Effects of feeding different microencapsulated sources of long and very-long chain unsaturated fatty acids on production and blood parameters in response to an immune challenge

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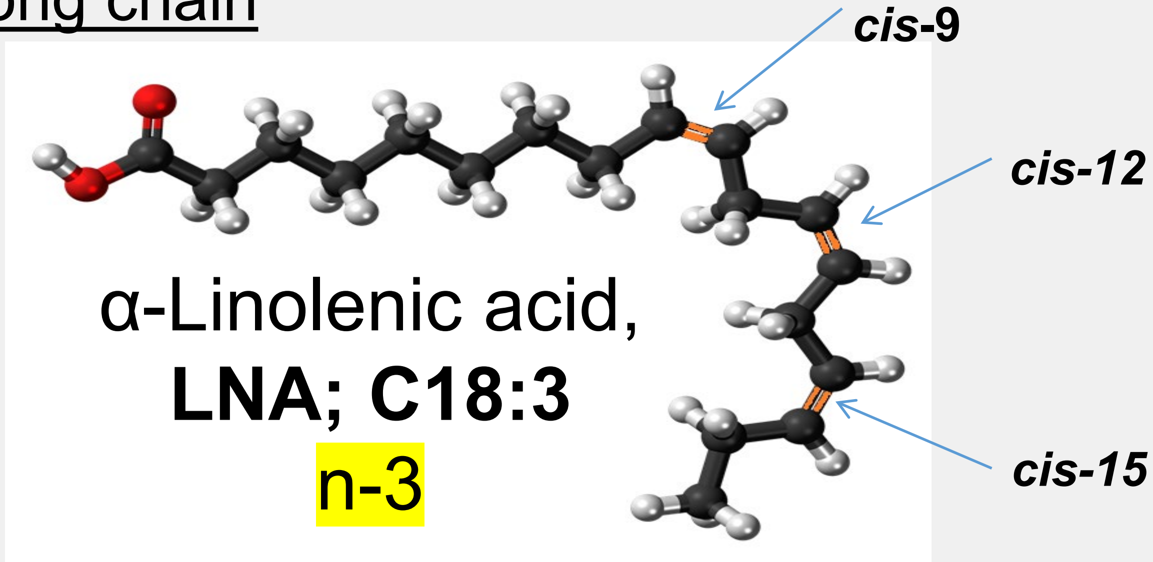
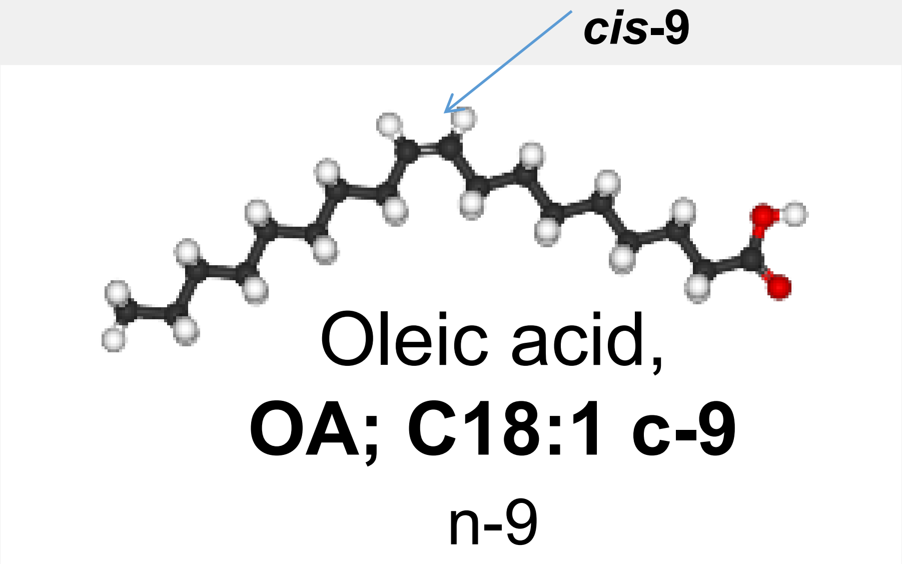
Long, very-long, and doble bonded fatty acids chains

