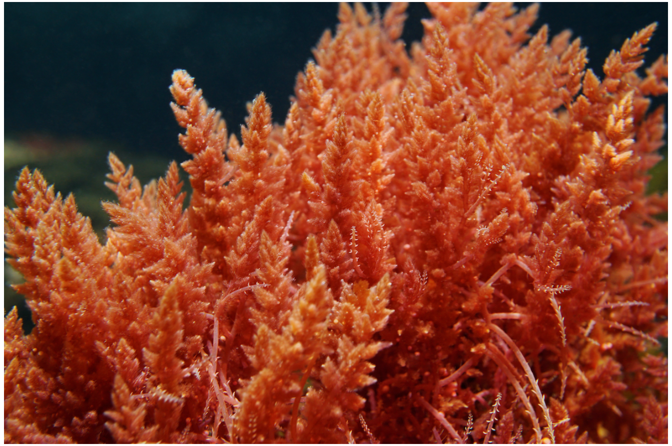
Representation of Enteric Methane Mitigation Supplements

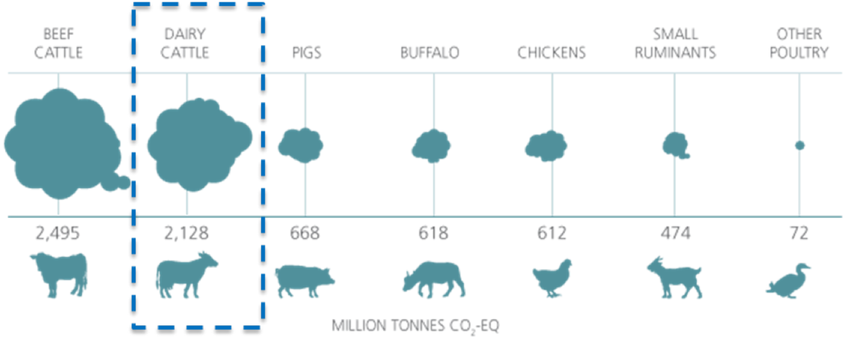
Edward H. Cabezas Garcia, PhD.

