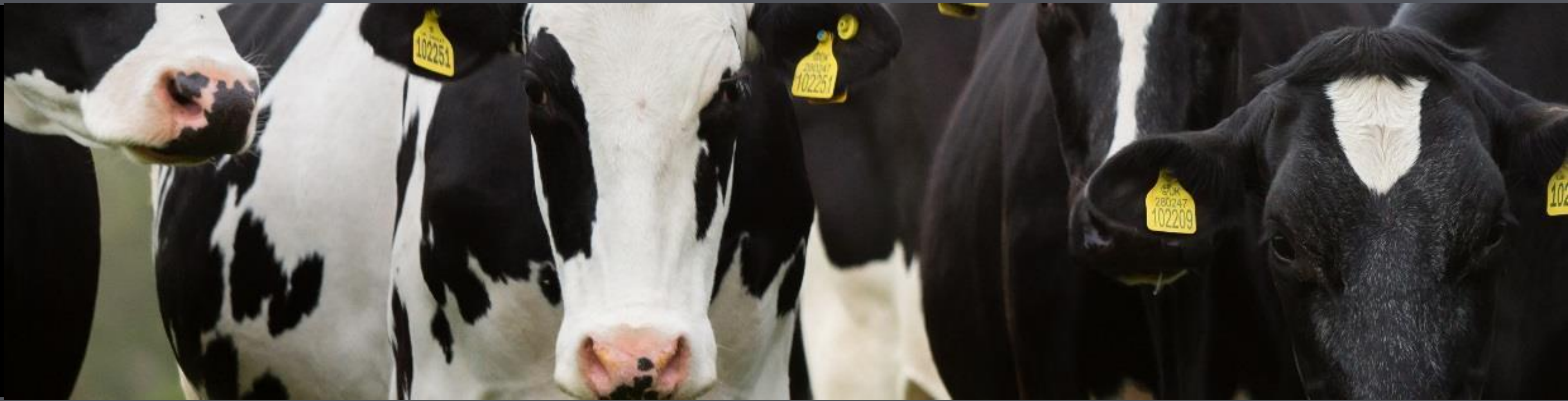
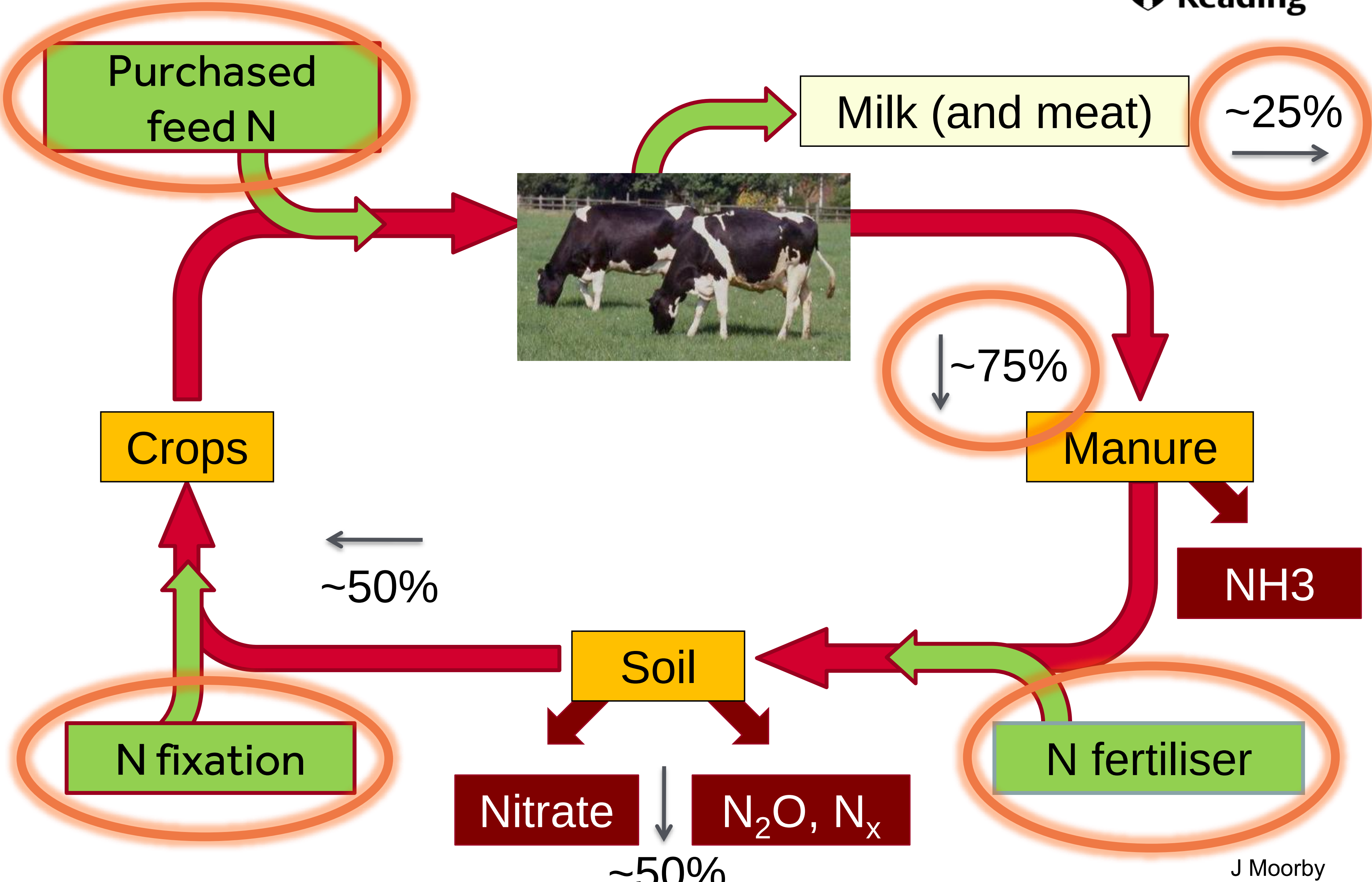
DEFRA Project ACO122

USING FEED PROTEIN MORE EFFICIENTLY - REDUCING ENVIRONMENTAL IMPACTS OF DAIRY PRODUCTION SYSTEMS



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

NITROGEN USE EFFICIENCY



J Moorby

NITROGEN USE EFFICIENCY

University of Reading

FW | LATEST | KNOW HOW | MARKETS | 8° Sutton

Farmers face restrictions to tackle ammonia emissions

Philip Case

14 January 2019

More in

Compliance | Environment | Farm policy | News

Recommended

Gove's new farm pollution controls: The details and reaction

© Tim Scrivener

Farms will face new restrictions on spreading manure and slurry under the government's "world-leading" plan to tackle air pollution.

The government plans to regulate to reduce ammonia emissions from farming, including a requirement to spread slurries and digestate using low-emission spreading equipment (trailing shoe or trailing hose or injection) by 2025.

In the UK, agriculture is responsible for 88% of all ammonia emissions – one-quarter of which comes from ammonia lost in the atmosphere when nitrogen fertiliser is made and spread on farmland.

~25%

e

NH3

ser

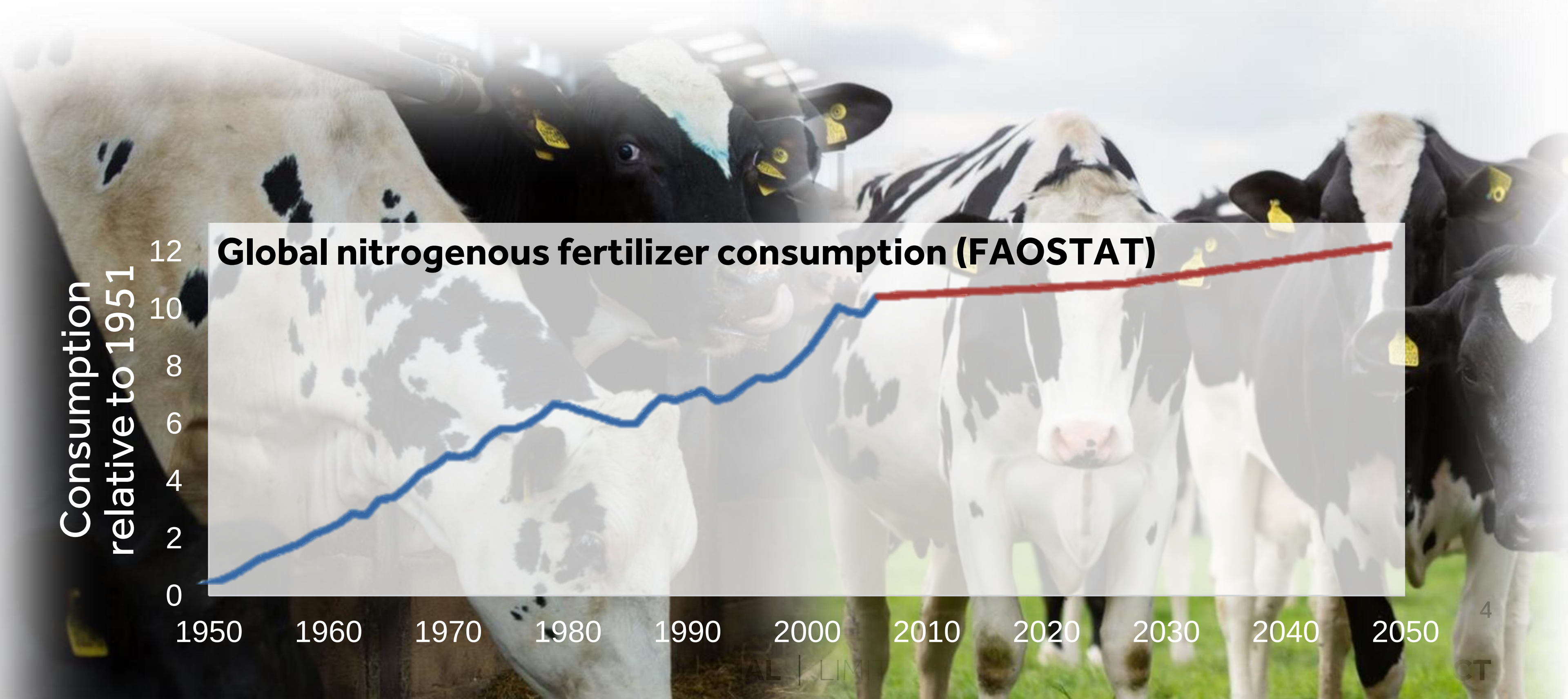
J Moorby

IMPACT

Cattle can convert human-inedible fibrous resources such as grass and other forages into high quality food for human consumption

However

Ruminant production also accounts for 40% of UK $N_{2}0$ emissions partly due to high levels of nitrogen fertiliser applied to pure grass pastures.



Energy-proofing by symbiotic N_2-fixation

- **Productive grass-clover mixtures fix about 200 kg N ha^{-1} yr^{-1}**
  - The corresponding energy to produce 200 kg N fertiliser = fuel needed to drive 10,000 km with a small car

Slide courtesy of Dr John Finn, Johnstown Castle

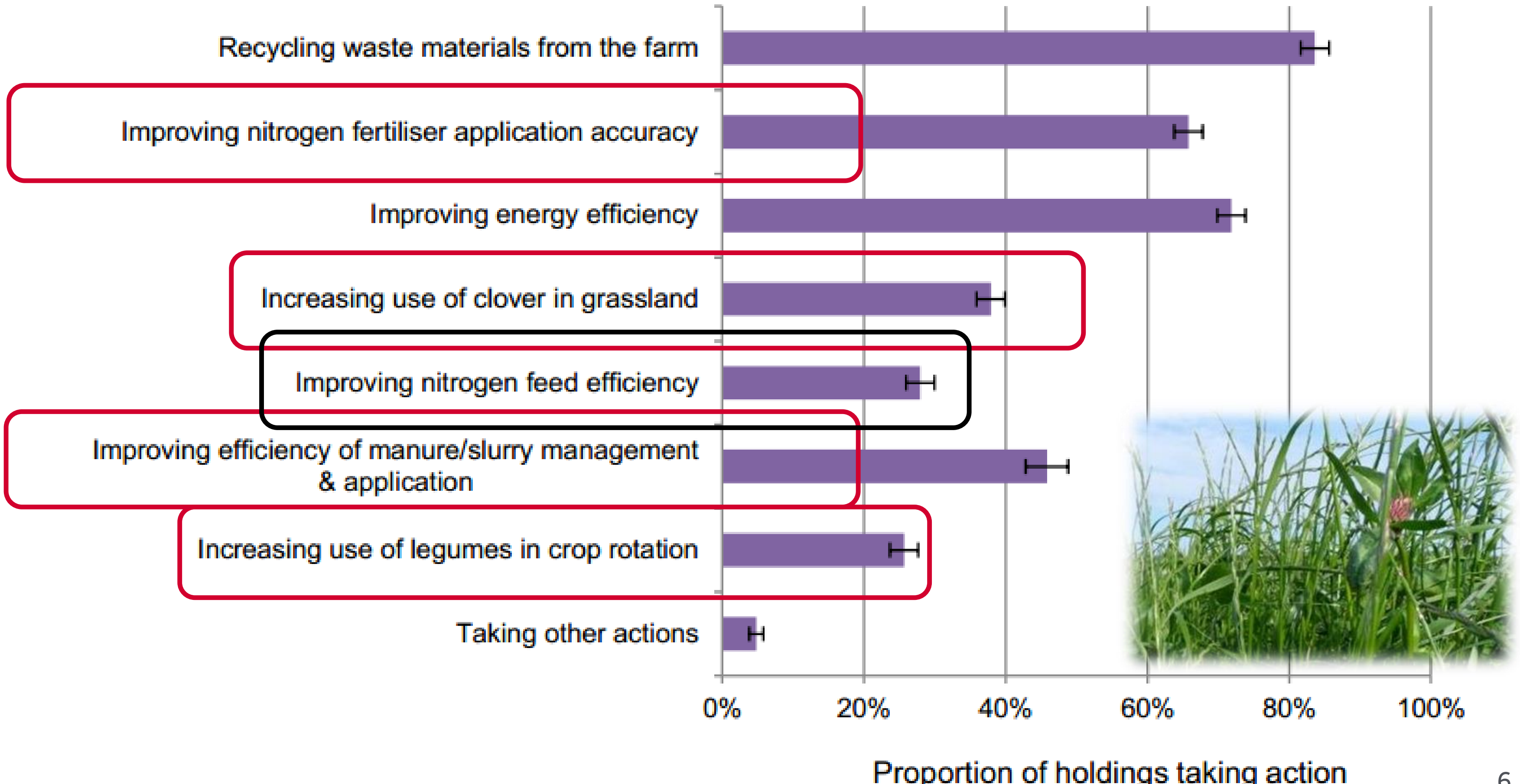
Teagasc
Agriculture and Food Development Authority

LEGUMES AS SUSTAINABLE FORAGES?

