The effect of feeding a calcium peroxide feed additive to mitigate enteric methane emissions in lambs

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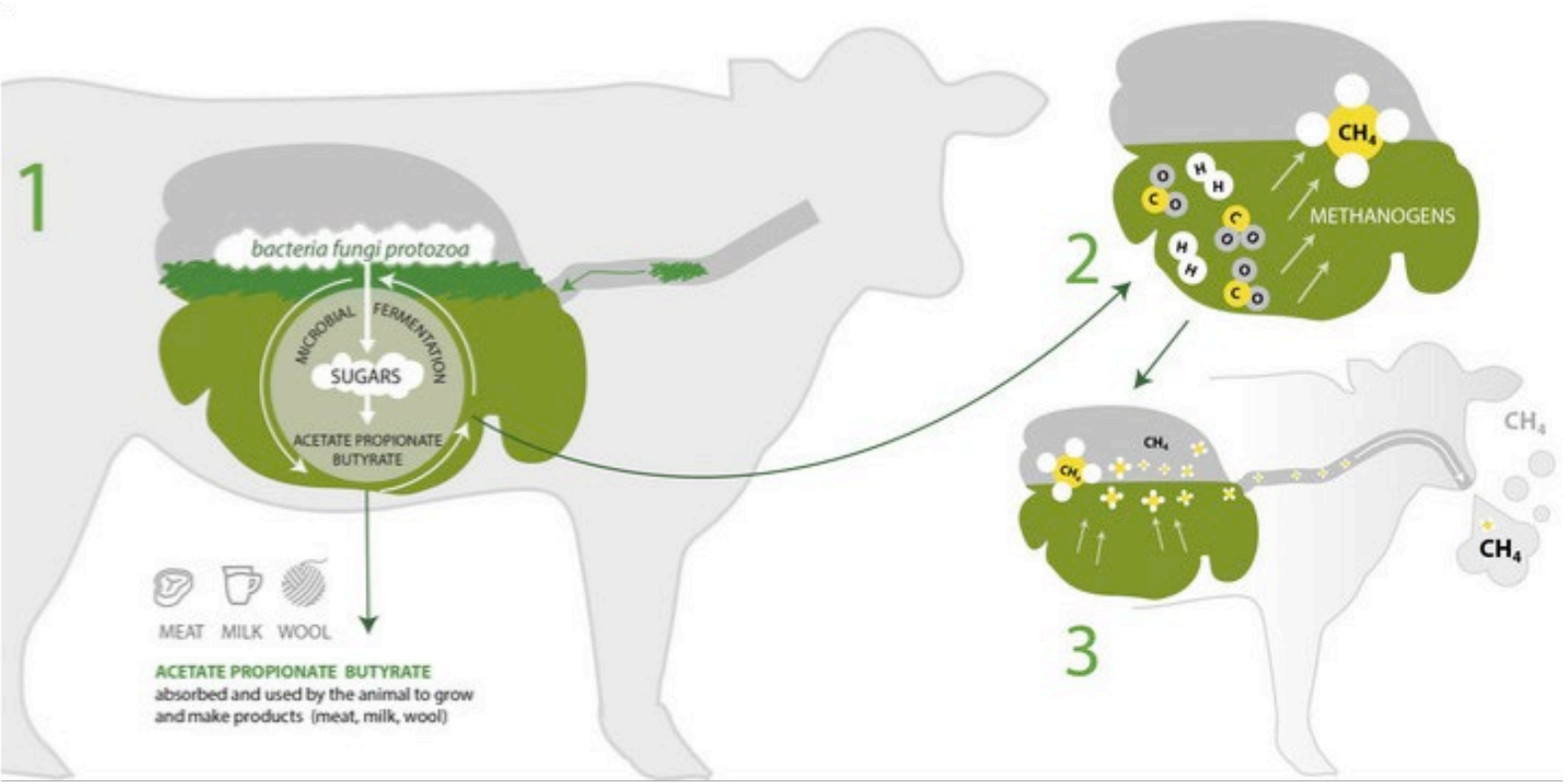
Introduction – Methane

- Methane production by livestock
  - Anthropogenic GHG emissions
  - Energy loss to the animal

https://edu.rsc.org/soundbite/can-seaweed-eating-sheep-curb-methane-emissions/4011074.article

The rumen and enteric methane



Source: FAO

- Microbial ecosystem consisting of bacteria, archaea, protozoa, fungi and phages.
- During feed digestion, microbial fermentation occurs within the rumen of the animal
- Most plant matter is broken down into volatile fatty acids and protein is degraded into amino acids and then ammonia, which are used as a source of energy and N for rumen microbial growth
- Their production however releases hydrogen ions, which are utilized by methanogenic archaea to produce methane as a by-product

