

# Supplementation with a calcium peroxide feed additive mitigates enteric methane emissions in beef cattle

**Emily Roskam**<sup>1,2</sup>, David A. Kenny <sup>1,3</sup>, Vincent O'Flaherty<sup>2</sup>, Alan K. Kelly<sup>3</sup> and Sinéad M. Waters<sup>1,2</sup>

<sup>1</sup>Animal and Bioscience Research Department, Teagasc Grange, Meath, Ireland

<sup>2</sup>School of Natural Sciences and Ryan Institute, University of Galway, Ireland

<sup>3</sup>UCD school of Agricultural and Food Science, University College Dublin, Ireland



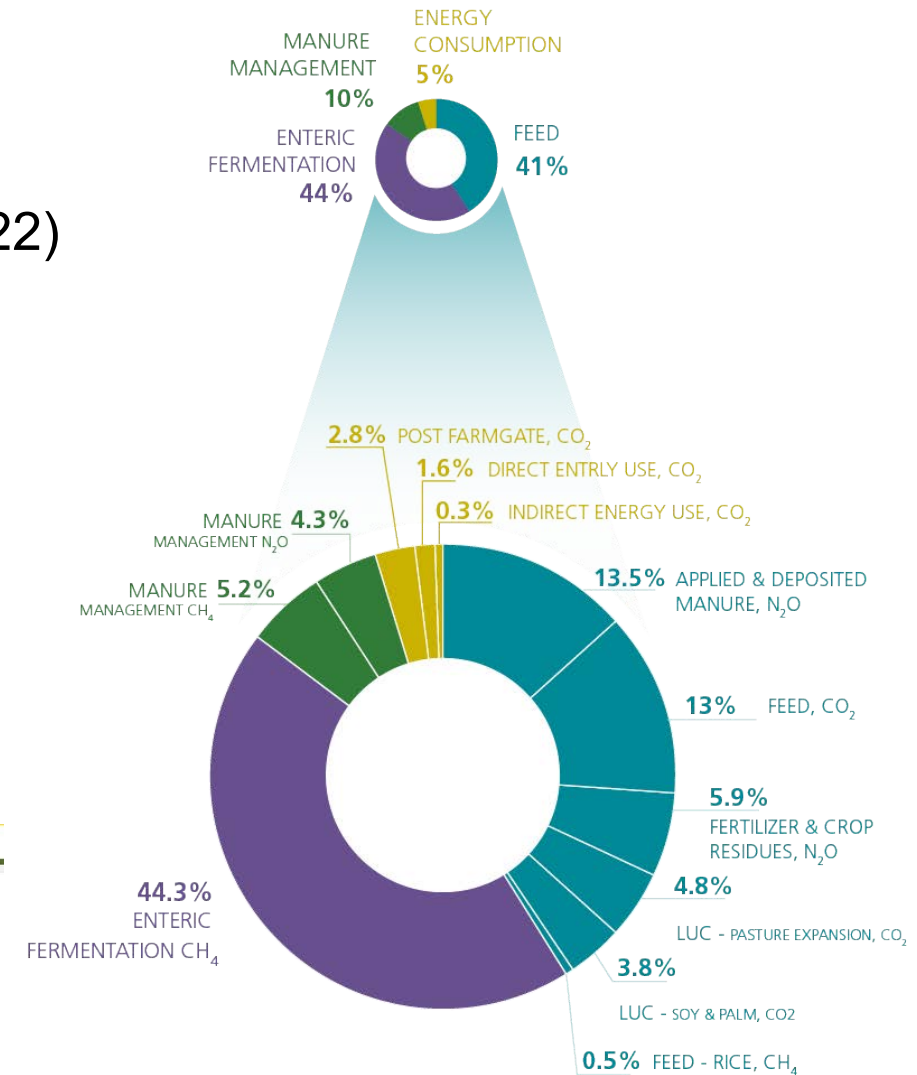
OLLSCOIL NA GAILLIMHE  
UNIVERSITY OF GALWAY