<u>Long chain</u>

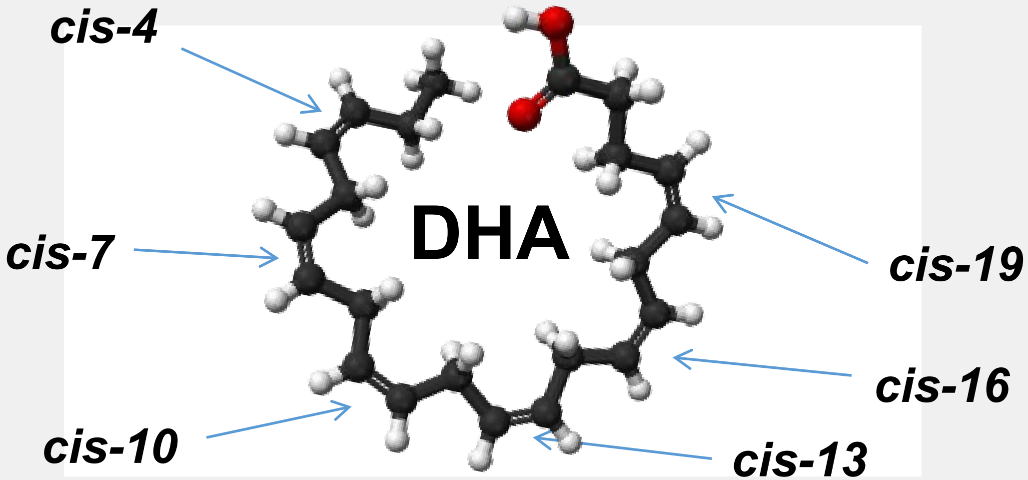




<u>Very-long chain **(VLC)**</u>

Eicosapentanoic acid, **EPA; C20:5** n-3

Docosahexaenoic acid, **DHA; C22:6** n-3



Omega-6 (n-6) and Omega-3 (n-3) are essential FA

Omega 6

Linolenic acid
LA, 18:2 n-6

Desaturases
Elongases

Arachidonic acid
AA, 20:4 n-6

Cyclooxygenase
/
lipoxygenase

2-series prostaglandins
2-series thromboxanes
4-series leukotrienes

Pro-inflammatory
Pro-aggregatory
Thrombotic

Omeg

α-linolenic acid
ALA, 18:3 n-3

Eicosapentaenoic acid
EPA, 20:5 n-3

D

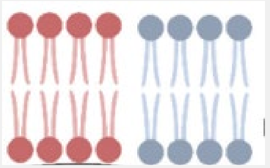
3-series prostaglandins
3-series thromboxanes
5-series leukotrienes

Anti-inflammatory
Anti-aggregatory
Vasodilatory

Docosahexaenoic acid
(DHA), 22:6 n-3

Resolvins and protectins

Inflammation resolution
Membrane component in brain, retina.



Conversion inefficiency problem
Very low activity of delta-6 desaturase enzyme
(Whelan and Rust, 2006)

C18:3 n-3 → **0.2%** → **C20:5** → **63%** → **C22:5** → 37% → **C22:6**

Rico and Rico et al., 2024. Soth West Nutr. Conf.

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Effects of n-3 and oleic acid in cows: why the interest?

Fertility

- P4, E2, PGF2-alpha modulation
- Increased # ovulatory follicles
- Increased quality of oocytes
- Increased quality of CL
- Reduced embryo mortality

DMI and milk production

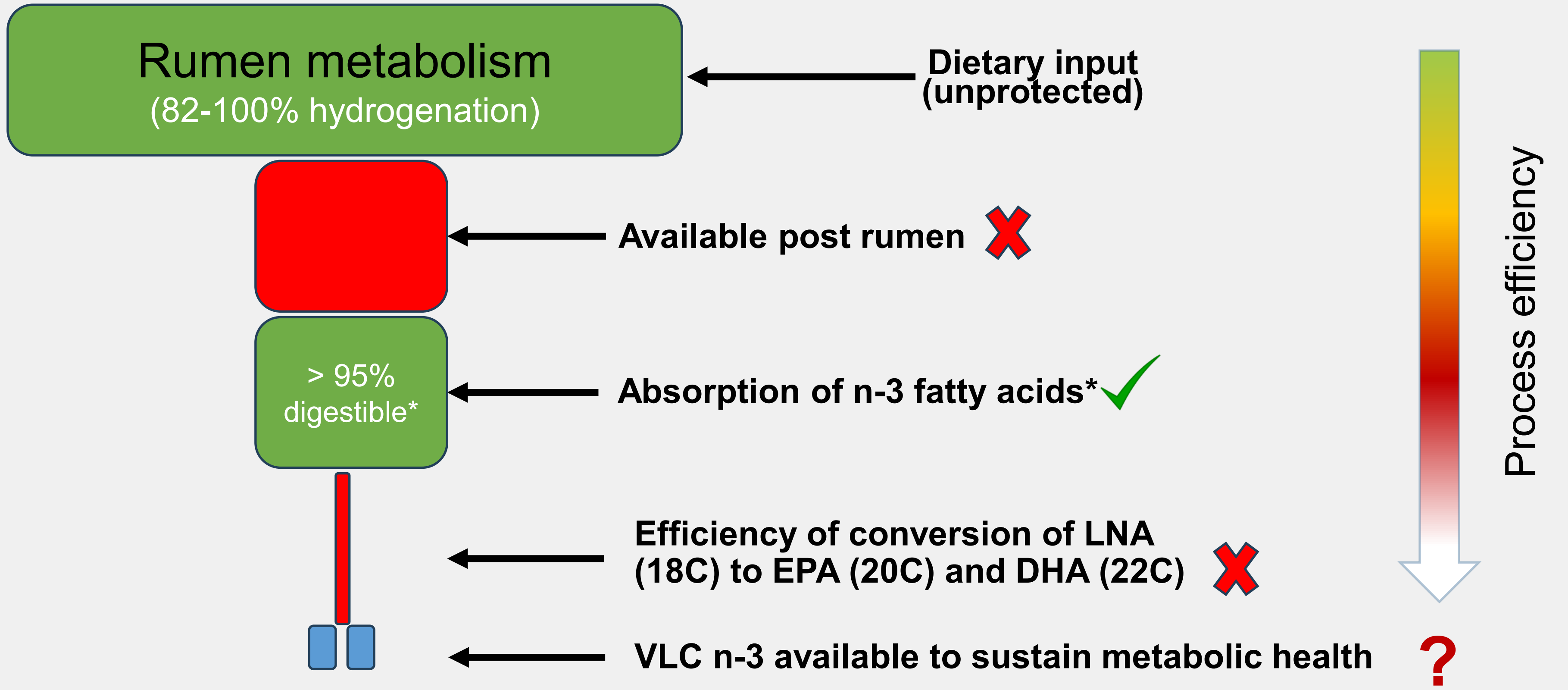
- Depends on amount, type, and form of fat (rumen availability)
- DMI, milk yield and milk components **reduced** by extruded linseed and oil
- DMI and milk yield **improved** in peripartal cows fed extruded oilseeds
- Oleic acid; increased insulin sensitivity and FA digestibility

