Advances in technologies for reducing enteric methane emission from livestock

Ermias Kebreab
Professor and Associate Dean, University of California, Davis

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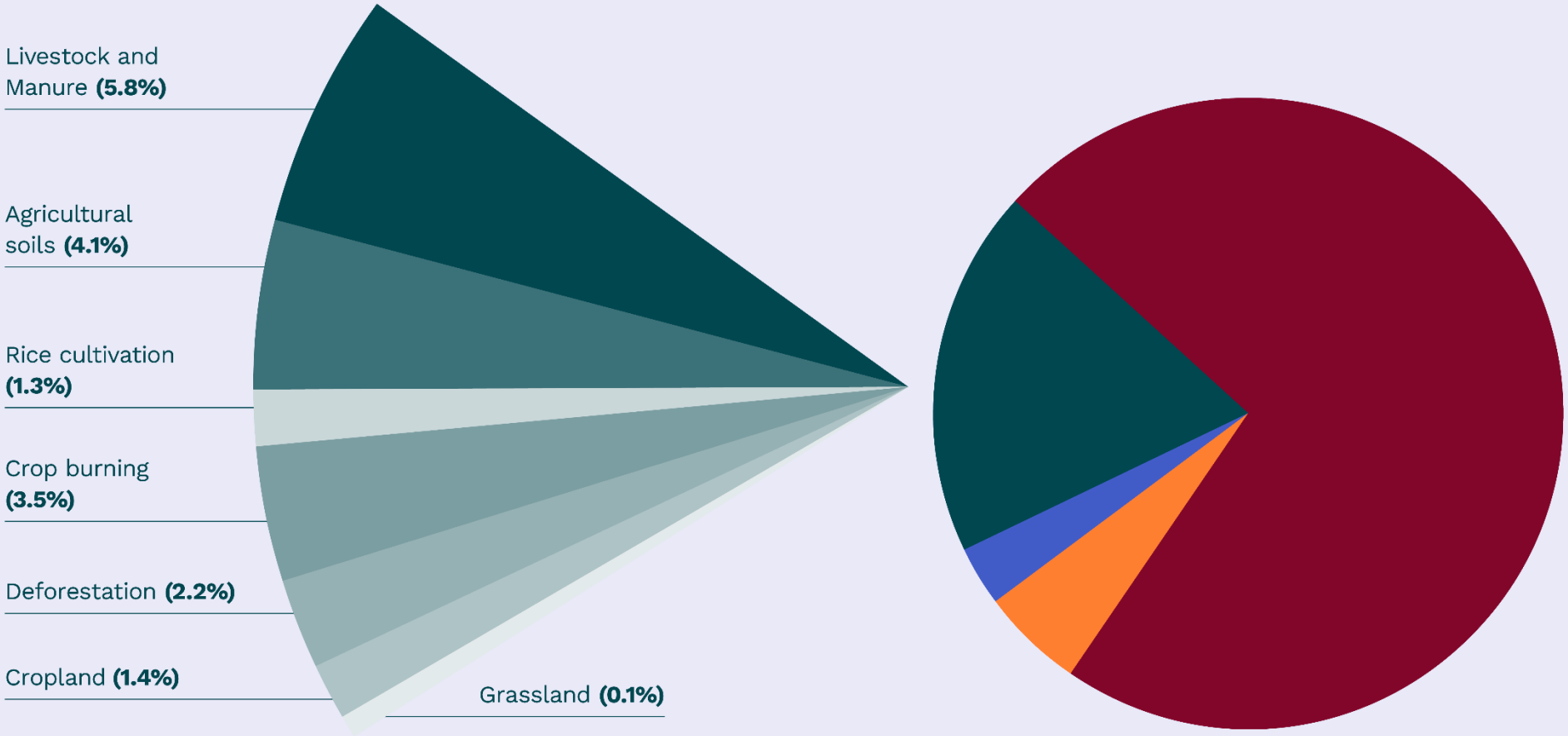
Environmental Impact (Global)



GLOBAL METHANE BUDGET 2008-2017

Global Carbon Project

	Bottom-up view (BU)	Top-down view (TD)
TOTAL EMISSIONS	737 (594-880)	576 (550-594)
CHANGE IN ATMOSPHERIC ABUNDANCE	> 100	13* (0-49)
TOTAL SINKS	625 (500-798)	556 (501-574)

	Bottom-up view (BU)	Top-down view (TD)
Fossil fuel production and use	128 (113-154)	111 (81-131)
Agriculture and waste	206 (191-223)	217 (207-240)
Biomass and biofuel burning	30 (26-40)	30 (22-36)
Wetlands	149 (102-182)	181 (159-200)
Other natural emissions (Inland waters, geological, oceans, termites, wild animals, permafrost, vegetation)	222 (143-306)	37 (21-50)
Sink from chemical reactions in the atmosphere	595 (489-749)	518 (474-532)
Sink in soils	30 (11-49)	38 (27-45)

EMISSIONS AND SINKS

In teragrams of CH_4 per year (Tg CH_4 / yr) average over 2008-2017

The observed atmospheric growth rate is 18.2 (17.3-19) Tg CH_4 / yr. The difference with the TD budget imbalance reflects uncertainties in capturing the observed growth rate.

Anthropogenic fluxes | Natural fluxes | Natural and anthropogenic fluxes

GLOBAL CARBON PROJECT

Methane ~70% Livestock GHG

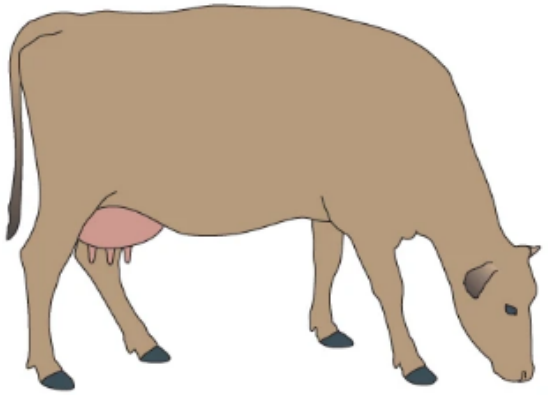
Table 5-1: Emissions from Agriculture (MMT CO_2 Eq.)

Gas/Source	1990	2005	2014	2015	2016	2017	2018
CO_2	**6.7**	**7.5**	**7.5**	**7.8**	**7.1**	**7.6**	**7.7**
Urea Fertilization	2.0	3.1	3.9	4.1	4.0	4.5	4.6
Liming	4.7	4.3	3.6	3.7	3.1	3.1	3.1
CH_4	**217.6**	**238.8**	**234.3**	**241.0**	**245.3**	**248.4**	**253.0**
Enteric Fermentation	164.2	168.9	164.2	166.5	171.8	175.4	177.6
Manure Management	37.1	51.6	54.3	57.9	59.6	59.9	61.7
Rice Cultivation	16.0	18.0	15.4	16.2	13.5	12.8	13.3
Field Burning of Agricultural Residues	0.3	0.4	0.4	0.4	0.4	0.4	0.4
N_2O	**330.1**	**329.6**	**366.7**	**365.8**	**348.1**	**346.2**	**357.8**
Agricultural Soil Management	315.9	313.0	349.2	348.1	329.8	327.4	338.2
Manure Management	14.0	16.4	17.3	17.5	18.1	18.7	19.4
Field Burning of Agricultural Residues	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Total	**554.4**	**575.9**	**608.6**	**614.6**	**600.5**	**602.3**	**618.5**

Note: Totals may not sum due to independent rounding.

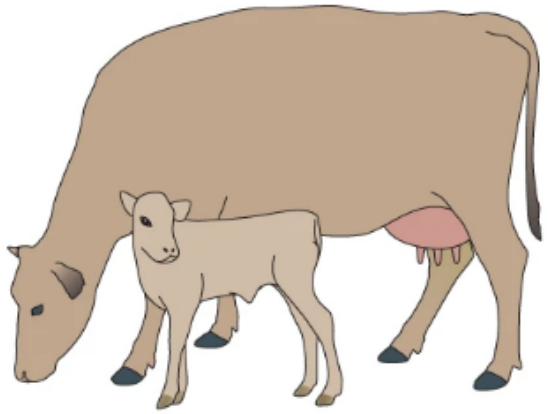
EPA, 2020

Methane Mitigation Strategies



Adult (direct)

- Direct inhibitors of methanogenesis or methanogenic archeae (*A. taxiformis* and 3-NOP)
- Anti-methanogen vaccines



Adult (indirect)

- Chemical composition of the fibre
- Concentrate level in ration
- Lipids and plant extracts
- Alternative metabolic pathways and hydrogen sinks (for example, favouring propionate)
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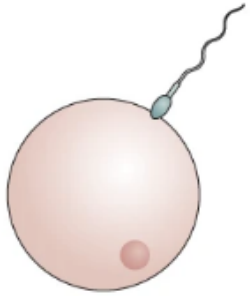


Birth

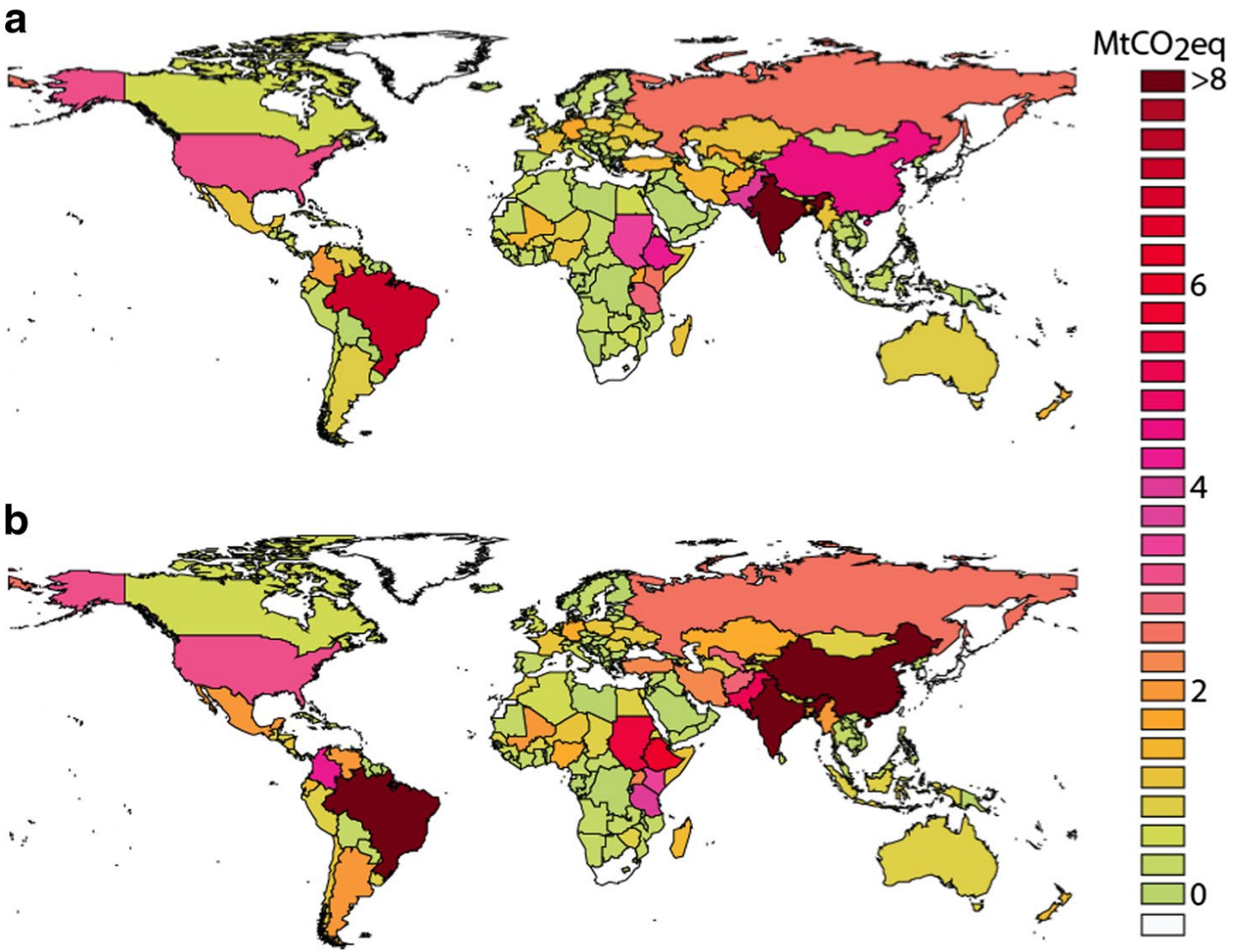
- Defaunation
- Modulation of rumen microbiome development from birth (historical contingency effects)

