Methane and carbon dioxide production of lactating Holsteins with different crude protein feeding strategies

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Introduction & Objectives

In ruminants, enteric methane (CH_4) production is largely determined by rumen fermentation capacity and fermentation patterns, whereas carbon dioxide (CO_2) arises predominantly from respiration and to a lesser extent from fermentation.[1] Dietary crude protein (CP) has been shown to affect dry matter intake and productivity and may influence microbial fermentation activity.[2] Whereas most nutrition research considered static dietary composition, diets that vary across time may alter systemic macronutrient metabolism and induce changes to rumen conditions. Although previous research showed that feeding CP in oscillating patterns had minor effects on production, dynamically altered rumen conditions, and increased N retention in body tissues, feeding pattern effects at different CP levels are unknown.[3-5] **Our objective was to quantify emissions of these gases in relation to potentially influential, potentially interacting factors: 1) CP level, and 2) CP feeding pattern.**

Scan for Abstract & References

https://tinyurl.com/tnej47x8

Materials and Methods

Animals

- Eight non-cannulated, multiparous Holstein cows
- Mid- to late-lactation (M = 133, SD = 12 days in milk)
- Median body condition score 3.50 (range 2.25 - 4.00)

Experimental Design

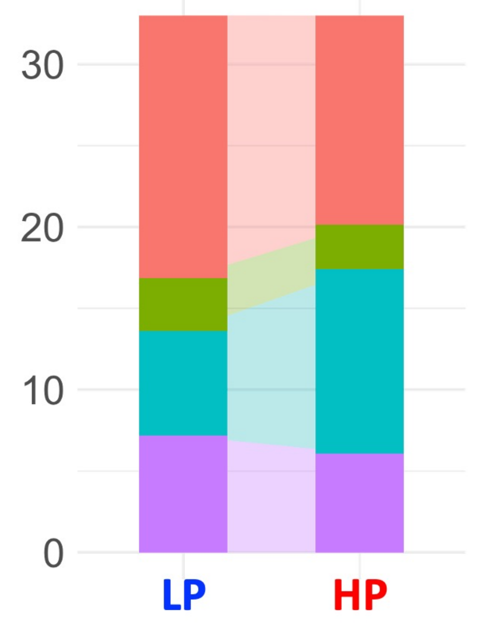
- Latin Square Design with four 28-d periods
- 2x2 factorial arrangement: Level of CP and Feeding Pattern (FP)

■ **S-LP** = Static diet with **Low Protein** level.
▲ **O-LP** = Diets alternated at 48 hr-interval to span ±2.0% CP around LP level.
■ **S-HP** = Static diet with **High Protein** level.
▲ **O-HP** = Diets alternated at 48 hr-interval to span ±2.0% CP around HP level.

