Enhancing Efficiency and Profitability While Reducing Methane Intensity in Organic Dairy Cows through Microbial Modulation with Essential Oils

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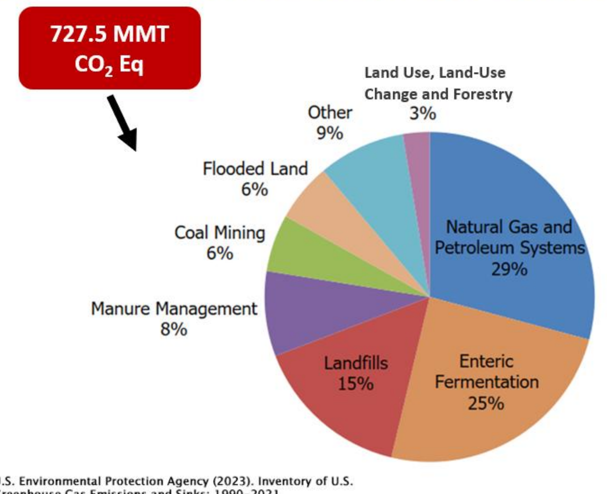
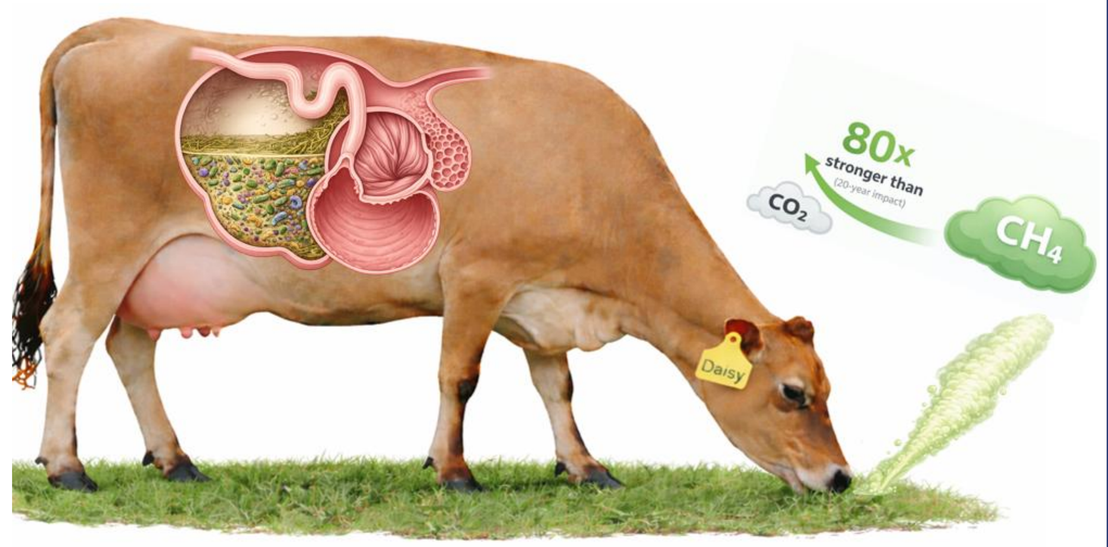
INTRODUCTION

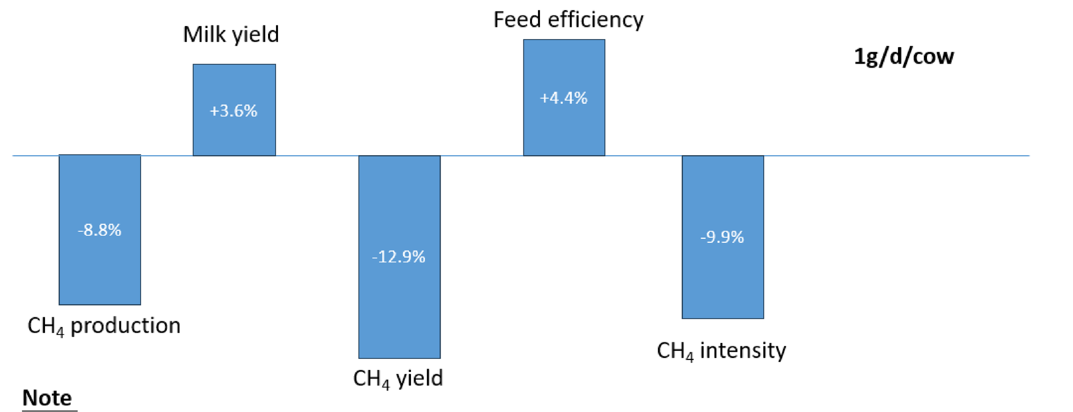
Methane emissions in the United States



U.S. Environmental Protection Agency (2023). Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2021



