# SmartCow

*an integrated infrastructure for increased research capability and innovation in the European cattle sector*

# Using N More Efficiently in Cattle Production Systems – Challenges and Opportunities

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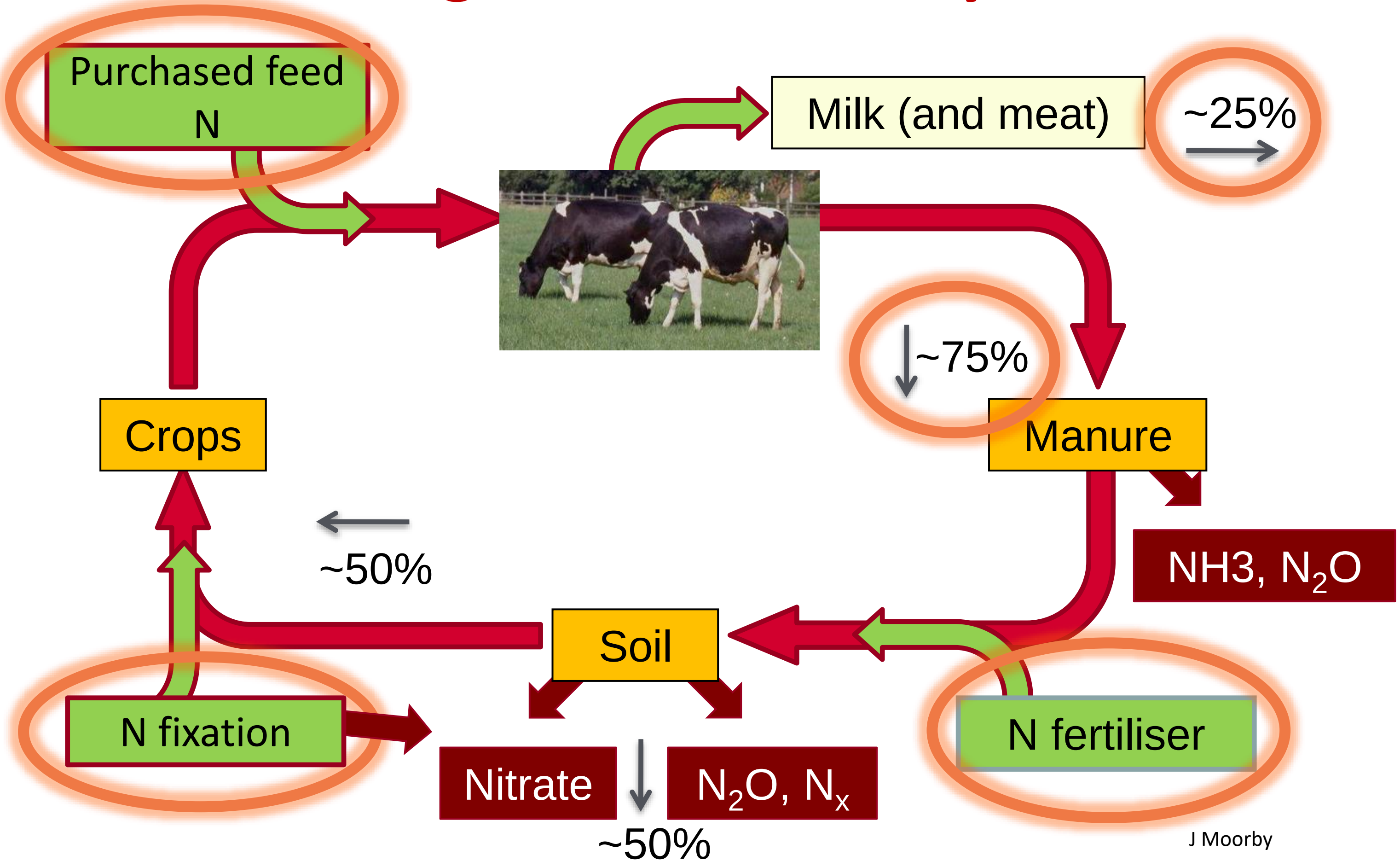
# Nitrogen Use Efficiency




J Moorby

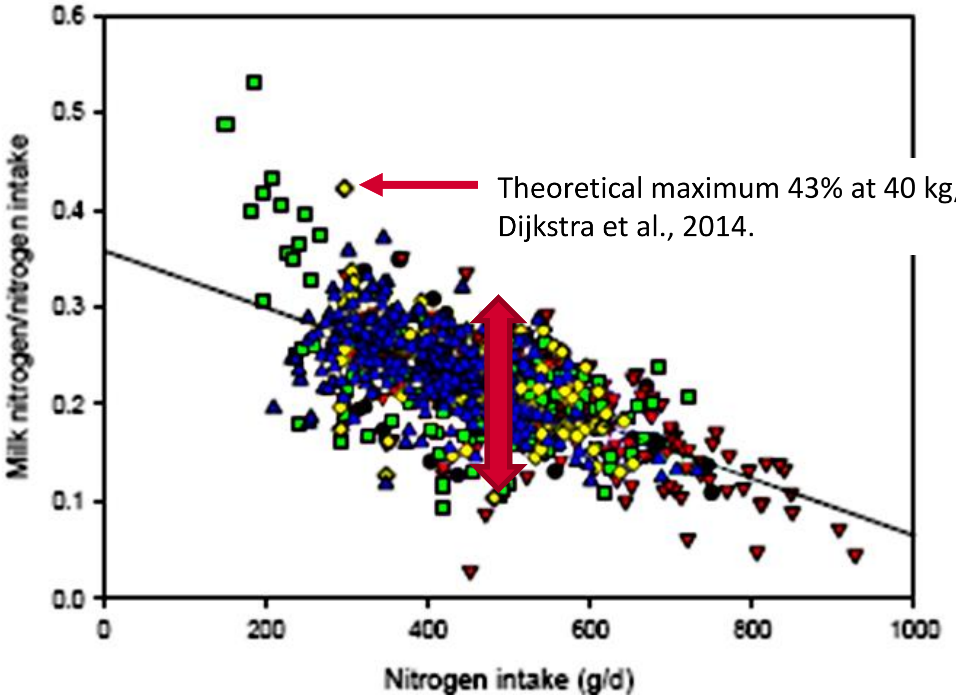
# Variation in N Use Efficiency in Lactating Dairy Cattle

| | 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)

# Milk N/Intake N vs. N Intake




Theoretical maximum 43% at 40 kg/d FPCM
Dijkstra et al., 2014.

Mills et al. (2009)