Prior to birth

- Breeding towards low methane-emitting animals
- Breeding towards modulation of specific microbiome composition

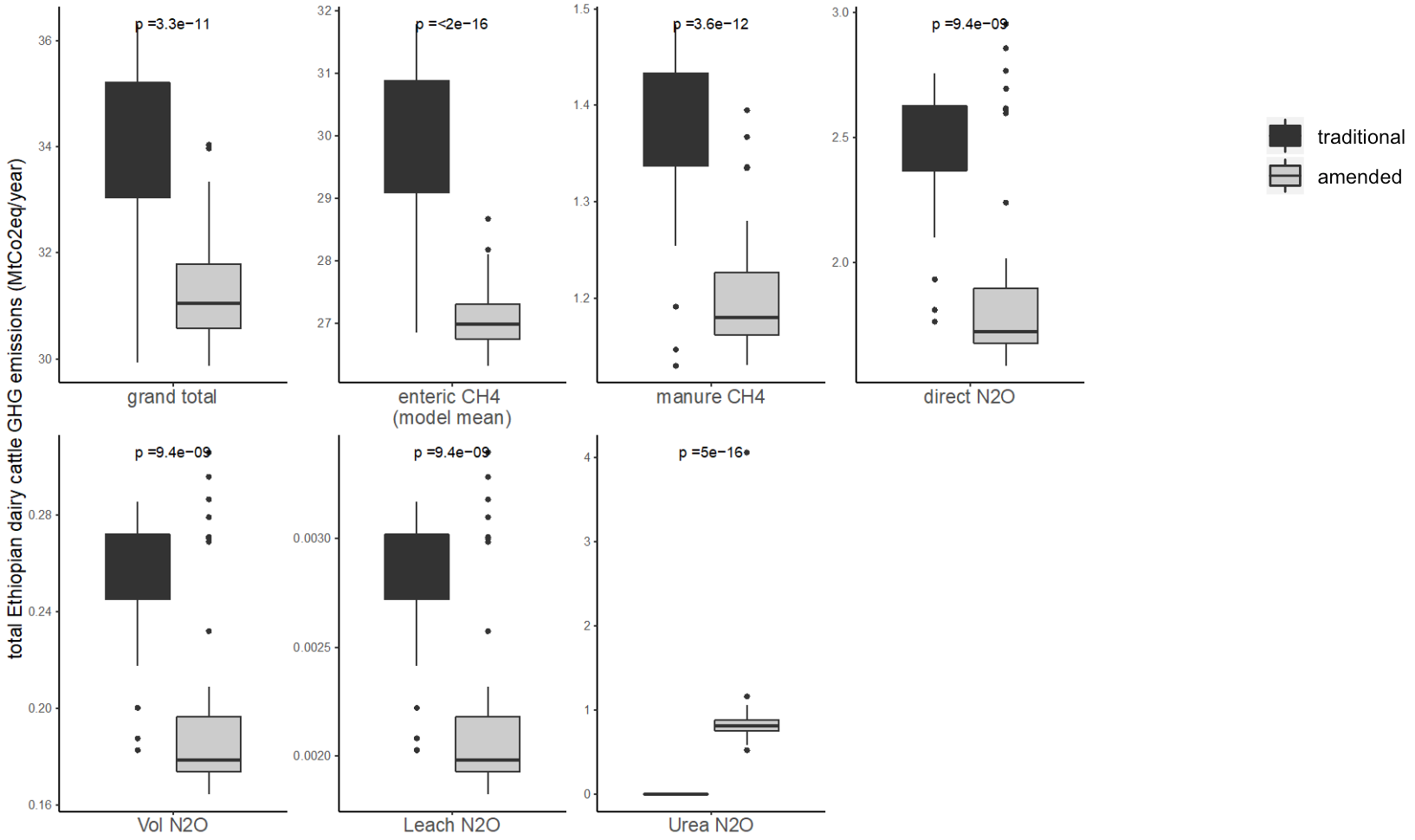
Mizrahi et al. 2021

Potential Solutions - Lipids



Caro et al. 2016

Potential Solutions - Diet



Pressman and Kebreab, in review

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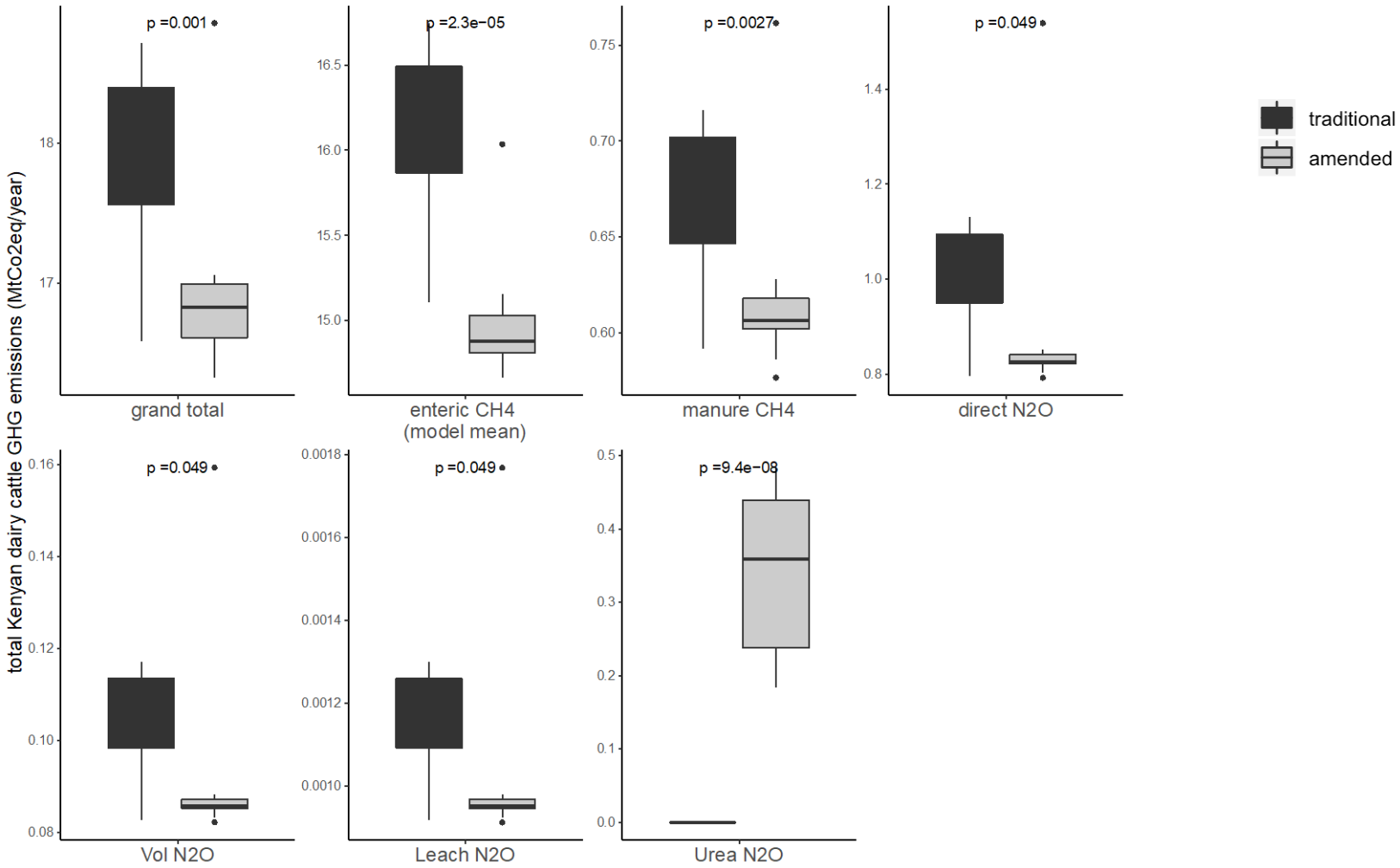

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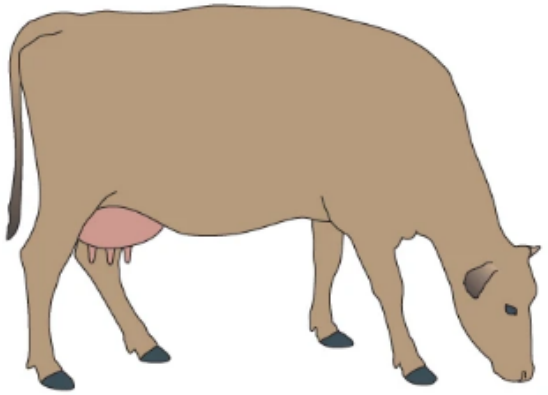
Methane Mitigation Strategies



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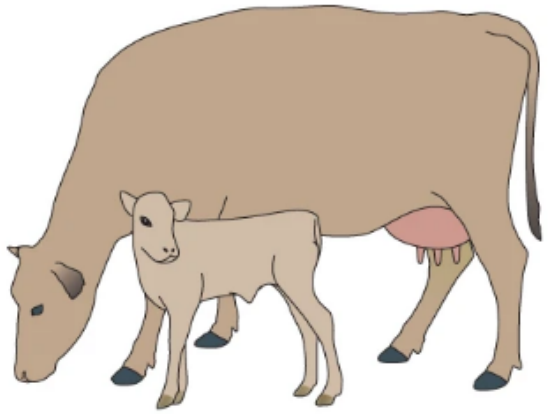

