Methane inhibitors: Update on the methane inhibitor Bovaer® (3-NOP)

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Reducing enteric methane one burp at a time

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DSM
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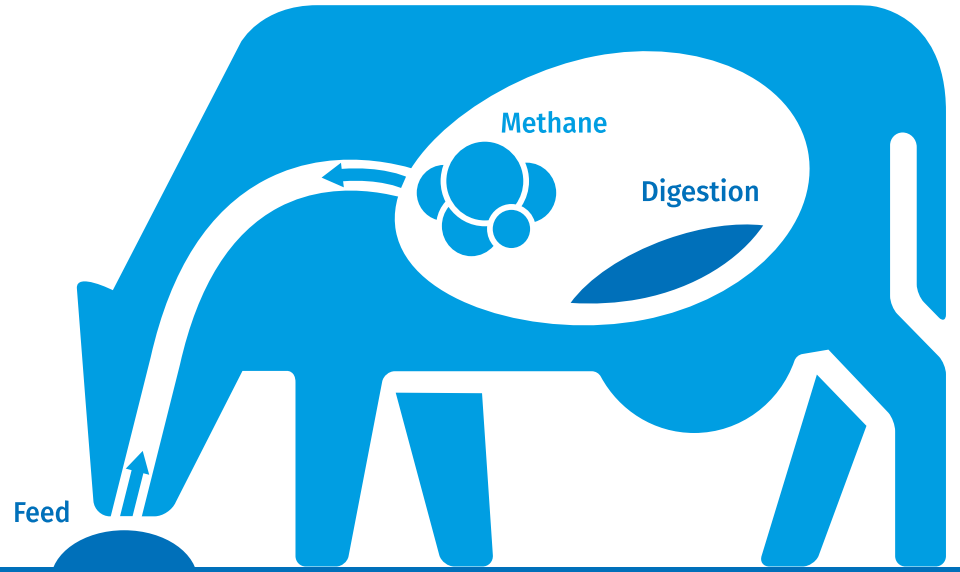
Cows make methane

It's not their fault. Methane is a byproduct of digesting the tough, fibrous food they eat. And it's released into the air burp by burp.

Methane traps heat

Like carbon dioxide (CO_2), methane is a greenhouse gas. Its warming effect is shorter lived, but much more potent than CO_2. So eliminating it begins to pay off right away.