Performance data of dairy cows supplemented with essential oils



Note
Feed efficiency means kilograms of milk over a kilogram of dry matter intake
CH_4 yield means CH_4 production (g) over a kilogram of dry matter intake
CH_4 intensity means CH_4 production (g) over a kilogram of milk yield

Meta-analysis, Belanche et al. 2020

- Organic farmers cannot use antibiotics in cows
- No previous study has evaluated essential oils derived from coriander, clove, and wild carrot in organic Jersey dairy cows
- No study has evaluated the effect of these essential oils on rumen (stomach) microbial communities during the transiting phase

OBJECTIVE

- To evaluate the effect of supplementing essential oils (AGOLIN® NATURU) on milk production and composition, rumen microbial communities, enteric methane emissions, and income over feed cost in Jersey cows transitioning from confinement to grazing systems

HYPOTHESIS

- Based on studies published in the literature, we hypothesize that supplementation of AGOLIN would modulate microbial communities, reduce the methane emissions, and improve feed efficiency by producing more propionate, leading to more milk production, and increased farm profitability

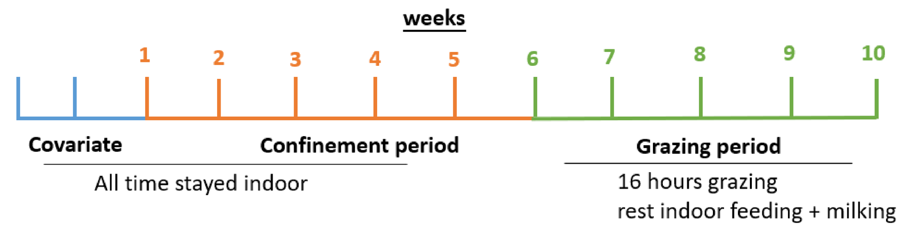
MATERIALS AND METHODS

Experimental design:
- A total of 22 (6 primiparous and 16 multiparous) organic certified Jersey cows (BW, 468 ± 51 kg/d) were used in a randomized complete block design with repeated measures over time

Treatment:
- **Control**: No supplementation of essential oils, n=11
- **AGOLIN**: Supplementation of 1 gram of essential oils (AGOLIN® NATURU), n=11

MATERIALS AND METHODS

Trial duration and feeding:



Data collection:
- Daily dry matter intake and milk yield
- During sampling weeks, milk sample, rumen fluid sample, feces and urine samples
- Two GreenFeed units were used to measure gaseous emissions.

Microbial data:
- Ruminal fluid was collected once via esophageal tubing and characterized using shotgun metagenomics to account for archaeal, bacterial, fungal, and protozoal populations.

Statistical analysis:
- Production data were analyzed using the MIXED procedure of SAS
- Microbial data were analyzed using centered-log ratio normalized data in R
- Significance was declared at $P \leq 0.05$ and trends at $0.05 < P \leq 0.10$.

Table 1. Ingredients and chemical composition of the diet fed to dairy cows during the experiment

Item	P1	P2
Ingredient, % of DM		
Alfalfa-grass baleage (late-budding)	46.5	25.5
Alfalfa-grass baleage (pre-budding)	13.6	–
Grass-legume pasture	–	34.4
Concentrate mash	39.3	39.5
Bypass fat	0.57	0.57
Composition, % of DM		
Dry matter	68.2	56.4
Crude protein	17.9	15.3
Ethanol soluble carbohydrates	4.40	4.49
Starch	21.9	22.7
Ether extract	3.93	4.30
Total fatty acids, g/kg of DM	24.3	21.9
Calcium	1.10	0.94
Phosphorus	0.41	0.35
Gross energy, Mcal/kg of DM	4.15	4.07