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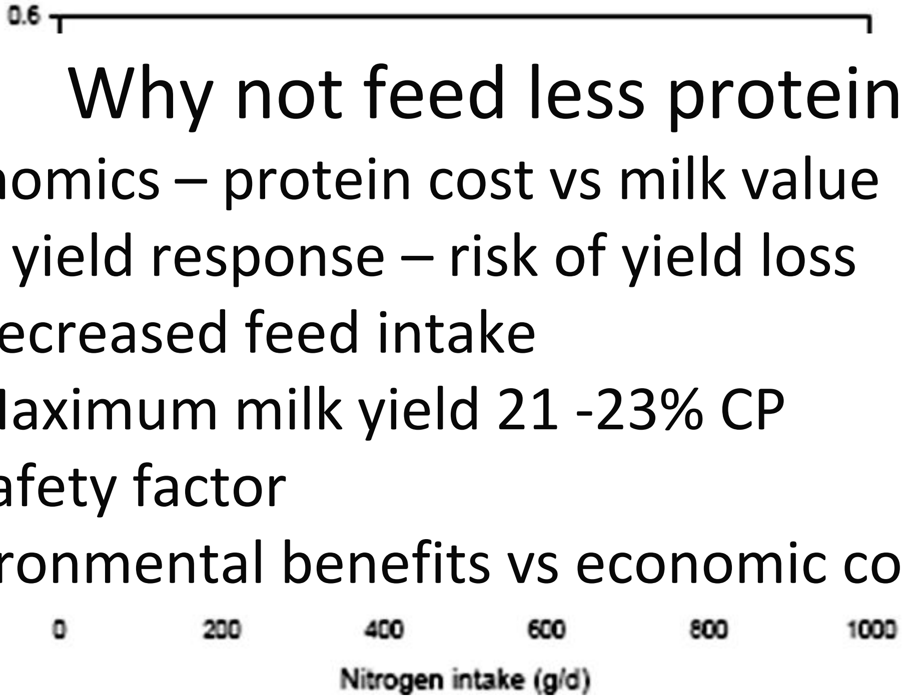
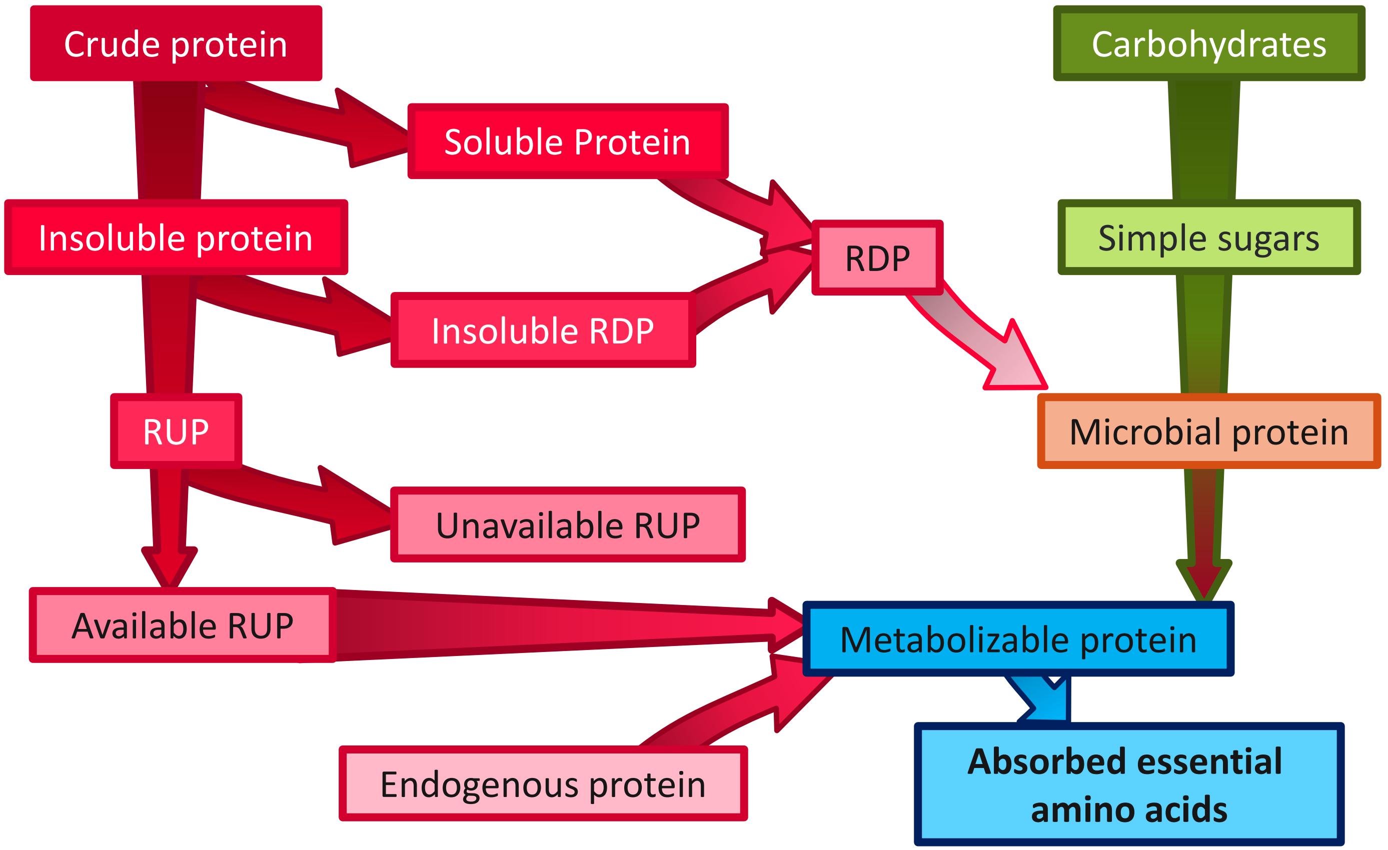



## Why not feed less protein?

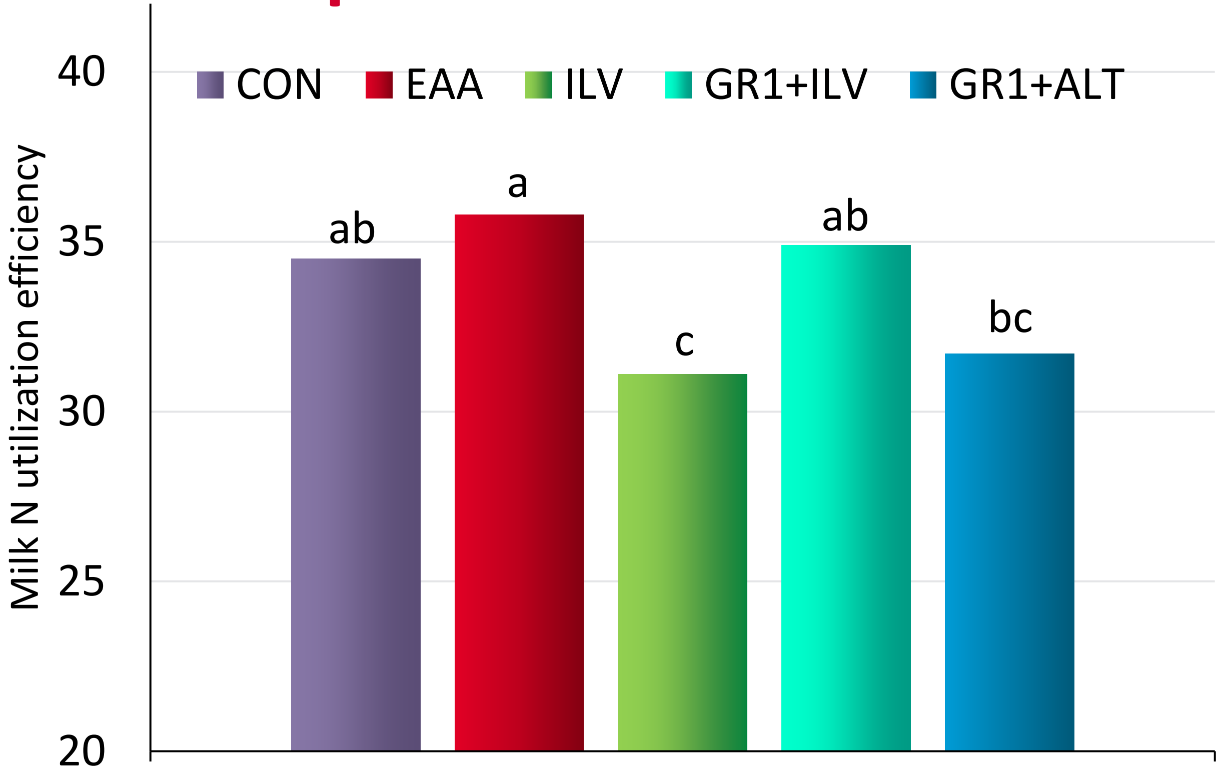
- Economics – protein cost vs milk value
- Milk yield response – risk of yield loss
  - Decreased feed intake
  - Maximum milk yield 21 -23% CP
  - Safety factor
- Environmental benefits vs economic costs?