Postdoctoral Associate

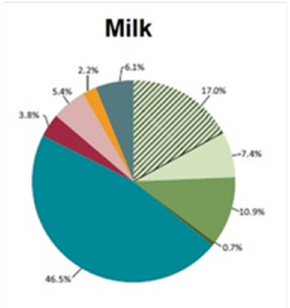
November 3 / 2022



A bit of context of global context…

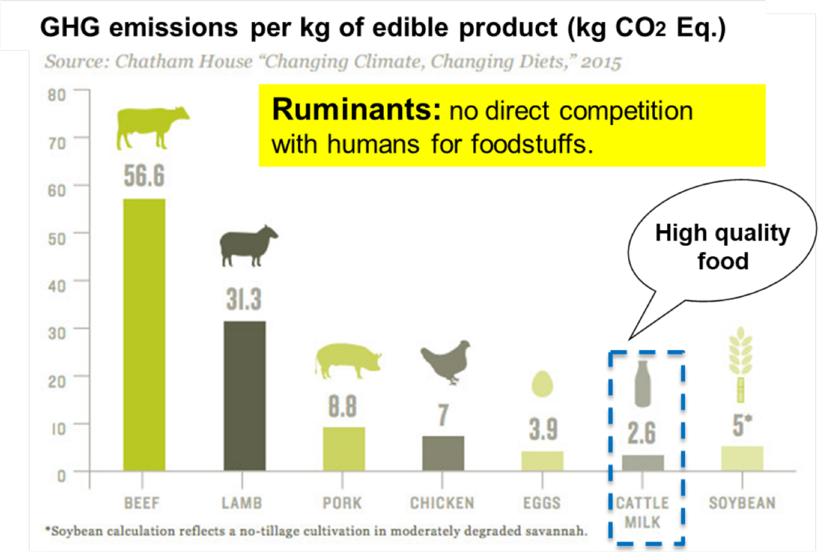


Global emissions



Enteric CH_4 = 46.5%

Source: **FAO**



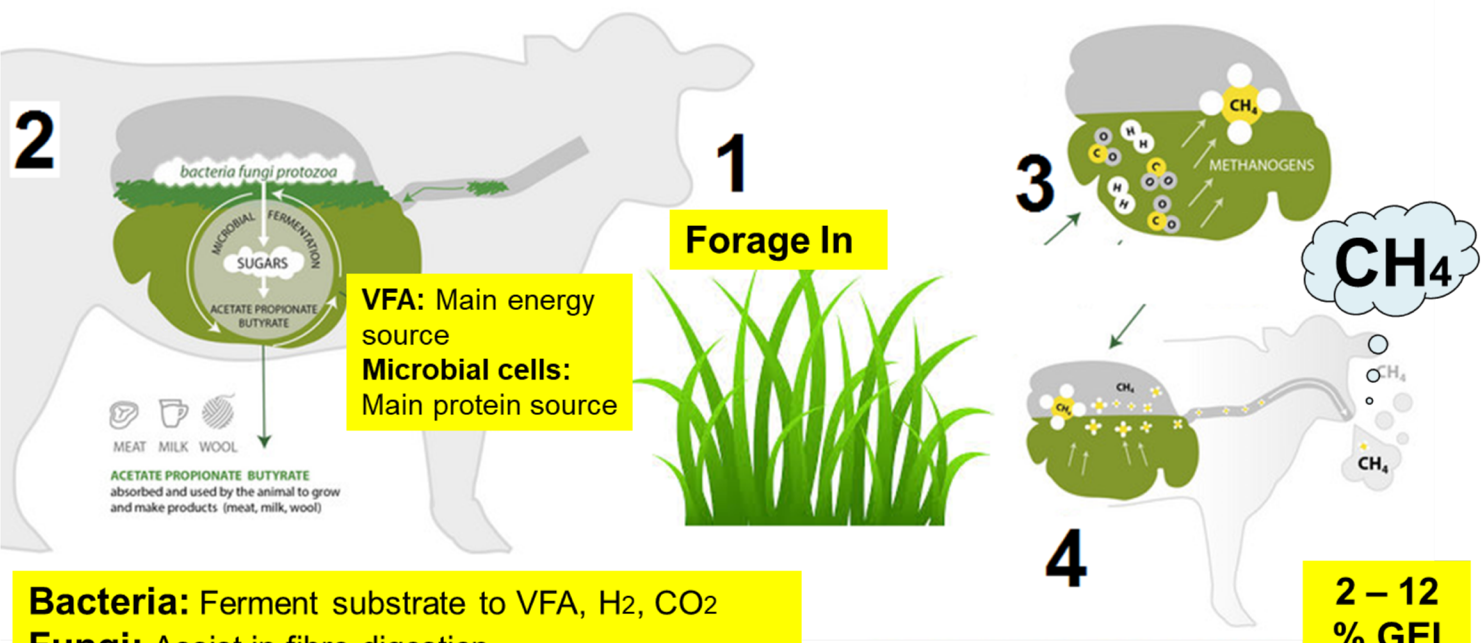
Ruminants: no direct competition with humans for foodstuffs.

High quality food

In dairy systems of the United States, the proportion of **enteric / manure emissions is close to 50:50.**

Enteric methane

Methanogens: Produce CH_4. Without methanogenesis fibre digestion is compromised



VFA: Main energy source
Microbial cells: Main protein source

Forage In

Bacteria: Ferment substrate to VFA, H_2, CO_2
Fungi: Assist in fibre digestion
Protozoa: Can modify rumen microbiome, starch

2 – 12 % GEI

Energy losses!!!

Source: http://www.fao.org/in-action/enteric-methane/background/what-is-enteric-methane/en/

Enteric CH_4 mitigation strategies

- ✓ As many as 98 mitigation strategies reported in 430 peer-reviewed journal publications (Arndt et al., 2022).

- ✓ Within the **<u>Global CH_4 Network Initiative</u>**, these are classified into three main categories:

1. Animal and feed management (e.g., Dry matter intake)
2. Diet formulation (e.g., NDF concentration on a DM basis)
3. **<u>Rumen manipulation strategies</u>** (e.g., 3-NOP, seaweeds, etc.).

Forage on enteric CH_4 emissions

- ✓ Increased dry matter intake (DMI) with improved digestibility decreases emissions per unit of DMI / energy corrected milk (ECM).
- ✓ More NDF in low digestibility silages → more CH_4.
- ✓ Enteric CH_4 emissions may be reduced when corn silage replaces grass silage.
- ✓ Silage fermentation quality.

Concentrate on enteric CH_4 emissions

- ✓ Changes in rumen fermentation pattern → more propionate.
- ✓ Improved microbial efficiency with optimal level?
- ✓ Concentrates have a higher fat (fatty acid) content.
- ✓ Greater proportion of starch than NDF digested post-ruminallly.

Metrics for accounting reductions in enteric CH_4 emissions

- ✓ Total CH_4, g/d.
- ✓ **CH_4 intensity** (g/kg) – per unit of product. E.g., CH_4 / ECM.
- ✓ CH_4 yield, g/kg DMI.

Convenient for comparing animal categories: calves, heifers, cows.