P1 = Confinement period
P2 = Grazing period

RESULTS

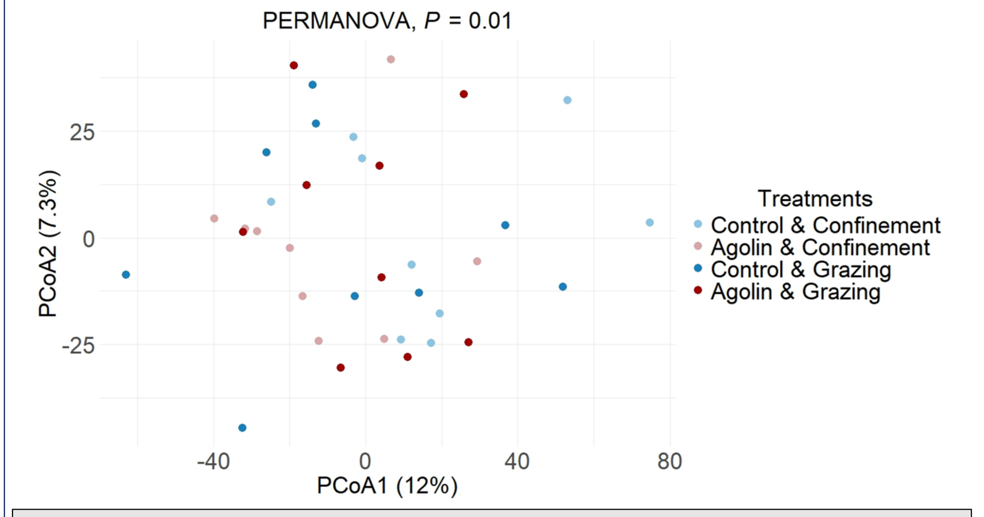


Figure 1. Principal coordinate analysis (PCoA) plots; significance by PERMANOVA (Euclidean distances)

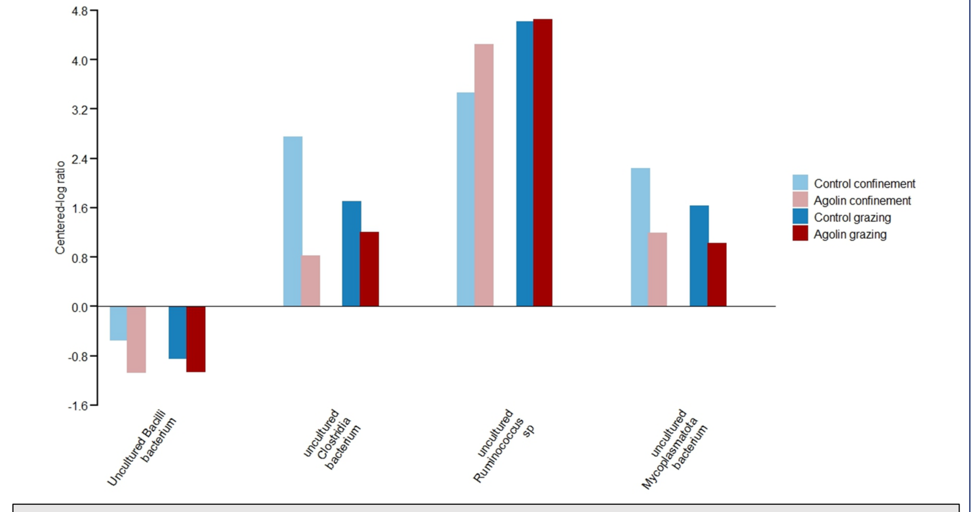


Figure 2. Bar plots of CLR-transformed relative (RA) abundance of selected rumen microbial taxa