University of Reading

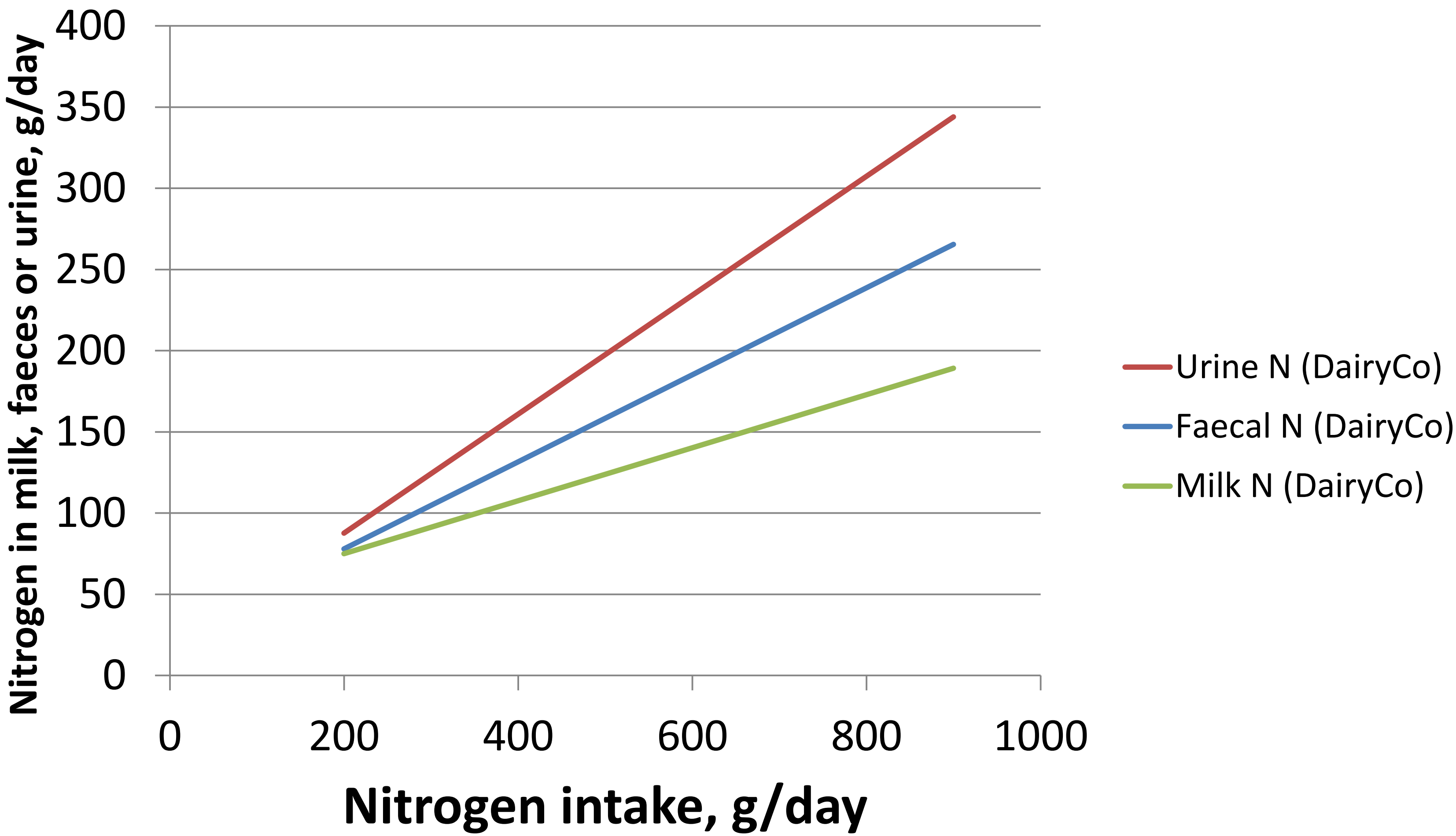
Using legumes (nitrogen-fixing plants) as forage for dairy cows reduces the need to apply nitrogen fertiliser to pasture.

Actions being taken by farmers to reduce greenhouse gas emissions



Source: Farm Practices Survey 2015

META-ANALYSIS OF N-BALANCE TRIALS



Mills et al. (2009)

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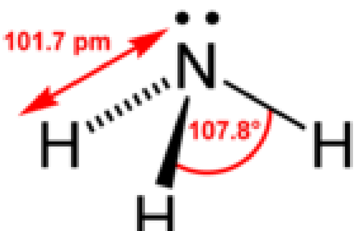


Ammonia

Slide courtesy of Dr Bill Weiss, Ohio State University

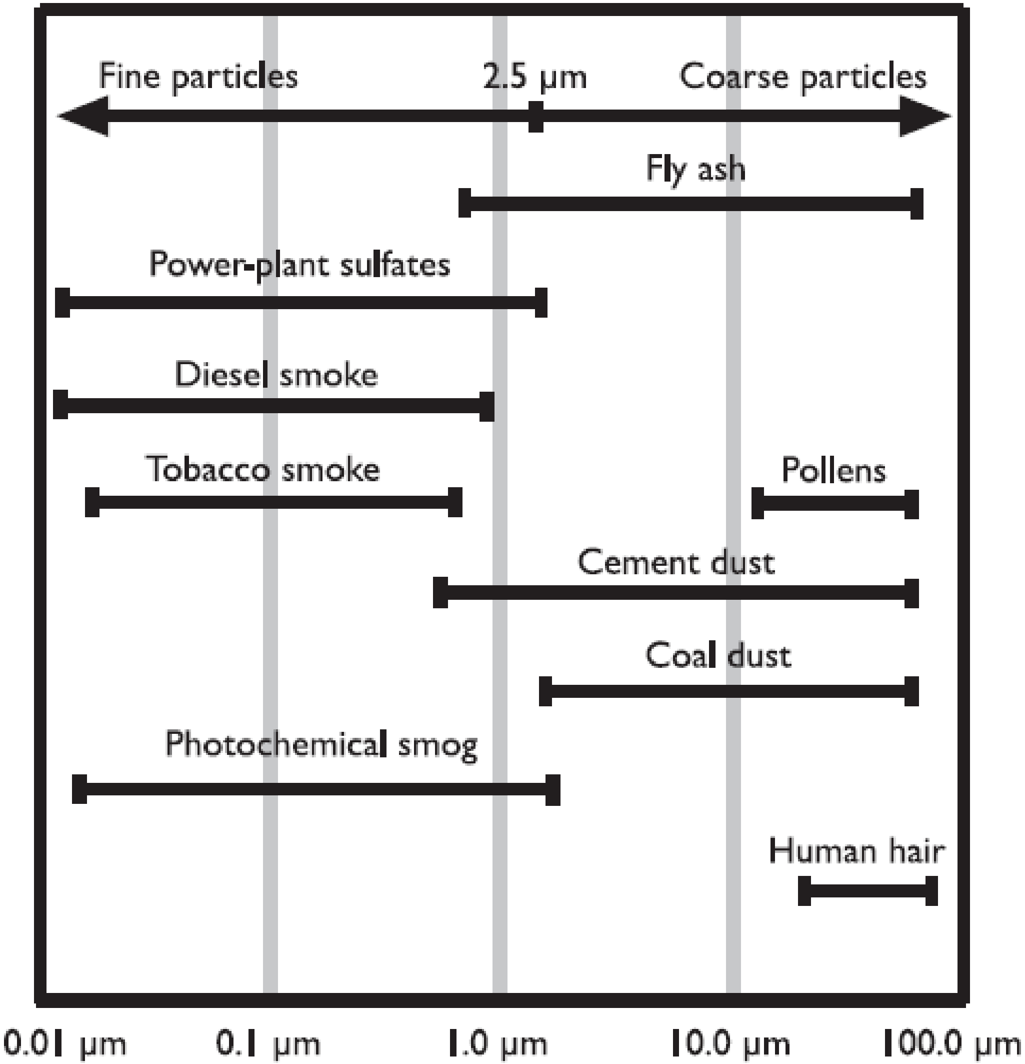


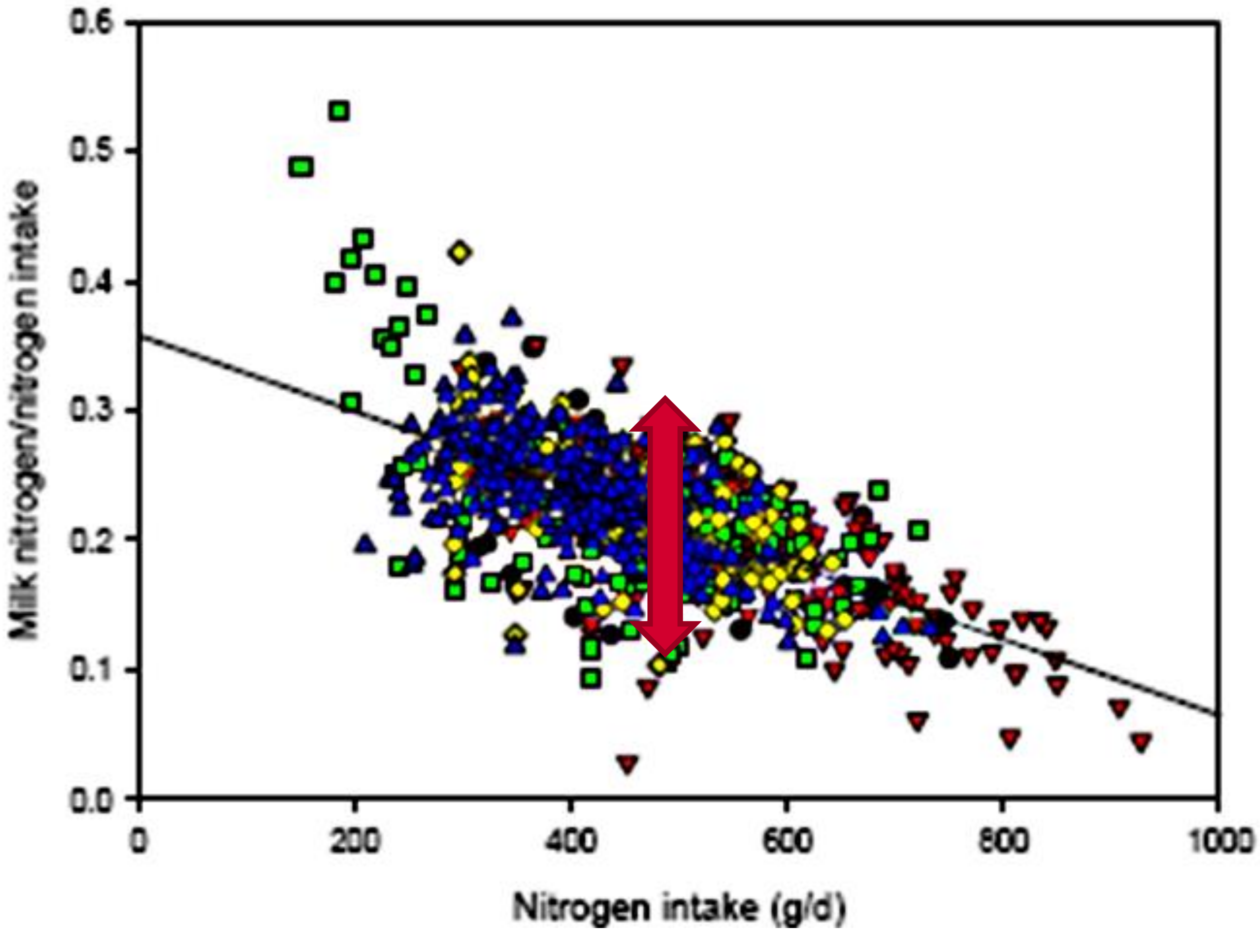
Figure 3. Size ranges of selected airborne particles in micrometers (Adapted from Heinsohn and Kabel, 1999).

Slide courtesy of Dr Jon Moorby, IBERS.

$PM_{2.5}$

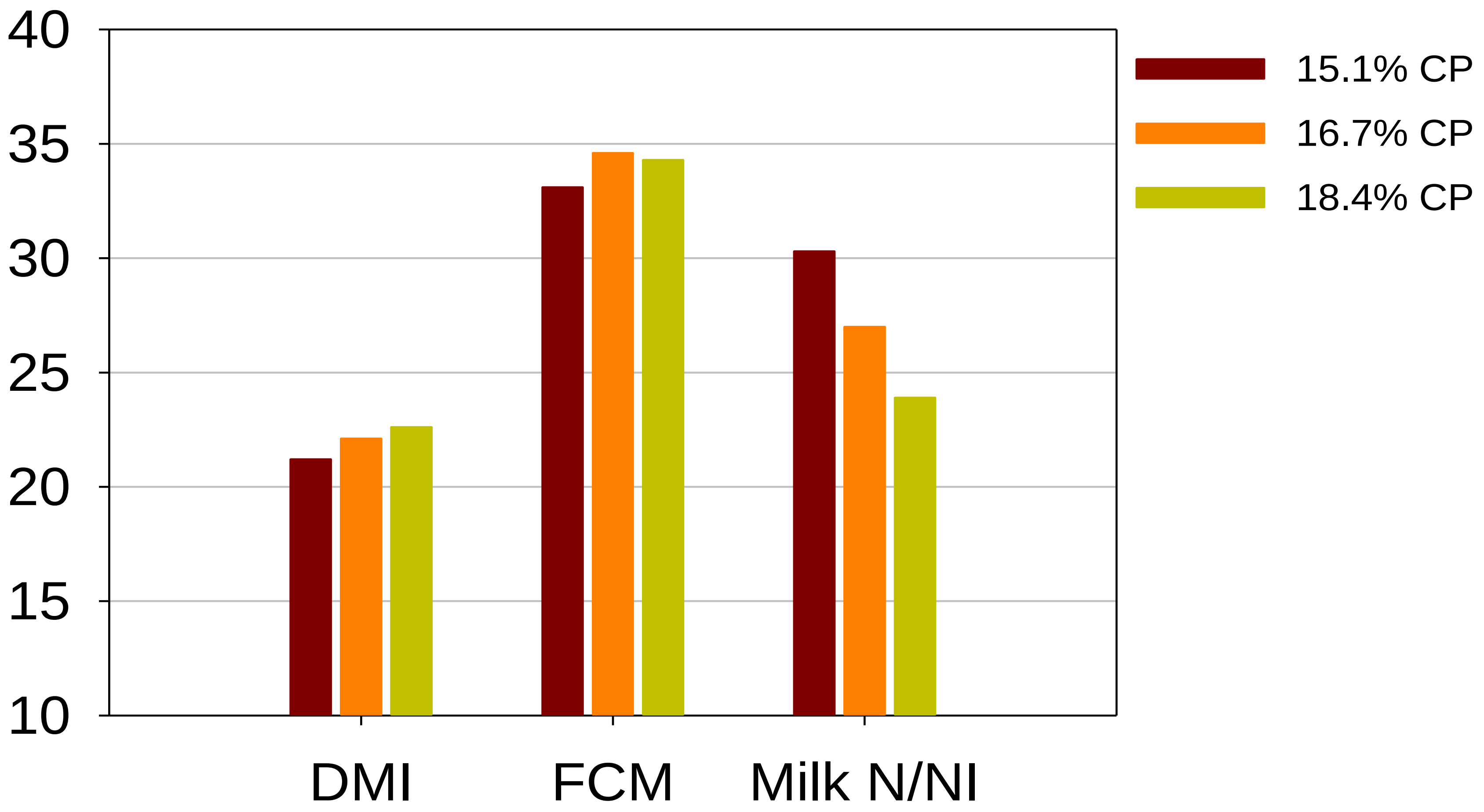
Ammonium sulfate
Ammonium nitrate
air quality issues

MILK N/INTAKE N VS. N INTAKE



Mills et al. (2009)

EFFECTS OF DIET CRUDE PROTEIN % ON DMI AND FAT CORRECTED MILK YIELD



Broderick (2003)

DIETARY PROTEIN CONCENTRATION AND MILK PRODUCTION

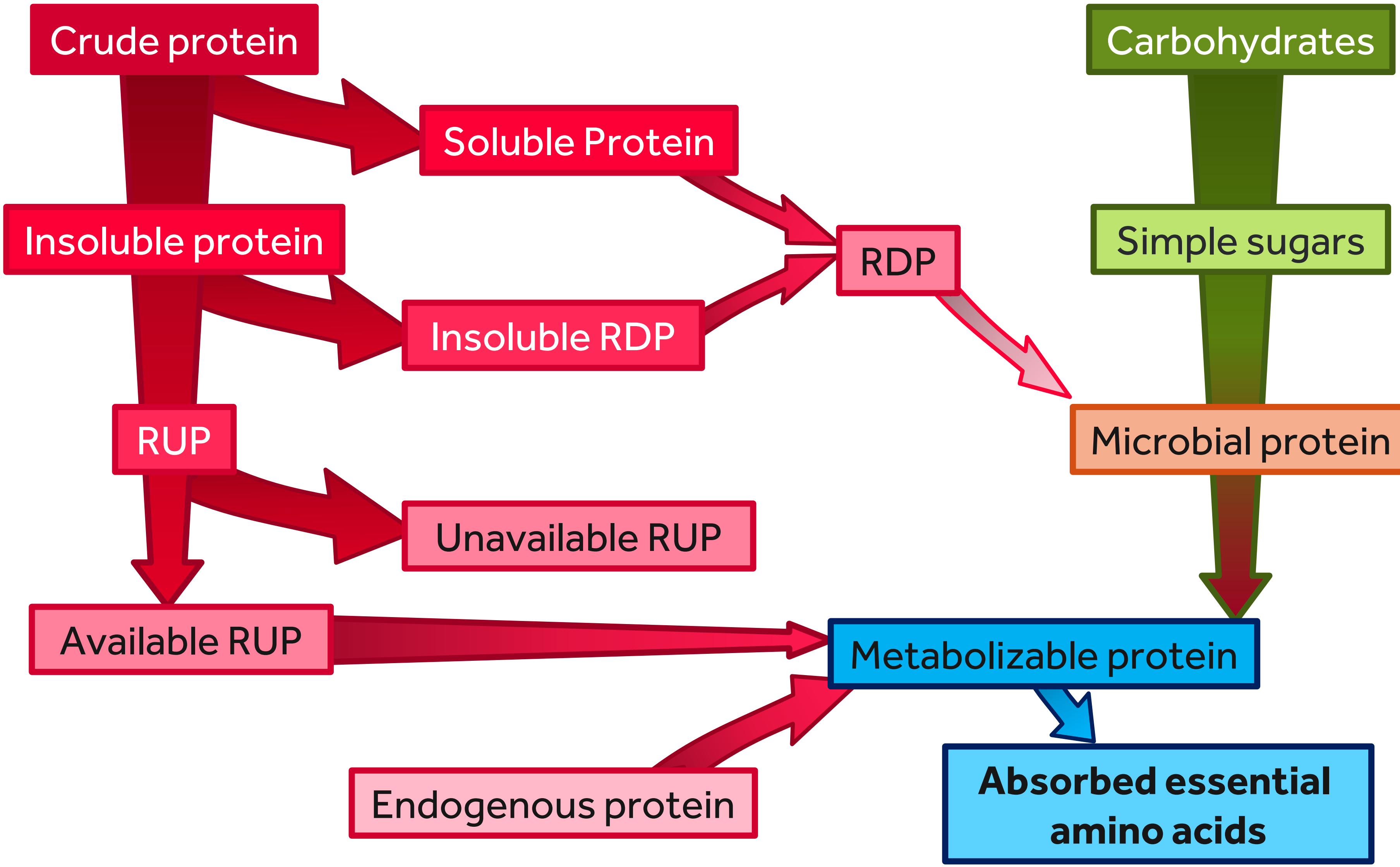
University of Reading

- Olmos Colmenero and Broderick 2006
  - Optimal milk and milk protein yield at 16.5% CP
  - Lucerne/maize silage and high moisture maize grain
  - 48 to 55% NFC!