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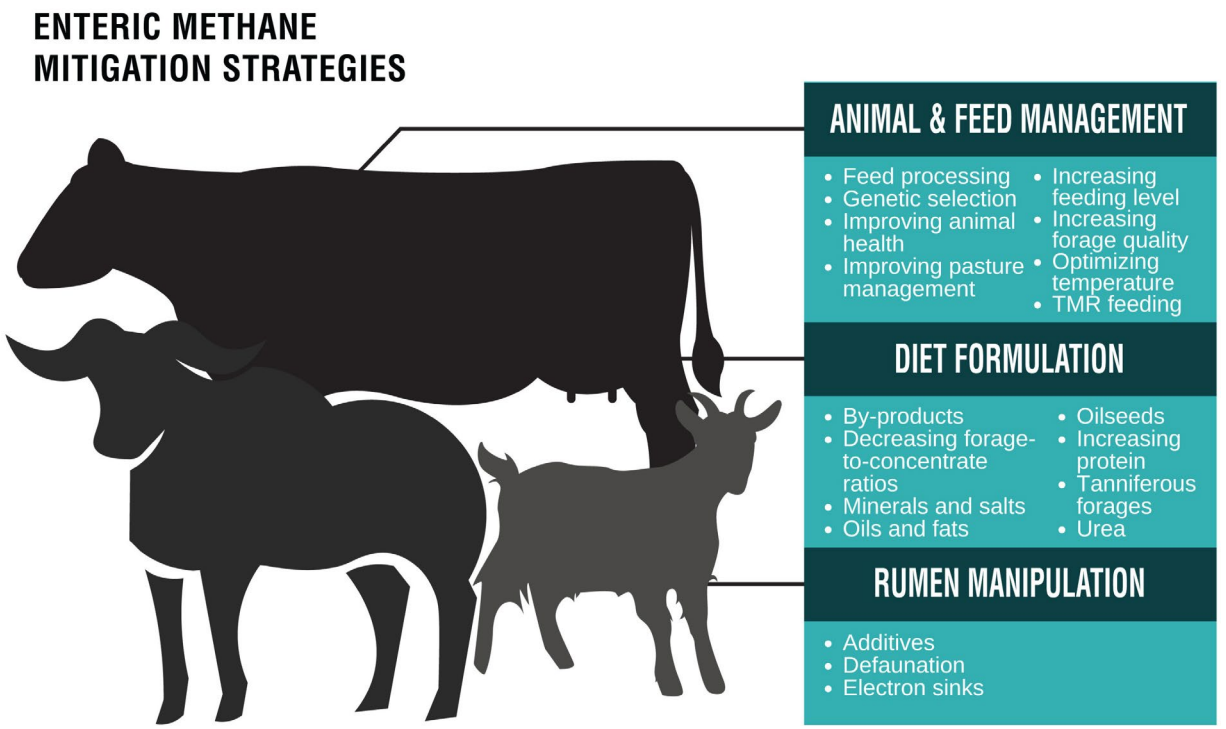
Introduction – Methane abatement

Over the last decade, a variety of dietary manipulation approaches have been proposed to reduce enteric methane emissions in ruminants

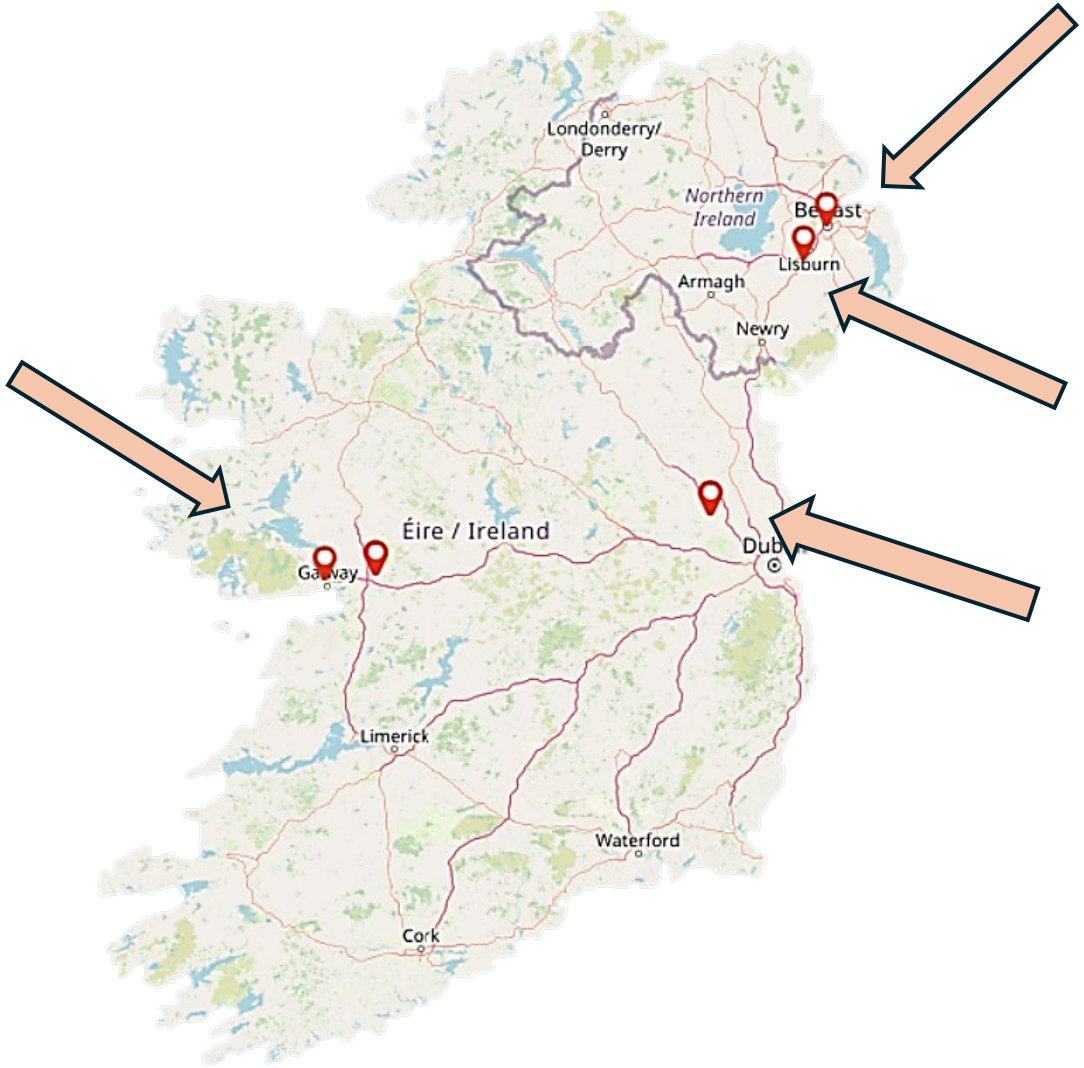
- However, most approaches have a limited success:
  - Requirement of continuous feeding and, therefore, costs.
  - Negative effects on animal production.