Diets & Feeding

- Total mixed ration
- Fed individually
- Fed 1x/d, 0830 h

Nutrient, %DM	LP	HP
CP	13.9	15.5
aNDFom	28	27
Starch	26	25

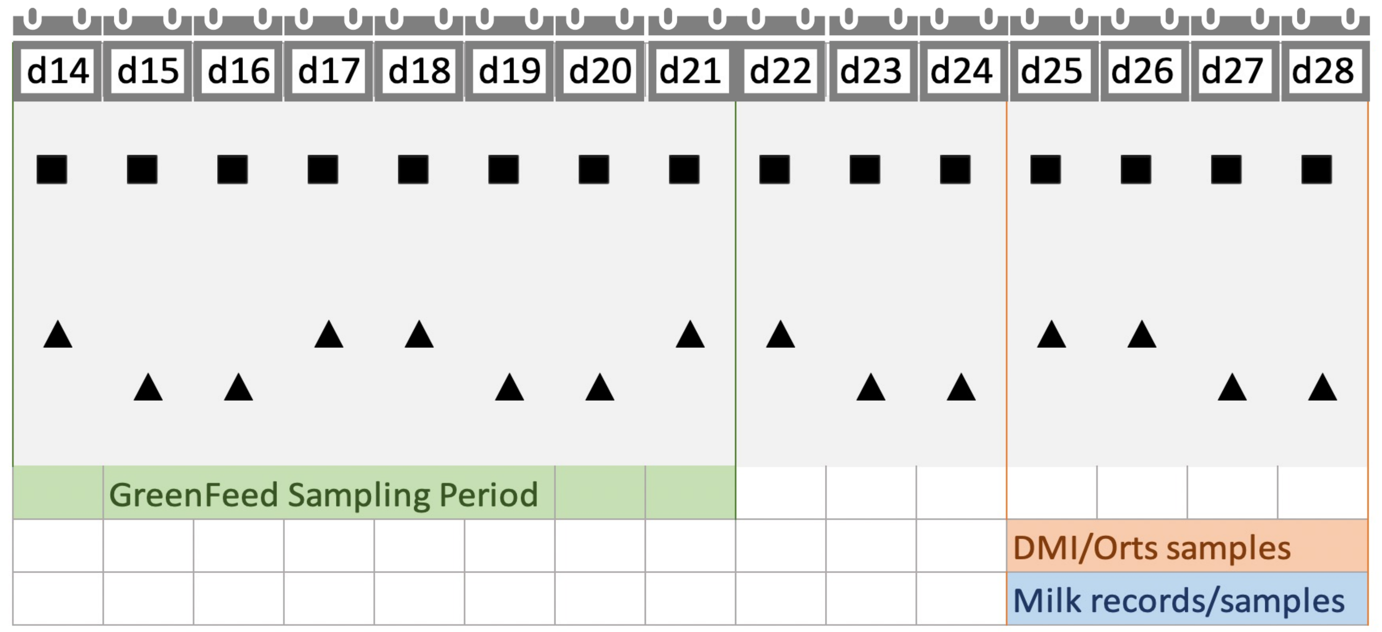


Ingredient, %DM

- Dried Ground Corn
- Expellers Soybean Meal
- Solvent Soybean Meal
- Soybean Hulls

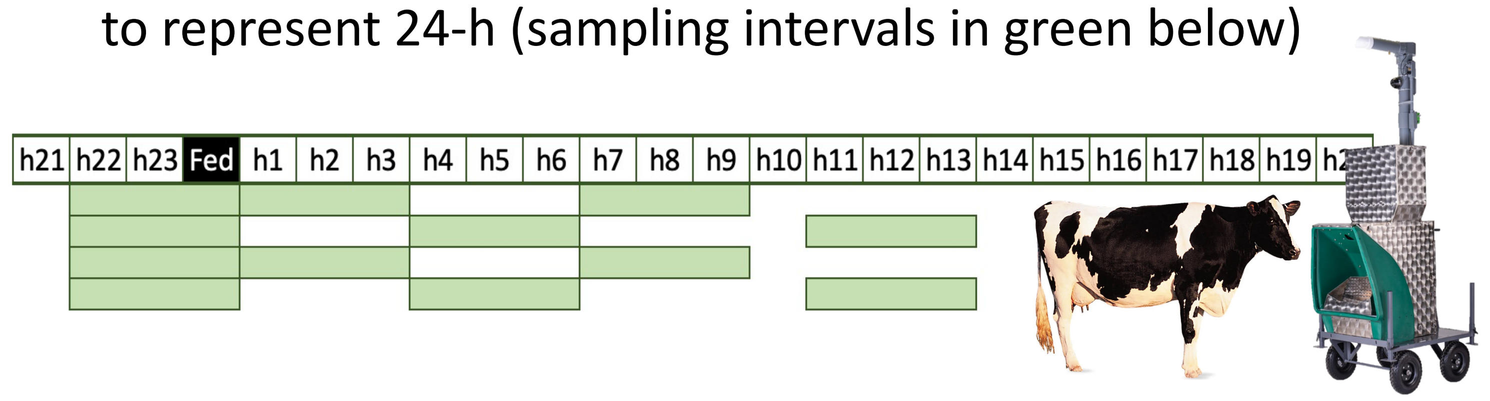
Changed ingredients represented 32.5% of total diet DM. Other ingredients were constant:
47.0% Corn silage
13.0% Alfalfa haylage
2.0% Fat supplement
2.8% Vitamin-mineral premix

Diet and Sampling Schedule



Gas Emission Sampling

- GreenFeed system (C-Lock, Rapid City, SD)
- Training 2 wk. prior to experiment, re-training as needed
- Bait feed: 90% dried ground corn, 10% molasses withheld from TMR on sampling days
- 3x/d sampling for 4-d
- Balanced intervals oversampling pre-feeding to represent 24-h (sampling intervals in green below)



Statistical Analysis

- Model-implied means computed after mixed model in R
- Fixed: period, CP, FP, and interaction; Random: cow