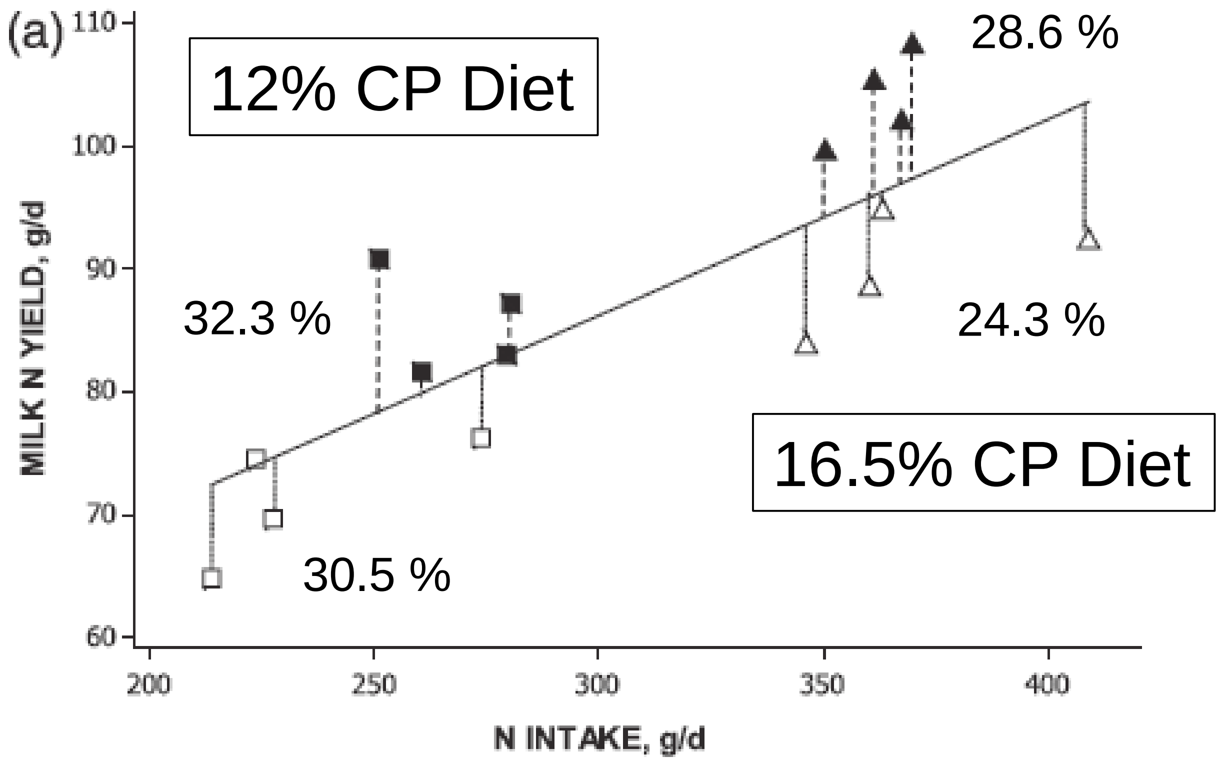
- Meta-analyses of published data:
  - e.g. NRC, 2001; Huhtanen and Shingfield, 2005; Ipharraguerre and Clark, 2005
  - Maximal milk and milk protein yield at 21-23% CP
  - Maximal digestibility of DM, NDF, etc. at 16.5% CP

MAKING METABOLISABLE PROTEIN

University of Reading



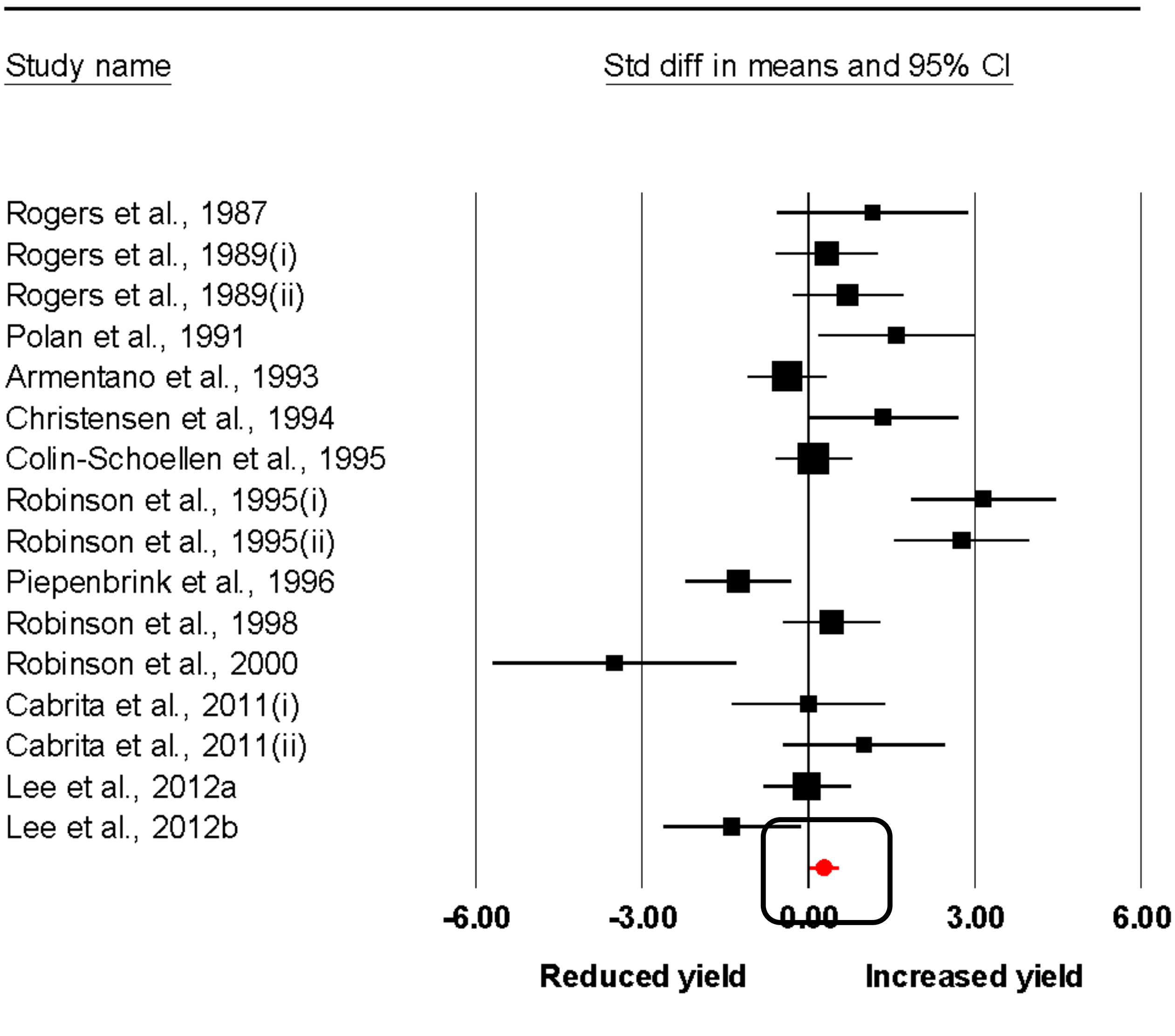
Effects of Higher Starch Diets on N Utilization



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

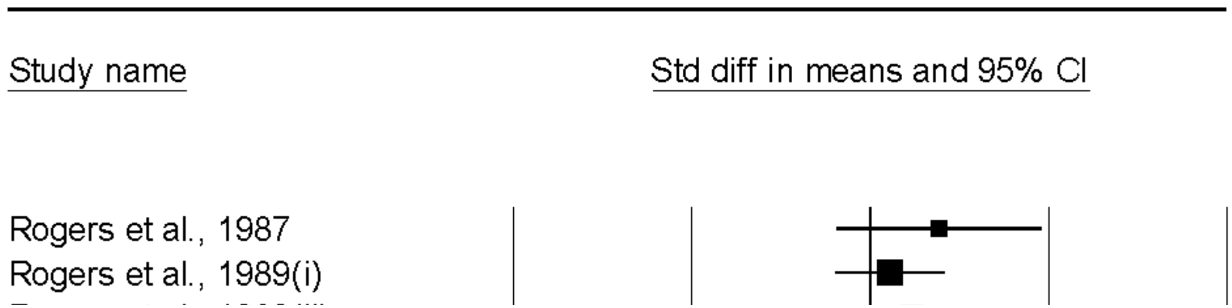
Using Jersey cows *Cantalapiedra-Hijar et al., 2013.*

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

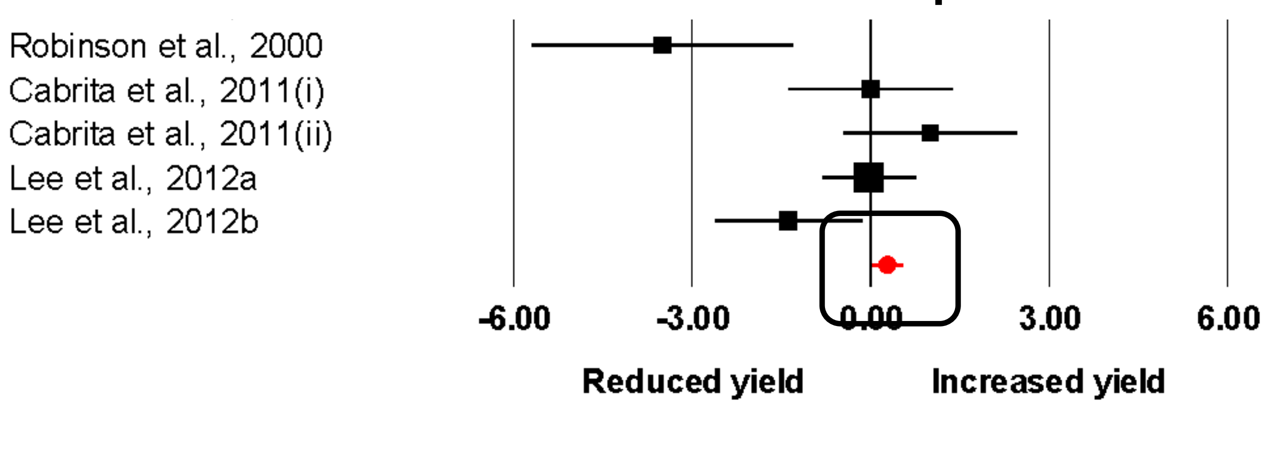


Sinclair et al 2014

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



Precision feeding lower protein diets balanced for supply of metabolizable protein (MP) and essential amino acids requires accurate and routine measurements of feed composition

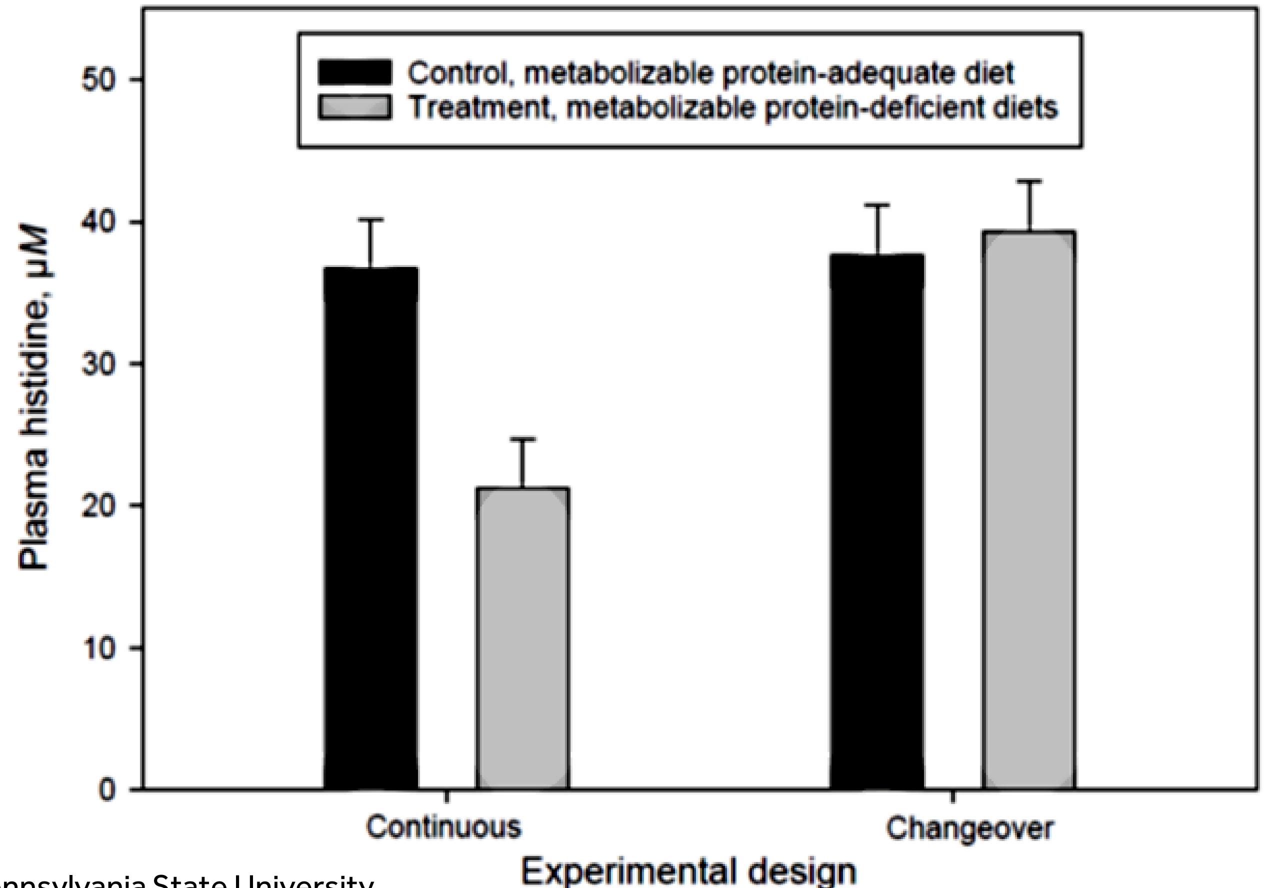


Sinclair et al 2014

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
- Recent interest in lower protein diets with rumen-protected protein or essential amino acids
  - Lysine and methionine (also histidine) considered first limiting
  - Digestive and metabolic effects of protein and AA supply
- **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
- **Long-term studies over an entire lactation(s) lacking**