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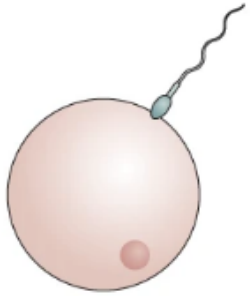
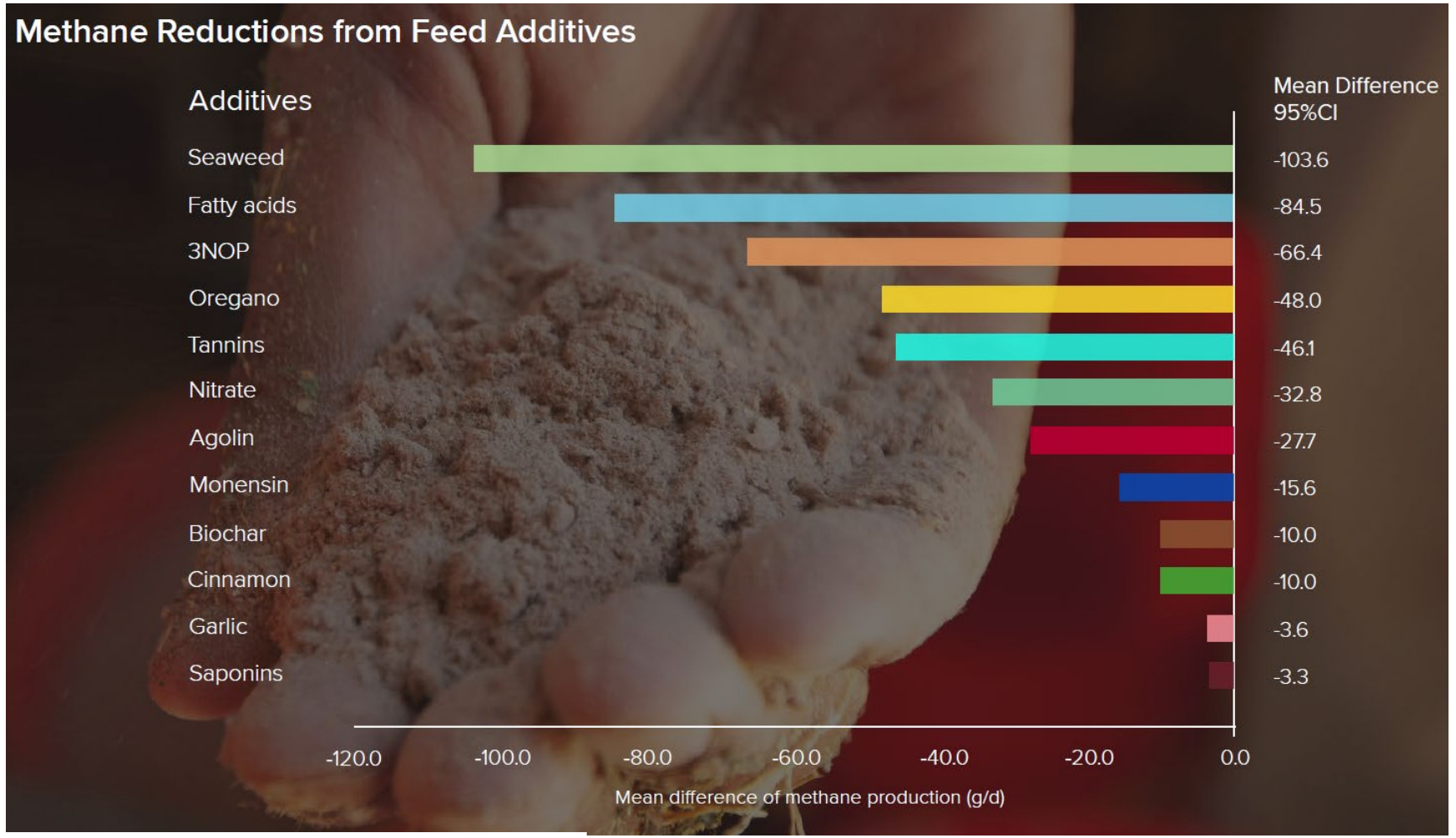


Prior to birth

- Breeding towards low methane-emitting animals
- Breeding towards modulation of specific microbiome composition

Mizrahi et al. 2021

Feed Additives



CLEAR Center
Clarity and Leadership for Environmental Awareness and Research at UC Davis

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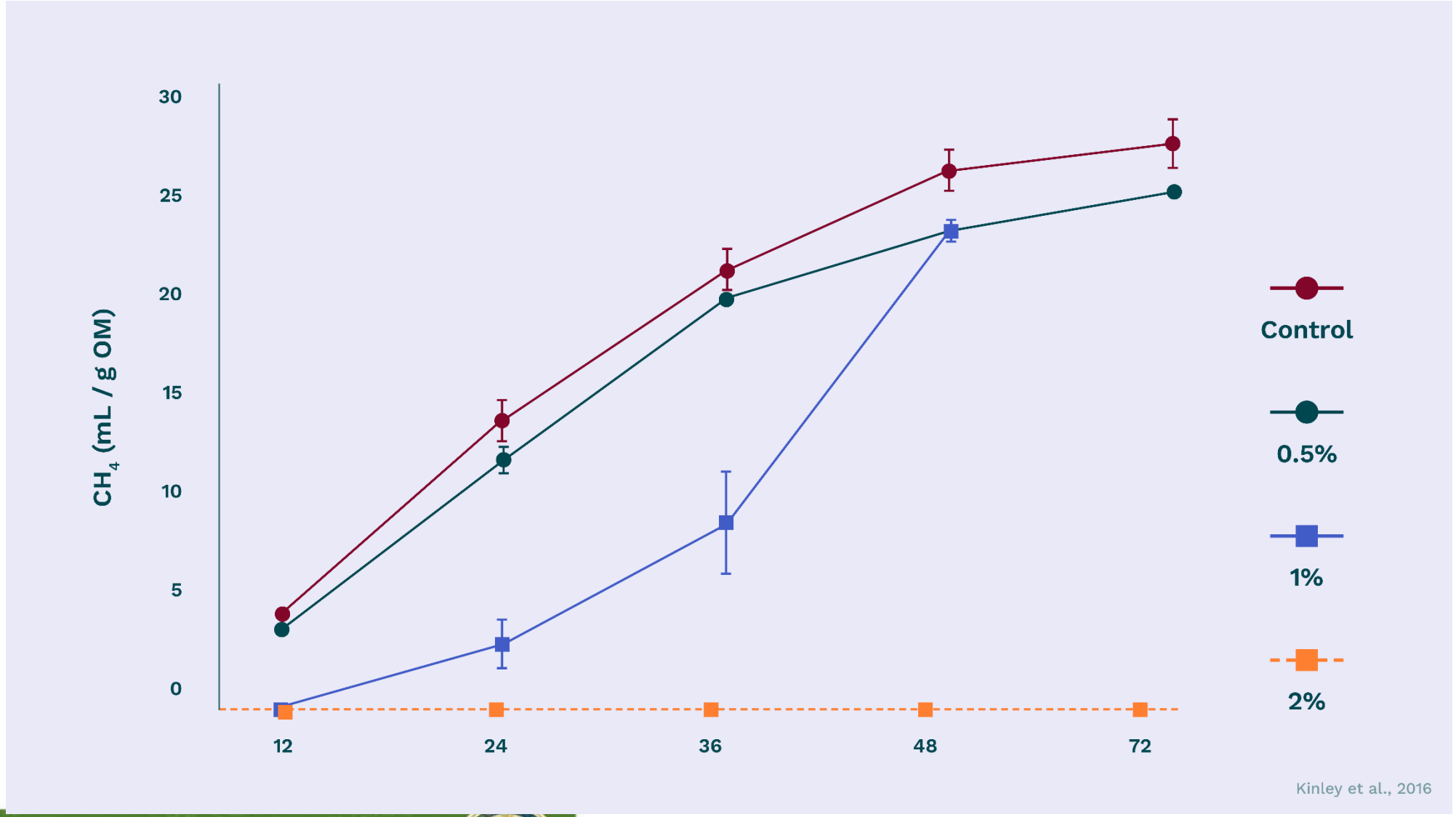
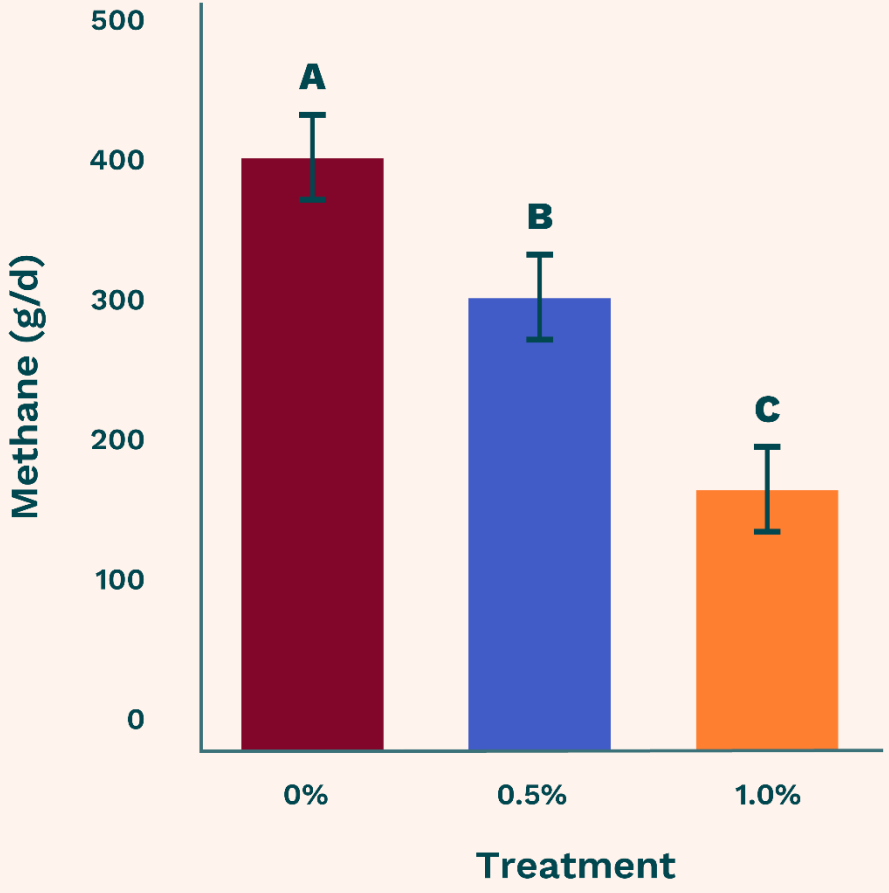
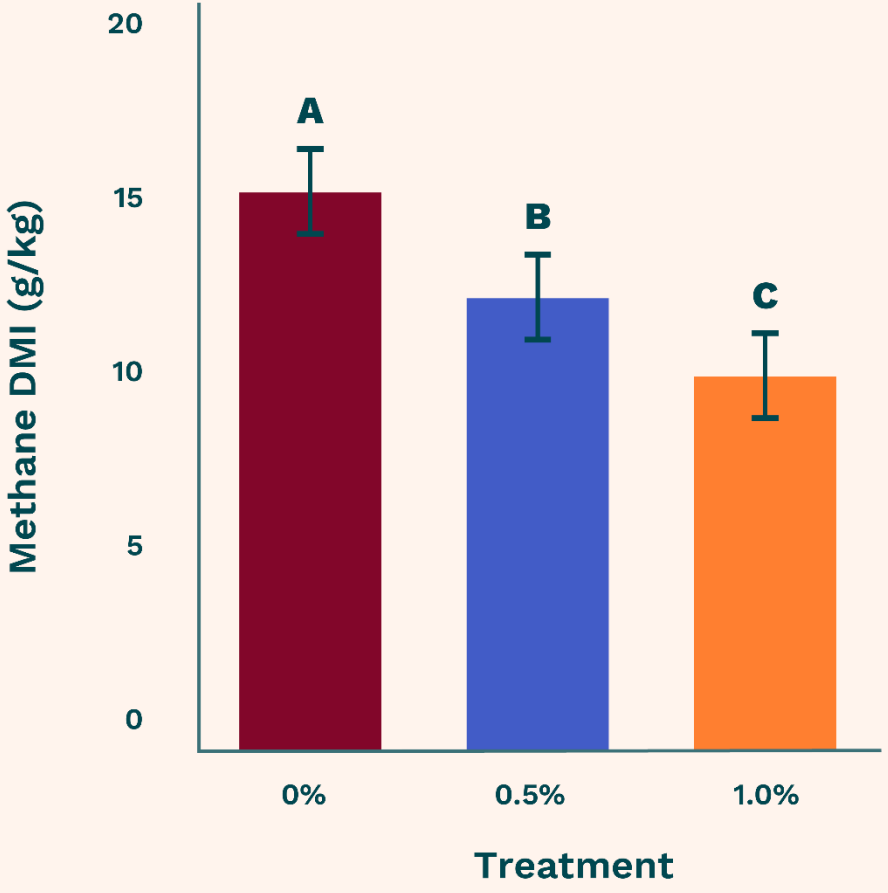
Honan et al. 2021