# Background

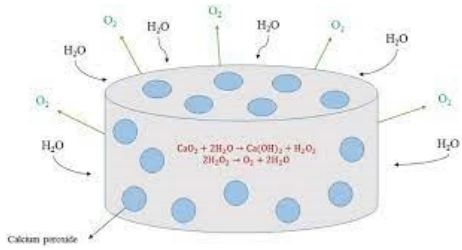
- Globally – CH<sub>4</sub> accounts for **44%** of livestock emissions
- Ireland – CH<sub>4</sub> accounts for ~70% of agri-emissions (EPA, 2022)
  - Enteric fermentation (feed digestion) **62%**
- Legally binding commitments to ↓ GHG
- Focus on dietary feed additives
  - (Hegarty et al., 2021; FAO., 2022; Beauchemin et al., 2022)

## Global livestock supply chain emissions by source



FAO, 2022 (GLEAM 2.0)





# Oxidising methane inhibitors

## ■ What are they?

- Peroxide based compounds
  - » Calcium peroxide ( $\text{CaO}_2$ )
- Based on the control of rumen oxidation-reduction potential (ORP)

## ■ Mechanism of action

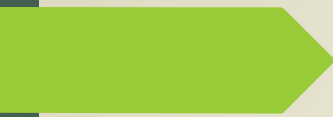
- Inhibit methanogens -  $\uparrow$  ORP
- Encourage microbial pathways that divert electrons from  $\text{H}_2$  and consume  $\text{H}_2$

## ■ Tested *in vitro* (O'Donnell et al., in prep; Graham et al., in prep)

## ■ Assessed in sheep (O'Donnell et al., in prep)

- No negative effects on ADG or DMI



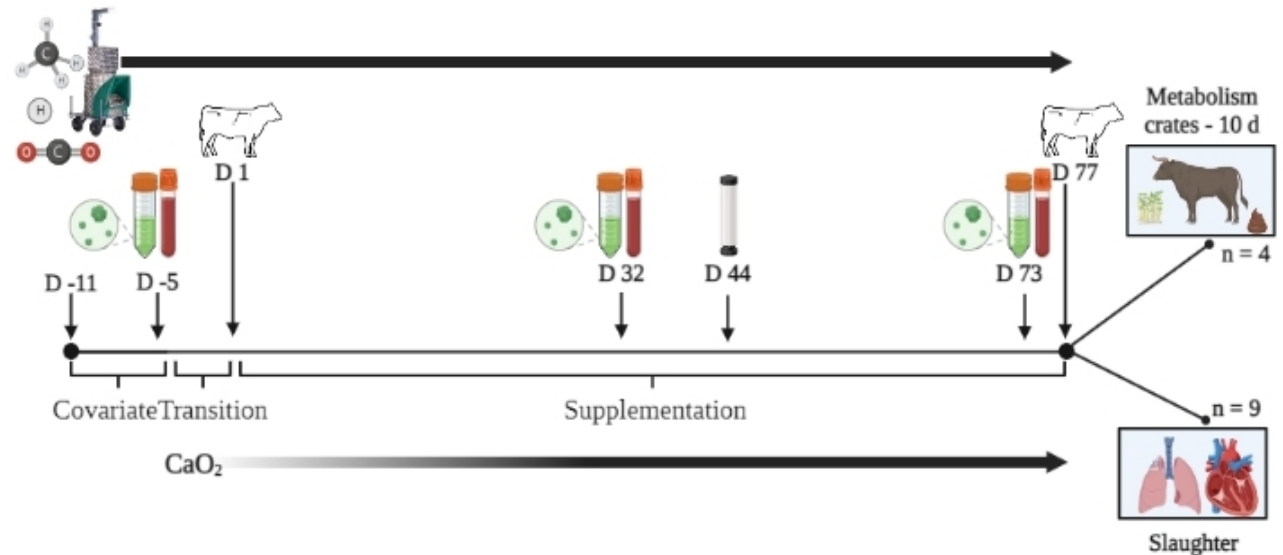


# Objectives

- Assess the effects of  $\text{CaO}_2$  supplemented twice daily at differing inclusion rates (Low vs High) and physical formats (Coarse ration vs Pellet) on:
  - Dry matter intake and digestibility
  - Animal performance
  - Rumen fermentation parameters
  - Gaseous emissions