Arndt et al., 2022
https://doi.org/10.1073/pnas.2111294119

Calcium peroxide as a methane mitigating additive

Formulation tested in-vitro at Queen's University Belfast



Inhibitors screened by Prof. Vincent O'Flaherty's research group (O'Donnell et al. 2024)

Calcium peroxide (CaO_2) significantly reduced CH_4 by 63% *in vitro* with no effects on digestibility (Graham et al., 2023, in prep)

CaO_2 selected as the optimal product to take forward to *in vivo* trials

Additive tested in two separate sheep trials at AFBI, Hillsborough

Additive tested in two beef trials in Teagasc, Grange

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Oxidising Methane Inhibitors

What are they?

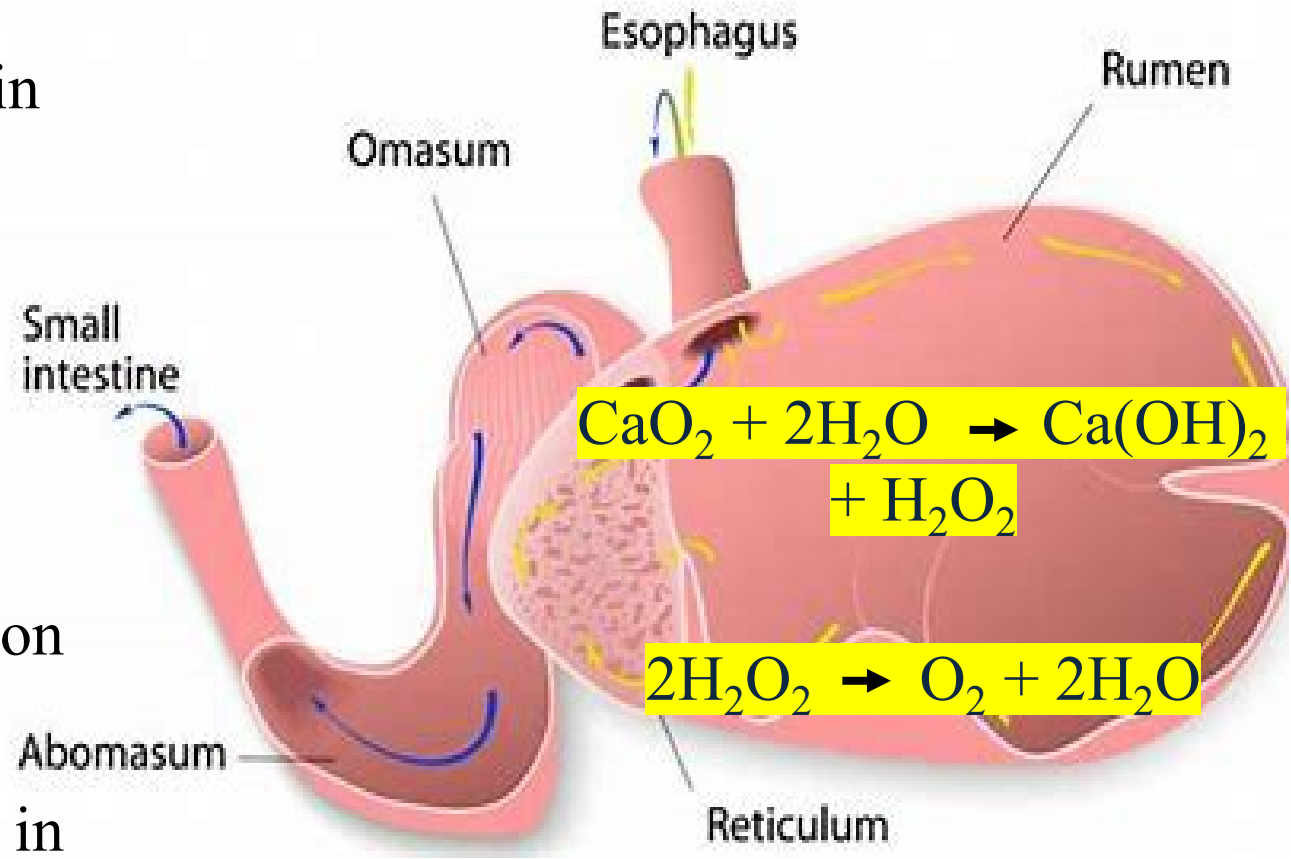
- **Peroxide based compounds** routinely used in human food
  - Calcium peroxide (CaO2)

Mechanism of action?

- 1. Inhibit methanogens

↑ ORP to favorably alter rumen fermentation pathways and suppress methanogenesis

- 2. Divert electrons from H_2 → trap energy in biomass



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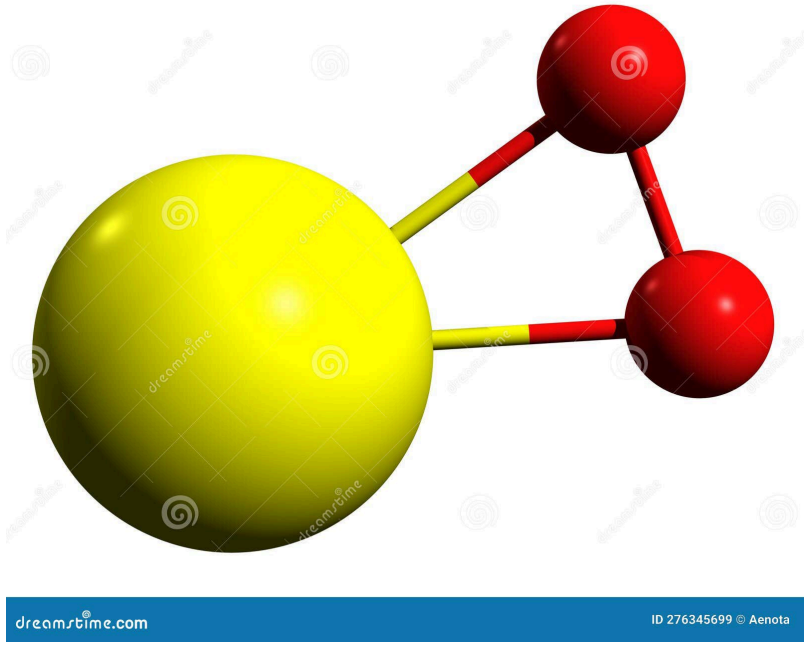
Aims