Macroalgae – in Vitro



Macroalgae – in Vivo



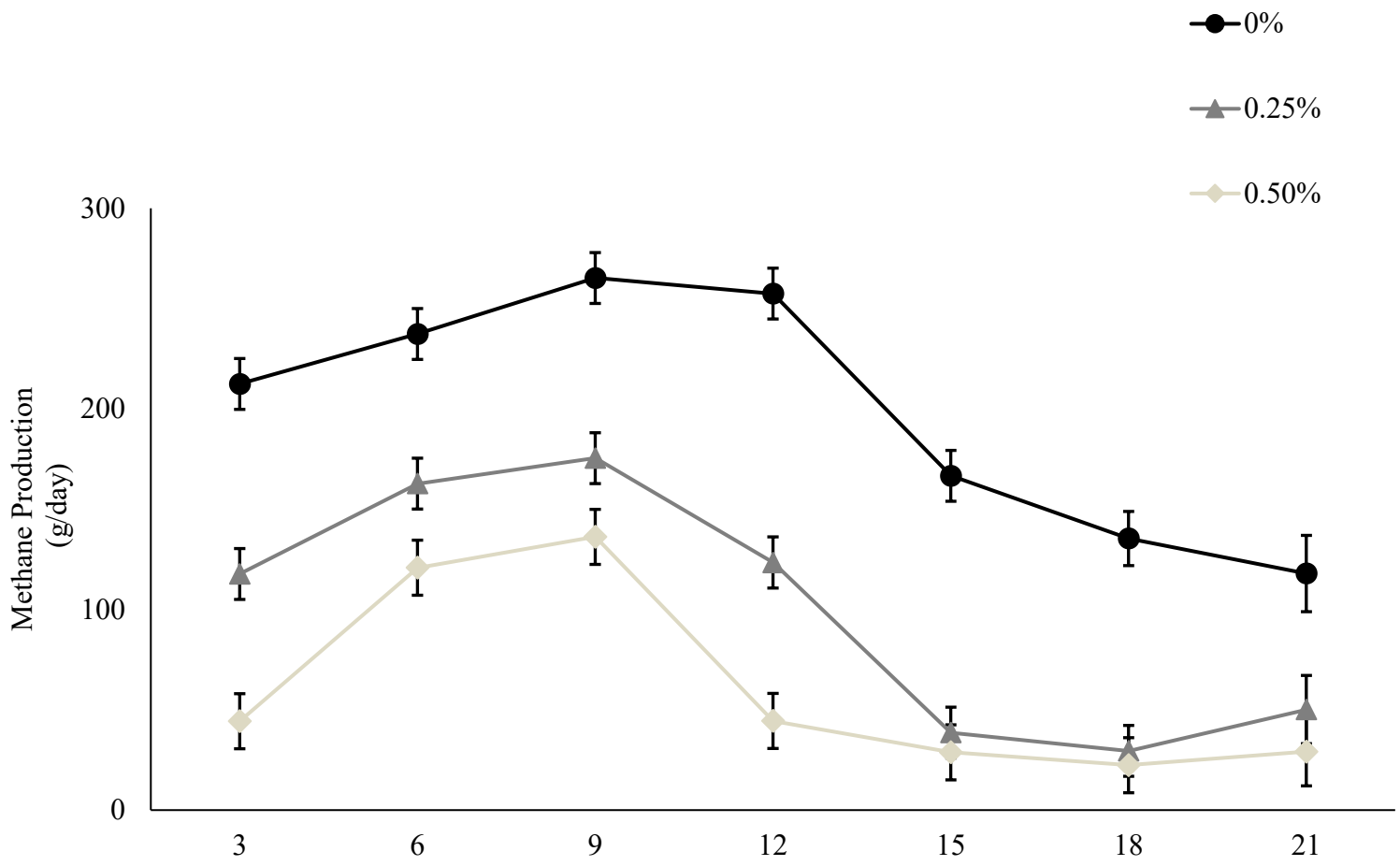


Roque et al., 2019

Follow-up Questions

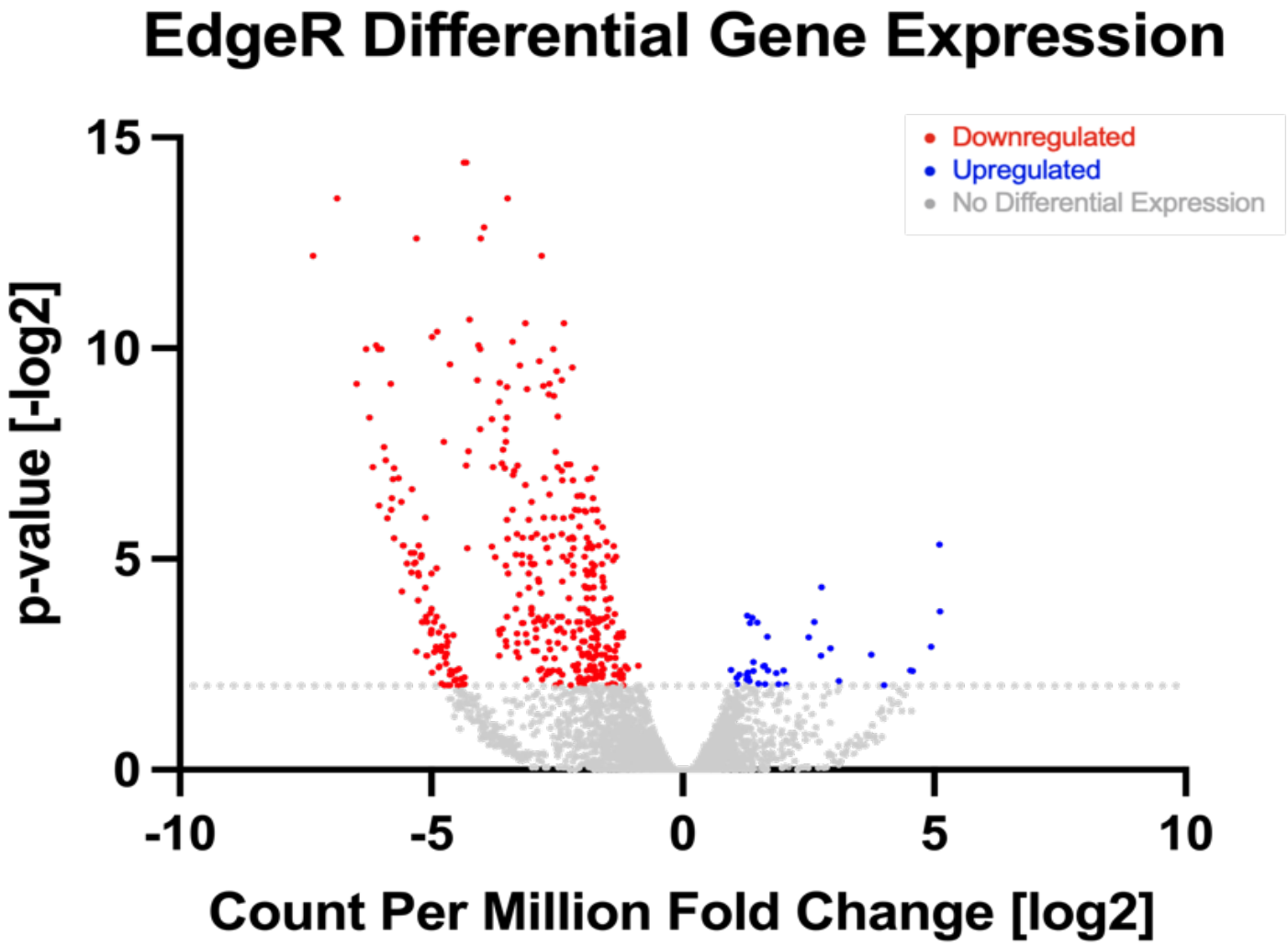
- Would the microbes in the gut get used to it?
- Would the seaweed be stable over a long time in storage?
- Would the taste be affected?
- Or would the seaweed affect the cows' health or milk production?