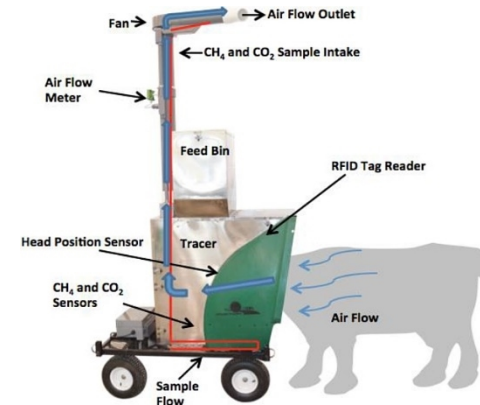
# Materials and Methods

- 72 dairy X bulls
  - ~16 months old/450kg
- RCB – BW, breed, baseline CH<sub>4</sub>
- 4 dietary treatments (n=18)
  - Control (No supplementation)
  - Low (1.35%) (4.35% of ration)
  - High (2.25%) (7.25% of ration)
  - **High pellet (2.25%) (7.25% of ration)**
- Diet
  - 60:40 forage:concentrate
  - Concentrates: Barley based with additive included
    - **Fed 2x/d (AM + PM)**
  - ~1kg bait feed from GreenFeed



Experimental timeline, indicating timepoints for gaseous emissions measuring, rumen and blood sampling, muscle and backfat scanning, digestibility study and organ observation at slaughter

Created in BioRender.com



# Effects of differing inclusion rate and delivery format of $\text{CaO}_2$ on animal performance and diet digestibility

| Item             | Treatment          |                     |                     |                    | SEM    | P-value |
|------------------|--------------------|---------------------|---------------------|--------------------|--------|---------|
|                  | CON                | LO                  | HC                  | HP                 |        |         |
| DMI, kg/d        | 8.37               | 8.00                | 7.97                | 8.02               | 0.374  | 0.855   |
| BW, kg           | 568                | 572                 | 566                 | 569                | 6.5    | 0.932   |
| DMI/kg BW        | 0.015              | 0.014               | 0.014               | 0.014              | 0.0664 | 0.841   |
| Faeces, kg/d     | 1.84               | 2.13                | 2.10                | 2.16               | 0.128  | 0.311   |
| Faecal Ca, % DM  | 2.96 <sup>a</sup>  | 4.61 <sup>b</sup>   | 5.41 <sup>c</sup>   | 5.67 <sup>c</sup>  | 0.116  | <.0001  |
| Digestibility, % |                    |                     |                     |                    |        |         |
| Dry matter       | 78.12 <sup>a</sup> | 73.44 <sup>b</sup>  | 73.63 <sup>b</sup>  | 72.99 <sup>b</sup> | 0.667  | 0.001   |
| Organic matter   | 80.41 <sup>a</sup> | 76.99 <sup>b</sup>  | 77.71 <sup>b</sup>  | 77.28 <sup>b</sup> | 0.615  | 0.008   |
| NDF              | 75.88 <sup>a</sup> | 71.89 <sup>ab</sup> | 72.00 <sup>ab</sup> | 69.68 <sup>b</sup> | 0.949  | 0.006   |

<sup>a,b</sup> Means within a row with different superscripts differ significantly ( $P < 0.05$ )

