Reducing the carbon footprint of beef production: current alternatives to mitigate enteric methane emissions

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Fiber and forage-based livestock systems

- **Grasslands occupy ~40% of ice-free terrestrial surface**

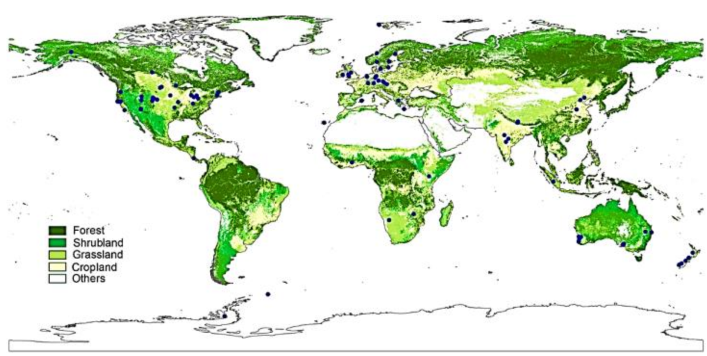
  (Hewins et al., 2018)

- **Forage grass is the most consumed livestock feed in the world (48% of all biomass consumed)**

  (Peters et al., 2013)

- **Even in the U.S. conventional beef production systems, 80% of total feed consumption is forage, 10% grain, and 10% other sources**

  (NASEM, 2016)



Qiao et al. (2019). Sci. Rep. 9:5621

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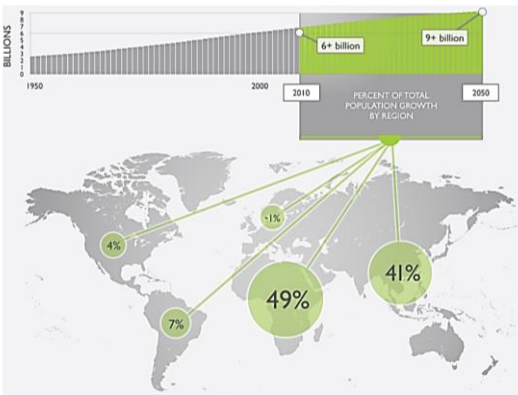
Beef production and human population growth

Global Population Growth and Percent of Growth by Region (2010 – 2050)



Silva 2018

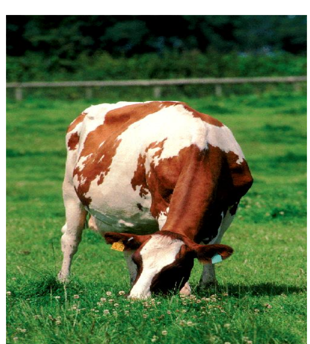
Global beef production 2023

1)	USA	20%
2)	Brazil	18%
3)	China	12%
4)	EU	11%
5)	India	7%
6)	Argentina	5%
7)	Australia	4%
8)	Mexico	3%
9)	Rest of the World	20%

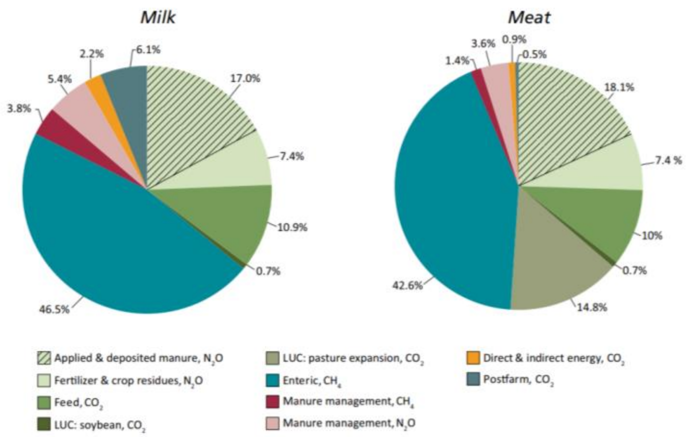
Capper 2012

The importance of ruminants in food production systems

- **Of the solar energy captured by the earth's biomass, only 5% potentially available for human food directly** (Russell and Gahr, 2000)
- **The rest…**



Global emissions of GHG from cattle destined to produce milk and meat: methane is the big one!