Mills et al. (2009)

# RUMEN METABOLISABLE PROTEIN



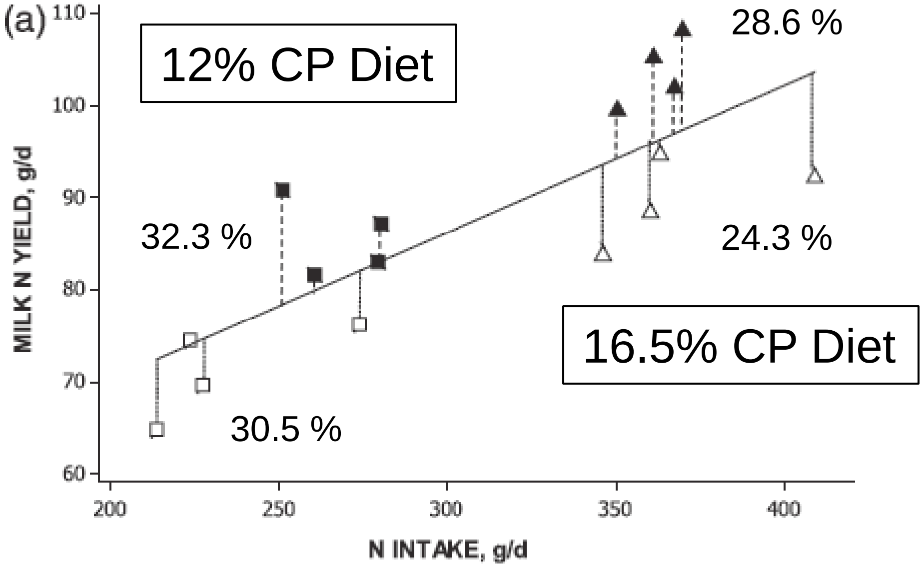
# Importance of AA Profile for Milk NUE




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

Nichols et al. (2019)

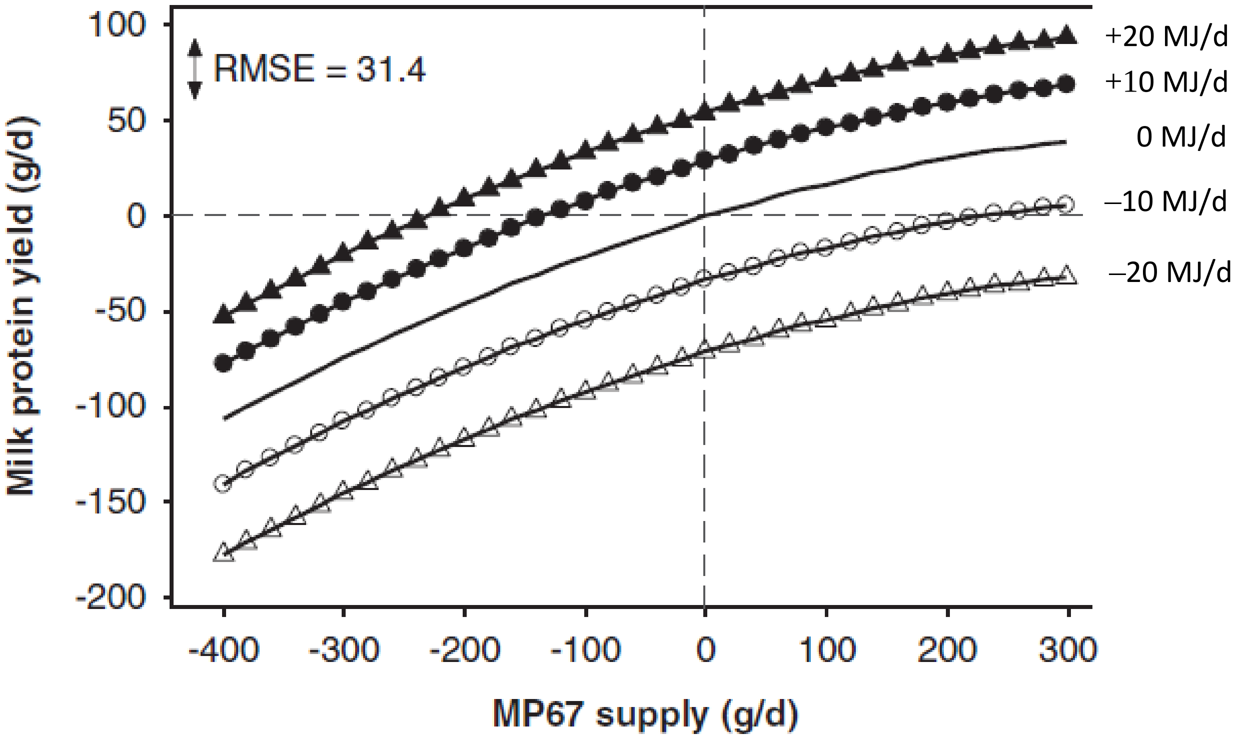
# Effect of Concentrate Energy Type (Starch vs Fibre) on N Utilization




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

*Using Jersey cows* *Cantalapiedra-Hijar et al., **2014.***

# Both MP and NEl Supply Affect Milk Protein Yield



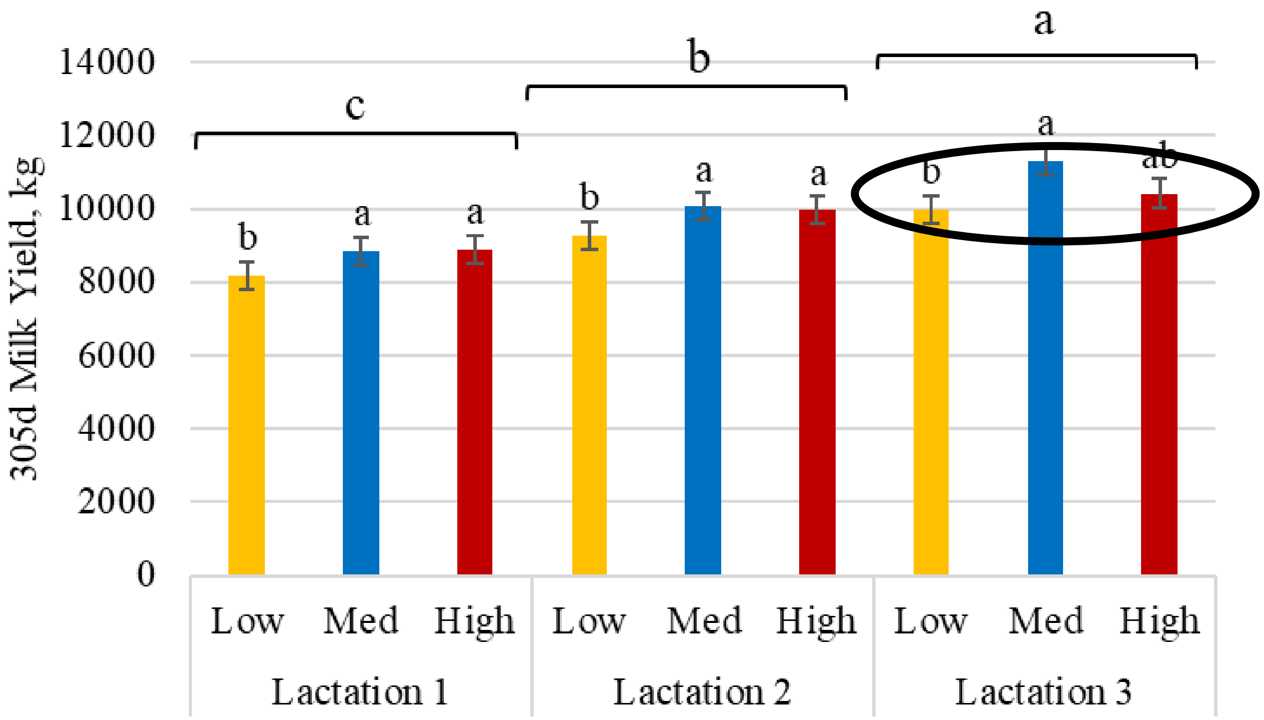

Daniel et al. (2016)

# Defra AC0122 – Long-term Lactation Trial

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 TMR diets – **Low 14%, Med 16%** and **High 18%** CP
  - Predicted MP below (90%), at (100%) or above (104%) expected requirement
- 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

