Effect of dietary protein concentrations on feeding efficiency and methane emissions of dairy cows across lactation

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Environmental impact

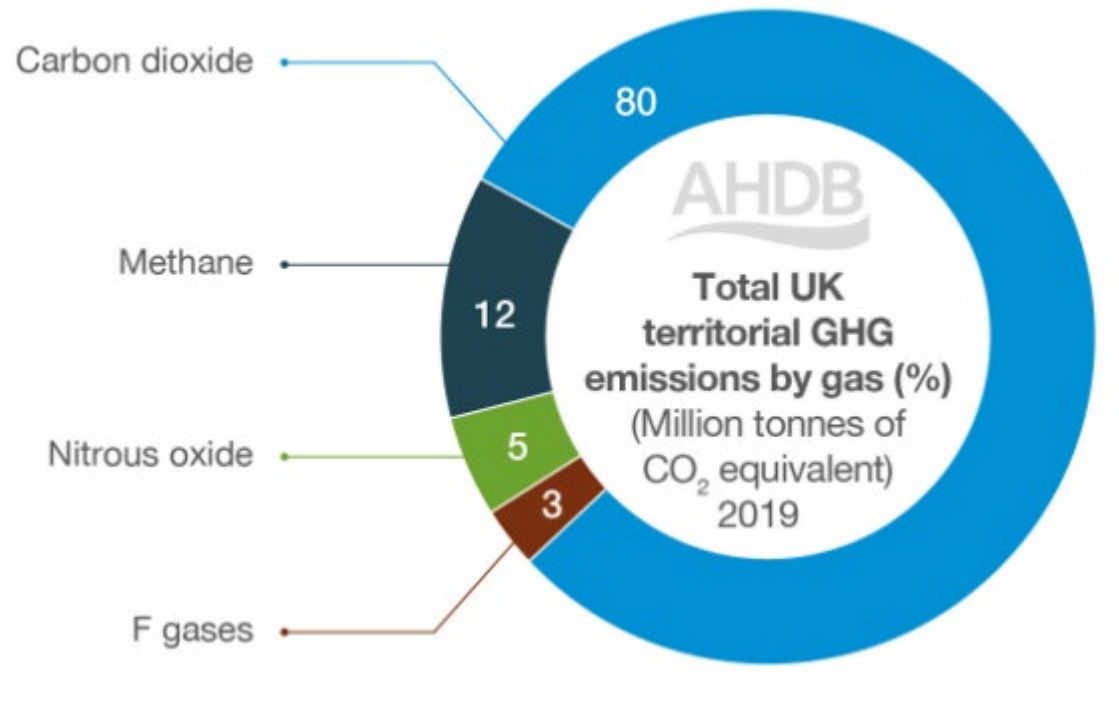

Figure 1: Total UK territorial GHG emissions by gas (2019) (Million tonnes of CO2 equivalent, using GWP100)

AHDB (2019) Greenhouse gas emissions: Agriculture

- Agriculture accounts for:
  - 11% of total GHG emissions in the UK
  - 71% of total nitrous oxide emissions
  - 49% of total methane emissions
  - 1.9% of total carbon dioxide emissions
- Methane (**CH_4**) from enteric fermentation of ruminant animals.
- Nitrous oxide from excretion of Nitrogen (**N**) from animals.