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Source: FAO, 2013

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Emissions intensities are going down…

- In the last 50 years GHG emissions intensities (per kg of milk or meat produced) have improved
- Dairy farms are producing almost twice the milk with approx. 25% fewer cows
- Beef cattle operations are producing approx. 20% more meat with 12% fewer cattle

- More work to do in beef systems

Alan Rotz (2022). GGAA 2022

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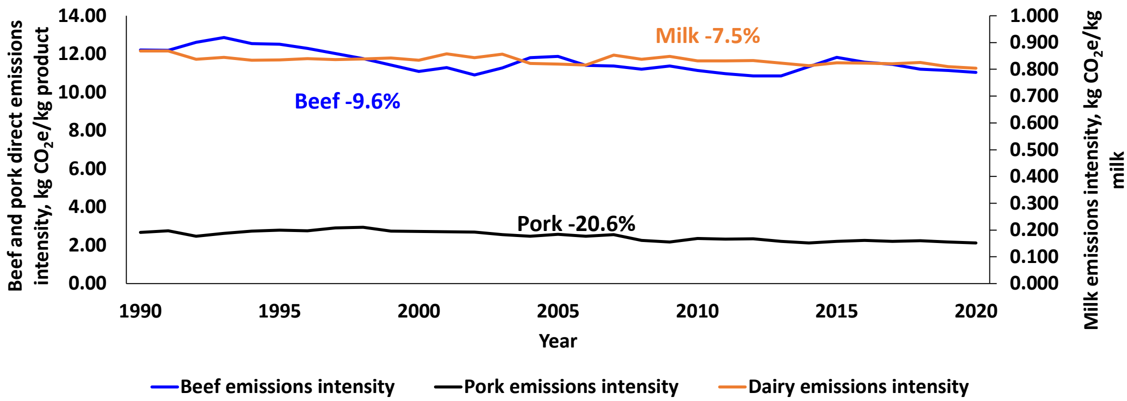
GHG emission intensity has declined in the US, but decoupling is not enough to halt absolute emissions growth



US EPA Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2020 and USDA NASS

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Improvements in beef cattle emissions intensity
(Rotz, 2022)

1970
Intensity = 24 kg CO2e/kg carcass
Total = 241 Tg CO_2e

2020
Intensity = 21 kg CO2e/kg carcass
Total = 255 Tg CO_2e

Source: https://www.cattlemax.com/

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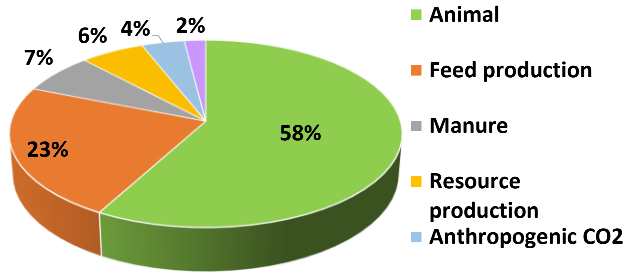
Beef Farm Gate Footprint in the U.S.

"The GHG emissions related to producing a kg of carcass weight is similar to that emitted by driving a car about 85 km"

A. Rotz, GGAA 2022, Orlando, FL

21 kg CO_2e/kg carcass weight

Ranges from:
17 to 27 across U.S. Regions
16 to 39 across Production systems



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Alan Rotz (2022). GGAA 2022

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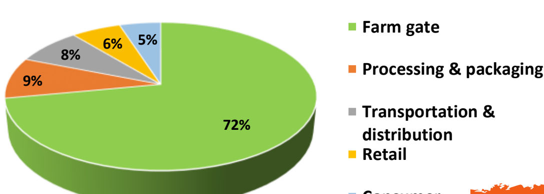
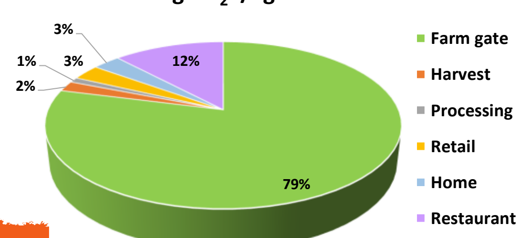
Full Life Cycle Emission

1.8 kg CO_2e/kg milk consumed



43 kg CO_2e/kg beef consumed



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Adapted from Rotz (2022; GGAA conference)

