DEFRA Project ACO122

University of Reading

HOW LOW CAN WE GO WITH CRUDE PROTEIN IN DAIRY COW DIETS? LONG-TERM EFFECTS OF FEEDING LOWER PROTEIN DIETS TO HIGH-YIELDING DAIRY COWS.

University of Reading, Aberystwyth University, SRUC, Rothamsted Research North Wyke

ROTHAMSTED RESEARCH · 1872 PRIFYSGOL ABERYSTWYTH UNIVERSITY · SRUC · AHDB DAIRY · Department for Environment Food & Rural Affairs

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LIMITLESS **POTENTIAL** | LIMITLESS **OPPORTUNITIES** | LIMITLESS **IMPACT**

NITROGEN USE EFFICIENCY

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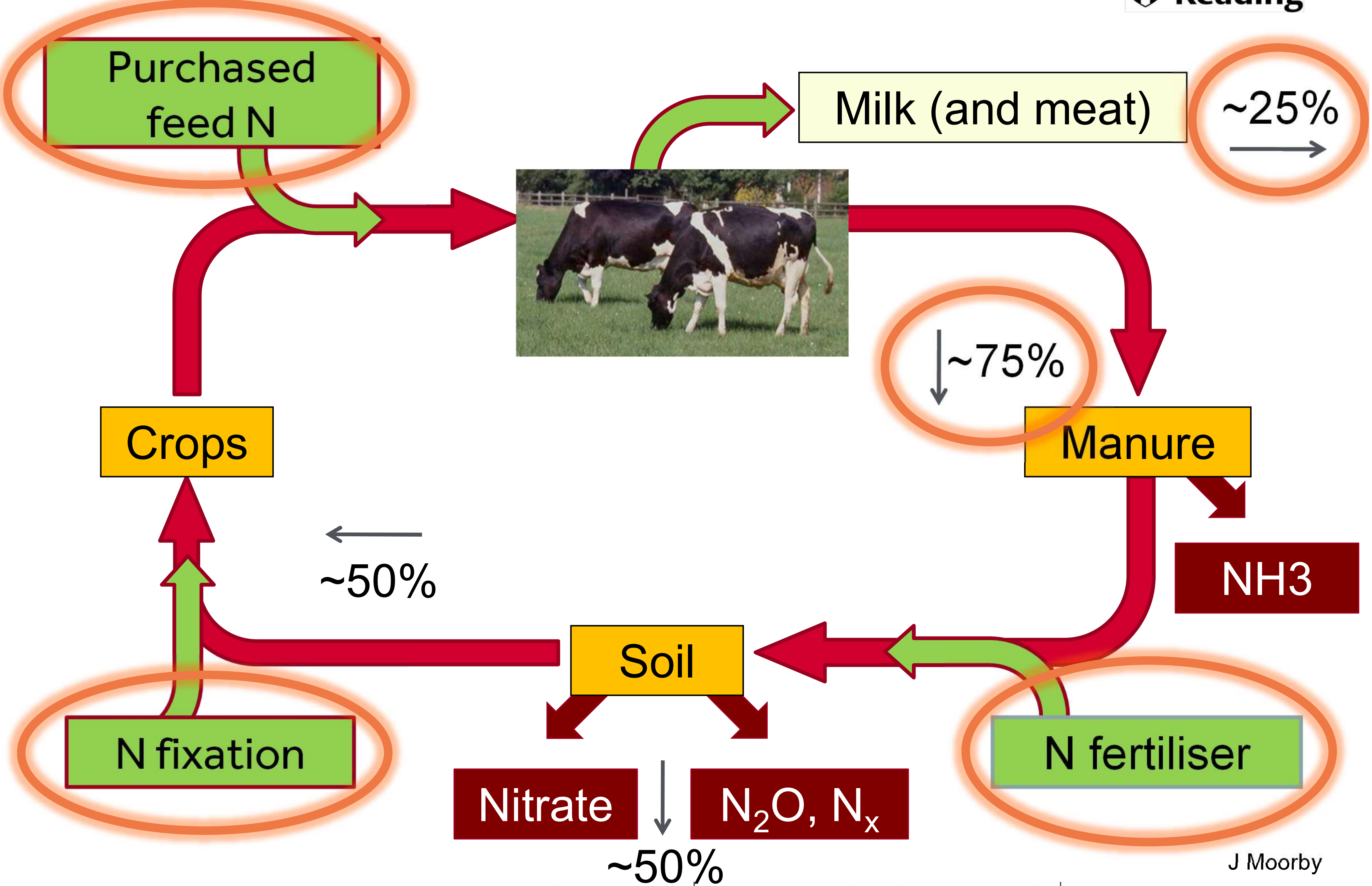

J Moorby

VARIATION IN N USE EFFICIENCY IN DAIRY CATTLE

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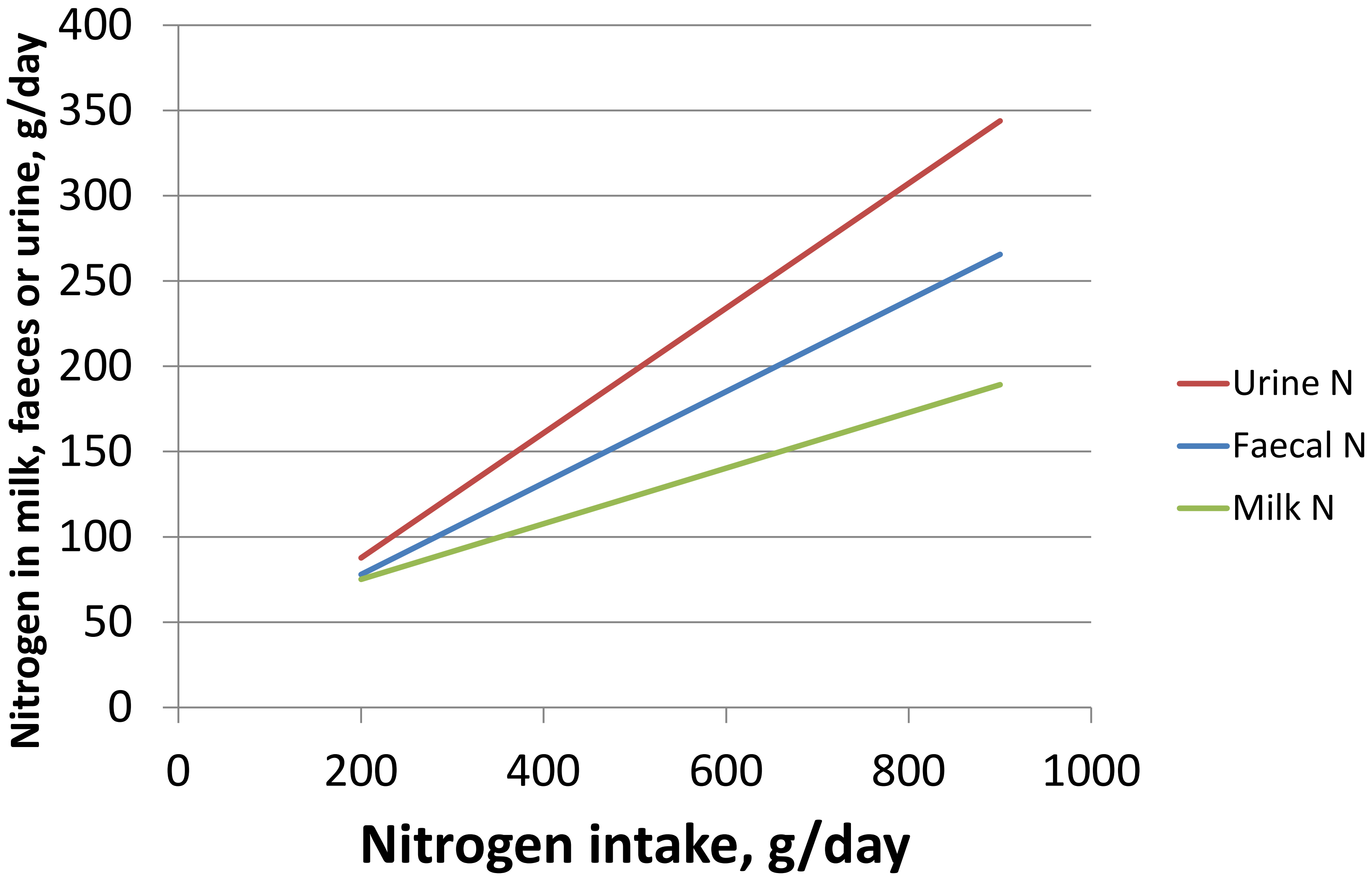
	Milk N efficiency			
	USA (n = 167)		EU (n = 287)	
	Low	High	Low	High
Milk N efficiency	0.22	0.33	0.21	0.32
DM intake (kg/d)	23.2	23.8	17.9	18.9
3.5% FCM (l/d)	31.8	38.2	26.8	31.2
Forage (g/kg DM)	534	526	665	569
Forage CP (g/kg DM)	179	154	200	148

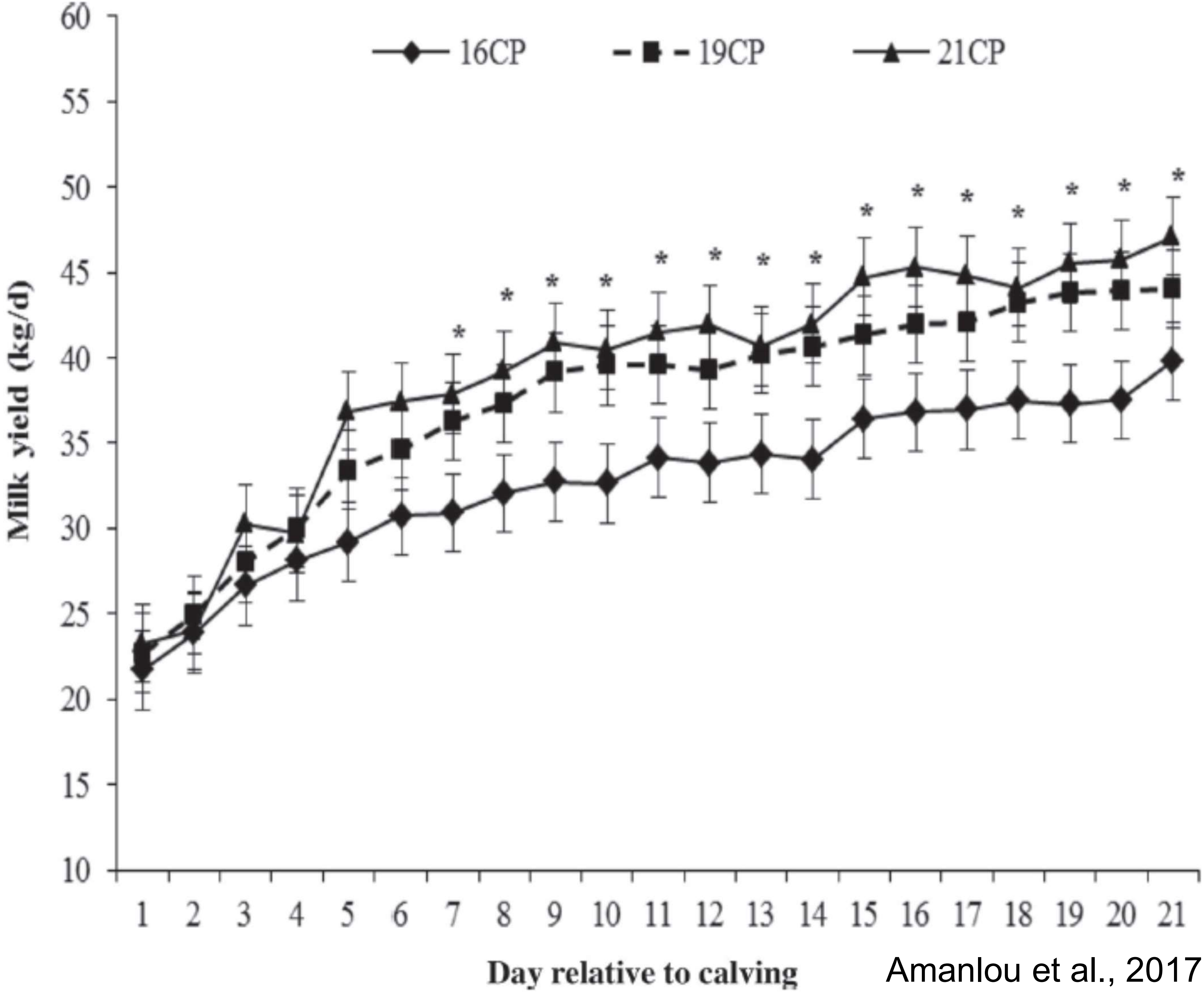
Lower (low) and upper (high) quartile for N efficiency

Calsamiglia et al. (2010)

META-ANALYSIS OF N BALANCE TRIALS



Mills et al. (2009)



Amanlou et al., 2017.