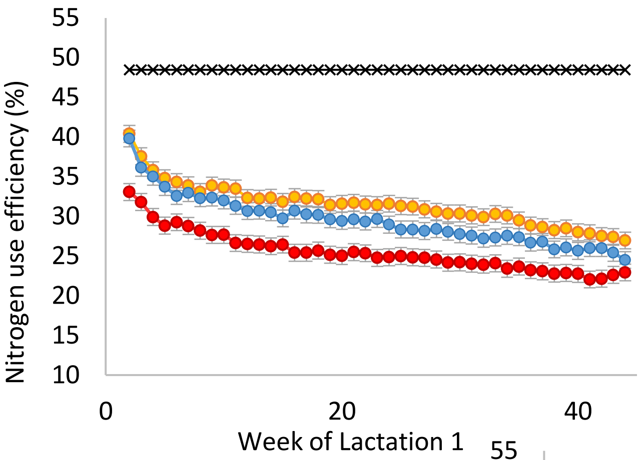
# 305 Day Milk Yield Over 3 Lactations

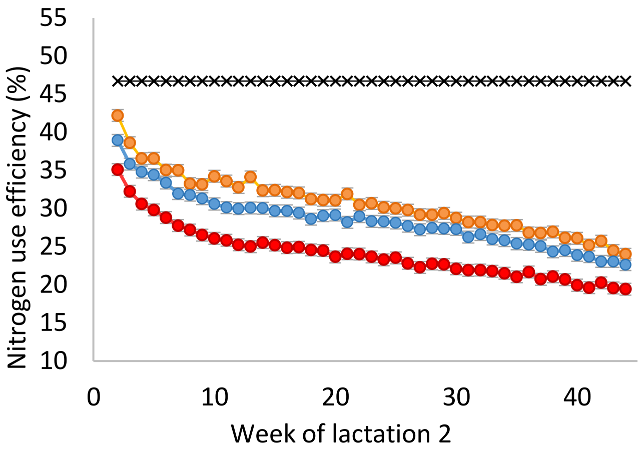



- Fed one of 3 diets: Low 14% - Med 16% - High 18% CP

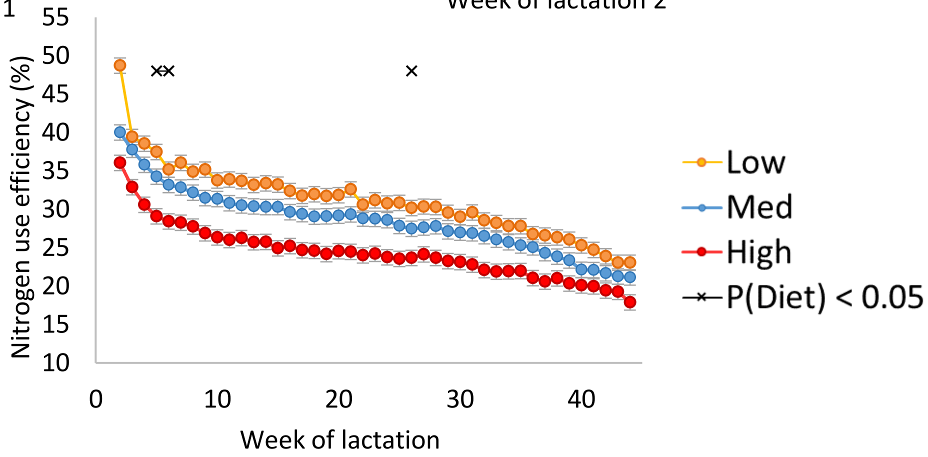
| Cows entering 4th lactation: | 23 (35%) | 33 (47%) | 32 (47%) |
|---|---|---|---|

# Nitrogen Use Efficiency



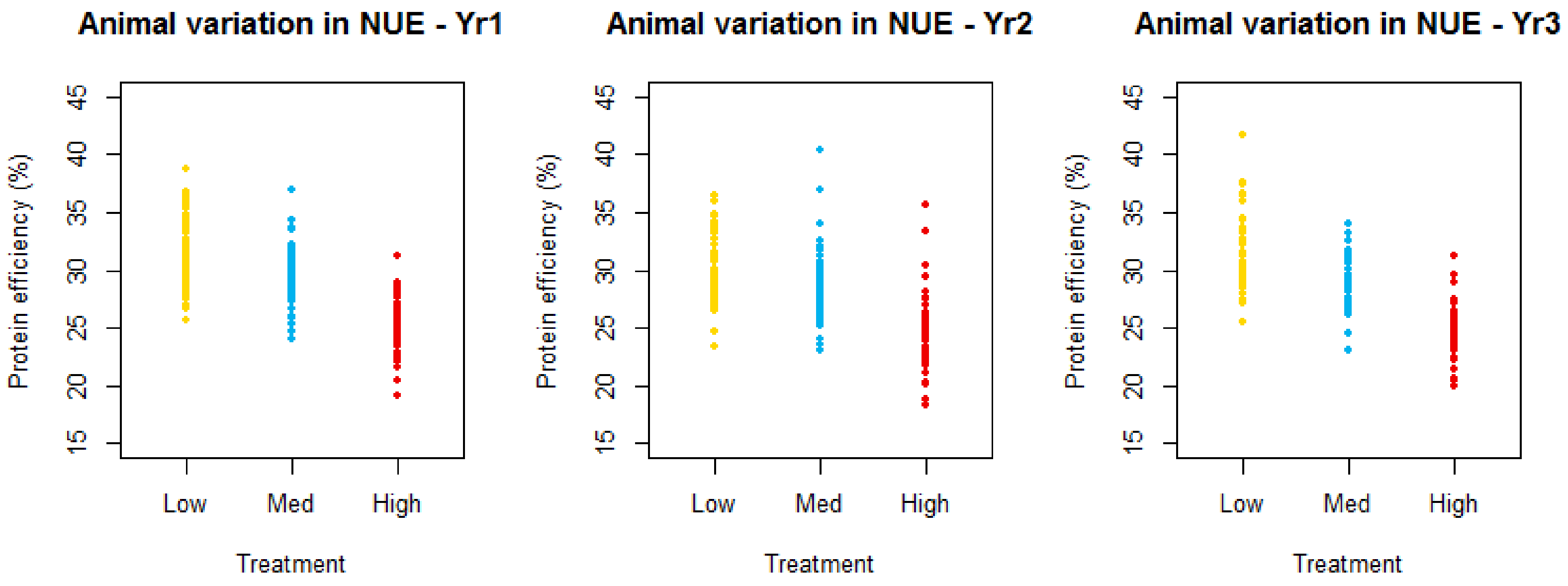




| | Low | Med | High |
|---|---|---|---|
| Lac 1 | 31.5[a] | 29.5[b] | 25.5[c] |
| Lac 2 | 30.7[a] | 28.4[b] | 24.1[c] |
| Lac 3 | 31.1[a] | 28.4[b] | 24.3[c] |

