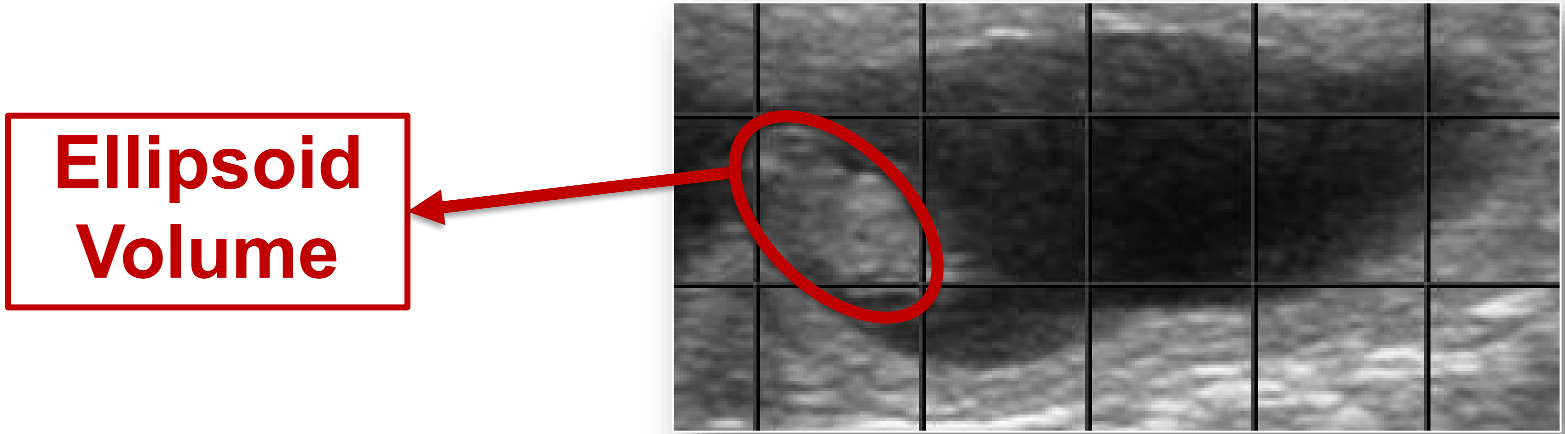


Pregnancy Losses (%) from 28 to 61 days after AI



Toledo et al., 2017

Amniotic vesicle size



Day 33	n	Volume (mm^3) ± SEM
Primiparous		
Control	31	**610.6** ± 38.6
RPM	36	**596.0** ± 36.9
P-value		**0.71**
Multiparous		
Control	35	**472.3** ± 28.6
RPM	45	**592.1** ± 46.0
P-value		**0.05**

Toledo et al., 2017

How about Lysine?

Feeding rumen-protected lysine prepratum increases energy corrected milk and milk component yields in Holstein cows during early lactation


J. Dairy Sci. 103:11386–11400
https://doi.org/10.3168/jds.2020-18542

Feeding rumen-protected lysine prepartum increases energy-corrected milk and milk component yields in Holstein cows during early lactation

L. K. Fehlberg, A. R. Guadagnin, B. L. Thomas, Y. Sugimoto, I. Shinzato, and F. C. Cardoso

ABSTRACT

INTRODUCTION

11386

PRE + → POST + / POST -

CALVING

PRE - → POST + / POST -

⇒

PRE-L POST-L

PRE-L POST-C

PRE-C POST-L

PRE-C POST-C

Fehlberg et al., 2020

TMR

Ingredient, % of DM	Prepartum	Postpartum
Corn silage	31.06	39.38
Canola meal	1.45	5.36
Alfalfa hay	-	20.95
Wheat midds	4.10	-
Corn gluten feed	6.69	-
Soybean meal, 48% CP	2.19	-
Wheat straw	40.25	-
Ground corn	0.16	15.26
Rumen-protected methionine	0.12	0.09
Rumen-protected fat	-	1.93
Soybean meal expeller	5.74	6.66
Anionic salt	3.85	-
Urea 46%	0.23	0.30
Mg oxide	-	0.09
Mg sulfate	0.25	-
Dicalcium phosphate	-	0.33
Molasses	-	4.43
Ca carbonate	2.08	-
Vitamin and mineral prepartum	1.31	-
Vitamin and mineral postpartum	-	4.73

Chemical composition

Item	Prepartum	Postpartum
DM, %	43.43 ± 1.42	45.71 ± 1.64
CP, % of DM	**14.22 ± 0.68**	**16.75 ± 1.06**
ADF, % of DM	28.41 ± 2.80	20.94 ± 1.77
NDF, % of DM	44.82 ± 2.75	31.25 ± 3.29
Lignin, % of DM	4.44 ± 0.74	3.80 ± 0.49
Starch, % of DM	**13.99 ± 1.69**	**24.39 ± 2.62**
Ehter extract, % of DM	3.03 ± 0.21	4.95 ± 0.51
Ash, % of DM	10.34 ± 1.34	9.16 ± 0.74
NE_L, Mcal/kg of DM	1.44 ± 0.03	1.67 ± 0.05
Ca, % of DM	1.46 ± 0.35	1.12 ± 0.21
P, % of DM	0.37 ± 0.04	0.41 ± 0.04
Mg, % of DM	0.50 ± 0.07	0.38 ± 0.03
K, % of DM	1.12 ± 0.11	1.75 ± 0.17
Mn, ppm	91.9 ± 17.5	99.3 ± 13.7
Mo, ppm	1.20 ± 0.30	1.32 ± 0.30

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Mo, ppm	1.20 ± 0.30	1.32 ± 0.30

Rumen-protected Lysine top-dressed
0.54% of DMI prepartum
0.40% of DMI postpartum

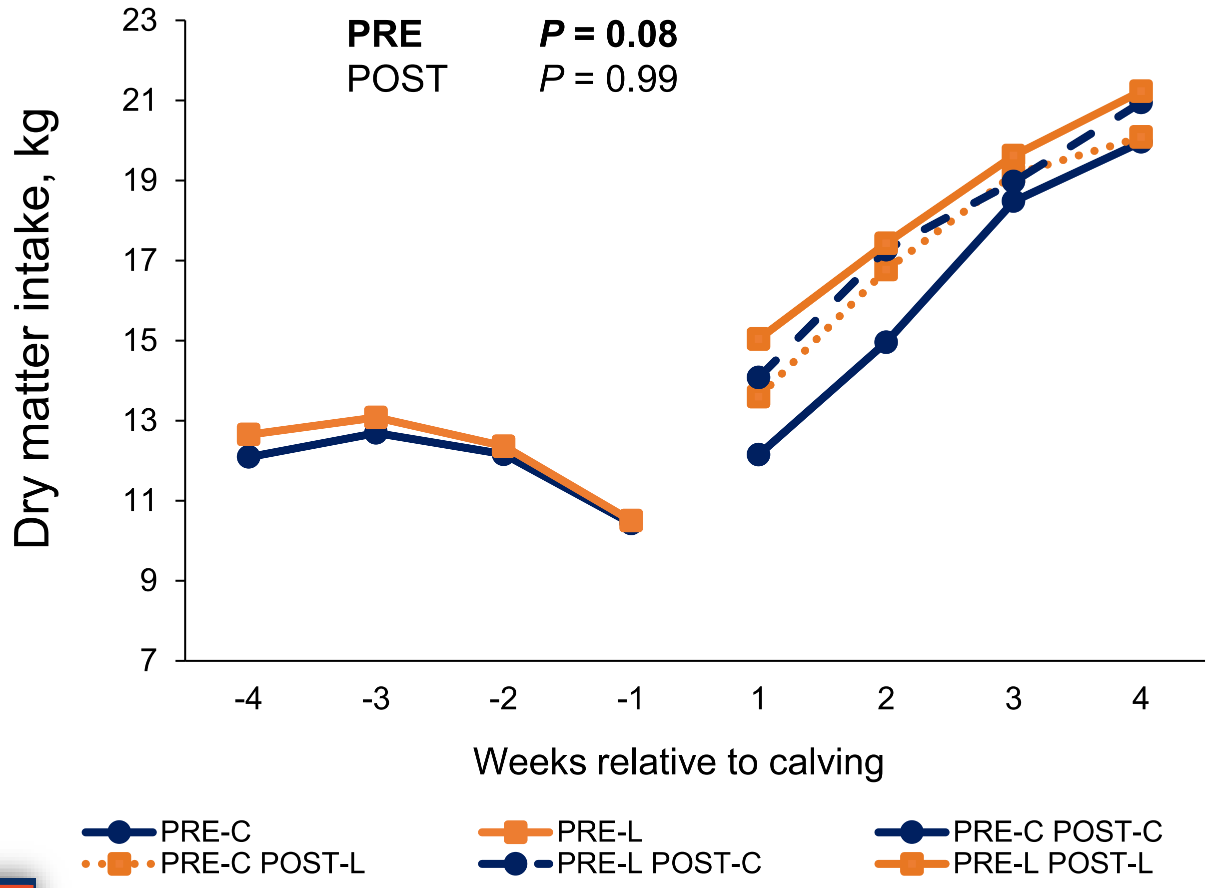
Amino acid supply

	Prepartum[2]		Postpartum[3]	
Composition of MP[1]	PRE-L	PRE-C	POST-L	POST-C
Metabolizable protein, g/d	1190	1170	2220	2280
Lys, % of MP	8.24	6.86	7.15	6.27
Met, % of MP	2.94	2.98	2.55	2.54
Lys:Met	2.80	2.30	2.80	2.46
Lys, g/d	98	80	159	143
Met, g/d	35	35	57	57
Lys, g/Mcal	3.55	2.95	3.11	2.73
Met, g/Mcal	1.27	1.19	1.11	1.11

[1]Metabolizable protein and AA predicted by AMTS
[2]Formulated for a dry cow at 1527 lb BW and 28.6 lb/d
[3]Formulated for a cow at 14 days in milk, 1612 lb BW, producing 86 lb/d of milk