MAKING METABOLISABLE PROTEIN

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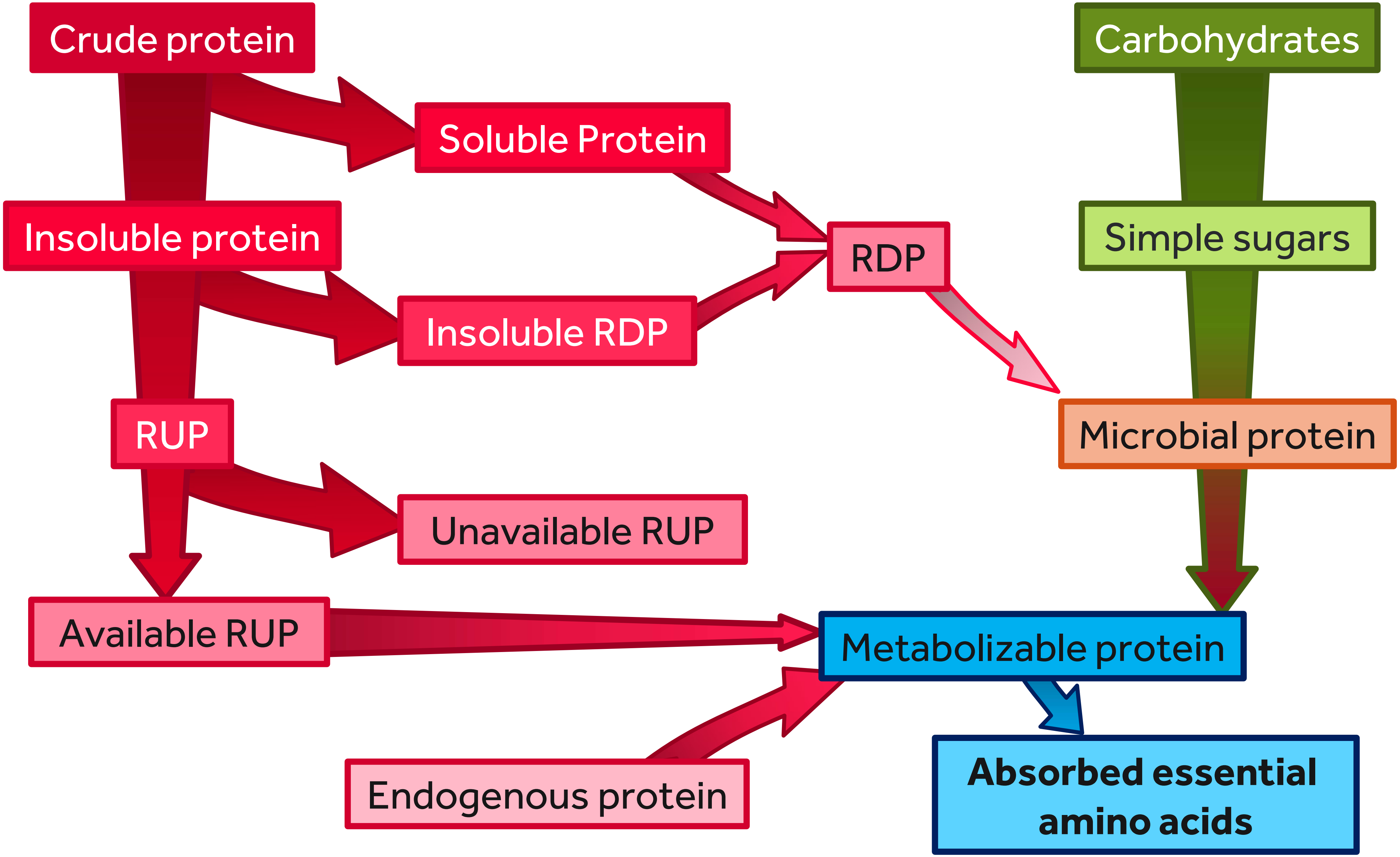

Effect of Rumen Protected Met and Lys on Milk Protein Yield for Diets With Less Than 15% CP

J. Dairy Sci. 104:7583–7603
https://doi.org/10.3168/jds.2020-19021
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Effects of feeding rumen-protected methionine pre- and postpartum in multiparous Holstein cows: Lactation performance and plasma amino acid concentrations

Mateus Z. Toledo,[1]* Matias L. Stangaferro,[2]* Rodrigo S. Gennari,[1] Rafael V. Barletta,[1] Martin M. Perez,[2] Robert Wijma,[2] Emily M. Sitko,[2] German Granados,[2] Magdalena Masello,[2] Michael E. Van Amburgh,[2] Daniel Luchini,[3] Julio O. Giordano,[2] Randy D. Shaver,[1] and Milo C. Wiltbank[1]†
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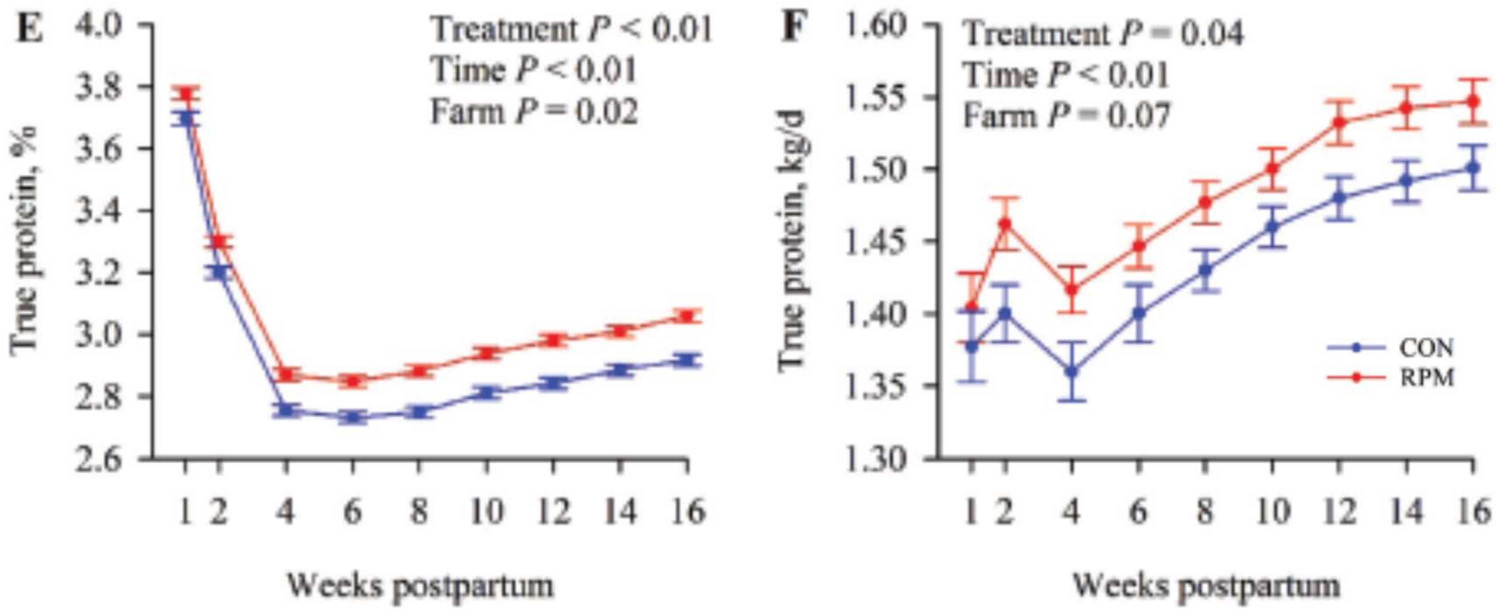
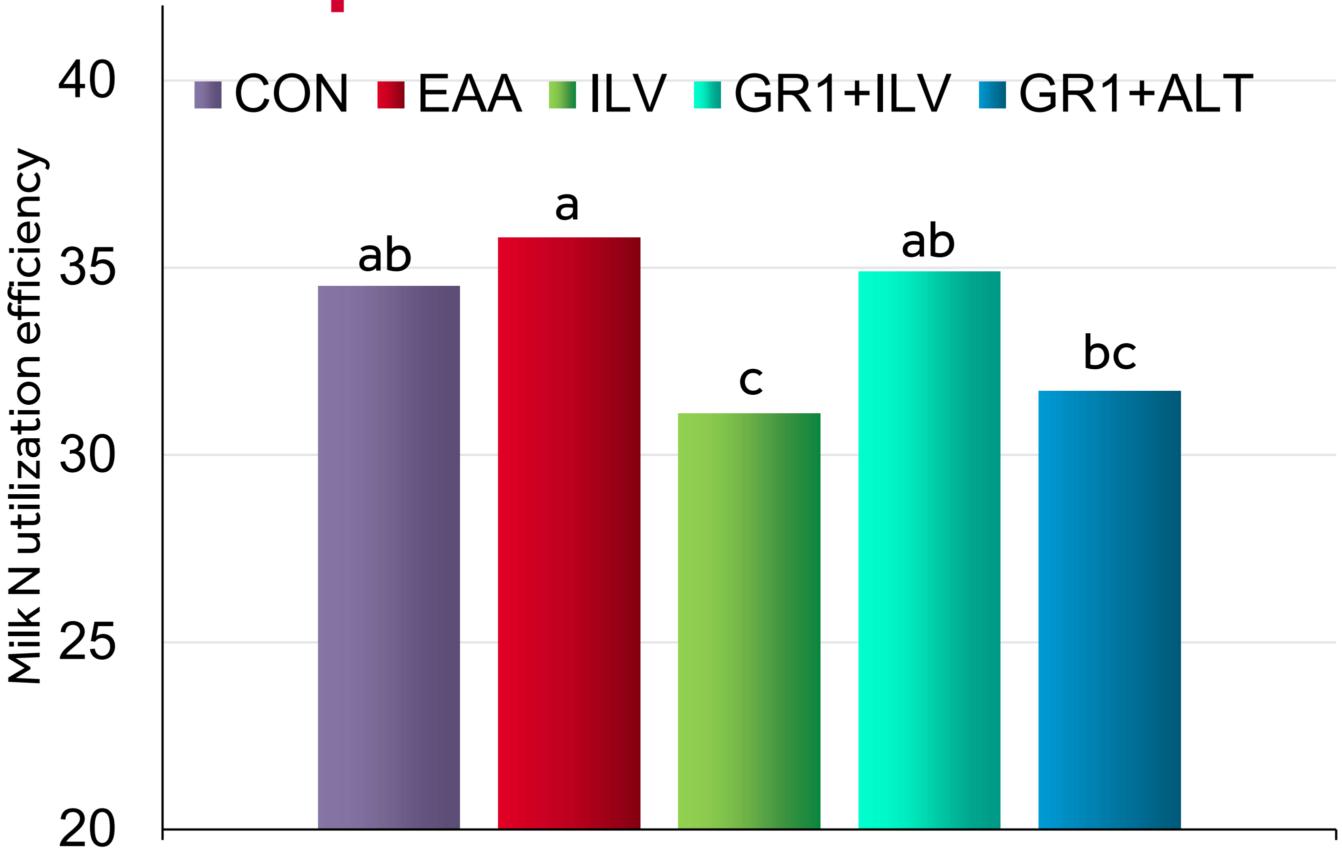


Sinclair et al 2014

JD1

Importance of AA Profile for Milk NUE



Nichols et al. (2019)

Diet CP 13% of DM

Abomasal infusion

562 g MP/d:

CON: none

EAA: Arg, His, Ile, Leu, Lys, Met, Phe, Thr, Trp, Val

ILV: Ile, Leu, Val

GR1+ILV: His, Ile, Leu, Met, Phe, Trp, Val

GR1+ALT: Arg, His, Lys, Met, Phe, Thr, Trp

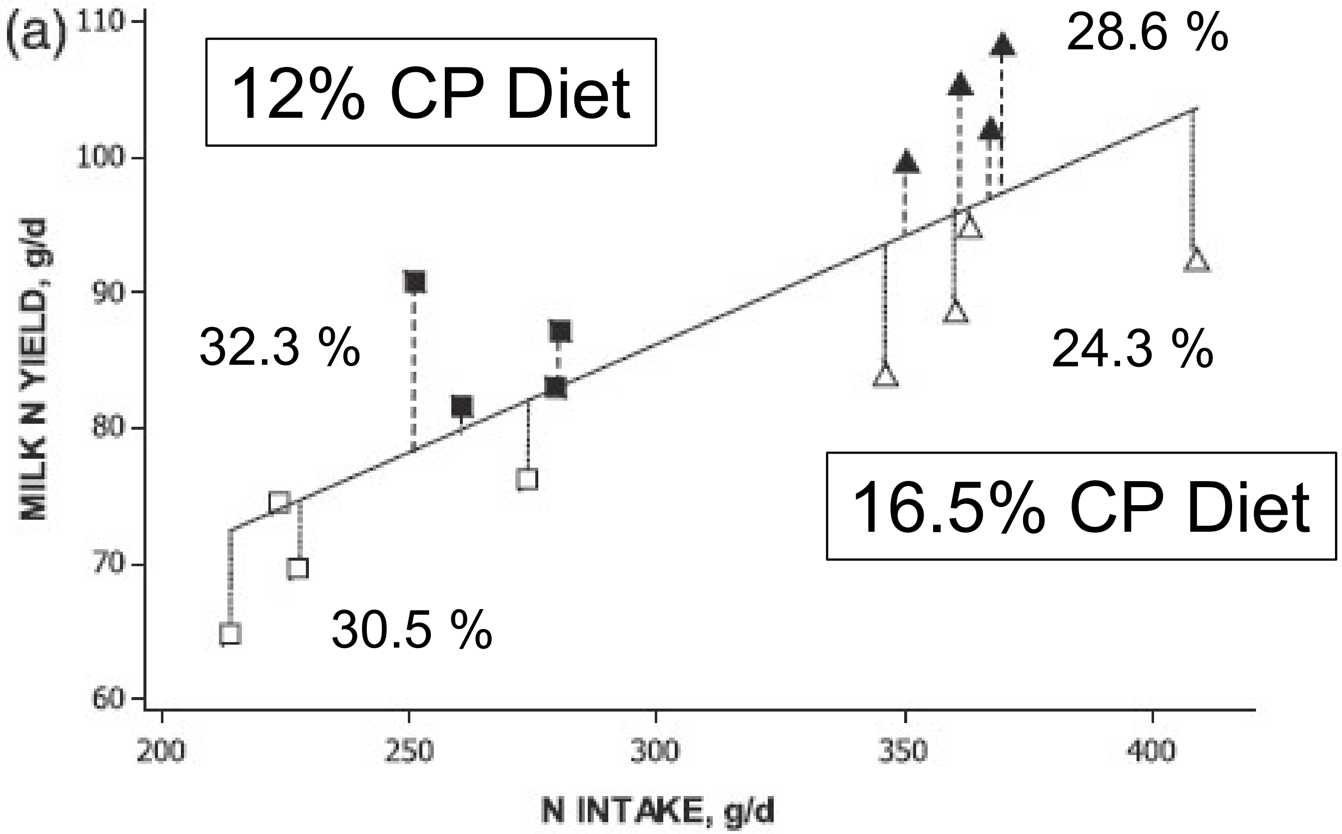
SEM = 0.89

Dia 8

JD1 AA profile as an important factor in NUE, probably in particular in diets low(er) in protein. Example slide from Nichols 2019.