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

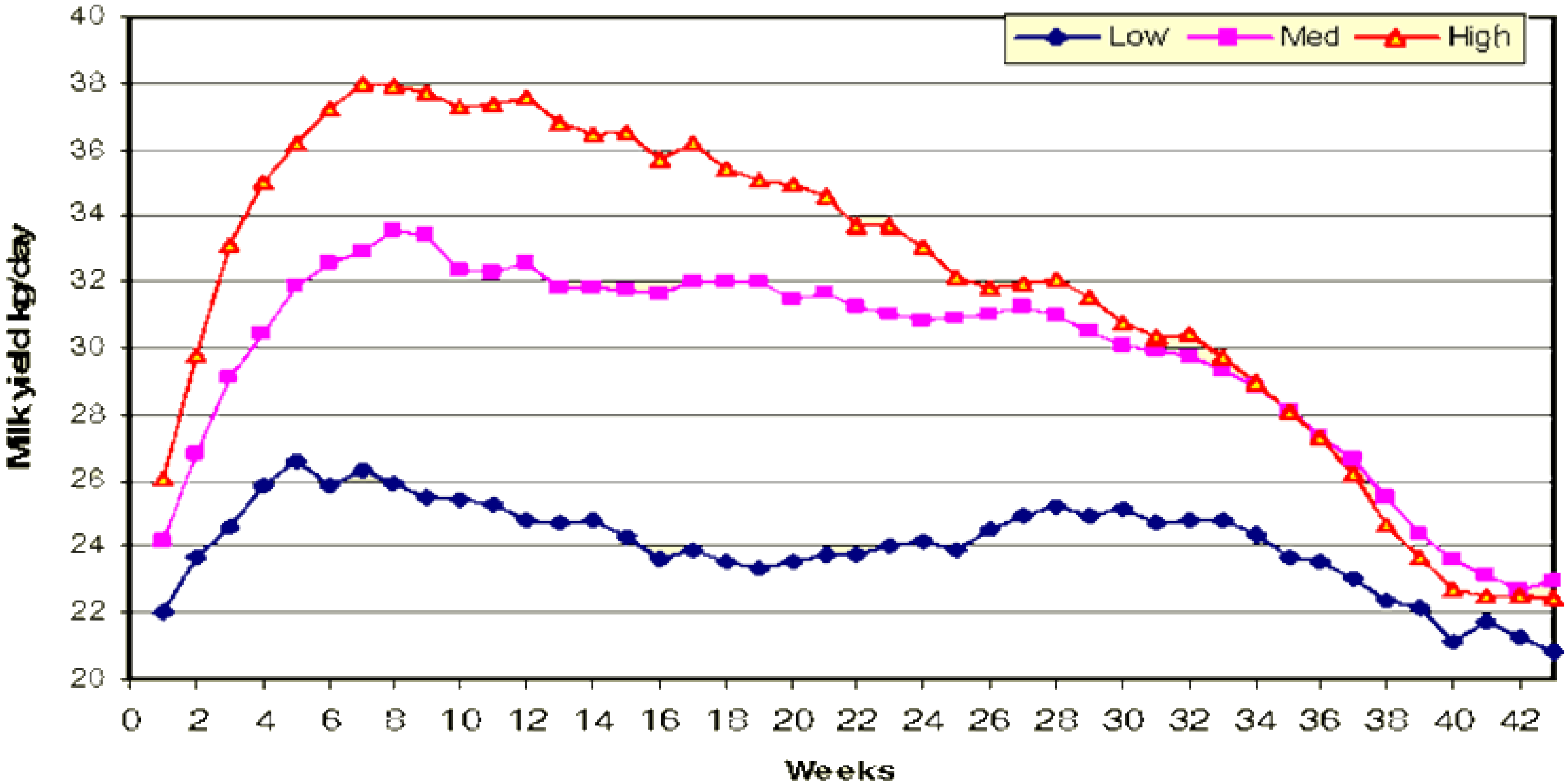


Alex Hristov, Pennsylvania State University
Lee et al., 2012 and 2015. 70 vs 28 day periods.

DIET PROTEIN CONCENTRATION
AFBI STUDY OVER ONE LACTATION

University of Reading

60:40 Grass:maize silage – 12%, 15%, 18% CP diets

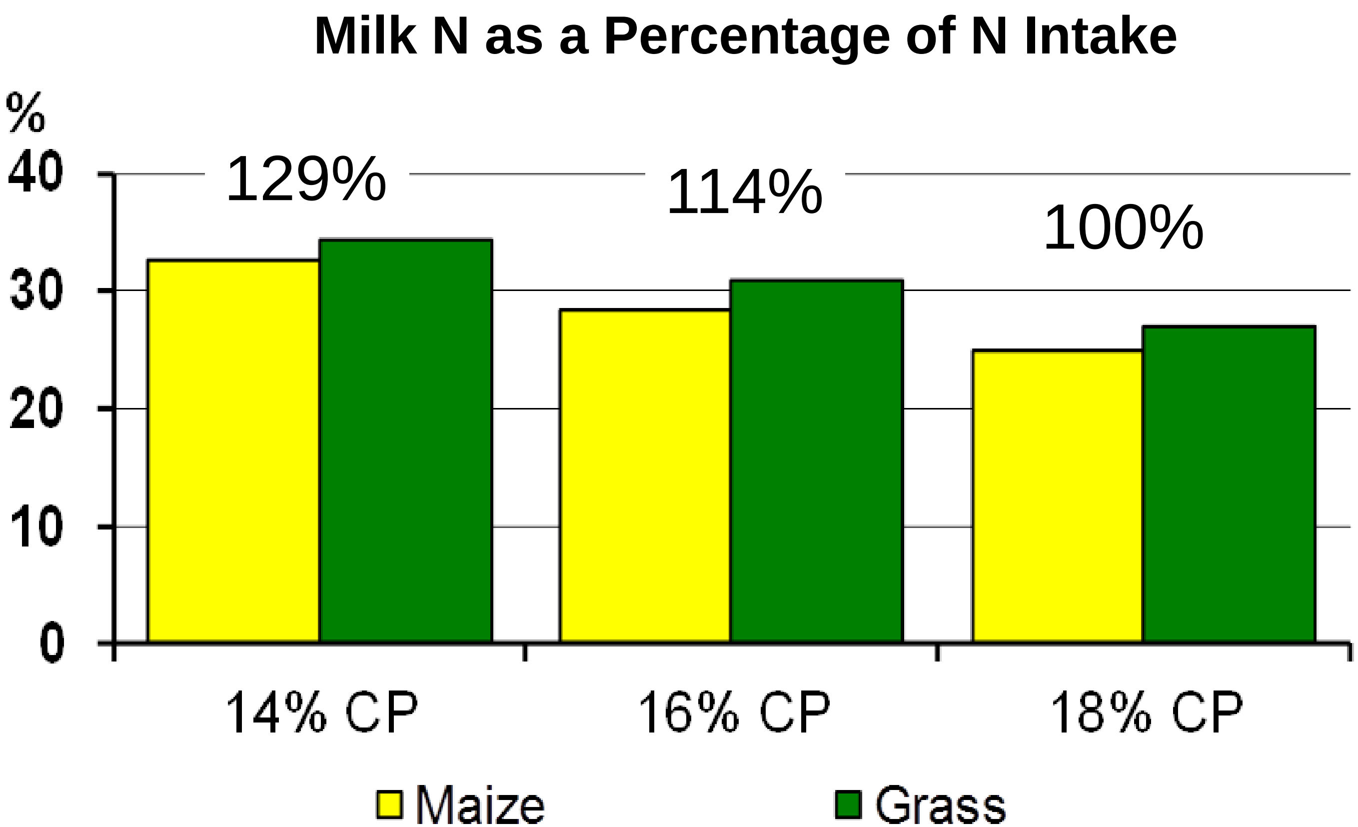


305 day yield

High 9653kg **Medium** 9089kg **Low** 7435kg

Law et al 2009; 2010

EFFICIENCY OF DIETARY N UTILIZATION FOR MILK PROTEIN PRODUCTION



DEFRA Project AC0209 – N intakes lower for grass-based ration

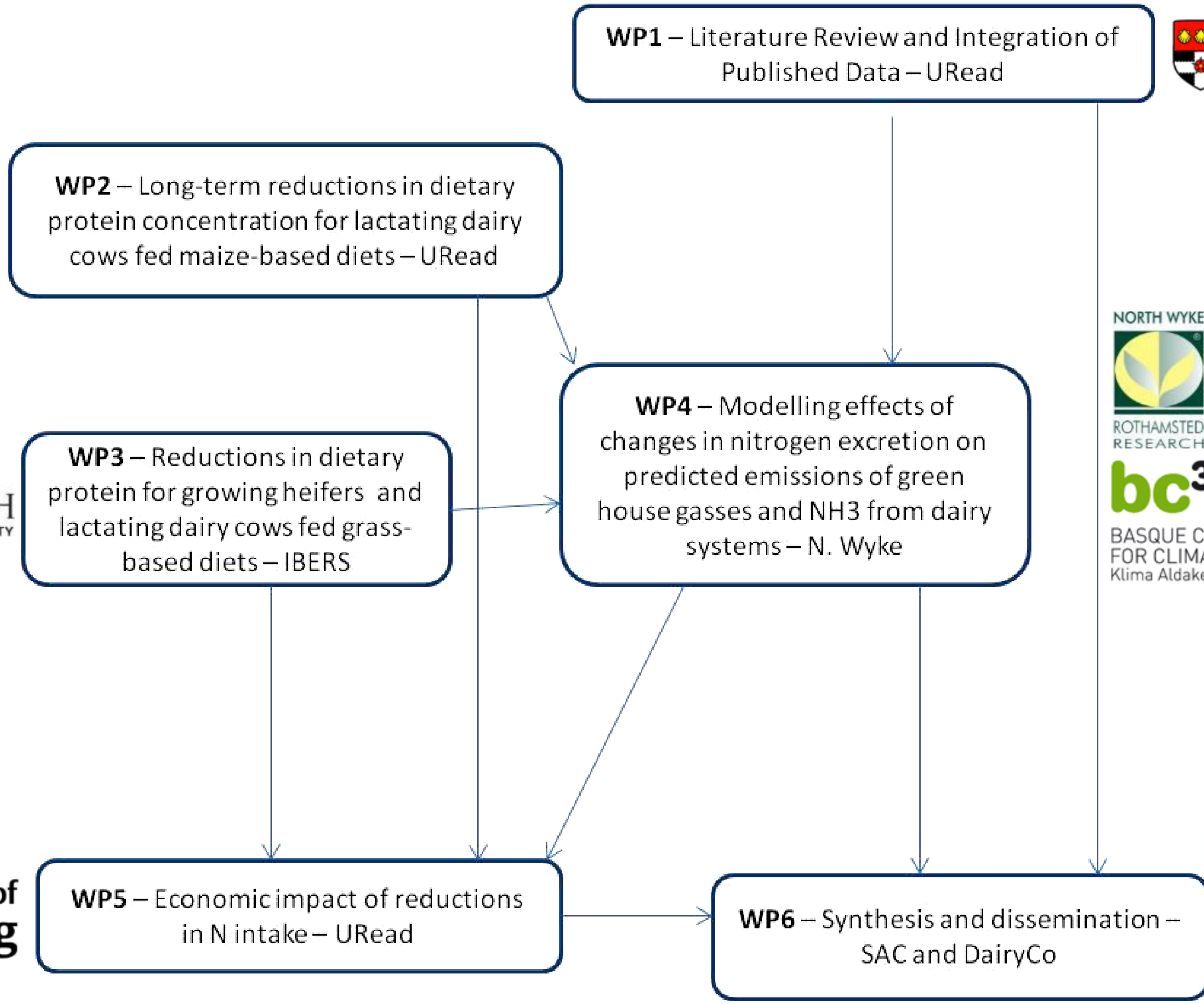
EFFICIENCY OF DIETARY N UTILIZATION FOR MILK PROTEIN PRODUCTION

Long term effects???? Defra AC0122

Reading, IBERS, SRUC, Rothamsted

Similar maize silage based diets
215 heifers – 3 lactations
6.5 year project

DEFRA PROJECT AC0122
WORK PACKAGES



APPLIED STUDY

CEDAR

- Started: Feb 2013
- Last animal completed: Nov 2017
- Data collation and some sample analysis ongoing

AC0122 - WP2 LACTATION TRIAL

University of Reading

- 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% crude protein
- 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
- Culling as for commercial herd
  - Served from day 50 - 200
  - Failed to conceive cows removed after 305 d lactation

AC0122 – LACTATION TRIAL

University of Reading

TWO CONCENTRATE BLENDS

	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

University of Reading

	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**

AC0122 - CEDAR LACTATION TRIAL

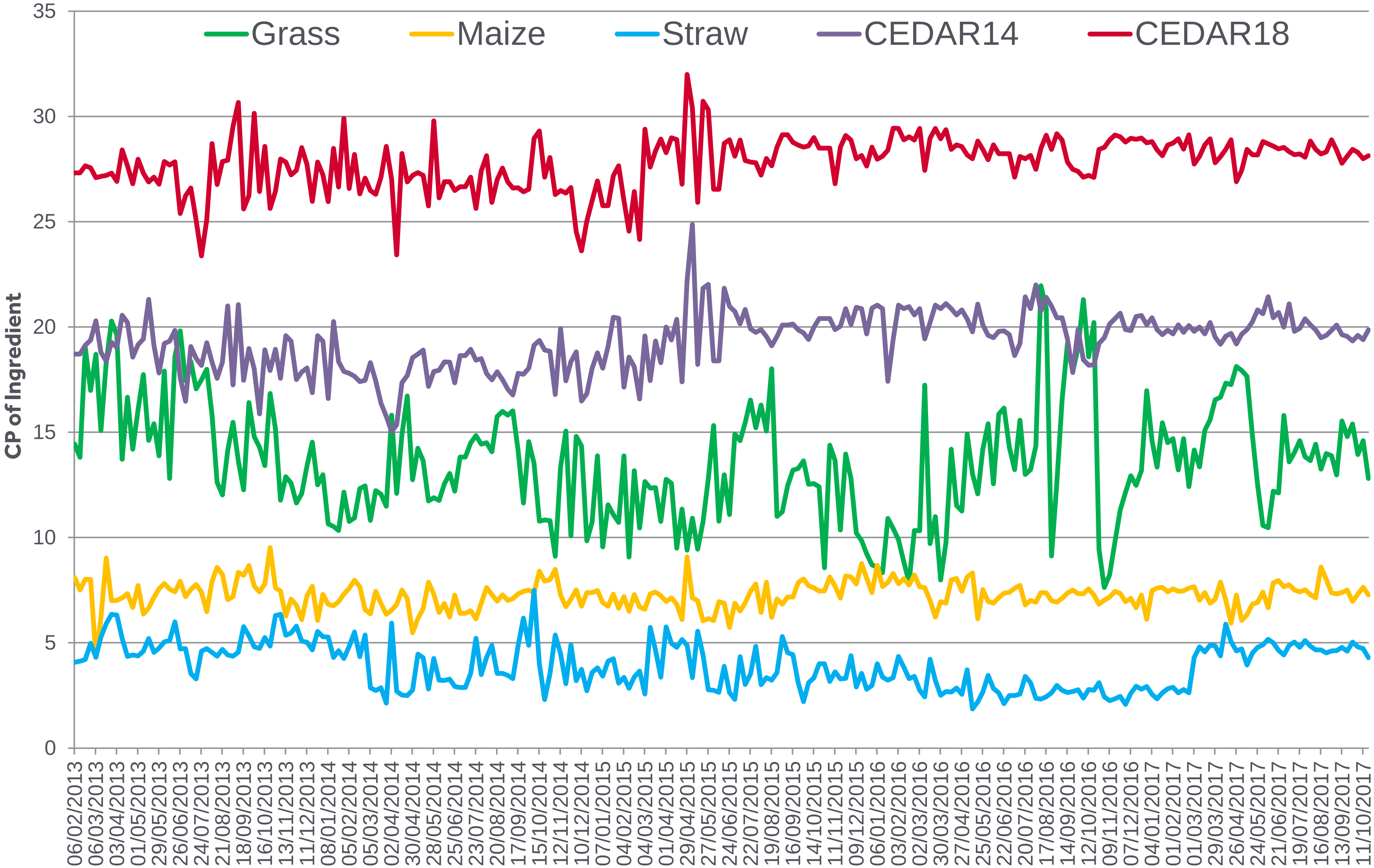
- Enrolment completed 26 September 2014
  - 20 months to enrol 215 heifers
- Cows completing each 305 day lactation:

  Lactation 1 completed (207 of 215)

  Lactation 2 completed (164 of 179)

  Lactation 3 completed (116 of 132)

DIET INGREDIENT VARIATION



TMR CP VARIATION (UNADJUSTED)

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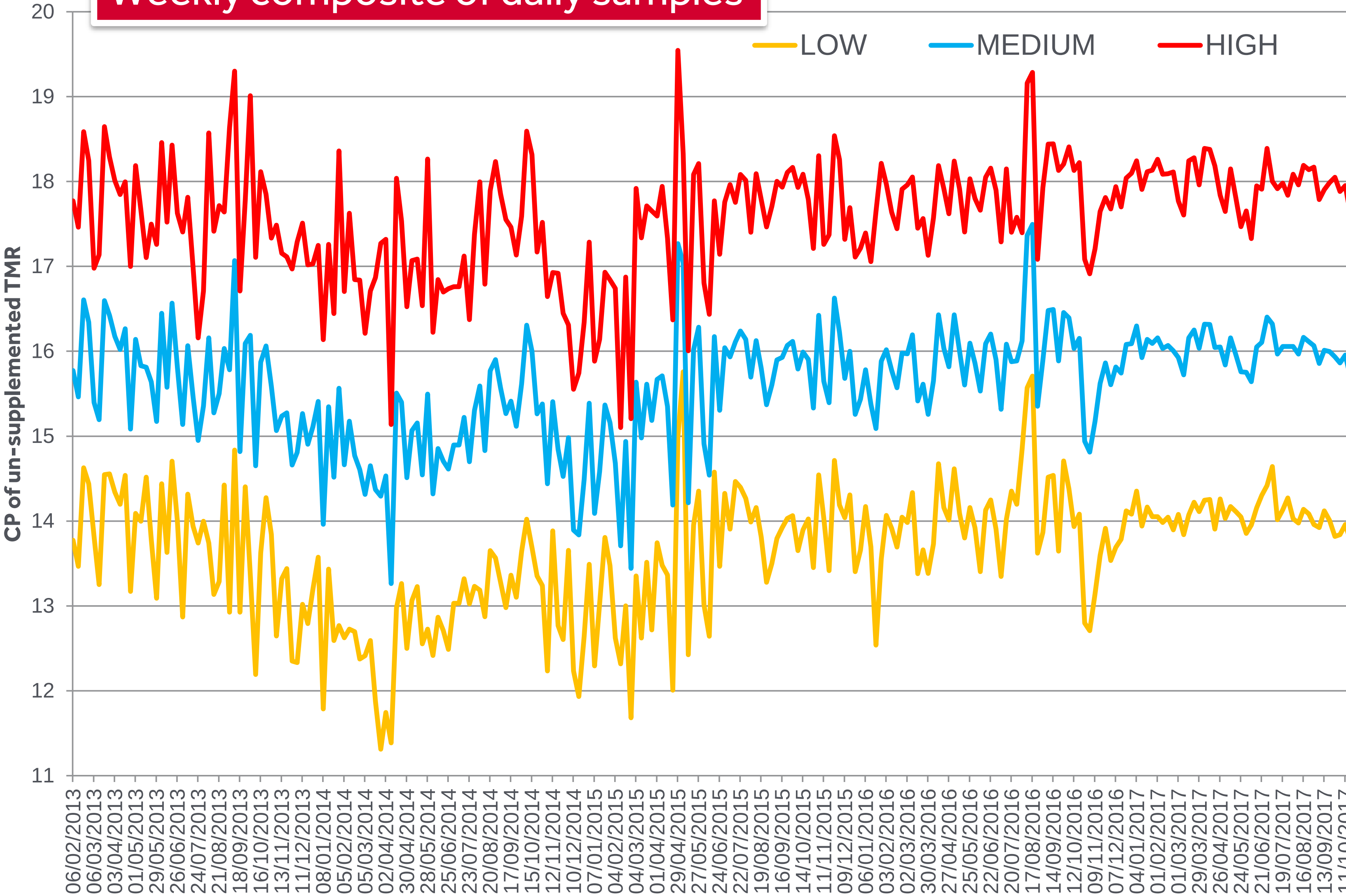
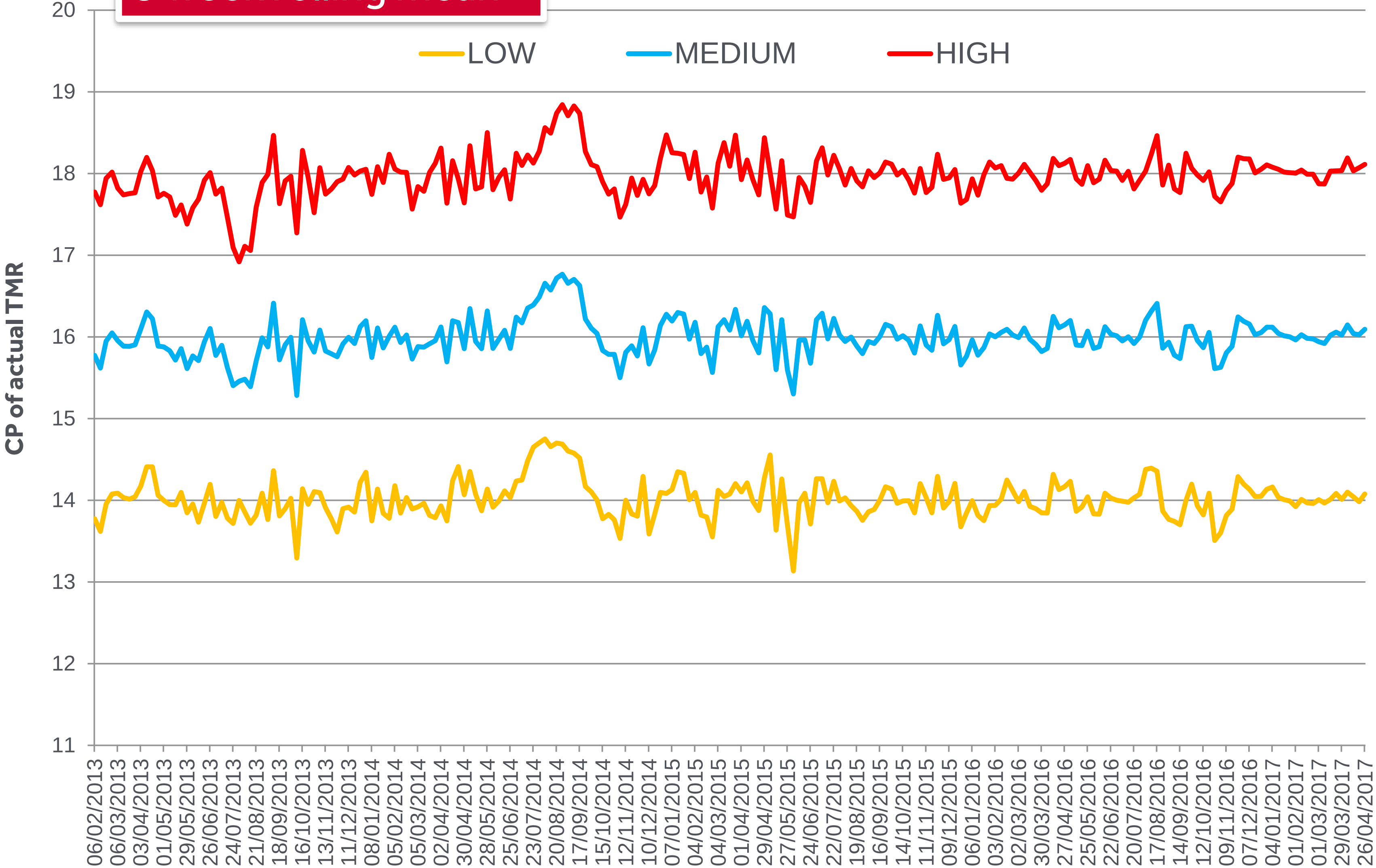
Weekly composite of daily samples



TMR CP VARIATION (SBM ADJUSTED)

University of Reading

3 week rolling mean



TMR CP VARIATION (ADJUSTED)

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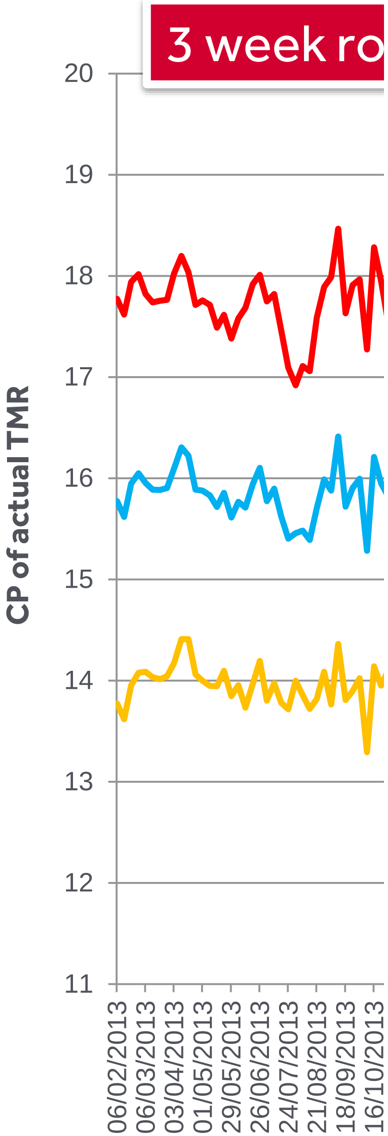
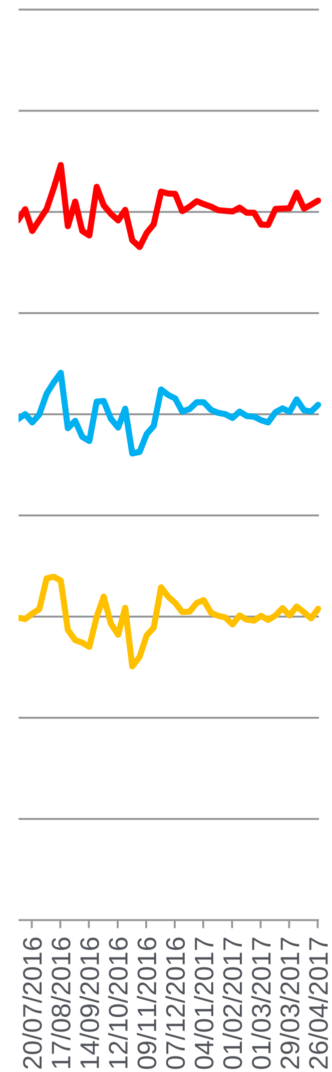


0342 Effects of oscillating the crude protein content in dairy cow rations. A. N. Brown*[1] and W. P. Weiss[2], *[1]The Ohio State University, Wooster, [2]Department of Animal Sciences, The Ohio State University, Wooster.*

Overfeeding crude protein (CP) is a common practice in the dairy industry to reduce the risk of a loss in milk; however, overfeeding CP increases costs and negatively impacts the environment. We hypothesized that oscillating dietary CP concentrations to equal the average concentration of a diet limited in metabolizable protein (MP) for lactating dairy cows will improve milk protein yield and milk N efficiency because oscillating CP should stimulate nitrogen recycling to the rumen. Twenty-one Holstein dairy cows averaging 123 DIM were randomly assigned to a treatment sequence in seven 3 × 3 Latin Squares with 28-d periods. The control diet contained 16.4% CP (MP allowable milk = 47 kg/d), the low protein diet contained 13.4% CP (MP allowable milk = 31 kg/d), and the oscillating treatment consisted of a diet with 10.3% CP fed for 2 d followed by a diet with 16.4% CP fed for 2 d repeated over the 28 d period to average 13.4% CP. The cows were fed once daily and milked twice daily. Cows on the low protein diet had greater DMI than cows on the oscillating treatment (24. 8 kg/d vs. 24.3 kg/d; $P = 0.04$) but were similar in DMI compared to



DRY MATTER INTAKE

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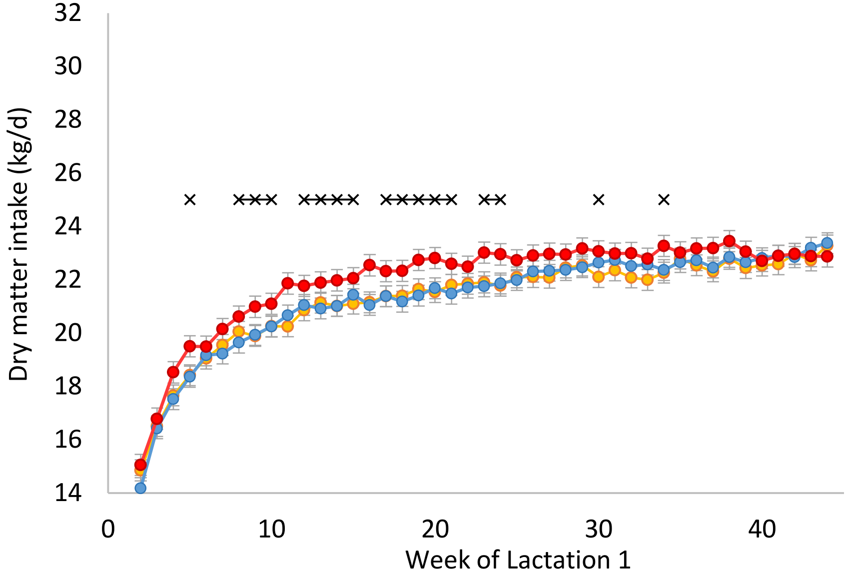
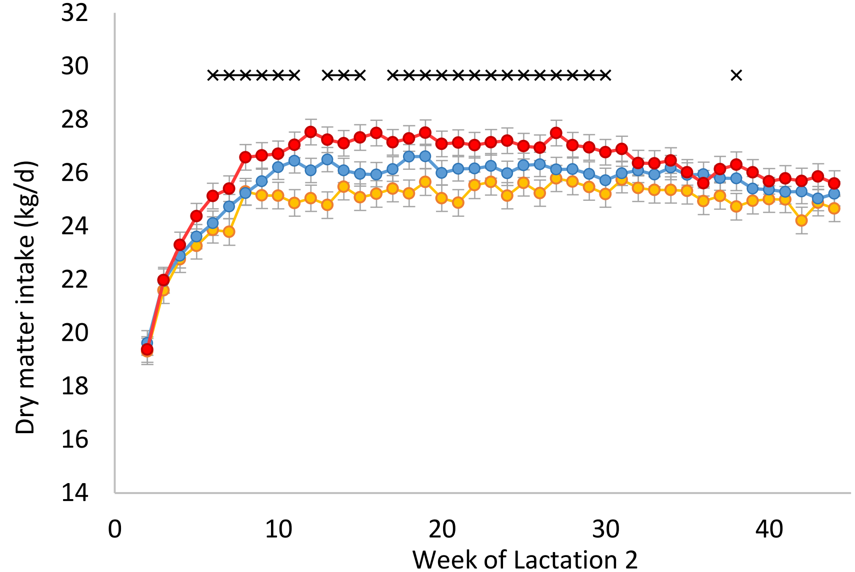
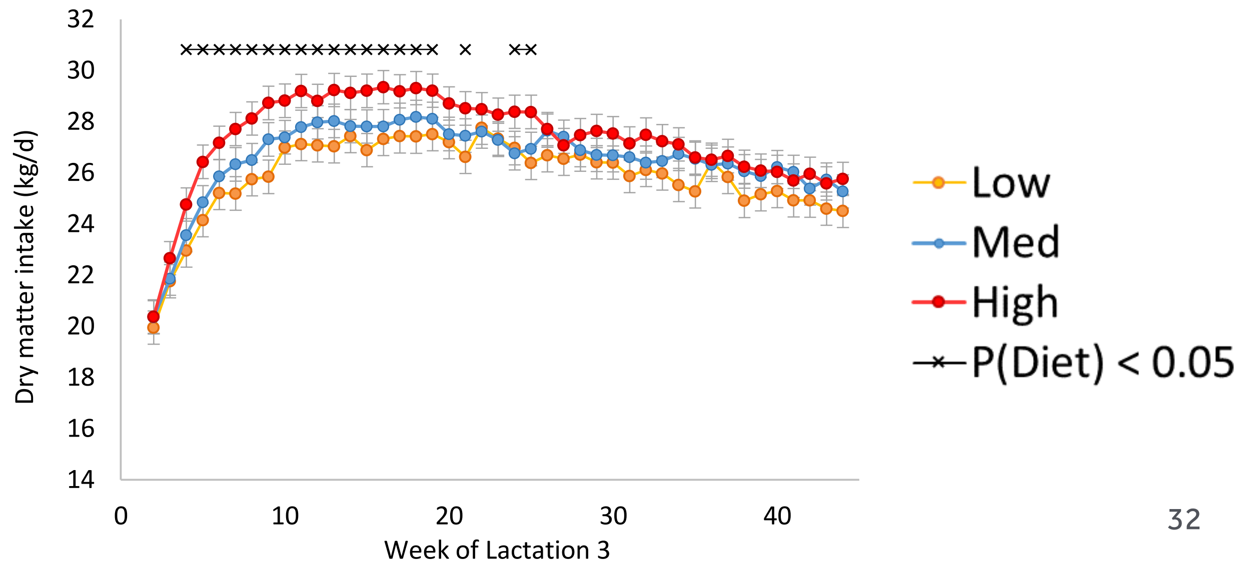