Fehlberg et al., 2020

RPL provided prepartum tended to increase DMI postpartum



Fehlberg et al., 2020

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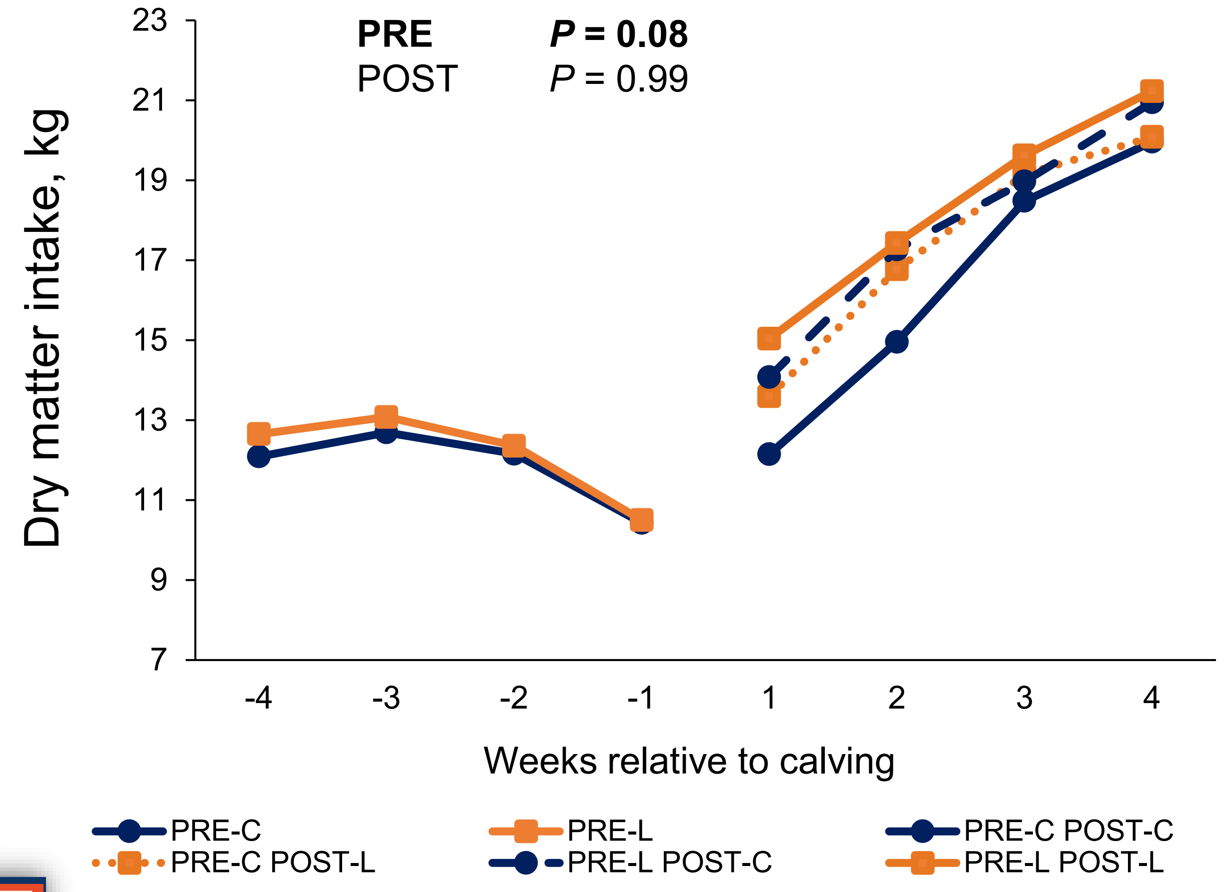
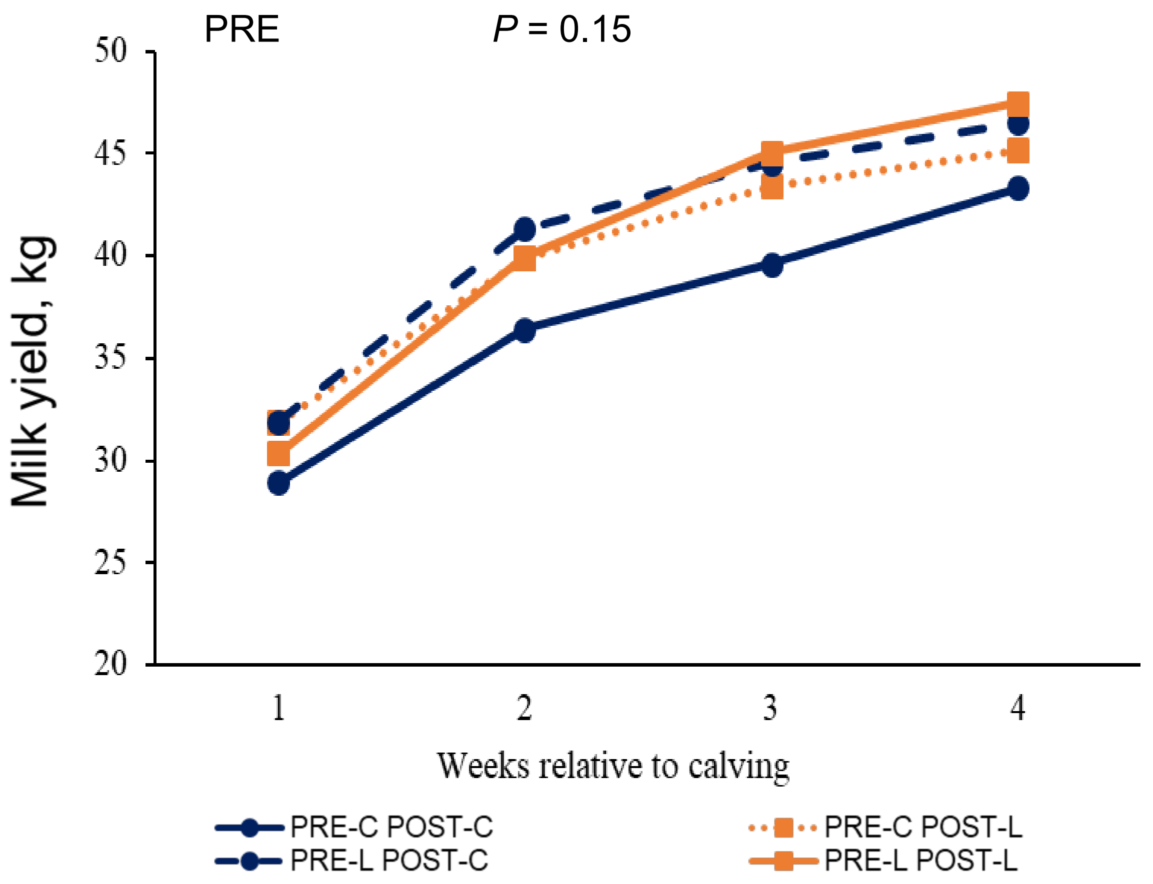
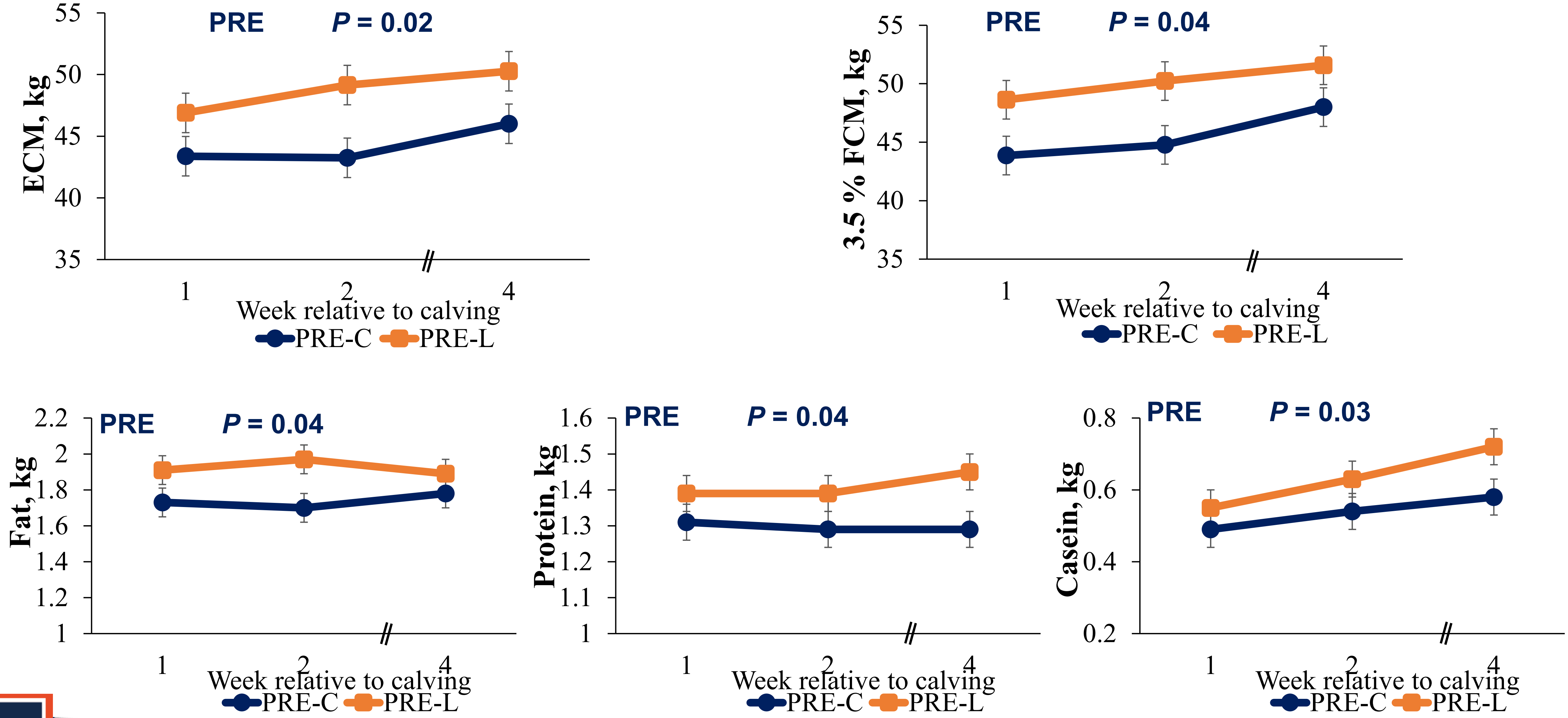




