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Canada

Including dried macroalgae in dairy cow diets decreases emissions, yield and intensity of enteric methane

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The 75th EAAP Annual Meeting

1/5 September 2024 - Florence, Italy

2015: GHG emissions from livestock systems = 6.2 Gt CO_2eq = 12% of anthropogenic GHG emissions (FAO, 2023)

IPCC Special Report on Global Warming of 1.5°C (2018)

- ✓ "Limiting warming to 1.5ºC implies reaching net zero CO_2 emissions globally around 2050 with concurrent deep reductions in emissions…, particularly CH_4"
- ✓ "24 to 27% reduction in global CH_4 needed by 2050 vs. 2010"

IPCC:

- ✓ CH_4 = 16% of global GHG (CO_2e)

Enteric CH_4 = 28%

Dietary mitigation strategies

Seaweed to mitigate enteric CH_4 emissions

- Red macroalgae in dairy cows:
  - *Asparagopsis armata :* - 67% (Roque et al., 2019)
  - *Asparagopsis taxisformis* : - 65% (Stefenoni et al., 2021)

- *Asparagosis sp.*:
  - Not native to Canada
  - Invasive species in the Northern hemisphere (e.g., Canada)
  - Import: increases GHG emissions (processing, packing, shipping, etc.)
  - Not approved in Canada
  - Adverse effects on intake and milk production (≥ 1% of DMI)

- Alternative: Cultivation of other seaweed species under optimal controlled environmental conditions, affecting:
  - Nutritive value (e.g., proteins, lipids, etc.) of the seaweed
  - Secondary metabolite content: Halogenated compounds, e.g., bromoform ($CHBr_3$).

Objectives

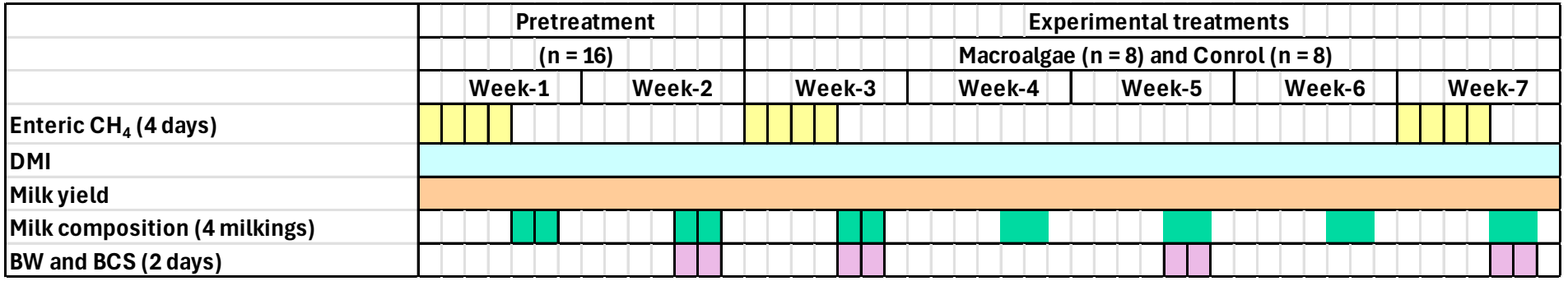
- Assess the effects of cultivated and dried mixture of red/brown macroalgae on:
  - ✓ Enteric CH_4 : Emission, yield, and intensity
  - ✓ Dry matter intake (DMI)
  - ✓ Milk performance (production and composition)
  - ✓ Feed efficiency

- Macroalgae (Synergraze Inc., Calgary, Alberta, Canada):
  - ✓ Cultivated under controlled environmental conditions
  - ✓ *Gracilaria* sp. (red algae) + *Laminaria* sp. (brown algae)
  - ✓ Bromoform : 4.65 ± 0.225 mg/g DM

Materials & Methods

- 16 multiparous lactating Holstein cows (DIM = 130 ± 30)
- Randomized complete block design
- Basal diet: Total mixed Ration (TMR)
  - 63% forages + 37% concentrate (DM basis)
  - Ad libitum
  - Twice daily (9h30, 21h30)
- Treatments:
  - **Control**: no macroalgae
  - **Macroalgae**:
    - 0.25% of dry matter intake (DMI)
    - Mixed with 50 g of protein supplement and 500 g of TMR
    - Fed twice daily: before delivering the basal diet (i.e., TMR)