Bovaer® reduces methane

1/4 teaspoon daily in a cow's feed

30% less methane produced

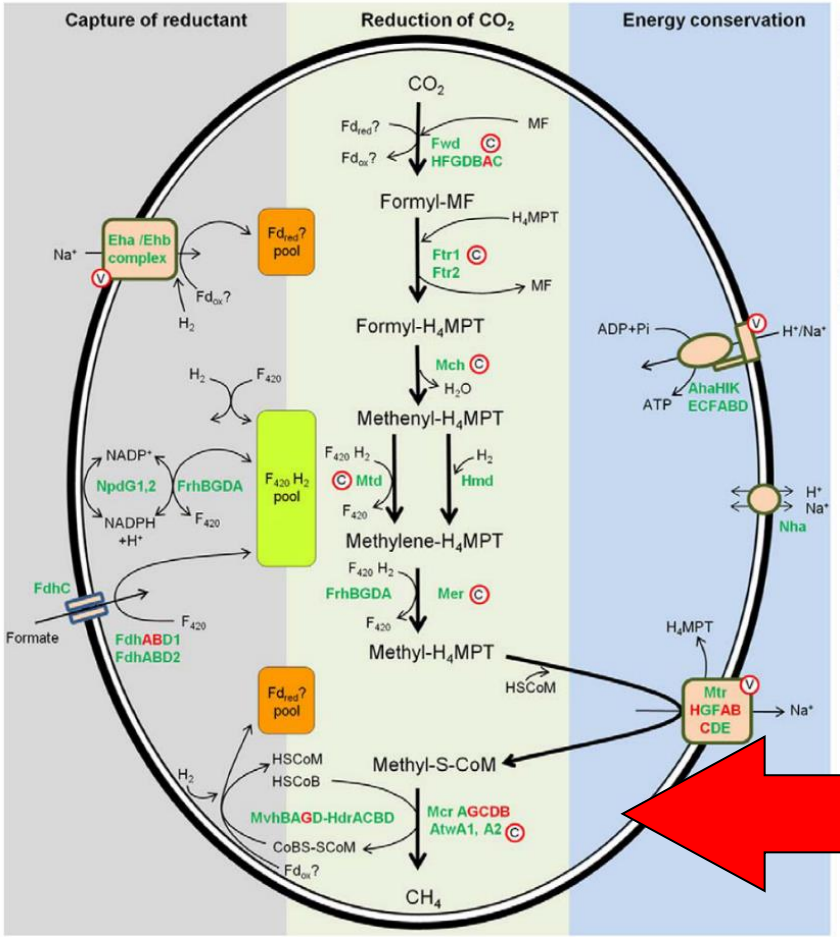
takes effect immediately

proven safe for consumers, for cows, and good for our planet

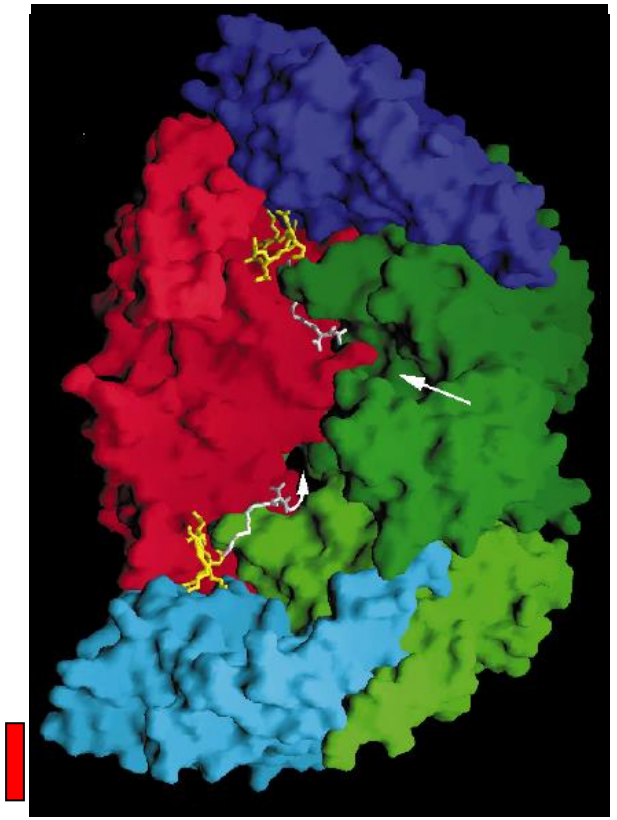
How it works

In a cow's stomach, microbes help food break down. This releases hydrogen and carbon dioxide. An enzyme combines these gases to form methane. **Bovaer® is a feed additive that suppresses the enzyme, so less methane gets generated.**

Targeting methanogenesis at the level of the function: Methanogenesis pathway in Archaea