Reducing N excretion

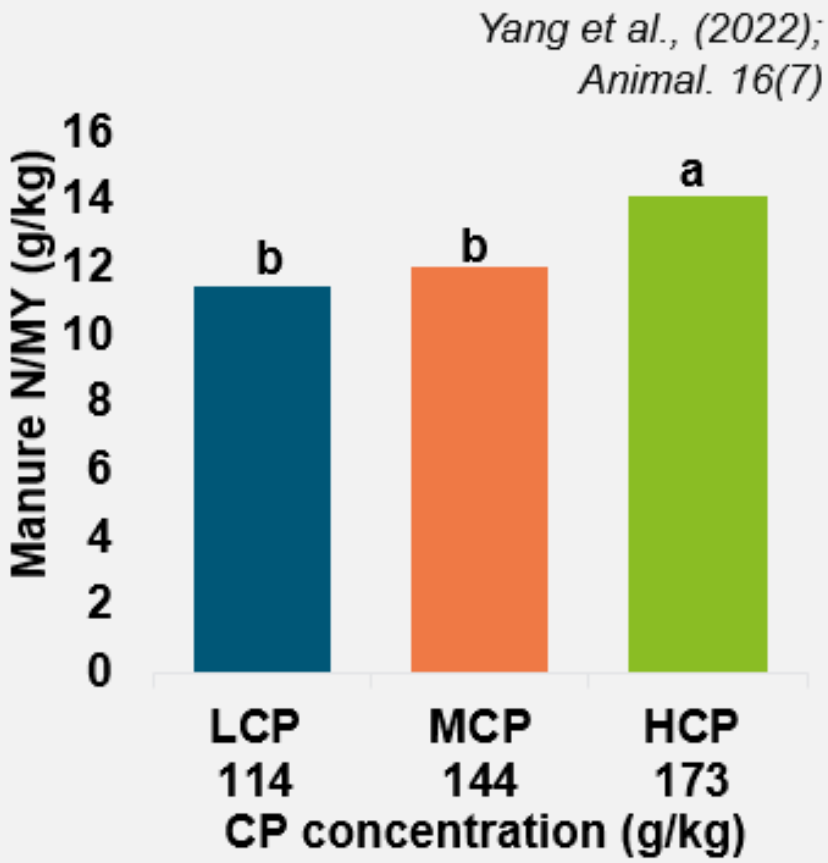

Figure 2: Effect of dietary CP concentration (g/kg) on N use efficiency

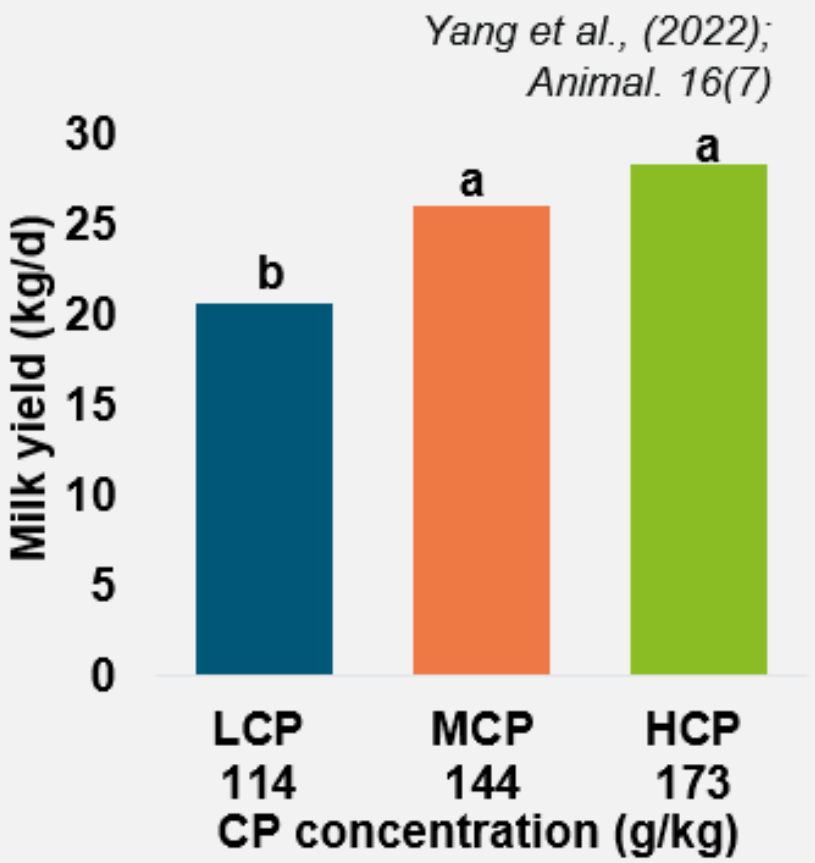

Figure 3: Effect of dietary CP concentration (g/kg) on productivity

- Poor Utilization of dietary protein in dairy cows
- Excreted as N in manure
- Reducing dietary CP content can reduce N excretion

CP = crude protein; N = nitrogen; MY = milk yield; DMI = dry matter intake; LCP = low CP; MCP = medium CP; HCP = high CP

Reducing dietary crude protein

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Productivity and feed efficiency

- Reductions in feed efficiency as CP concentration reduces

Economic and environmental sustainability

- High cost of protein in animal diets
- CH_4 emissions represent a loss of 3.7-10.1% of gross energy intake (**GEI**)
- Reducing CH_4 emissions could increase the availability of metabolizable energy (**ME**) and improve energy use efficiency (**EUE**; energy output in milk/gross energy intake)

