Feed additives - part of the solution to reduce livestock's contribution to GHG emissions?

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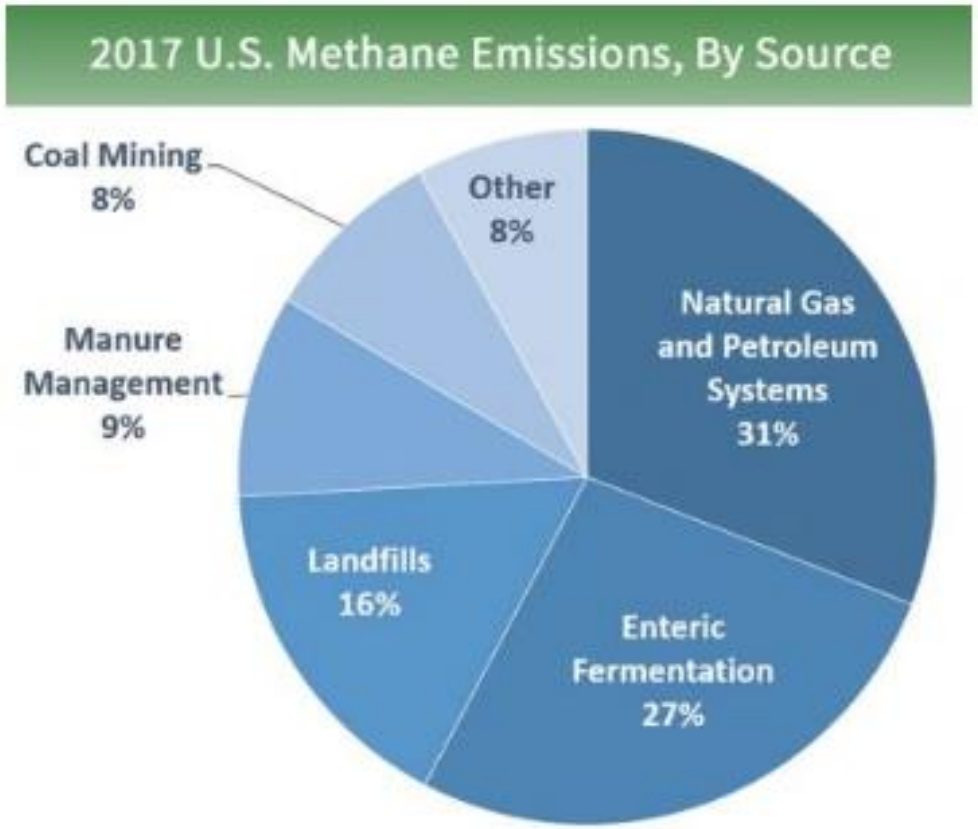
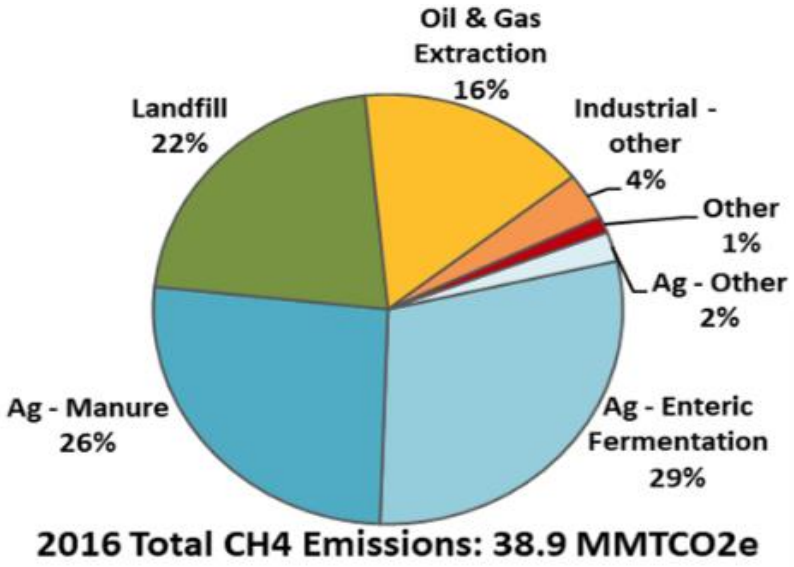
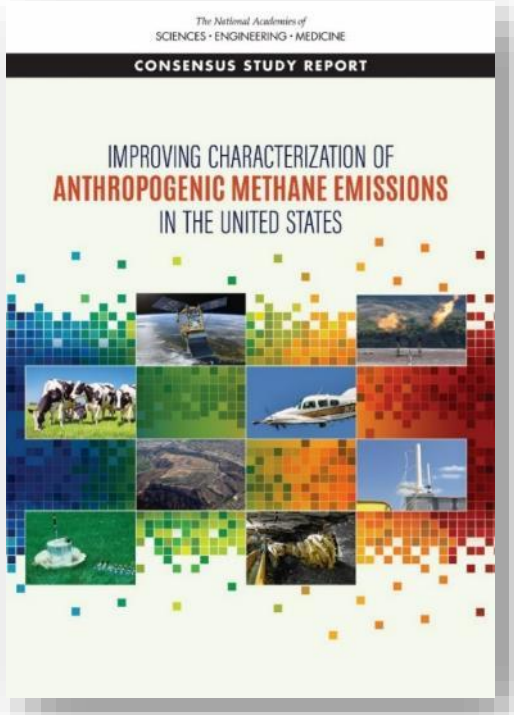
SUSTAINABLE AGRICULTURE at UCDAVIS

