PRODUCTION PERFORMANCE, MILK FATTY ACID PROFILE, ENTERIC METHANE EMISSSIONS, AND ENERGY UTILIZATION IN GRAZING DAIRY COWS FED A FLAXSEED-BASED SUPPLEMENT

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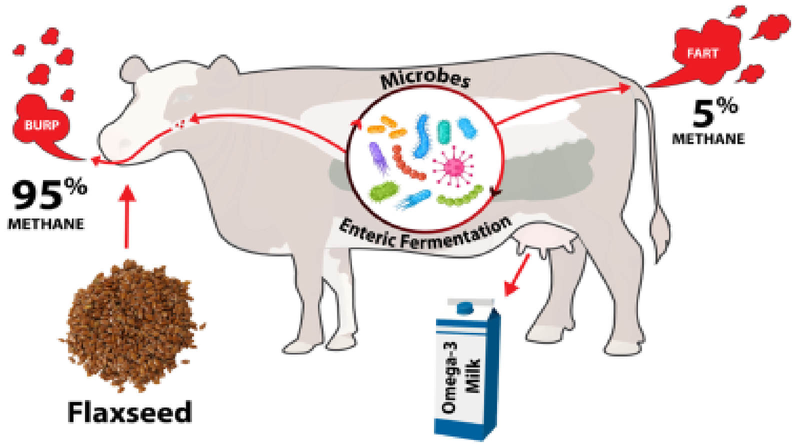

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Challenges for the organic dairy industry

- Lack of pasture
- Poor pasture quality
- Lack of legume forage
- Energy:protein ratio in the diet

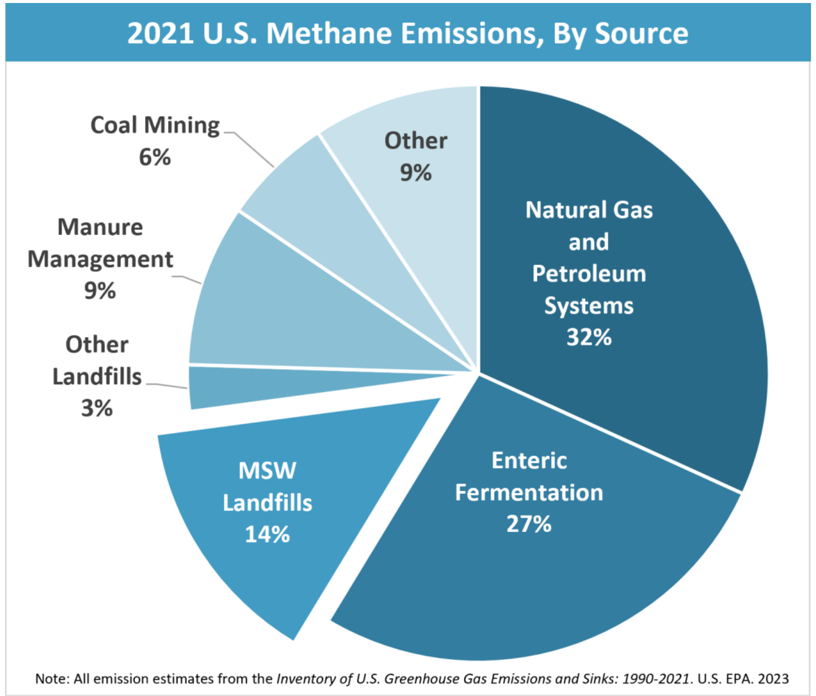
- Previous study from our lab showed that 86% of the pasture in the Northeastern region are failed to meet the energy requirement of the dairy cow**!!!**

Key is to finding cost-effective supplements that could be fed with pasture-based diet to increase energy density, thereby maintaining production performance!

(Hafla et al., 2016; McBride and Greene, 2009)

Enteric methane emissions

- CH_4 is potent greenhouse gas, and it has a global warming potential 28-34 times greater than carbon dioxide (CO_2).
- It has been proposed that **47% of CH_4 emissions are from grazing ruminants** (FAO, 2021)
- Grazing ruminants may have greater CH_4 emissions due to decreased animal performance from high forage diets (Leng, 1993).