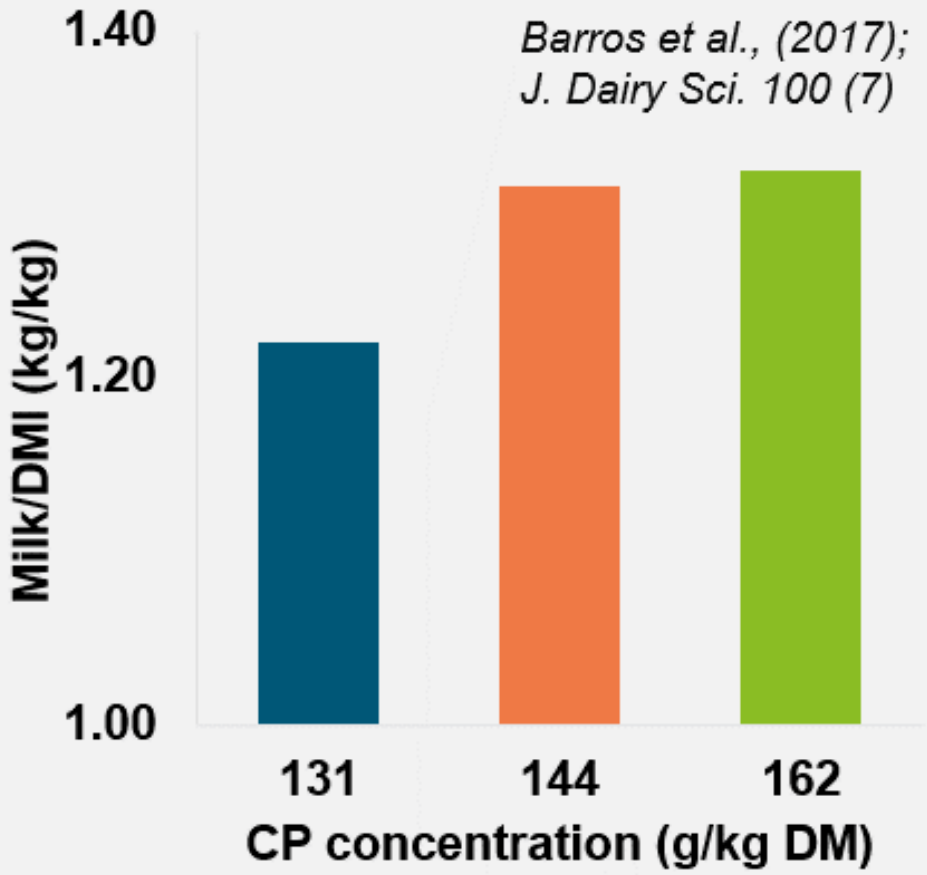

Figure 4: Effect of dietary CP concentration on Milk/DMI (kg/kg)

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CP = crude protein; DMI = dry matter intake

Study aims

- High cost of protein and the poor nitrogen use efficiency
- Growing pressure for dairies to reduce dietary CP in cows diets
- Pressure for dairies to reduce their environmental impact
- It is important to identify an optimal dietary CP concentration that does not negatively impact:
    - productivity and feeding efficiency,
    - CH_4 production parameters
- The study aimed to:

- Investigate the effect of diet CP concentration, stage of lactation and parity on
    - Productivity
    - Feed efficiency (Product/intake)
    - Energy use efficiency (**EUE**)
    - CH_4 production parameters

CP = crude protein; dry matter intake; CH_4 = methane

Materials & Methods

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Contents lists available at ScienceDirect

Animal

The international journal of animal biosciences

Effects of dietary crude protein concentration on animal performance and nitrogen utilisation efficiency at different stages of lactation in Holstein-Friesian dairy cows

C.T. Yang, C.P. Ferris, T. Yan *

Agri-Food and Biosciences Institute, Hillsborough, Co. Down, United Kingdom

J. Dairy Sci. 92:1001–1012
doi:10.3168/jds.2008-1155

Effect of dietary protein content on animal production and blood metabolites of dairy cows during lactation