Methane Emissions in California





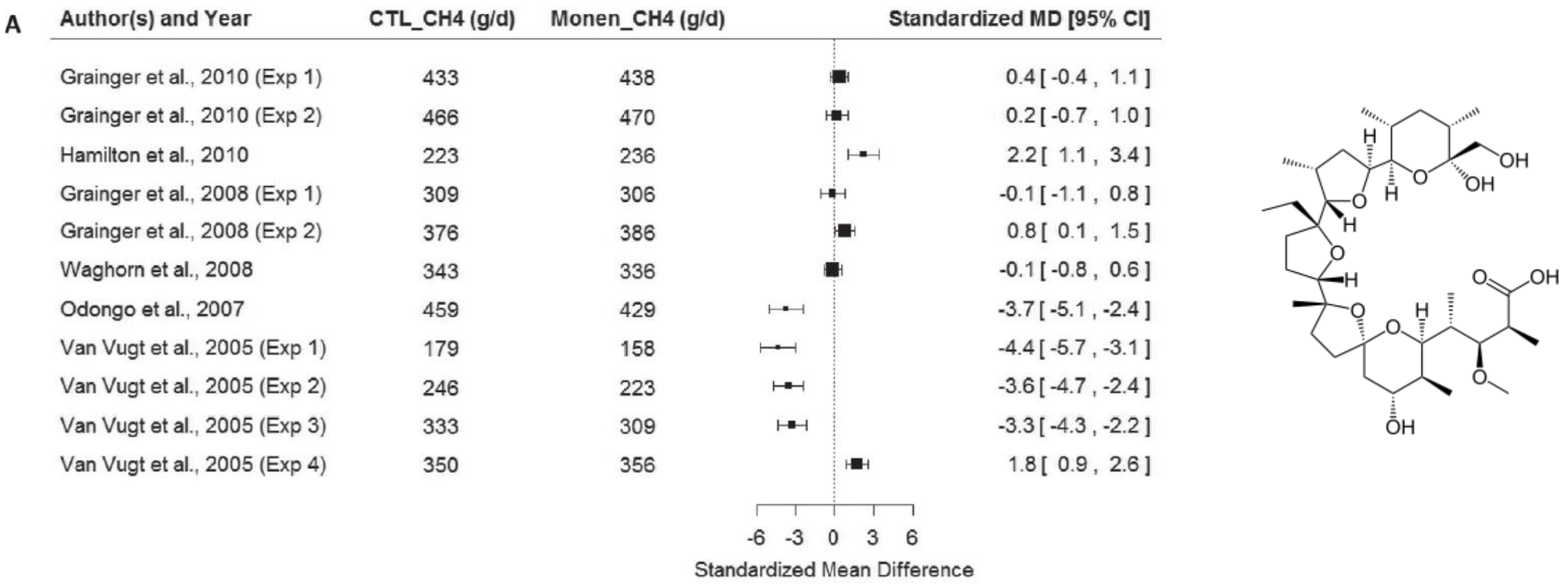


Feed Additives

- Rumen Modifiers
  - Ionophores
  - Plant Bioactive compounds
  - Direct Fed Microbials
  - Dietary Lipids
- Inhibitors/Electron receptors
  - Nitrates
  - 3-nitrooxypropanol
  - Seaweed

Ionophores

- Monensin in beef and dairy in North America



(Appuhamy et al. 2013)

Plant Bioactive Compounds

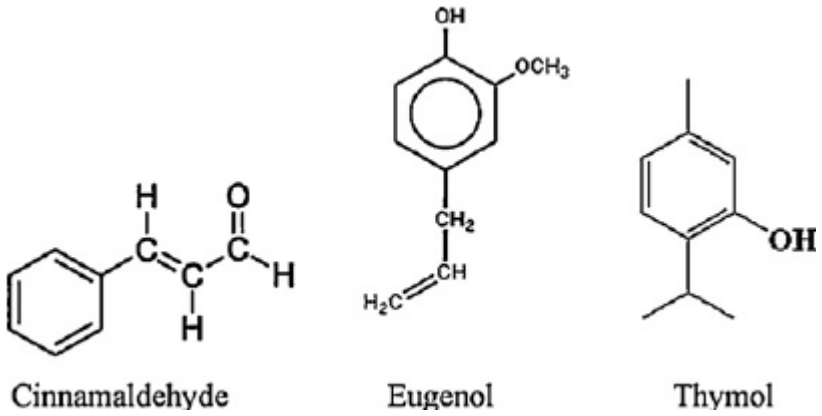
- Tannins and saponins show promise
- Grape pomace contains tannins and may reduce emissions