New frontiers

- Control of inflammation
  - Response to stress
  - Temperature / appetite
  - Response to immune challenges (e.g.,cytokine / temperature)
- Fatty acid transfer into milk

Staples et al., 1998; Mattos et al., 2004; Staples et al., 1998; Bilby et al., 2006a, 2006b; Chilliard et al., 2009; Zachut et al., 2010, Greco et al., 2015

Bottlenecks in n-3 feeding efficiency



Hagemeister, 1991; Pawlosky et al., 2001; Rico et al., 2019

Objective

Caracterization of:

1. Digestibility of rumen-protected fish, algae and oleic acid oils
2. Effects on lactation performance
3. Effects on nutrient digestion
3. Fatty acid transfer into milk
4. Ability of VLC n-3 to modulate immune response

Hypothesis

Milk transfer and response to an immune challenge may **depend upon chain length degree of saturation** of the unsaturated fat supplements

Methods: Design and treatments

- **Multiparous lactating cows (n = 9)**
  - 82 ± 18 DIM
  - 3.7 ± 0.9 lactations
- **Triplicated 3 x 3 Latin Square**

Microencapsulated
in a triglyceride matrix

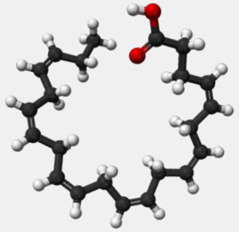
226 g FA/cow/day

Fish Oil (FO)
EPA+DHA
25 g/d

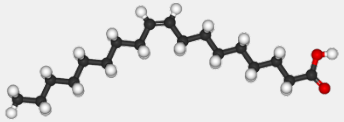
Algae Oil (ALG)
DHA
25 g/d

Oleic Acid (OA)
40 d/d

Very long chain n-3

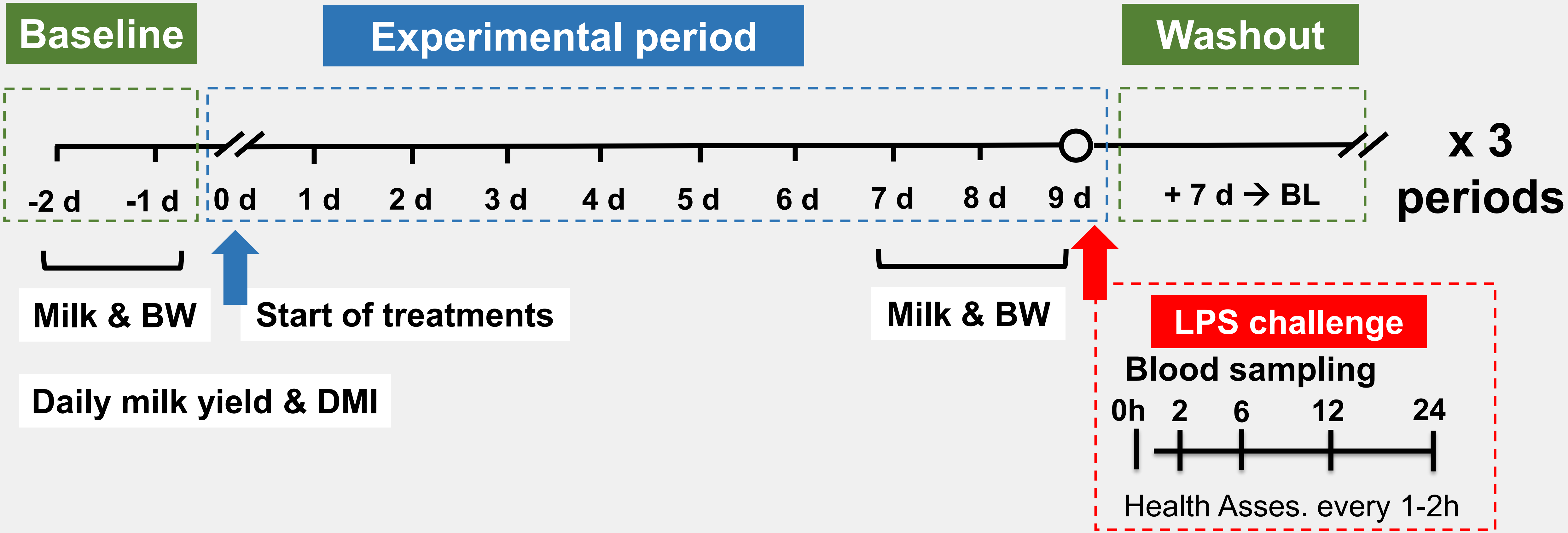


Long chain n-9



- **Treatments were top-dressed daily and cows fed at 115% of nutrient recommendations**