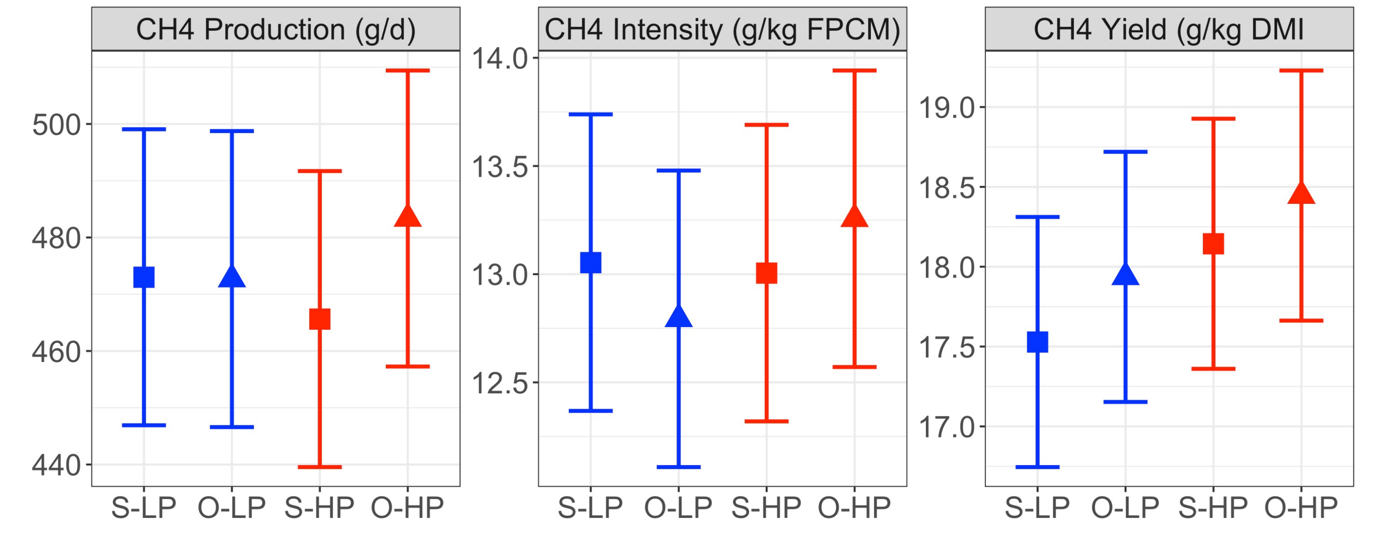
$$y_{ijkl} = \mu + period_j + CP_k + FP_l + (CP_k \times FP_l) + cow_i + \epsilon_{ijkl}$$

$$cow_i \sim N\left(0, \sigma^2_{cow}\right)$$

Results

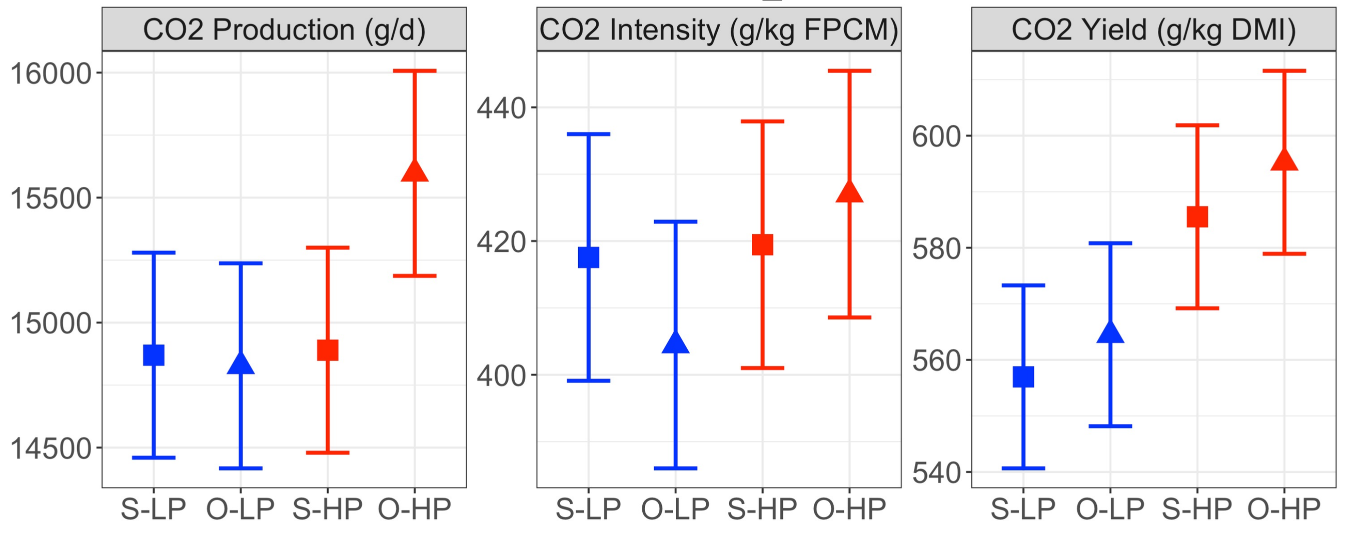
DMI = Dry Matter Intake; **FPCM** = fat-protein-corrected milk