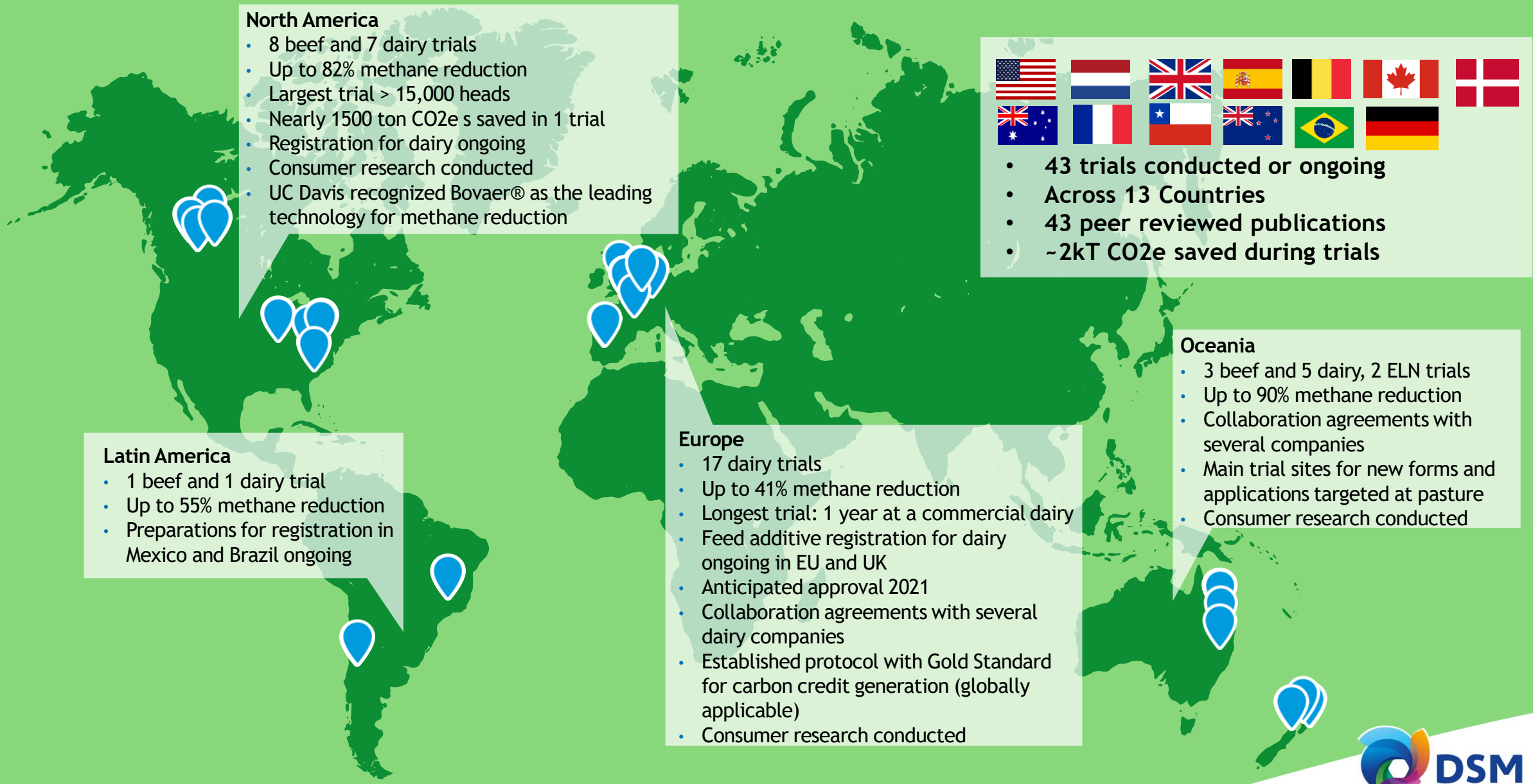
Target:
Methyl Coenzyme M Reductase



Leahy SC, Kelly WJ, Altermann E, Ronimus RS, Yeoman CJ, et al. (2010) The Genome Sequence of the Rumen Methanogen Methanobrevibacter ruminantium Reveals New Possibilities for Controlling Ruminant Methane Emissions. PLoS ONE 5(1): e8926. doi:10.1371/journal.pone.0008926

Protein Data Bank code 1HBN (46).
U. Ermler et. al. *Science*, 1997, 278, 1457.