- (1) the residual effect (early life intervention), by feeding CaO_2 to late pregnancy ewe (with twin) and lamb rearing period, on performance and CH_4 emissions of their lambs
- (2) the direct effect of feeding lamb CaO_2 on performance and CH_4 emissions during the growing period



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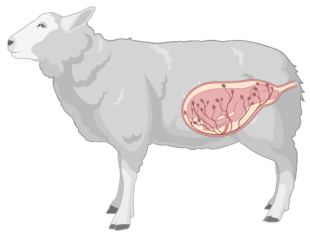
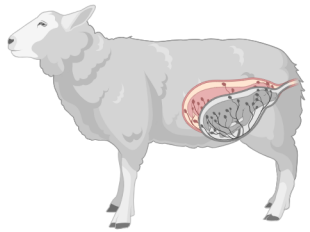
1. Artificial insemination of~100 ewes
2. Selection of ewes expecting twins
3. Ewes fed treatments
4. Twin lambs weaned





Control Treatment

Precursor trial used Control, low and high inclusions of the additive tested in 3 groups of 20 ewes.

5. 4 treatment groups
6. 10 weeks greenfeed measurements
7. Sample collection until slaughter

CC
CT
TC
TT

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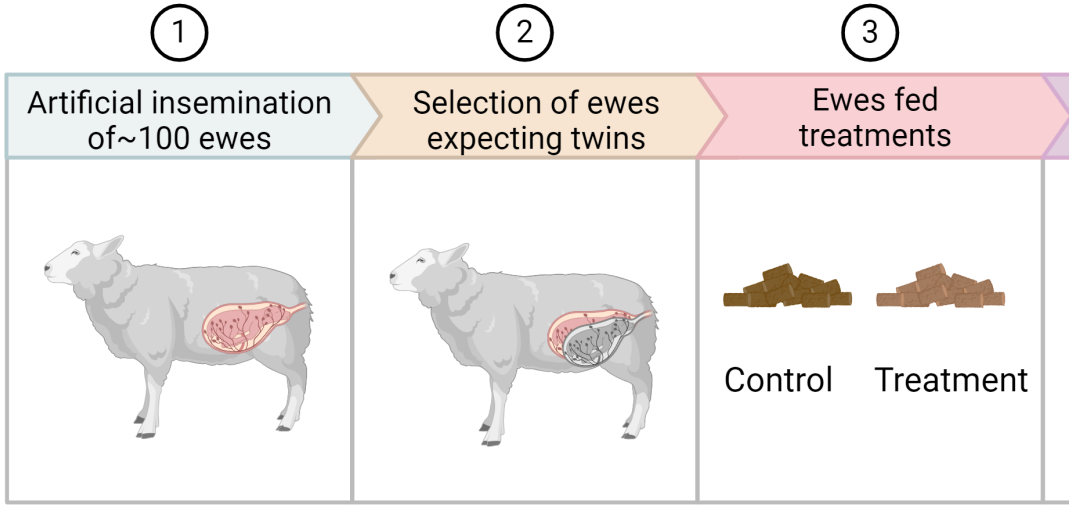
This was a 2 (ewe: control vs additive – early life intervention) * 2 (lamb: control vs additive) factorial design study

Early life intervention

- 12 late pregnant ewes (6 Suffolk and 6 Texel) with twin were divided into 2 groups (control and additive) and fed experimental diets from ~3 weeks before lambing to weaning at 10 weeks after lambing
- All ewes offered grass silage ad libitum, and 700 – 850 g DM/d of concentrate pellets before lambing, and 850 – 400 g DM/d after lambing until weaning at ~12 weeks.
- Control group fed $CaCO_3$ (limestone) and Additive group offered CaO_2 (mixed with pellets) at a rate 2.2% (DM basis) of total diet



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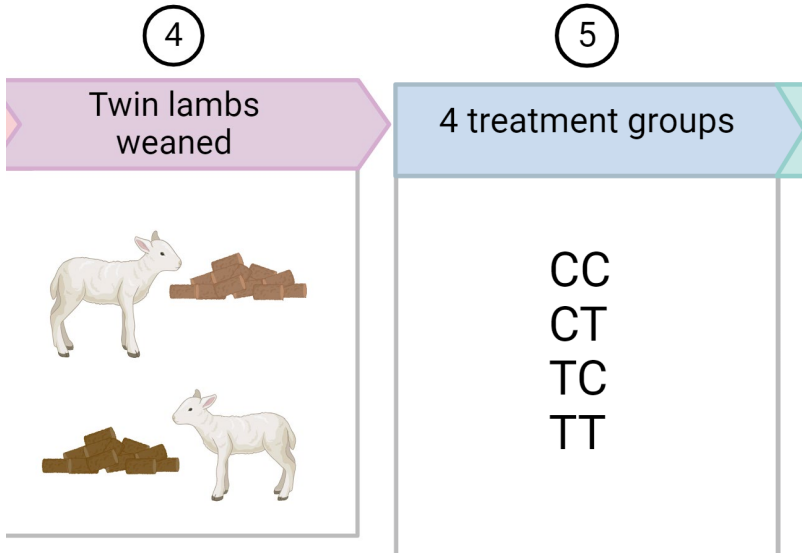
Lamb treatment

- After weaning at ~12 weeks, the twin lambs from each Control ewe and Treatment ewe were separated as follows:
  - Control diet - grass silage ad libitum and $CaCO_3$ concentrate pellets
  - Treatment diet - grass silage ad libitum and concentrate pellets with CaO_2 included at a rate of 2.2% of total diet
- The feeding period lasted for 10 weeks



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Measurements

- Live weight – recorded weekly in the morning before feeding
- Feed intake – recorded daily using automatic feed recording feeder (BioControl)
- Methane emissions – measured using GreenFeed

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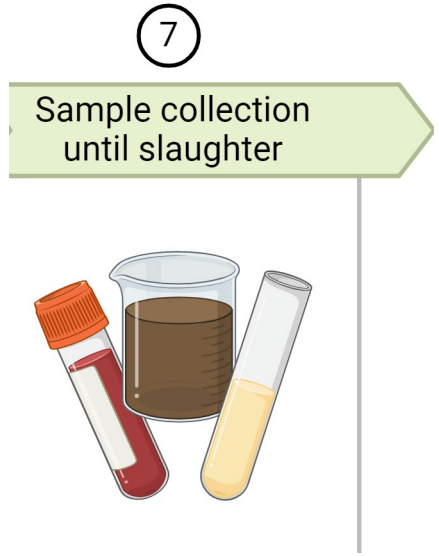
Samples

- Grass silage:
  - Daily sampled for oven DM measurement
  - Weekly bulked for:
    - Dry – wet chemistry measurements.
    - Fresh – measurements of fermentation variables, N and GE.