Methods: Timeline



0.30 ng/kg of BW of *Escherichia coli* O111:B4, Millipore Sigma

Statistical Approach

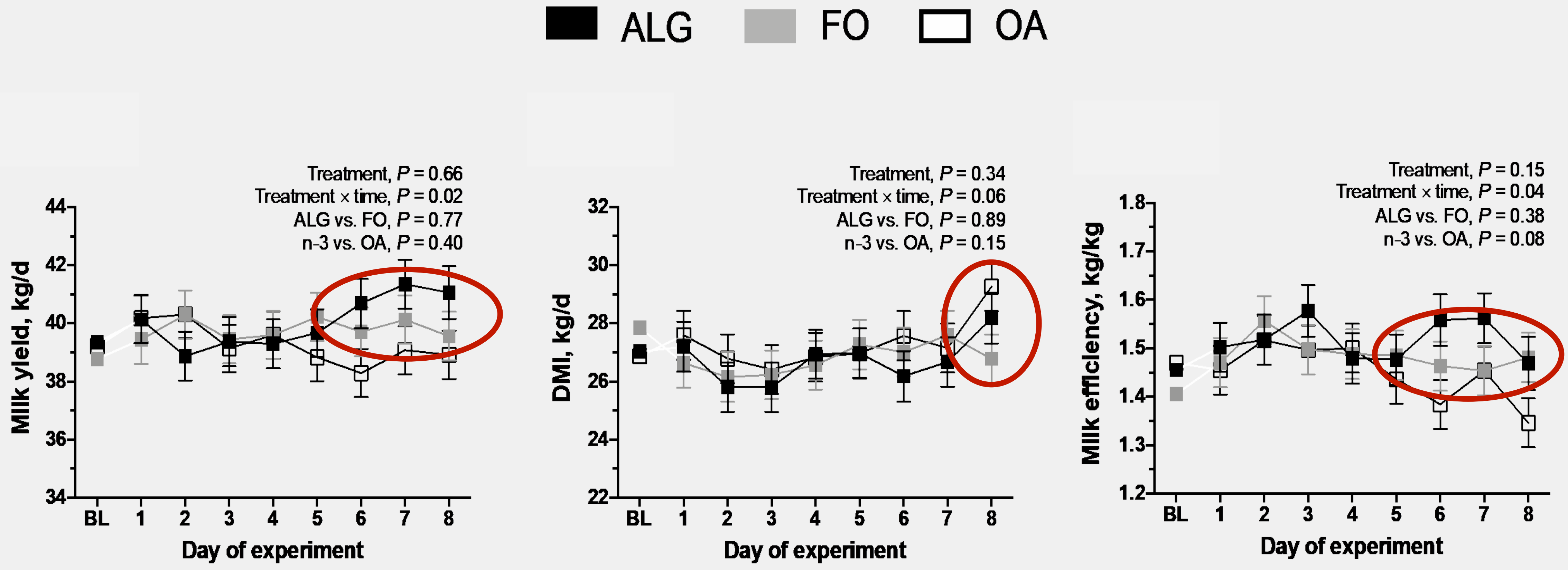
- General Linear Mixed Model
  - Random effect: Cow
  - Fixed effects: Treatment, Time, Interaction, Block
  - Covariates: LACT, DIM, baseline_VAR

- Pre-planned non orthogonal contrasts of interest:
  - ALG vs. FO
  - n-3 (ALG + FO) vs. OA

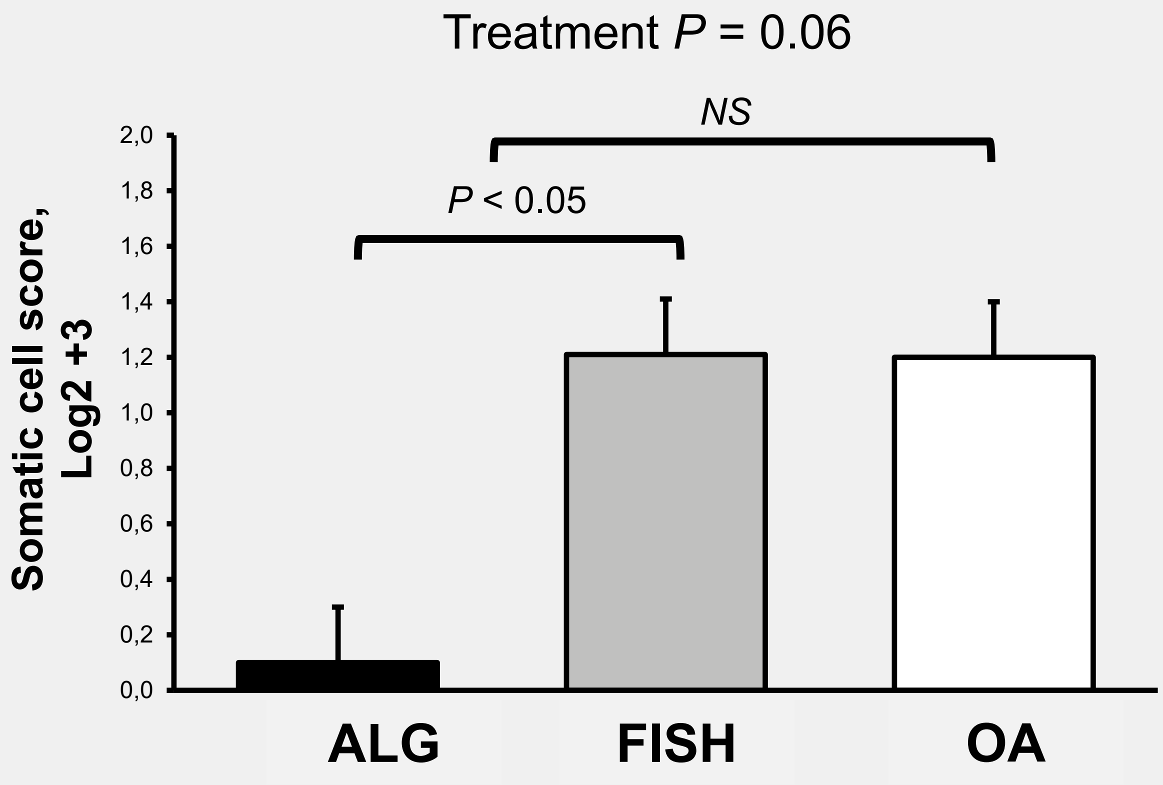
- Normality of Studentized Residuals
  - (+3.0, -3.0) and Q-Q plots

Statistical Discovery.™ From SAS.