Dijkstra, Jan; 23-8-2021

Effects of Higher Starch Diets on N Utilization

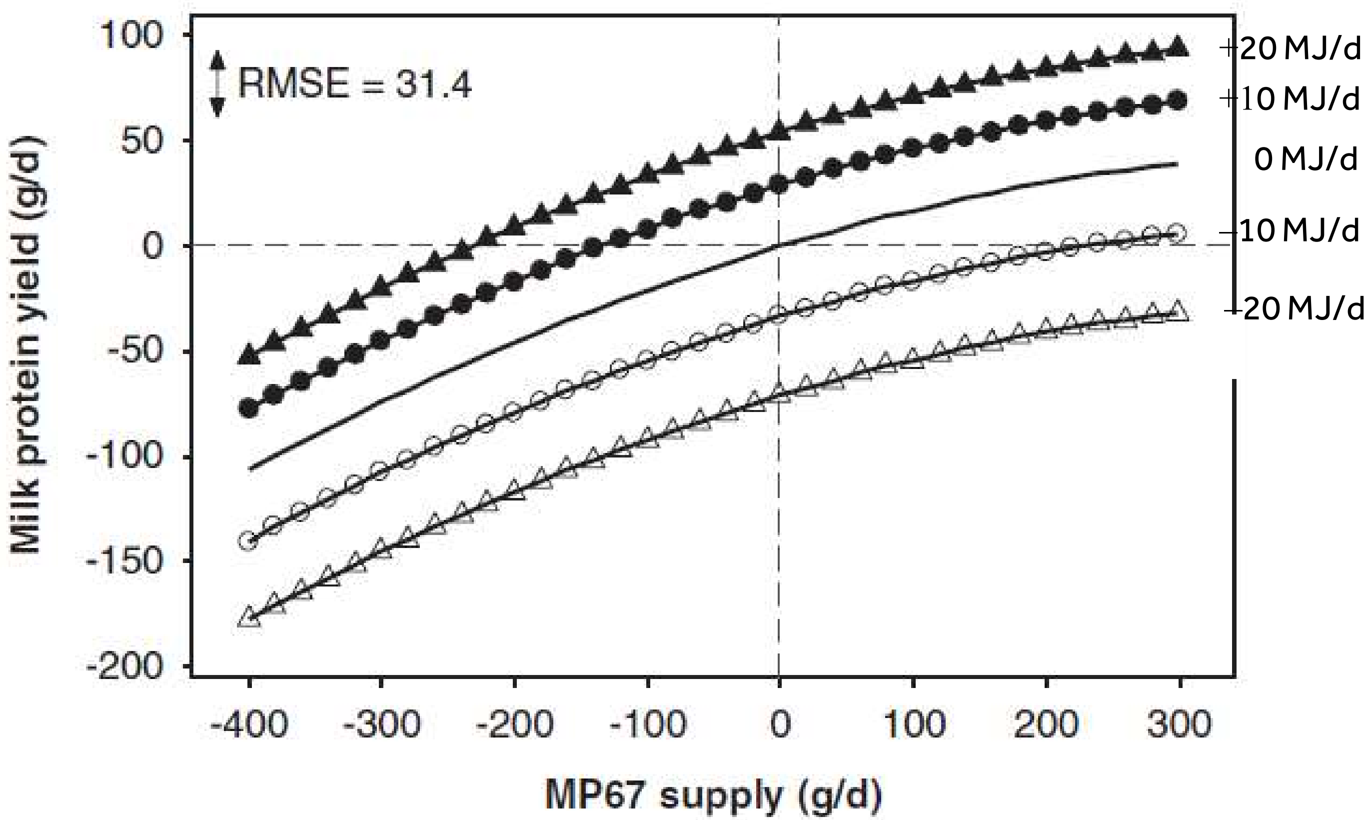


11% improvement in N milk / N intake with higher starch diets

Using Jersey cows *Cantalapiedra-Hijar et al., 2013.*

JD2

Both MP and NEl Supply Affect Milk Protein Yield



Daniel et al. (2016)

Dia 10

JD2 Slide 9 is on type of energy - important. Equally important is amount of energy. Hence suggestion to include a slide, from meta-analysis work of Daniel ea 201

Dijkstra, Jan; 23-8-2021

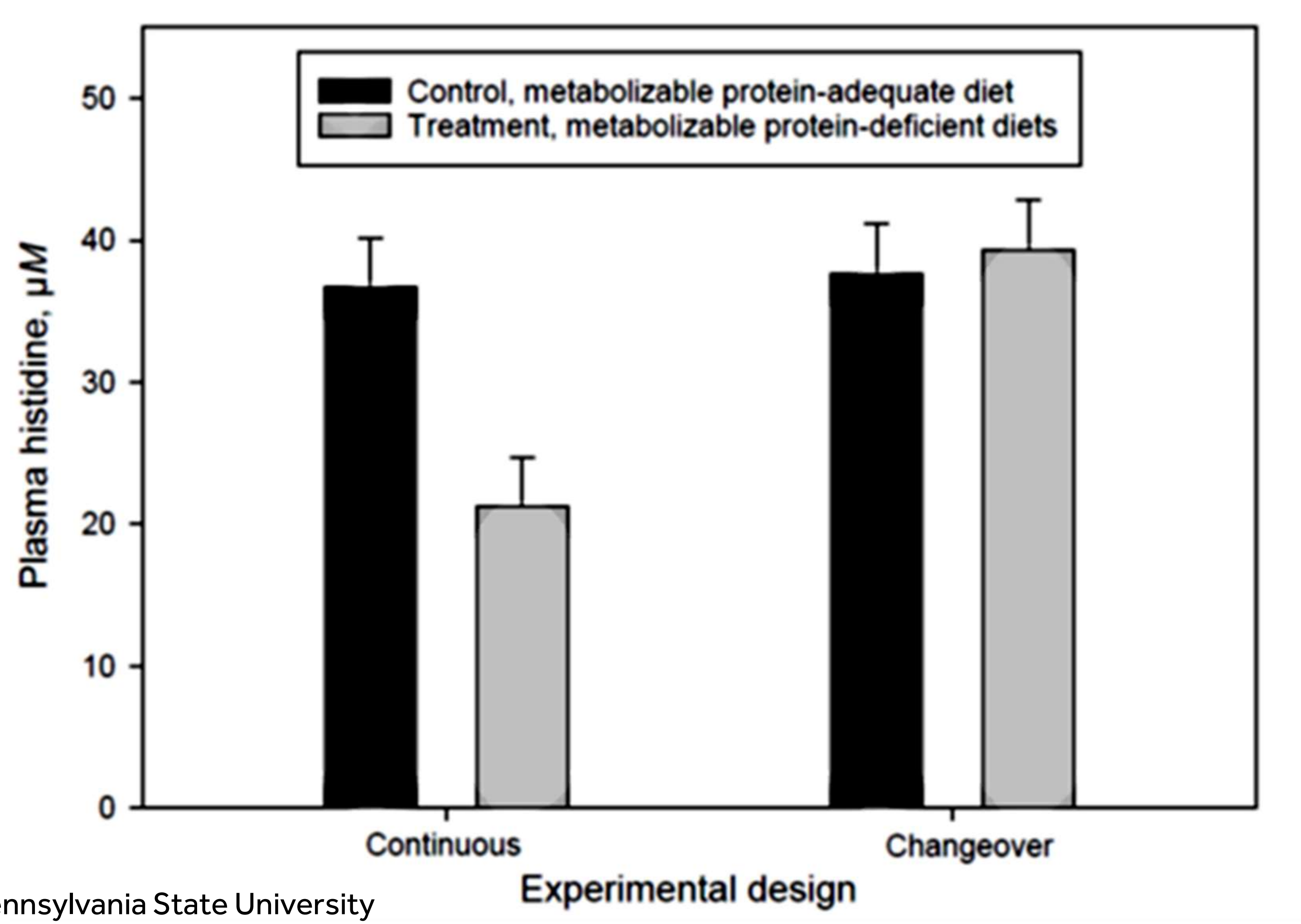
DIETARY PROTEIN AND MILK PRODUCTION

- Numerous (!) studies examining the effect of dietary protein supply on animal performance
  - Concerns over environmental impacts → lower protein diets
  - Accompanied by changes to dietary energy supply
  - Fermentable energy and metabolizable energy both important
- Interest in lower protein diets with rumen-protected protein or essential amino acids
  - Methionine, lysine, histidine… considered as limiting

- **Short-term, cross over designs, often periods of weeks**
  - Dietary adaptation – changes to labile protein pool
  - Differential response to dietary protein content
    - Low to high different from high to low

- **<u>Long-term studies over an entire lactation(s) lacking</u>**

PLASMA HISTIDINE RESPONSE TO A DEFICIT OF MP
CONTINUOUS VS CHANGEOVER DESIGN



Alex Hristov, Pennsylvania State University
Lee et al., 2012 and 2015. 70 vs 28 day periods.

Potential Effects of Lower Dietary Protein?

Lower protein diets

Benefits

- Reduced manure N per litre milk – less land
- Improved biological efficiency of cow
  - Less loss of body reserves?
  - Higher fertility?
  - Reduced culling and more longevity?

Costs

- Reduced milk yield?
- Profitability?
- Fertility loss?

- Maintaining milk yield with lower protein diets by diet formulation?
  - Energy source, essential amino acid balance etc

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EFFICIENCY OF PROTEIN UTILISATION IN LACTATING DAIRY COWS:

LONG TERM EFFECTS OF REDUCED PROTEIN SUPPLY

University of Reading, Aberystwyth University, SRUC, Rothamsted Research

2012-2018

ROTHAMSTED RESEARCH

1872 PRIFYSGOL ABERYSTWYTH UNIVERSITY

SRUC

AHDB DAIRY

Department for Environment Food & Rural Affairs

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LIMITLESS **POTENTIAL** | LIMITLESS **OPPORTUNITIES** | LIMITLESS **IMPACT**

AC0122 - WP2 LACTATION TRIAL

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Aim: Measure the long-term effects of incremental reductions in protein concentration of maize silage-based diets for high yielding dairy cows

- **215 heifers** at Cedar enrolled at calving
- Fed one of 3 diets – **Low 14%, Med 16%** and **High 18%** CP
- Treatments maintained for **3 lactations**
- Managed as for commercial herd except:
  - No grazing and common dry period management
  - No change in diet protein concentration in late lactation
  - Served from day 50 - 200
  - Failed to conceive cows removed after 305 d lactation

AC0122 – LACTATION TRIAL

TWO CONCENTRATE BLENDS

University of Reading

	Crude protein concentration		
	14%	16%	18%
Grass silage	150	150	150
Maize silage	350	350	350
Barley straw	15	15	15
Cracked wheat	**115**	**100**	**85**
MSBF	40	40	40
Soy hulls	**81**	**73**	**65**
Wheat feed	**139**	**93.3**	**47.6**
Soybean meal	**37.5**	**71.9**	**106.2**
Rapeseed meal	**37.5**	**71.9**	**106.2**
Molasses	15	15	15
Mins & vits	20	20	20

LACTATION RATIONS

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	Crude Protein Concentration		
Item	14%	16%	18%
CP	140	160	180
ME – MJ/kg DM	11.27	11.32	11.38
NDF	**352**	**343**	**334**
ADF	238	237	236
Starch	**231**	**213**	**195**
WSC	49	52	54
EE	45	45	45
Starch + WSC	**280**	**265**	**249**
MPn - % of required	**89.9**	103.2	115.9
MPe - % of required	95.2	**99.9**	**103.8**

TMR CP VARIATION (UNADJUSTED)

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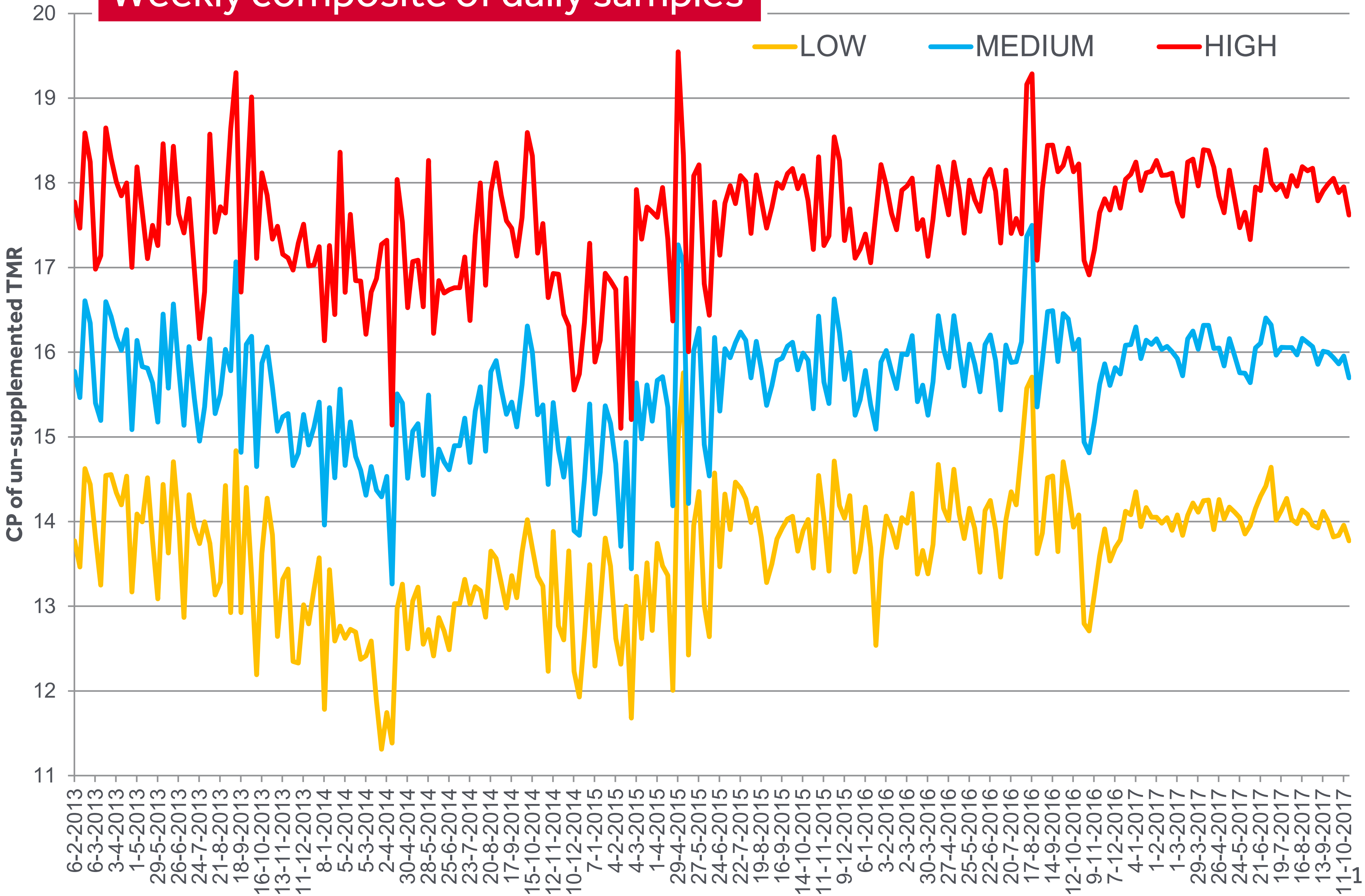
Weekly composite of daily samples