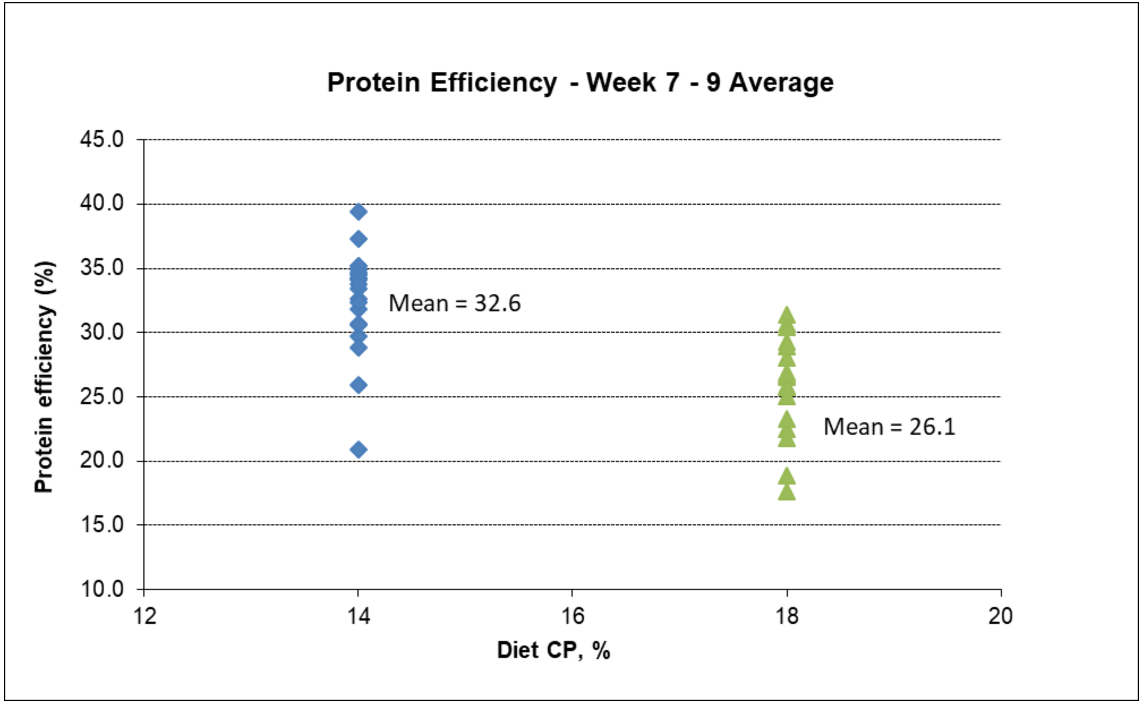


# Nitrogen Use Efficiency:

## Animal Variation Over 3 Lactations



# AC0122 Follow on Trial
# Individual Cow N Efficiency




Diets changed from 16% CP to 14% (Low) or 18% (High) week 0
21 Mid-lactation cows per treatment diet

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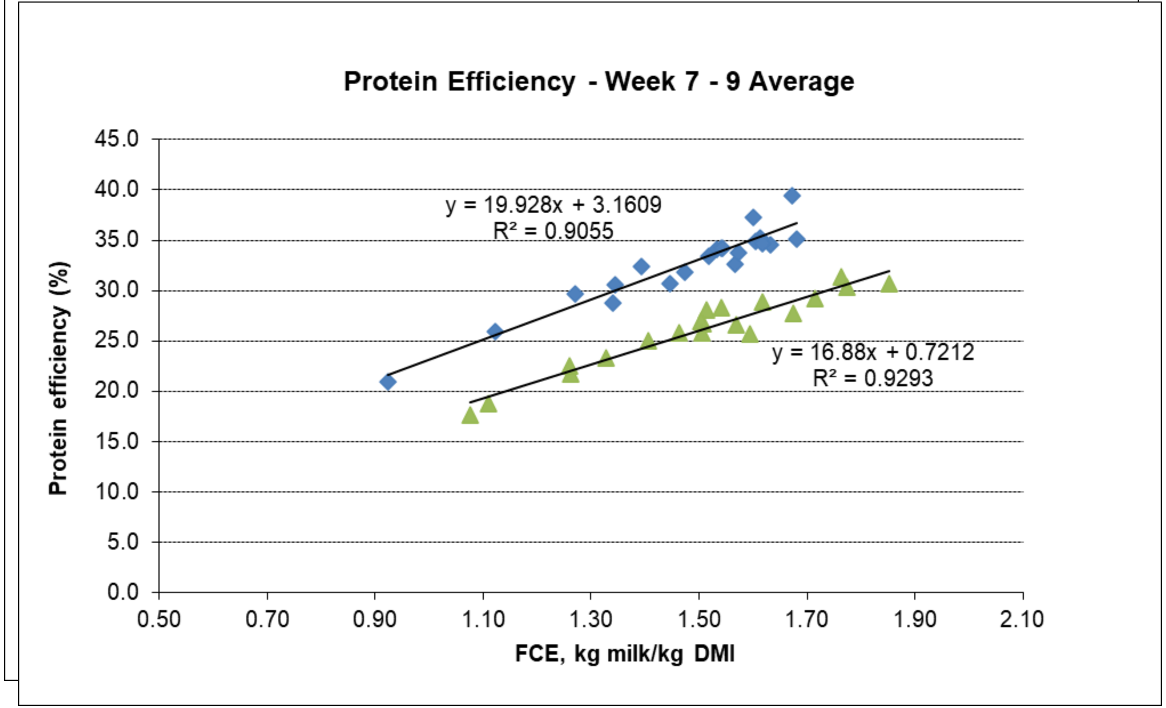


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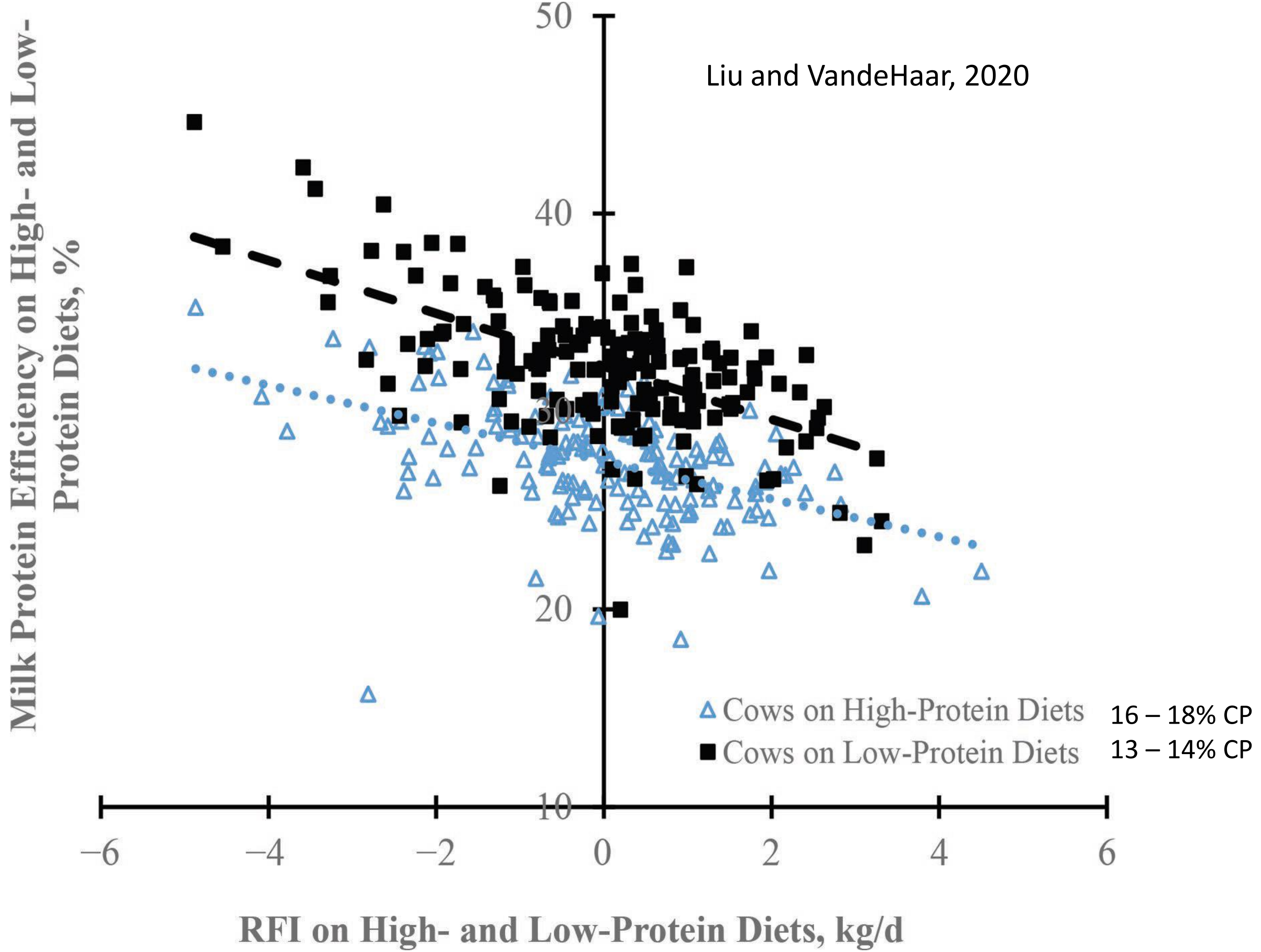
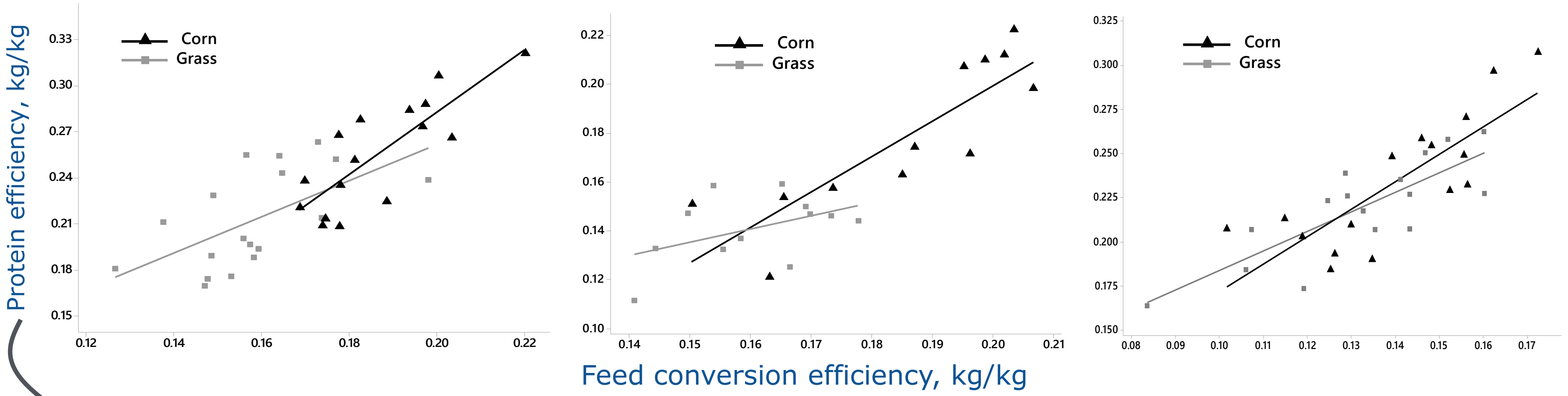
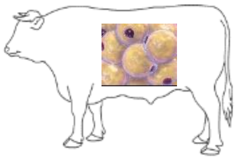