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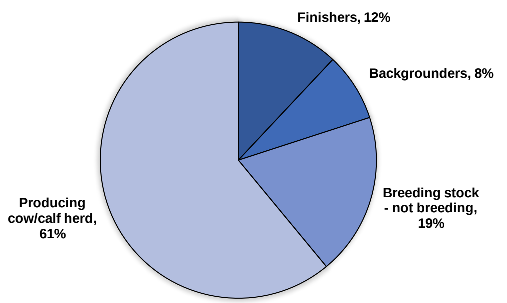
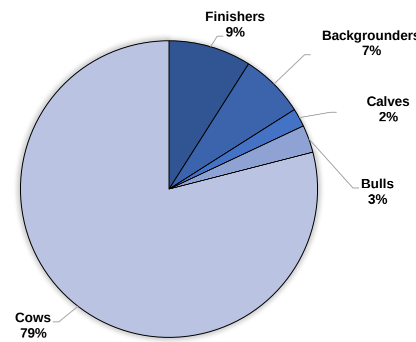
Beef cattle emissions: cow/calf is the low-hanging fruit!

Breakdown of total GHG emissions in CO_2e



Breakdown of enteric CH_4 emissions



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Beauchemin et al. (2010). Agr Systems. 103:371-379

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Where to focus mitigation efforts?

Cow/calf segment

- Grazing management (⇧C seq.)
- Reproduction
- Cow size
- Feed (forages) digestibility
- Reduced mortality/morbidity
- Implants

Carbon Footprint Reduction

	Beef feedlot
More efficient feeding	1-2%
Enteric methane inhibitor	8
Feeding of fat	4-5
Scraped feed lane	7-8
Anaerobic digester	18-20
No manure storage	18-25
Improved animal health	1-2
Solar collection	10-20
Combined system	50-60%

- Feedlot: improvements may impact overall C footprint by 3%
- Cow-calf: combination of techniques may lead to 8-10% potential reduction in C footprint

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Alan Rotz (2022). GGAA 2022

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However, little work has been done on cow/calf systems in terms of GHG emissions

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What is the "State of the Science" in terms of enteric methane mitigation?

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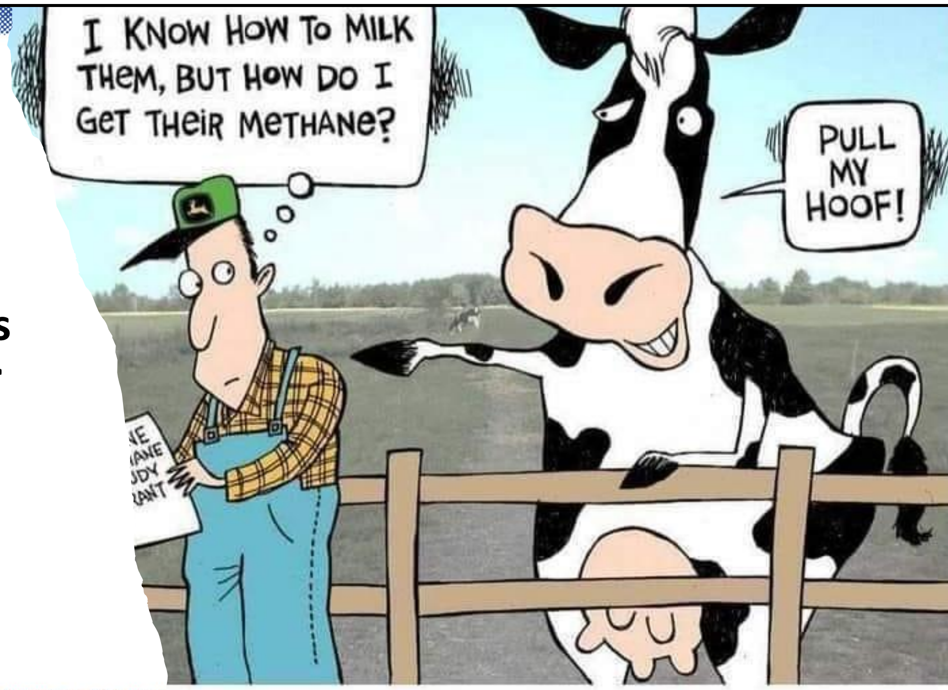
Measuring CH_4 emissions in vivo under grazing conditions: a challenge



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The SF_6 tracer technique

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The challenges of measuring methane under grazing conditions

University of Florida

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Can intensification of grazing management help?

agronomy

Article

Can Intensified Pasture Systems Reduce Enteric Methane Emissions from Beef Cattle in the Atlantic Forest Biome?

Paulo Meo-Filho [1,2,*,†], Alexandre Berndt [2], José R. M. Pezzopane [2], André F. Pedroso [2], Alberto C. C. Bernardi [2], Paulo H. M. Rodrigues [3], Ives C. S. Bueno [1], Rosana R. Corte [3] and Patrícia P. A. Oliveira [2]

Meo-Filho et al. (2022; Agronomy, doi.org/10.3390/agronomy12112738)

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Can intensification of grazing management help?