Enteric CH_4 emissions of cows fed incremental amounts of extruded flaxseed (0, 5, 10, and 15% of diet DM) with hay-based diet

Item	Treatments H0	H5	H10	H15	SEM	*P-value* L[1]	Q[2]
CH_4 g/d (-40%)	485	411	394	289	29.9	**<0.01**	0.58
CH_4 yield, g/kg of DMI	23.4	21.8	19.9	14.6	1.45	**<0.01**	**0.03**
DMI kg/d	20.8	18.9	19.9	19.9	0.70	0.55	0.15
Nutrient digestibility, %							
DM, %	70.5	68.8	70.5	69.8	0.84	0.89	0.58
OM, %	72.1	70.5	72.1	71.4	0.84	0.92	0.61
NDF,%	61.4	60.8	63.5	61.9	1.29	0.45	0.66
Milk yield	26.1	25.8	28.3	26.4	1.68	0.58	0.59

[1]L = Linear [2]Q = Quadratic

CH_4 production dropped by 40% when extruded flaxseed was fed 15% diet DM compared to control.

Martin et al. (2016)

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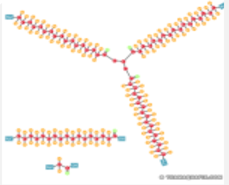
Flaxseed in dairy diet: Opportunities

Flaxseed as fat supplement can increase the energy consumption of cows, thereby supporting milk production performance.



Flaxseed is rich in omega-3 FA particularly ALA that can be transferred to the milk, suggesting potential health benefits for humans (Zachut et al., 2010). Milk CLA has also been shown to increase (Glasser et al., 2008).

Flaxseed has also been shown to decrease enteric CH_4 emissions in previous research (Martin et al., 2008; Martin et al., 2016; Beauchemin et al., 2009)

Knowledge gap

- Limited studies with feeding extruded **flaxseed in pasture based-diet**
- Studies investigating extruded **flaxseed as anti-methanogenic** feed supplement are scarce as well.
- Some studies have investigated extruded flaxseed effects on production performance, nutrient digestibility, and milk FA profile but evaluating EF for **energy utilization in cows are very limited**!

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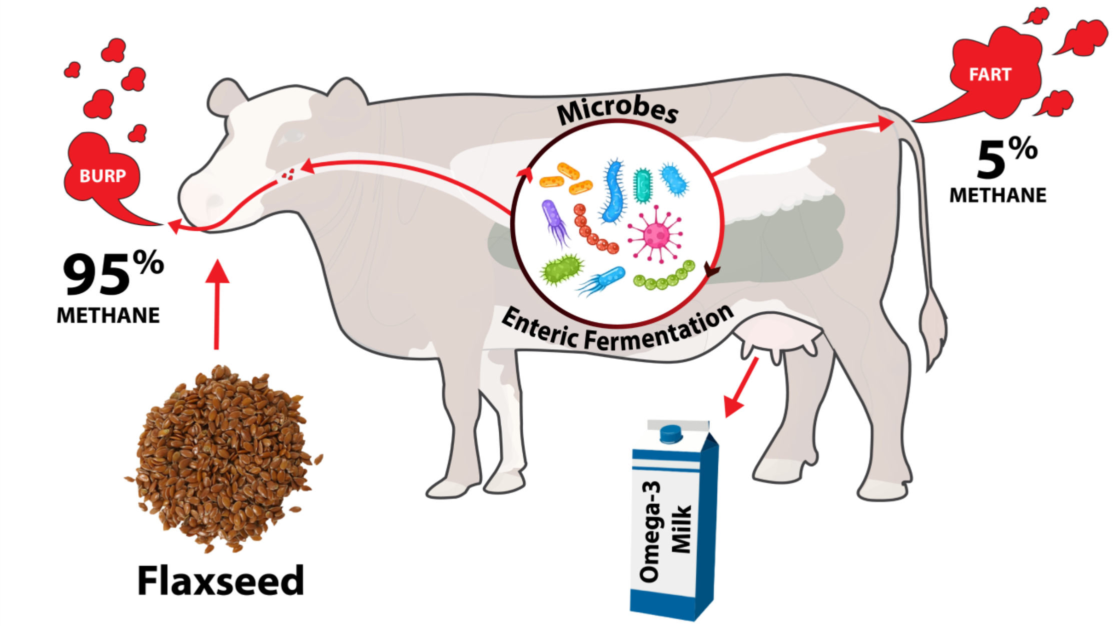
Objective and Hypothesis



- Evaluating the effects of EF-based supplement (LinPRO-R) on **milk production** and **compositions, fatty acid profile**, **energy utilization**, and **enteric methane emissions** in grazing dairy cows.