Parameter[2]	Treatment		
	CON	DGM	EGM
Number of cows	11	10	9
CH_4 (g/cow per day)	470[a]	375[b]	389[b]
CH_4 (g/kg of DMI)	26.1[a]	20.2[c]	21.5[b]
CH_4 (g/kg of milk)	35.3[a]	26.1[b]	35.2[a]
Milk yield (kg/d)	13.4[ab]	15.0[a]	11.5[b]

(Moate et al. 2014)

Bioactives (essential oils/oregano)

- Up to 27% reduction was reported (Hristov et al. 2013)
- Effects on methane production are inconsistent
- Results from in vitro continuous culture studies suggest that rumen microbial populations may adapt to essential oils



Cinnamaldehyde Eugenol Thymol

(Benchaar et al. 2018)

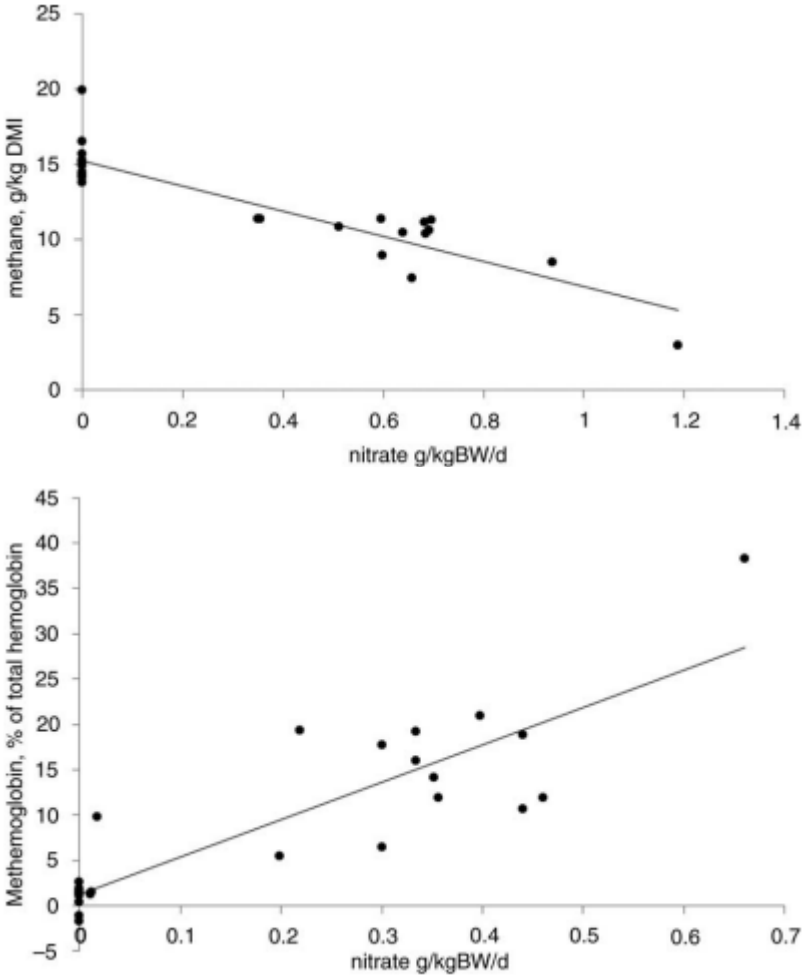
Plant Bioactives (Mootral)

- Made from allicin (garlic extract) and citric extract
- Most work conducted in vitro shows anti-methanogenic effect
- In ewes, allicin reduced methane emissions (Ma et al. 2016)
- New study conducted at UC Davis (results still in preparation)

Inhibitors/receptors (Nitrates)