Variables	Systems *					
	n	EXT	INT	iCL	SEM	*p*-Value
ILW (kg)	60	253	267	256	8.39	0.5940
FLW (kg)	60	429 [b]	484 [a]	466 [a]	16.76	<0.0001
DMI (kg day^{-1})	60	9.8 [a]	8.7 [ab]	7.5 [b]	0.31	<0.0001
LWG (kg ha^{-1} $year^{-1}$)	60	290 [c]	615 [a]	487 [ab]	53.98	<0.0001
CH_4 (g day^{-1})	60	199.7	226.1	209.8	7.3	0.1606
CH_4 (g kg LW^{-1})	60	0.62	0.58	0.61	0.03	0.2047
CH_4 (kg $kgDMI^{-1}$)	60	0.028 [a]	0.028 [a]	0.029 [a]	0.001	<0.0001
gCH_4 $kgADG^{-1}$ LWG ha^{-1} $year^{-1}$	60	1.6 [a]	0.6 [c]	0.8 [bc]	0.09	0.0031
$kgCH_4$ kg Carcass $eq.^{-1}$	60	0.496 [a]	0.250 [b]	0.297 [b]	0.024	0.0047

- EXT = continuous stocking, low input
- INT = rotational grazing, lime and fertilizer applied
- iCL = integrated crop/livestock: corn harvested for silage in a rotation

- 3 year-study with 6 replicated pastures/trt

Meo-Filho et al. (2022; Agronomy, doi.org/10.3390/agronomy12112738)

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Intensification of grazing management and crop rotation

- **Can reduce GHG emissions intensity by 62%**
- **More studies like this needed**
- **Recovery of degraded pastures has great potential to increase C sequestration**
- **LCA is needed for systems approach (impact of fertilization, liming, additional fuel, etc.?)**

Meo-Filho et al. (2022; Agronomy, doi.org/10.3390/agronomy12112738)

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We need to tackle emissions in grazing systems…

Technologies available for this are still insufficient

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Tools available to mitigate enteric methane

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Additive	Efficacy: CH_4 reduction potential [1]	Efficacy: No. of academic papers [2]	Efficacy: Confidence in efficacy [3]	Potential animal welfare risks	Potential food safety risks
3-Nitrooxyproponal	Very High	> 20	5	None known	None known
Asparagopsis	Very High	< 10	1	Damage to rumen wall	Bromide & iodine residues in animal tissue/products
Nitrate	High	< 20	4	Toxicity in non-adapted animals	None known
Essential Oils	Low	< 20	2	None known	None known

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Fuente: Hegarty et al. (2021)

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Additive	Efficacy: CH_4 reduction potential [1]	Efficacy: No. of academic papers [2]	Efficacy: Confidence in efficacy [3]	Potential animal welfare risks	Potential food safety risks
Saponin	Low	< 15	1	None known	None known
Tannins	Low	< 15	2	None known	None known
Monensin	Low	> 20	5	None known	None known
Microalgae	Low	< 5	1	None known	None known

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Fuente: Hegarty et al. (2021)