Modeling approaches I, II, and III

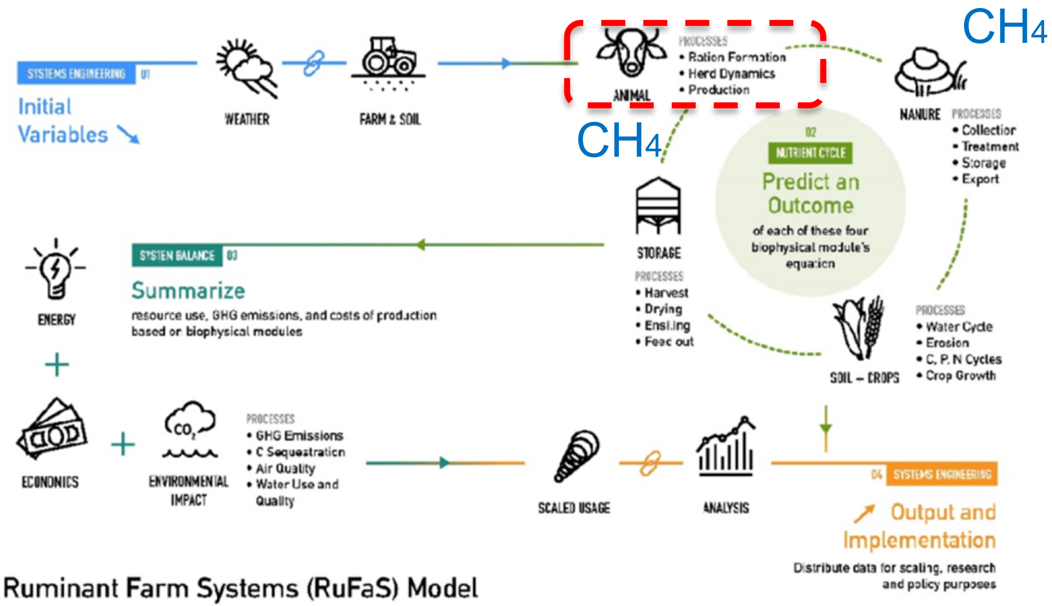
- ✓ **Empirical.** Rely on experimental data to quantify relationships directly and based on a single level (e.g., whole animal). Commonly used for inventory purposes. **E.g., IPCC, NASEM, etc.**

- ✓ **Mechanistic.** These are constructed by examining the structure of a system and analyzing the behavior of the system in terms of its individual components and their interactions with one another. **E.g., Molly model.**

- ✓ **Whole-farm models.** Some existing models incorporate a number of sub-systems to model the dairy operations. **E.g., The Integrated Farm System Model.**

Modeling approaches IV

✓ **The Ruminant Farm Systems Model (RuFaS).** Combines elements from I, II, III and embraces: “technological advances; open, harmonized data; transdisciplinary collaboration; modularity and interoperability; user-driven data and model development”.



Ruminant Farm Systems (RuFaS) Model

Diet and feed additives - overview

B

	MITIGATION STRATEGY	INTAKE	DIGESTIBILITY	MILK	GAIN
		Relative Treatment Effect on Animal Performance			
Product-Based Reductions	1 INCREASING FEEDING LEVEL	+58%	-7%	+17%	+162%
	2 DECREASING GRASS MATURITY	No Effect	+15%	+9%	No Data
	3 DECREASING DIETARY FORAGE-TO-CONCENTRATE RATIO	+9%	No Effect	+17%	+21%
Absolute Reductions	1 CH_4 INHIBITORS	No Effect	No Effect	No Effect	No Effect
	2 TANNIFEROUS FORAGES	No Effect	-7%	No Effect	No Effect
	3 ELECTRON SINKS	-2%	No Effect	+3%	No Effect
	4 OILS & FATS	-6%	-4%	No Effect	No Effect
	5 OILSEEDS Lactating animals only	No Effect	-8%	No Effect	-13%

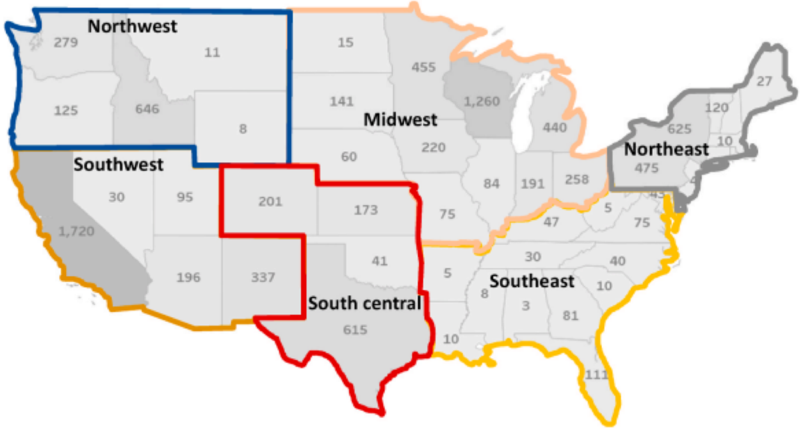
Aspects of Diet formulation

The ideal situation is do not compromise productivity

Arndt et al. PNAS, 2022

Proposed diets scenarios: forages and concentrates

Proportions of within the forage part of the diet		% within forage category	Forage as % of the total diet on a DM basis	Concentrate as % of the total diet on a DM basis
Corn silage	Grass silage			
75	25	100	75	25
50	50	100		
25	75	100		
25	75	100		
75	25	100	50	50
50	50	100		
25	75	100		
25	75	100		
75	25	100	25	75
50	50	100		
25	75	100		
25	75	100		