Algae outperformed on d 6-8 while oleic acid tended to increase DMI



Algae-fed cows showed lowest SCC



Production results after LPS challenge

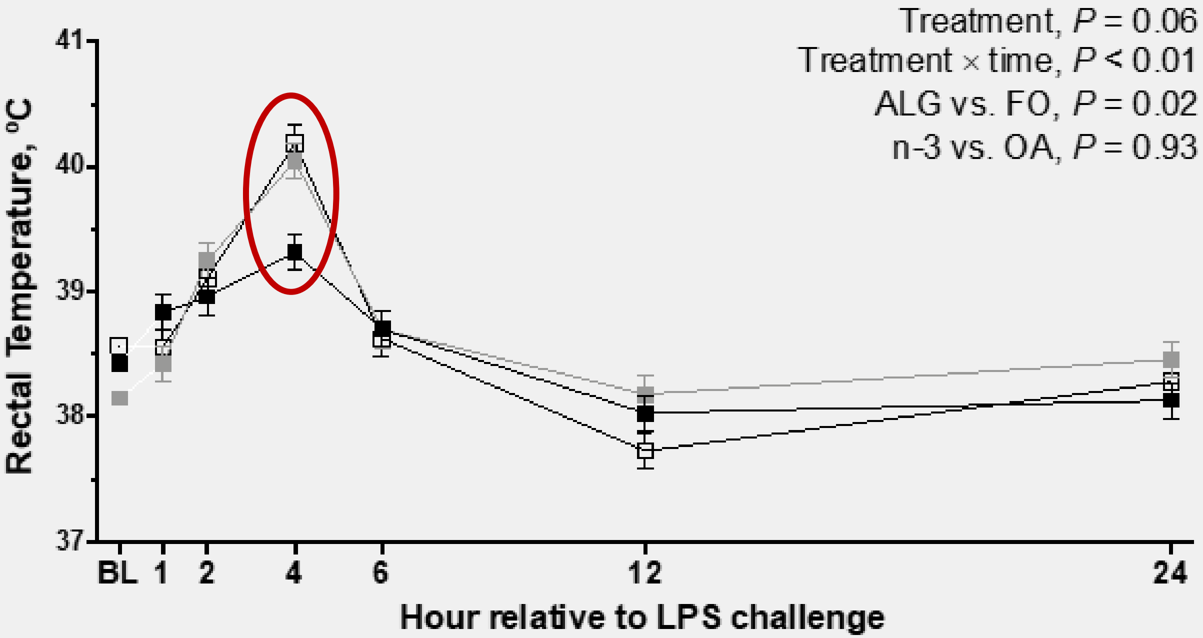
Variable	Treatment[1]			SEM	P-values[2]		
	ALG	FO	OA		Treatment	ALG vs. FO	n-3 vs. OA
Productive performance							
Milk yield, kg/d	34.9	35.1	32.1	1.49	0.36	0.93	0.16
Milk yield reduction, %	-11.8	-11.4	-19.5	3.75	0.29	0.95	0.12
DMI, kg/d	26.3	24.0	24.3	1.14	0.14	0.06	0.38
DMI reduction, %	-7.96	-13.35	-13.0	5.56	0.42	0.24	0.53
ECM, kg/d	37.8	37.1	34.9	1.49	0.47	0.81	0.22
3.5% FCM, kg/d	38.7	37.8	35.7	1.53	0.48	0.73	0.23
Milk composition, %							
Fat	4.33	4.02	4.29	0.11	0.07	0.04	0.36
Protein	3.10	3.15	3.18	0.03	0.32	0.33	0.23
Lactose	4.77	4.78	4.78	0.02	0.90	0.69	0.83
SCS, Log2 +3	1.52	1.38	1.37	0.26	0.92	0.74	0.82
MUN, mg/dL	15.3	15.2	15.6	0.30	0.64	0.86	0.39
Milk solids, kg/d							
Fat	1.38	1.41	1.36	0.06	0.86	0.75	0.68
Protein	1.04	1.11	1.02	0.05	0.40	0.33	0.37
Lactose	1.57	1.67	1.52	0.09	0.51	0.47	0.39
Feed efficiency							
Milk[3]	1.34	1.47	1.35	0.06	0.16	0.11	0.38
ECM[4]	1.44	1.55	1.46	0.10	0.16	0.09	0.45
3.5% FCM[5]	1.47	1.58	1.49	0.08	0.19	0.10	0.57

