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Effects of dietary nitrate and increased lipid on methane emissions from beef cattle are independent

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Study part of larger project

NUTRI-BEEF

"Nutritional improvements using diets and novel feed additives to enhance overall efficiency of beef production including meat quality and mitigation of greenhouse gas emissions as identified by characterization of the rumen microbial population"

Session 44: Cattle feeding practices and efficiency:

Carol-Anne Duthie et al.

Effects of dietary nitrate and increased lipid concentration on the performance of finishing steers abstract 409

Nitrate: mechanism

- Reduction of nitrate to ammonia

$$NO_3 + 4H_2 = NH_4 + 2H_2O$$

yields more energy than

$$CO_2 + 4H_2 = CH_4 + 2H_2O$$

- If 100% effective, for 1 mole nitrate (62 g) fed there is a reduction of 1 mole (16 g) in methane emissions
- Nitrate used successfully in previous experiments
- Potential problem: nitrite toxicity

Feeds containing lipid: mechanism

- Reduction in enteric methane emissions
  - Non-fermentable feed component
  - Inhibition of protozoa, archaea, cellulolytic bacteria
  - Biohydrogenation of unsaturated fatty acids
- Many different potential feeds for cattle

<u>Different mechanism to nitrate</u>

Limitations to inclusion

Nitrate

- Nitrite toxicity

Increased lipid content

- Reductions in fibre digestion and feed intake

Hypothesis

The reduction in methane emissions when two mitigation strategies with different mechanisms are combined is additive

2 x 4Factorial Design

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- 2 **breeds**
  - Crossbred Limousin (LIMx)
  - Crossbred Aberdeen Angus (AAx)
- 1 **basal diet** (DM basis)
  - 520:480 (forage:concentrate ratio)
- 4 **treatments**
  - Control
  - Nitrate
  - Lipid
  - Combined: Nitrate + Lipid
- **20 animals / nutritional treatment**

Ingredient composition (dry matter basis, g/kg)

Ingredient	Control	Nitrate	Lipid	Combined
Grass silage	210	211	209	210
WCBS	347	347	346	346
Bruised barley	336	388	289	263
Rapeseed meal	79	0	0	0
Calcinit	0	25	0	25
Maize dark grains	0	0	128	127
Molasses	19	20	19	19
Minerals*	9	9	9	9

Diet composition (g/kg DM)

	Control	Nitrate	Lipid	Combined
CP	135	141	136	162
NDF	308	295	317	313
Starch	281	308	264	295
Ether extract	25	23	37	36

Time line of the experiment

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Adaptation phase A

- 4 weeks
- Adaptation to the basal diets
- Learning to use feed barriers

Adaptation phase B

- 4 weeks
- Adaptation to feed additives, weekly increment of 25%

Feed and productive efficiency

- 8 week test period

Chamber based measurements

- 13 week period

Carcass and meat quality based measurements

- Animals slaughtered in batches

Experimental procedure

- 13 week period
- 6 respiration chambers
- Batches of 6 animals per week
- Animals acclimatised in training pens for 7 days pre- measurement
- Methane measured over 48 h period
- Ad libitum feeding