TMR CP VARIATION (ADJUSTED)

University of Reading

3 week rolling mean

J. Dairy Sci. 104:10714–10726
https://doi.org/10.3168/jds.2021-20219
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Dietary protein oscillation: Effects on feed intake, lactation performance, and milk nitrogen efficiency in lactating dairy cows

Rainer Rauch,[1,2]* Javier Martín-Tereso,[1] Jean-Baptiste Daniel,[1] and Jan Dijkstra[2]
[1]Trouw Nutrition R&D, PO Box 299, 3800 AG, Amersfoort, the Netherlands
[2]Animal Nutrition Group, Wageningen University and Research, PO Box 338, 6700 AH Wageningen, the Netherlands

Table 2. Performance of lactating dairy cows (n = 25/treatment) receiving TMR based on either static (ST; daily CP 149 g/kg of DM) or oscillating (OS; CP 134 g/kg of DM for 48 h, followed by CP 165 g/kg of DM for 48 h) dietary CP concentration

	Treatment			*P*-value		
Item	ST	OS	SEM	Treatment	Period	Period × treatment
DMI,[1] kg/d	25.5	25.5	0.31	0.95	0.62	0.62
CP intake,[1] kg/d	3.80	3.81	0.042	0.77	0.58	0.66
Yield[1]						
Milk, kg/d	31.5	31.5	0.34	0.99	0.43	0.88
Fat, g/d	1,384	1,382	23.4	0.97	0.15	0.17
CP, g/d	1,156	1,157	13.2	0.95	0.15	0.77
Lactose, g/d	1,449	1,437	17.0	0.63	0.16	0.91
FPCM, kg/d[2]	33.6	33.6	0.45	0.91	0.18	0.32

DRY MATTER INTAKE

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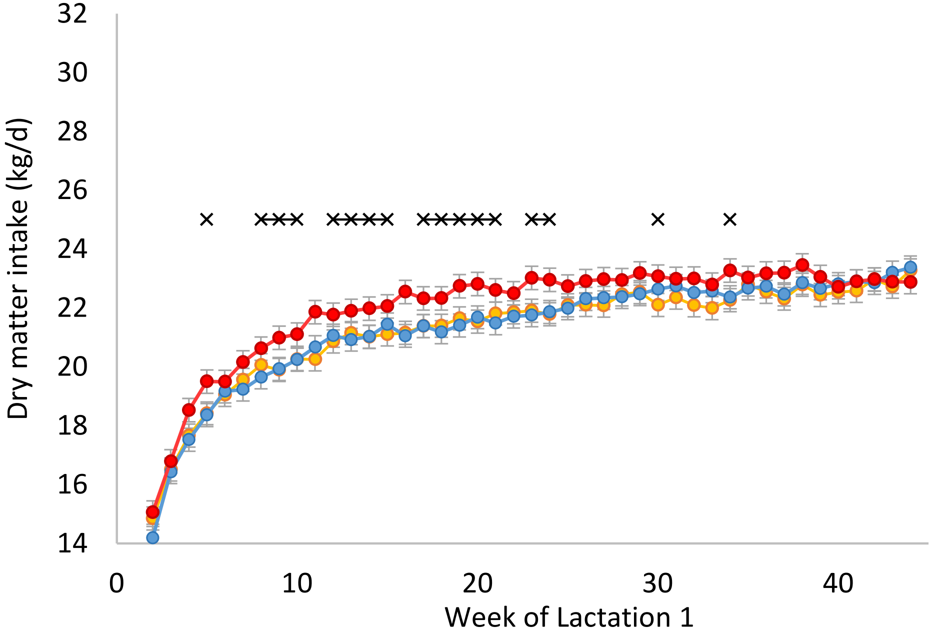
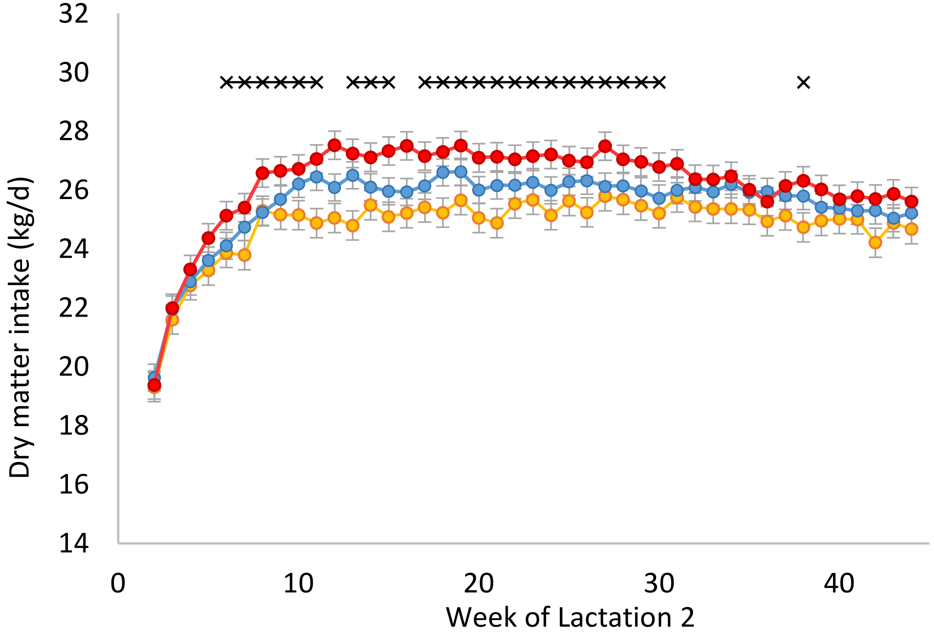
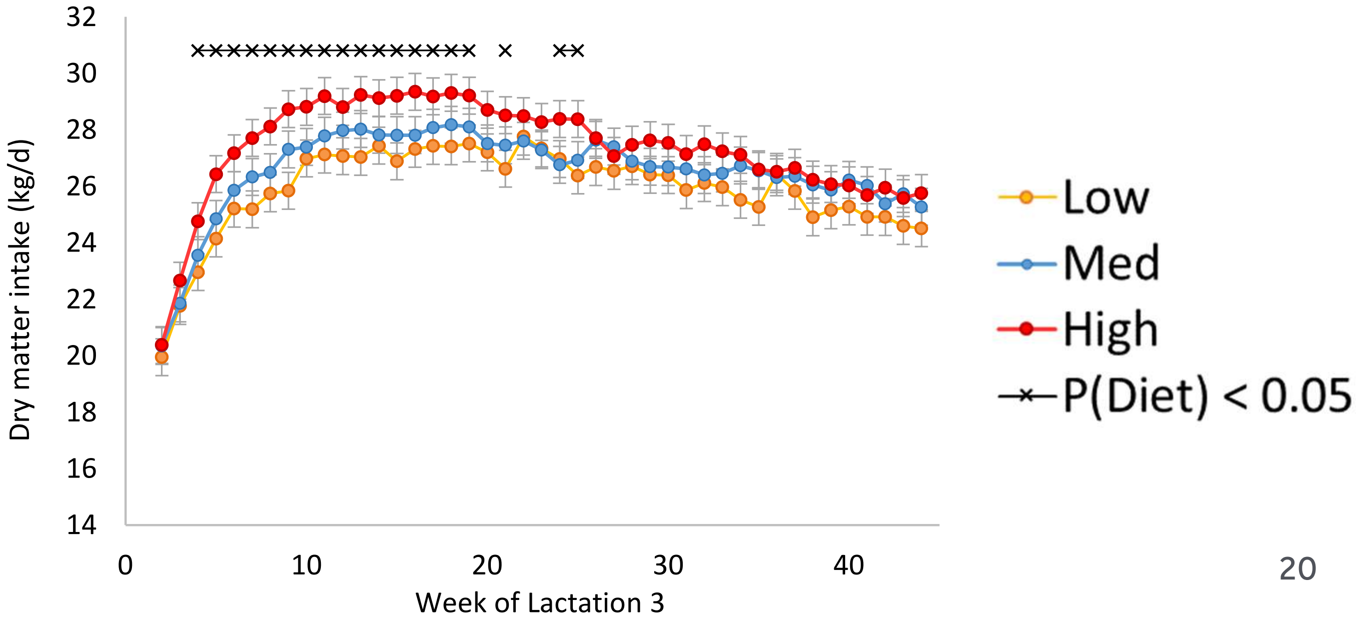




	Low	Med	High
Lac 1	21.3[b]	21.3[b]	22.0[a]
Lac 2	24.8[b]	25.5[ab]	26.2[a]
Lac 3	25.9[c]	26.5[b]	27.3[a]



MILK YIELD

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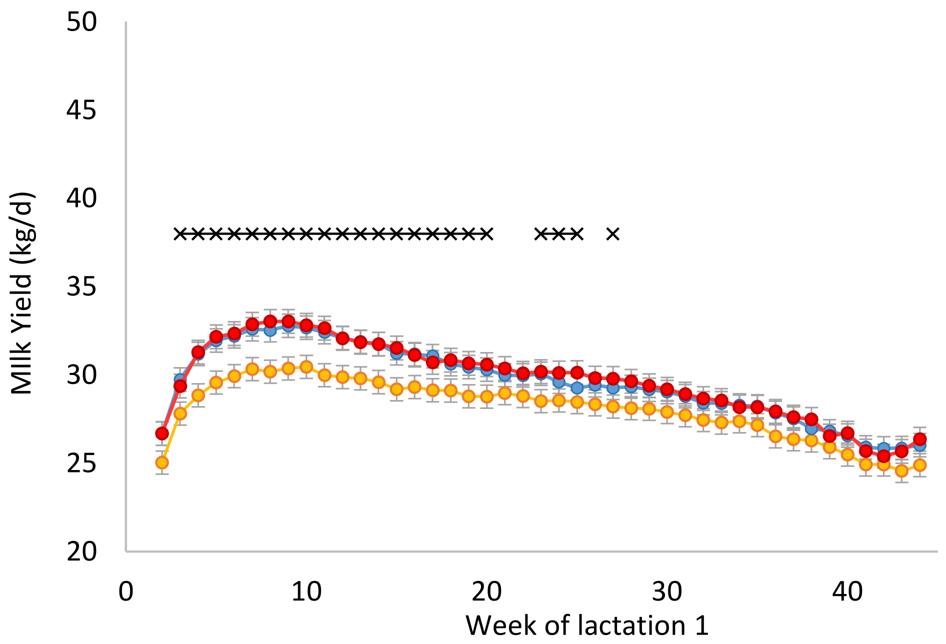
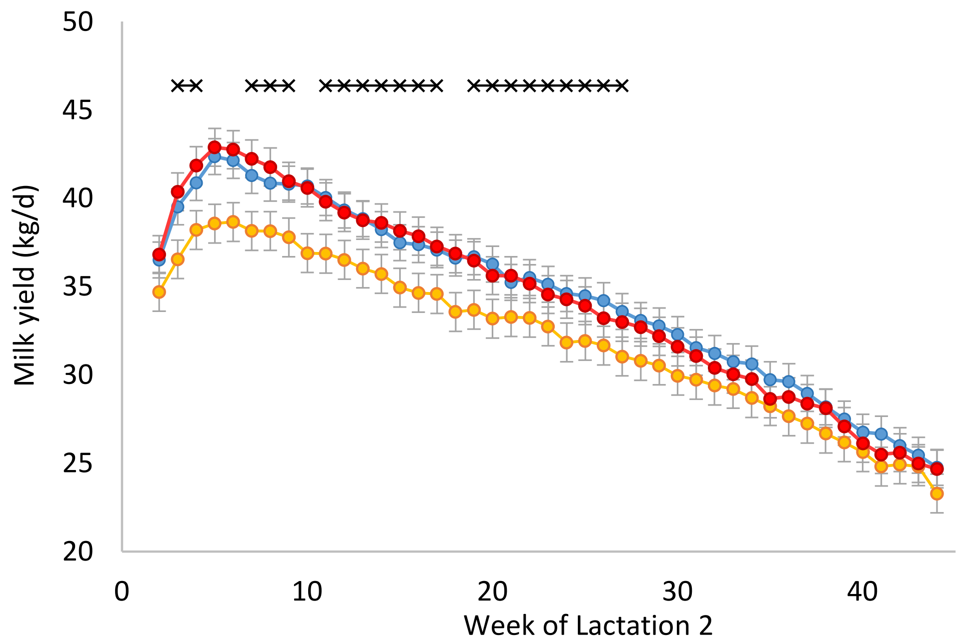
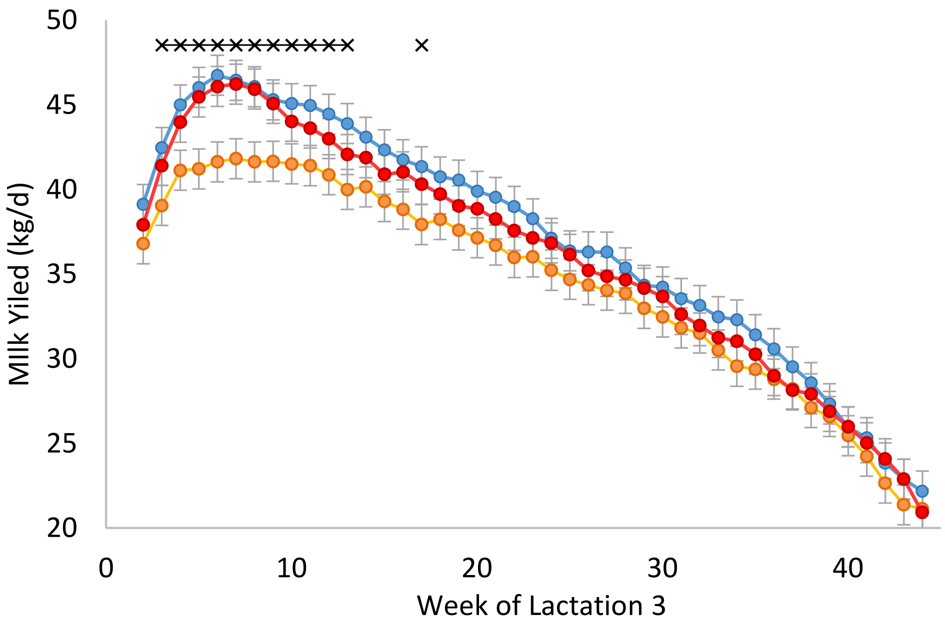
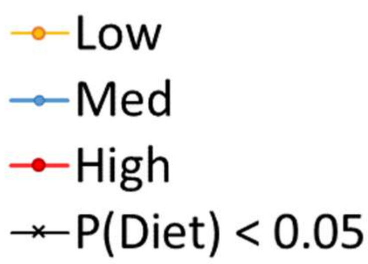