Seaweed cuts emissions 80% - Beef



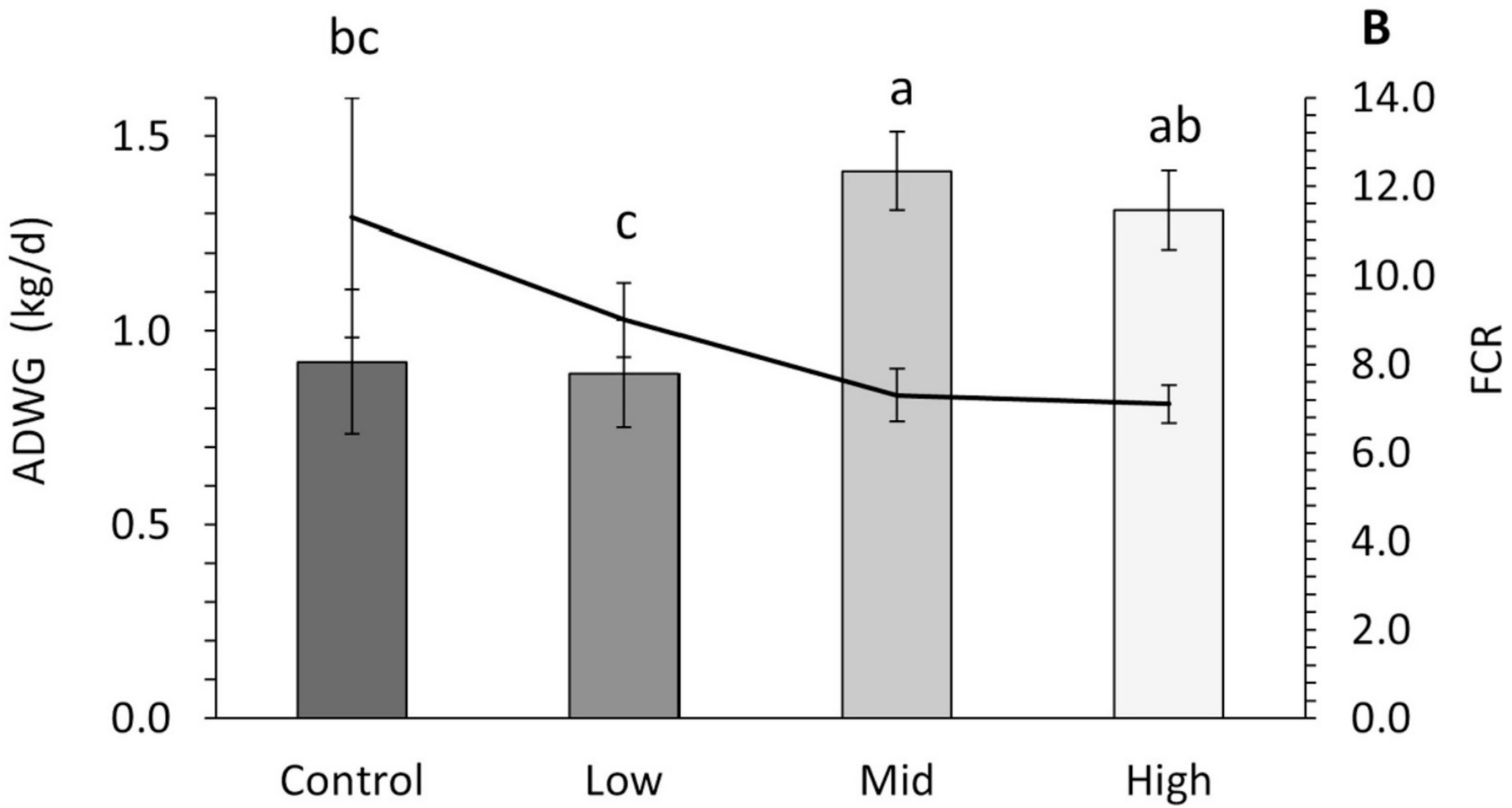
Roque et al. 2021

Seaweed - Mode of Action



Roque et al. 2021

Improved ADG - Beef

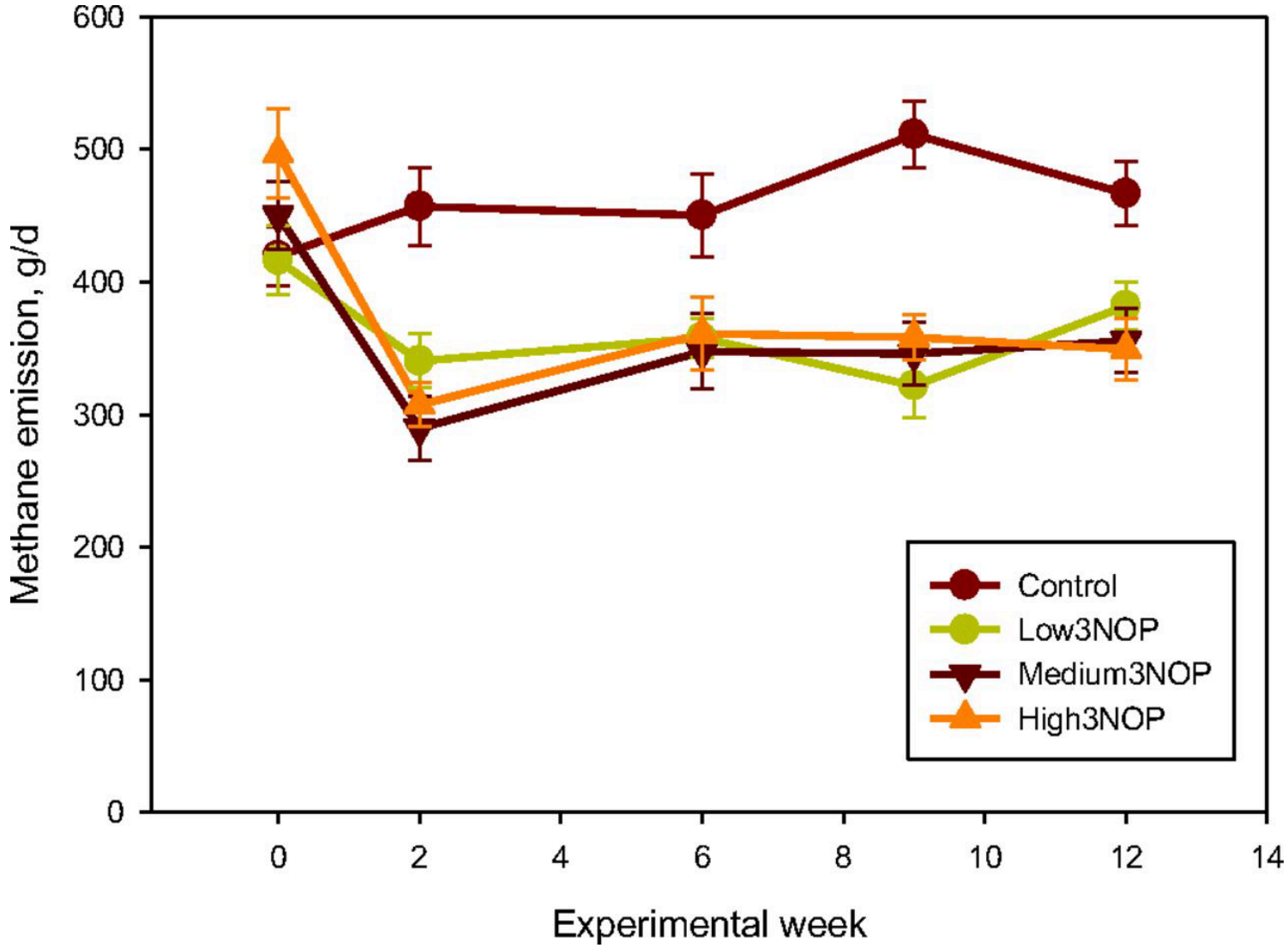


(Kinley et al. 2020)