Materials & Methods



- **Covariate period** (i.e., pretreatment): **2 weeks**
  - 16 cows
  - Blocks: DIM, milk yield, and parity
  - Diet: **Basal diet (no macroalgae)**

- **Treatment period**: **5 weeks**
  - 16 cows (2 cows/block).
  - Blocks : milk yield and CH_4 emission (g/d)
  - **1) Control**; **2) Macroalgae (0.25% DMI)**

- **Statistical analysis:**
  - SAS MIXED Procedure
  - Model: Repeated measures, adjusted for covariate with treatment, block, week, and treatment × week interaction = fixed effects.
  - Significance: $P \leq 0.05$

View of the respiration chambers

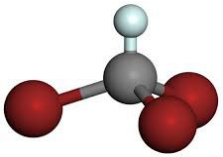

Results

Bromoform ($CHBr_3$) concentration

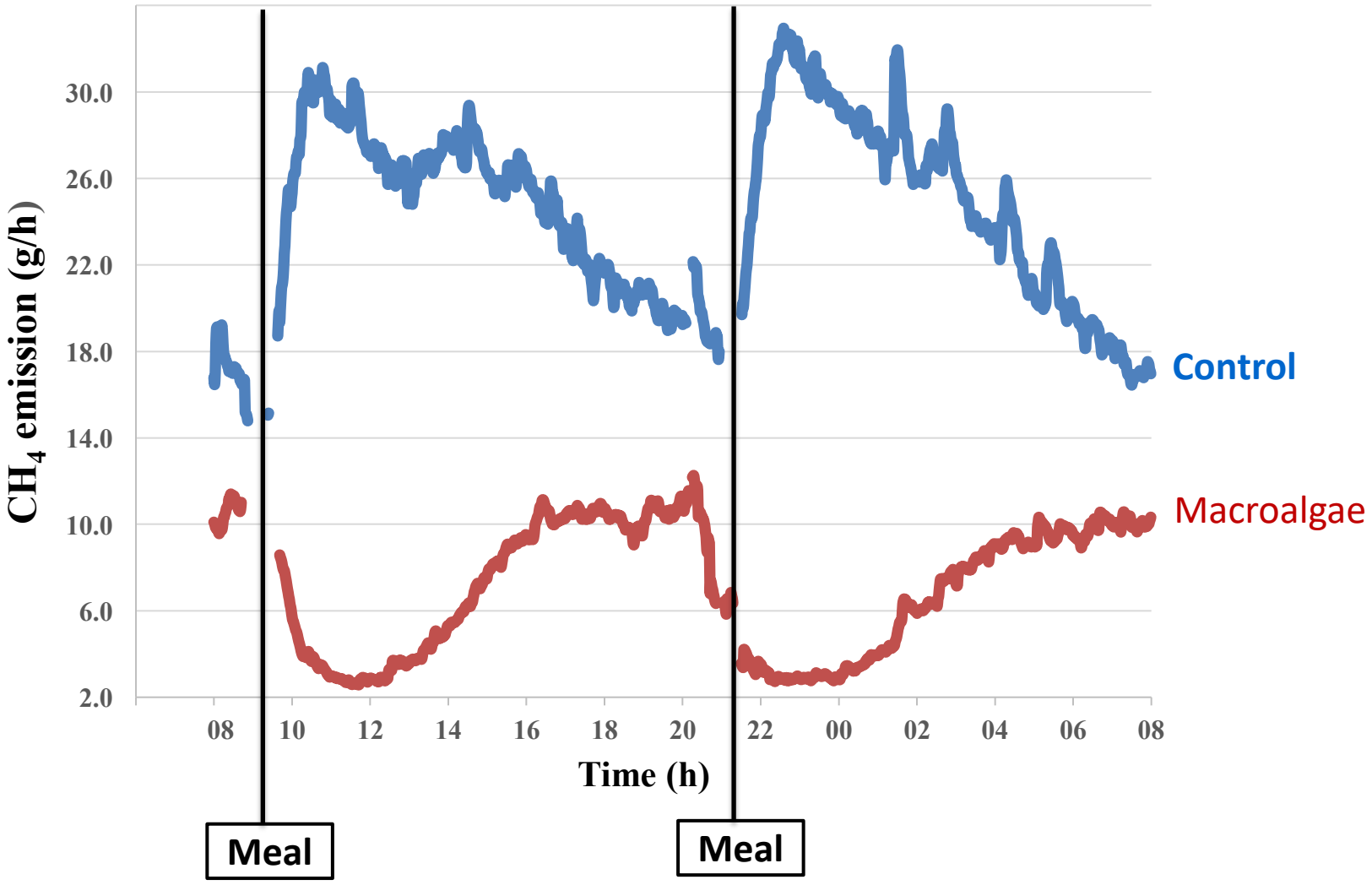
Bromoform concentration in macroalgae (4.65 ± 0.225 mg/g DM)