# Effects of differing inclusion rate and delivery format of $\text{CaO}_2$ on animal performance and diet digestibility

|                  | 0                   | 0.5                 | 1.0                 | 1.5                | 2.0   | P      | SE     |
|------------------|---------------------|---------------------|---------------------|--------------------|-------|--------|--------|
| DMI, kg          | 1.84                | 1.84                | 1.84                | 1.84               | 1.84  | 0.855  |        |
| BW, kg           | 2.9                 | 2.9                 | 2.9                 | 2.9                | 2.9   | 0.932  |        |
| DMI/kg BW        | 0.63                | 0.63                | 0.63                | 0.63               | 0.63  | 0.0664 | 0.841  |
| Faeces, kg/d     | 1.84                | 1.84                | 1.84                | 1.84               | 1.84  | 0.128  | 0.311  |
| Faecal Ca, % DM  | 2.9                 | 2.9                 | 2.9                 | 2.9                | 2.9   | 0.116  | <.0001 |
| Digestibility, % |                     |                     |                     |                    |       |        |        |
| Dry matter       | 73.6                | 73.6                | 73.6                | 73.6               | 73.6  | 0.667  | 0.001  |
| Organic matter   | 76.99 <sup>a</sup>  | 76.99 <sup>b</sup>  | 77.71 <sup>b</sup>  | 76.99              | 76.99 | 0.615  | 0.008  |
| NDF              | 71.89 <sup>ab</sup> | 71.89 <sup>ab</sup> | 72.00 <sup>ab</sup> | 69.68 <sup>a</sup> | 69.68 | 0.049  | 0.006  |

<sup>a,b</sup> Means within a row with different superscripts differ significantly ( $P < 0.05$ )

# Effects of differing inclusion rate and delivery format of CaO<sub>2</sub> on intake, animal performance and ultrasonically measured muscle and back fat depth

| Item                         | Treatment         |                   |                   |                   | SEM   | P-value |
|------------------------------|-------------------|-------------------|-------------------|-------------------|-------|---------|
|                              | CON               | LO                | HC                | HP                |       |         |
| DMI, kg/d                    | 9.27 <sup>a</sup> | 9.73 <sup>a</sup> | 8.23 <sup>b</sup> | 9.17 <sup>a</sup> | 0.206 | <.0001  |
| Start weight, kg             | 476               | 477               | 472               | 473               | 3.4   | 0.65    |
| Mid weight, kg               | 514               | 521               | 518               | 516               | 3.7   | 0.51    |
| End weight, kg               | 556               | 564               | 550               | 553               | 5.0   | 0.1615  |
| ADG, kg/d                    | 1.32              | 1.41              | 1.30              | 1.30              | 0.060 | 0.4836  |
| FCR <sup>1</sup>             | 7.14              | 7.13              | 6.56              | 7.15              | 0.281 | 0.3554  |
| Ultrasound measurements (mm) |                   |                   |                   |                   |       |         |
| Lumbar fat                   | 2.99              | 2.95              | 2.80              | 3.02              | 0.106 | 0.47    |
| Rump fat                     | 3.99              | 3.95              | 4.38              | 3.62              | 0.222 | 0.12    |
| Muscle depth                 | 55.0              | 56.5              | 54.0              | 55.8              | 0.77  | 0.14    |

<sup>a,b</sup> Means within a row with different superscripts differ significantly ( $P < 0.05$ )

<sup>1</sup> kg of DM/kg of gain

# Effects of differing inclusion rate and delivery format of $\text{CaO}_2$ on enteric gaseous emissions

| Item                     | Treatment           |                      |                     |                      | SEM    | P-value |
|--------------------------|---------------------|----------------------|---------------------|----------------------|--------|---------|
|                          | CON                 | LO                   | HC                  | HP                   |        |         |
| $\text{CH}_4$ : g/d      | 238.3 <sup>a</sup>  | 197.7 <sup>b</sup>   | 171.3 <sup>c</sup>  | 172.8 <sup>c</sup>   | 3.25   | <.0001  |
| $\text{CH}_4$ : g/kg DMI | 26.08 <sup>a</sup>  | 20.70 <sup>b</sup>   | 20.84 <sup>b</sup>  | 18.99 <sup>b</sup>   | 0.583  | <.0001  |
| $\text{CH}_4$ : g/kg BW  | 0.467 <sup>a</sup>  | 0.383 <sup>b</sup>   | 0.332 <sup>c</sup>  | 0.336 <sup>c</sup>   | 0.0062 | <.0001  |
| $\text{CH}_4$ : g/kg ADG | 182.6 <sup>a</sup>  | 145.7 <sup>b</sup>   | 133.1 <sup>b</sup>  | 135.6 <sup>b</sup>   | 5.76   | <.0001  |
| $\text{H}_2$ : g/d       | 0.590 <sup>a</sup>  | 0.380 <sup>b</sup>   | 0.382 <sup>b</sup>  | 0.404 <sup>b</sup>   | 0.0176 | <.0001  |
| $\text{CO}_2$ : g/d      | 8231.8 <sup>a</sup> | 7895.8 <sup>ab</sup> | 7309.0 <sup>c</sup> | 7664.4 <sup>bc</sup> | 147.35 | 0.0003  |