What next? Growing Seaweed

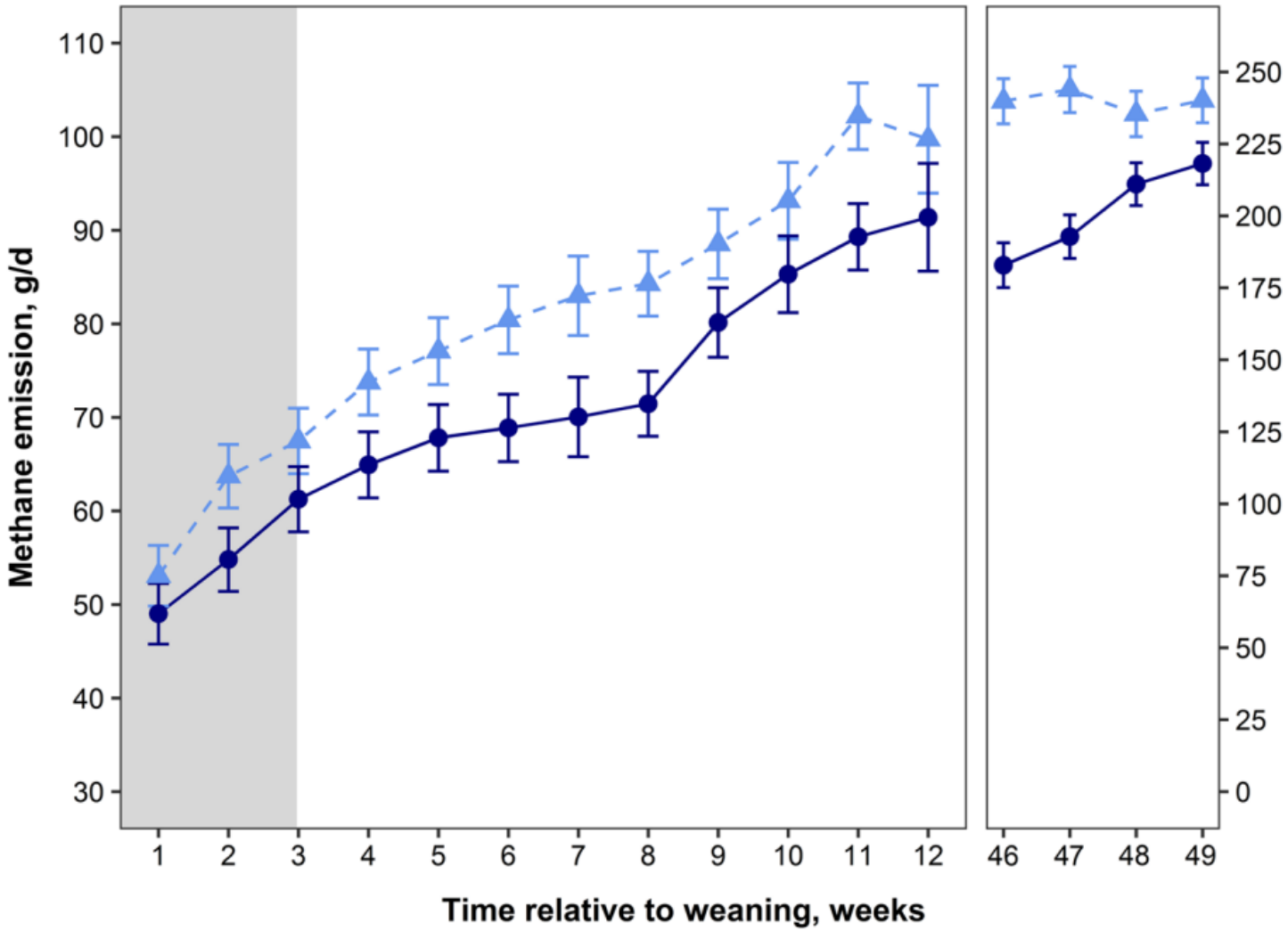
Blue Ocean Barns

3NOP cuts emissions 32% - Dairy



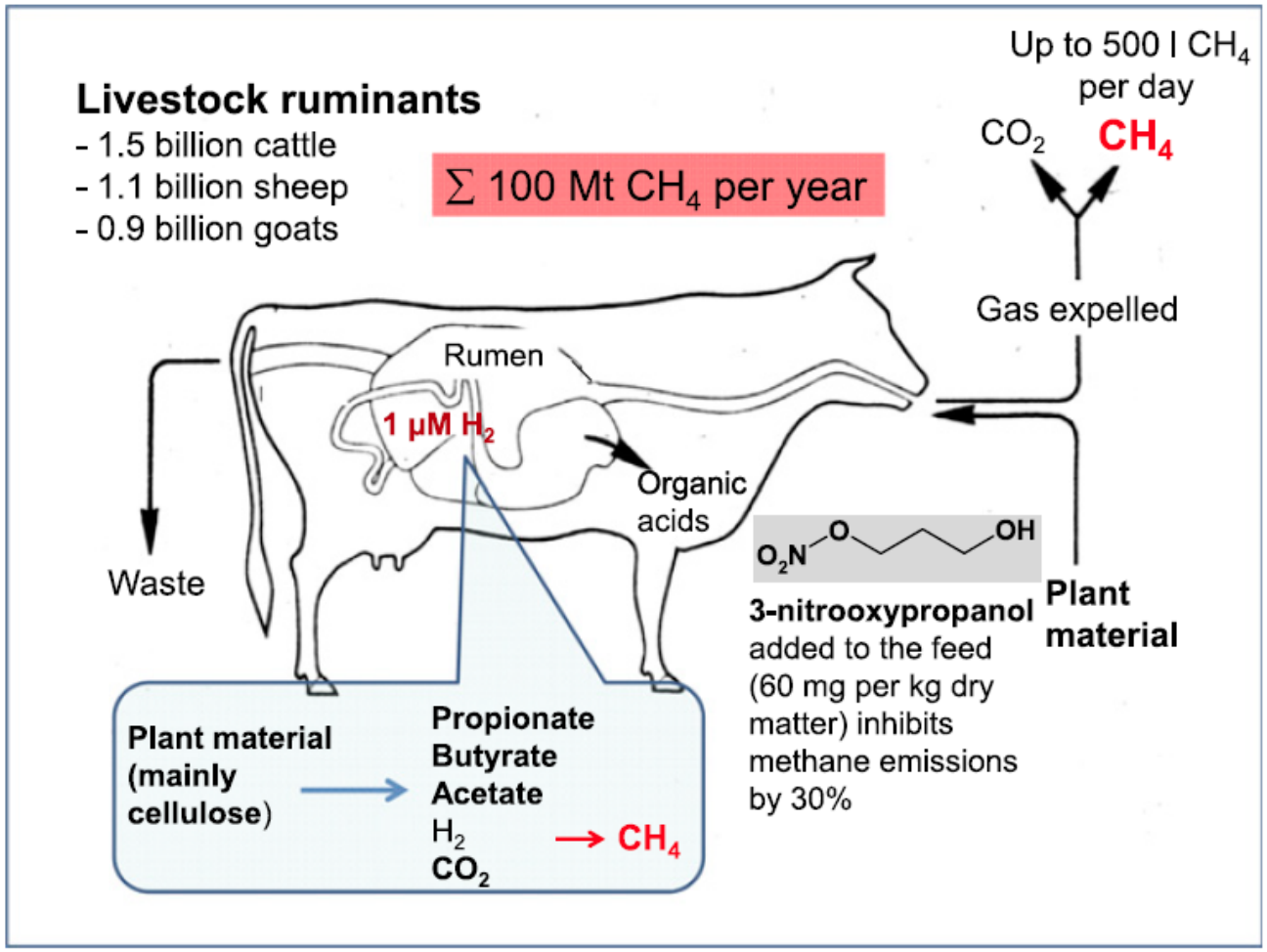
Hristov et al. 2015

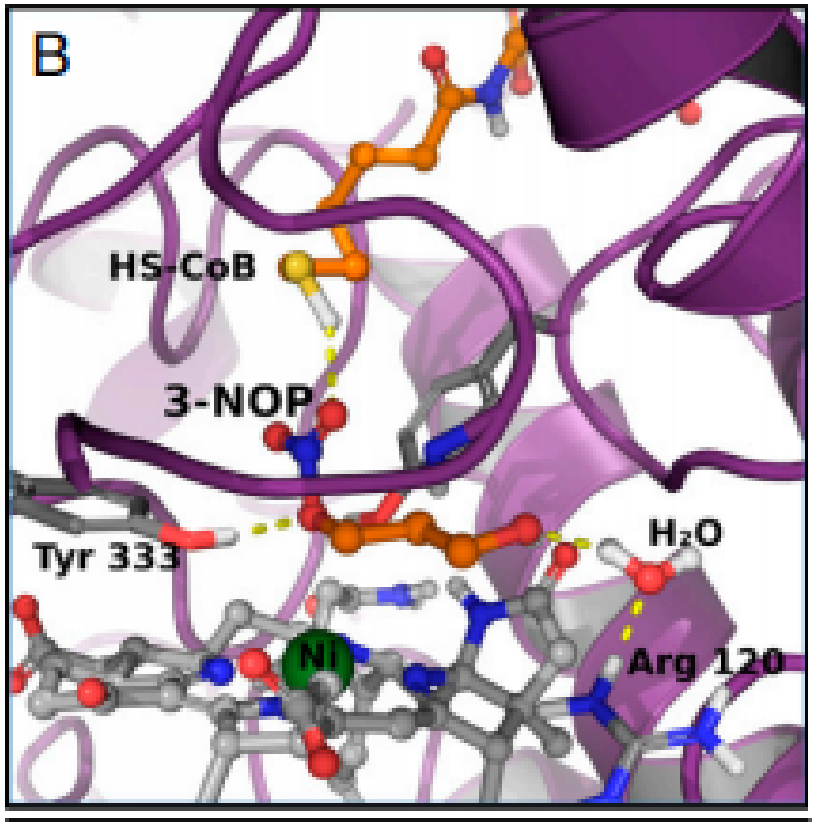
3NOP – Early Life Intervention



Meale et al., 2021

3NOP – Mode of Action

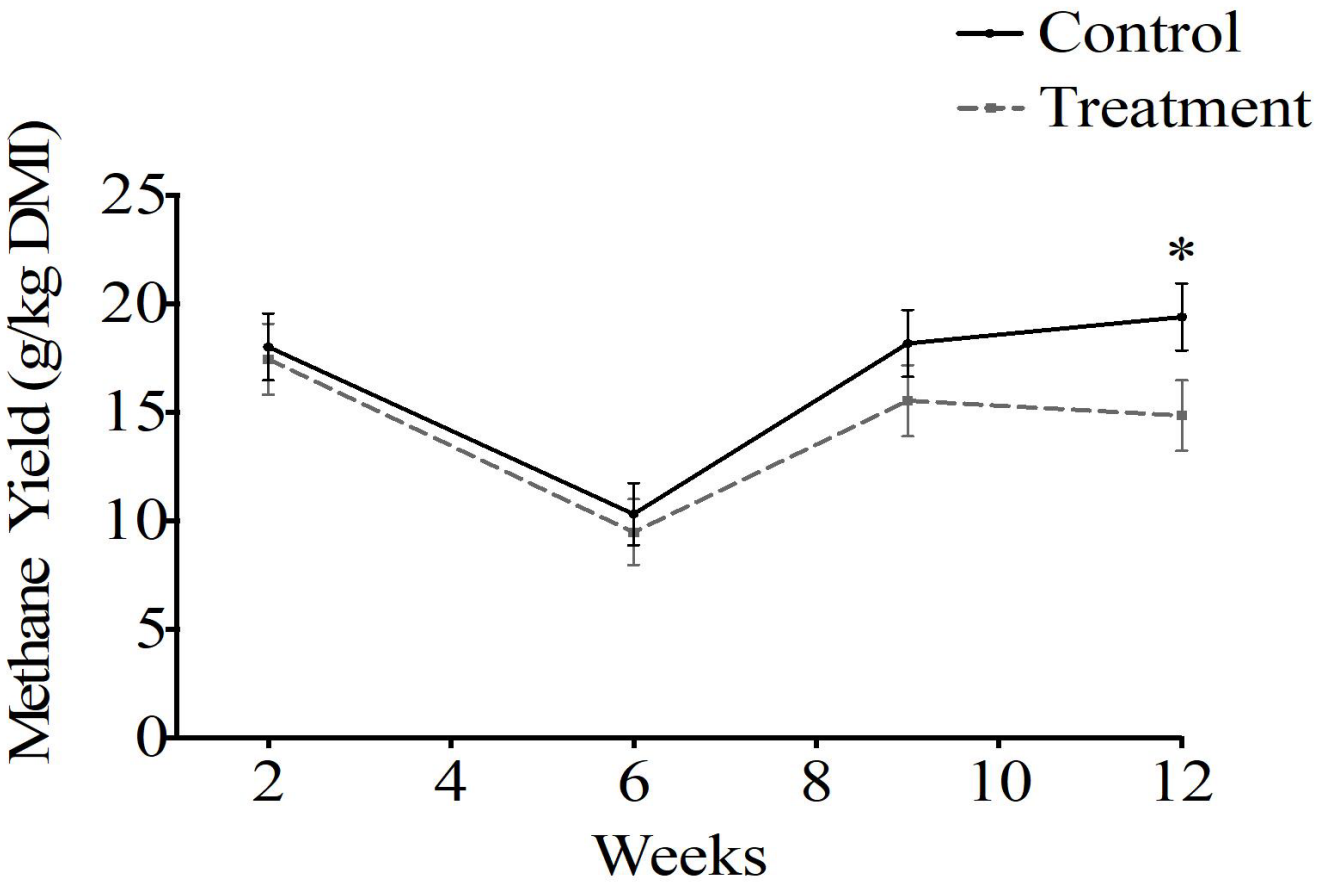




Duin et al. 2016

Plant Bioactive Compounds - EO

- Based on garlic and citrus extracts
- Added at 15 g/d
- 23% reduction after 12 weeks
- More work needed to determine effectiveness



Roque et al. 2019

Bioactive Compounds – Tannins/EO

- Lemongrass at 2% DM reduced emissions 33% (MX)
- CA grown lemongrass did not reduce methane
- Main differences was in tannin and Essential oils concentration
- Chamomile – no effect

Vázquez-Carrillo et al. (2020)

Plant Bioactive Compounds - Tannins

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]

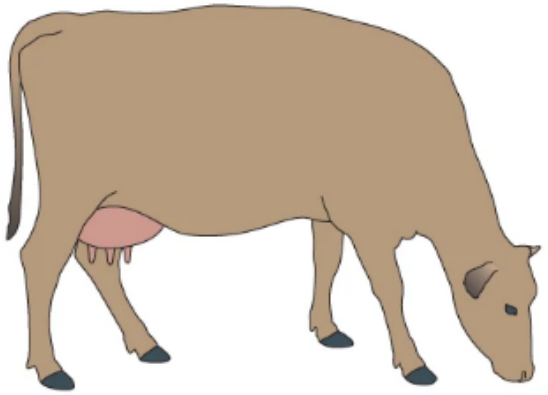
Moate et al. 2014

Short Sheep Vineyard and micro winery

Variate	Diet [1] CON	RGM	WGM	SEM [2]
Number of cows	11	10	10	-
Total DMI [5] (kg/d)	18.4	18.8	18.6	0.29
Methane emission (g/d)	383	326	326	12.9
Methane intensity (g/kg ECM [6])	13.3	12.8	12.5	0.47

Moate et al. 2020

Methane Mitigation Strategies



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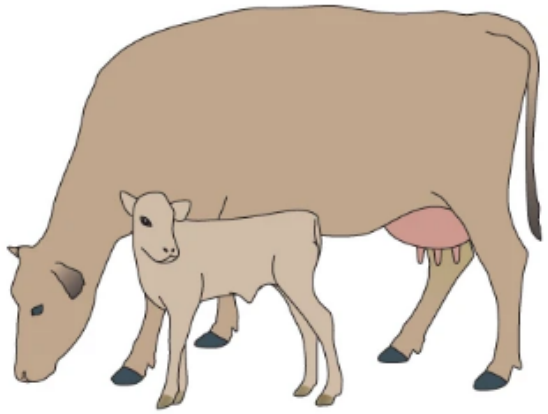

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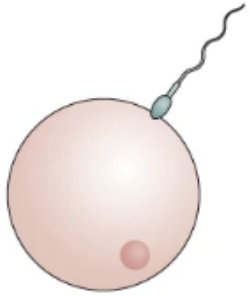