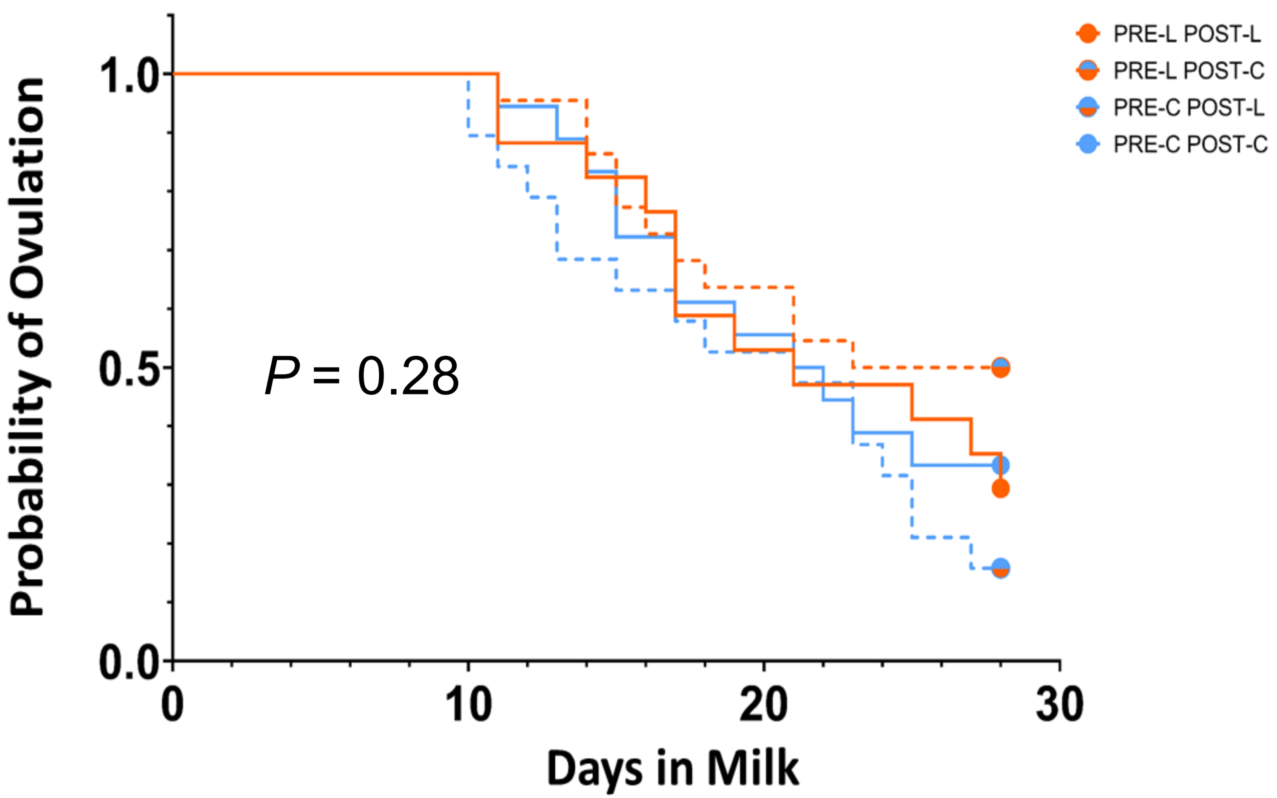
Fehlberg et al., 2020

RPL prepartum increased ECM, FCM, and milk composition yields postpartum



Fehlberg et al., 2020

Feeding rumen-protected lysine prepartum alters the uterine environment 28 days after calving



Guadagnin et al., 2022

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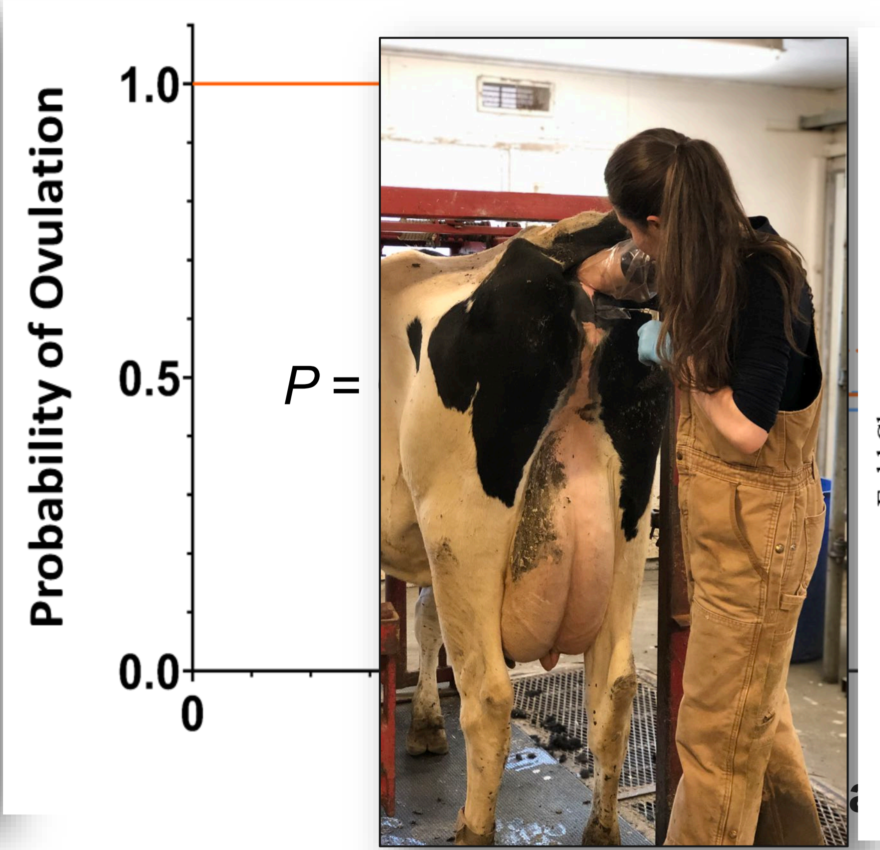
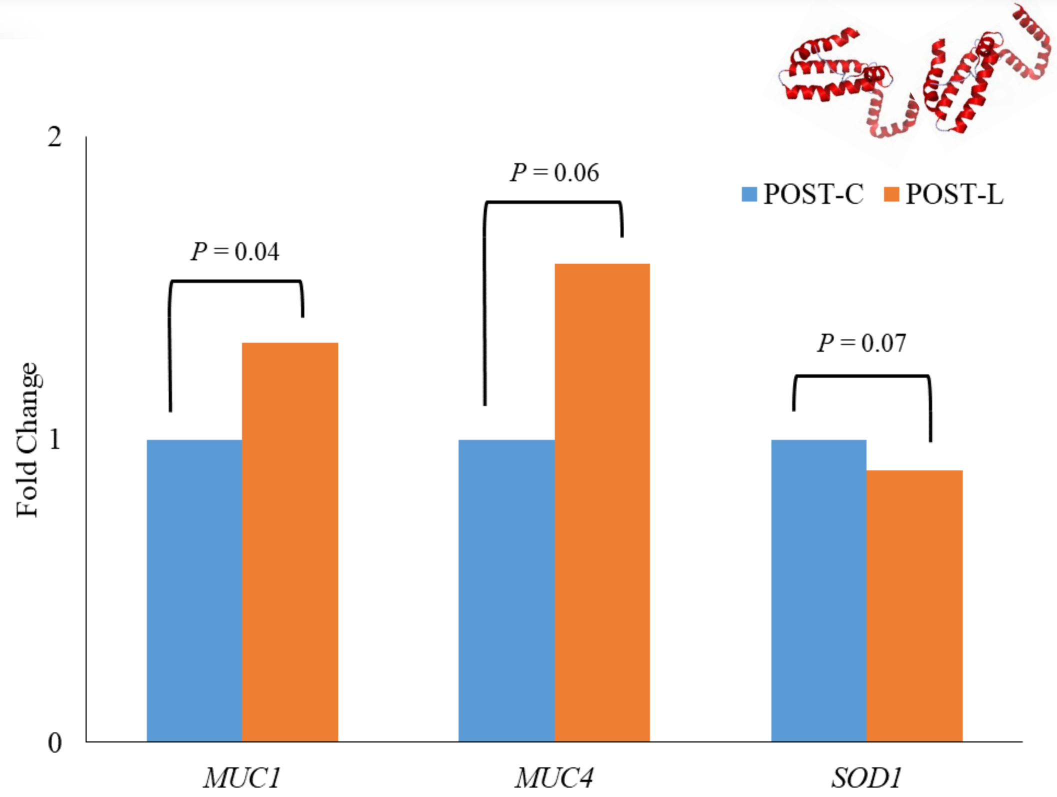
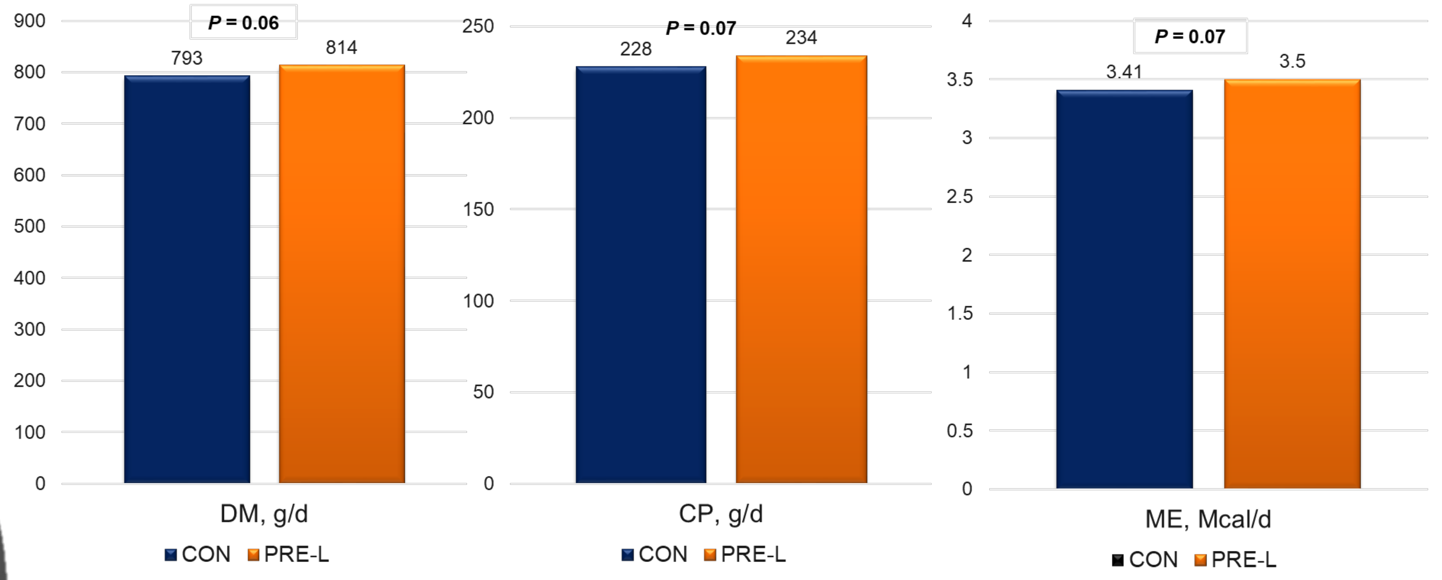
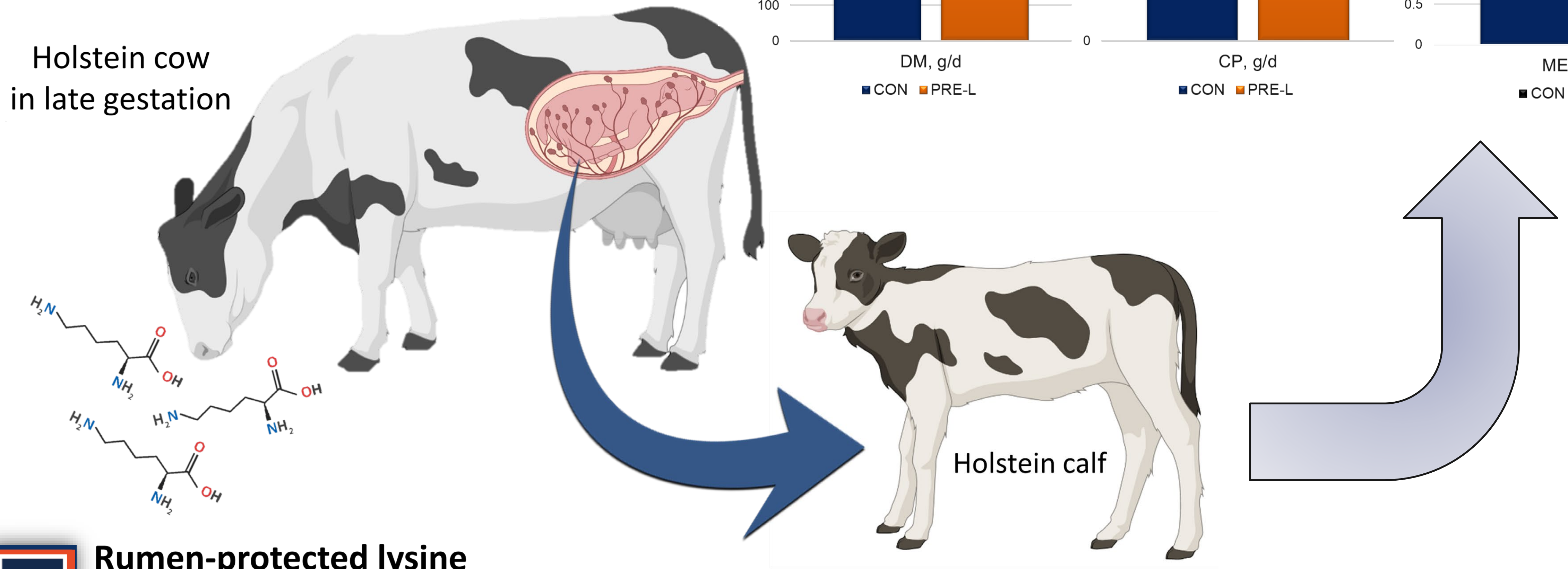




