Prof. Sinéad M. Waters

Principal Research Scientist Animal and Bioscience Research Department Teagasc

Development and evaluation of feed additives to reduce enteric methane emissions

Agriculture and Climate Change – Science into Action 15th November, 2023





An Roinn Talmhaíochta, Bia agus Mara Department of Agriculture, Food and the Marine

Introduction

- Agriculture is responsible for 37% of Ireland's GHG emissions
- **Methane** is a potent greenhouse gas (GHG)
- Methane accounts for ~72% of Irish Agri-GHG emissions (EPA, 2023)
- Ireland: Climate Action and Low Carbon Development Bill 2021
 - ≥ 25% reduction in Agri-emissions by 2030
 - > 10% reduction in ruminant derived methane





How are we going to reduce methane emissions from agriculture?

- Improved management practices Farm efficiency
- Teagasc MACC
 - Reducing age of slaughter
 - Reducing age of first calving
- Grassland management
 - Significantly lower methane in pasture based settings
- Breeding strategies (Teagasc and ICBF)
 - Enhance feed efficiency and lower methane
 - Longer term strategy





Marginal Abatement Cost Curve 2023

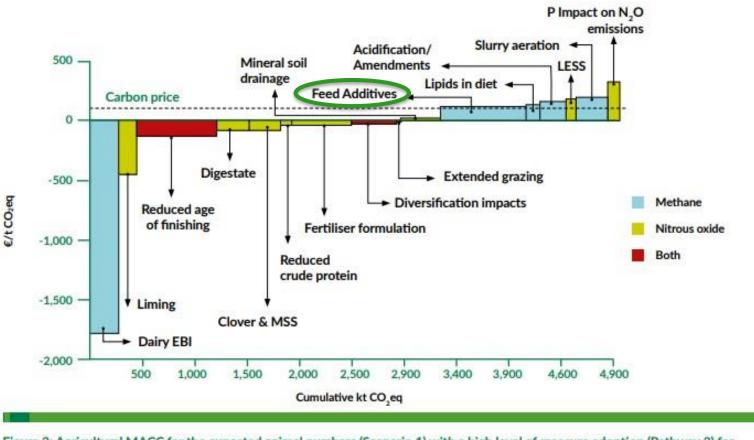


Figure 2: Agricultural MACC for the expected animal numbers (Scenario 1) with a high level of measure adoption (Pathway 2) for methane, nitrous oxide and both gases. The dashed line indicates a Carbon Price of €100 per tonne CO₂eq.

• Feed additives can reduce methane emissions by 788kt CO2 eq per year by 2030



International reports

Dr Roger Hegarty NZAGRC

- Only two of the additives evaluated delivered over 20% mitigation
 - Bovaer (3-NOP)
 - Asparagopsis (red algae)
 - SilvAir Nitrate (~10% reduction)

Constraints with feed additives:

- 'Insufficient evidence of a co-benefit of increased production'
- Rely on additives mixed into a total mixed ration fed continuously

TAG FAO LEAP Partnership 2022

'more research is needed to develop, adapt, and evaluate antimethanogenic strategies for grazing systems' (Beauchemin et al., 2022)



An evaluation of evidence for efficacy and applicability of methane inhibiting feed additives for livestock

November 2021

A partnership of: New Zealand Agricultural Greenhouse Gas Research Centre (NZAGRC) Global Research Alliance on Agricultural Greenhouse Gases (GRA) Climate Change, Agriculture and Food Security (CCAFS) Agriculture and Agri-Food Canada (AAFC) Climate and Clean Air Coalition (CCAC) United States Agency for International Development (USAID)





What do we want from a feed additive?

Must Have

- Consistent methane reduction potential
- Mechanism of delivery to the animal
- > Capable of counting in the national inventory
- No food safety/residue implications
- > No negative performance effects and palatability
- Desirable
 - Low cost
 - Increased performance benefits
 - Natural origin
 - Potential for combination with other solutions



'METH-ABATE': Development of novel farm ready technologies to reduce methane emissions from pasture based Irish agricultural