- EF diet would provide more dietary energy; therefore, milk production will increase while enriching **omega-3 FA in milk.**

- Oil in flaxseed would **be toxic to the ruminal methanogens** that will **decrease CH_4 production** in cows.

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Experimental Design

- Two primiparous and 18 multiparous organically certified Jersey cows (128 ±52 DIM)
- Randomized Complete Block Design (RCBD)
- Cows grazed a mixed grass-legume pasture (herbage allowance = 15 kg of DM/cow daily) overnight and received a partial total-mixed ration (pTMR) during the day
- Cows were randomly assigned to 1 of 2 diets: 1. pasture plus pTMR (control = **CTRL**), 2. pasture, pTMR, and 6% (diet DM) LinPRO-R (**LIN**)

4:30 AM — Fed pTMR Indoor — 5:30 PM

5:30 PM — Overnight Grazing — 4:30AM

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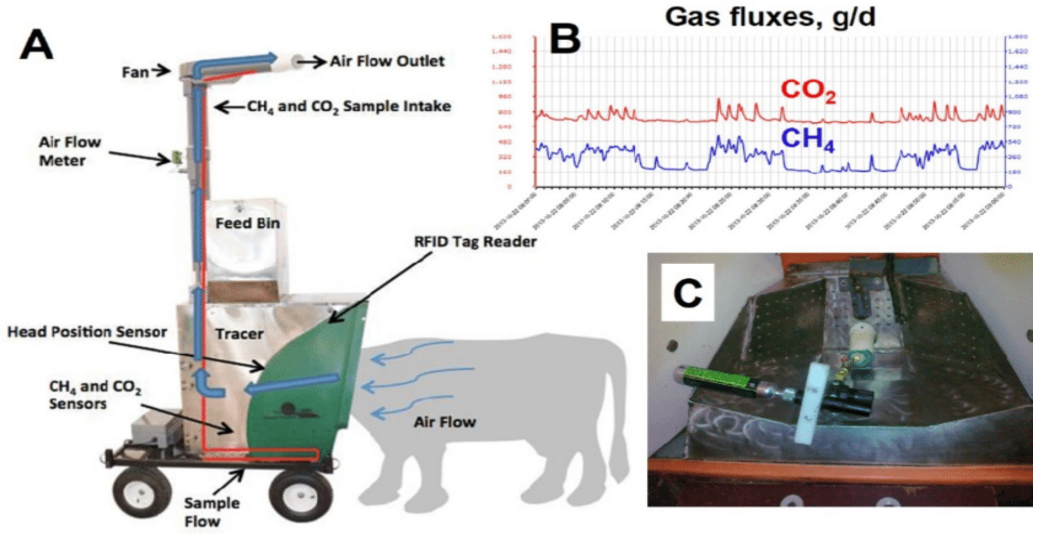
Sample Collection

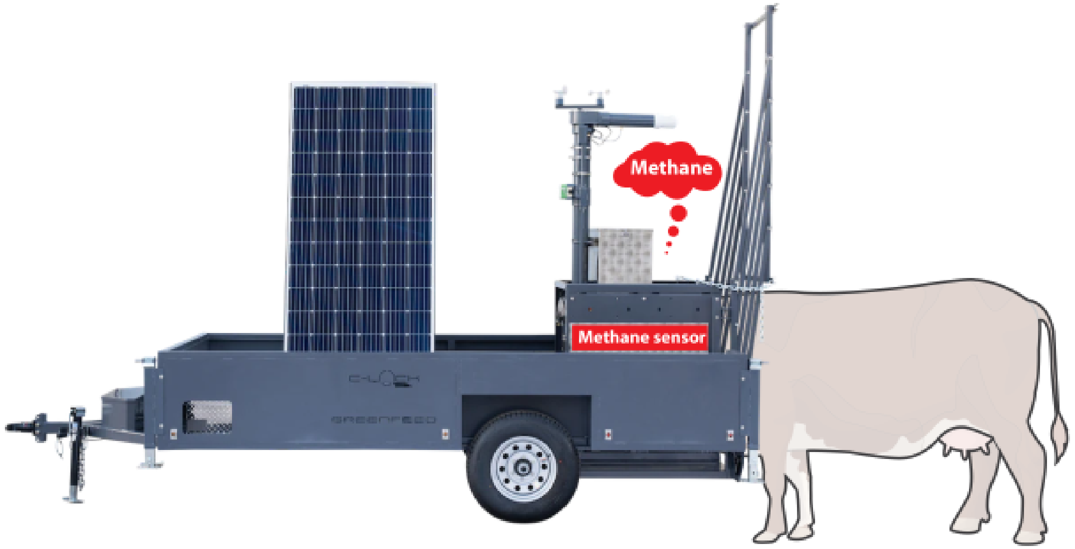
Covariate | Sampling (wk-4 to wk-10)