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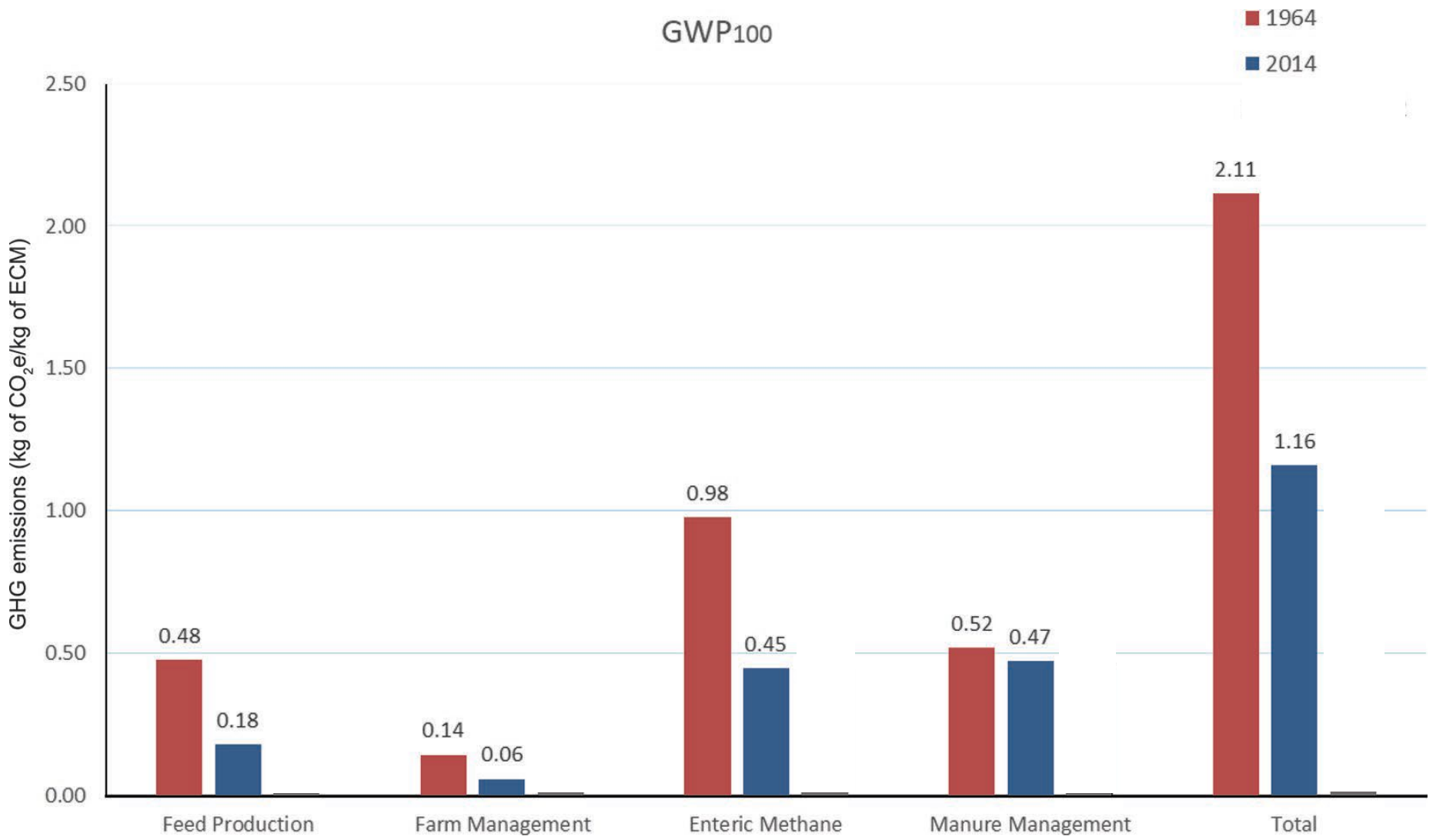
Mizrahi et al. 2021

Diet/Nutrition/Genetics



Naranjo et al., 2020

Methane Intensity

45%

Reduction

Per Unit of Milk Production

- Conservative estimate
- Primarily enteric methane
- Reductions on CO_2 & N_2O

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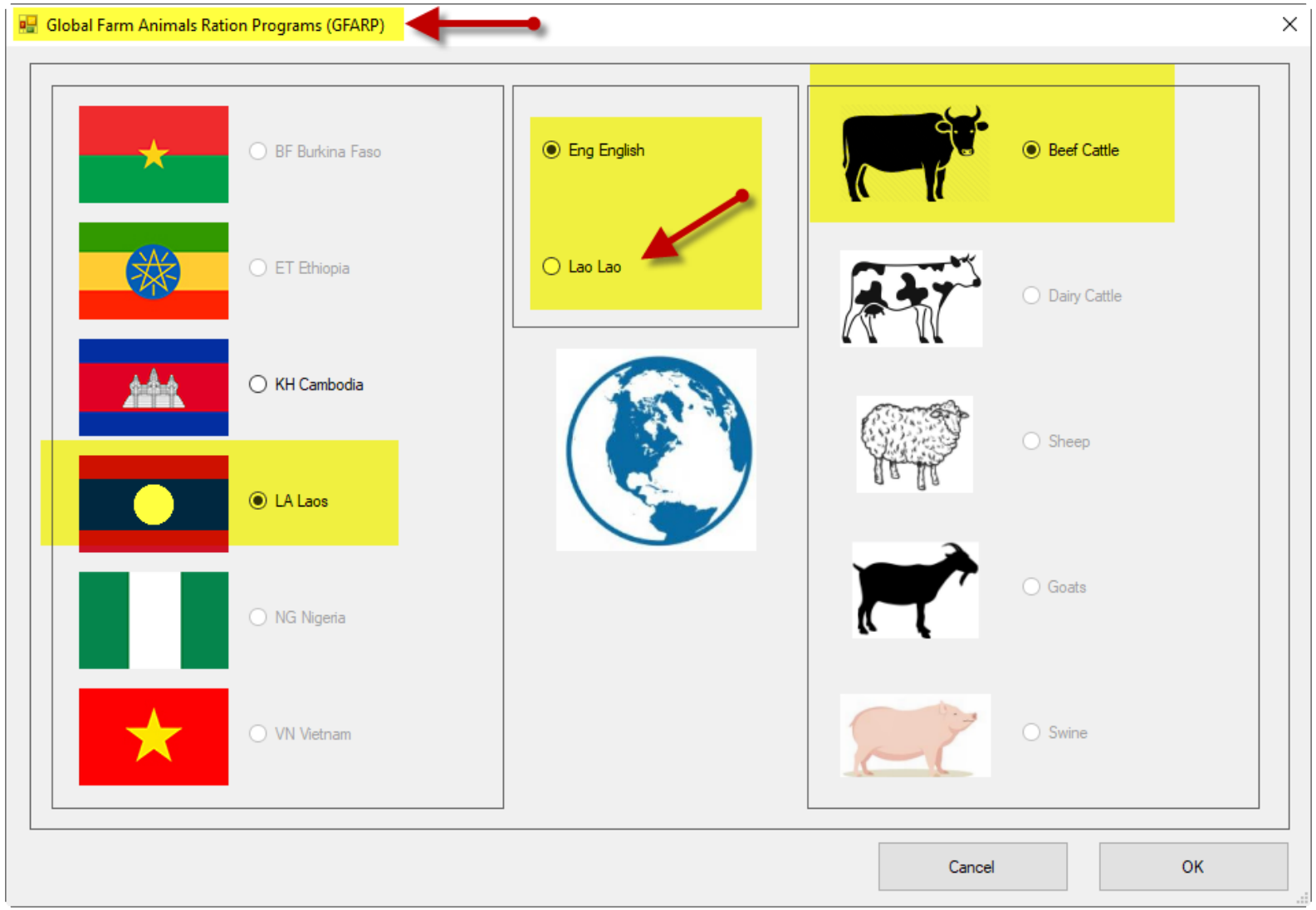
Improving Production/CH_4 Intensity