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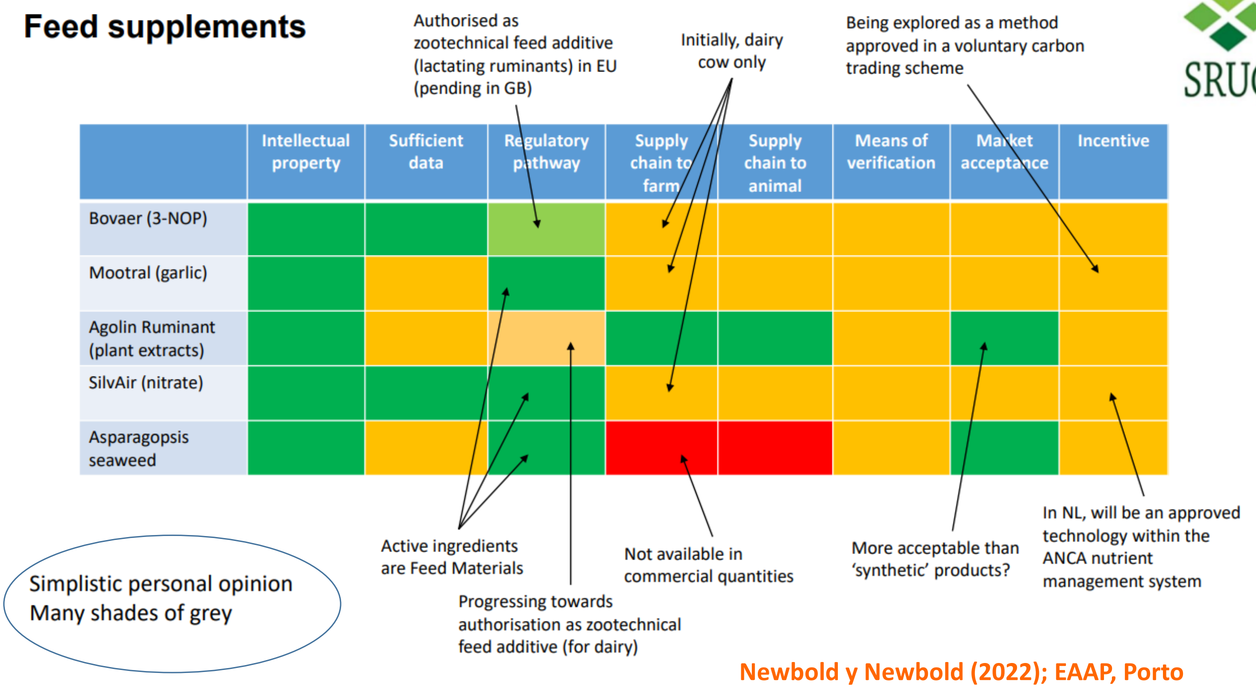
Feed supplements



Newbold y Newbold (2022); EAAP, Porto

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UF studies addressing enteric methane

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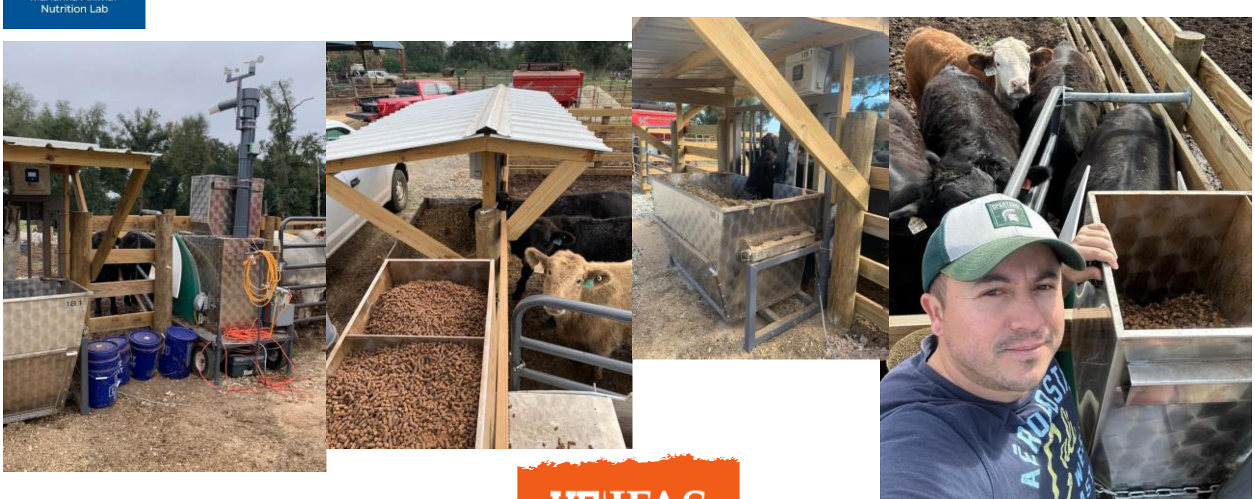
NFREC Marianna Animal Nutrition Lab



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Replacing urea with nitrates as a non-protein nitrogen source can decrease enteric methane by 11% (Henry et al., 2020; J. Anim. Sci.)

Meta-analysis of beef and dairy studies shows a mean reduction of 12.2% for beef (Feng et al., 2022; J. Dairy Sci.)