COVARIATE WEEK	wk-4	wk-7	wk-10
Body weight	**Sampling week**	**Sampling week**	**Sampling week**
BCS	BW & BCS	BW & BCS	BW & BCS
Blood samples	Milk	Milk	Milk
Rumen Fluid	Blood	Blood	Blood
Milk yield	Urine and fecal	Urine and fecal	Urine and fecal
	Pasture	Pasture	Pasture
	Rumen Fluid	Rumen Fluid	Rumen Fluid

Feed intake, milk yield, methane were recorded throughout the study

Gaseous emissions measurements





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Statistical Analysis

- Data were analyzed using mixed procedure of SAS

Linear model: $Y_{ijkl} = \mu + B_i + D_j + W_k + \beta C_{ijkl} + D \times W_{jk} + \varepsilon_{ijkl}$,

Y_{ijk} = dependent variable

μ = overall mean

B_i = = Random effect of the ith block (pair of cows)

D_j = fixed effect of the jth diet

W_k = fixed effect of the kth week

β = regression coefficient of the covariate C

C_{ijkl} = = The covariate variable for the lth cow within the ith block of the jth treatment in the kth week

$D \times W_{jk}$ = interaction between the jth diet and kth week

ε_{ijk} = error term (assumed to be normally distributed with mean = 0 and constant variance)

Ingredient and Chemical Composition of the Diet

Item	Diet (% of diet DM)	
	CTRL	LIN
Pasture	37.0	37.4
pTMR		
Baleage	23.6	23.6
CTRL mash[1]	39.4	0.00
LinPRO mash[2]	0.00	33.0
LinPRO-R[3]	0.00	6.0
Composition		
DM, % of diet fresh matter	67.4	64.2
CP, % of DM	14.2	14.0
Ash, % of DM	8.90	8.50
NDF, % of DM	35.7	36.1

[1]CTRL mash was included in the CTRL diet
[2]LinPRO mash was included in the LIN diet
[3]Consisted 54.7% extruded flaxseed, 37.8% ground field peas, 6.9% dehydrated alfalfa, 0.15 vitamin E, 0.3% mold inhibitor, 0.05% ethoxyquin (O&T Farms, Canada)

Ingredients	Mash	
	CTRL mash[1]	LinPRO mash[2]
Corn meal – ground	65.8	68.8
Soybeans – extruded	7.67	4.49
Soybeans – roasted	6.00	4.50
Barley grains - ground	15.02	15.85
Salt - plain	1.27	1.47
Magox – 54 % Mg[3]	0.53	0.58
Dikal[4] – 21	0.33	0.35
Limestone[5] – 35.5 Ca	0.40	0.42
Magnesium Sulfate	0.49	0.57
Sodium bicarbonate	1.60	1.85
XP yeast	0.17	0.19
Morrison dairy premix	0.65	0.75
CA sulfate granular	-	0.02

[1]Concentrate blend (10% CP) was included in pTMR for the LIN diet.
[2]Concentrate blend (12% CP) was included in pTMR for the CTRL diet.
[3]Magox contained 54% Mg.
[4]Dikal contained 19% Ca and 21% P
[5]Limestone contained 35.5% Ca.