Efficacy of Bovaer® extensively demonstrated globally



North America
- 8 beef and 7 dairy trials
- Up to 82% methane reduction
- Largest trial > 15,000 heads
- Nearly 1500 ton CO2e s saved in 1 trial
- Registration for dairy ongoing
- Consumer research conducted
- UC Davis recognized Bovaer® as the leading technology for methane reduction

- **43 trials conducted or ongoing**
- **Across 13 Countries**
- **43 peer reviewed publications**
- **~2kT CO2e saved during trials**

Latin America
- 1 beef and 1 dairy trial
- Up to 55% methane reduction
- Preparations for registration in Mexico and Brazil ongoing

Europe
- 17 dairy trials
- Up to 41% methane reduction
- Longest trial: 1 year at a commercial dairy
- Feed additive registration for dairy ongoing in EU and UK
- Anticipated approval 2021
- Collaboration agreements with several dairy companies
- Established protocol with Gold Standard for carbon credit generation (globally applicable)
- Consumer research conducted

Oceania
- 3 beef and 5 dairy, 2 ELN trials
- Up to 90% methane reduction
- Collaboration agreements with several companies
- Main trial sites for new forms and applications targeted at pasture
- Consumer research conducted

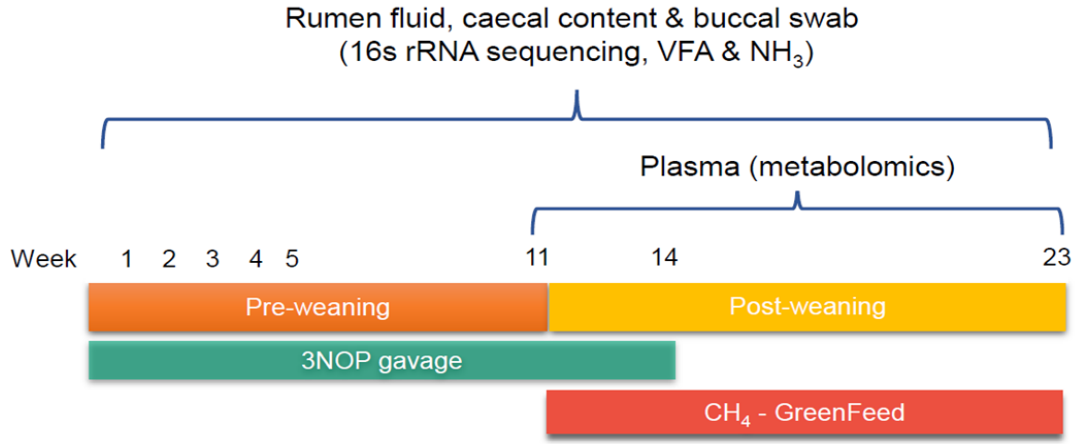
Early Life Nutrition as a methane inhibition strategy (Meale et al, 2021)

- Early Life nutritional intervention strategies, using either improved nutrition, probiotics or other feed additives has been investigated for many years resulting in improved health and performance, with varying degrees of success.

- Research question: Can Bovaer® as an early life intervention strategy have a persistent effect on methane emissions?
  - Both during and after supplementation
- Trial site: INRAe, France