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USDA United States Department of Agriculture National Institute of Food and Agriculture

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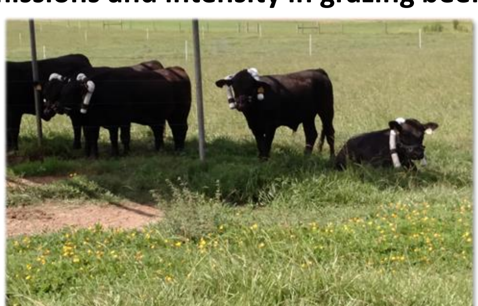
Inclusion of legumes in pastures

University of Florida

Hypothesis

The inclusion of legumes will decrease enteric methane emissions and intensity in grazing beef cattle



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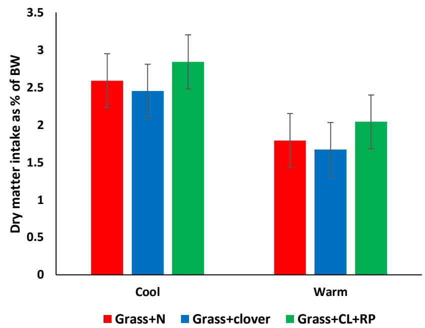
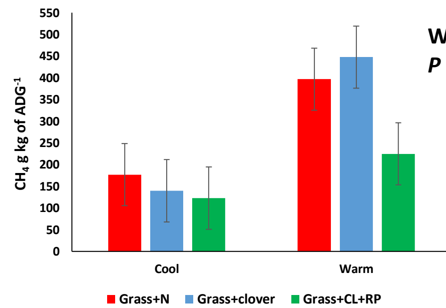
DMI as % of body weight and CH_4 emissions intensity in cool and warm season



Treatment × season, *P* = 0.99
Season effect, *P* = 0.01



Warm season, *P* = 0.18

Treatment × season, *P* = 0.36
Season effect, *P* < 0.001

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Garcia et al. (2019)

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Feeding *Aspergillus oryzae* prebiotic (AOP)

	Treatment			
	AOP	CTL	SEM	*P*- value
Intake				
DM, kg/d	6.9	7.3	0.24	0.17
OM, kg/d	6.6	7.0	0.23	0.16
DM, as % of BW	2.62	2.67	0.070	0.58
Methane emissions				
g/d	262.8	237.8	19.03	0.26
g/kg DMI	39.1	32.8	2.73	0.09
g/kg OMI	40.7	34.1	2.85	0.09
g/kg DMD	58.2	50.2	4.15	0.14
g/kg OMD	59.1	51.0	4.20	0.15
g/kg MBW	4.0	3.5	0.28	0.16

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Podversich et al. (unpublished)

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Most of the research conducted is in *Bos taurus*

- What is the impact of selection for feed efficiency on mature cow productivity and methane emissions on Brahman-influenced cattle
- The UF multibreed herd
- Collaboration with:
  - Drs. Mateescu, Rezende, Jeong, Nelson, Batistel, and Lourenço (UGA)

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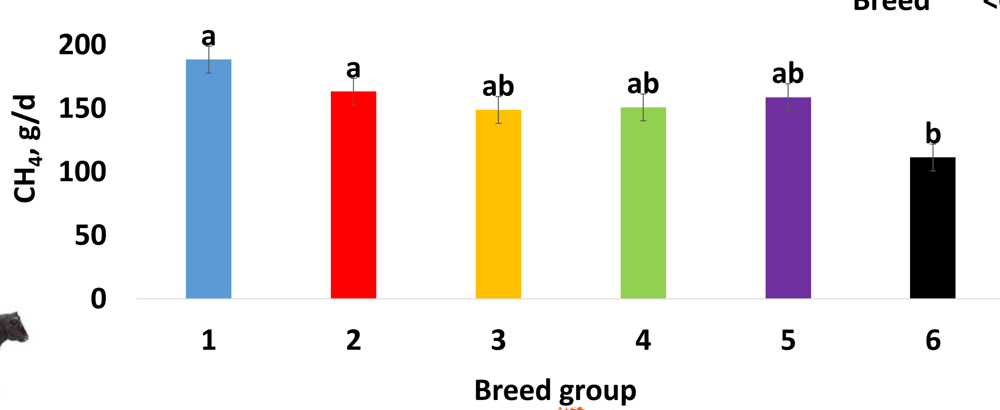
Effect of breed on methane emissions rate