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Results – Milk yield and Components

Item	Treatment		SEM	*P*-value[1]		
	CTRL	LIN		TRT	Week (W)[2]	TRT × W
Estimated pasture DMI[3], kg/d	7.39	5.95	0.41	**<0.01**	<0.03	**0.01**
pTMR DMI, kg/d	14.5	14.9	1.01	0.14	<0.01	0.90
Total DMI[4], kg/d	23.3	22.3	0.51	**0.06**	<0.01	0.06
Milk yield, kg/d	27.6	27.1	0.91	0.68	<0.01	0.55
4% FCM, kg/d	30.3	29.5	1.07	0.62	<0.01	0.77
ECM yield, kg/d	32.5	31.8	1.11	0.68	<0.01	0.87
Milk fat, %	4.54	4.60	0.13	0.47	<0.01	0.08
Milk fat, kg/d	1.26	1.27	0.04	0.78	<0.01	0.74
True protein, %	3.49	3.46	0.05	0.67	<0.01	0.56
True protein, kg/d	0.95	0.95	0.03	0.74	<0.01	0.54
Milk lactose, %	4.78	4.80	0.01	0.40	<0.01	0.61
Milk lactose, kg/d	1.31	1.32	0.04	0.76	<0.01	0.72
MUN, mg/dL	11.0	8.38	0.39	**<0.01**	<0.01	0.27

[1]Significance was declared at $P \leq 0.05$ and trends at $0.05 < P \leq 0.10$

[2]Wk 4 (August 5 to August 11); Wk 7 (August 26 to September 1); Wk 10 (September 16 to September 22)

[3]Estimated pasture DMI (kg/d) = [{fecal DM output (kg/d) – GF pellet DMI (kg/d) x (1 - IVDMD of GF pellet) – Cr_2O_3 pellet DMI (kg/d) x (1 - IVDMD of Cr_2O_3 pellet) - TMR DMI (kg/d) x (1- IVDMD of TMR)] / (1 - IVDMD of pasture) (Bargo et al., 2002a)