- Concentrates – weekly sampled for wet chemistry measurements

- Rumen and blood samples:
  - Weaning
  - Week 5
  - Week 10



Results

	Ewe Control		Ewe additive			P value		
Parameter	Lamb control	Lamb additive	Lamb control	Lamb additive	s.e.d.	Ewe treatment	Lamb treatment	Ewe*Lamb
Weaning LW (kg)	29.81	28.68	29.06	29.25	1.665	0.9	0.387	0.347
Slaughter LW (kg)	45.34	47.98	48.79	50.57	2.24	0.442	0.005*	0.226
Mean LW (kg)	39.35	41.96	43.31	44.79	1.877	0.236	0.006*	0.175
Mean DMI (g/day)	1668	1613	1653	1720	138.3	0.931	0.262	0.384
Methane production (g/day)	38.44	34.78	37.65	37.84	2.107	0.621	0.701	0.5
Methane Yield (g/kd DMI)	23.13	21.64	23.08	22.39	1.4	0.771	0.216	0.978
Methane Intensity (CH4/mean LW)	0.992	0.85	0.874	0.857	0.071	0.224	0.074	0.225
Methane Intensity (CH4/ADG)	152.8	142.5	163.6	162.7	19.89	0.6	0.282	0.611

Note: LW = Live Weight, DMI = Dry Matter Intake, ADG = Average Daily Gain. P-values marked with * indicate statistical significance ($p < 0.05$).

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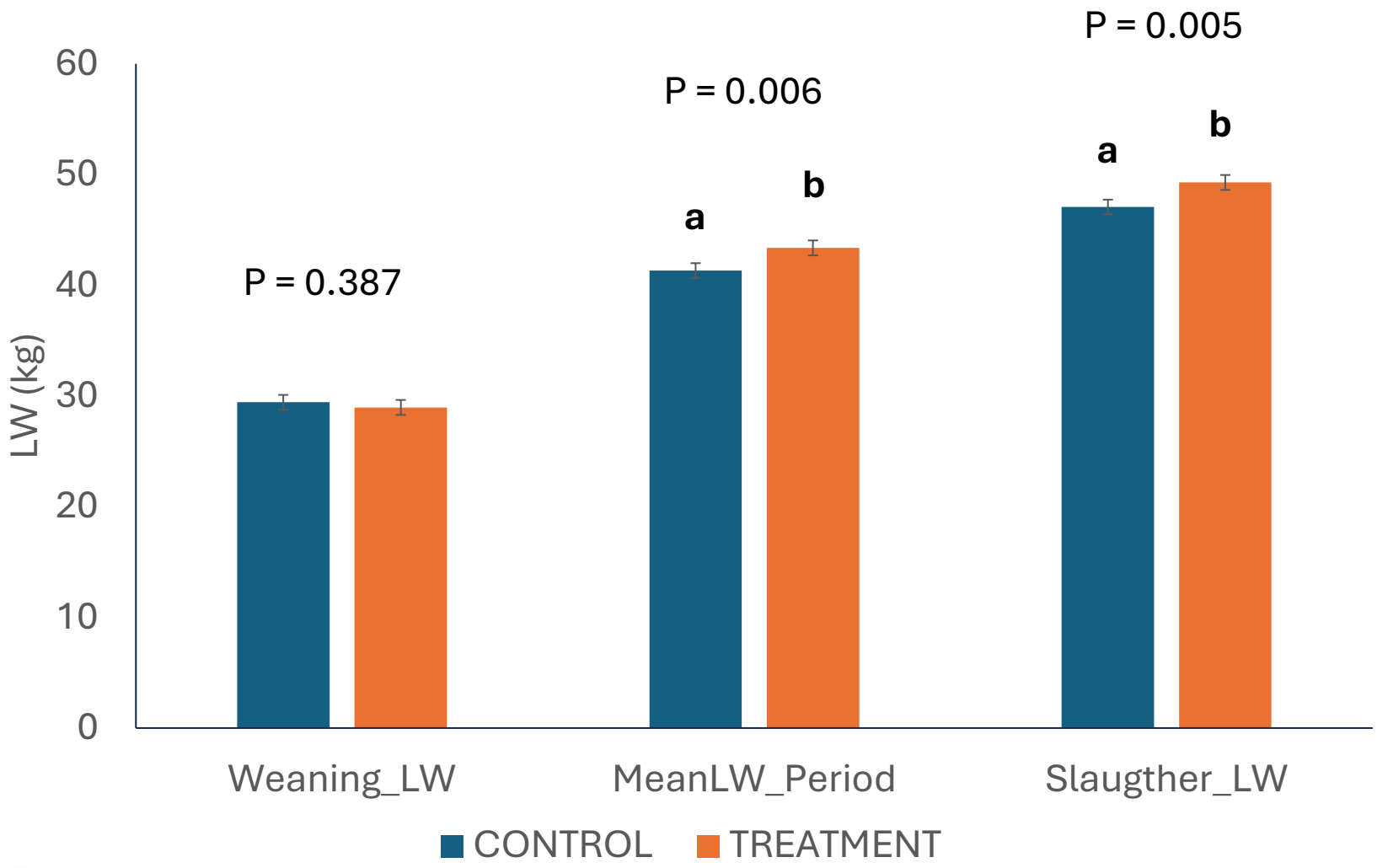
Results – Live weight