Item	*P*-value
Breed	<0.01



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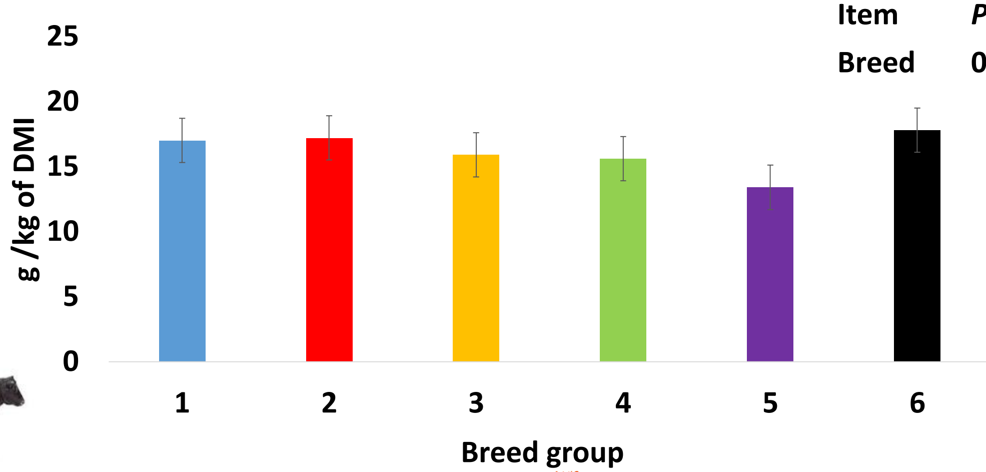
No breed differences on methane yield

Item	*P*-value
Breed	0.68



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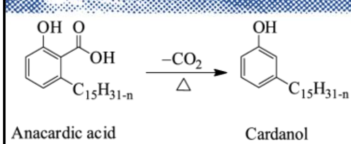
Essential oils: CNSE
Anacardic acid and cardanol



SUPPLEMENT'S DELIVERING

CNSE // CON (pellet)
3 lb / d / steer
EU = Steer
Same feeder to each steer
(1, 2 Vs 3,4) throughout experiment

BASAL DIET (TMR)

08:00
Ad libitum
Finishing diet
(84:16% DM basis)

CO_2 and CH_4 emissions

1.5 Lb/d / Steer
Up to 30 drops/d (50g/drop)
5 visits/d (3 visits min)
Aim to ≥ 38 visits / period

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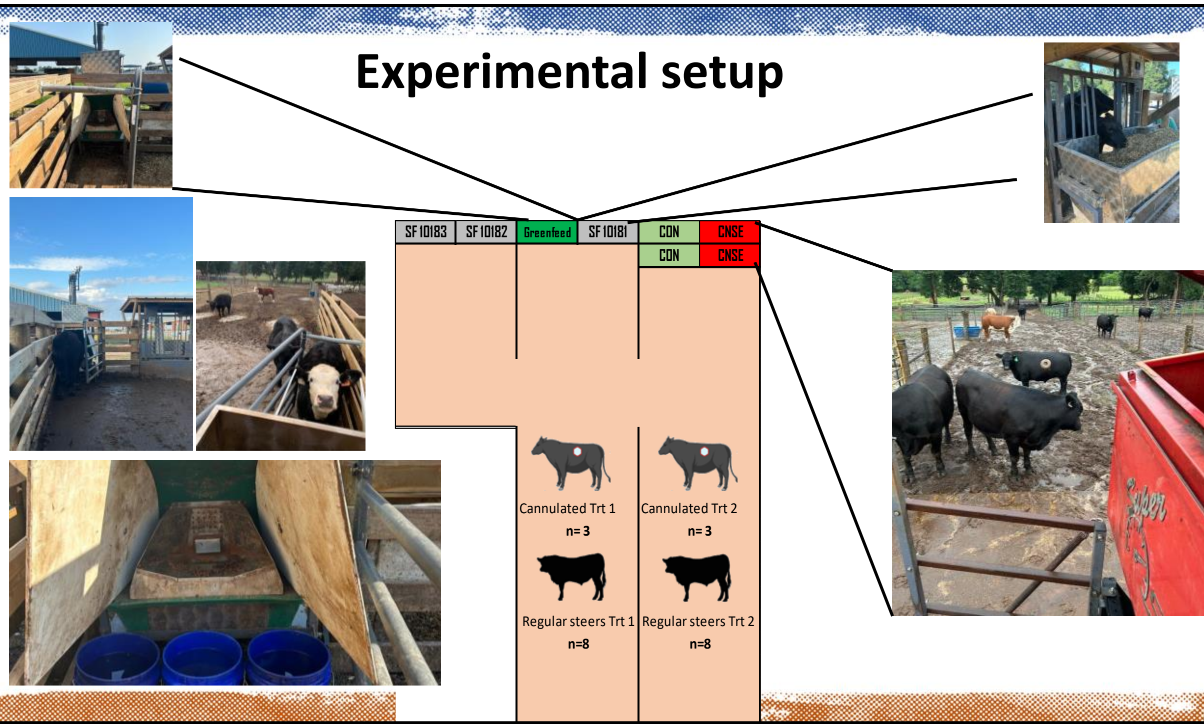
Experimental setup