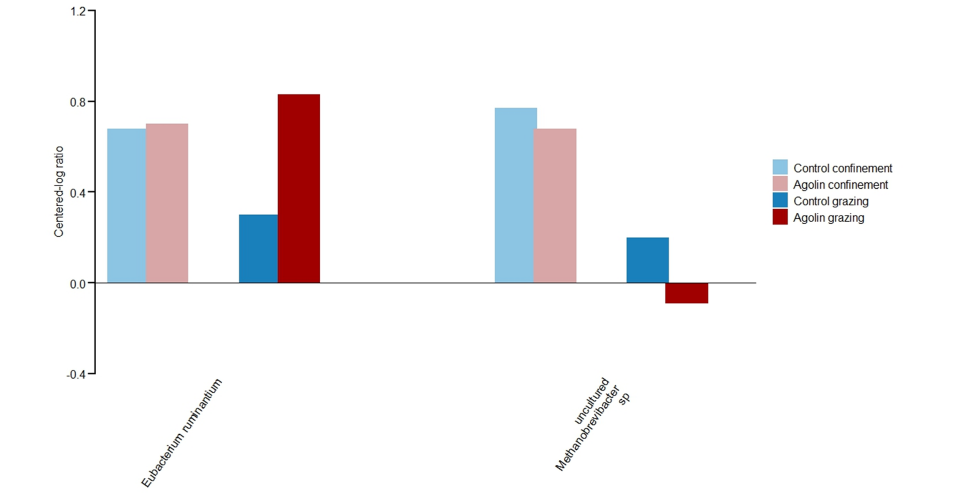


Figure 3. Bar plots showing CLR-transformed RA

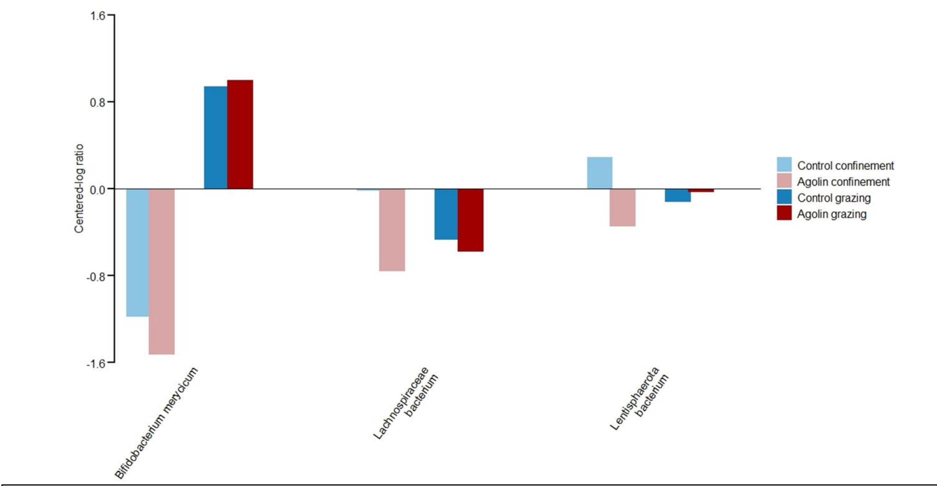


Figure 4. Bar plots showing CLR-transformed RA

RESULTS

Table 2. Effect of essential oils supplementation on milk production and composition of organic dairy cows

	Confinement (P1)		Grazing (P2)			*P*-value		
Item	Control	AGOLIN	Control	AGOLIN	SEM	Trt (T)	Period (P)	T × P
Dry matter intake, kg/d	20.6	21.1	22.1	21.8	0.29	0.75	0.01	0.06
Milk yield, kg/d	**31.2**	**32.1**	**29.1**	**30.5**	0.39	**0.01**	0.01	0.41
Milk fat, kg/d	**1.37**	**1.47**	**1.30**	**1.36**	0.04	**0.05**	0.02	0.67
Milk true protein, kg/d	**1.06**	**1.07**	**0.97**	**1.02**	0.03	**0.08**	0.01	0.24
Milk lactose, kg/d	**1.50**	**1.55**	**1.38**	**1.48**	0.04	**0.06**	0.01	0.26
Milk total solid, kg/d	**4.25**	**4.44**	**3.93**	**4.25**	0.12	**0.01**	0.01	0.41
Feed efficiency	1.49	1.51	**1.33**[b]	**1.41**[a]	0.03	0.15	0.01	**0.03**

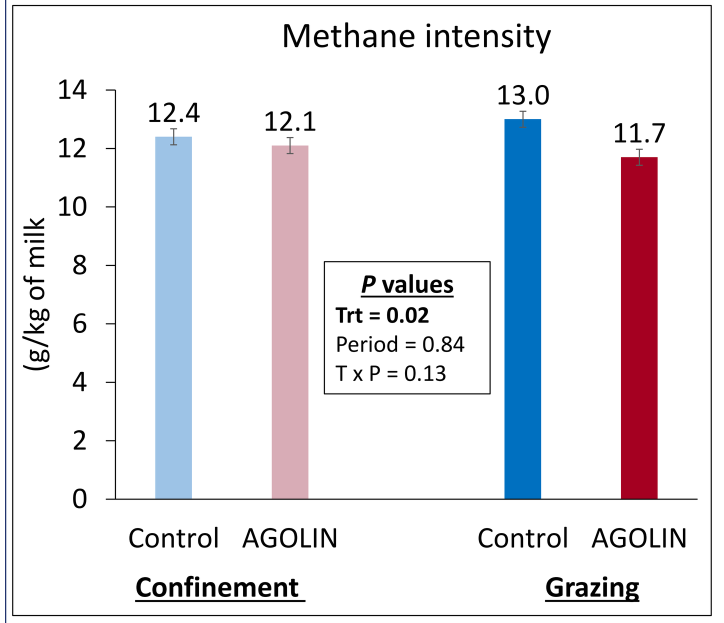


Figure 5. Bar plot of methane intensity

Income over feed cost (IOFC)