[4]Cr_2O_3 pellet and GreenFeed pellet were included in the total DMI

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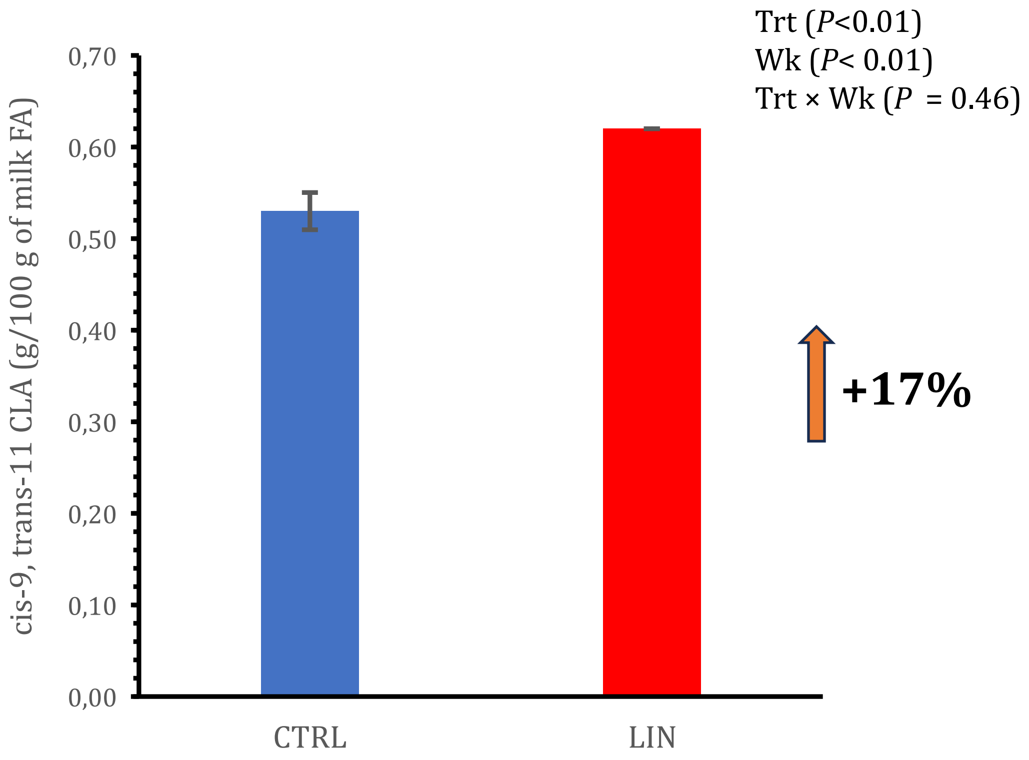
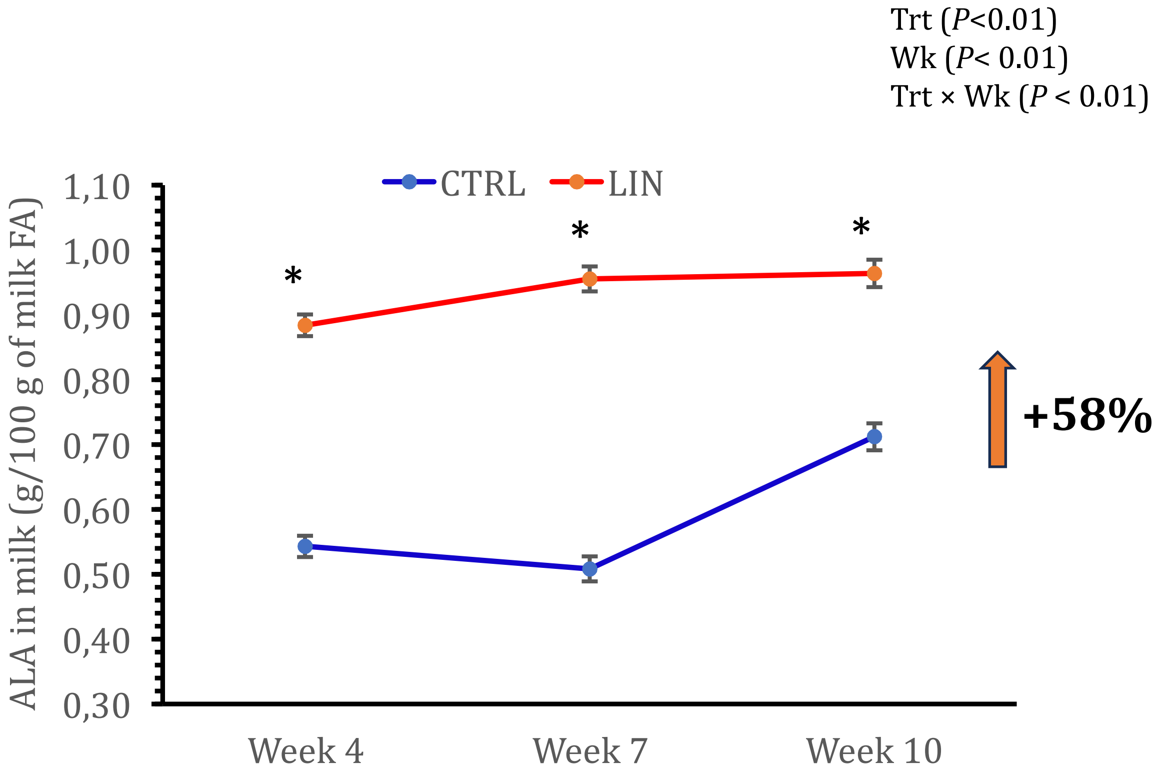
Results – CLA and ALA in milk