Sample ID	$CHBr_3$ (mg/g DM)
May 16	3.64
May 23	4.90
May 30	4.33
June 6	4.70
June 13	4.34
June 20	4.56
June 27	4.50
July 4	4.59
July 11	4.90
July 18	4.67

$CHBr_3$



Daily enteric CH_4 emission variation (g/h)



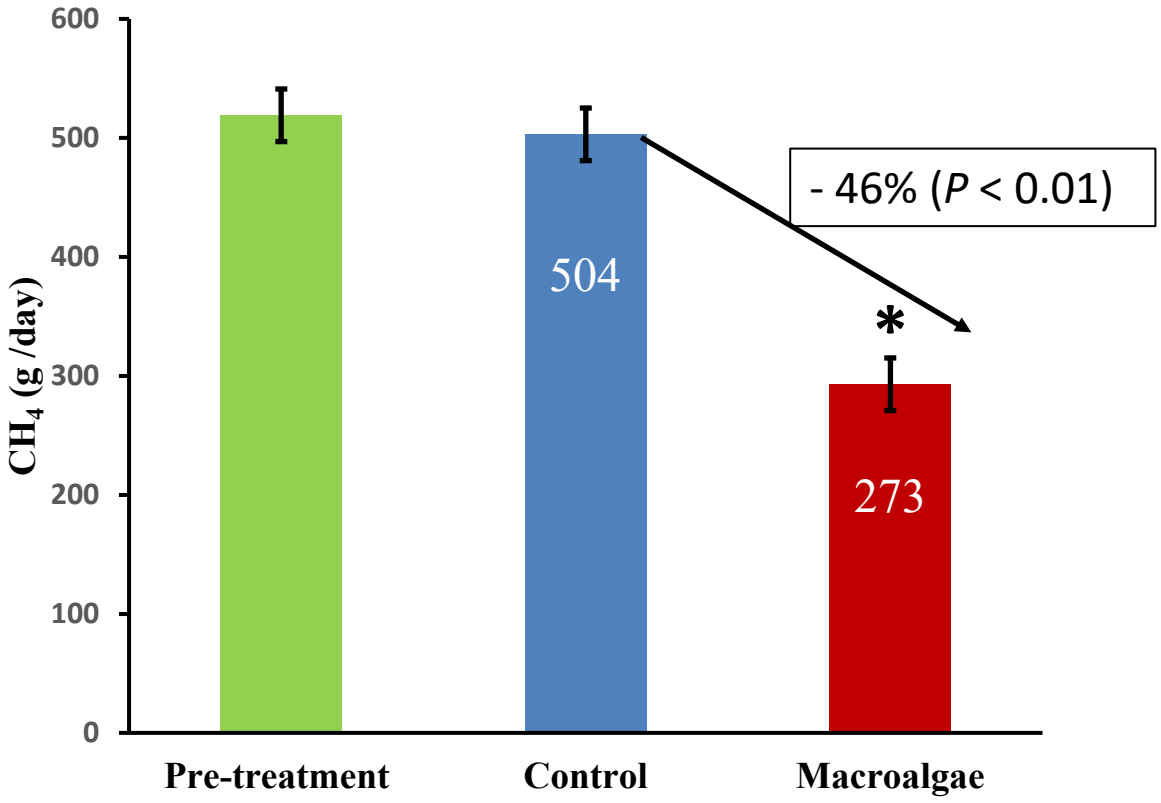
Milk and feed efficiency

Item	Diets		SEM	*P*-value
	Control	Macroalgae		
DMI (kg/d)	26.8	25.1	0.84	0.17
Production (kg/d)				
Milk	39.2	39.4	1.84	0.93
ECM	41.2	41.3	2.24	0.98
Fat	1.49	1.47	0.098	0.89
Protein	1.28	1.32	0.064	0.66
Composition (%)				
Fat	3.81	3.77	0.155	0.83
Protein	3.31	3.4	0.081	0.48
Feed efficiency				
kg milk/kg DMI	1.46	1.58	0.06	0.18
kg ECM/kg DMI	1.54	1.65	0.065	0.25