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Materials & Methods

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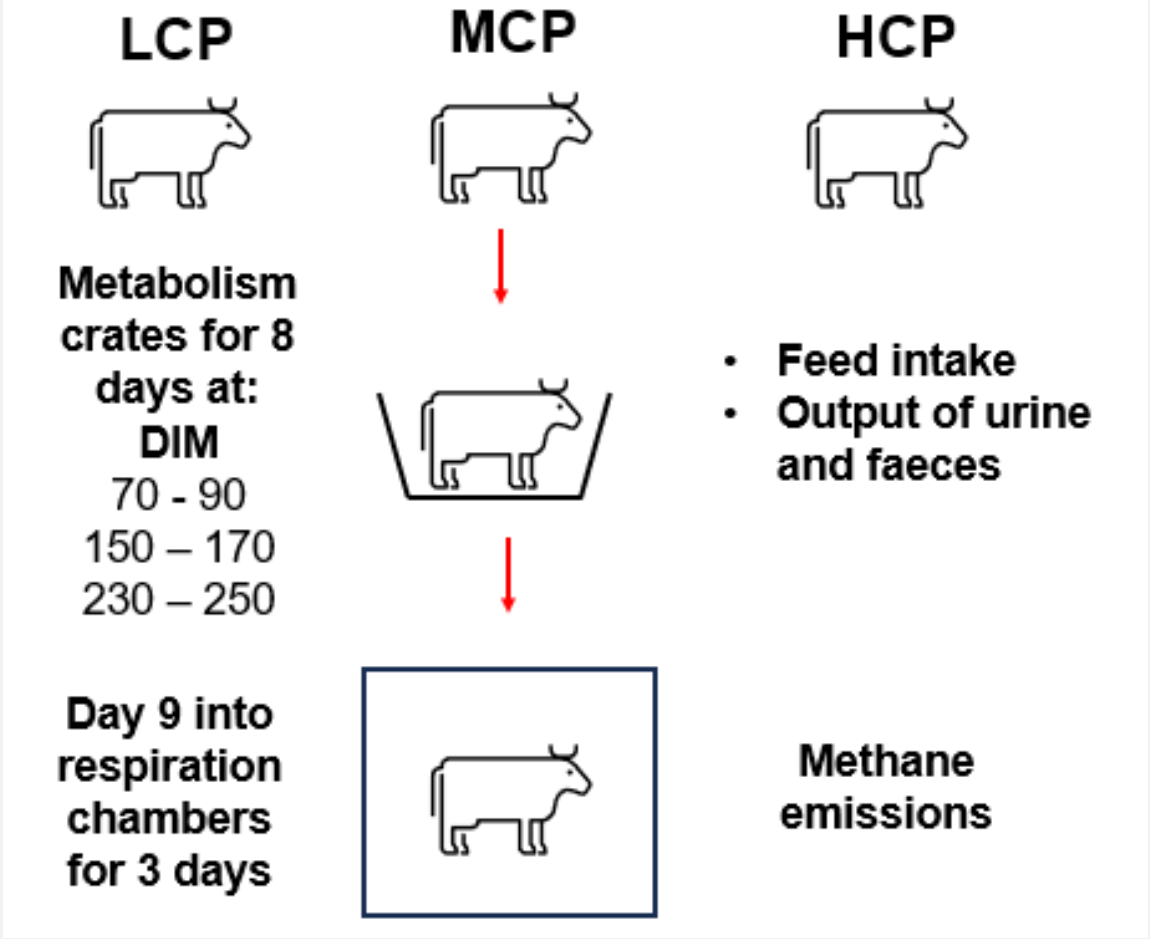
Animals and diets

- 24 lactating Holstein-Friesian dairy cows were randomly allocated to one of three **TMR** containing either:
  - Low CP; 120 CP/kg DM **(LCP) (8 cows)**
  - Medium CP; 150 CP/kg DM **(MCP) (8 cows)**
  - High CP 180 CP/kg DM **(HCP) (8 cows)**

Statistical analysis

- **REML using Genstat:**
  - Fixed effects: CP level, stage of lactation, parity and interactions.
  - Random effects: cow ID, stage of lactation.
- **Regression equations**
  - CP content.
  - Random: cow, stage of lactation and parity.



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CP = crude protein; LCP = low CP; MCP = medium CP; HCP = high CP

Results: Intake, productivity and feed efficiency

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Table 1. Means ± SE and P-values for the effect of dietary CP level on feed intake, productivity and efficiency

	LCP	MCP	HCP	SE	P-value
Feed intake (kg/d)					
Total DMI	16.5[b]	**18.4[a]**	**19.5[a]**	0.43	<0.001
DM Digestibility (%)	72.0[b]	73.0[b]	74.0[a]	0.50	0.020
Productivity (kg/d)					
Milk Yield	20.6[b]	**26.1[a]**	**28.3[a]**	1.09	<0.001
ECMY	20.7[b]	**25.7[a]**	**27.8[a]**	0.91	<0.001
Feed efficiency (kg/kg DMI)					
Milk/DMI	1.26	1.41	1.44	0.047	0.080
ECMY/DMI	1.27[b]	**1.40[a]**	**1.42[a]**	0.037	0.010
Milk solids/DMI (g/kg)	154[b]	**170[a]**	**174[a]**	4.6	0.020

LCP = low CP (120 g/kg DM); MCP = medium CP (150 g/kg DM); HCP = high CP (180 g/kg DM); ECMY = energy corrected milk yield

- MCP and HCP resulted in higher DMI than LCP.
- MCP and HCP resulted in higher milk and ECMY than LCP.
- MCP and HCP had higher ECMY/DMI and milk solids/DMI than LCP.
- There were no differences between MCP and HCP for DMI, Milk yield, ECMY, ECMY/DMI and milk solids/DMI.