CLA in milk of cows fed either CTRL or LIN diet



α-Linolenic acid (ALA) in milk of cows fed either CTRL or LIN diet

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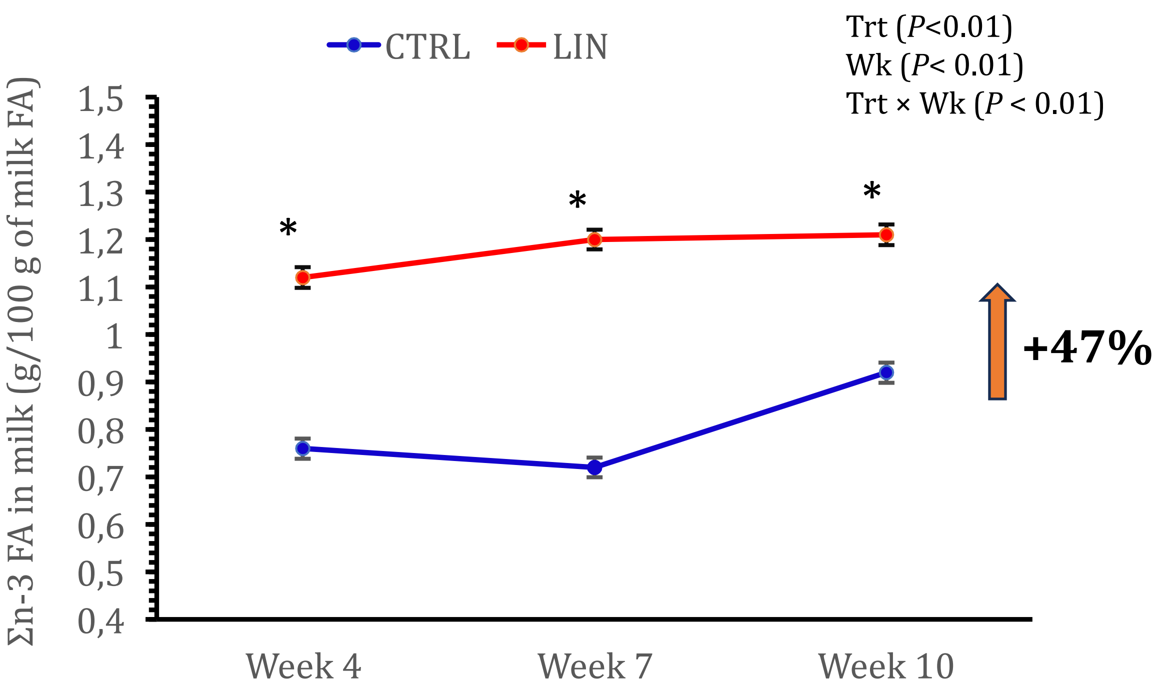
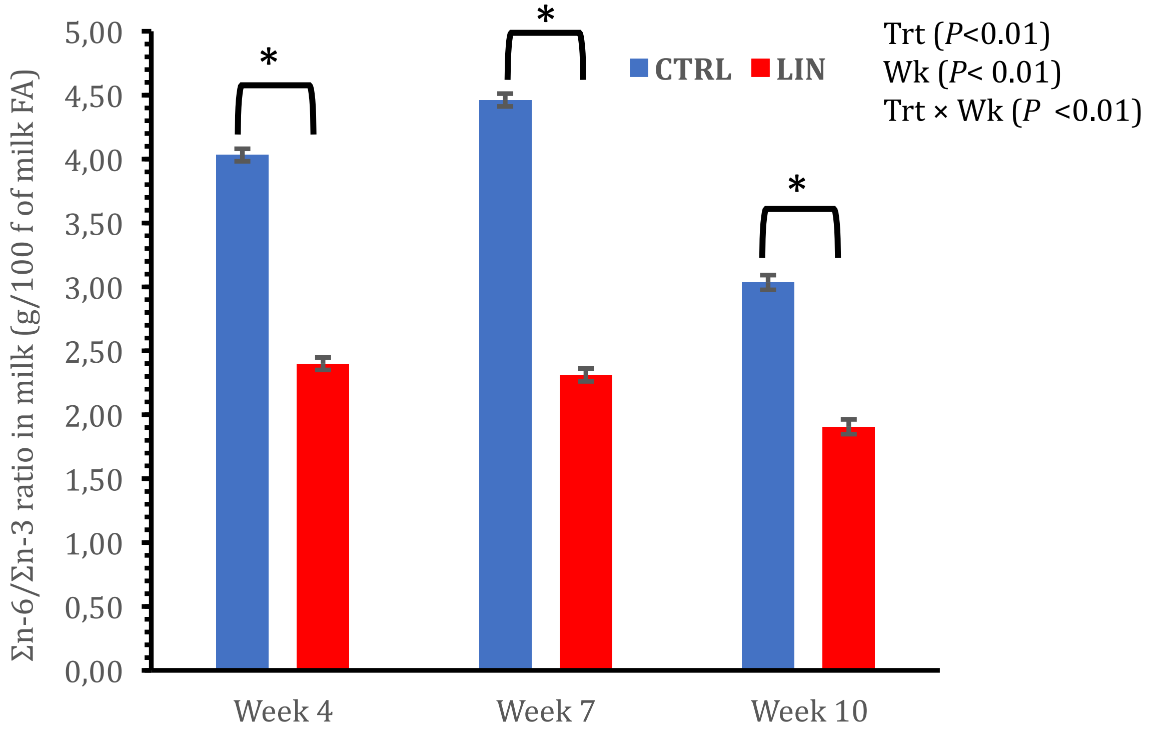
Results – Σn-3 FA and n-6/n-3 ratio in in milk