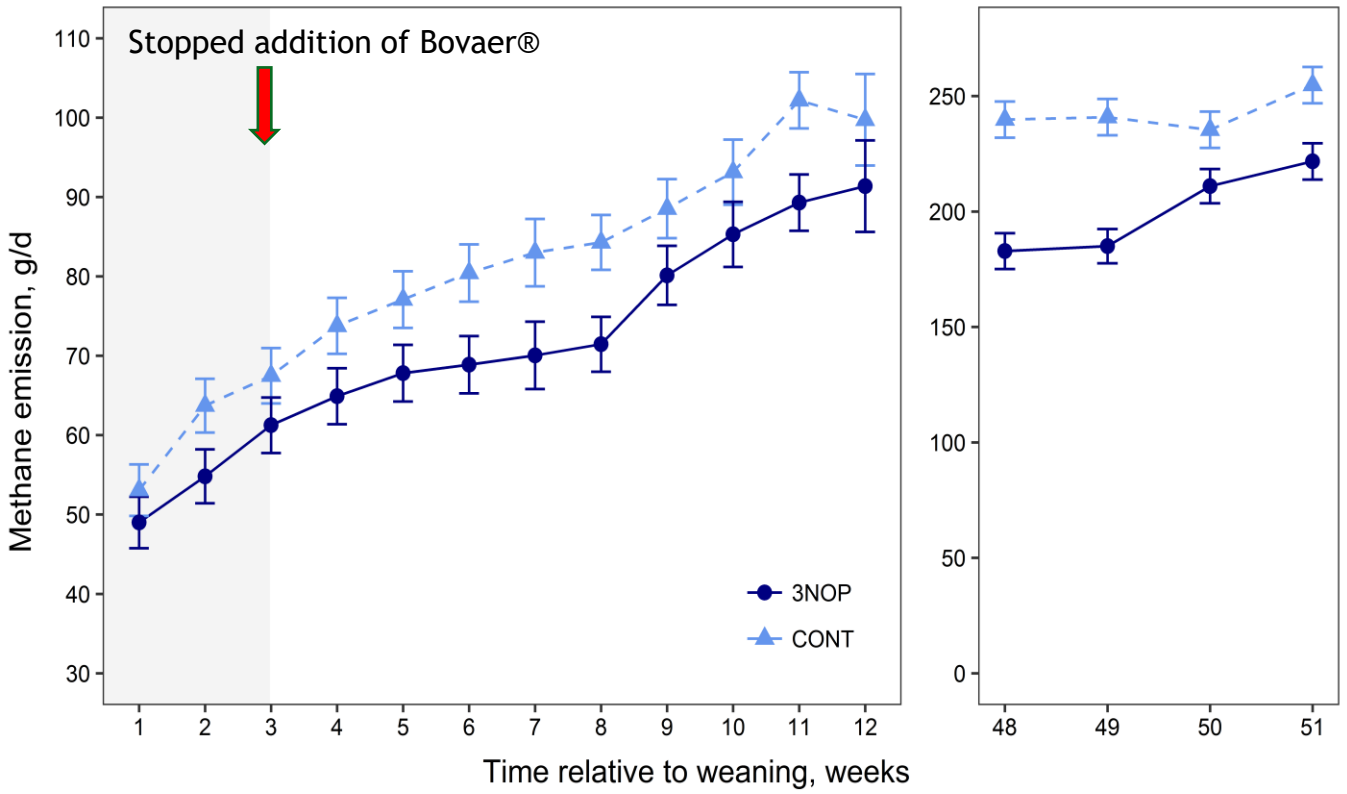
Trial design:

- 18 newly born female dairy calves enrolled on day 1 of life and either given a placebo or Bovaer® (3 mg/kg BW) in a solution as a gavage every day for 14 weeks.
- CH4 was measured using GF systems between weeks 11 to 23 and at weeks 56 to 60 of life
- Performance monitored: Total DMI, BW and ADG.



Early Life Nutrition – dairy calves: 18% reduction in CH4

(Meale et al, 2021)



- Methane emissions were significantly reduced in the treated calves.
- Effect persistent even after daily supplementation with Bovaer® had stopped at 14 weeks of life/ 3 weeks after weaning.
- Overall, a reduction of 18% (p =0.08) in methane emissions were recorded across the study. (=150kg CO2e reduction in year 1)
- BW, NH3 and VFA parameters were similar in the control and treatment group, indicating no effect on performance

Early Life Nutrition – grazing suckler beef calves: 18% reduction in CH4 emissions

Aim: to determine whether feeding Bovaer® as an early life intervention strategy in grazing beef suckler calves had a persistent effect on methane emissions, both in the short term and even after supplementation had stopped.