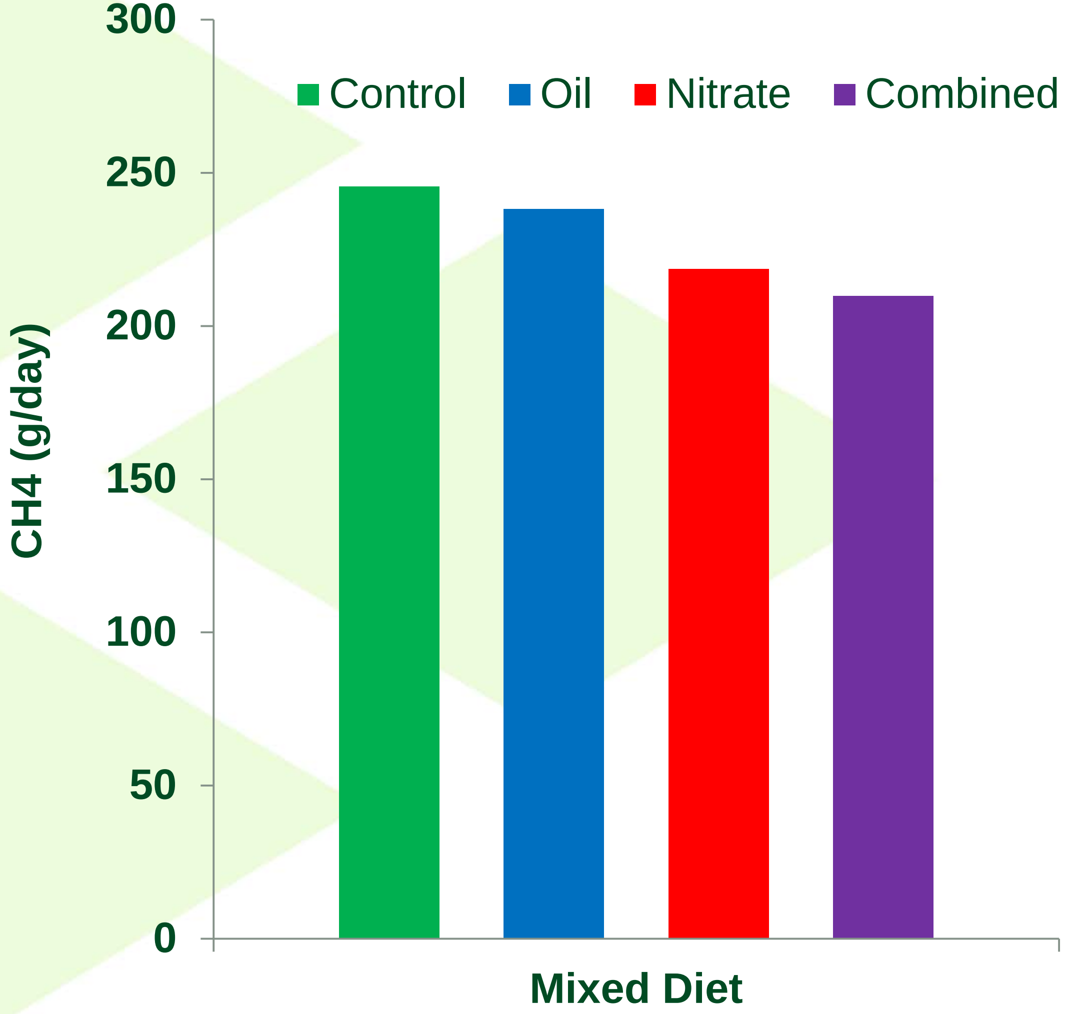
- Methane
- Hydrogen
- VFA in rumen fluid
- Feed intake
- Live-weight

Animal characteristics

	Control	Lipid	Nitrate	Combined
Live-weight (kg)	677	652	650	655
Dry matter intake (kg/d)	10.3	9.8	10.2	10.2