<sup>a,b,c</sup> Means within a row with different superscripts differ significantly ( $P < 0.05$ )

# Effects of differing inclusion rate and delivery format of $\text{CaO}_2$ on enteric gaseous emissions

| Item                     | CON    | LO     | HP     | SEM    | P-value |
|--------------------------|--------|--------|--------|--------|---------|
| $\text{CH}_4$ ; g/d      | 888.88 | 730.88 | 730.88 | 8.85   | <.0001  |
| $\text{CH}_4$ ; g/kg BW  | 182.7  | 152.7  | 152.7  | 5.76   | <.0001  |
| $\text{CH}_4$ ; g/kg ADG | 182.7  | 152.7  | 152.7  | 5.76   | <.0001  |
| $\text{H}_2$ ; g/d       | 0      | 0      | 0      | 0.0176 | <.0001  |
| $\text{CO}_2$ ; g/d      | 730.88 | 730.88 | 730.88 | 47.35  | 0.0003  |

a,b,c Means within a row that differ significantly ( $P < 0.05$ )

- Dose dependent
- HC and HP  $\downarrow$   $\text{CH}_4$  g/d by 27 and 28%
- $\text{CaO}_2 \downarrow \text{H}_2$  by 32-36%

# Effects of differing inclusion rate and delivery format of CaO<sub>2</sub> on rumen fermentation parameters

| Item                     | Treatment           |                    |                    |                      |        | Day    |       |       | P value |        |
|--------------------------|---------------------|--------------------|--------------------|----------------------|--------|--------|-------|-------|---------|--------|
|                          | CON                 | LO                 | HC                 | HP                   | SEM    | D32    | D73   | SEM   | Trt     | Day    |
| pH                       | 6.89 <sup>a</sup>   | 7.14 <sup>b</sup>  | 7.17 <sup>b</sup>  | 7.12 <sup>b</sup>    | 0.044  | 7.06   | 7.10  | 0.030 | <.0001  | 0.27   |
| NH <sub>3</sub> -N, mg/L | 98.04 <sup>a</sup>  | 81.57 <sup>b</sup> | 77.96 <sup>b</sup> | 70.90 <sup>b</sup>   | 4.986  | 96.40  | 67.84 | 3.400 | 0.01    | <.0001 |
| Lactic acid              | 0.185               | 0.160              | 0.221              | 0.158                | 0.0176 | 0.190  | 0.172 | 0.012 | 0.05    | 0.30   |
| TVFA mM                  | 118.93 <sup>a</sup> | 99.15 <sup>b</sup> | 93.26 <sup>b</sup> | 105.26 <sup>ab</sup> | 4.881  | 115.63 | 92.67 | 3.344 | 0.01    | <.0001 |
| Acetate                  | 75.95               | 74.94              | 72.94              | 74.58                | 0.983  | 76.76  | 72.45 | 0.673 | 0.19    | <.0001 |
| Propionate               | 12.94 <sup>a</sup>  | 15.71 <sup>b</sup> | 19.13 <sup>c</sup> | 16.88 <sup>bc</sup>  | 0.672  | 15.58  | 16.75 | 0.461 | <.0001  | 0.08   |
| Butyrate                 | 10.99 <sup>a</sup>  | 8.58 <sup>b</sup>  | 7.70 <sup>bc</sup> | 7.21 <sup>c</sup>    | 0.330  | 7.47   | 9.80  | 0.226 | <.0001  | <.0001 |
| Valerate                 | 1.00                | 1.08               | 1.14               | 1.21                 | 0.059  | 1.23   | 1.00  | 0.041 | 0.08    | <.0001 |
| A:P ratio                | 8.53 <sup>a</sup>   | 5.40 <sup>ab</sup> | 4.56 <sup>b</sup>  | 7.97 <sup>ab</sup>   | 0.979  | 8.59   | 4.64  | 0.671 | 0.01    | <.0001 |