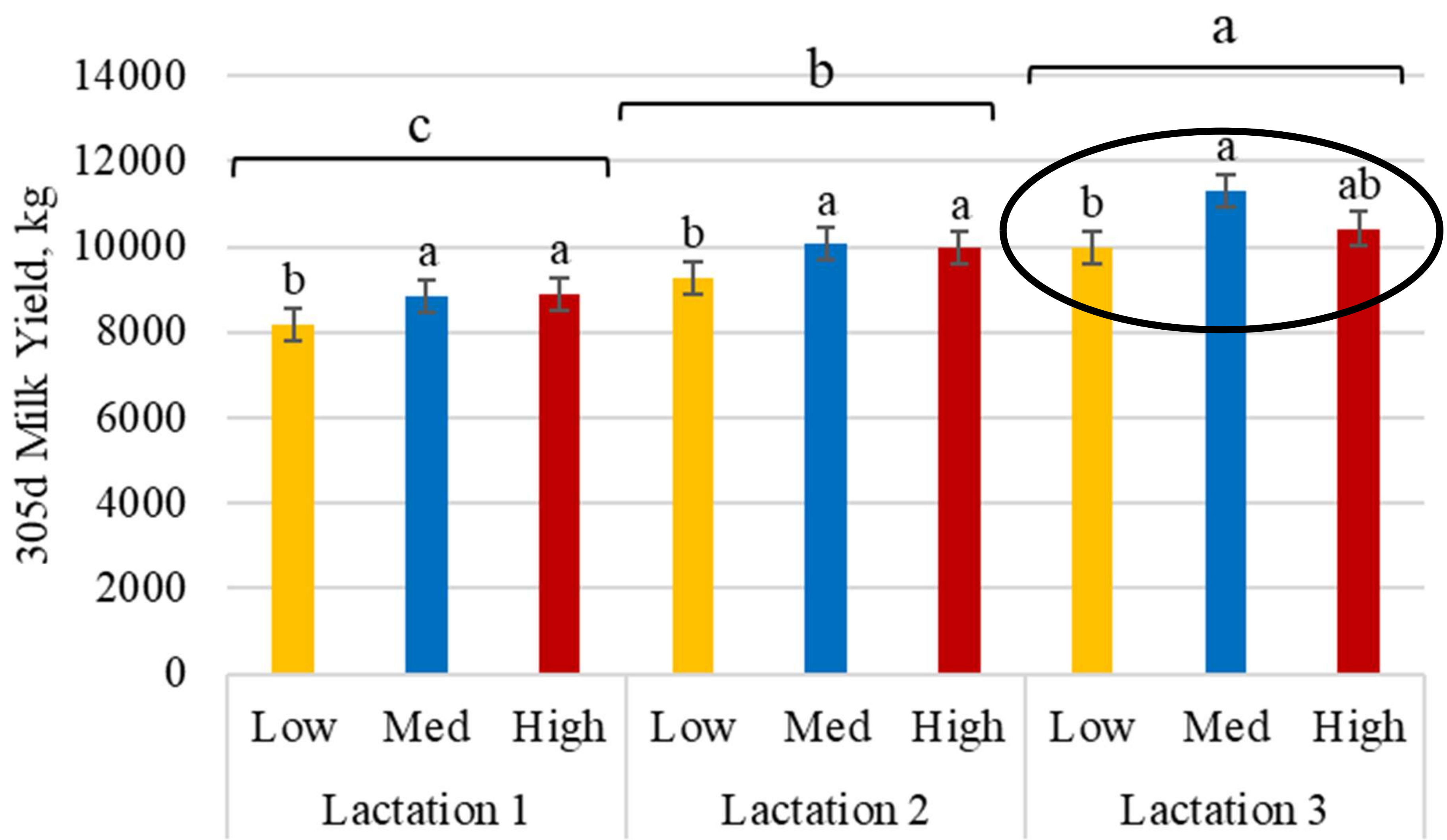


	Low	Med	High
Lac 1	28.1[b]	29.6[a]	29.7[a]
Lac 2	32.1[b]	34.5[a]	34.3[a]
Lac 3	34.5[b]	37.0[a]	36.1[ab]

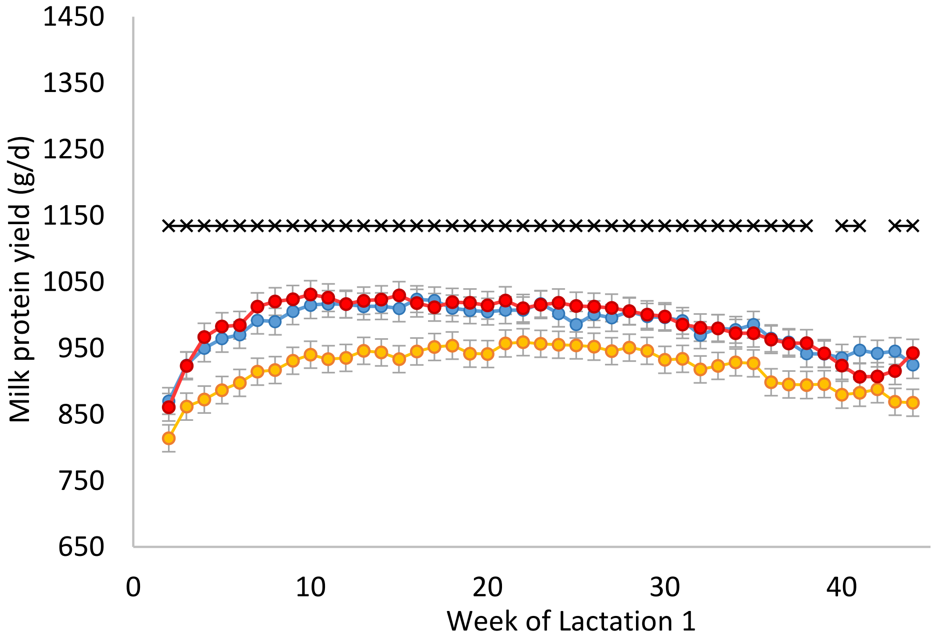


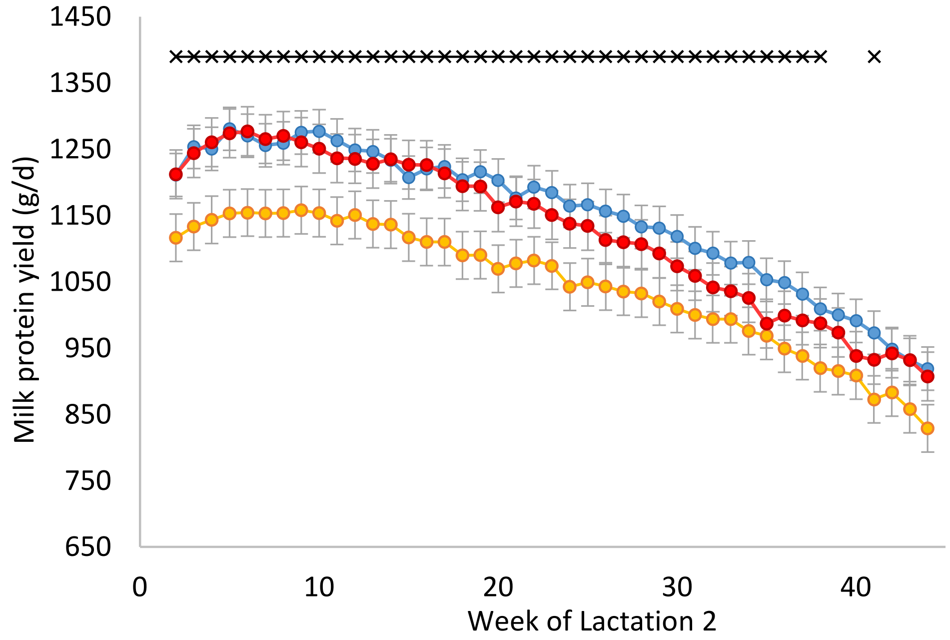


305 DAY MILK YIELD

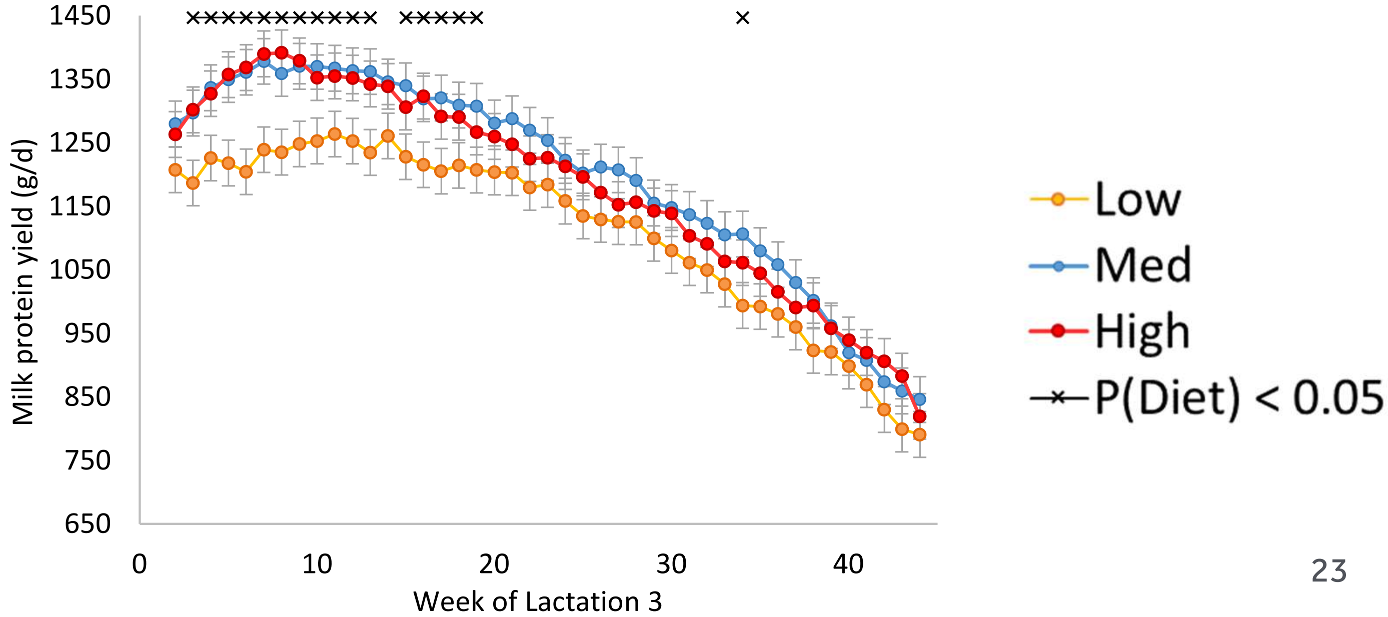


MILK PROTEIN YIELD

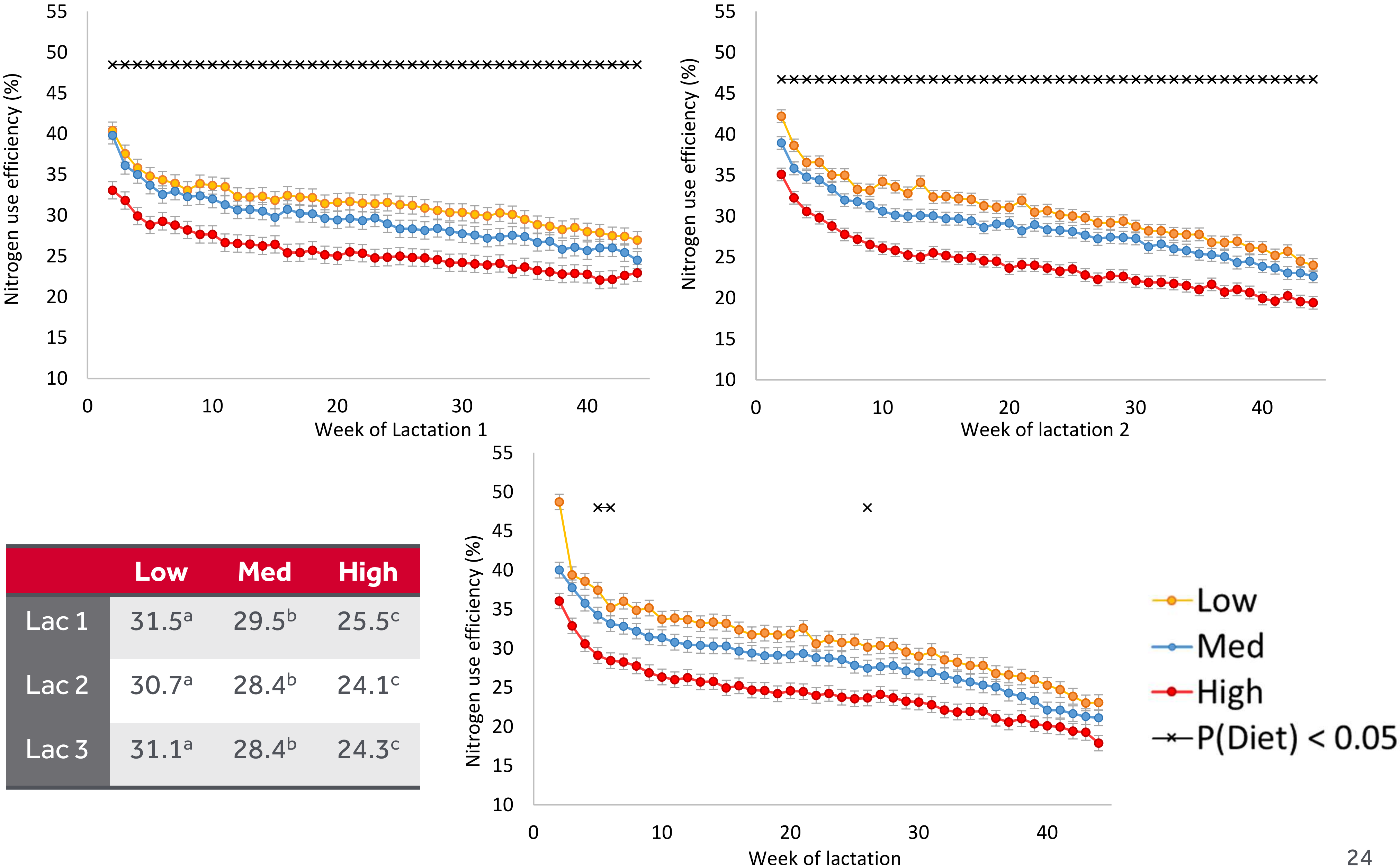




	Low	Med	High
Lac 1	920[b]	982[a]	986[a]
Lac 2	1045[b]	1150[a]	1127[a]
Lac 3	1112[b]	1199[a]	1184[a]