Expected differences in concentrates composition as a result of feedstuffs availability

Suggested empirical models to be compared within RuFaS simulations

n	Model	Equation
1	IPCC	(0.065 × GEI)/0.055565
2	Ramin-Huhtanen	51.5 × DMI^0.792
3	Mills	(56.27 x (1 - exp (-0.028 x DMI))) / 0.05565
4	Nielsen et al. 2013	0.294 × DMI -0.347 × FA + 0.0409 × dNDF
5	Niu (Intercontinental database)	126 + 11.3 × DMI + 2.30 × NDF + 28.8 × MilkFat + 0.148 × BW

NASEM, 2021

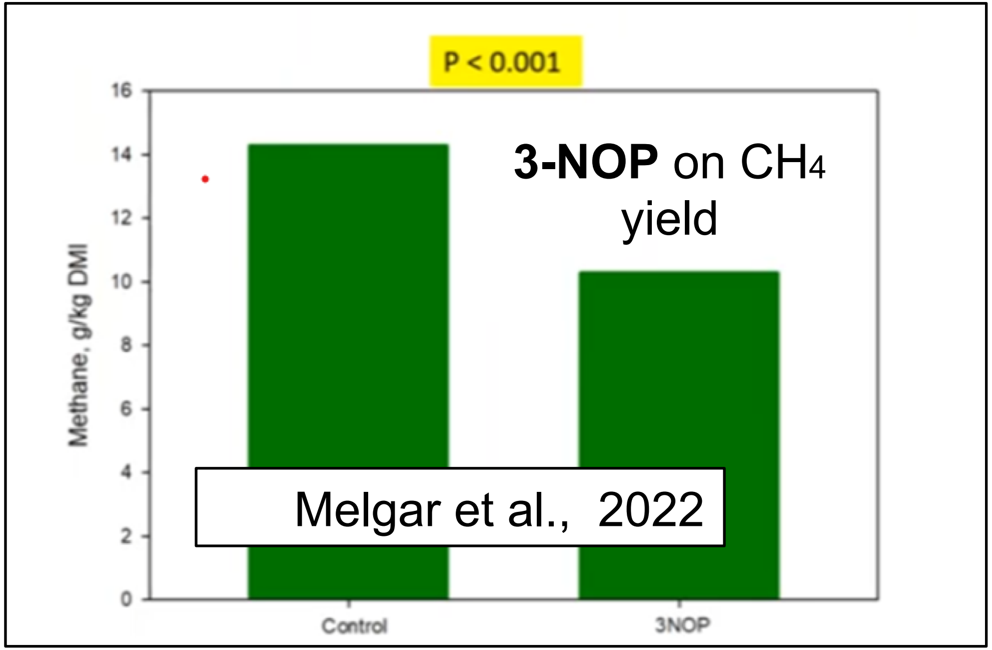
GEI = gross energy intake; **DMI** = dry matter intake; **FA** = fatty acids; **dNDF** = digested neutral detergent fiber; **NDF** = diet concentration; **MilkFat** = as it stands for; BW = body weight.

Comments on empirical equations for predicting enteric CH_4 emissions

- ✓ Different levels of complexity.
- ✓ Literature models agree that **DMI is the main factor** driving emissions.
- ✓ Effects of diet composition is reported to be lower than DMI but still important for fine tuning models' predictions.

Proposed additives to be tested

- ✓Monensin
- ✓Fatty acids
- ✓Agolin
- ✓3-NOP
- ✓Seaweeds



Literature data collection is on-going to assess the **linear rate of decrease** in CH_4 emissions.

On-going work…

- ✓ **We are developing a method** to evaluate the effects of diet composition, feed additive, and their interactions on expected enteric CH_4 emissions within RuFaS.
- ✓ **To assess effectiveness and establishing boundaries for using feed additives** in response to simulation of dairy herd dynamics over time.
- ✓ **User-input diets** to be compared against ideal diet for fulfilling nutritional requirements.
- ✓ Impacts may differ depending on chosen metrics for accounting for CH_4 reductions.

Thank you!