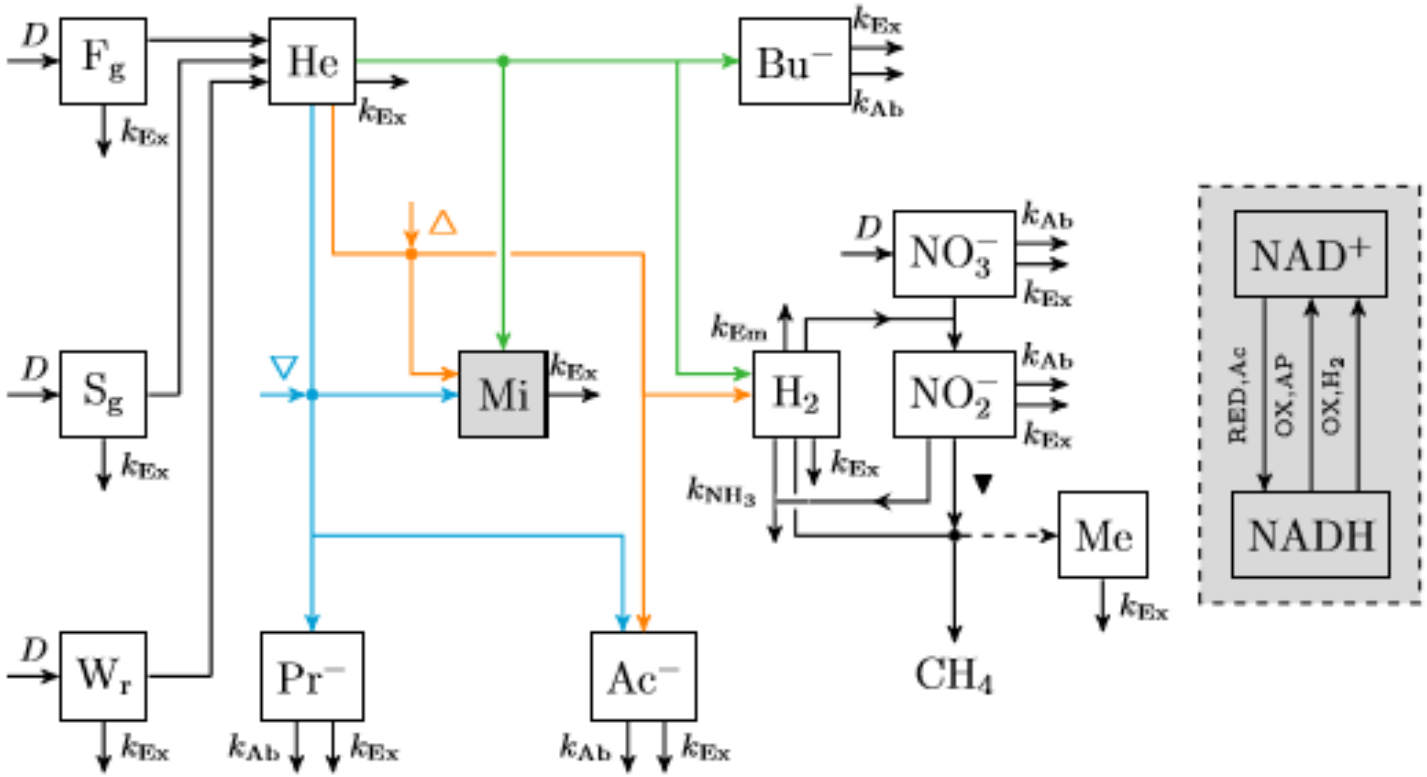
- Decreased 16% methane production(and yield)
- This is less than full theoretical potential (28%)
- Milk yield or energy retention was not affected
- Nitrate fed cows had greater methemoglobin levels

(van Zijderveld et al. 2011)



(Beauchemin et al. 2014)

Inhibitors/receptors (Nitrates)



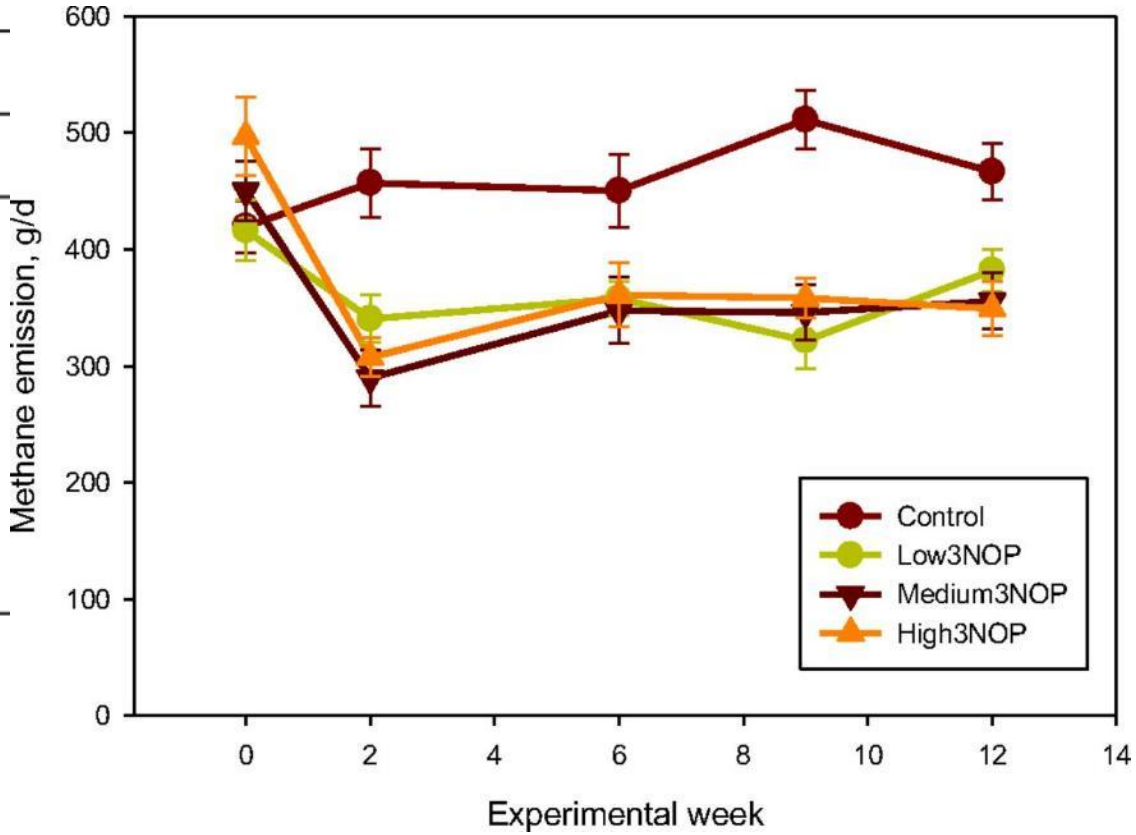
(van Lingen et al. in prep)