Guadagnin et al., 2022

Calves from cows fed rumen-protected LYS tended to consume more milk replacer (wk 1-6)



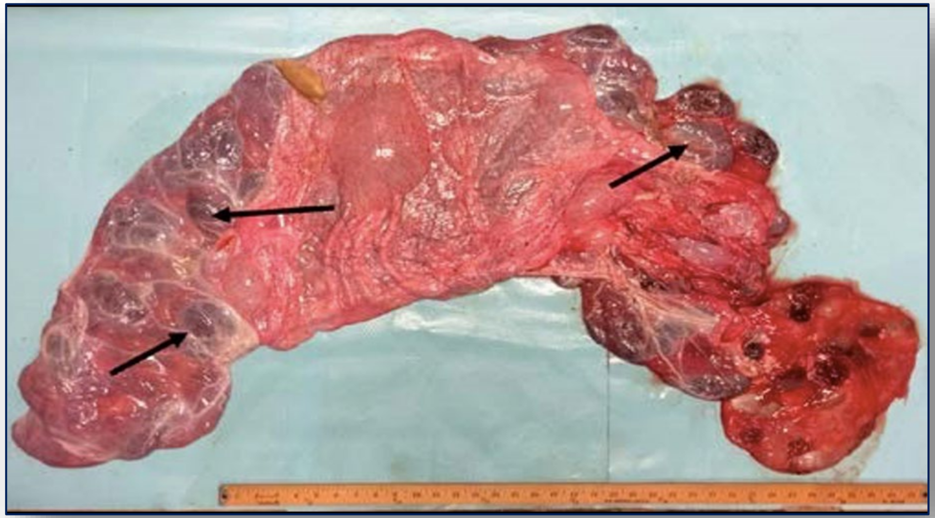


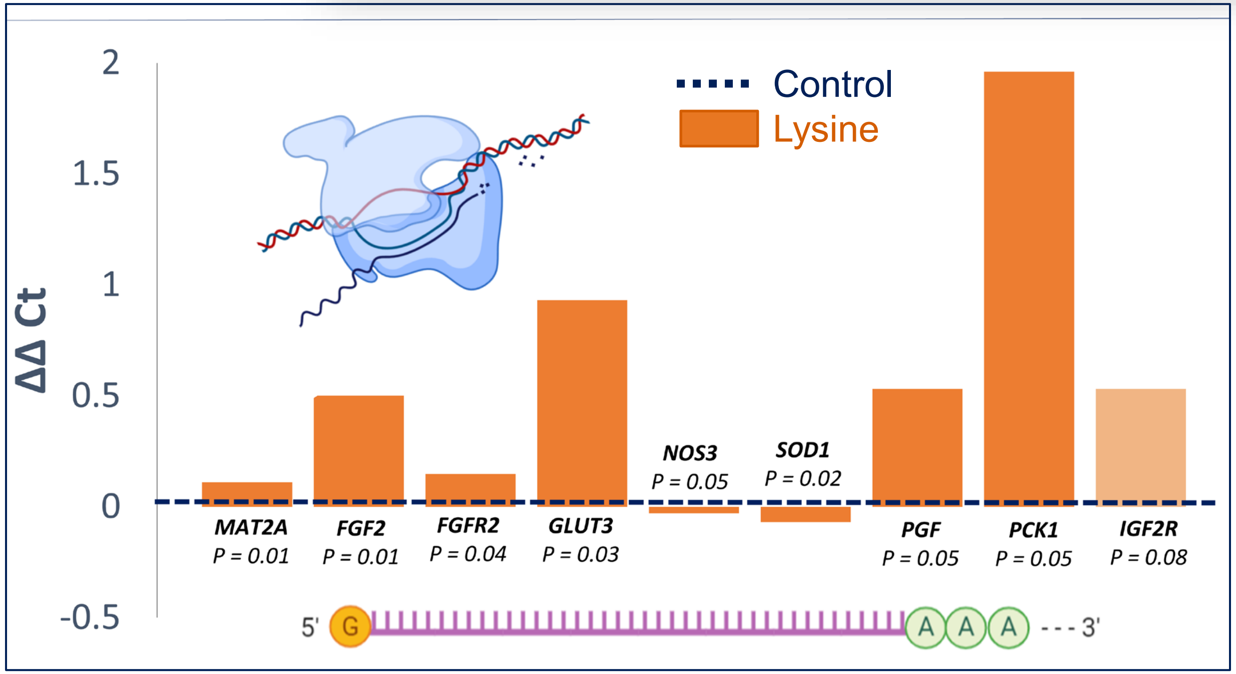
Rumen-protected lysine

University of Illinois at Urbana-Champaign

Thomas et al., 2021

Placental transcript expression from cows fed rumen-protected LYS

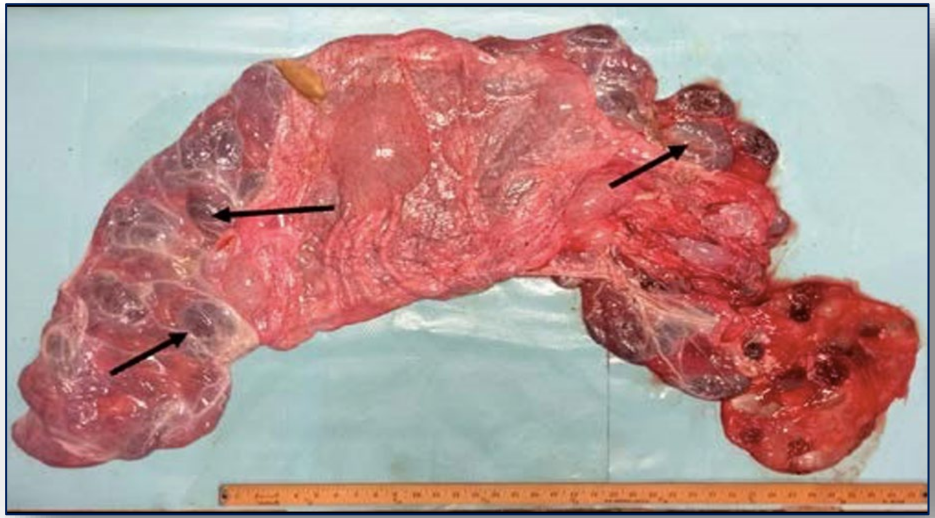


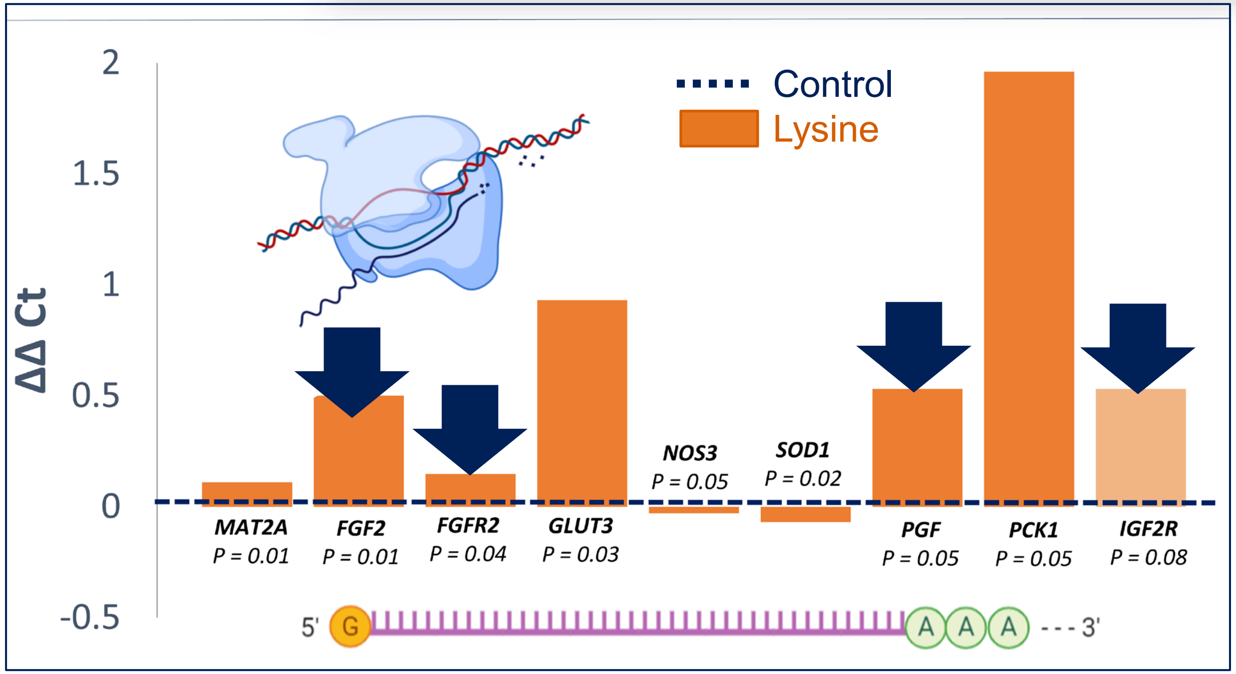


Guadagnin et al., 2023

Placental transcript expression from cows fed rumen-protected LYS

- **Increased placental cell processes**, such as cell proliferation and growth, are indicated by the upregulation of *FGF2*, *FGF2R*, *PGF*, and *IGF2R*, the latest being a major fetal growth factor.