NITROGEN USE EFFICIENCY



	Low	Med	High
Lac 1	31.5[a]	29.5[b]	25.5[c]
Lac 2	30.7[a]	28.4[b]	24.1[c]
Lac 3	31.1[a]	28.4[b]	24.3[c]

MILK UREA CONCENTRATION

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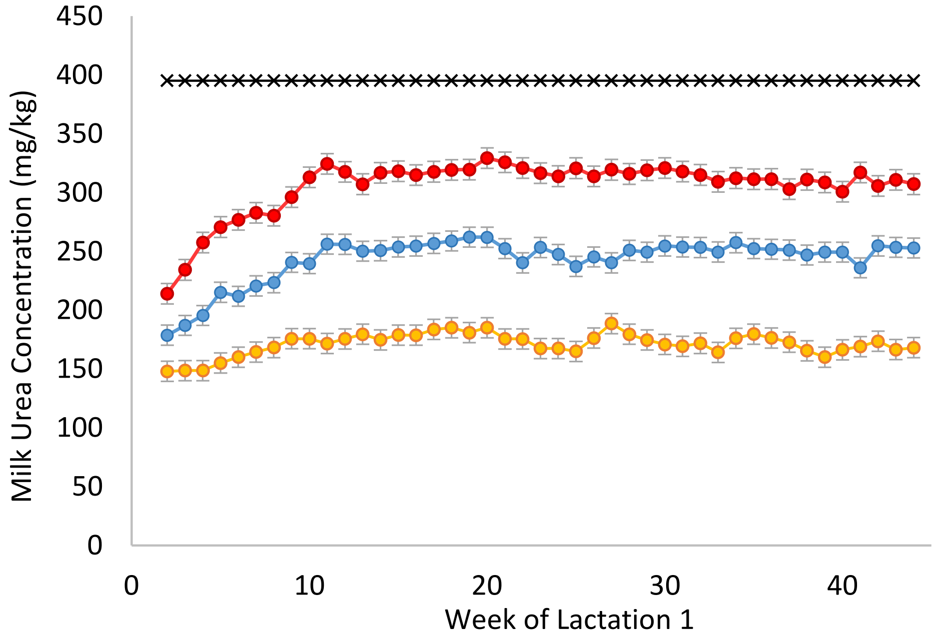
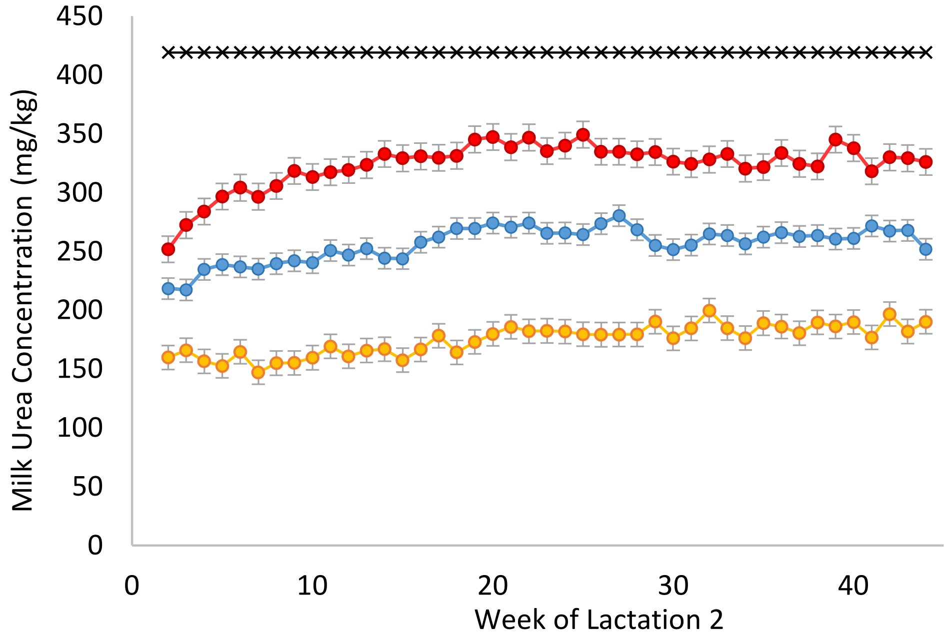
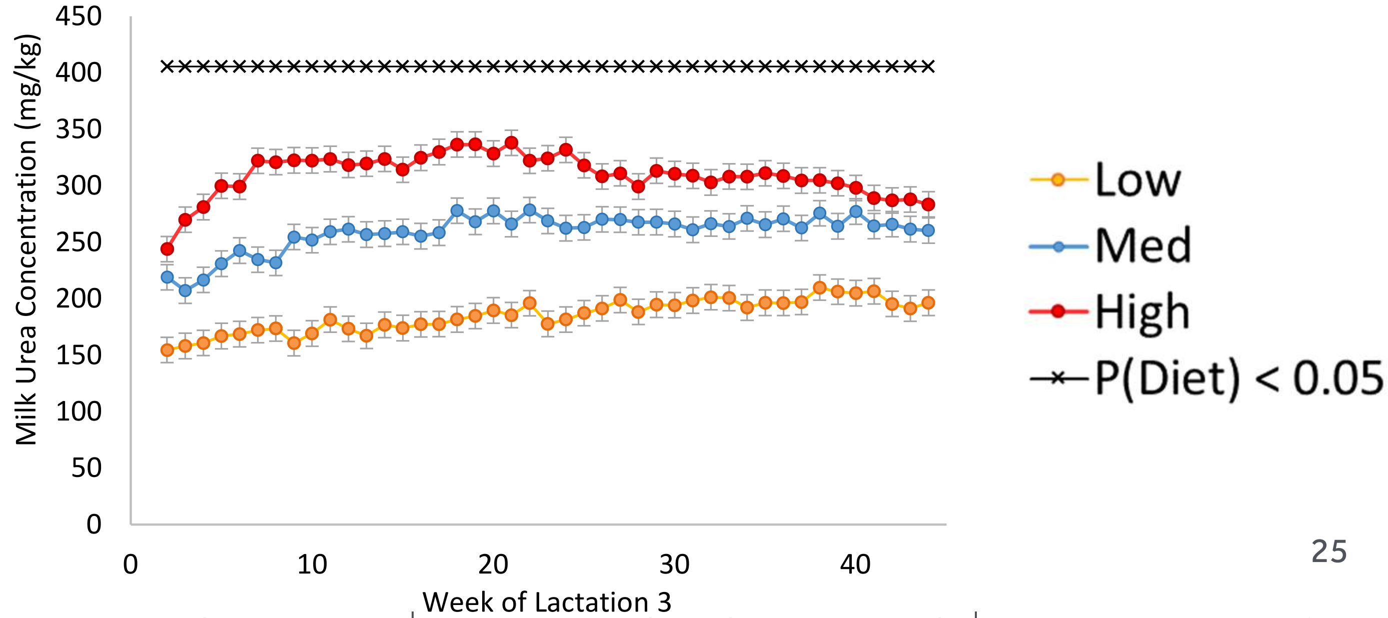




	Low	Med	High
Lac 1	171[c]	243[b]	305[a]
Lac 2	174[c]	256[b]	324[a]
Lac 3	185[c]	259[b]	310[a]



SLURRY AMMONIA EMISSION

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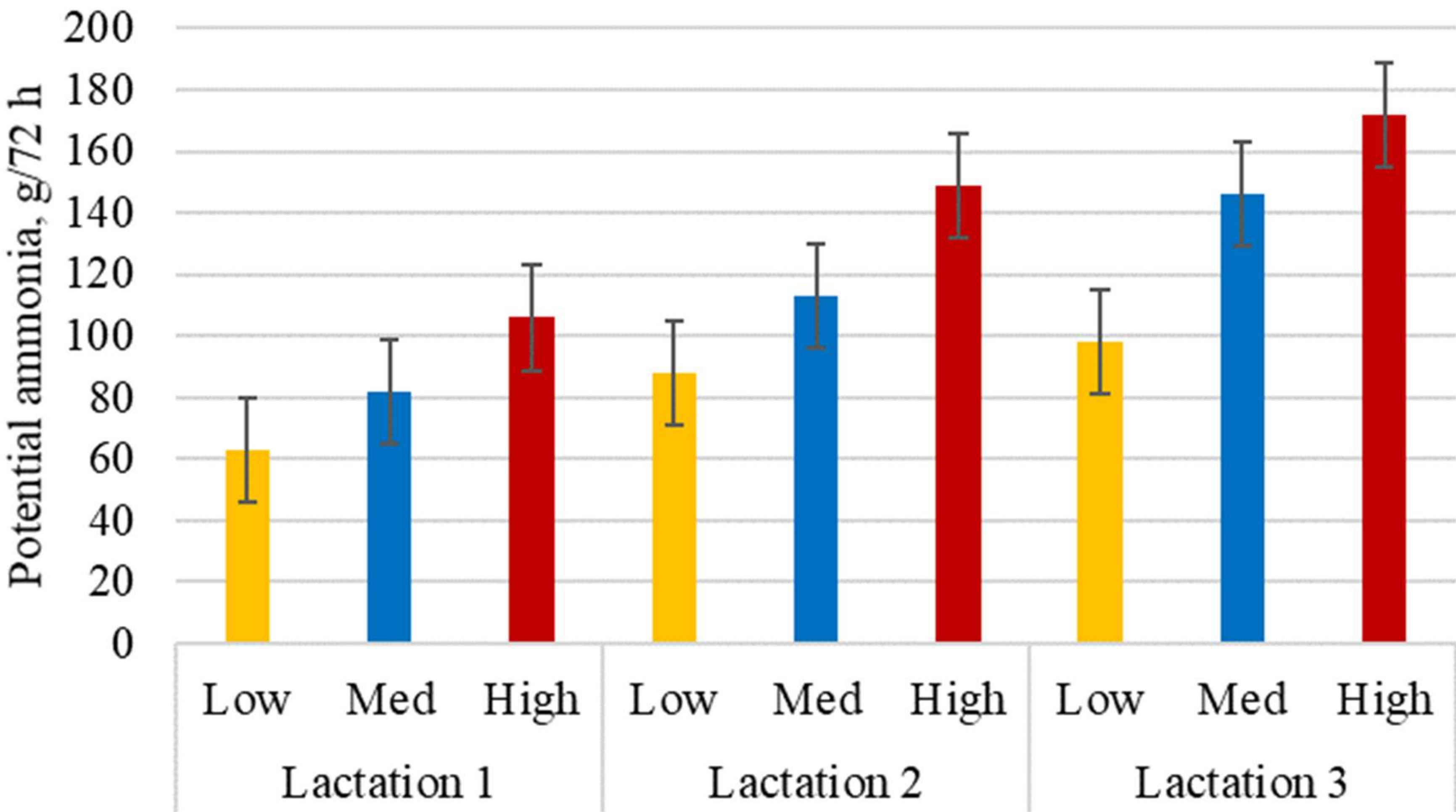