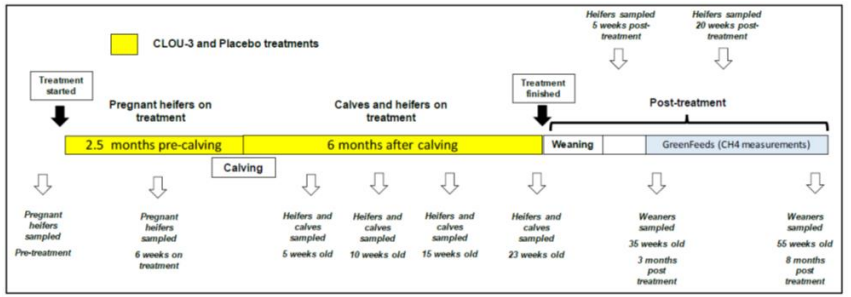
Trial site: CSIRO, Australia

Trial design

Grazing Beef suckler calves were supplemented with either a placebo or Bovaer (3 mg/kg BW) in feed from d1 up to 6 months of age when they were weaned.

Rumen samples were removed and analysed by Illumina sequencing.

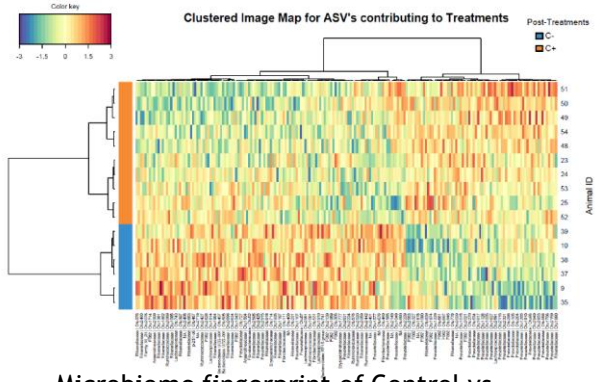
CH4 emissions from the calves were monitored using GFs from 9 to 14 months of age



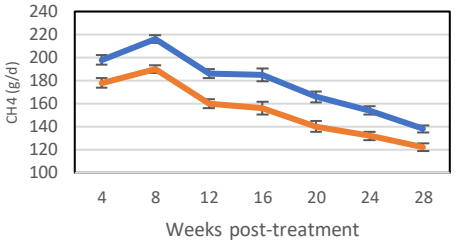
With Bovaer supplementation: Distinct changes in microbiome and rumen fermentation characteristics associated with Bovaer supplementation up to 6 months of age.

Microbiome fingerprint of Control vs treated calves at 6 months of age

Post-treatment: At 14 months of age, 8 months after stopping supplementation with Bovaer, distinct differences in microbiome composition still observed. No significant difference in BW and fermentation profile observed. Significant decrease in CH4 observed (-12 to -18%) from 9 to 14 months of age.



Microbiome fingerprint of Control vs treated calves at 14 months of age



CH4 production of Control vs treated calves from 9 to 14months of age

Beef feedlot Australia: Up to 90% reduction in CH4 emissions

Aim: Investigate the effect of feeding Bovaer to Adult finishing beef cattle fed a typical Australian diet