- systems
- Feed additives to mitigate methane emissions
 - Bovaer (3-NOP)
 - Seaweeds and seaweed extracts
 - Lipids (e.g., linseed oil, olive feed)
 - Novel oxidising methane inhibitors (RumenGlas)
 - Commercial products
- Monitoring their effects on animal productivity
- Formulations for **slow release** options at pasture
- Nutritional and toxicological composition of meat and milk no residues
- Life Cycle Analysis (LCA) and farm level cost effectiveness

QUEEN'S UNIVERS









Screening candidates for methane mitigation

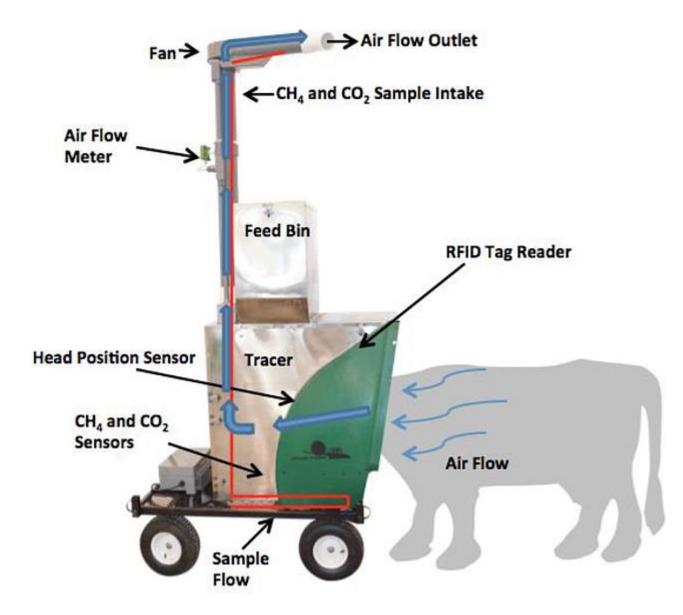
Feed additive	Change in methane emissions (%)
Oxidising methane inhibitors	-67%
Asparagopsis taxiformis	-68%
Ascophyllum nodosum	-36%
Brown seaweed extract	-15%
Olive feed extract	-26%



In vitro RUSITEC system



GreenFeed technology to measure methane







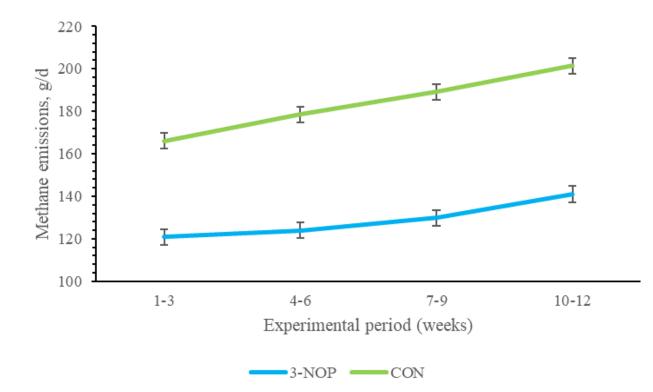
Bovaer (3-nitrooxypropanol; 3NOP)

- Synthetic non-toxic compound, 3-nitrooxypropanol
- Mean reduction of **30%** in methane
- Mode of action limits the last step of the methanogenesis cycle
- Immediate reduction to CH₄ once fed
 - Emissions will increase once feeding stopped
- Challenge to incorporate into a pasture based diet
- EFSA approved in EU for feeding to dairy cattle
- Cost
 - ► €25.55 annually for beef cattle
 - ➤ €60.59 annually for dairy cows



Bovaer (3-NOP) supplementation in young beef cattle

- Efficacy of 3-NOP in growing beef cattle
- DMI, daily methane output, daily live-weight gain