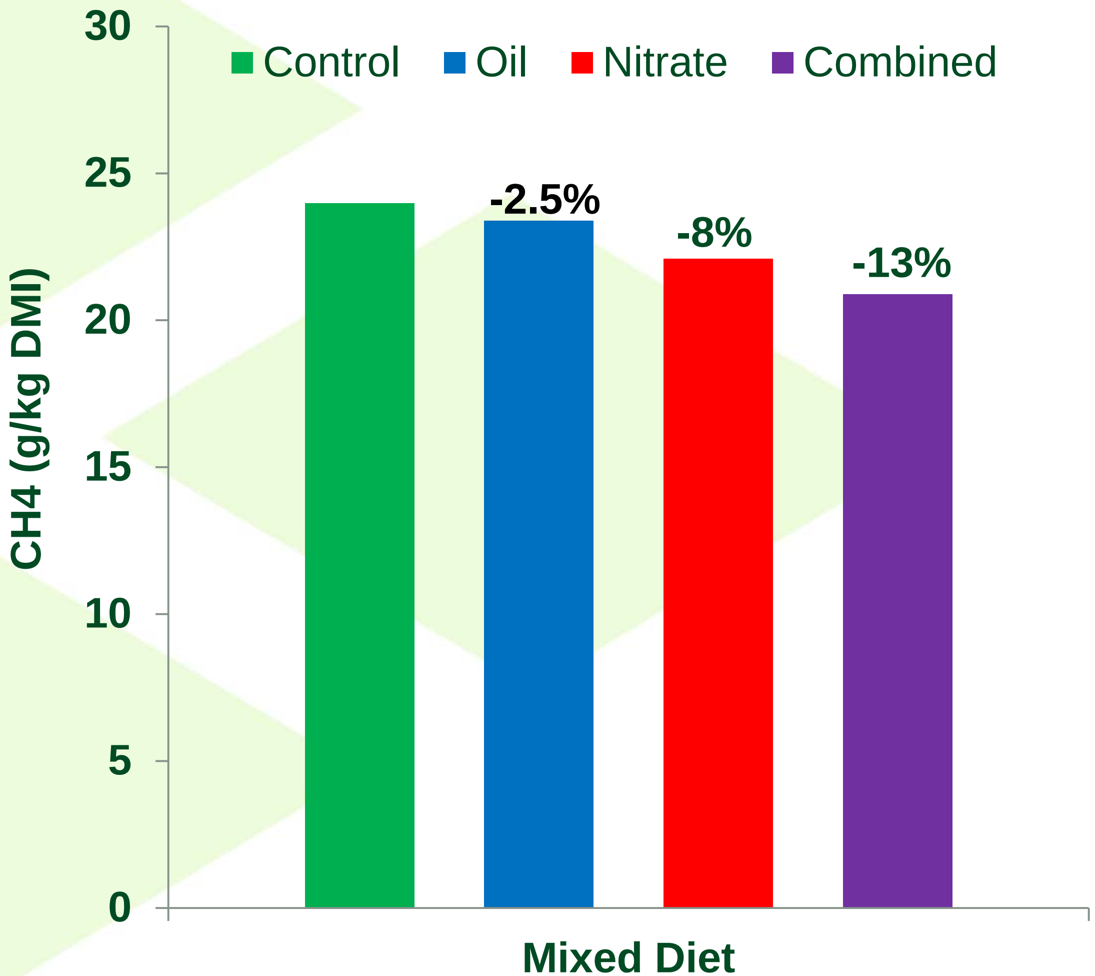
No differences between treatments ($P>0.05$)

Methane emissions – g/day



- Significant reduction in CH_4 by adding nitrate ($P<0.001$)
- No overall effect of adding lipid; non-significant reduction ($P=0.37$)
- No interaction between nitrate and lipid ($P=0.59$)
- AAx produced more CH_4 than LIMx (g/day; $P<0.001$)