CP = crude protein; DMI = dry matter intake; LCP = low CP, 120; MCP = medium CP, 150; HCP = high CP, 180; ECMY = energy corrected milk yield

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Results: Intake, productivity and feed efficiency

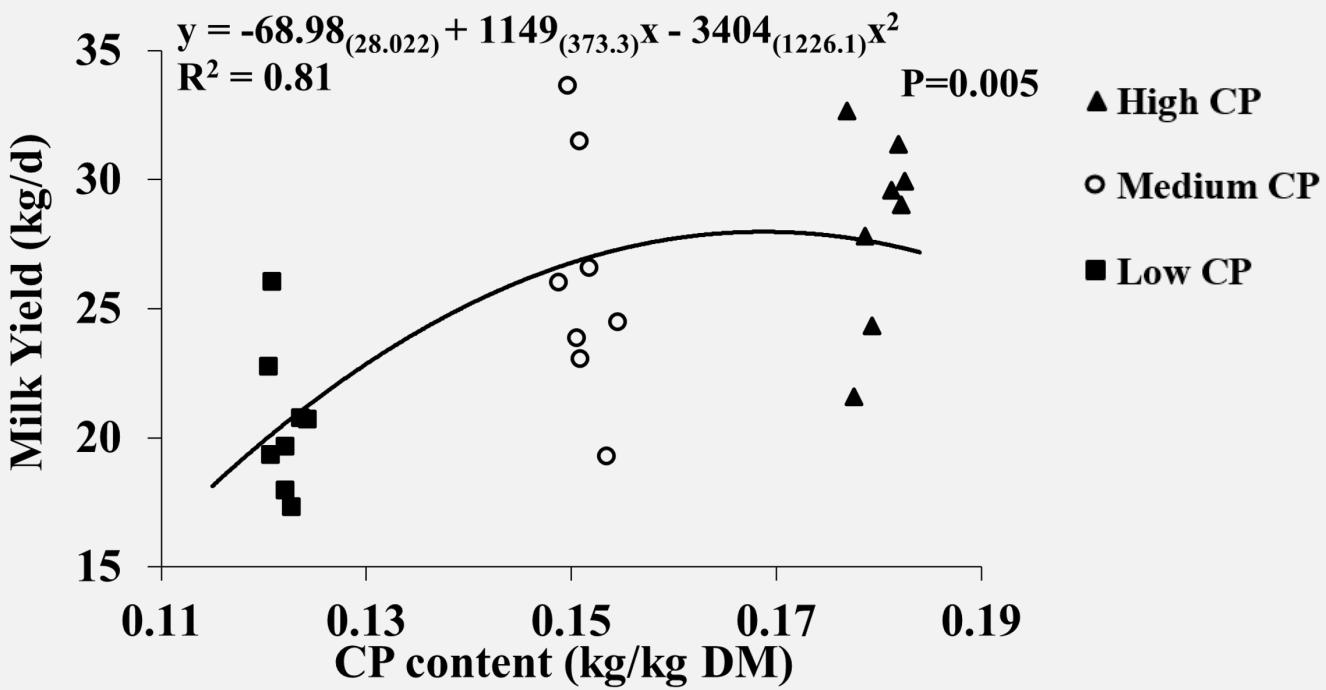

Figure 5: Relationship between dietary CP and milk yield (kg/d)

- Milk yield peaked (28.0 kg/d) at CP concentrations of 0.17 kg/kg DM, after which Milk yield would decrease.