Σn-3 FA in milk of cows fed either CTRL or LIN diet



Σn-6/Σn-3 ratio in milk of cows fed either CTRL or LIN diet

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Results – Enteric Gas Emissions

Item	Treatment		SEM	*P*-value		
	CTRL	LIN		TRT	Week (W)	TRT × W
CH_4, g/d	355	348	16.1	0.77	0.31	0.86
CH_4 yield, g/kg of DMI	15.3	15.7	0.69	0.70	<0.01	0.58
CH_4 production, g/kg of milk	13.2	13.5	0.78	0.73	0.01	0.55
CH_4 intensity, g/kg of ECM	11.6	11.0	0.63	0.46	<0.01	0.50
CO_2, kg/d	11.0	10.8	0.28	0.64	0.03	0.40
CO_2 yield, g/kg of DMI	478	487	1.03	0.54	0.28	0.30
O_2, kg/d	8.17	7.95	0.20	0.46	0.62	0.69

[1]Significant difference between diets was declared at $P \leq 0.05$ and trends at $0.05 < P \leq 0.10$.
[2]Wk 4 (August 5 to August 11); Wk 7 (August 26 to September 1): Wk 10 (September 16 to September 22).
[3]ECM yield = [0.327 × milk yield (kg/d)] + [12.95 × milk fat yield (kg/d)] + [7.2 × milk true protein yield (kg/d)] (Orth, 1999]

Results – Energy utilization and efficiency

Item, Mcal/d	Treatment		SEM	*P*-value		
	CTRL	LIN		TRT	Week (W)	TRT × W
GE intake	100	96	2.15	**0.04**	<0.01	0.06
DE intake	68.7	66.4	1.44	0.14	<0.01	0.10
ME intake	60.6	59.0	1.03	0.45	<0.01	0.09
NE_L intake[4]	40.2	38.9	1.03	0.50	<0.01	0.11
Fecal energy	31.4	29.2	0.77	**<0.01**	<0.01	0.05
Urinary energy	2.39	2.30	1.12	0.83	0.63	0.52
CH_4 energy	4.67	4.58	0.22	0.77	0.31	0.86
Heat production	28.3	27.7	0.71	0.53	0.56	0.87
Milk energy	22.4	22.6	0.89	0.87	<0.01	0.16
Tissue energy	10.1	8.90	0.50	0.87	0.03	0.64
ME/DE	89.1	89.0	0.48	0.87	<0.01	0.44
Milk energy/ME	36.8	37.5	1.33	0.71	0.01	0.04
Heat production/ME	46.8	47.0	1.03	0.87	0.02	0.13
Tissue energy/ME	19.7	19.0	1.10	0.86	0.13	0.02

[1]Significant difference between diets was declared at $P \leq 0.05$ and trends at $0.05 < P \leq 0.10$

[2]Wk 4 (August 5 to August 11); Wk 7 (August 26 to September 1): Wk 10 (September 16 to September 22).

[3]GE = gross energy; digestible energy (DE) intake (Mcal/d) = GE intake (Mcal/d) − fecal energy (Mcal/d); ME intake (Mcal/d) = DE intake (Mcal/d) − urinary energy (Mcal/d) − CH4 energy (Mcal/d) (NRC, 2001).

[4]NE_L intake (Mcal/d) = ME intake (Mcal/d) × 0.66 [NASEM, 2021]

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Summary

- LinPRO-R fed at 6% diet DM had:
  - **no effect** on **milk yield and components except MUN** which decreased in LIN diet.
  - **Omega-3 FA increased by 47%** in LIN diet compared to CTRL.
  - Enteric CH_4 production did not differ between diets
  - No major effects on energy utilization efficiency
  - Industry adoption for n-3 enriched milk will determine its profitability for dairy farmers
  - A higher inclusion in the diet may improve milk production and decrease enteric methane emissions.

Questions??