- These processes require **energy** and, thus, are likely related to the upregulation of *GLUT3* and *PCK1*.
- The downregulation of *SOD1* could indicate a **better redox status**, due to less need of the superoxide dismutase enzyme.
- It is likely that increasing supply of lysine allows for a greater **utilization of other amino acids** as well, such as methionine, exemplified by the upregulation of *MAT2A*.





Guadagnin et al., 2023

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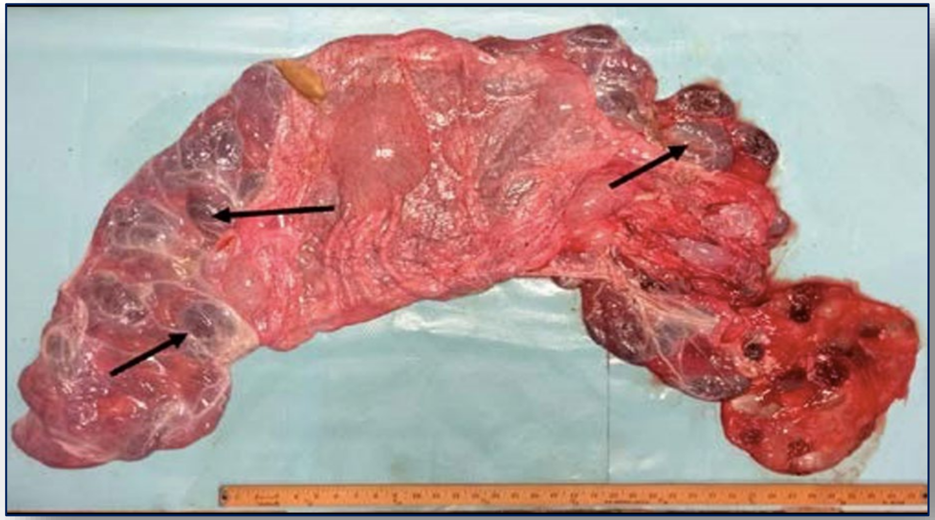

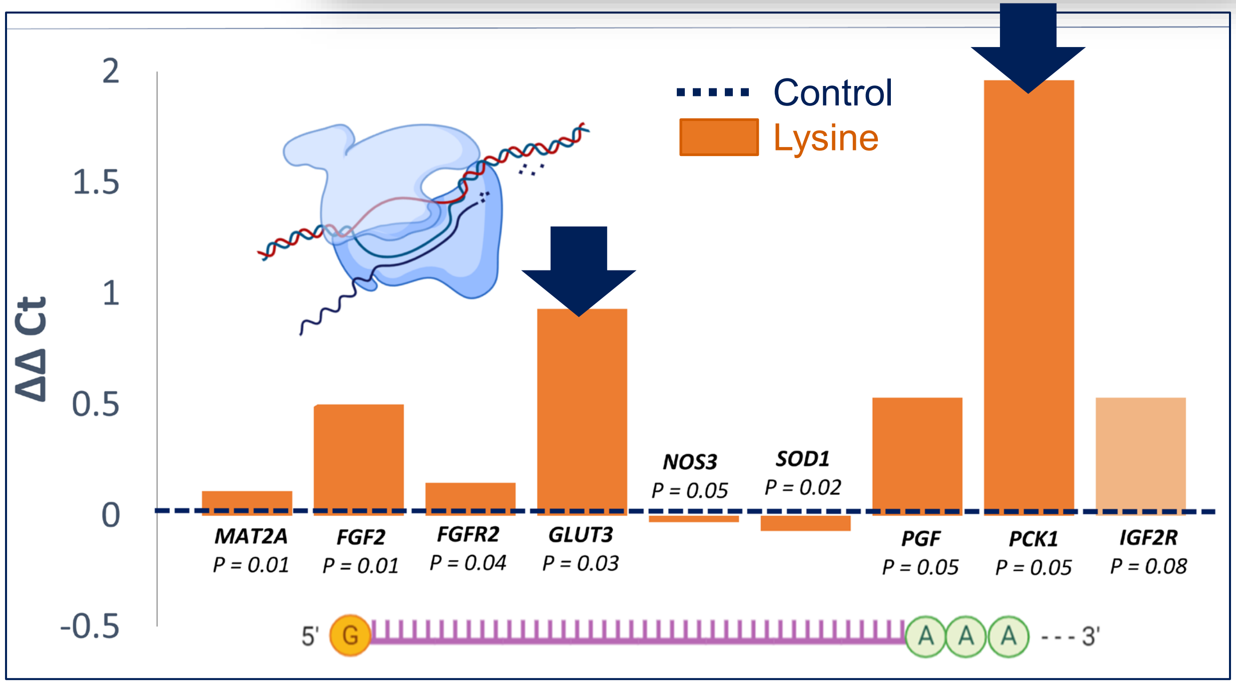

Guadagnin et al., 2023

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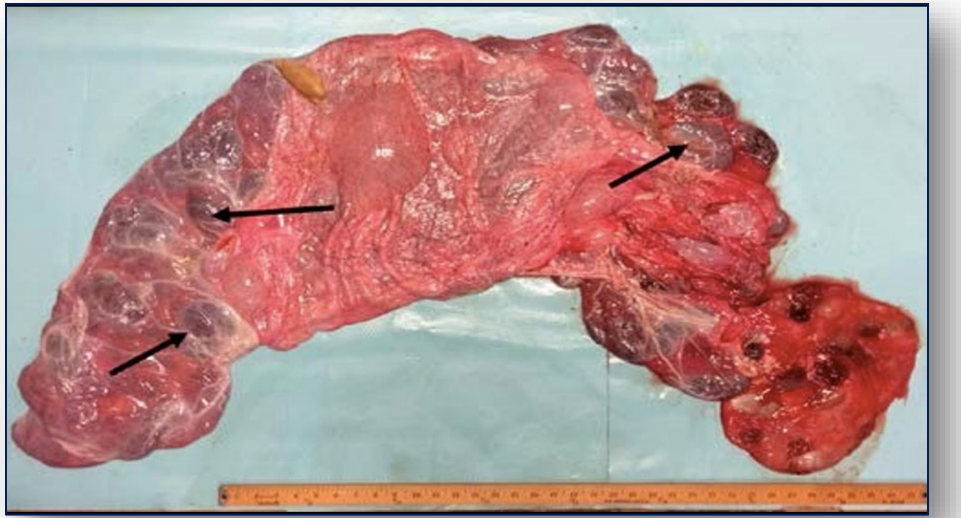