Potential 3 day emission from daily manure excretion

NITROGEN USE EFFICIENCY:
ANIMAL VARIATION

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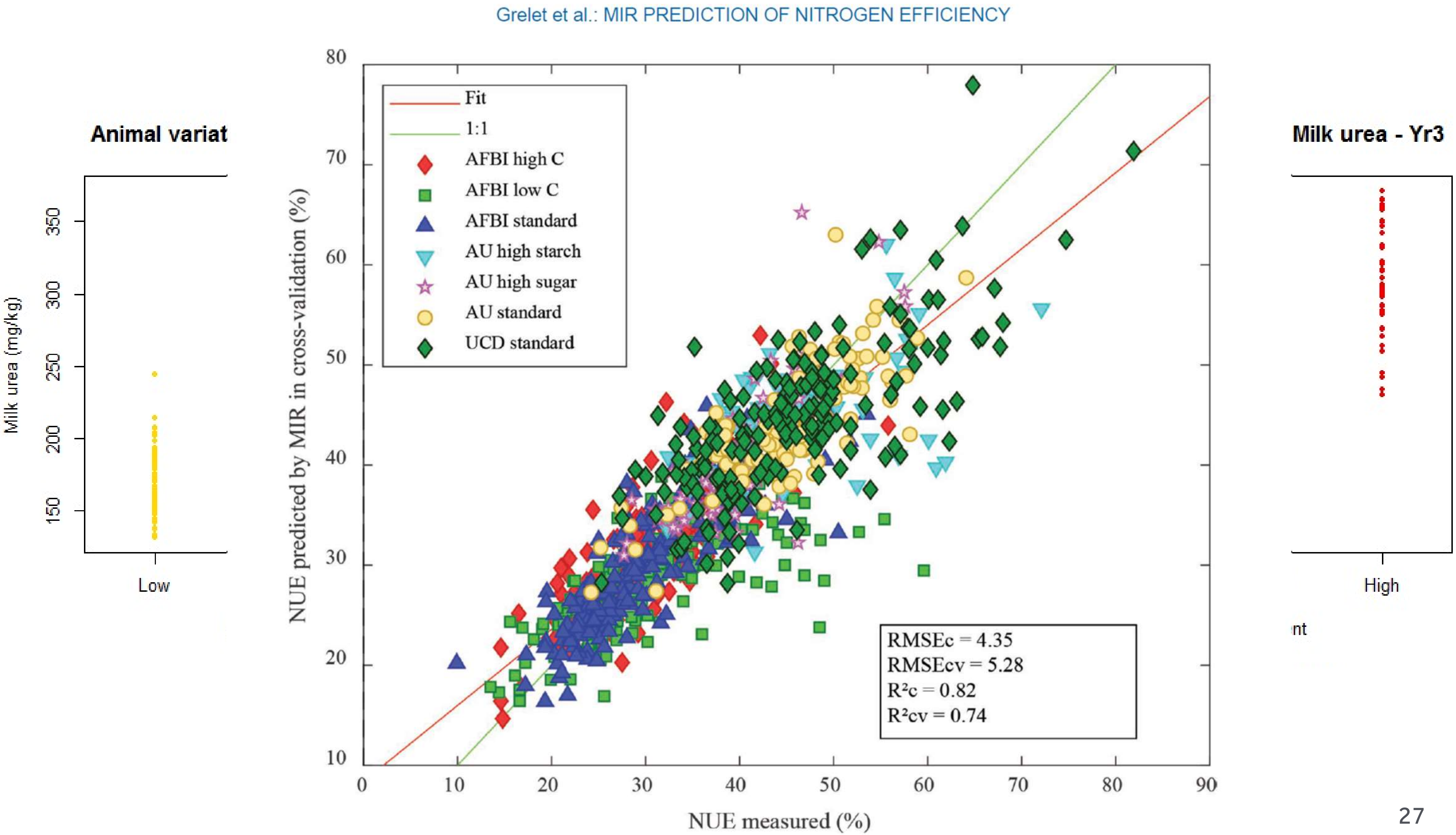

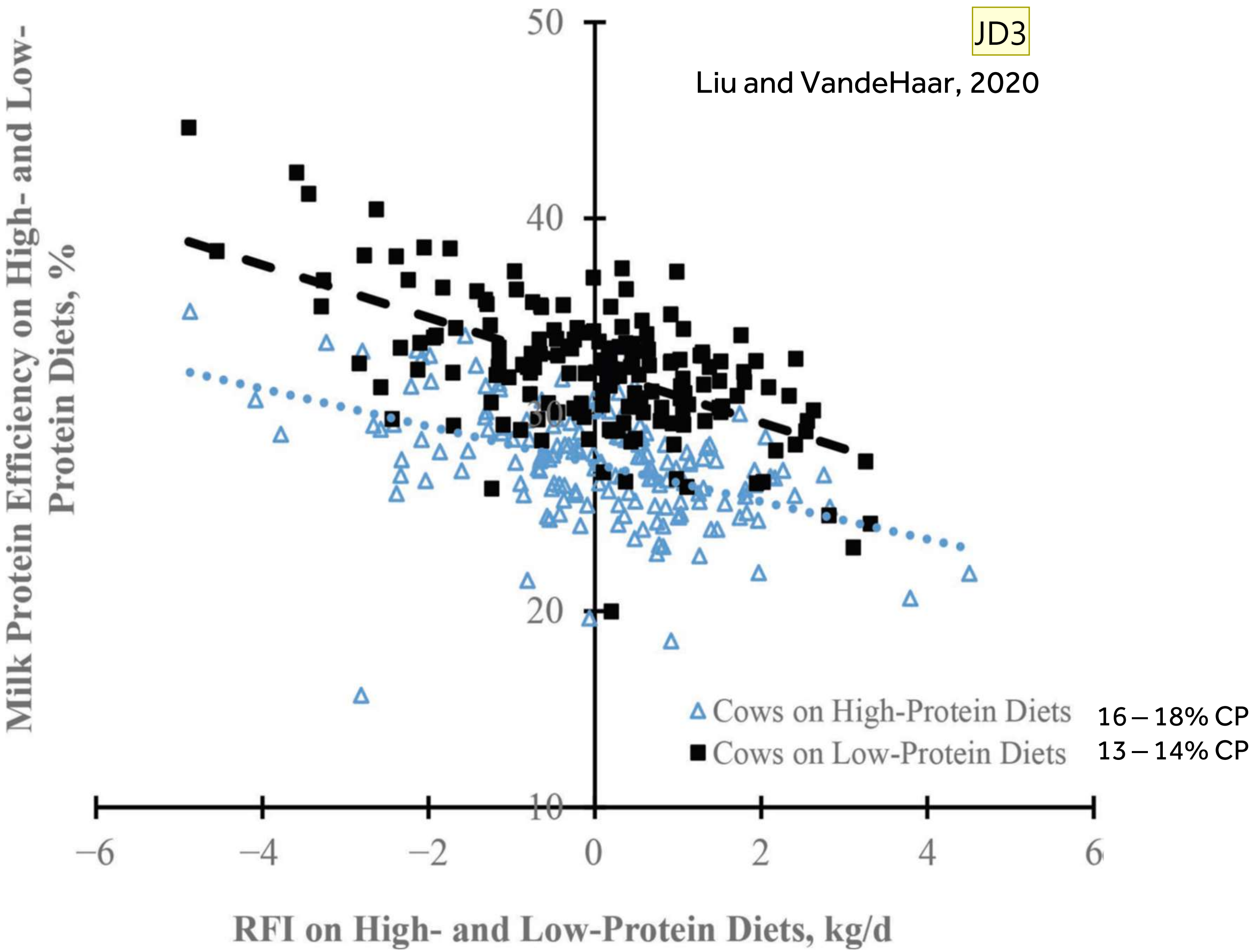

JD3
Liu and VandeHaar, 2020
Milk Protein Efficiency on High- and Low-Protein Diets, %
RFI on High- and Low-Protein Diets, kg/d
50
40
30
20
10
−6
−4
−2
0
2
4
6
Cows on High-Protein Diets
Cows on Low-Protein Diets
16 – 18% CP
13 – 14% CP

Dia 28

JD3 could you add here as indication how much CP (% of diet DM) is in high protein diets, and in low protein diets?
Dijkstra, Jan; 23-8-2021

BODYWEIGHT

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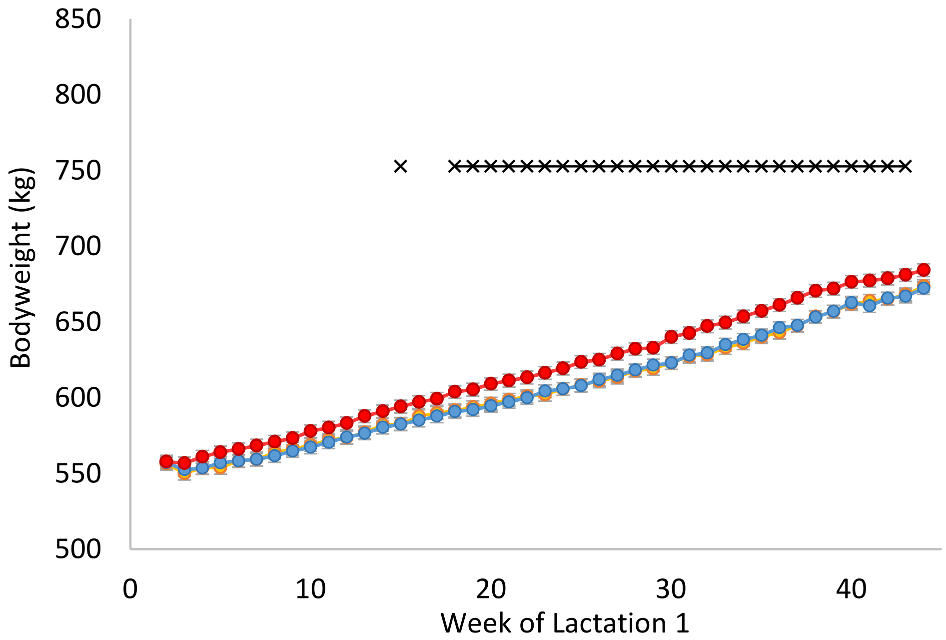
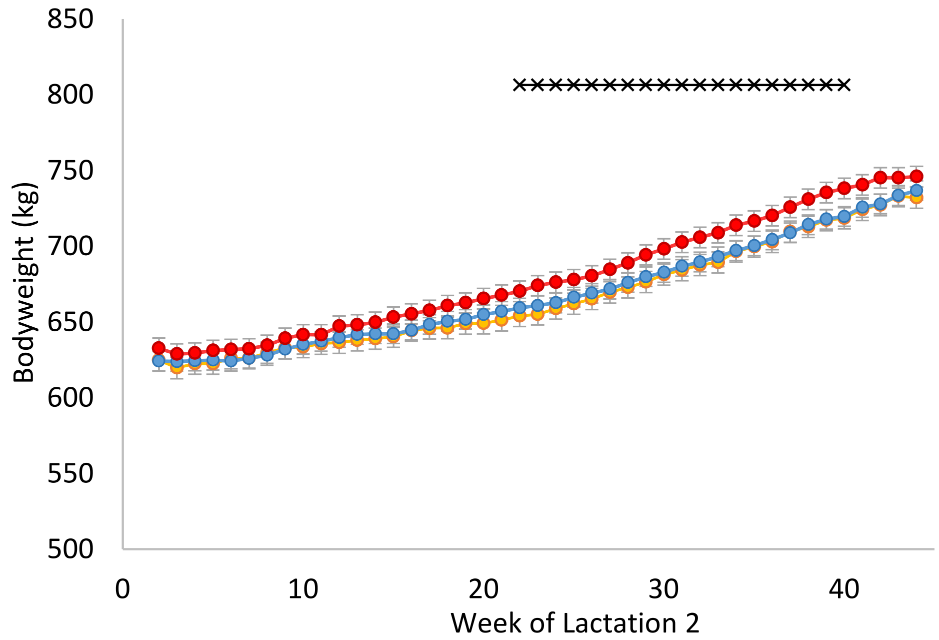
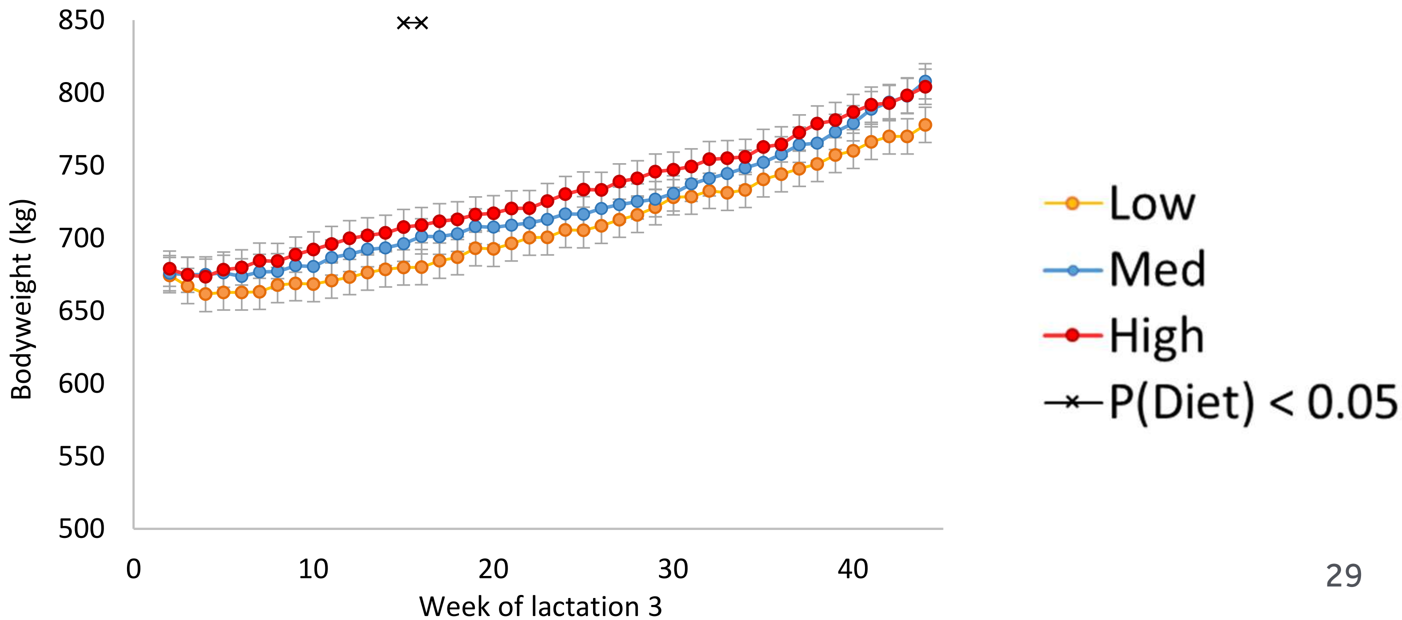




	Low	Med	High
Lac 1	606[b]	606[b]	619[a]
Lac 2	666[b]	668[b]	680[a]
Lac 3	707[b]	721[ab]	730[a]