Inhibitors (NOP)

Table 2. Estimates of overall 3-nitrooxypropanol (NOP) effect size and of explanatory variables[1] from random- and mixed-effect models for relative mean difference[2] (MD) in CH_4 production (g/d) and yield (g/kg of DMI)

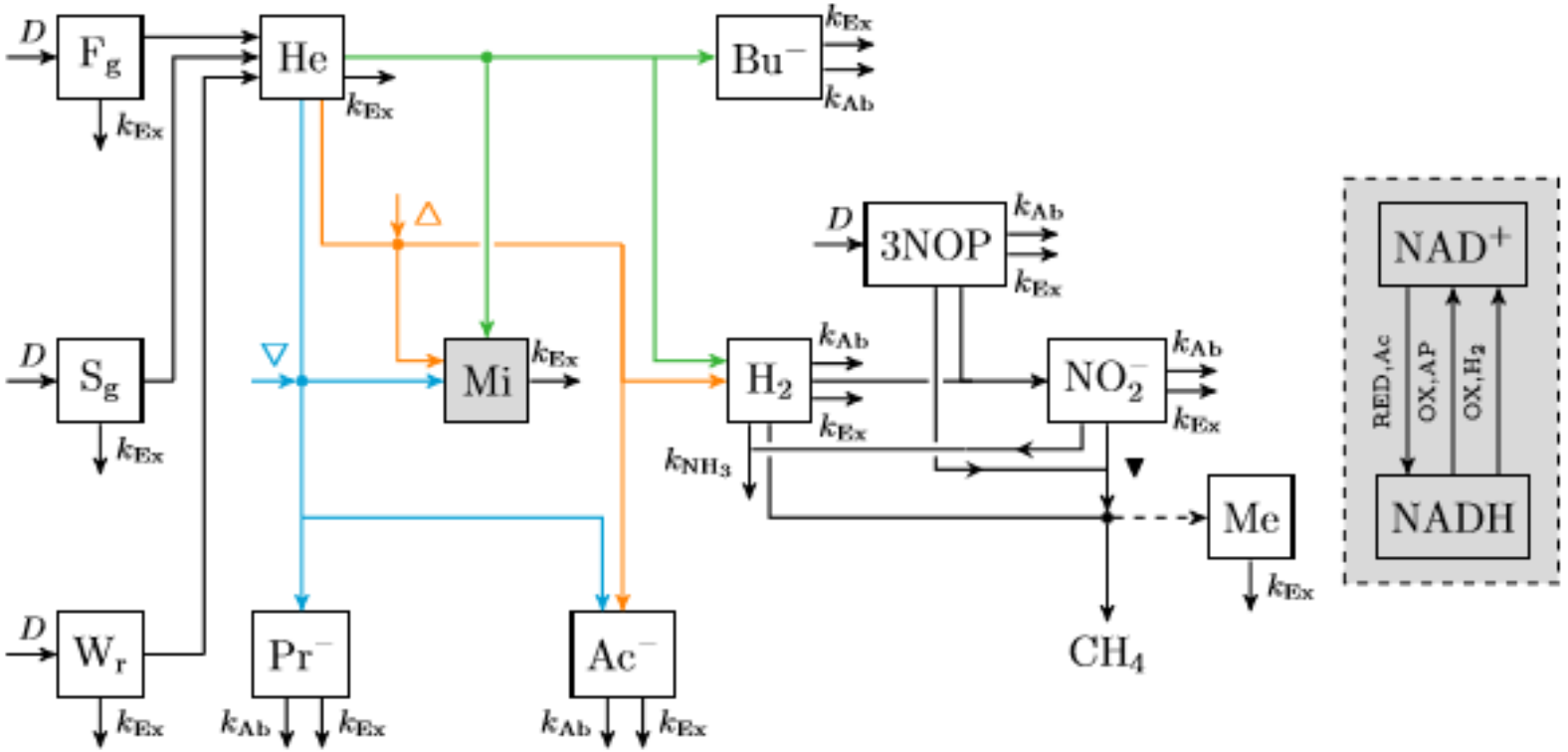
	CH_4 production		
Variable and model	Mean	SE	*P*-value
Random-effect model			
Overall NOP effect size	–32.5	5.74	<0.001
Mixed-effect model, 1 explanatory variable[3]			
Overall NOP effect size	–30.5	4.79	<0.001
NOP dose (mg/kg of DM)	–0.176	0.0441	0.016
Final mixed-effect model[4]			
Dairy cattle	–39.0	5.40	0.002
Beef cattle	–22.2	3.33	0.003
NOP dose (mg/kg of DM)	–0.256	0.0550	0.006
NDF content (g/kg of DM)	0.164	0.0330	0.016