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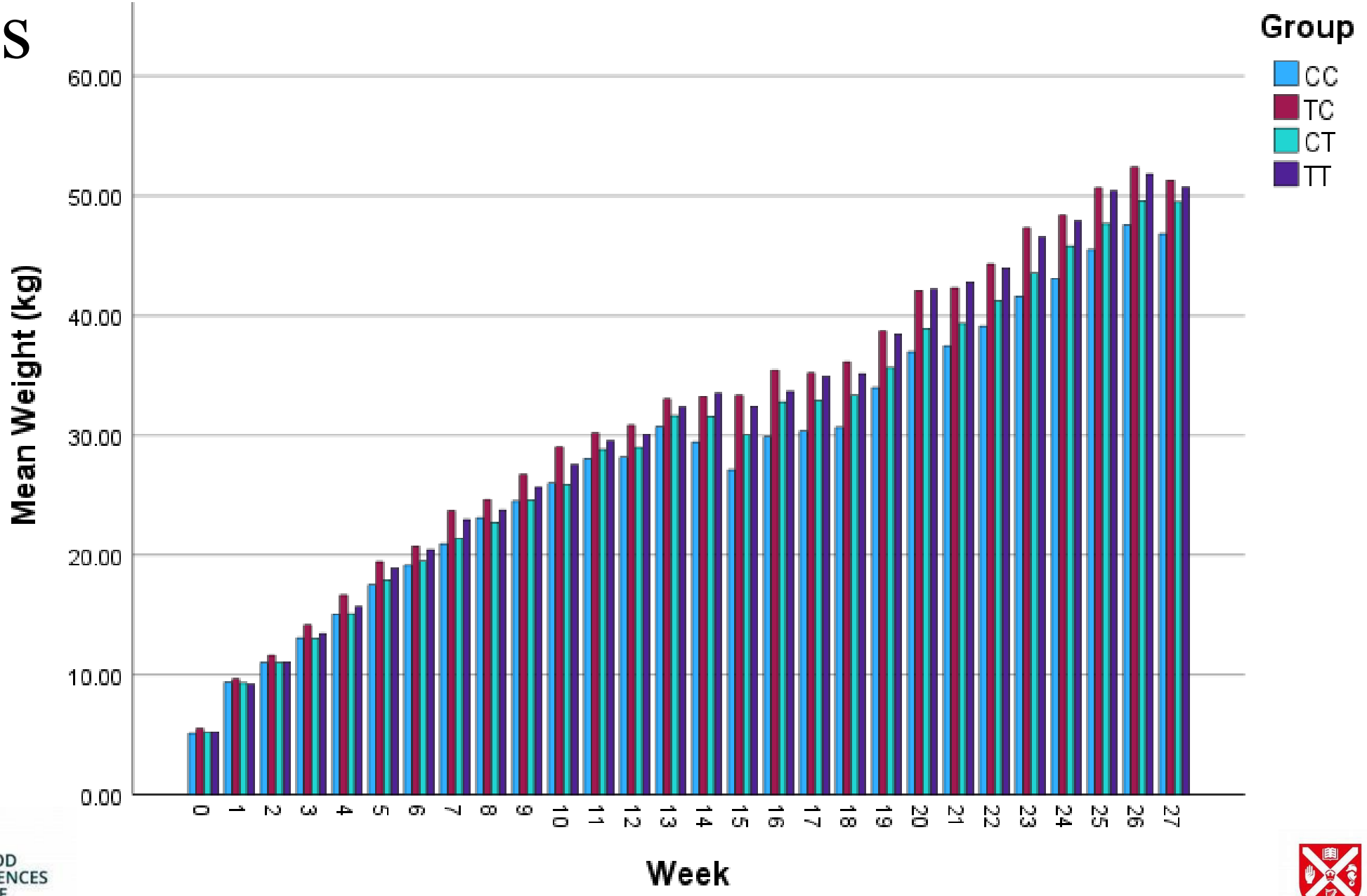
Results