Sáinz de la Maza-Escolà et al., 2024. J. Dairy Sci. Vol. 107, Suppl. 1

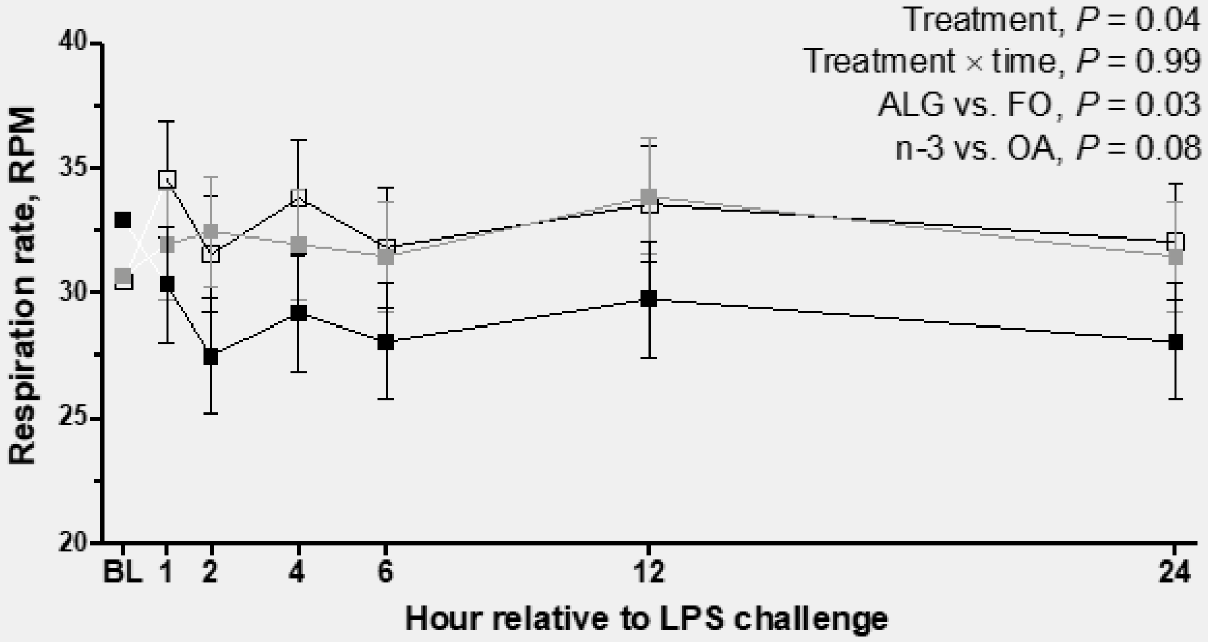
Algae tended to lower rectal Tº and RT after LPS challenge

ALG FO OA

Rectal Tº



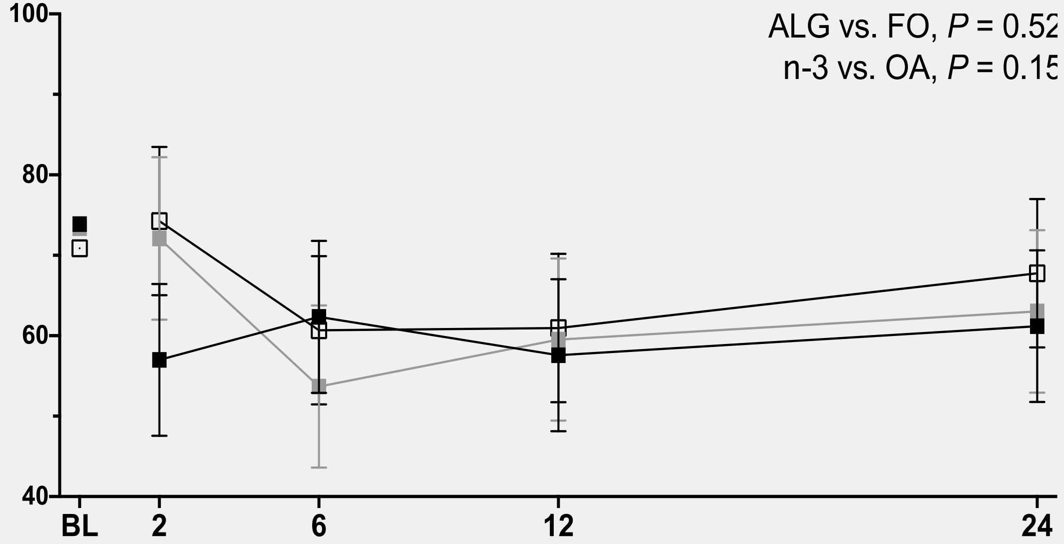
Respiration rate



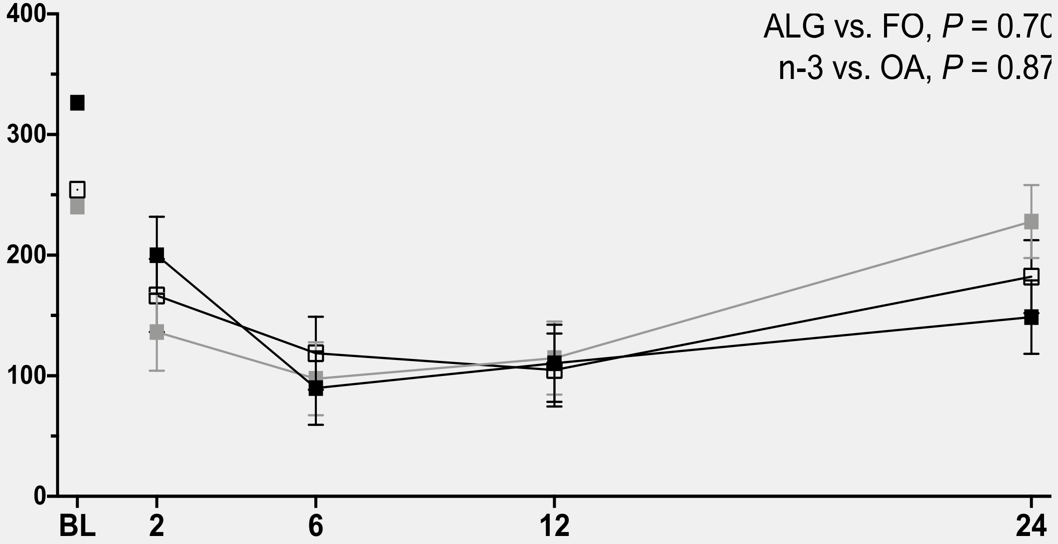
No remarkable changes in glucose and NEFAs