BODY CONDITION SCORE

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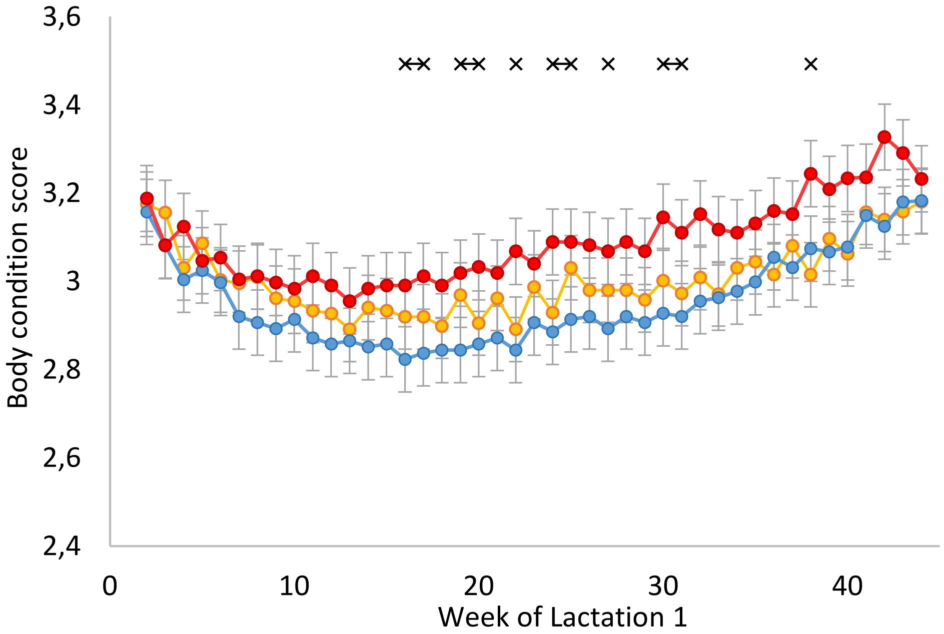
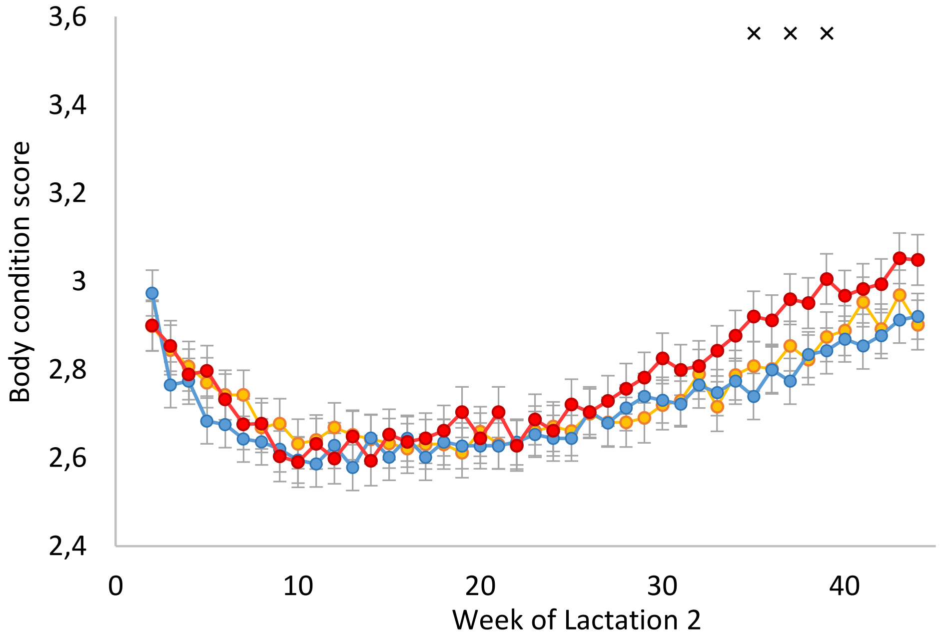
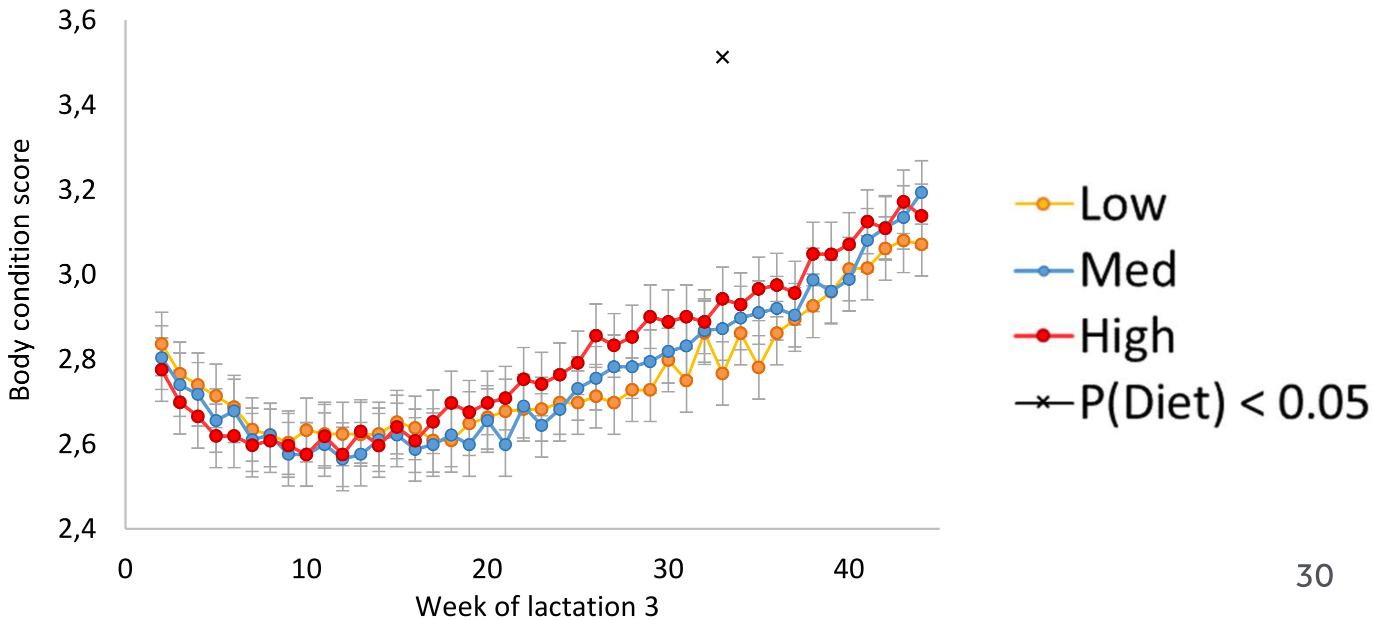




	Low	Med	High
Lac 1	3.01[ab]	2.96[b]	3.09[a]
Lac 2	2.74	2.71	2.78
Lac 3	2.76	2.77	2.80



ATTRITION – WHOLE STUDY

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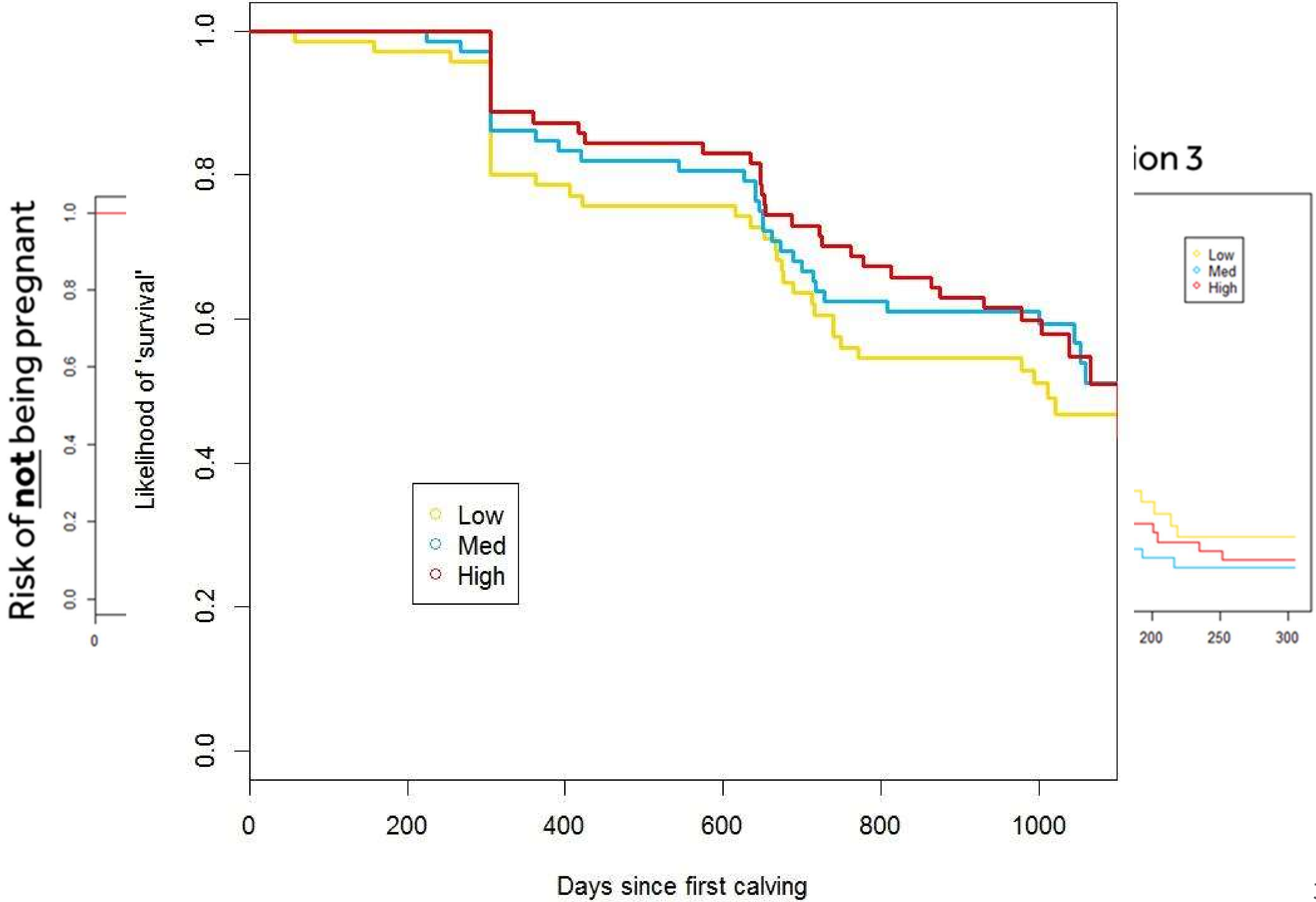
	Low	Med	High
Started	72	72	71
Stealers	7	2	3
Start minus stealers	65	70	68
Cull or died	10	8	10
Reproductive failures			
Abortion	9	4	3
Not in calf	19	22	21
Culled after study	4	3	2
Would continue to 4th lactation[1]	23 (35%)	33 (47%)	32 (47%)

[1]Final percentages = [would continue] / [start minus stealers] *100

Embryo loss not included (some rebred): **8, 2, and 4** for low, medium and high, respectively.
Days to first progesterone rise and days to conception not affected by diet.

ATTRITION – WHOLE STUDY

University of Reading



RPM and Fertility in Dairy Cows

University of Reading

Table 7. Effect of rumen-protected methionine (RPM) feeding on ultrasonographic morphometry of amniotic vesicle and embryo on gestation Day 33.

		Amniotic Vesicle	Embryo			
Treatment[1,2]	n	Volume (mm^3)	n	Crown-rump Length (mm)	Abdominal Diameter (mm)	Volume (mm^3)
Overall						
CON	63	542.6 ± 25.7	69	10.5 ± 0.2	5.5 ± 0.1	167.1 ± 6.0
RPM	80	594.9 ± 30.6	82	11.0 ± 0.2	5.8 ± 0.1	201.2 ± 10.6
P-value		0.27		0.08	0.04	0.01
Primiparous						
CON	30	617.1 ± 39.3	34	10.5 ± 0.2	5.6 ± 0.2	171.6 ± 7.6
RPM	36	596.0 ± 37.0	38	10.9 ± 0.2	5.7 ± 0.2	191.9 ± 14.3
P-value		0.67		0.21	0.61	0.38
Multiparous						
CON	33	479.4 ± 29.4	36	10.6 ± 0.2	5.3 ± 0.1	162.7 ± 9.2
RPM	44	593.9 ± 46.0	44	11.0 ± 0.2	5.9 ± 0.2	209.3 ±15.6
P-value		0.04		0.22	0.02	0.009

Pregnancy loss reduced from 19.6 (10/51) to 6.1% (3/49) by rumen-protected methionine ($P < 0.03$).

Toledo et al., 2017.

SOME LESSONS – CEDAR TRIAL

University of Reading

- Lower protein diets more 'N efficient' but need to consider longer term effects at systems level
  - Economic and environmental implications
  - High degree of animal variation in NUE
  - Risk of reduced milk yield and fertility
- Large variation in diet protein concentrations
  - Implications for precision feeding lower protein diets
  - Cows resilient to daily fluctuations
- Longer-term negative effects of 'sub-optimal' protein supply evident – survival reduced
- A 16% crude protein diet was 'optimal' in many respects - this was by design

SOME QUESTIONS – CEDAR TRIAL

- Reasons for animal variation in NUE of interest
  - Linked to overall feed efficiency
  - Similar degree of animal variation across treatments
  - Genetic components (animal and rumen)?

- How to address variation in diet composition
  - Do day-to-day variations matter?
  - Use of precision technology?

- Are higher starch/sugar diets a concern?

- Role of RUP and/or rumen-protected EAA essential for precision feeding lower CP concentration diets?

SOME TAKE HOME MESSAGES

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- Diets can be formulated to meet requirements with 'lower' crude protein concentrations – need to consider EAA supply
  - Energy supply key to maximum dietary N efficiency
    - Dietary N efficiency linked to milk protein yield and feed efficiency
  - Precision feeding lower protein diets
    - challenges of variations in feed composition
    - cows very resilient – long term average important
    - Under supply of EAA linked to reduced 'survival'
- Need to consider NUE on a system basis – not just what goes into and comes out of a cow – balancing benefits and risks
  - Fertilizer/slurry use and rearing diets also important

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THANK YOU!

www.reading.ac.uk/apd/research-and-facilities/cedar.aspx

www.reading.ac.uk/DiverseForages

www.reading.ac.uk/protein-efficiency

#DiverseForagesStudy

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