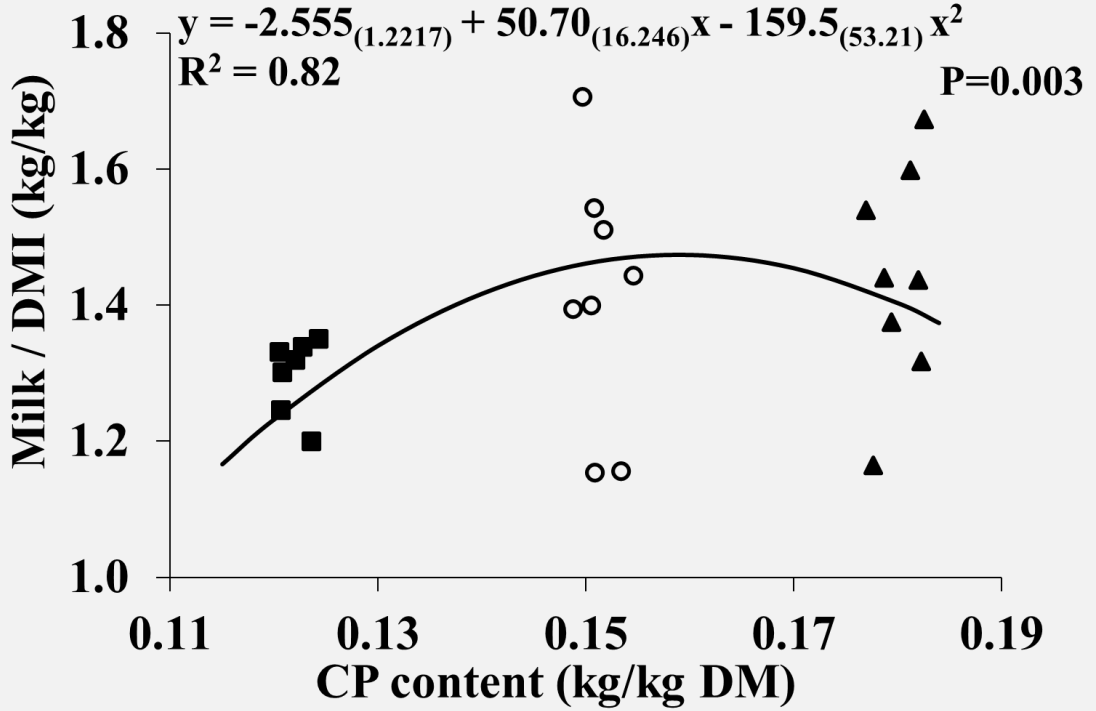

Figure 6: Relationship between dietary CP and milk yield/DMI (kg/kg)

- Milk/DMI peaked (1.47 kg/kg) at CP concentrations of 0.16 kg/kg DM, after which milk/DMI would decrease.

CP = crude protein; DMI = dry matter intake

Results: EUE and methane parameters

Table 1. Means ± SE and P-values for the effect of dietary CP level on energy use efficiency

	LCP	MCP	HCP	SE	P-value
Energy efficiency					
DEI/GEI	0.72^{b}	0.72^{b}	**0.74^{a}**	0.005	0.013
MEI/GEI	0.61^{c}	0.62^{b}	**0.64^{a}**	0.004	<0.001
MEI/DEI	0.85^{b}	**0.86^{a}**	**0.87^{a}**	0.002	0.001
Methane parameters					
CH_4 (g/d)	363	367	391	12.0	0.362
CH_4/DMI (g/kg)	22.2	20.1	20.1	0.66	0.068
CH_4/Digestible DMI (g/kg)	**30.7^{a}**	27.5^{b}	26.9^{b}	0.88	0.018
CH_4/Milk yield (g/kg)	18.3	14.9	14.6	1.00	0.051
CH_4/ECMY (g/kg)	**17.9^{a}**	14.8^{b}	14.5^{b}	0.81	0.011

LCP = low CP (120 g/kg DM); MCP = medium CP (150 g/kg DM); HCP = high CP (180 g/kg DM); DEI = digestible energy intake; GEI = gross energy intake; MEI = metabolizable energy intake; CH_4 = methane, ECMY = energy corrected milk yield.

- Digestibility (DEI/MEI) and metabolizability (MEI/GEI) were higher for HCP compared to LCP and MCP.
- MEI/DEI was similar between MCP and HCP.
- MCP and HCP resulted in less CH_4/DDMI and ECMY.