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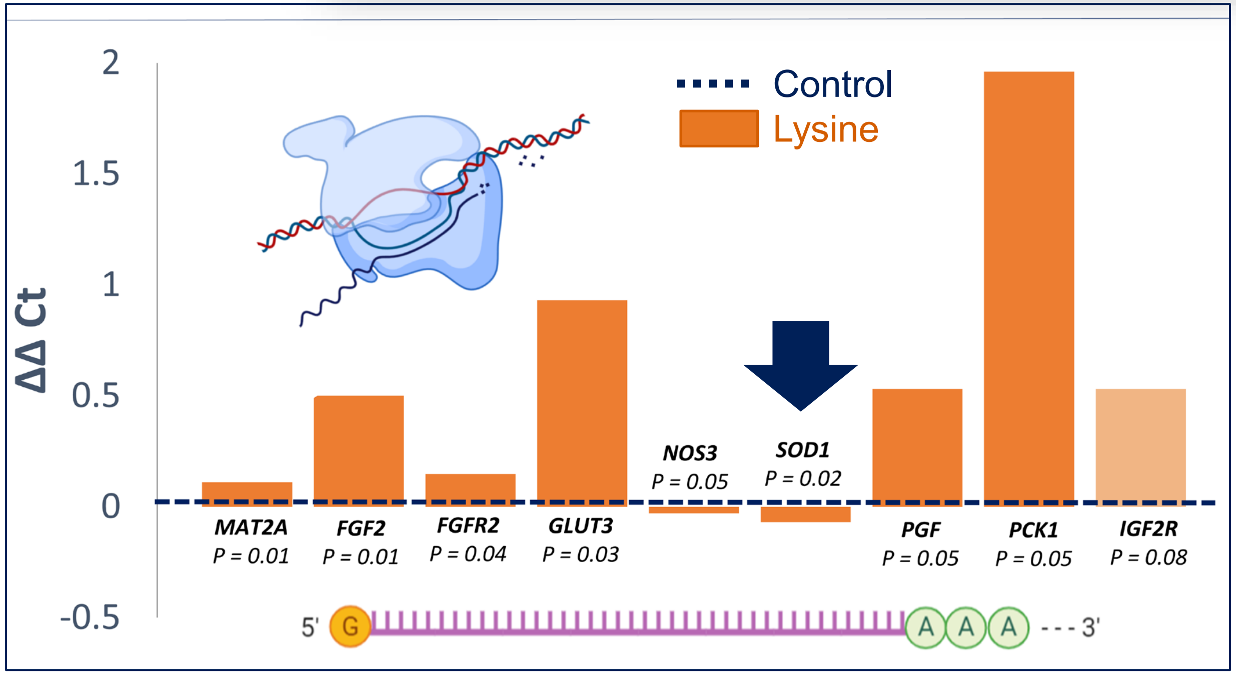

Guadagnin et al., 2023

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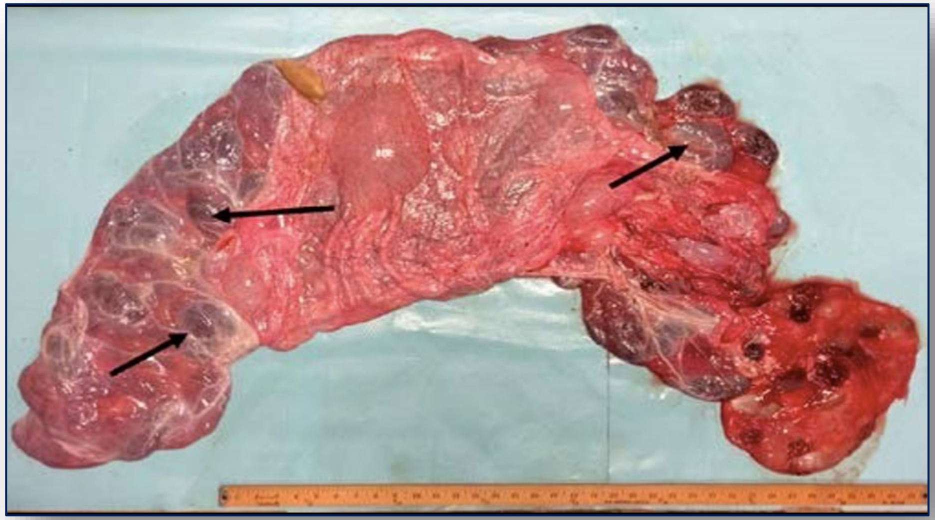

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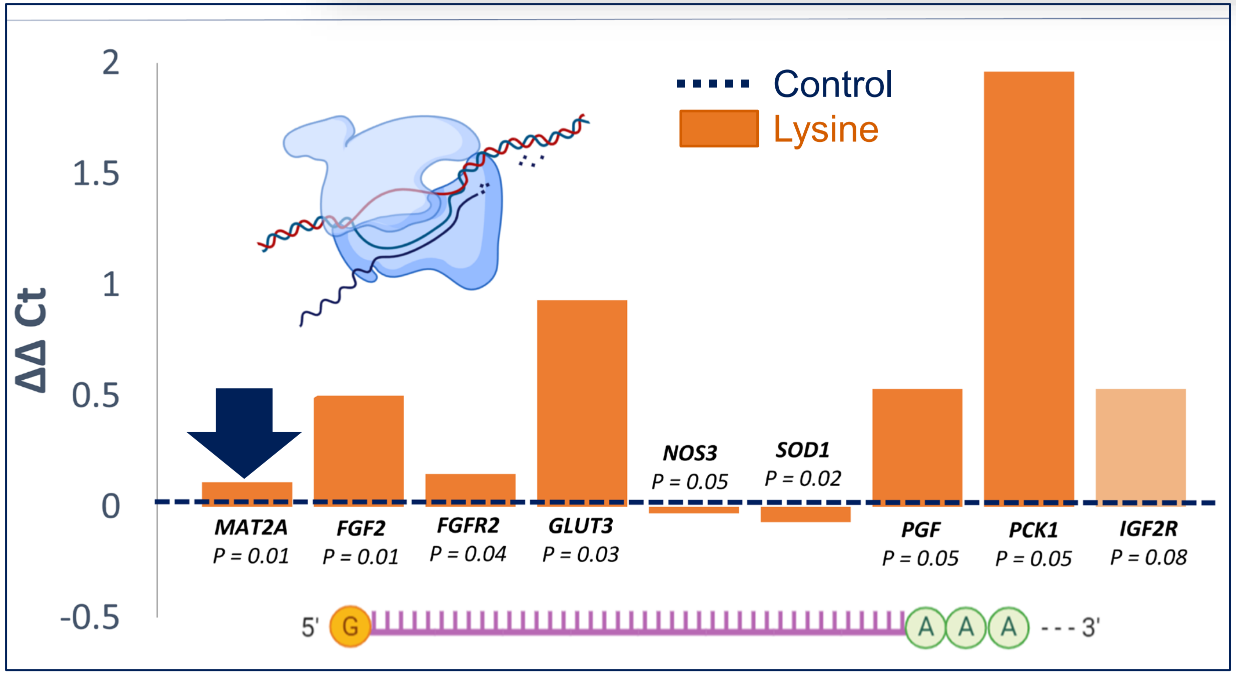
- The downregulation of *SOD1* could indicate a **better redox status**, due to less need of the superoxide dismutase enzyme.
- It is likely that increasing supply of lysine allows for a greater **utilization of other amino acids** as well, such as methionine, exemplified by the upregulation of *MAT2A*.



Guadagnin et al., 2023


1537
1362

431 lactating cows.

Annual rolling herd milk average: **37,424** lb (16,975 kg)

102.5 lb/cow/day (**46.5** kg/cow/day)

Milk fat: 4.2%

Milk protein: 3.1%

Fat + protein yield: **7.57** lb/cow/day (**3.44** kg/cow/day)

Haybuster with a 2" to 3" screen

Haybuster with a 2" to 3" screen

PRESCRIPTION PREMIX

[redacted]

Dry matter: 53.5% - Moisture: 46.5%

New recipe Dry Cow			N° of
Ingredients	AF lb/d	DM lb/d	
[redacted] Dry Cow Mix 040220	11.4407	10.4131	
Water	7.0000	0.0035	
corn [redacted]	1.5000	1.3154	
straw [redacted]	9.0518	8.2000	
corn silage 2021 [redacted]	29.0500	11.1000	
TOTAL	58.0424	31.0319	