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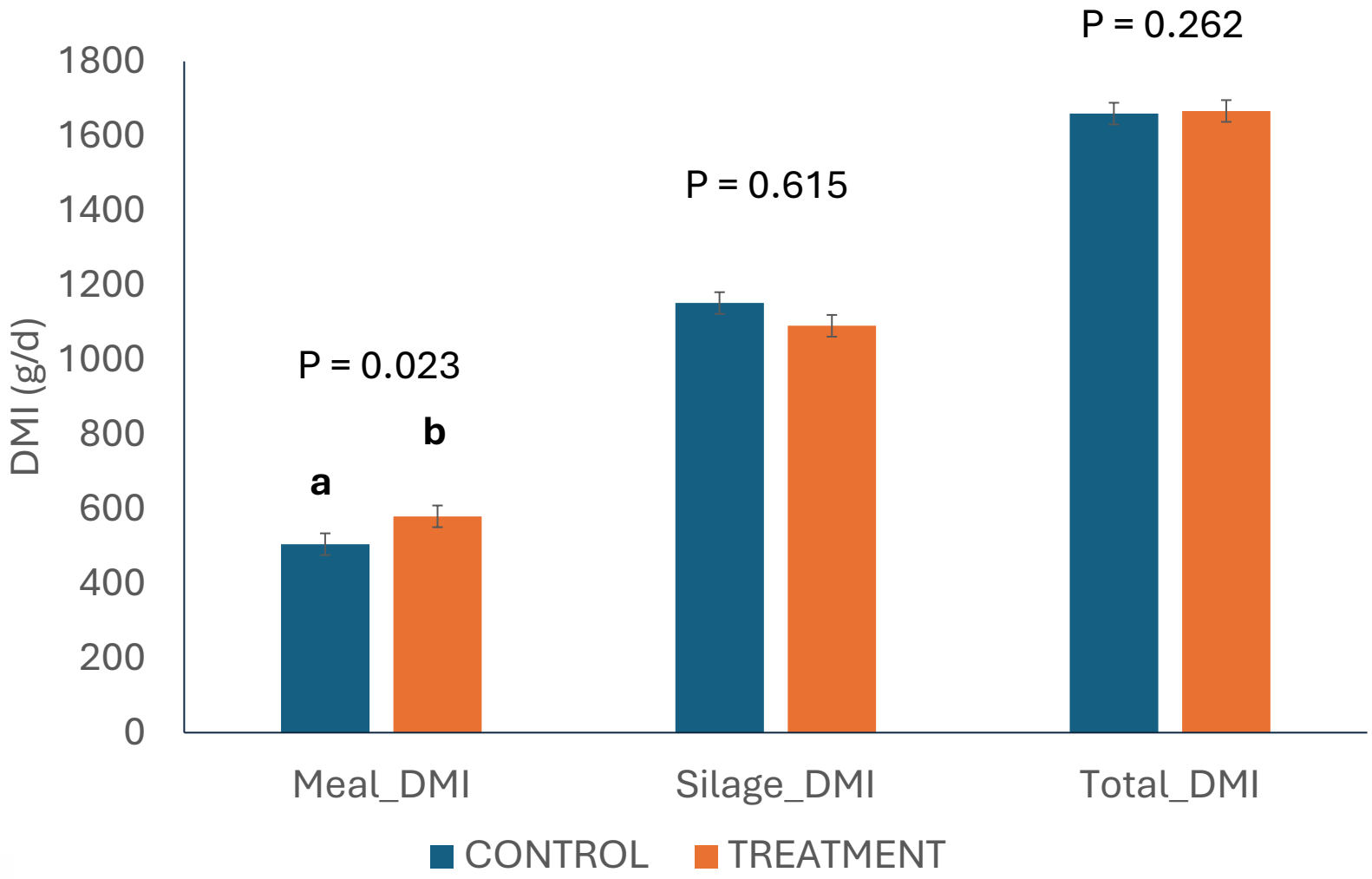
Results – Dry matter intake



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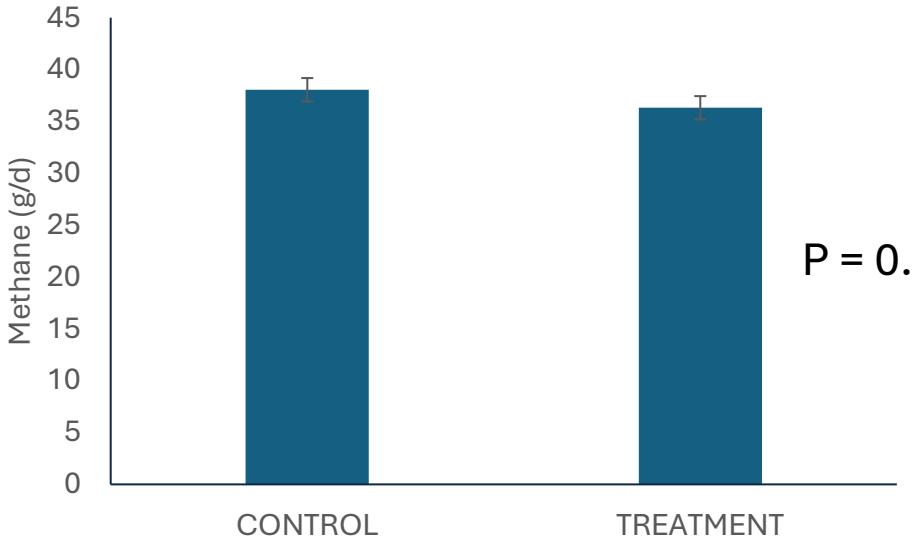
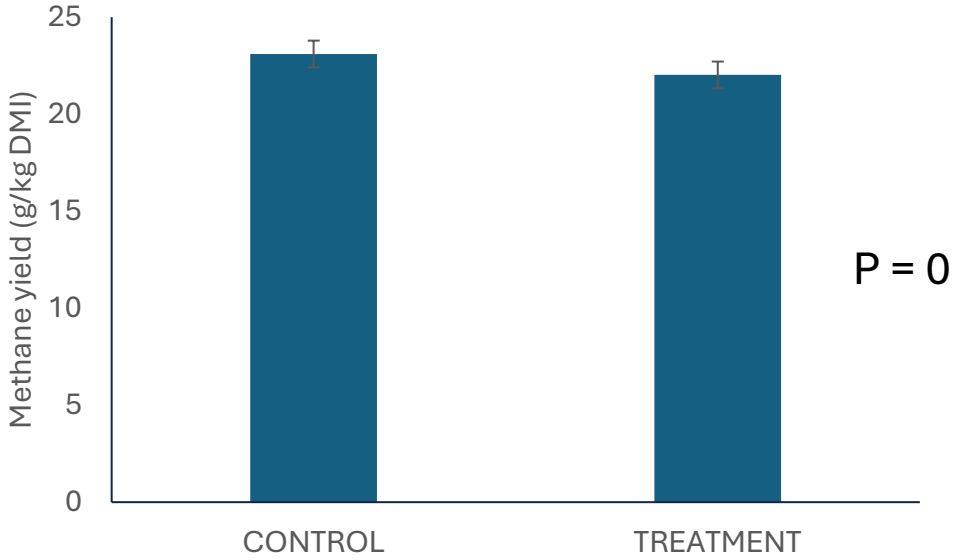
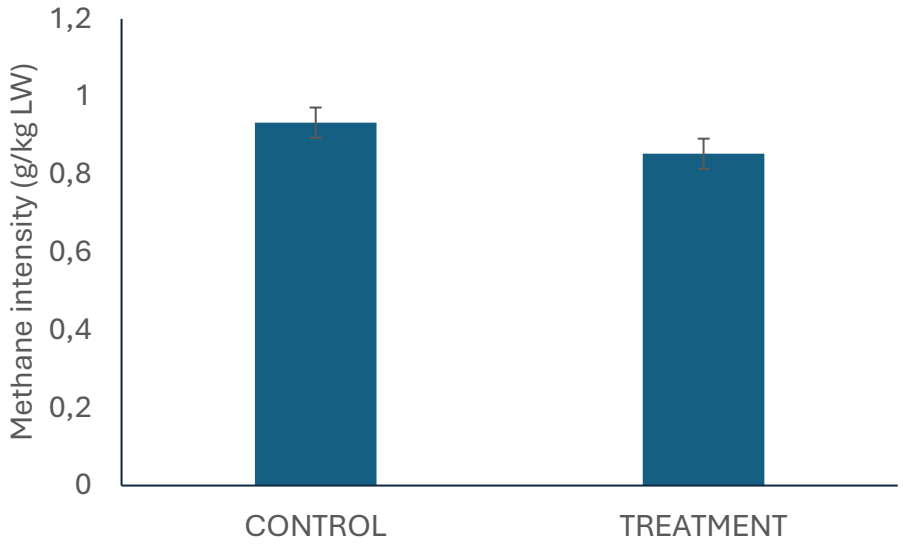
Results – Methane emissions