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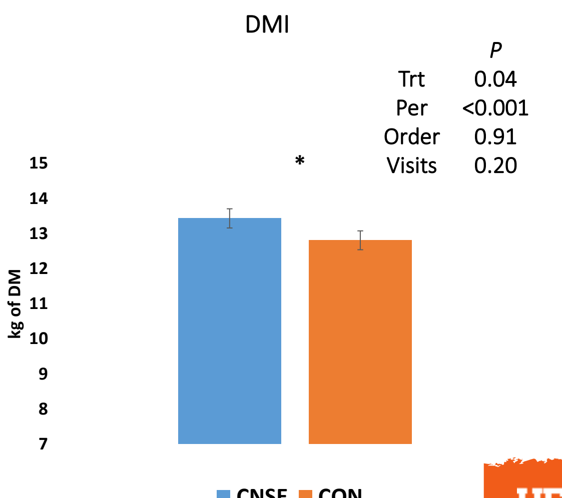
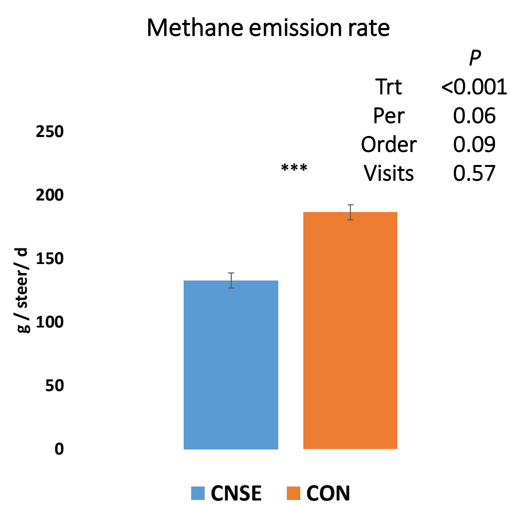
Cashew nutshell extract (CNSE) may decrease CH_4 in high-concentrate diets





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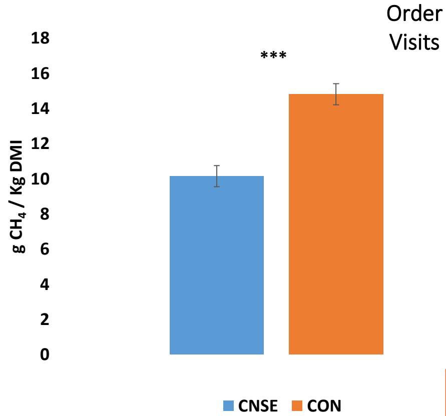
Cashew nutshell extract (CNSE) may decrease CH_4 yield and intensity

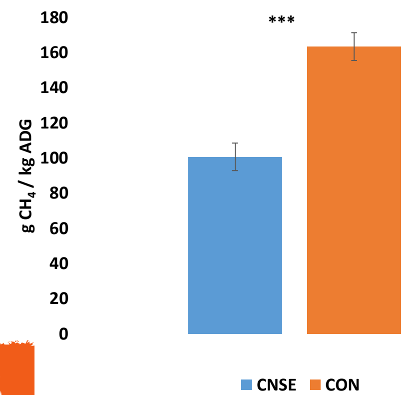
CH_4 yield

	P
Trt	<0.001
Per	0.06
Order	0.09
Visits	0.57



CH_4 emissions intensity

	P
Trt	<0.001
Per	0.17
Order	0.76
Visits	0.64



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Conclusions

- More focus on cow-calf and grazing systems is needed in order to make an impact on GHG emissions
- Legumes in pastures
  - ✓ With tannins: direct inhibition of methanogens (intensity?)
  - ✓ Without tannins: it needs to improve intensity
- Grazing management can help a lot
  - ✓ ⇧C sequestration and improve emissions intensity
- Tools for confinement: some additives show potential (3-NOP, algae, polyphenols?)
  - ✓ No production benefits associated so far
- 8-10% emissions improvement potential in cow-calf and stocker systems ➔ more focus on these!

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Thanks!

https://www.dilorenzonutritionlab.com/

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