Liu and VandeHaar, 2020
Milk Protein Efficiency on High- and Low-Protein Diets, %
50
40
30
20
10
−6
−4
−2
0
2
4
6
RFI on High- and Low-Protein Diets, kg/d
Cows on High-Protein Diets
16 – 18% CP
Cows on Low-Protein Diets
13 – 14% CP

# LINK BETWEEN PROTEIN EFFICIENCY AND FEED EFFICIENCY IN BEEF

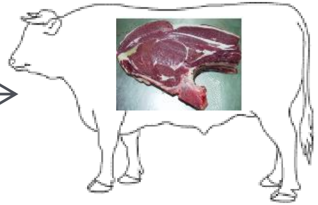
*Cantalapiedra-Hijar et al., 2015* | *Nasrollahi et al., 2020* | *Guarnido et al., unpublished*




ESTIMATION OF PROTEIN RETENTION



SUBCUTANEOUS ADYPOCITES SIZE

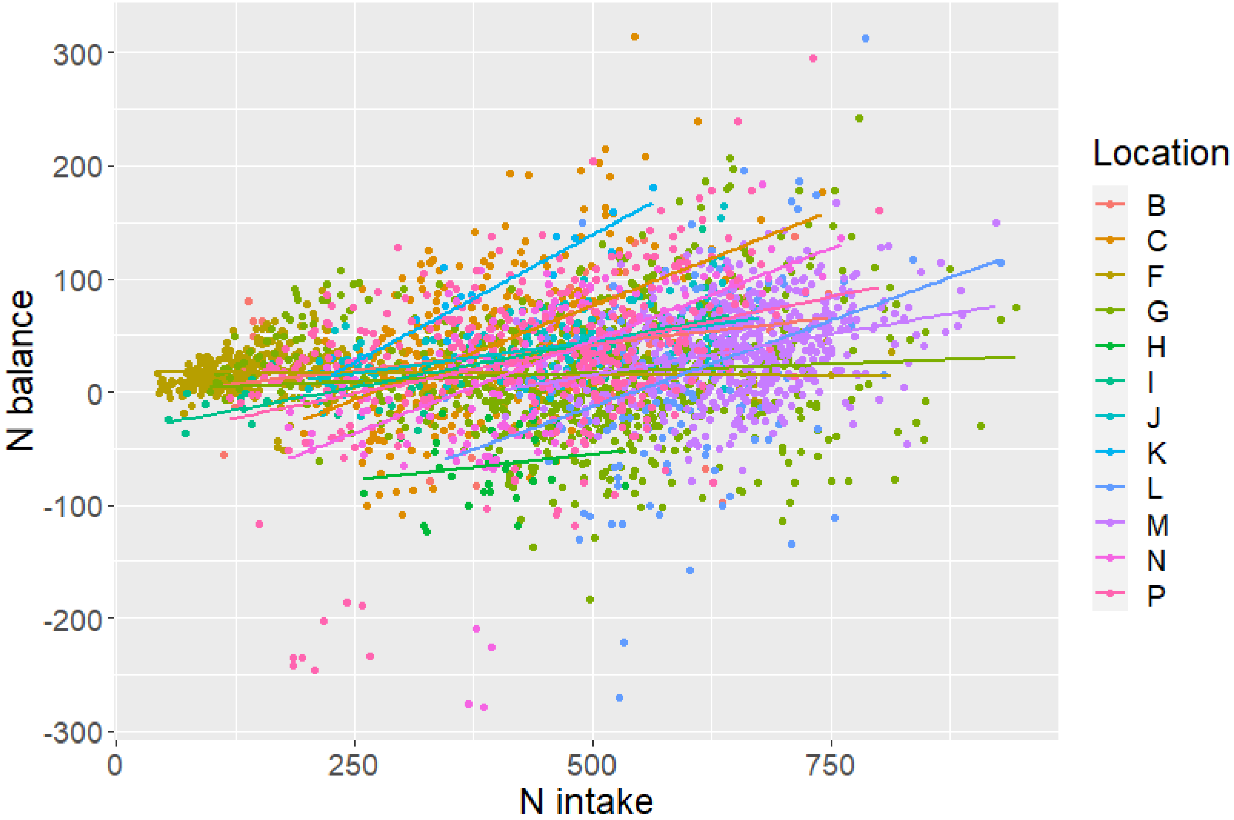


6th RIB DISSECTION

# Digestion and N Balance Trials

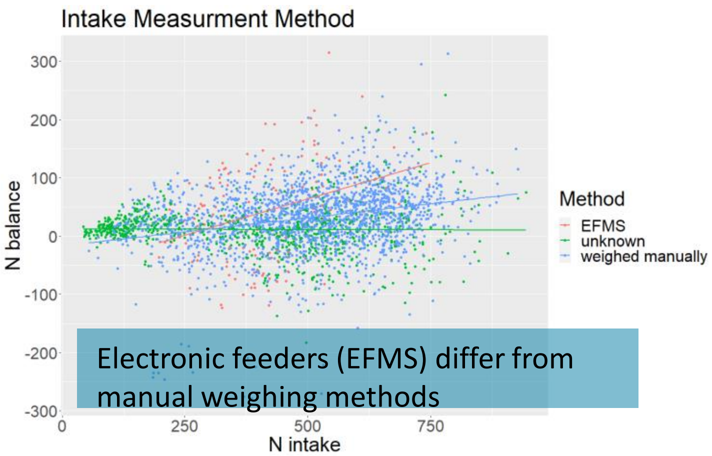
## Demanding on Time, Resources, and Animals