ALG FO OA

Glucose

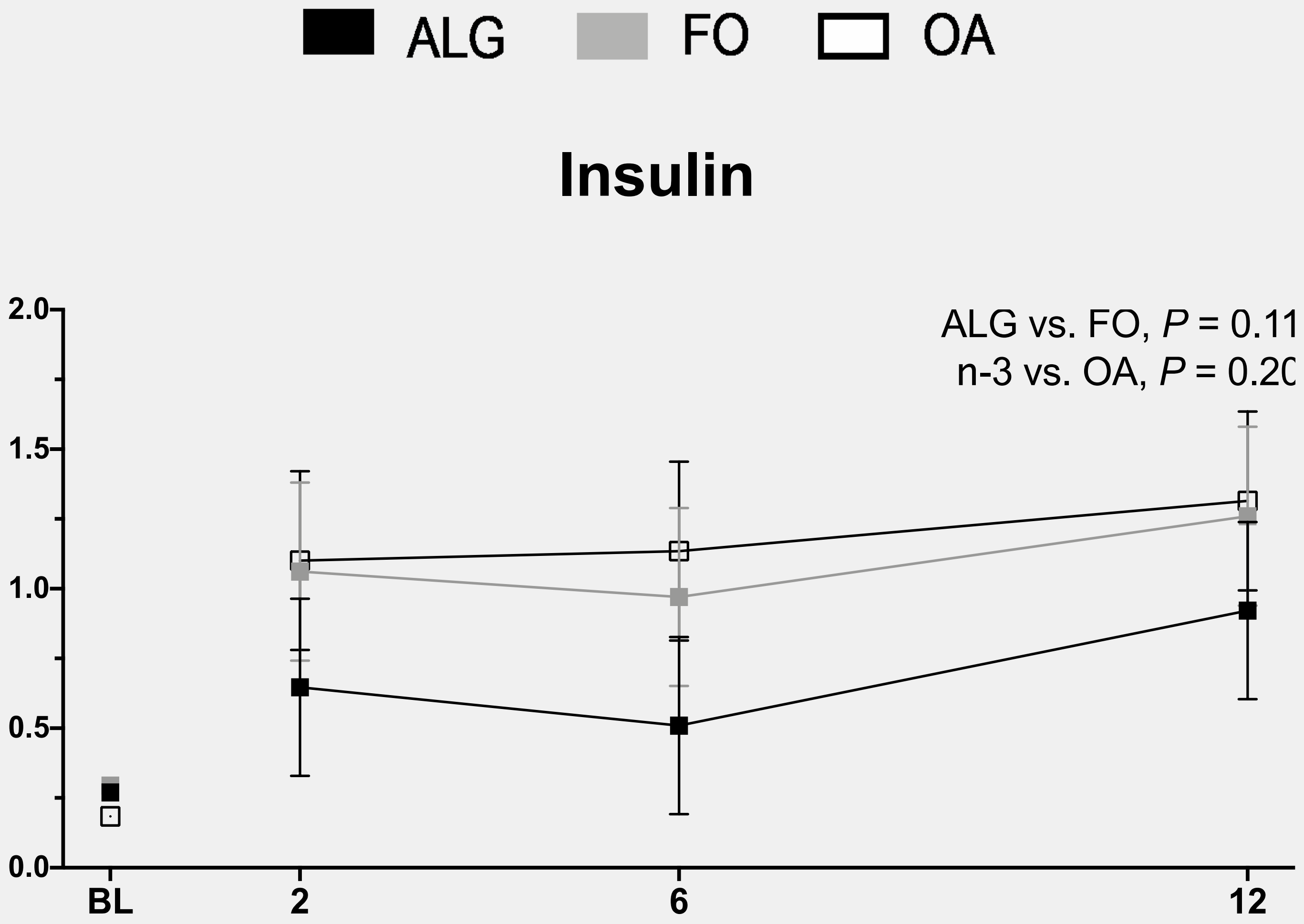


Non-esterified fatty acids



Sáinz de la Maza-Escolà et al., (unpublished)

Algae tended to keep lower insulin levels

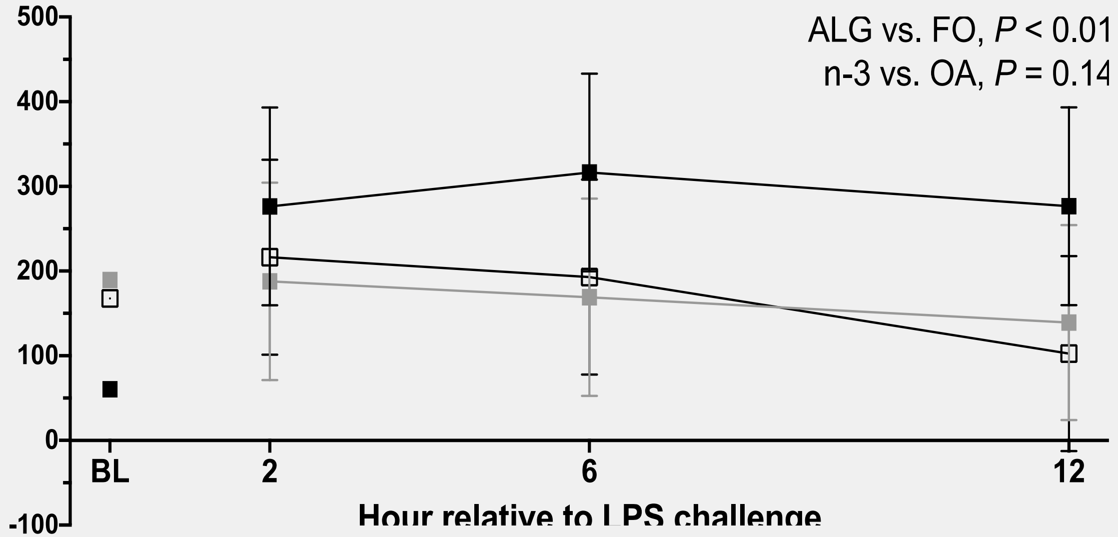


Sáinz de la Maza-Escolà et al., (unpublished)