P = 0.701



P = 0.216



P = 0.074

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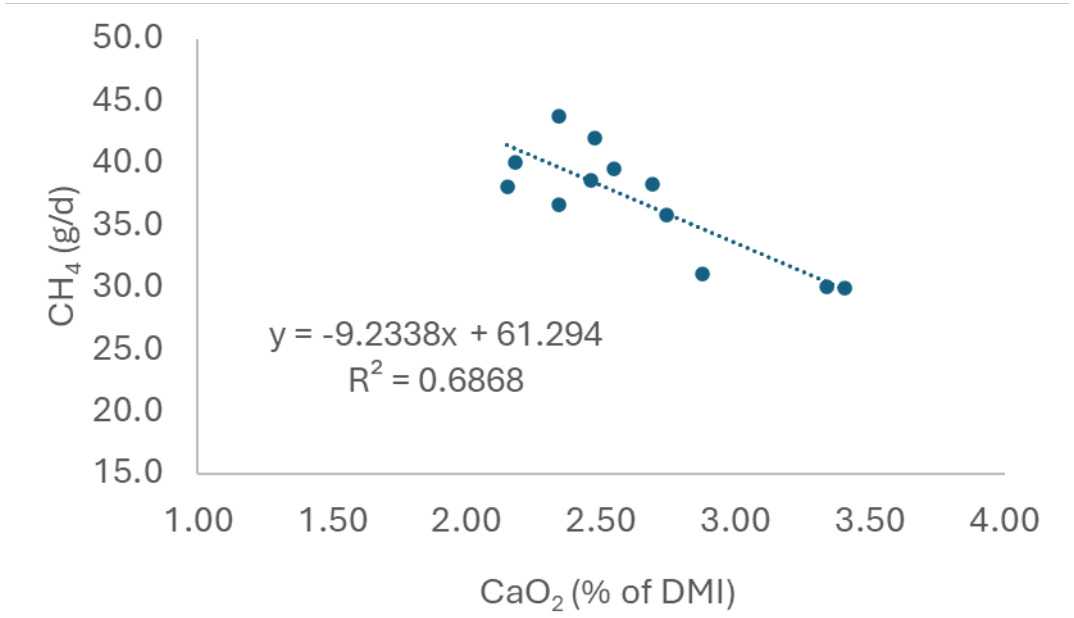
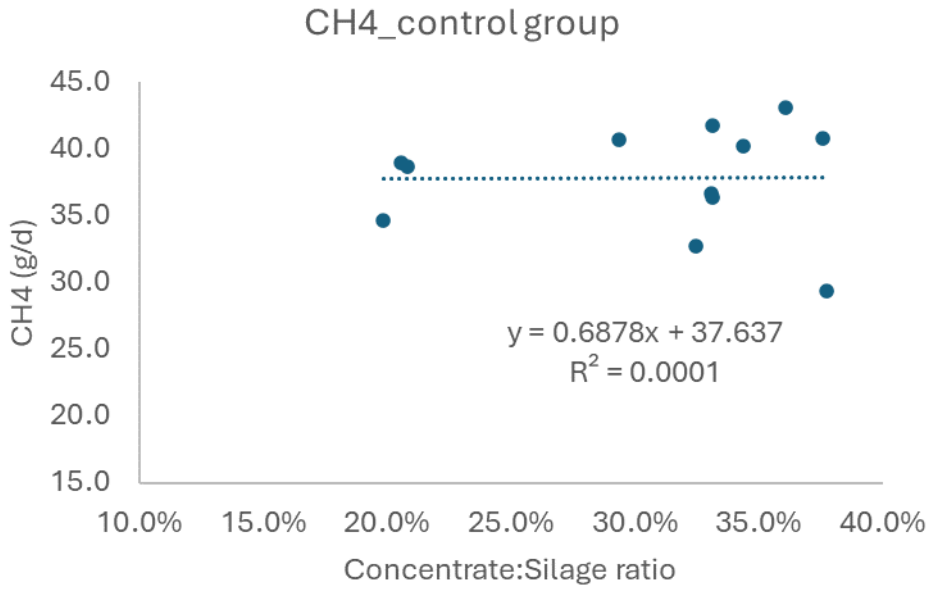
Results





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Conclusions and continuation of research

- The use of CaO_2 in pre-lambing and lactating ewes did not have a residual effect on CH_4 emissions and performance of post-weaned lambs.
- Feed intake was not affected in post-weaned lambs consuming CaO_2.
- The use of CaO_2 in post-weaned lambs resulted in heavier animals at slaughter; with a tendency to reduce methane per kilogram of LW.
- Next steps are to sequence the rumen fluid samples for insights into changes occurring at microbiome level (VFA and metagenomic sequencing)
- Further studies are required to evaluate the inclusion of a higher CaO_2 dose in the diet of post-weaned lambs on GHG emissions, animal performance, rumen fermentation and microbiome, and health.

Thank you!

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