# SmartCow – WP 5 N intake v N balance

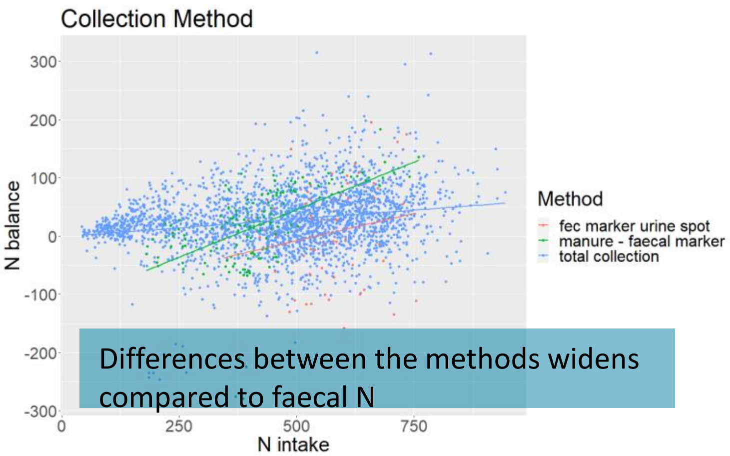



## Measurements at Individual Locations

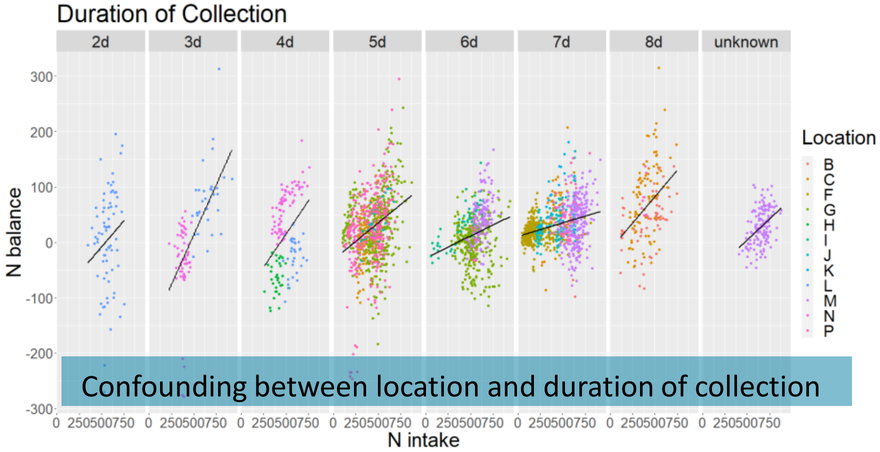
# SmartCow – WP 5 - N intake v N balance: Methods



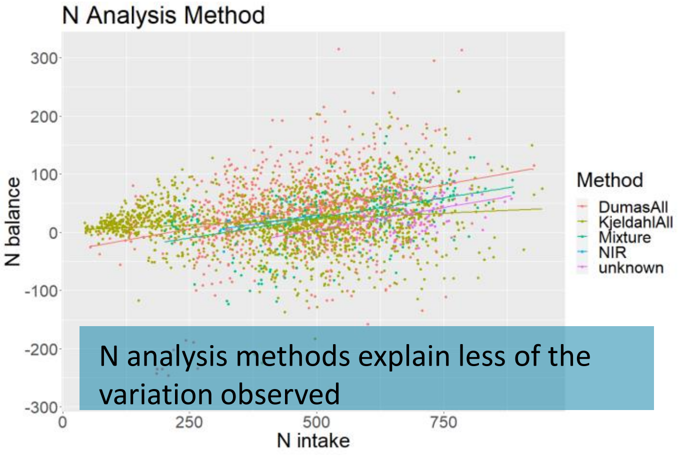

Electronic feeders (EFMS) differ from manual weighing methods




Differences between the methods widens compared to faecal N




Confounding between location and duration of collection




N analysis methods explain less of the variation observed

# N Balance Measurement Errors

Br. J. Nutr. (1966), 20, 325
H.D.R.I. Reprint No. 588

**Some errors in the determination of nitrogen retention of sheep by nitrogen balance studies**

By A. K. MARTIN
*Hannah Dairy Research Institute, Ayr*

mined, an average loss of 3·14 ± 0·55 mg N/kg body-weight per day was found. This loss was independent of food intake and larger than the loss of N in suint which was estimated to range

ELSEVIER
Livestock Production Science 52 (1997) 113–122
LIVESTOCK PRODUCTION SCIENCE

**Critical analysis of N balance experiments with lactating cows**

## Alternatives to digestion trials for determining diet digestibility and feed and N efficiency?

J. Dairy Sci. 102:5212–5218
https://doi.org/10.3168/jds.2019-16256


***Short communication:* Effects of drying and analytical methods on nitrogen concentrations of feeds, feces, milk, and urine of dairy cows**

D. L. Morris, A. W. Tebbe, W. P. Weiss, and C. Lee*
Department of Animal Sciences, Ohio Agricultural Research and Development Center, The Ohio State University, Wooster 44691



**Updating analysis of nitrogen balance experiments in dairy cows**

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[2]Department of Animal Nutrition and Biotechnology, and Fisheries, University of Agriculture in Krakow, Krakow 30059, Poland

### ABSTRACT

Nitrogen balance (NB) experiments allow calculation of N retention in the body by subtracting N excreted in feces (NF), urine (NU) and milk (NM) from N intake (NI). In a previous study, we found that NB data from experiments with lactating dairy cows were generally high and, in the current meta-analysis, we update our

**Key words:** dairy cow, nitrogen balance, nitrogen excretion

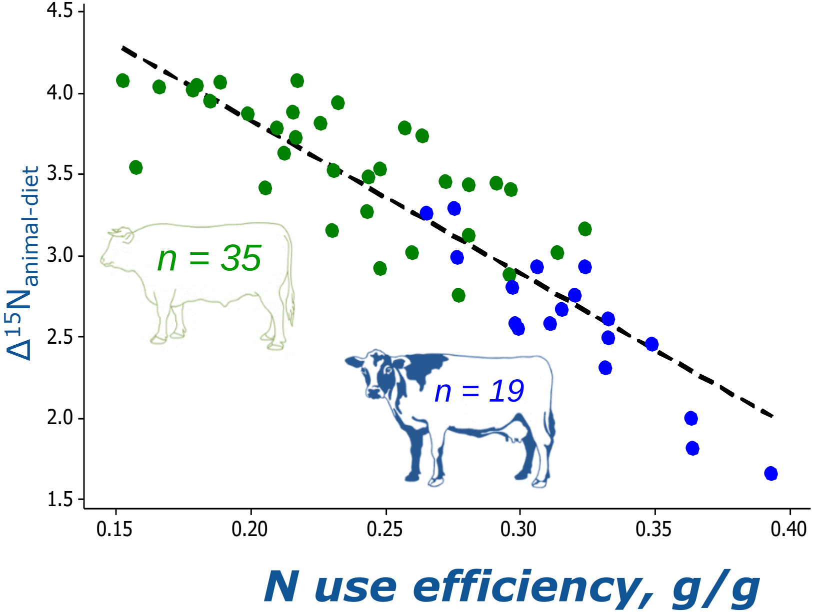
### INTRODUCTION

Nitrogen balance (NB) experiments are in vivo trials that allow calculation of N retention or mobilization into and out of the body by subtracting N excretions