ECM : energy-corrected milk

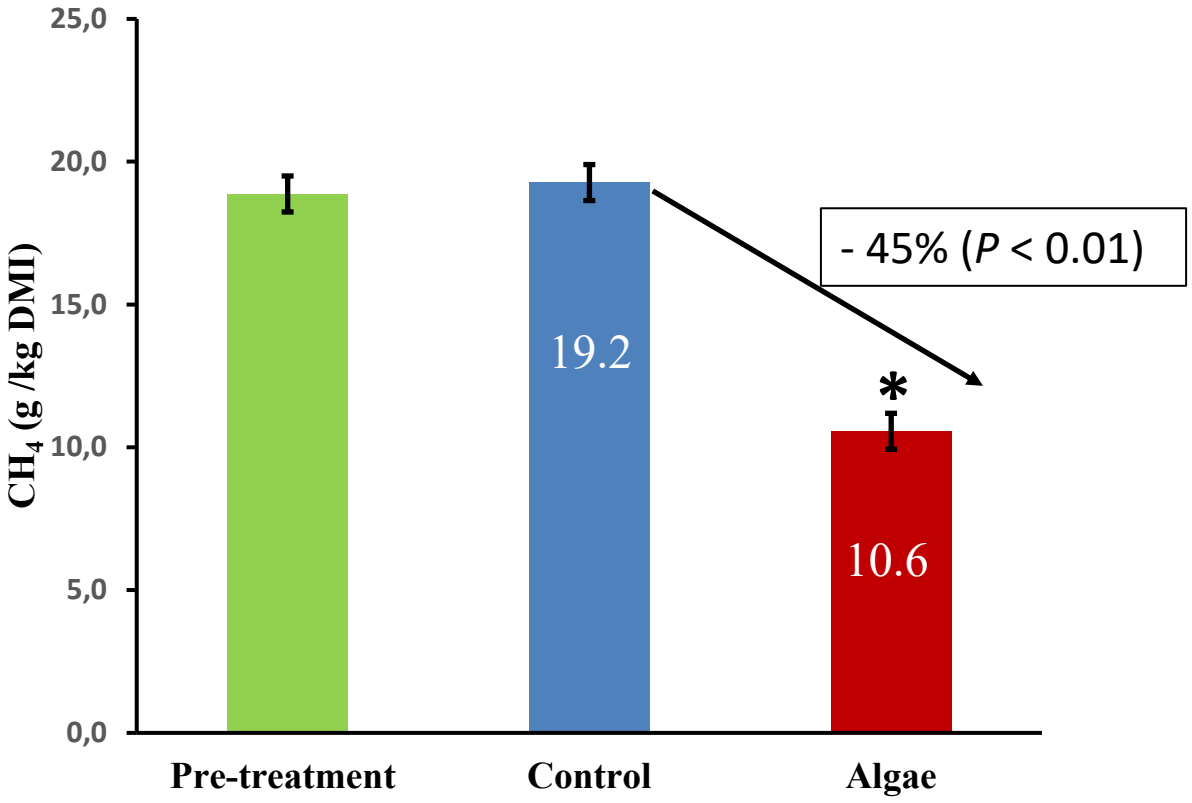
No significant treatment × week interaction

Enteric CH_4 emissions (g/day)