Results: methane parameters

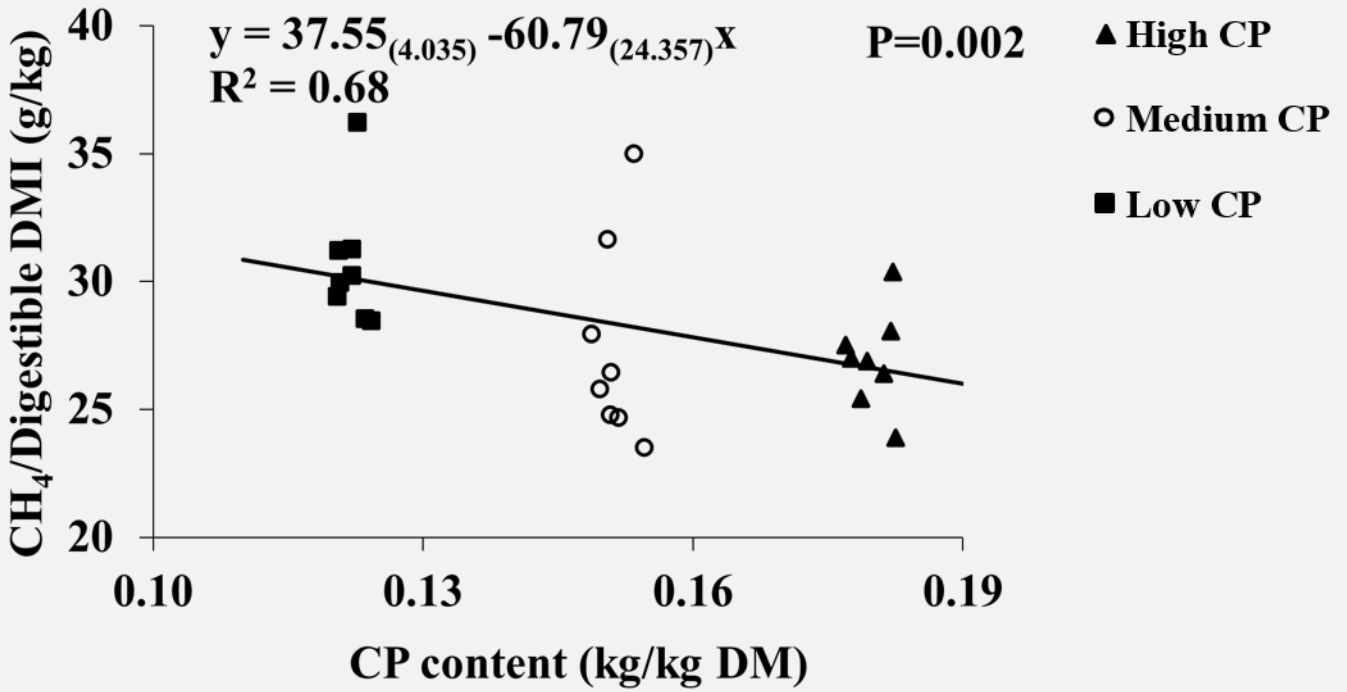

Figure 7: Relationship between dietary CP concentration (kg/kg DM) and CH_4/Digestible DMI(g/kg).

- CH_4 as a proportion of Digestible DMI reduces by 6.1 g/kg, with each incremental increase of CP by 10% of DM.

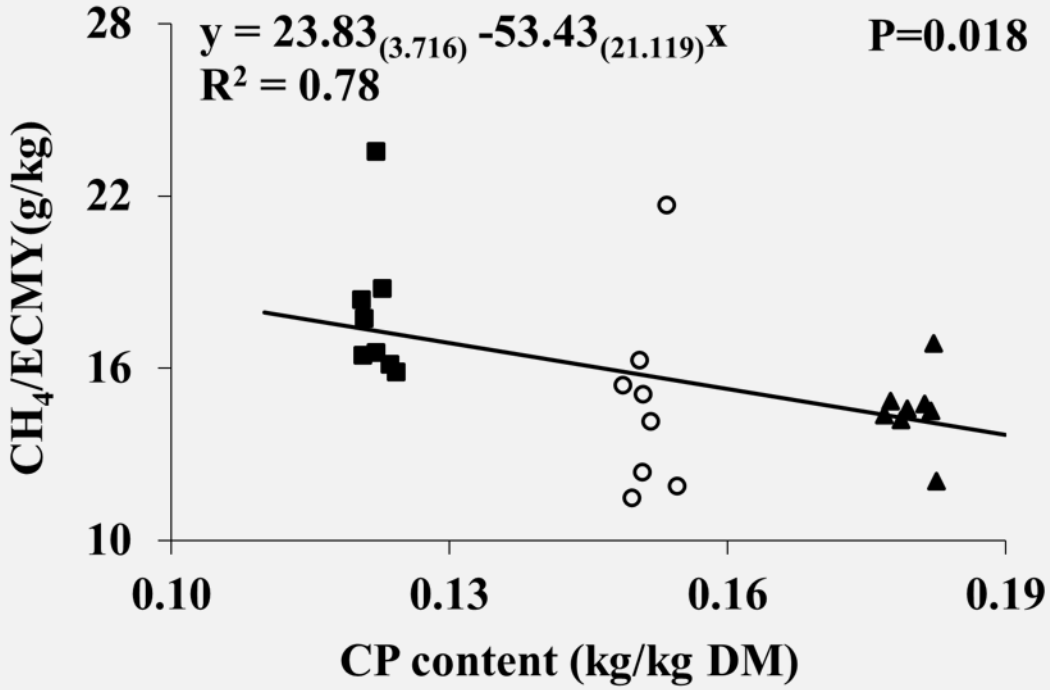

Figure 8: Relationship between dietary CP concentration (kg/kg DM) and CH_4/ECMY (g/kg).

- CH_4 as a proportion of ECMY reduces by 5.3 g/kg, with each incremental increase of CP by 10% of DM.