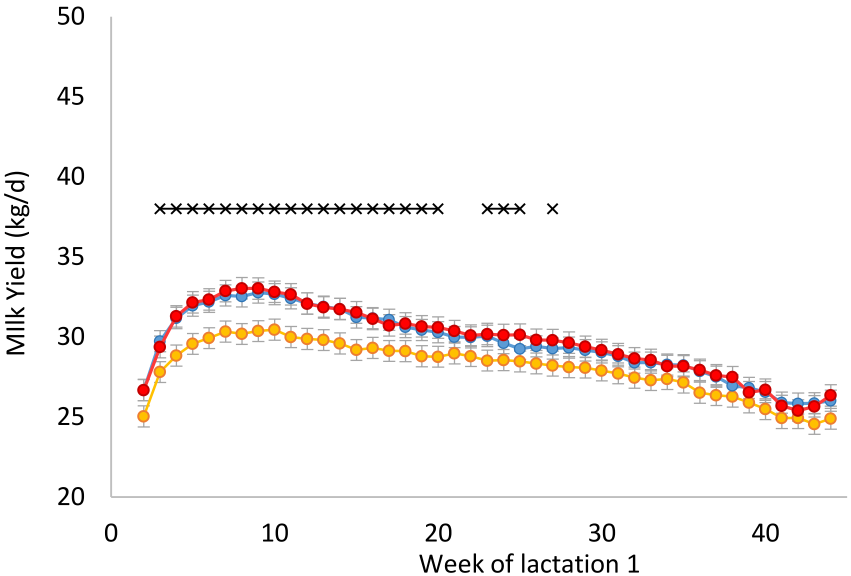


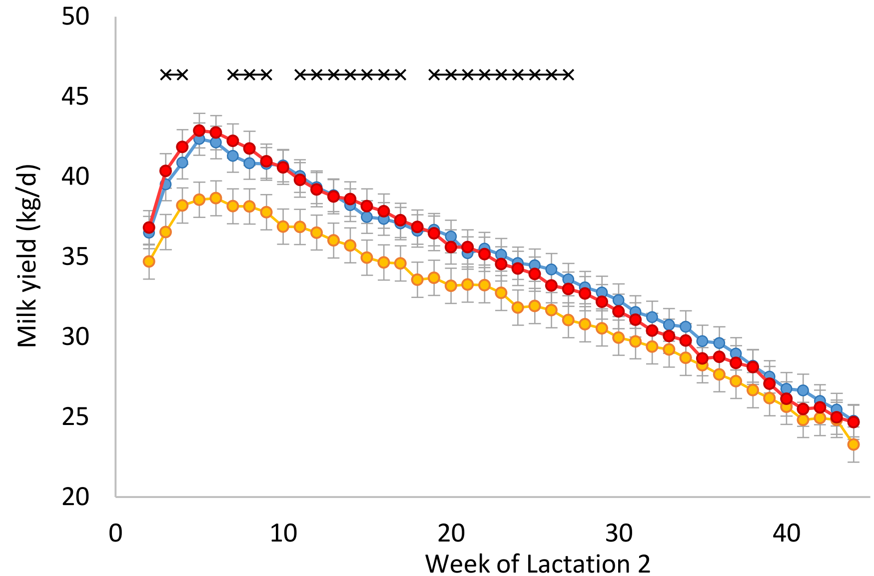
	Low	Med	High
Lac 1	21.3[b]	21.3[b]	22.0[a]
Lac 2	24.8[b]	25.5[ab]	26.2[a]
Lac 3	25.9[c]	26.5[b]	27.3[a]



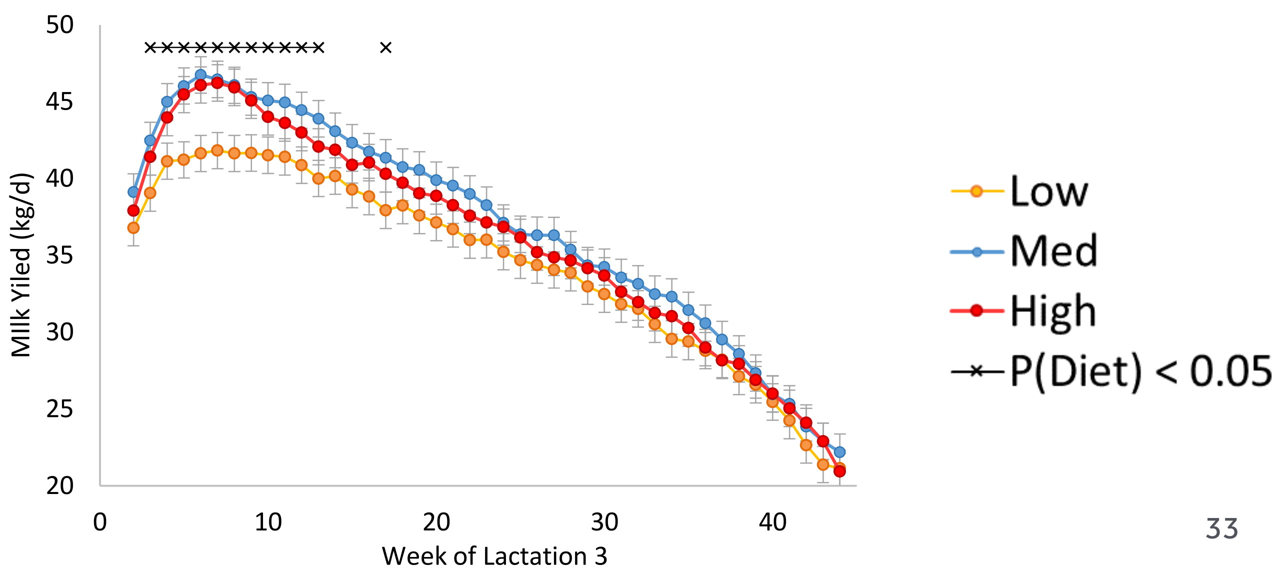
MILK YIELD

University of Reading





	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]



MILK UREA CONCENTRATION

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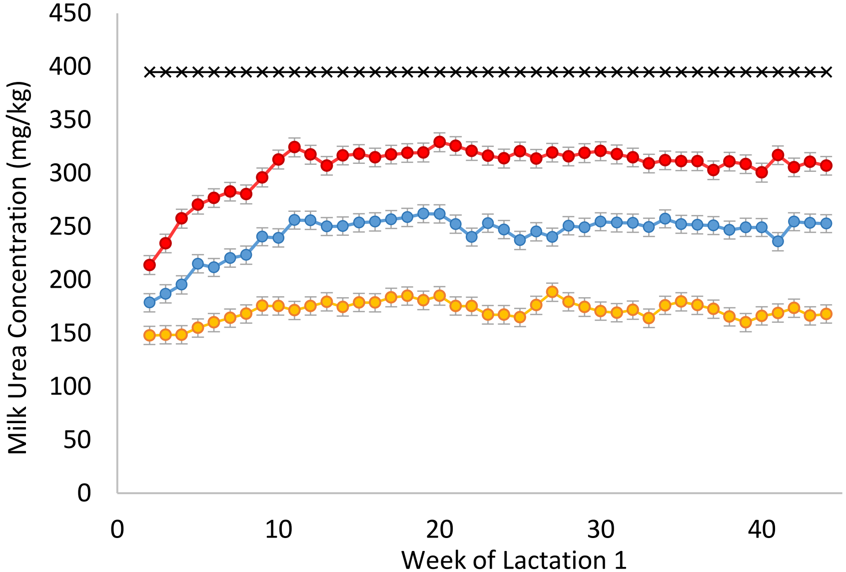
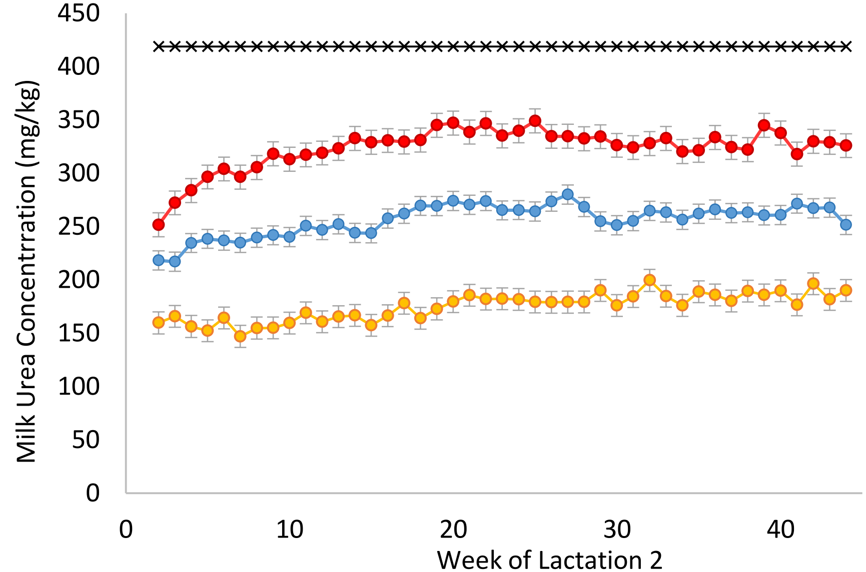
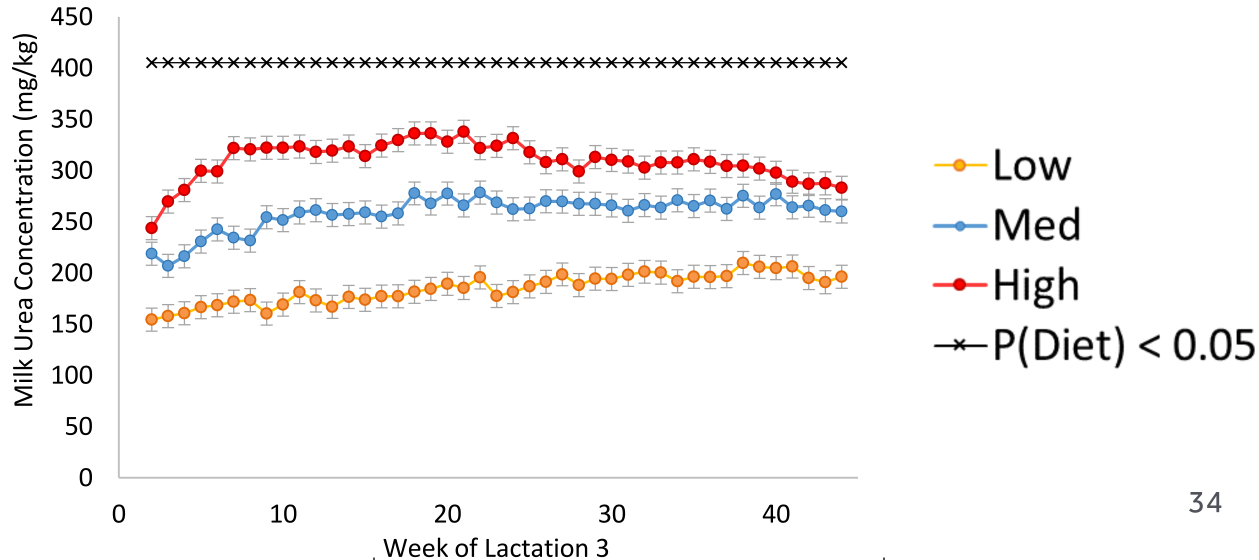




	Low	Med	High
Lac 1	171[c]	243[b]	305[a]
Lac 2	174[c]	256[b]	324[a]
Lac 3	185[c]	259[b]	310[a]



MILK PROTEIN YIELD

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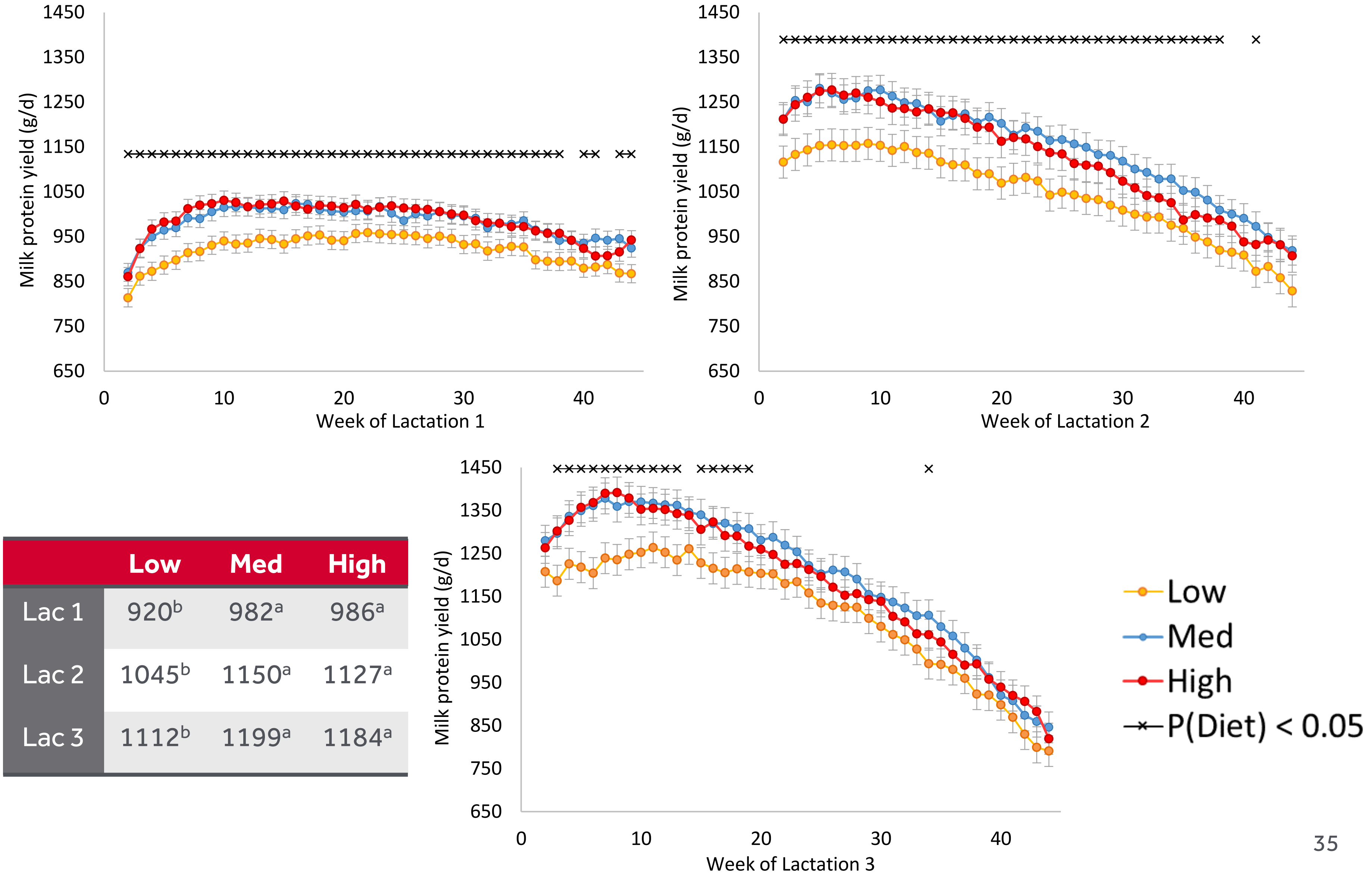