(Dijkstra et al. 2018)



(Hristov et al. 2015)

Inhibitors (NOP)



(van Lingen et al. in prep)

Inhibitors (Seaweed)

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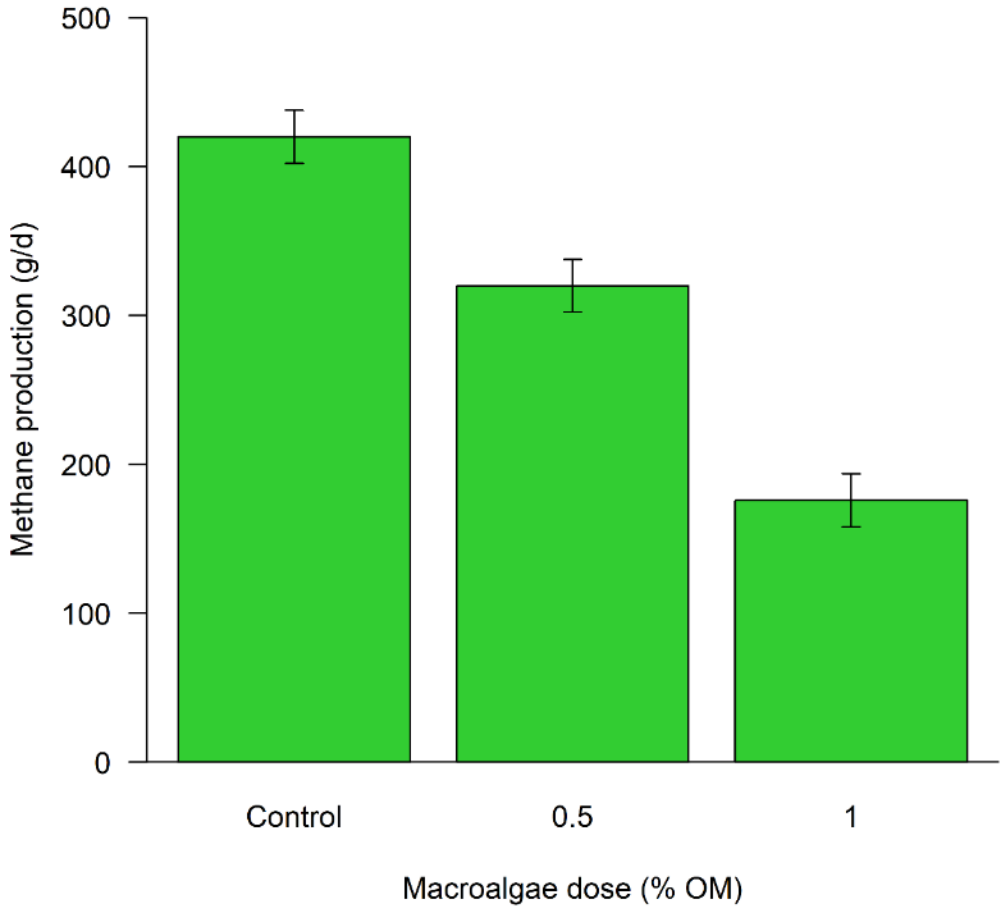
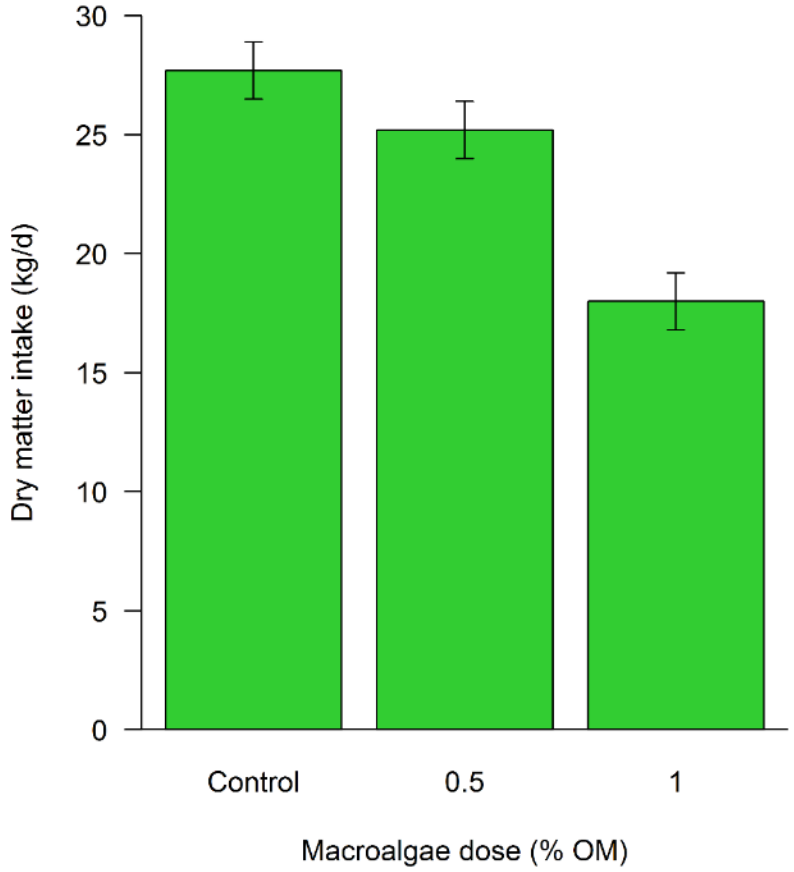
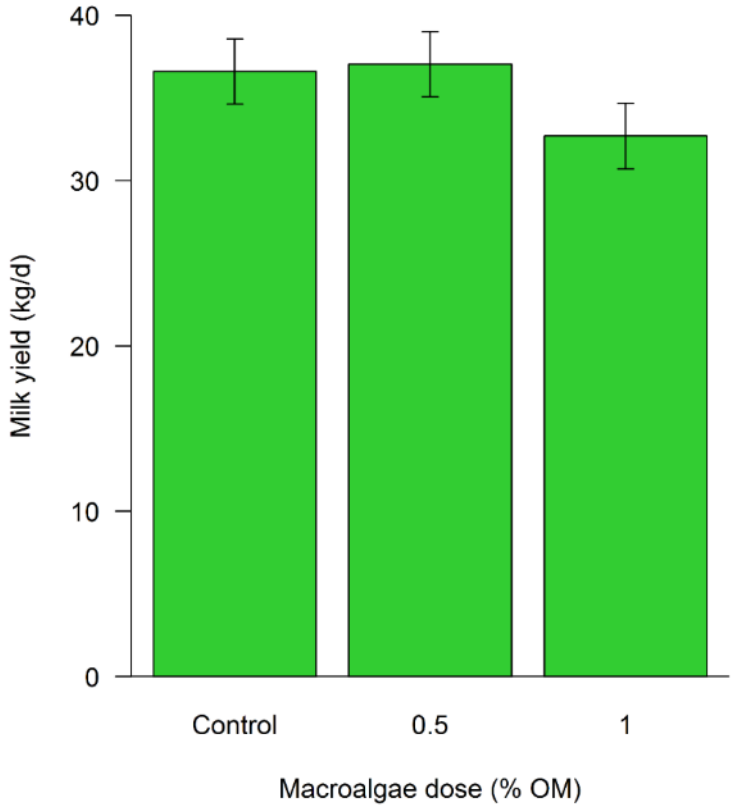