CP = crude protein; DMI = dry matter intake; ECMY = energy corrected milk yield; CH_4 = methane

Results: CP level × Stage of lactation

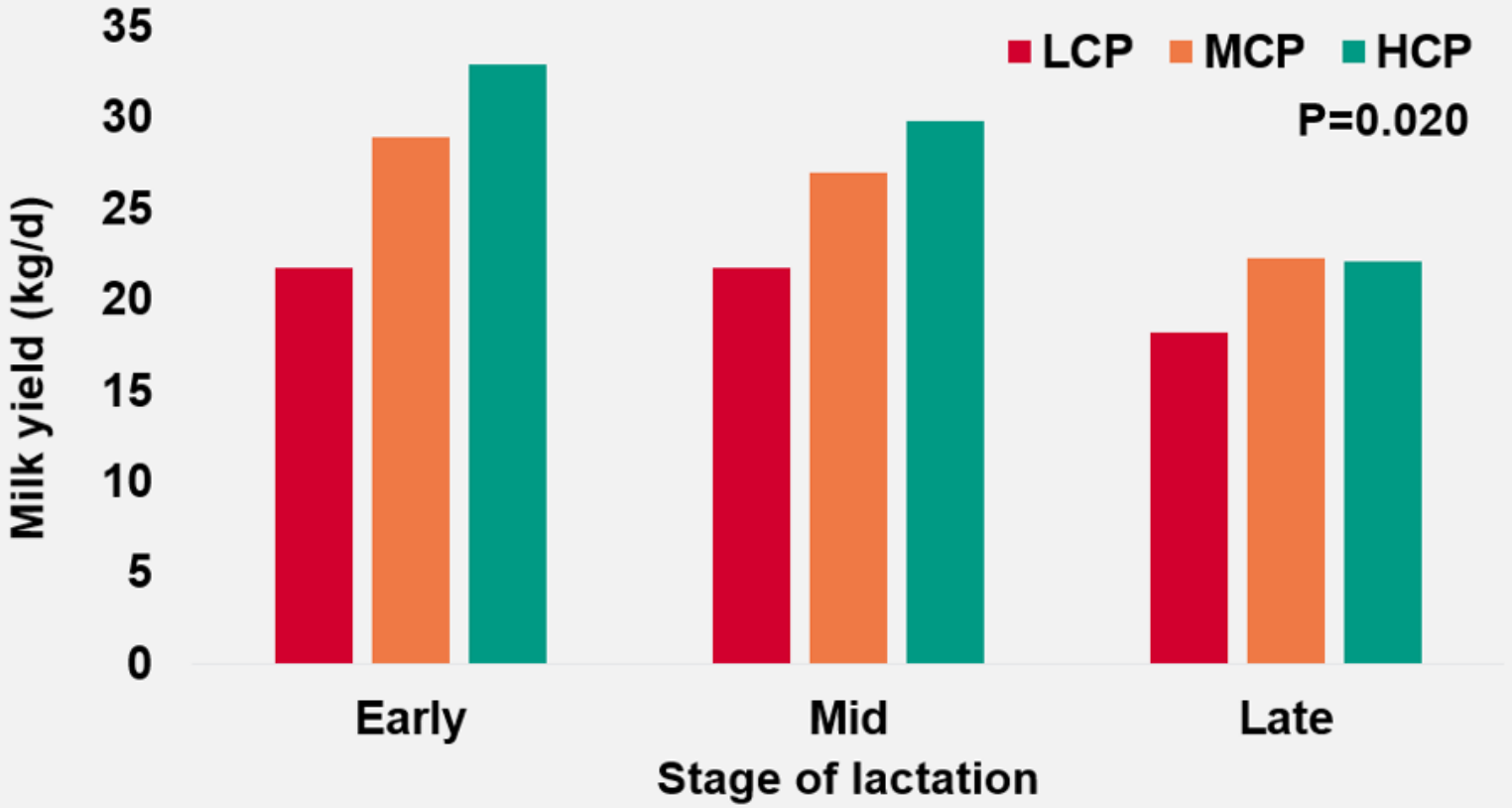

Figure 9: Impact of CP level x stage of lactation interactions on milk yield (kg/d)

- Linear CP x stage of lactation interactions were found for:
  - Intake parameters
  - Milk yield
  - ECMY
- Responses to CP level may be dependent on stage of lactation
- Effect on milk yield and ECMY were smaller between treatment as lactation progressed

CP = crude protein; DMI = dry matter intake; LCP = low CP, 120; MCP = medium CP, 150; HCP = high CP, 180; ECMY = energy corrected milk yield

Conclusion

- Similar results for milk yield, ECMY and efficiency parameters between cows fed 150 g/kg or 180 g/kg CP of DM
- Milk and ECMY could continue to increase between 150 and 180 g/kg
- Interactions between CP level × stage of lactation suggests that productivity responses to CP content could be dependent on stage of lactation
- CP concentrations of 120 g/kg had negative implications
- Dietary CP between 150 and 180 g/kg could provide sufficient protein to maintain production and feeding efficiency while reducing CH_4 as a proportion of intake and yield.
- Optimal CP level for milk yield, was found at a dietary CP concentration of 170 g/kg but these results may also be dependent on stage of lactation

Acknowledgements

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