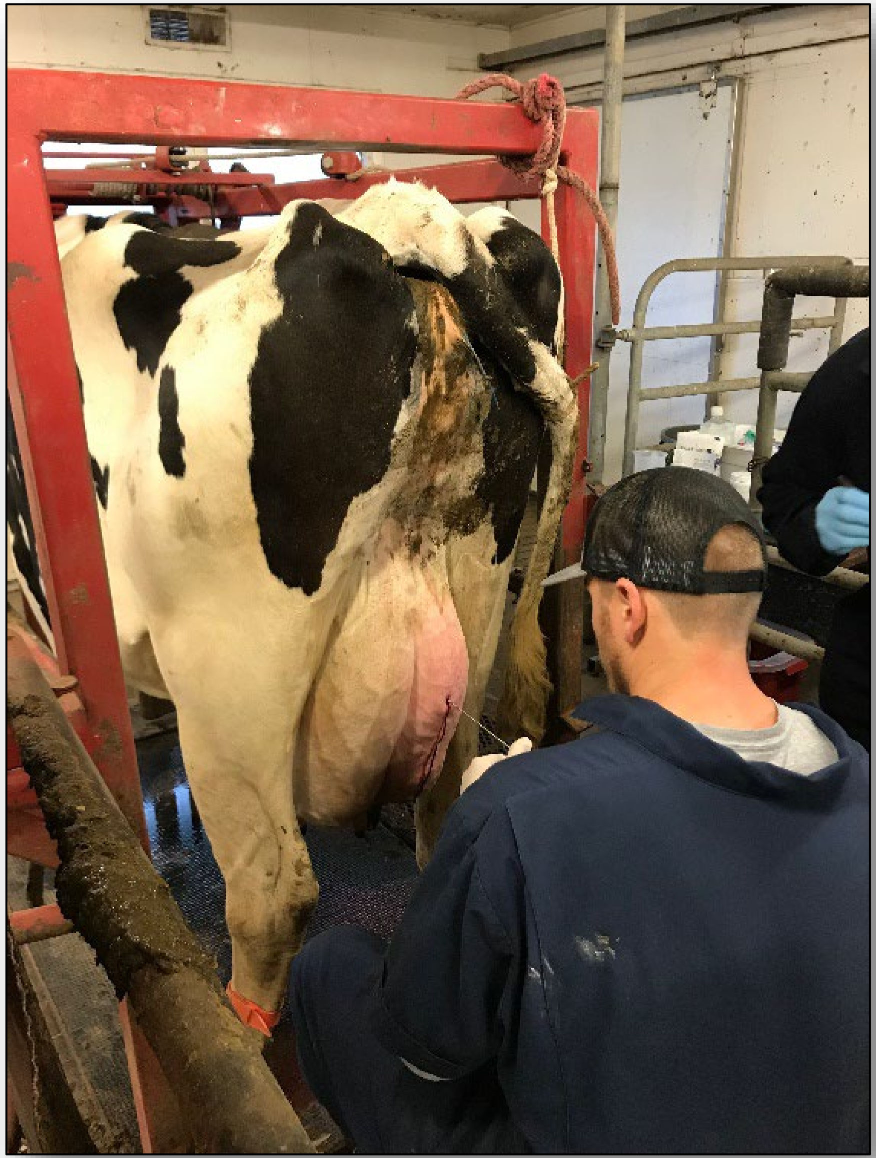
University of Illinois Dairy Farm

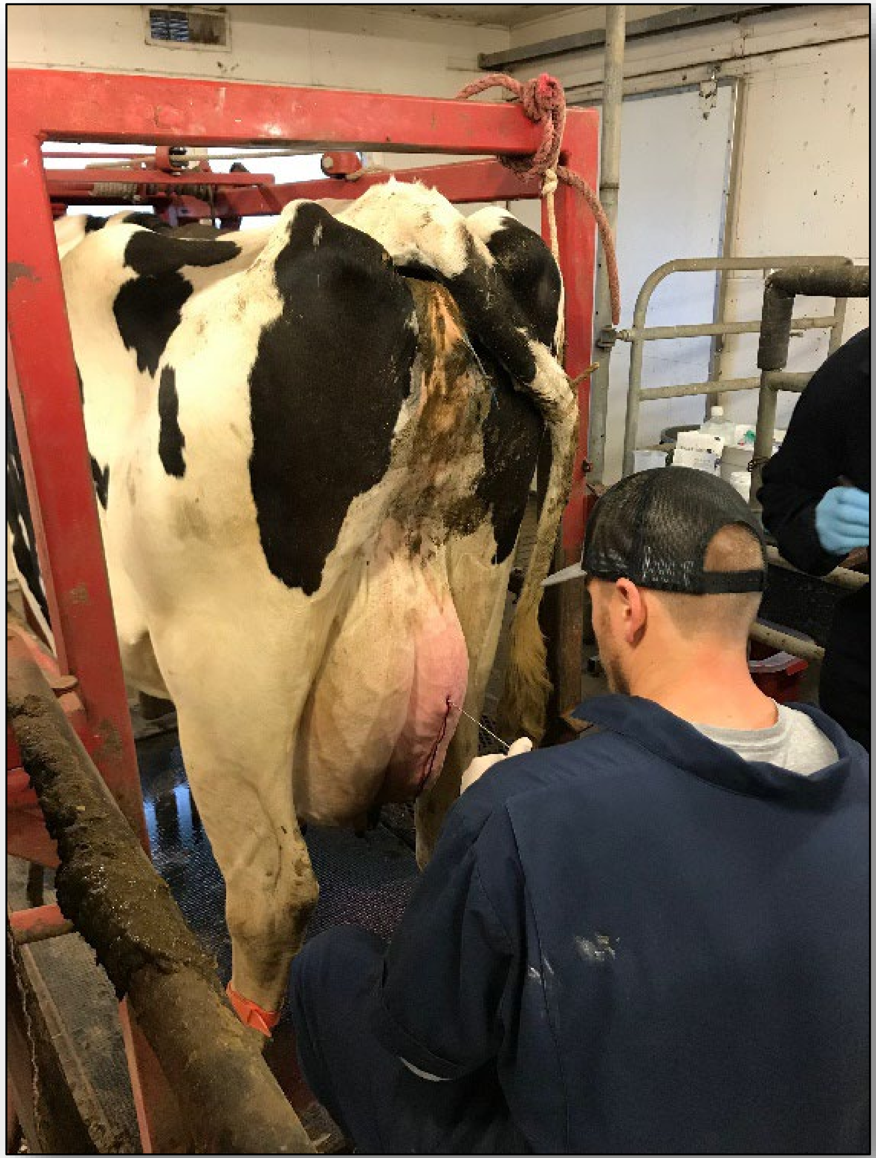
Effects of rumen-protected methionine on lactation performance and physiological variables during a heat stress challenge in lactating Holstein cows

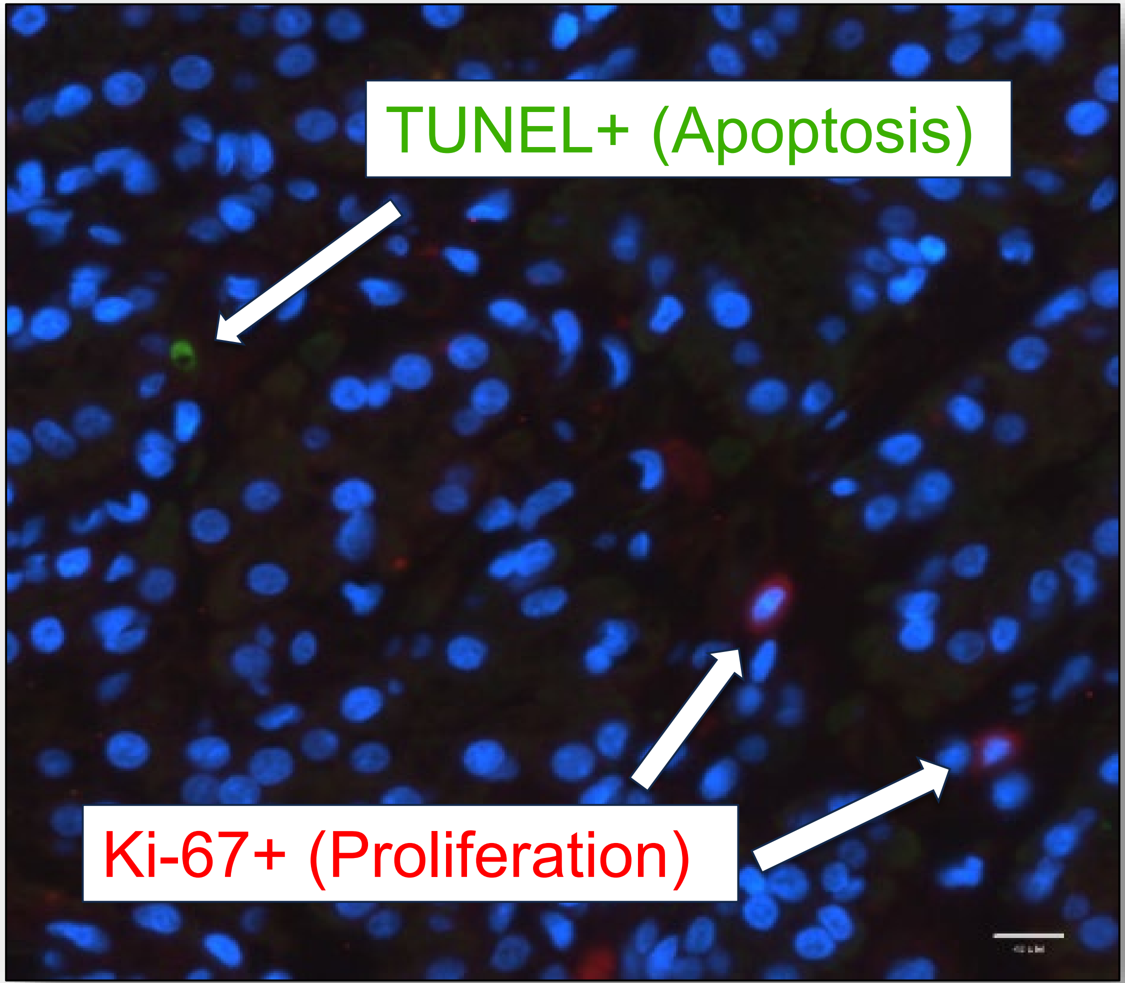
Heat Stress Challenge

Pair-Fed Thermoneutral

Pate et al., 2020







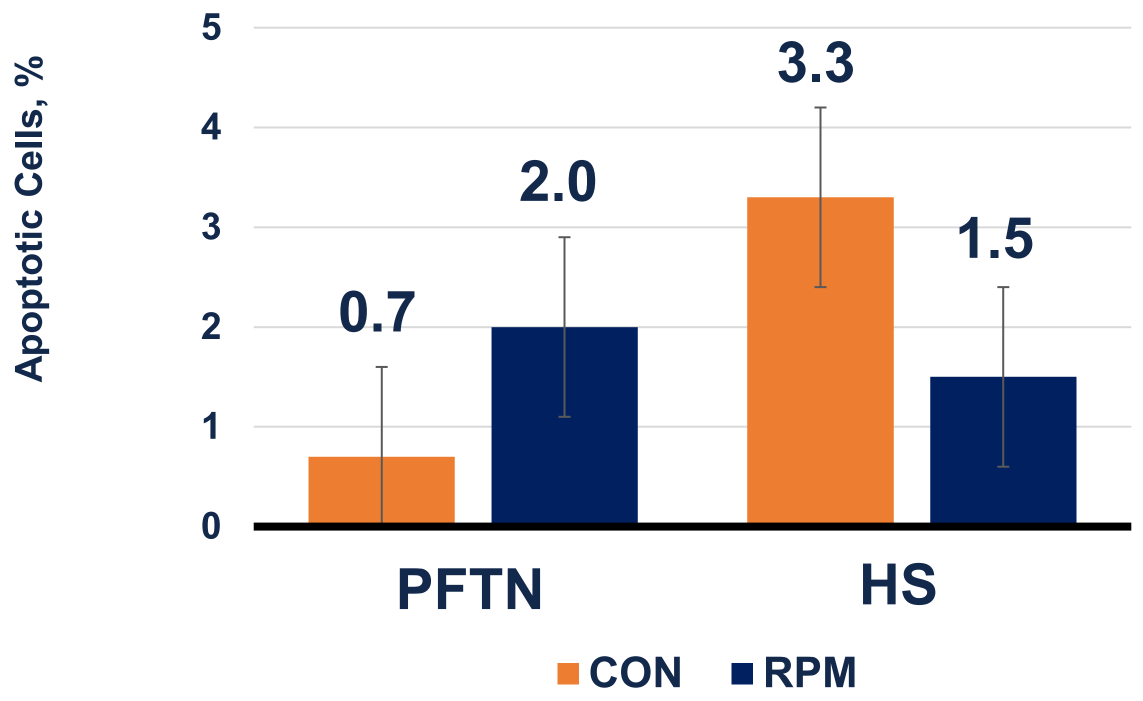
Mammary Immunohistochemistry

Pate et al., 2021

Cows in CON had greater % apoptosis and apoptosis:proliferation than cows in RPM during HSC