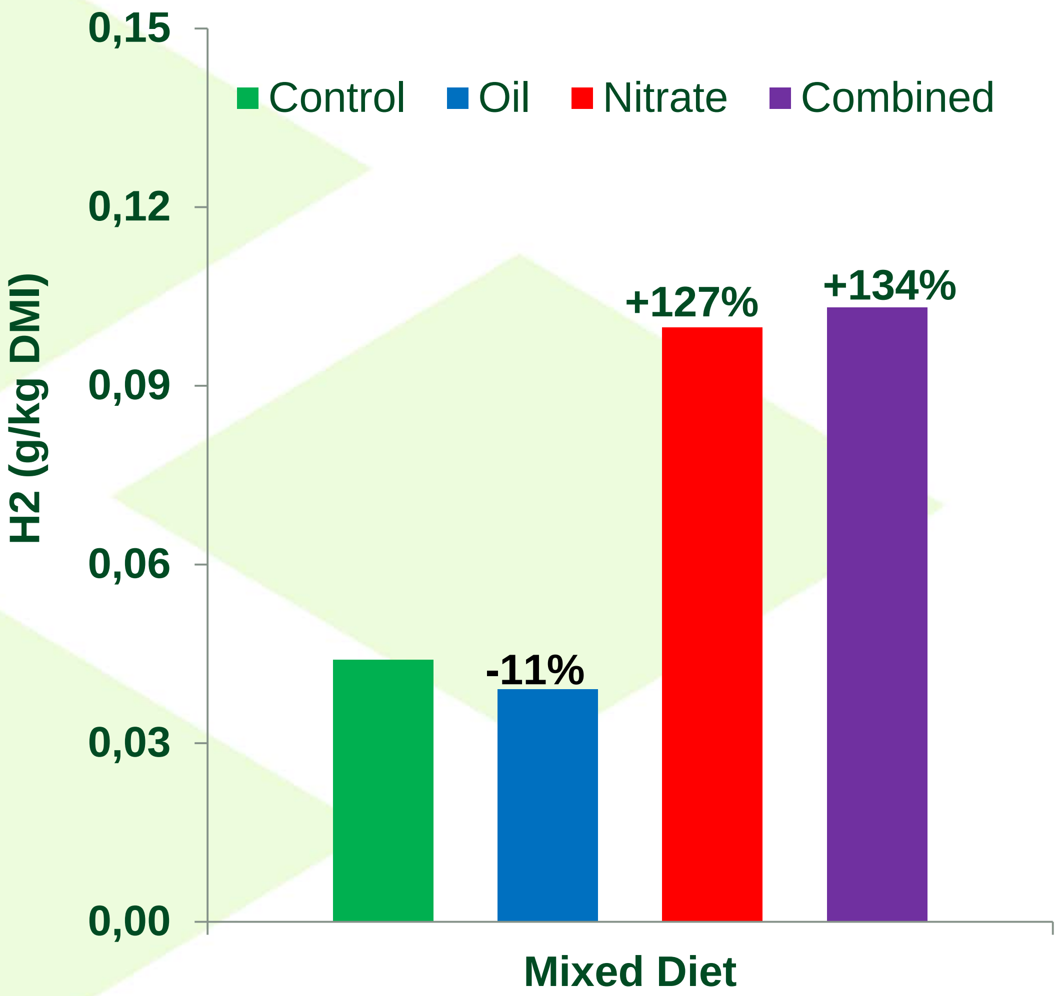
Methane emissions – g/kg DMI



- Significant reduction in CH_4 by adding nitrate ($P<0.001$)
- No overall effect of adding lipid; non-significant reduction ($P=0.12$)
- No interaction between nitrate and lipid ($P=0.82$)
- LIMx produced more CH_4 than AAx (g/kg DMI; $P<0.05$)

Other changes

Hydrogen emissions – g/kg DMI



- Significant increase in H_2 by adding nitrate ($P<0.001$)
- No effect of adding lipid ($P=0.91$)
- No interaction between nitrate and lipid ($P=0.50$)

VFA (mmol / mol total VFA)

	Control	Lipid	Nitrate	Combined
Acetate	664	676	685	696
Propionate	175	164	154	150

Acetate greater ($P<0.001$) and propionate lower ($P<0.01$) when nitrate fed

Acetate greater ($P<0.05$) when lipid fed

Breed effects

	AAx	Limx	Significance
Intake (kg DM/d)	11.0	9.3	**
Methane			
(g/d) (g/kg DMI)	241 22.0	214 23.2	*** *
VFA (mmol/mol)			
Acetate	672	689	**
Propionate	167	155	*

Summary

Nitrate

- Methane emissions reduced by 8%
- 45% of maximum possible from stoichiometry
- Reduction in methane less than in other studies

Lipid

- Methane reduced by 2.5%
- Equivalent to 0.53 g reduction per 10 g/kg increase in dietary lipid
- Grainger & Beauchemin (2011) report a decrease in of c.1 g/kg DMI for every 10 g/kg DM increase in lipid

Combined

- Methane emissions reduced by 13%
- The effects of nitrate addition and increased lipid **were independent**.

Conclusions

- Reductions in methane output from cattle fed nitrate and dark grains are independent

- **Compared to previous study** (Troy et al, 2015: J Anim Sci 93: 1815)
- Nitrate addition resulted in a lower reduction in methane emissions than expected – 45% of the theoretical CH_4 reduction potential in this study, compared with 80% of the theoretical CH_4 reduction potential (Troy et al)
- Nitrate had a negative impact on growth and feed efficiency (Duthie et al., abstract 409): no effect of growth in Troy et al.

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