<sup>a,b,c</sup> Means within a row with different superscripts differ significantly ( $P<0.05$ )

# Effects of differing inclusion rate and delivery format of $\text{CaO}_2$ on rumen fermentation parameters

| Item          | Treatment          |                    |                    | Day                |                    |       | P value |        |
|---------------|--------------------|--------------------|--------------------|--------------------|--------------------|-------|---------|--------|
|               | CON                | LO                 | HI                 | D32                | D73                | SEM   | Trt     | Day    |
| pH            | 6.89 <sup>a</sup>  | 7.14 <sup>b</sup>  | 7.17 <sup>b</sup>  | 7.06               | 7.10               | 0.030 | <.0001  | 0.27   |
| $\text{NH}_3$ |                    |                    |                    |                    |                    |       | <.0001  |        |
| Lactic acid   |                    |                    |                    |                    |                    |       | 0.05    | 0.30   |
| TVFA mM       | 116.1              | 118.1              | 118.1              | 116.1              | 118.1              | 0.344 | 0.01    | <.0001 |
| Acetate       | 75.95              | 74.45              | 74.45              | 75.95              | 74.45              | 0.673 | 0.19    | <.0001 |
| Propionate    | 12.94 <sup>a</sup> | 15.7 <sup>b</sup>  | 15.7 <sup>b</sup>  | 12.94 <sup>a</sup> | 15.7 <sup>b</sup>  | 0.461 | <.0001  | 0.08   |
| Butyrate      | 10.99 <sup>a</sup> | 8.5 <sup>b</sup>   | 8.5 <sup>b</sup>   | 10.99 <sup>a</sup> | 8.5 <sup>b</sup>   | 0.226 | <.0001  | <.0001 |
| Valerate      | 1.00               | 1.00               | 1.00               | 1.00               | 1.00               | 0.041 | 0.08    | <.0001 |
| A:P ratio     | 8.53 <sup>a</sup>  | 7.97 <sup>ab</sup> | 7.97 <sup>ab</sup> | 8.53 <sup>a</sup>  | 7.97 <sup>ab</sup> | 0.671 | 0.01    | <.0001 |

<sup>a,b,c</sup> Means within a row with different superscripts differ significantly ( $P < 0.05$ )

- $\text{CaO}_2 \uparrow$  pH
- $\text{CaO}_2 \uparrow$  propionate

# Conclusions

- Novelty: Twice daily supplementation; Pellet
- $\text{CaO}_2$  pellet:  $\downarrow \text{CH}_4$  by 28%,  $\downarrow \text{H}_2$  by 32%,
- $\text{CaO}_2$ : no negative effect on production or health;  $\downarrow$  digestibility
- $\text{CaO}_2$ : unaffected by heat and pressure of pelleting process
- Future work: high forage diet indoors; at pasture with once a day feeding



# Acknowledgments

## ■ Funders

- Department of Agriculture, Food and the Marine (DAFM)

## ■ Project partners

- METHABATE (Contract no. DAFM\_RSF 2019R479)

- Teagasc Grange farm staff and technical help



Prof. Sinead Waters



Prof. David Kenny



Prof. Vincent O'Flaherty



Dr. Alan Kelly

Twitter @METHABATE  
emily.roskam@teagasc.ie



OLLSCOIL NA GAILLIMHE  
UNIVERSITY OF GALWAY