CH_4



	CH4 Production	CH4 Intensity	CH4 Yield
CP	p = .892	p = .612	p = .280
FP	p = .477	p = .943	p = .491
CP*FP	p = .461	p = .500	p = .917

CO_2

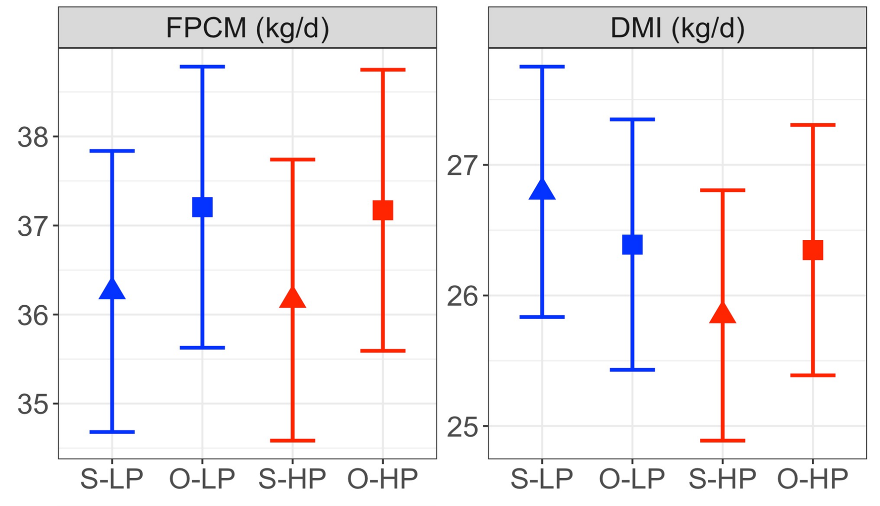


	CO2 Production	CO2 Intensity	CO2 Yield
CP	**p = .070**	p = .226	**p = .022**
FP	p = .123	p = .870	p = .474
CP*FP	**p = .084**	p = .262	p = .927

Production & Other

Null results were observed for:

- **the ratio of CH_4:CO_2 in daily emissions** (0.095 ± 0.004 L/L)
- **oxygen consumption** (10,362 ± 296 g/d)
- **respiratory quotient** (1.05 ± 0.01 L/L)



	FPCM	DMI
CP	p = .907	p = .401
FP	p = .353	p = .935
CP*FP	p = .910	p = .442

Discussion

Results suggested minimal effects of CP, FP, and CP*FP on gas emissions with the exception that HP diets, especially O-HP, appeared to promote greater CO_2 production. It is unclear which mechanisms contributed: Ruminal, e.g., alterations to microbial biomass, species composition, or substrate usage; or whole-animal, e.g., changes to macronutrient metabolism, body composition and maintenance requirements. Future work is needed to test explanations suggested by the literature:

- Greater CO_2 yield without changes to O_2 consumption could occur with lipogenesis or upregulation of the pentose phosphate pathway.[6]
- Tissue protein synthesis could consume oxygen and produce CO_2 without affecting methane production[7]
- CO_2 emissions could be affected by bicarbonate usage in body buffering systems which HP diets may have affected by increasing urea transport into the rumen and into urine[4,8]

Additionally, our research assessed only cow-level emissions. Future work is needed to quantify impacts on emissions at the farmgate scale.

Take-Home Points

- CH_4 production, intensity, and yield were unaffected by CP level or feeding pattern
- CO_2 production tended to increase with greater CP, yet cows consuming high CP in an oscillating pattern produced more CO_2 than any other treatment
- CO_2 yield increased with greater CP
- Tracking fermentative and respiratory emissions may increase in importance with carbon measurement and accounting schemes

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