	Confinement		Grazing	
Item	**Control**	**Agolin**	**Control**	**Agolin**
IOFC[1]	12.3	12.7	8.8	9.7

[1]Income over feed cost ($/cow/day) = daily milk sale price – daily feed cost

Overall, between the two systems, a 6.3% improvement

RESULTS

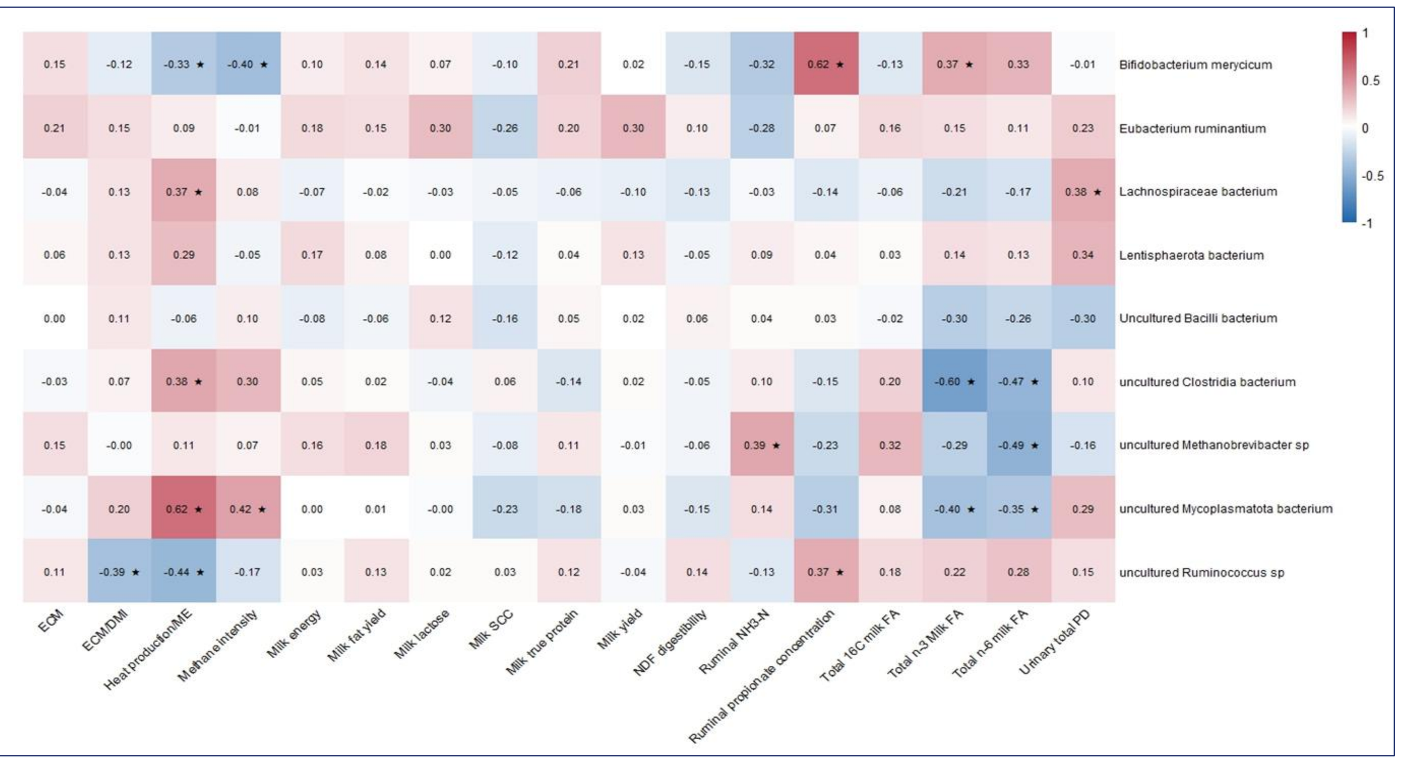


Figure 6. Heat map of Pearson correlations between ruminal microbial taxa and production, fermentation, and milk composition traits, with effects of treatment, interaction, and week. *Indicates correlations with $P \leq 0.05$.

CONCLUSIONS

AGOLIN supplementation reduced methane intensity and increased IOFC by 6%, improving milk yield, fat, and total solids without affecting DMI; 6% feed efficiency improved only during grazing. Uncultured *Ruminococcus* sp. increased (P < 0.01), while uncultured *Methanobrevibacter* sp. decreased during grazing. Overall, AGOLIN altered ruminal microbial community structure, with no relationship with enteric methanogenesis.