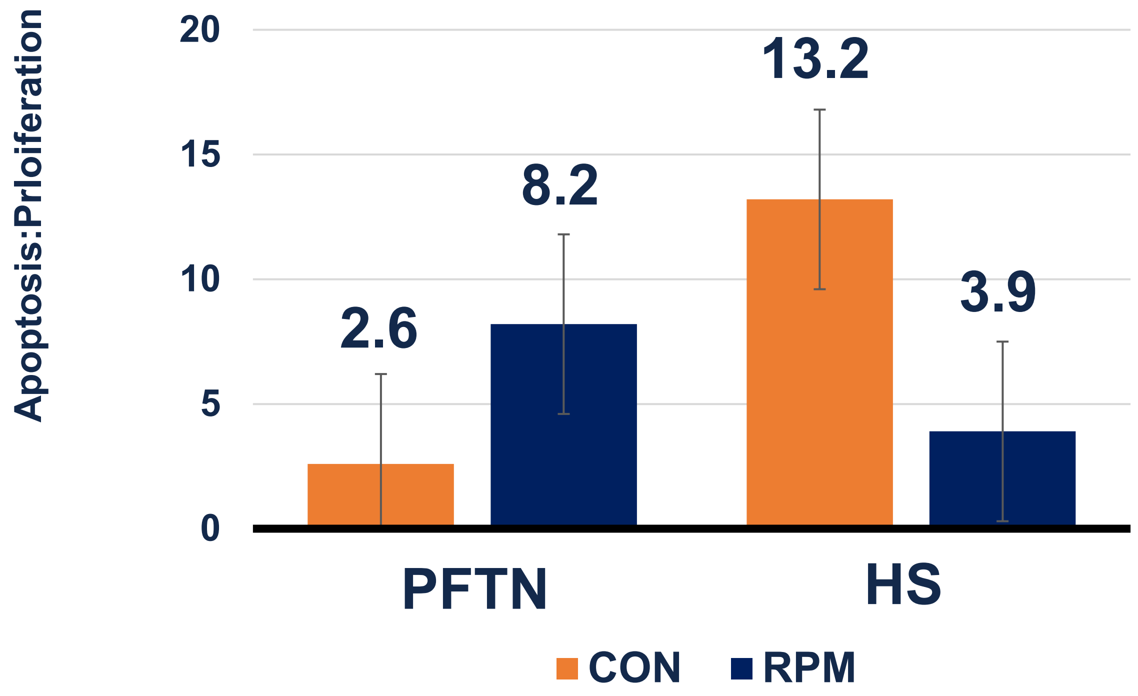
Apoptotic Cells, %

Env	*P* = 0.88
Diet	*P* = 0.15
Env × Diet	*P* = 0.03



Apoptosis:Proliferation

Env	*P* = 0.91
Diet	*P* = 0.33
Env × Diet	*P* = 0.005



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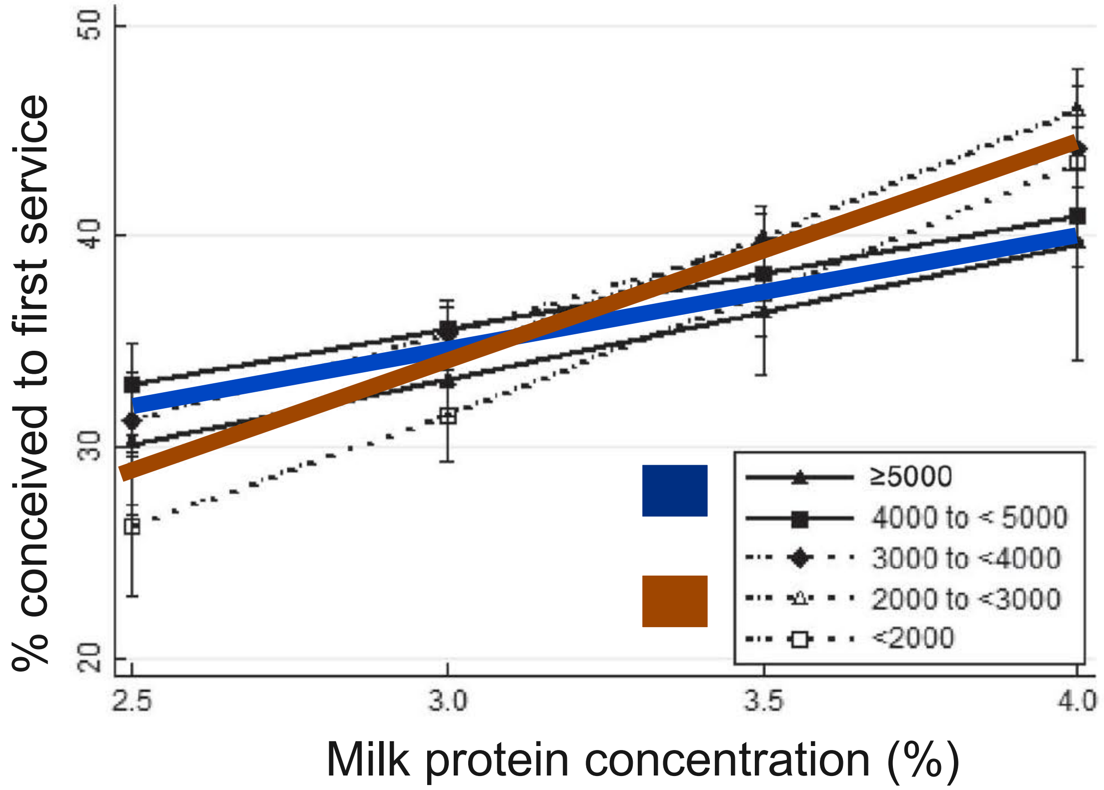
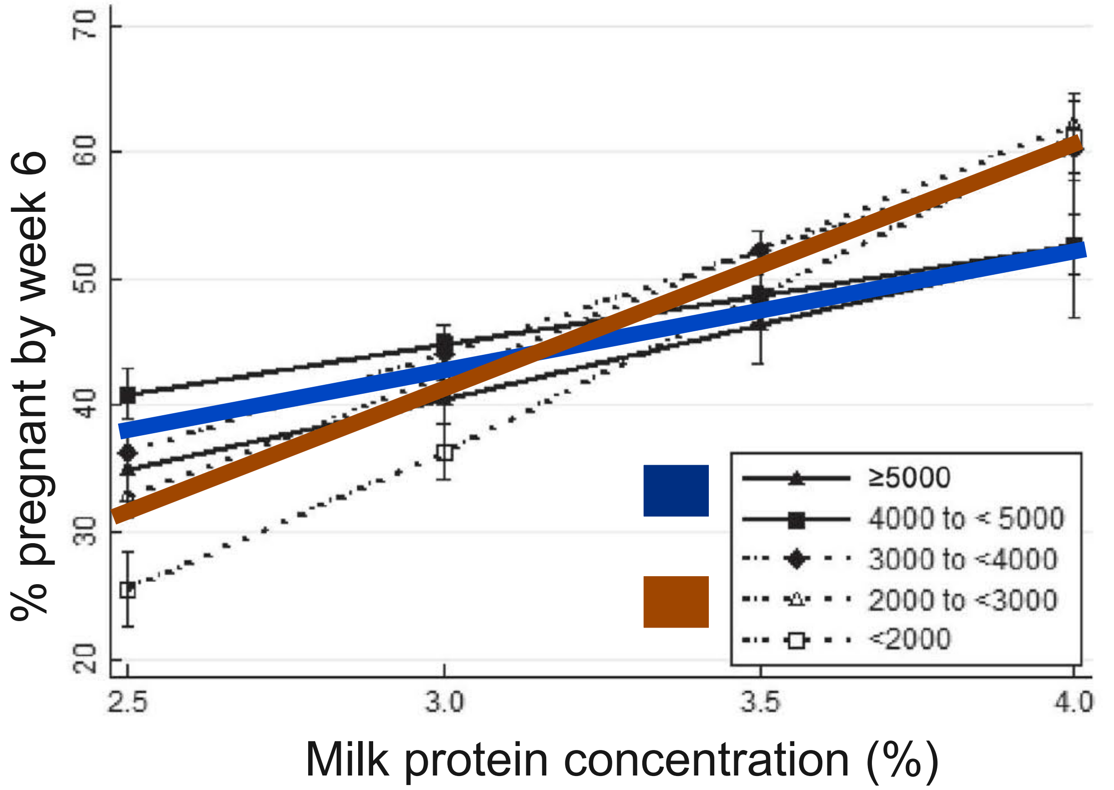
Pate et al., 2021

Cows with higher milk protein concentration had *increased* conception at first service and pregnancy by week 6





A retrospective, single cohort study was conducted using data collected from 74 Australian dairy herds. These herds provided data for 126,277 cows; these cows had 359,892 calvings (and hence lactations) recorded.

Morton et al., 2016


Take Home Message!

Summary

- Amino acid balancing (methionine and lysine) and adequate amount of metabolizable protein during the transition period seems to improve the performance of dairy cows by:
  - Increased milk yield and milk composition
  - Reduced oxidative stress
  - Lower embryonic loss

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  - Increased milk yield and milk composition
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- Consider checking for the amount of AA prepartum rather than associate it with energy (target at ~ 35g metabolizable Met and ~100g metabolizable Lys).

Summary

- Amino acid balancing (methionine and lysine) and adequate amount of metabolizable protein during the transition period seems to improve the performance of dairy cows by:
  - Increased milk yield and milk composition
  - Reduced oxidative stress
  - Lower embryonic loss
- Consider checking for the amount of AA prepartum rather than associate it with energy (target at ~ 35g metabolizable Met and ~100g metabolizable Lys).
- High milk protein concentration seems to be associated with reproductive success.

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THANKS!

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Dairy Focus Lab