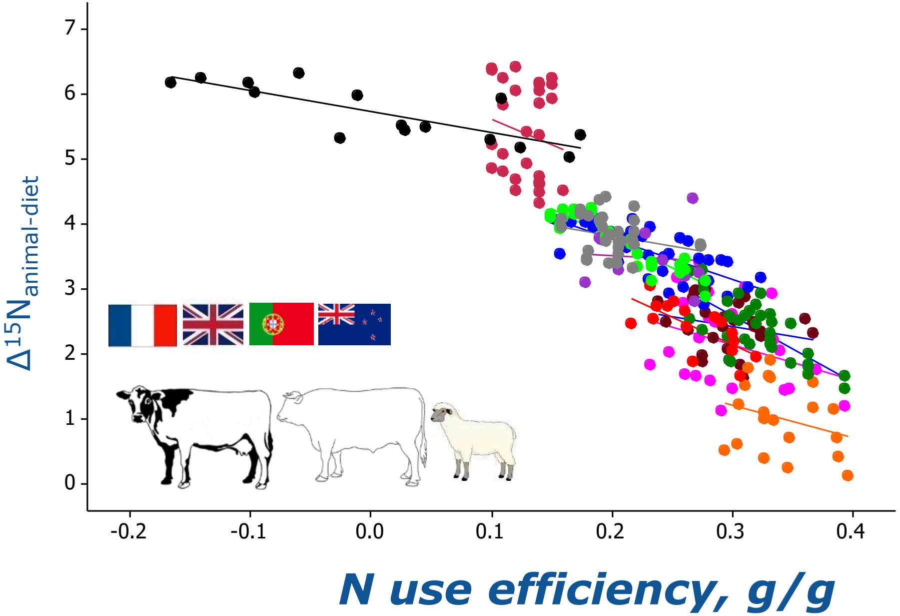
# NUE predictions from natural 15N abundance (before Smartcow)

PROOF OF CONCEPT

CONFIRMATION BY META-ANALYSIS: SMALL DATASET




Cantalapiedra-Hijar et al., 2015

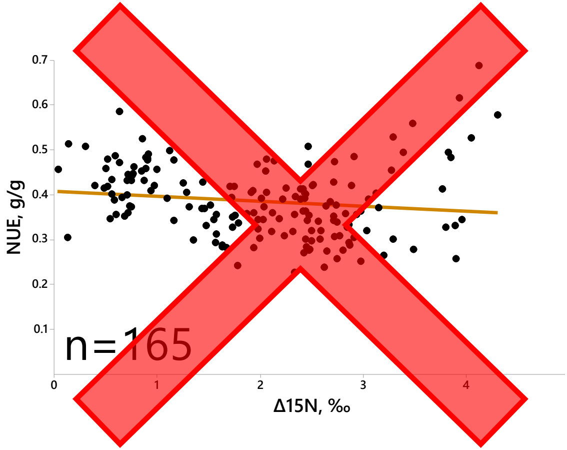



Cantalapiedra-Hijar et al., 2018

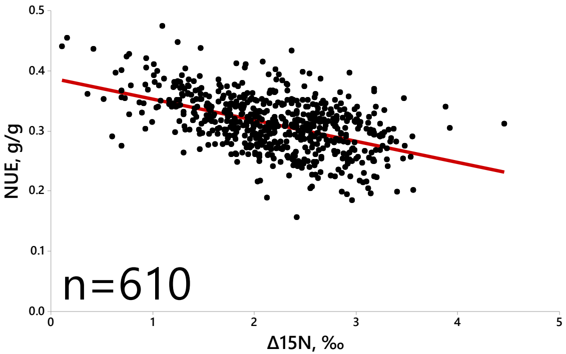
# *Confirmation NUE predictions from natural 15N abundance (Smartcow)*

## Simple linear relationship between $\Delta^{15}N$ and NUE

EARLY LACTATION (<50 DIM)




MID LACTATION (50 - 150 DIM)

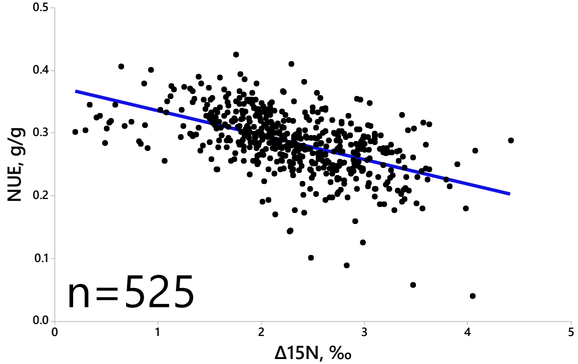



$NUE = 0.388 - 0.035 \times \Delta^{15}N$

r = -0.50

RSE = 0.04

LATE LACTATION (>150 DIM)




$NUE = 0.374 - 0.039 \times \Delta^{15}N$

r = -0.53

RSE = 0.04

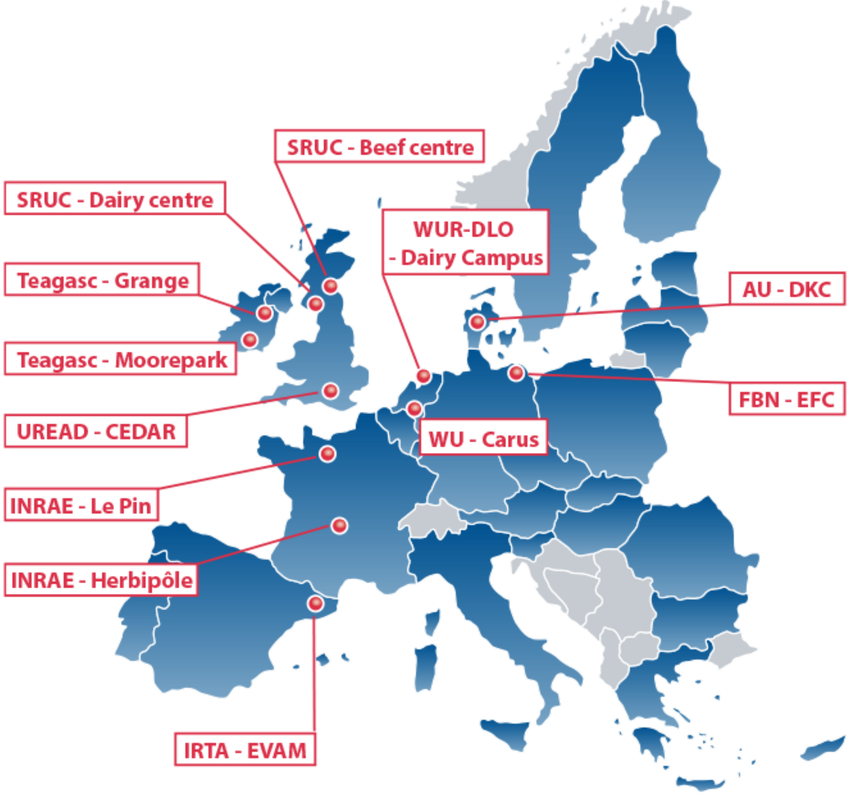
Martin Correa-Luna
Postdoc – INRAE

SmartCow

# Conclusions

- Environmental pressure to reduce nitrogen inputs
  - Less environmental impact but risk of reduced production
- Diets can be formulated to meet requirements with lower protein concentrations
  - Energy supply key to maximum dietary N efficiency
  - N efficiency linked to milk protein yield and feed efficiency
  - Animal variation in dietary N efficiency substantial
- Precision feeding lower protein diets – challenges of variations in feed composition
  - Risk of reduced milk yield and fertility if deficiencies occur
- N balance measurements require attention to detail
  - Numerous sources of variation and apparent volatile N losses
- $\Delta^{15}N$ measurements a potential biomarker for NUE

# SmartCow at a glance




**First-class Cattle Research Infrastructures (RIs) across Europe:**

- 11 major RIs distributed in 7 EU countries
- 12 locations, which include 18 installations
- 2500 dairy and 1000 beef cows

- **Networking of RIs** to inventorize resources, harmonize procedures, and share data
- **Joint research activities** to improve experimental methods and phenotyping capability
- **Interaction with stakeholders** to stay in line with industry needs and improve dissemination

**http://www.smartcow.eu/stakeholders/**

## TRAINING PROGRAM

For Scientists, Technicians, Stakeholders, PhD students

- Face-to-face training courses
- Free web-conferences
- One-day study tours in 4 different countries

**http://www.smartcow.eu/resources/training/**

## TRANSNATIONAL ACCESS CALLS

Offers external users (academic and industry) free access to SmartCow RIs

- 30 projects during the 4 years of SmartCow
- Access to around 10,000 cow-weeks

**http://www.smartcow.eu/calls/**

*This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Grant Agreement n°730924.*

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