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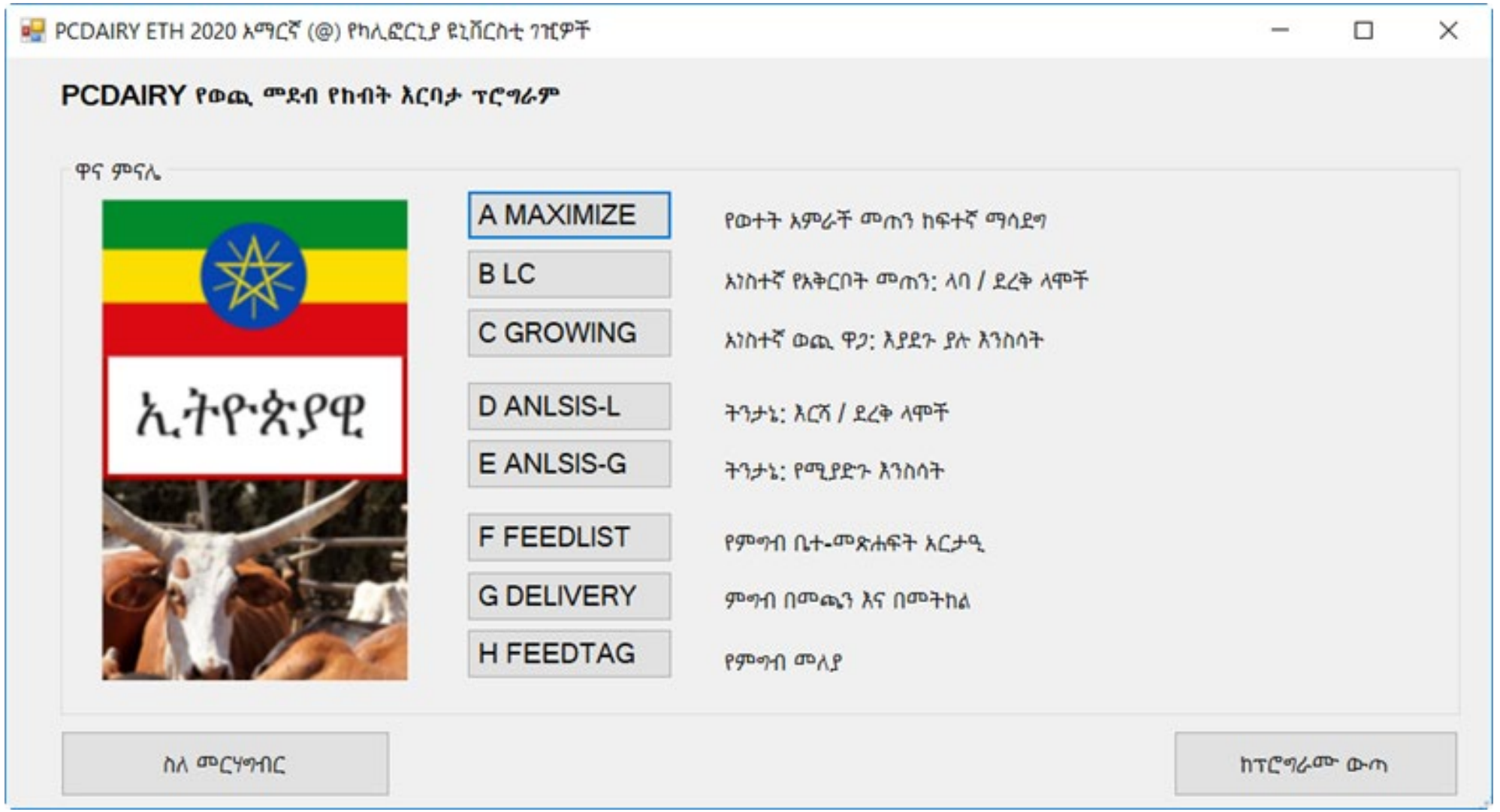
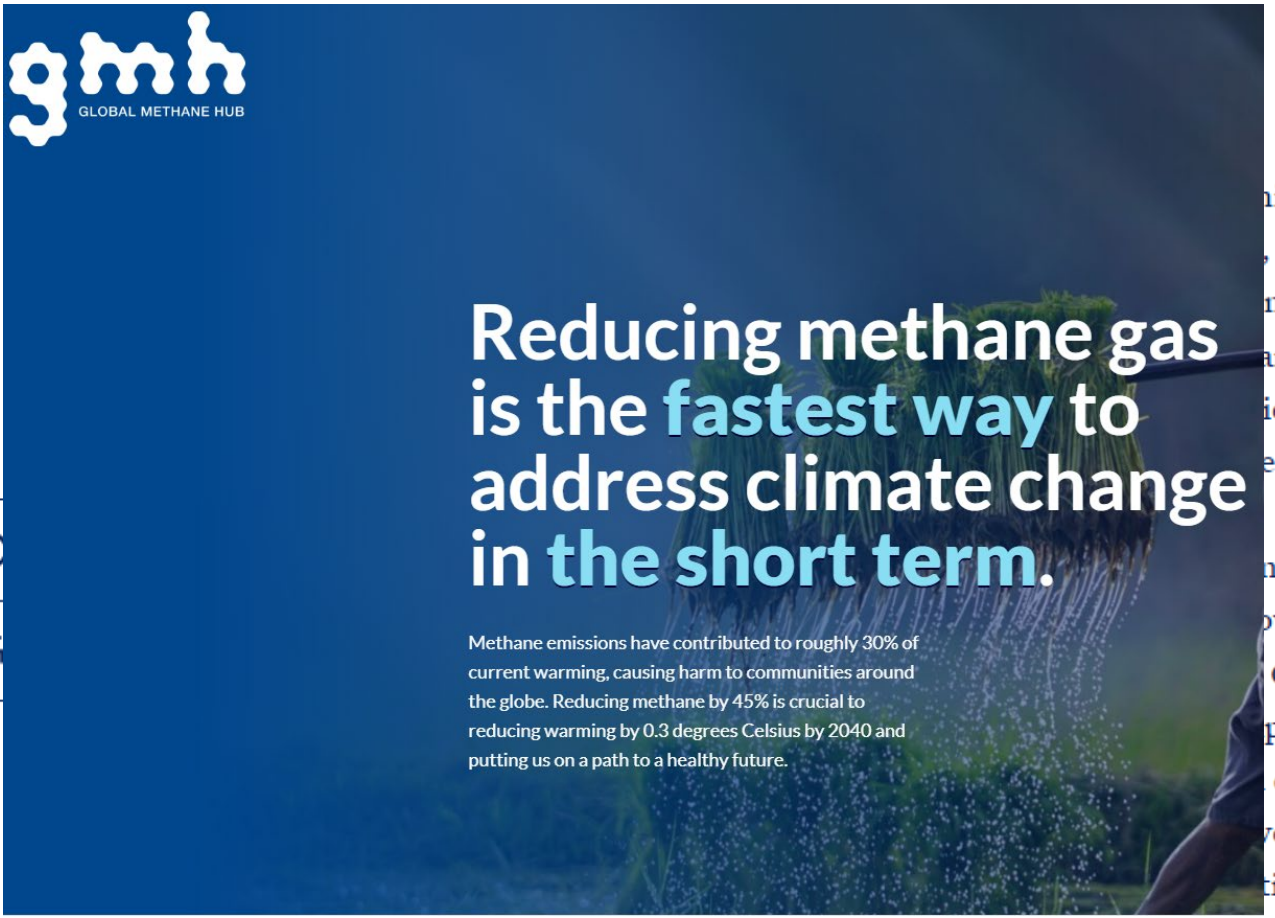


Improving Production

BRIEFING ROOM

Joint US-EU Press Release on the Global Methane Pledge

SEPTEMBER 18, 2021 • STATEMENTS AND RELEASES

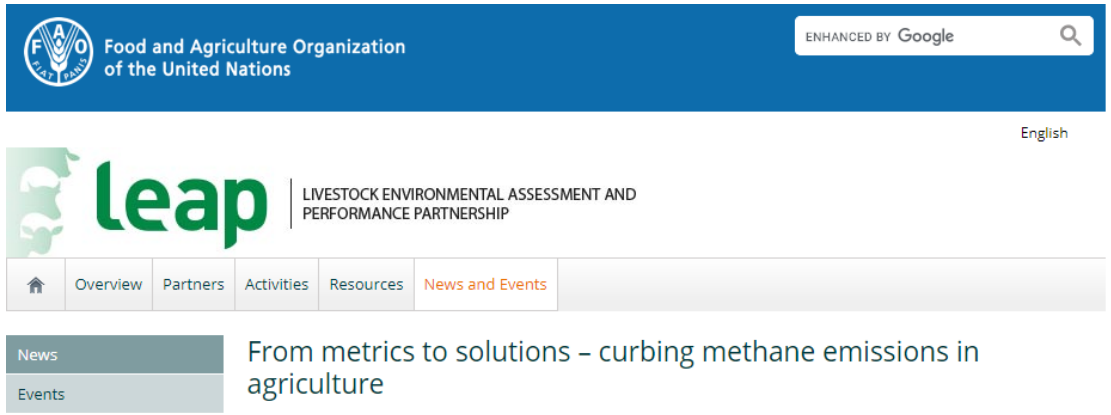


nited States and European Union announced today the Global Methane , an initiative to reduce global methane emissions to be launched at the mate Change Conference (COP 26) in November in Glasgow. President and European Commission President Ursula von der Leyen urged ies at the U.S.-led Major Economies Forum on Energy and Climate to e Pledge and welcomed those that have already signaled their support.

ne is a potent greenhouse gas and, according to the latest report of the overnmental Panel on Climate Change, accounts for about half of the 1.0 Celsius net rise in global average temperature since the pre-industrial pidly reducing methane emissions is complementary to action on dioxide and other greenhouse gases, and is regarded as the single most ve strategy to reduce global warming in the near term and keep the goal ting warming to 1.5 degrees Celsius within reach.

Other Solutions

- Animal Breeding and Management (5)
- Feed management, diet formulation and precision feeding (4)
- Forages (8)
- Rumen manipulation (16)



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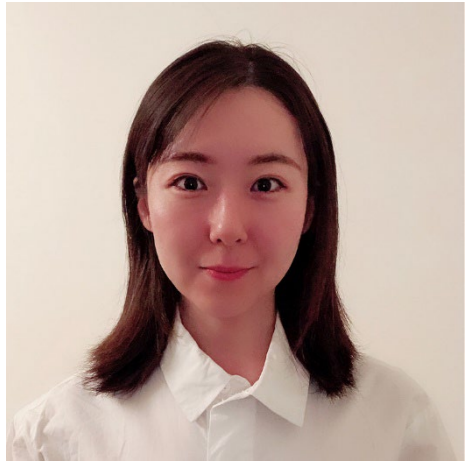
Conclusions

- Several solutions to mitigate GHG emission exist
- For methane some exciting and practical solution on the way – still not on the market
- In low income countries methane intensity can be substantially reduced
- Next 5 year ~30% reduction in GHG

Acknowledgments


BLUE OCEAN BARNS
Solving agriculture's biggest climate challenge.

CALIFORNIA DAIRY RESEARCH FOUNDATION
Science for a Sustainable Future

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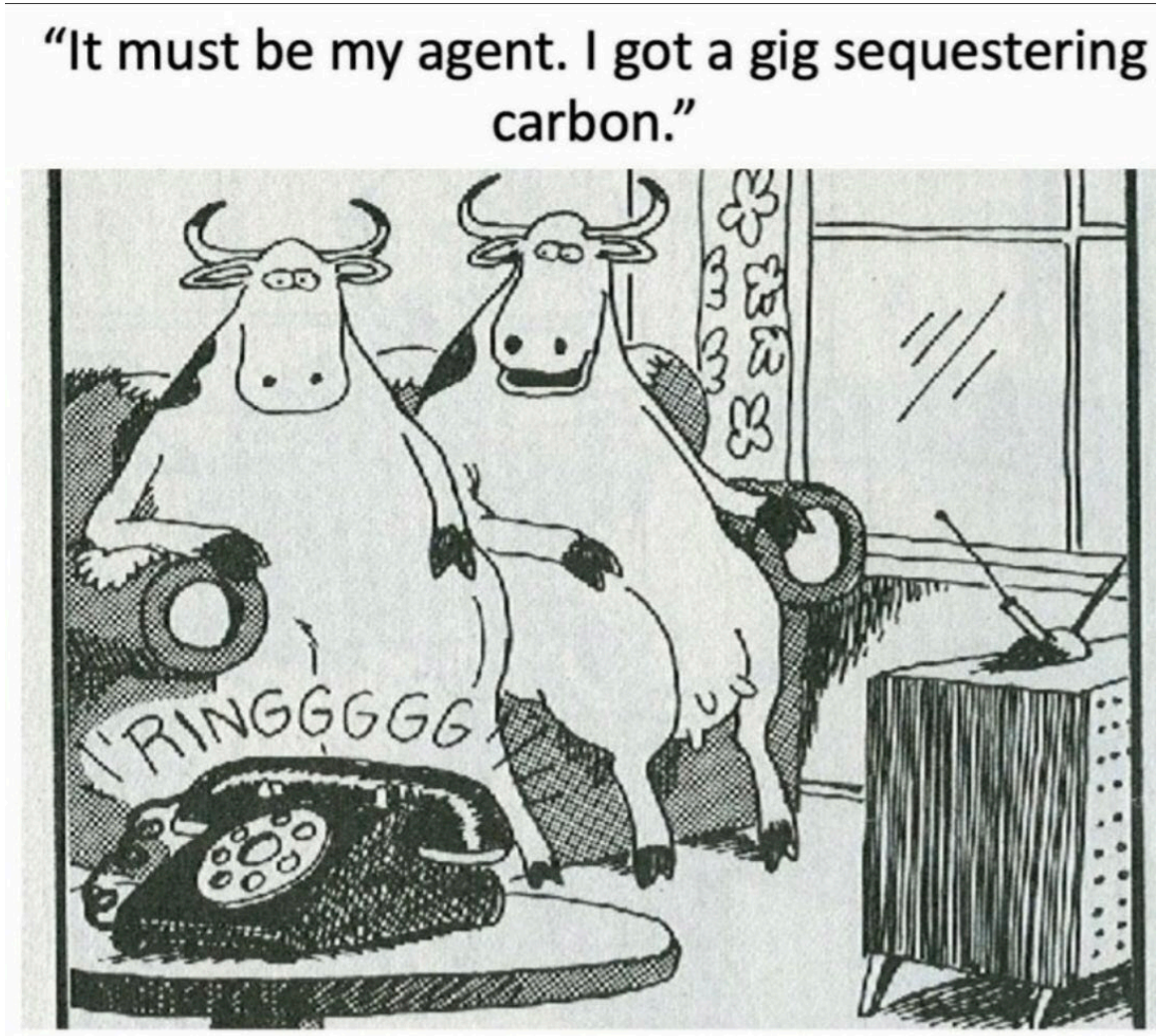
BILL & MELINDA GATES foundation

Thank You!



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