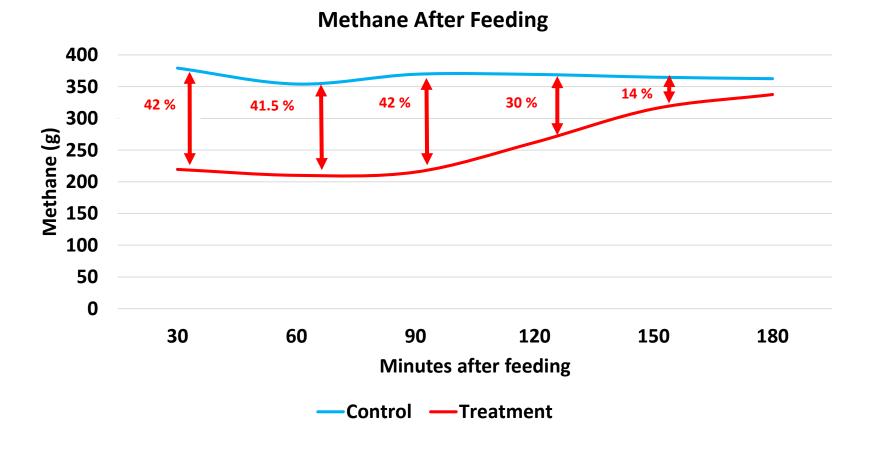


- No effect on DMI, ADG, feed efficiency
- Methane emissions 430%



Bovaer supplementation in grazing dairy cows

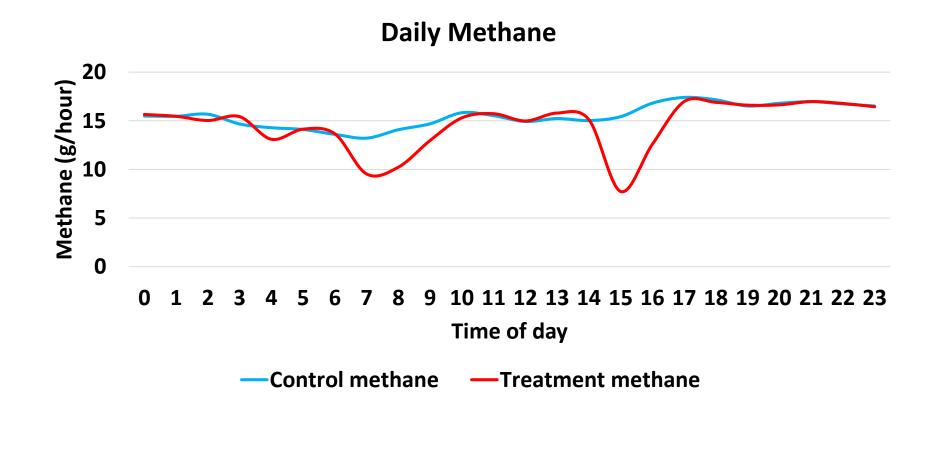
~30% reduction in methane for 2.5 hours after feeding







Bovaer supplementation in grazing dairy cows





- Twice a day supplementation
- Overall 7% reduction in methane emissions

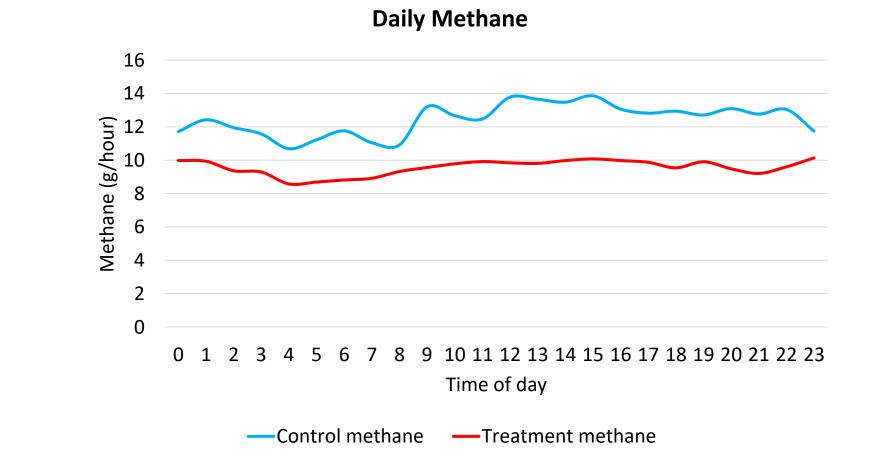


Bovaer supplementation in dairy cows during the dry period

- Mixed throughout feed using a diet feeder
- 22% reduction in methane

VistaMilk

• No significant effect on performance



eagase

Supplementation with lipids

- Dietary supplementation of dairy cross beef bulls with linseed oil (4%) reduced methane emissions by 18%
 - > DMI (1 5%) tended to be reduced
- Dietary supplementation of Charolais heifers with:
 - Rapeseed cake (14.5%) reduced CH₄ by 7.87%
 - Rapeseed oil (2.5%) reduced CH₄ by **8.05%**
 - > No reduction in intake or diet digestibility