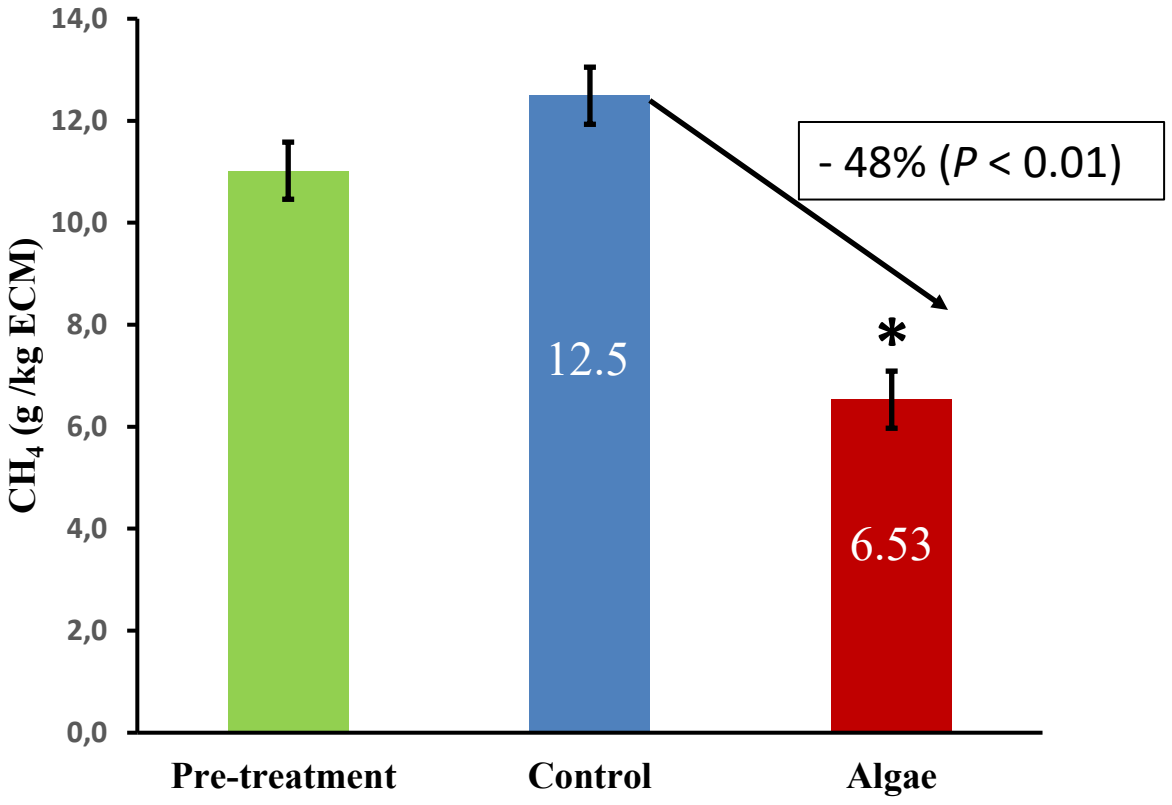
No significant treatment × week interaction

Enteric CH_4 yield (g/kg DMI)



No significant treatment × week interaction

Enteric CH_4 intensity (g/kg ECM)



No significant treatment × week interaction

Conclusions

- Mixture of cultivated and dried macroalgae
  - ✓ *Gracilaria* sp.: red algae
  - ✓ *Laminaria* sp.: brown algae
  - ✓ 0.25% of DMI
  - ✓ High-forage diet (63%, DM basis)
    - No adverse effects on DMI, milk performance and feed efficiency
    - Decreases enteric CH_4 :
      - Emissions (g/d) : 46%
      - Yield (g/kg DMI): 45%
      - Intensity (g/kg ECM): 48%

Conclusions

Future research:

- ✓ Long-term studies (possible adaptation of rumen microbes to bromoform exposure?)
- ✓ Feeding rate effect on milk residues (e.g., iodine, bromide, bromoform)
- ✓ Diet effect
- ✓ Diet composition × macroalgae interaction

Current research

- ✓ *Gracilaria* sp. + *Laminaria* sp.
- ✓ Diet effect
- ✓ Measurements:
  - DM and nutrient intake and digestibility
  - In situ ruminal degradation
  - Nitrogen utilization
  - Ruminal fermentation characteristics (pH, VFA, NH_3, protozoa)
  - Milk performance: Production, components, feed efficiency
  - Milk residues: Bromoform, iodine, and bromide
  - Methane emissions: Enteric fermentation and stored manure
  - Microbiome (metagenomic): Rumen and manure
  - Life Cycle Assessment.

Acknowledgments

Research Team:

- Collaborator: F. Hassanat, Ph.D.
- Research Assistant: L. Croteau
- Technicians: V. Roy, C. Bourdeau, A. Martineau and C. Nadeau
- Respiration chamber maintenance: J. Dubreuil
- Help with statistics: S. Méthot
- Barn staff (i.e., care of the animals)
- Financial support (Project # J-003078)
  - ✓ Agriculture and Agri-Food Canada (Ottawa, Ontario)
  - ✓ Synergraze Inc. (Calgary, Alberta, Canada)

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Questions?