	Low	Med	High
Lac 1	920[b]	982[a]	986[a]
Lac 2	1045[b]	1150[a]	1127[a]
Lac 3	1112[b]	1199[a]	1184[a]

BODY CONDITION SCORE

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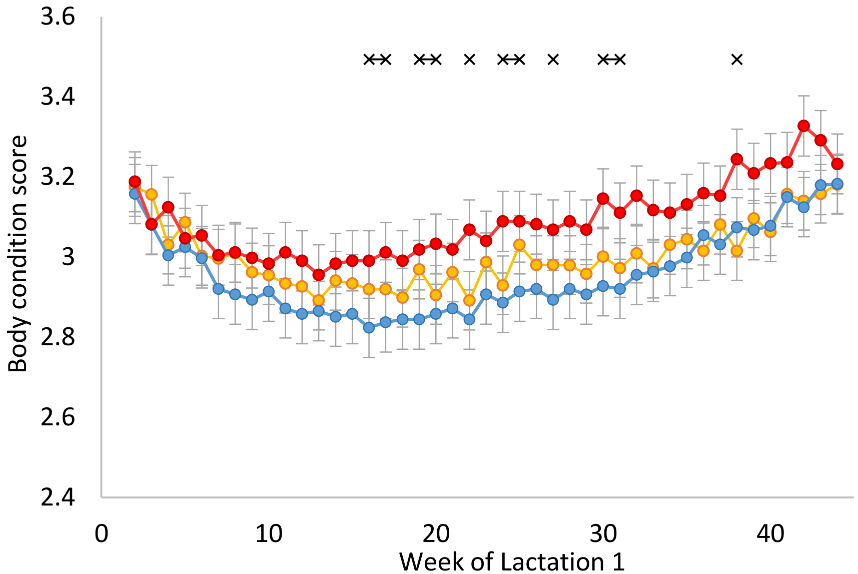
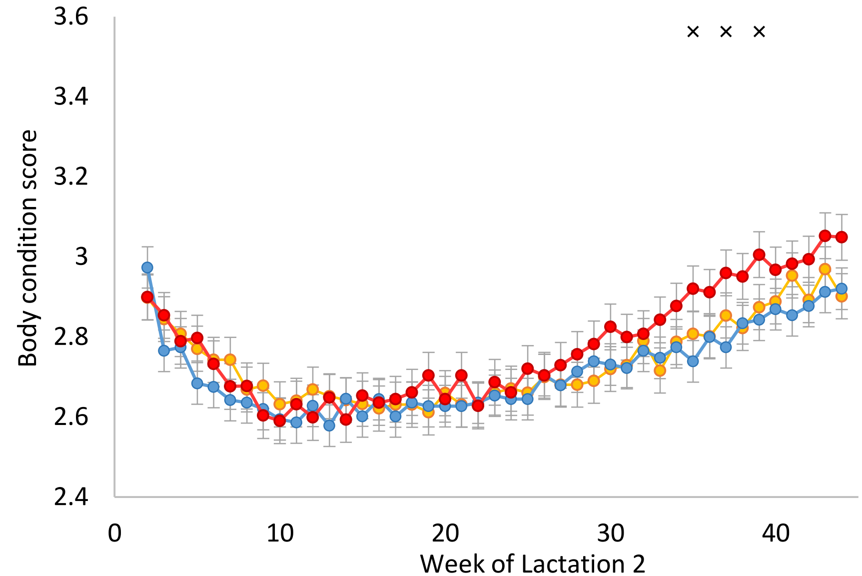
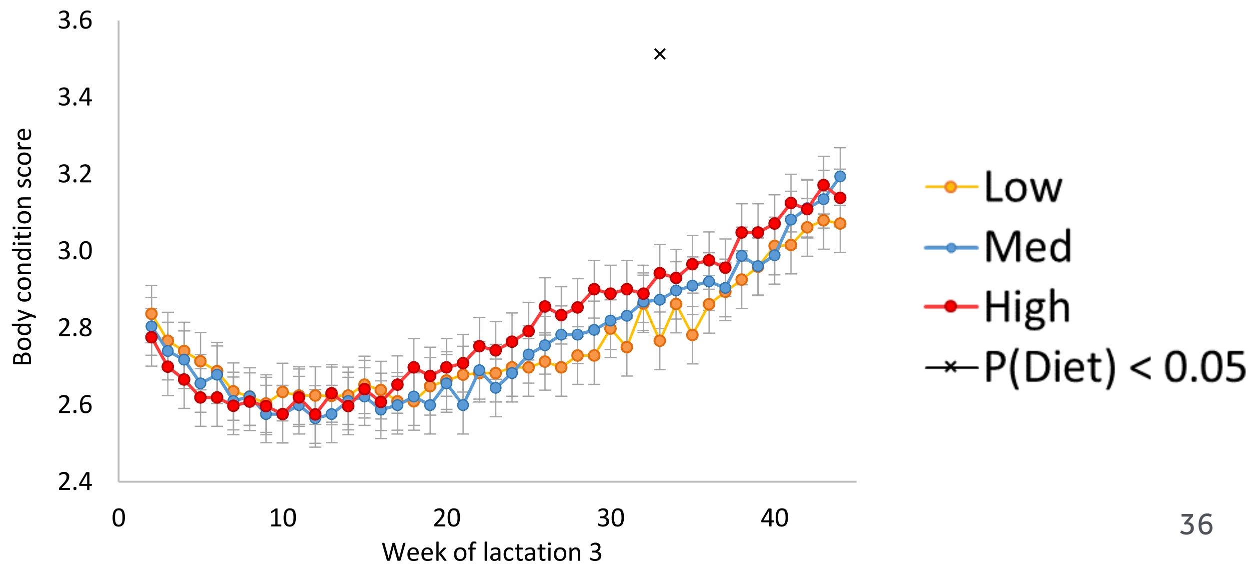




	Low	Med	High
Lac 1	3.01[ab]	2.96[b]	3.09[a]
Lac 2	2.74	2.71	2.78
Lac 3	2.76	2.77	2.80



NITROGEN USE EFFICIENCY

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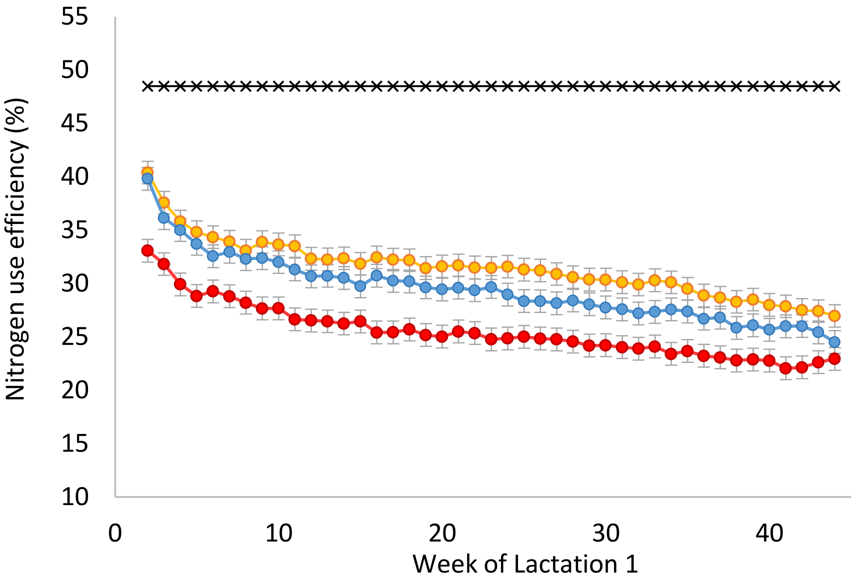
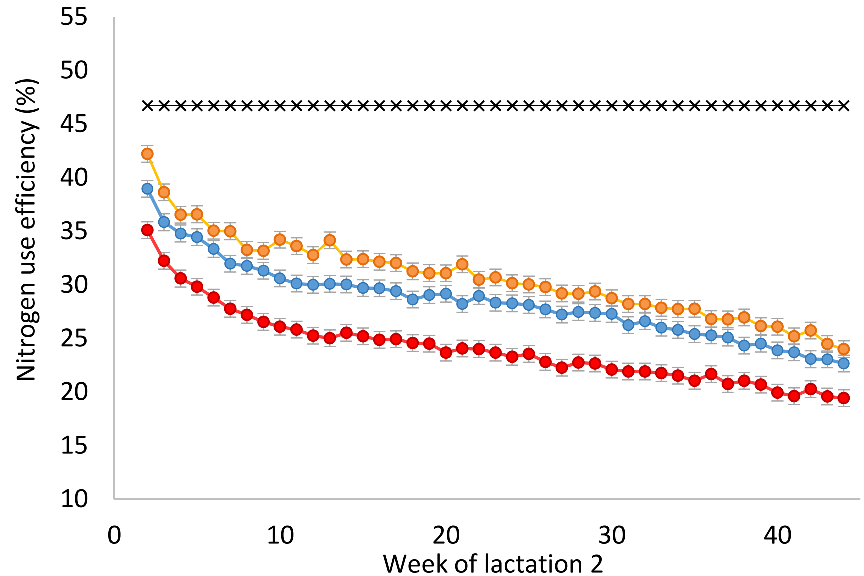
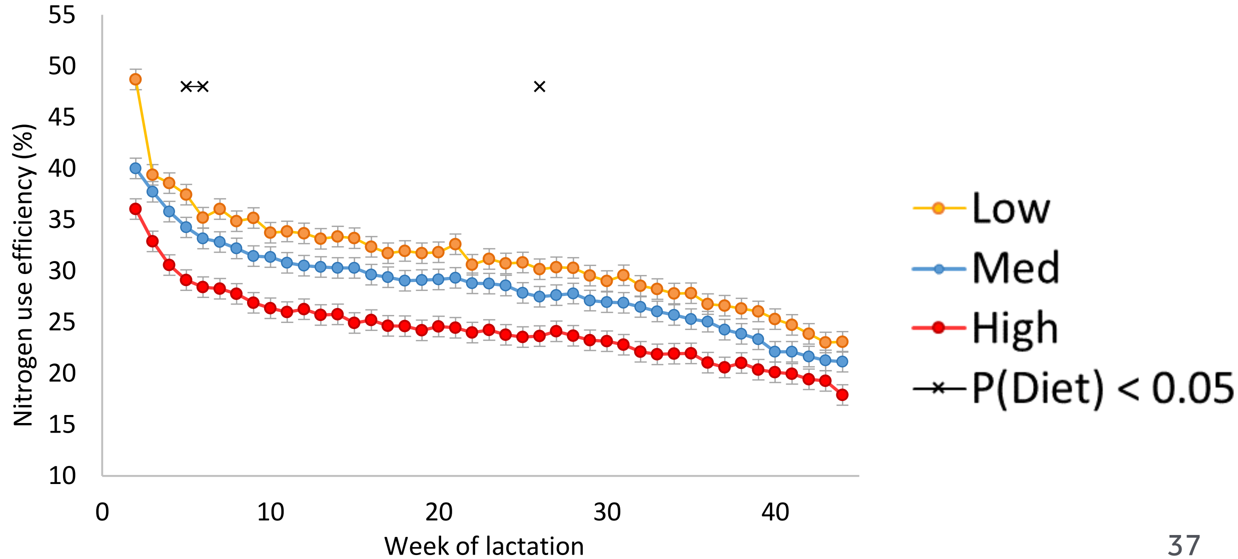
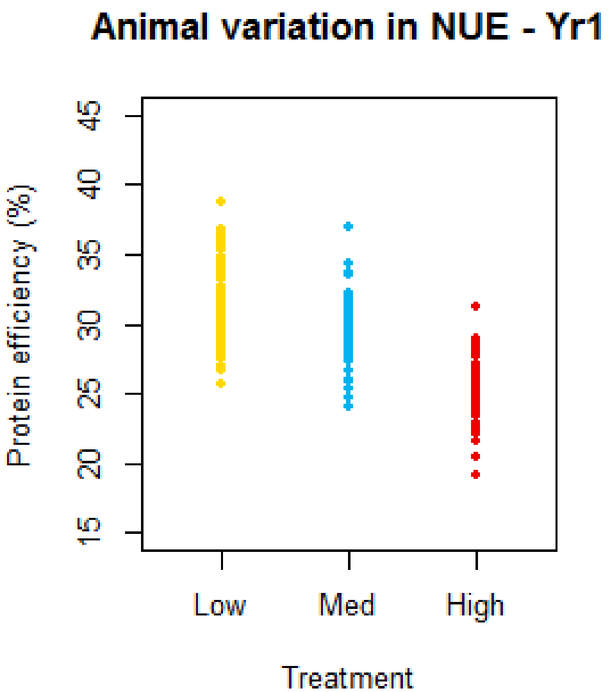


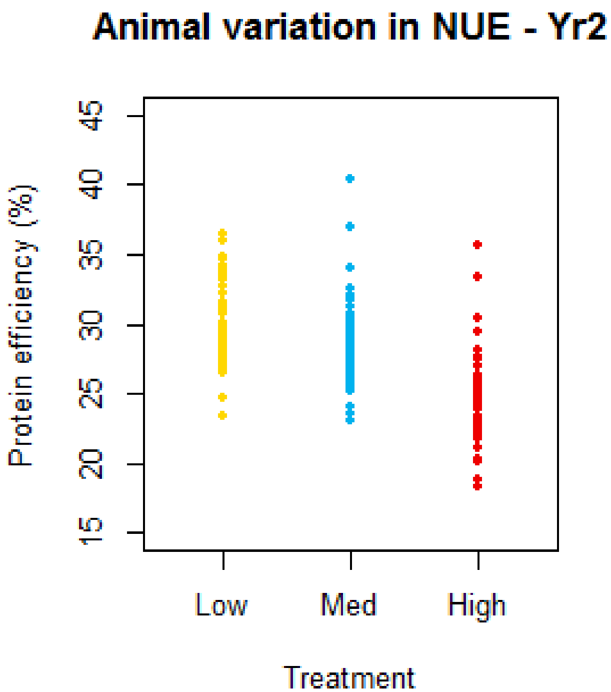


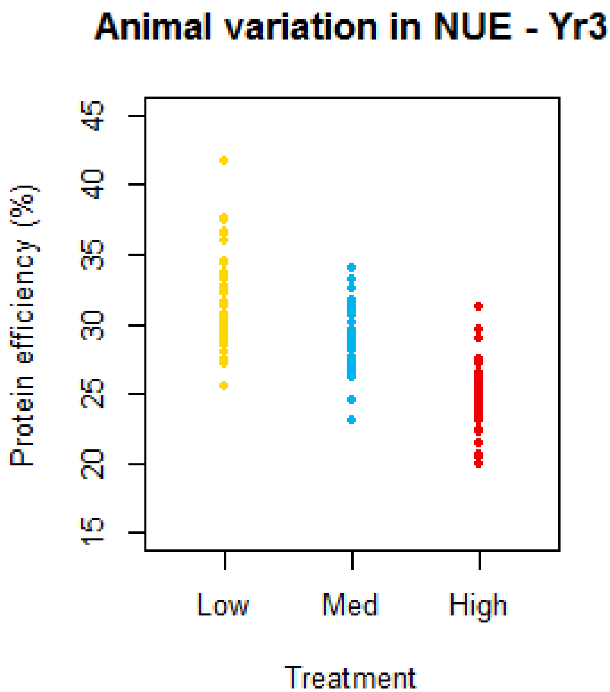
	Low	Med	High
Lac 1	31.5[a]	29.5[b]	25.5[c]
Lac 2	30.7[a]	28.4[b]	24.1[c]
Lac 3	31.1[a]	28.4[b]	24.3[c]