- Costly to add to the diet
 - > 1t rapeseed oil ~€450 → €60/head/year
 - > 1t linseed oil ~ \in 2,500 \rightarrow \in 325/head/year





Supplementation with seaweeds

- Global seaweed production 30.4 m t FW
 - Impractical for transport
 - > Requirement to identify and extract bioactive component for reduction in methanogenesis
- Red seaweeds Asparagopsis spp.
 - > **A. taxiformis**: \downarrow CH₄ by >80% in vitro, in sheep and in beef

Issues:

- > Tropical species: not native to Ireland, lack of consistency and high cost
- > **Bromoform**: Bioactive in A. taxiformis is a known carcinogen
- > Environmental concerns ozone depletion





Supplementation with seaweeds

Brown seaweeds

- > Indigenous, plentiful, inexpensive
- > Main bioactive phlorotannin
- High protein
- Inconsistent anti-methanogenic results
- Ascophyllum nodosum (2%)
 - > No effect on CH₄ in sheep
 - > Reduced methane by 4% in beef cattle
- A. nodosum extract (2%)
 - > 9% reduction in CH₄ in sheep
 - > 7% reduction in CH₄ in beef







Oxidising methane inhibitors

What are they?

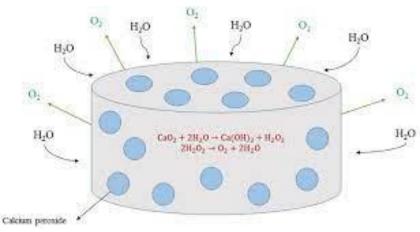
- Peroxide based compounds routinely used in human food
 - Calcium peroxide (CaO₂) RumenGlas
- Based on the control of rumen oxidation-reduction potential (ORP)

Mechanism of action?

- > 1. Inhibit methanogens
 - » \uparrow **ORP** to favourably alter rumen fermentation pathways and suppress methanogenesis
- > 2. Divert electrons from $H_2 \rightarrow$ trap energy in biomass

Cost?

€0.09-0.13 per head per day







RumenGlas supplementation in beef cattle

Reduction in methane by 17% (low dose) and 28% (High dose) vs CON

- > $H_2 \downarrow$ by 32-36%
- > ORP ↑ for 2 h post feeding
- No effect on feed intake or ADG (1.3-1.4 kg/d)

Ease of delivery 2x/d feeding in a pellet









Take home messages

- Most promising feed additives evaluated:
 - Bovaer (3-NOP)
 - RumenGlas

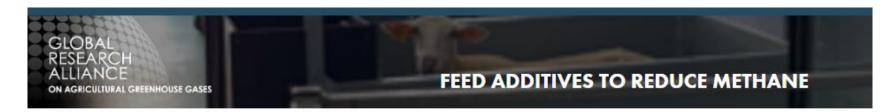
- Oils (rapeseed oil) offer some reductions but expensive
- Seaweeds: Limited effectiveness of brown seaweeds and issues with Asporogopsis taxiformis

Future priorities:

- Potential for synergy combining feed additives as different mechanisms of action
- Challenges at grazing: Slow release and bolus technology for application during grazing
- EFSA approval required
- Exploring opportunities to combine with other strategies such as breeding



GRA Flagship on feed additives



- Ireland is a partner
- GRA Flagship PhD student
- Development of feed additives for grazing systems
- International review paper



Technical guidelines to develop feed additives to reduce enteric methane

Flagship Goal: To accelerate the development and use of feed additives to reduce global enteric methane emissions from livestock.



An Roinn Talmhaíochta, Bia agus Mara Department of Agriculture, Food and the Marine



Acknowledgements









Emily Roskam



Dr Ben Lahart



Caroline O'Donnell



Dr Maria Hayes Alison Graham Dr Hazel Costigan

Funding:

Irish Department of Agriculture, Food and the Marine (RSF contract no. 2019R479) Science Foundation Ireland (19/FFP/6746) EU ERA-NET (SeaSolutions: 696231)

National University of Ireland, Galway











An Roinn Talmhaíochta, **Bia agus Mara** Department of Agriculture, Food and the Marine