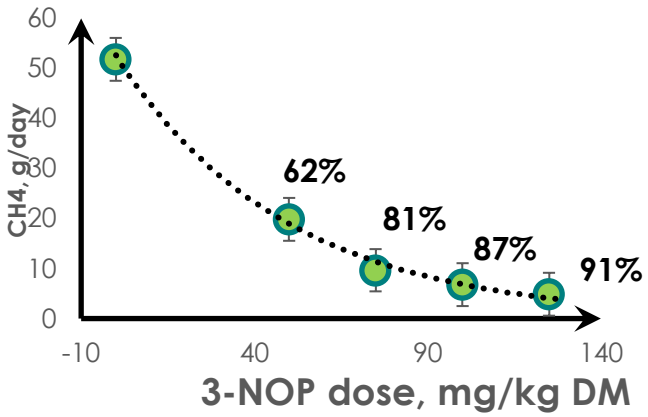
Trial site: UNE, Australia

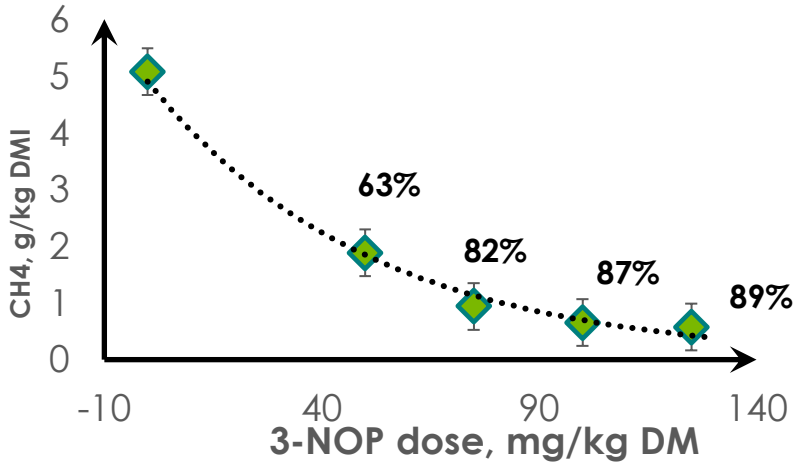
Trial design:

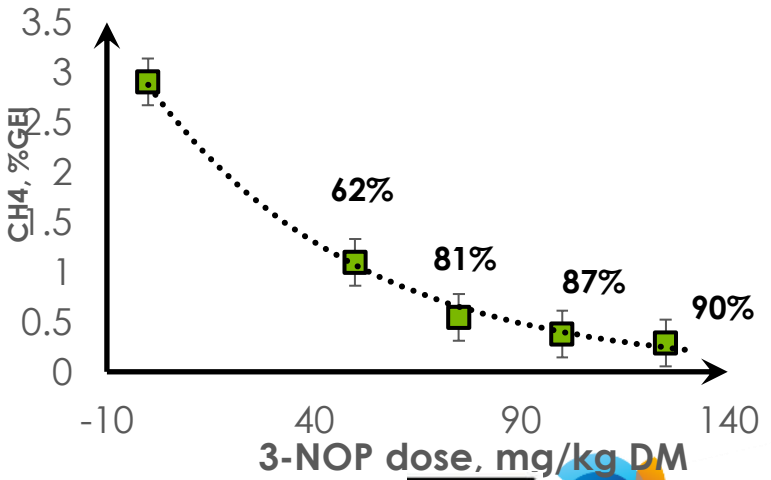
- 20 adult Angus steers assigned to 5 treatment groups (0, 50, 75, 100 and 125 mg/kg DM Bovaer). Animals went through a 3 week step-up adaptation period before entering the finishing phase which lasted 90 days.
- Finishing diet consisted of 83% tempered barley, 3% oaten chaff, 8% whole cottonseed, 2% molasses, 2% Veg oil, 2% dry supplement
- Methane emissions were measured in respiration chambers over a 24 h period on d7, 14, 21, 28, 49, 70, 91, 112. DMI was measured daily, BW weekly

Results

- **Methane emissions (g/d, g/kg DMI, CH4 %GEI) were significantly reduced (P<0.01) at all dose rates, with the greatest reduction observed (-90%) at 125 mg/kg DM**
- **In terms of performance, animals performed very well, approx 2 kg/d ADG, 9.8 kg/d DMI. No significant difference was observed between control and the different dose rates of Bovaer.**







Conclusions

- Bovaer®, formerly known as 3-NOP, a methane inhibitor, has been proven to be highly specific in targeting the methanogenic archaea and efficacious in reducing methane emissions across different ruminant species fed different diets.
- New strategies such as feeding Bovaer® as an intervention in Early Life are showing promise as having persistent effects on methane reduction, even after supplementation has stopped.
- This approach will prove key in extensive pastoral-based systems.
- Further research into the use of Bovaer® is currently ongoing to maximise its use in pastoral-based systems and to be able to understand diet interactions on methane mitigation potential.
- Recent trial in adult finishing beef cattle has observed more than 90% reduction in methane emissions.

Acknowledgements and a big thank you to all our research partners