NITROGEN USE EFFICIENCY:
ANIMAL VARIATION

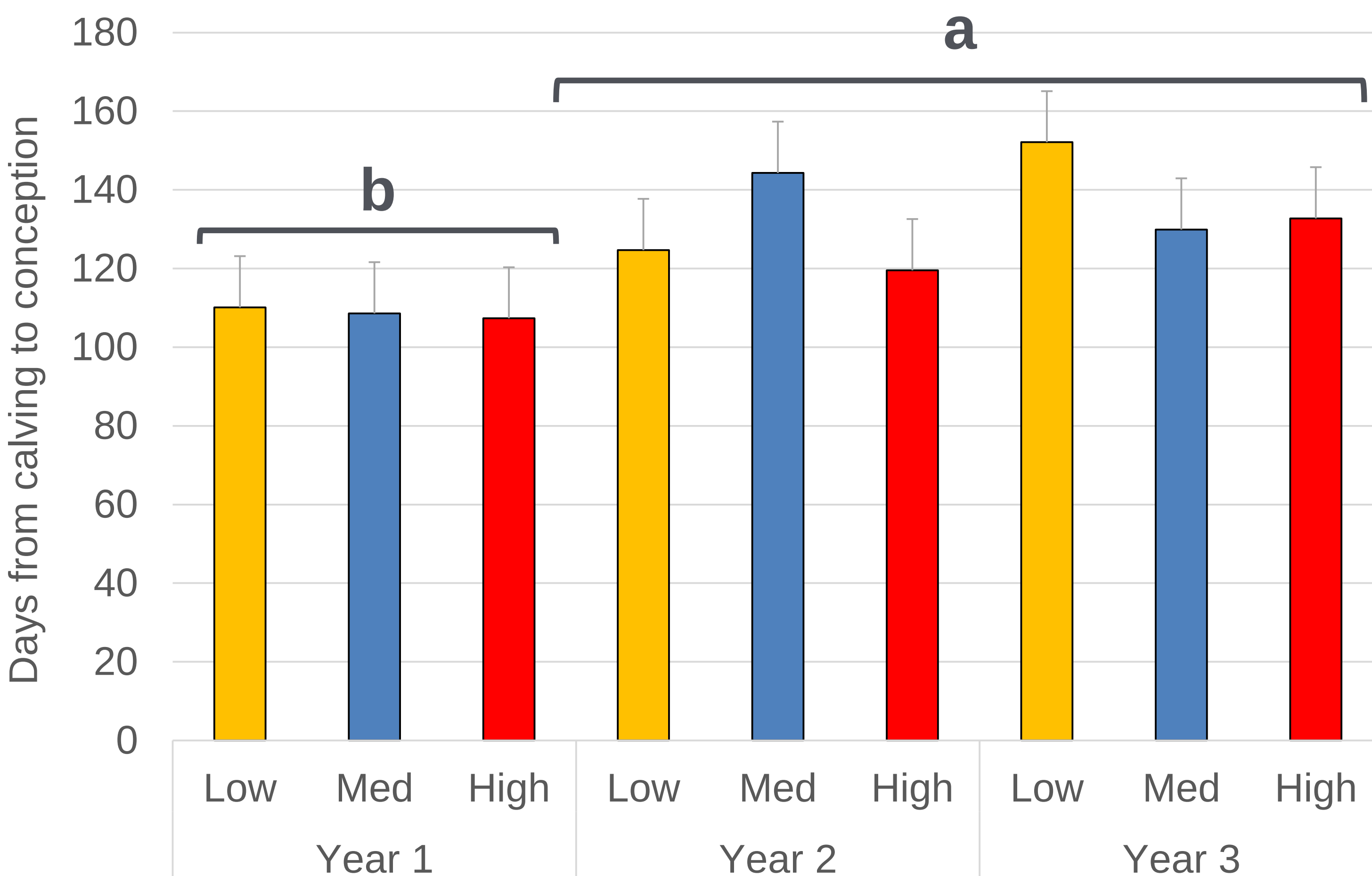






CALVING TO CONCEPTION

Treatment = NS
Year x Treatment = NS



ATTRITION – WHOLE STUDY

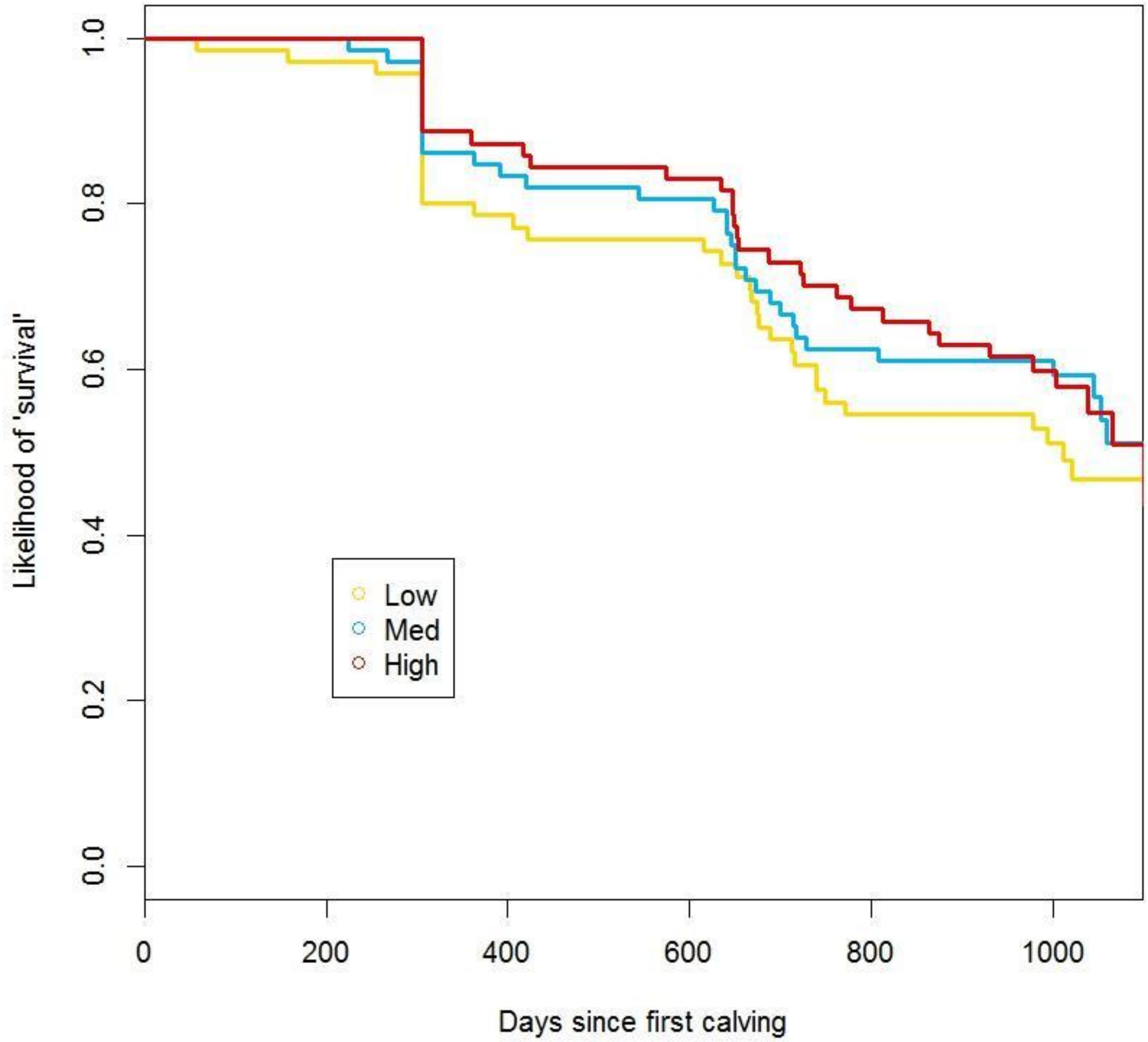
University of Reading

	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.

ATTRITION – WHOLE STUDY



ECONOMIC IMPACT

University of Reading

- Financial model of dairy enterprise to examine effect of varying dietary nitrogen
  - Variable inputs, fixed costs, output/revenue, gross and net margin

- Medium protein ration generates highest net margin

- Variable costs increase with both high and low protein diets
  - Feed costs highest in the HIGH group
  - Vet & med costs highest for LOW group
  - Replacement costs highest in the LOW group
  - Milk dumping highest for the LOW group

CONCLUSIONS – 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
  - Similar degree of animal variation across treatments
  - Reasons for animal variation of interest
  - Potential for epigenetic effects

- Large variation in diet protein concentrations
  - Implications for precision feeding lower protein diets

- Long-term negative effects of 'sub-optimal' protein supply evident (numerically) – survival reduced

- For this study, the 16% crude protein diet was 'optimal' in many respects - this was by design

AC0122 – Heifer Growth Study

Structure - diets

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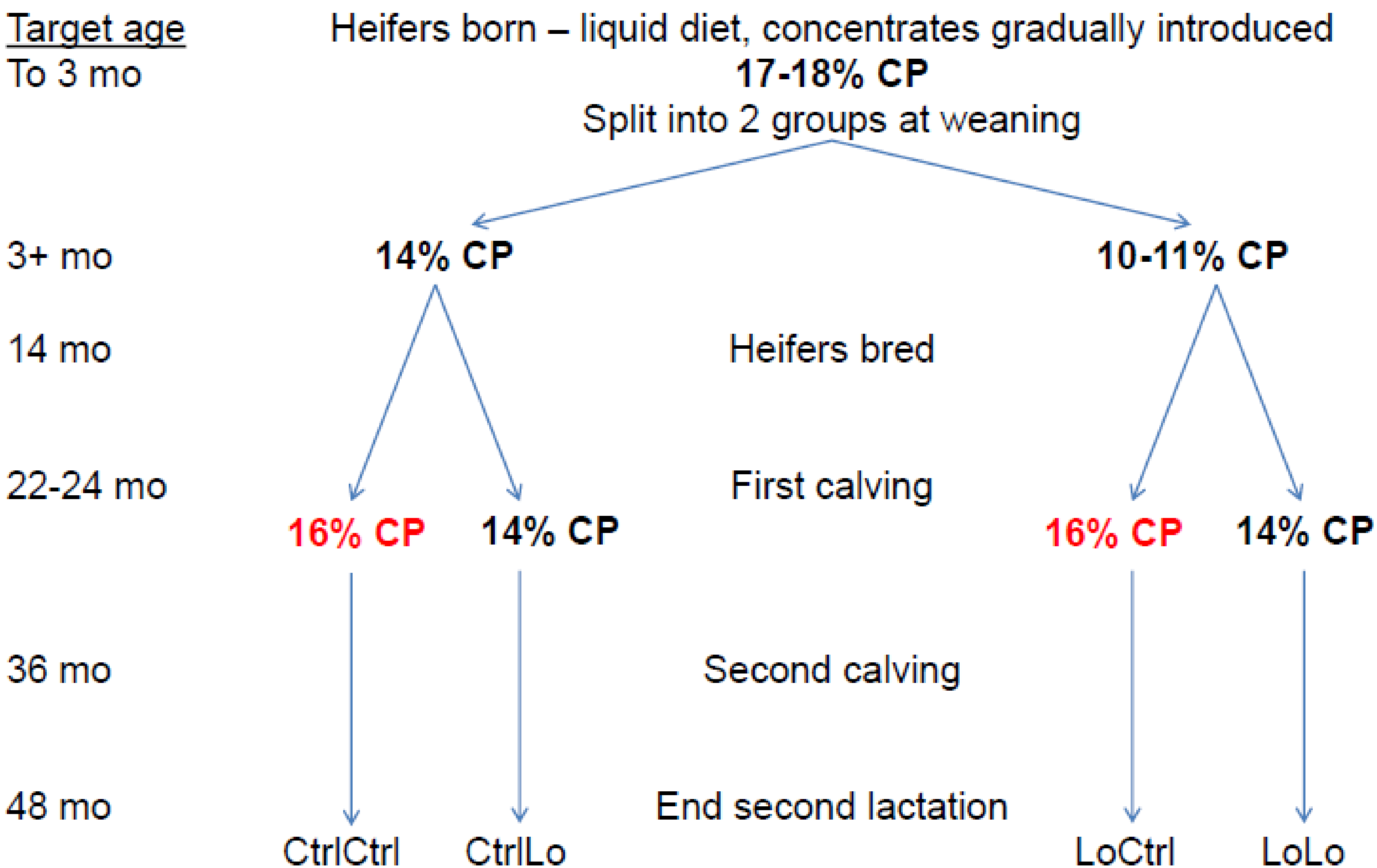
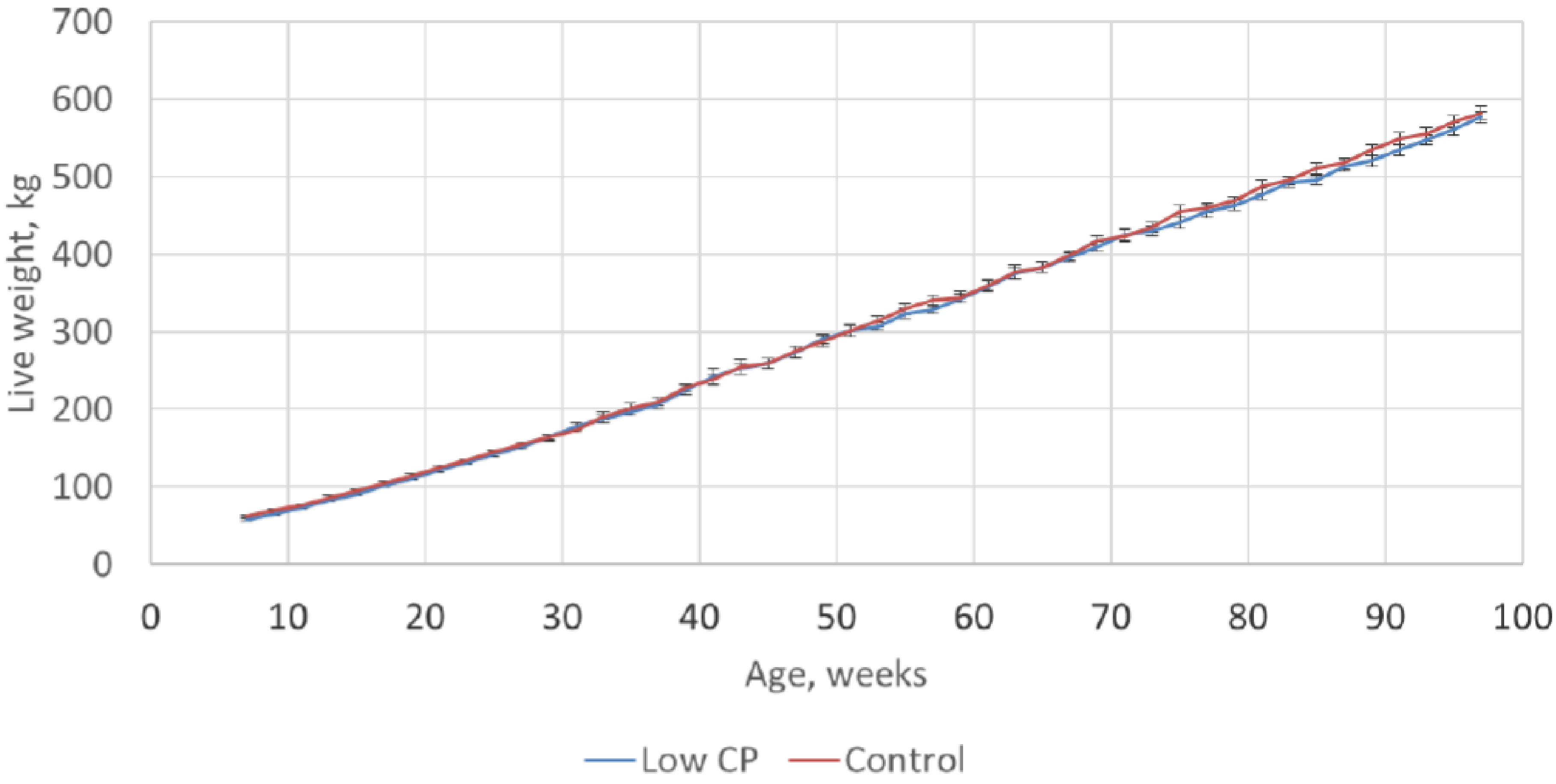


AC0122 – Heifer Growth Study



Moorby et al., preliminary data.

AC0122 Demonstration - Crichton

- 48 cows , 2 levels of protein, 2 calving periods
- 2 years – include grazing

- Lower protein level - similar production and health
  lower feed costs £76/cow/year

SOME TAKE HOME MESSAGES

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- Economic and environmental pressure to reduce dietary protein inputs (especially imported feed proteins)
  - Less environmental impact
  - Risk of reduced milk yield
- Lower protein diets more 'N efficient' ….

  but need to consider longer term effects at systems level
  - Energy supply key to maximum N use efficiency
- Precision feeding lower protein diets – challenges of variations in feed composition – cows very resilient – long term average important
- The longer term effects of 'sub-optimal' metabolizable protein supply must be assessed relative to the benefits
  - Including effects during the rearing period – often 'over' fed protein
  - Animal and system level
  - Economic and environmental impacts
    - Benefits vs risks and costs

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THANK YOU!

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www.reading.ac.uk/protein-efficiency