(Roque et al. 2018)

DMI and Methane Yield

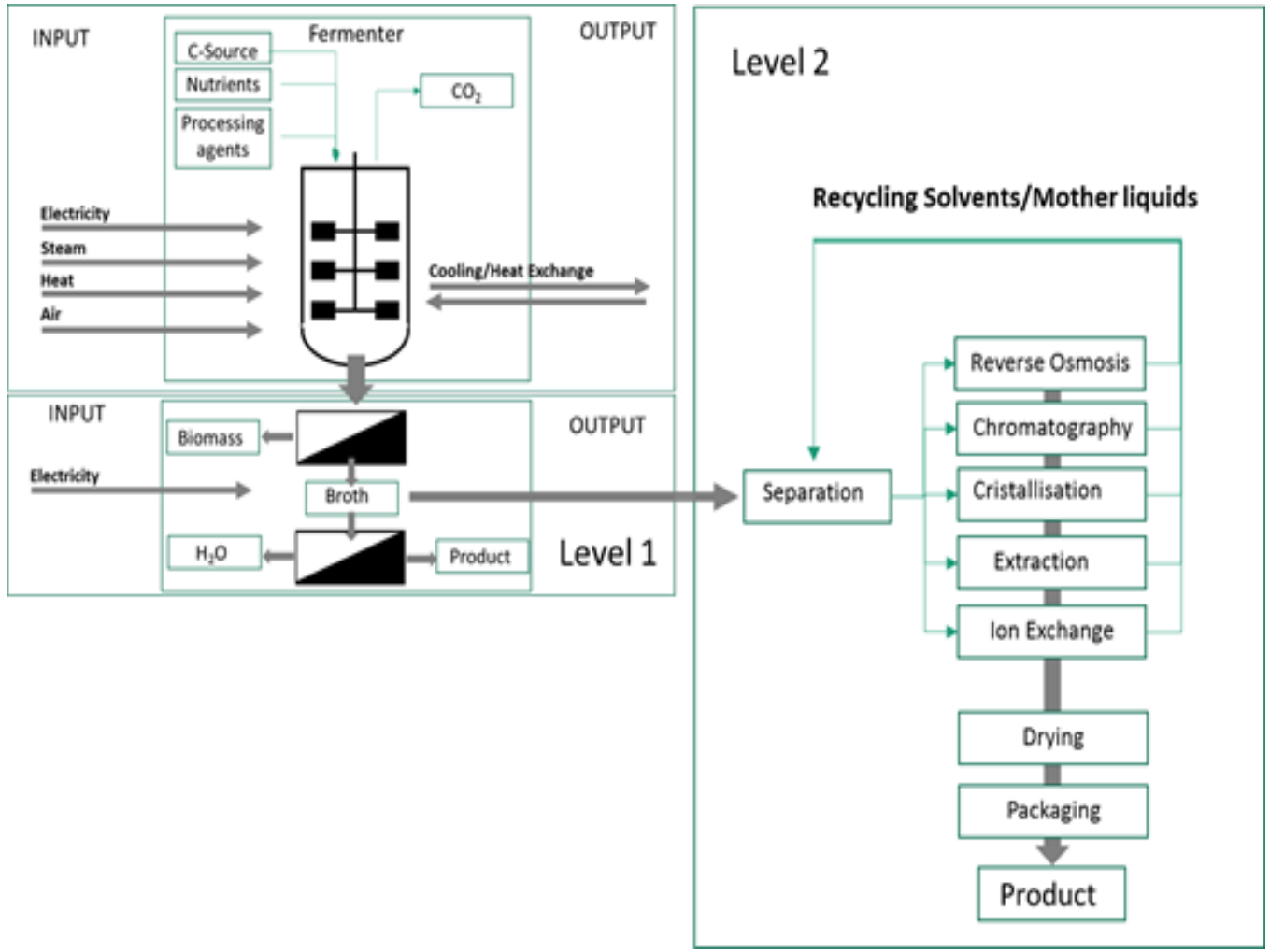


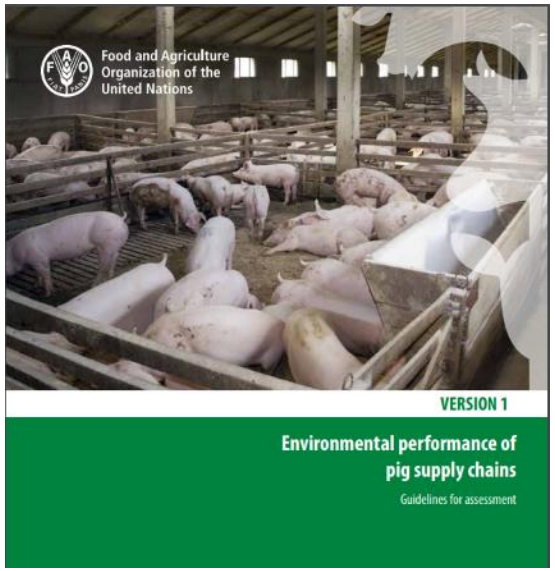


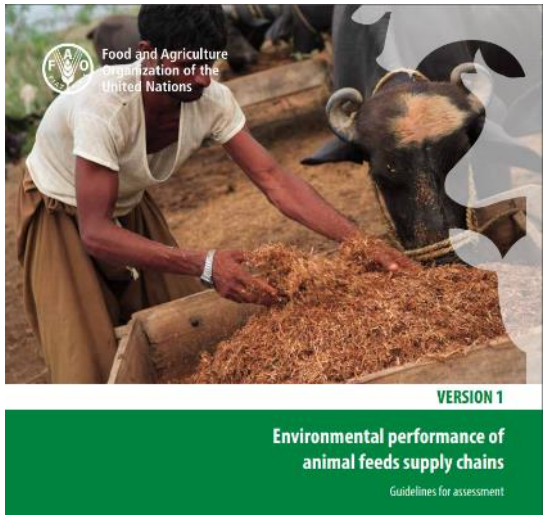
Current Study

- Long term effect of seaweed on
  - production
  - Persistence of mitigation
  - health
- Effect of diet (e.g. fiber content)on efficacy of mitigation
- Effect on product quality (concentration of halogenated compounds, taste, etc)

Lifecycle Analysis







Conclusion

- Several solutions are being developed:
  - Rumen modifiers
  - Inhibitors
- In the next 5 years we will have additives on the market that will reduce enteric methane emissions by at least 30% (net)

Acknowledgment

UCDAVIS World Food Center

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Thank You!

Questions?

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