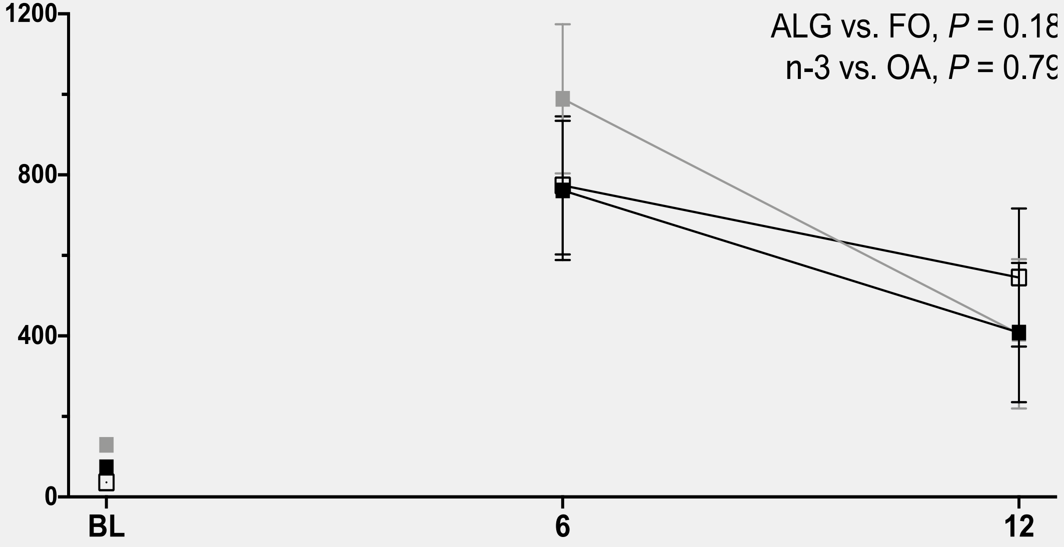
Algae increased interleukin 1- β compared to fish oil

ALG FO OA

Interleukin 1-β



Tumor necrosis factor -α



Sáinz de la Maza-Escolà et al., (unpublished)

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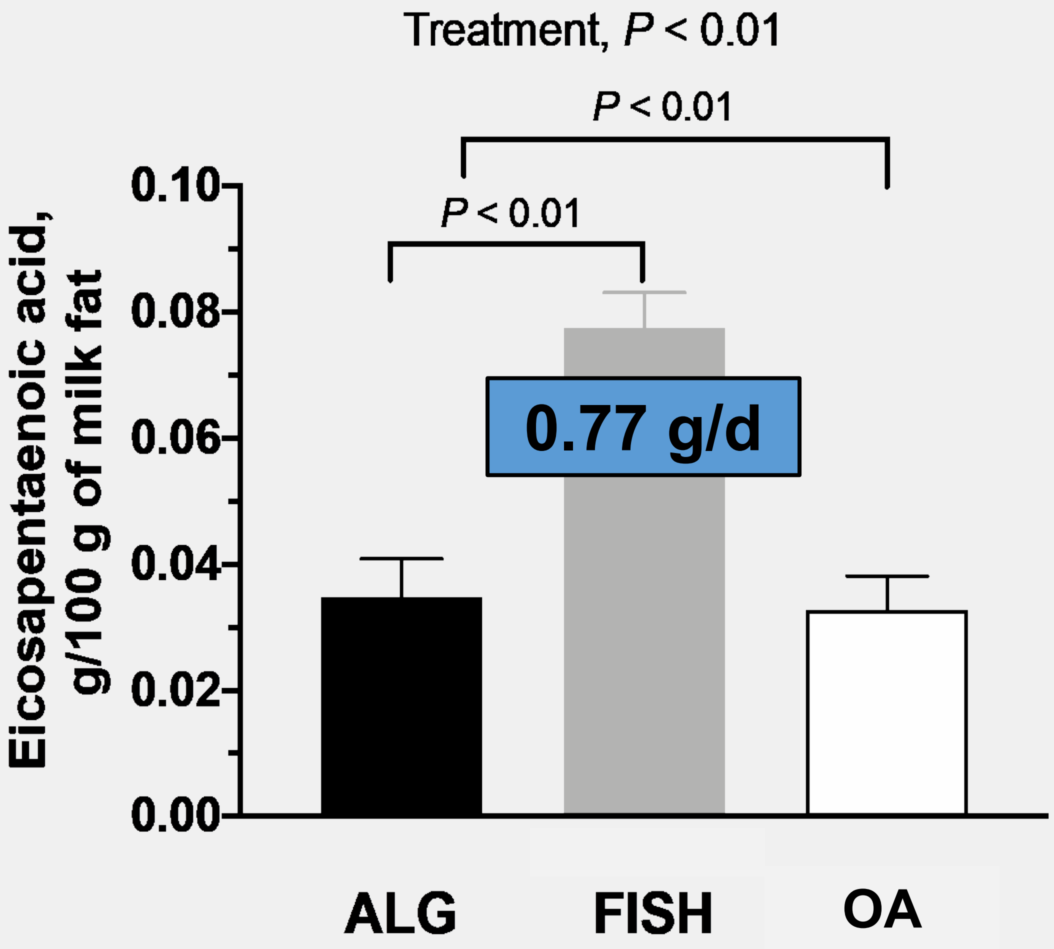
Transfer of dietary EPA into milk



EPA transfer efficiency
RP FISH → 5.05%

Treatment	Type of FA	EPA supply (g/d)
RP Fish oil	n3	**15.33**
RP Algae	n3	0.17
RP Oleic acid	OA	0.00

Sáinz de la Maza-Escolà et al., (unpublished)

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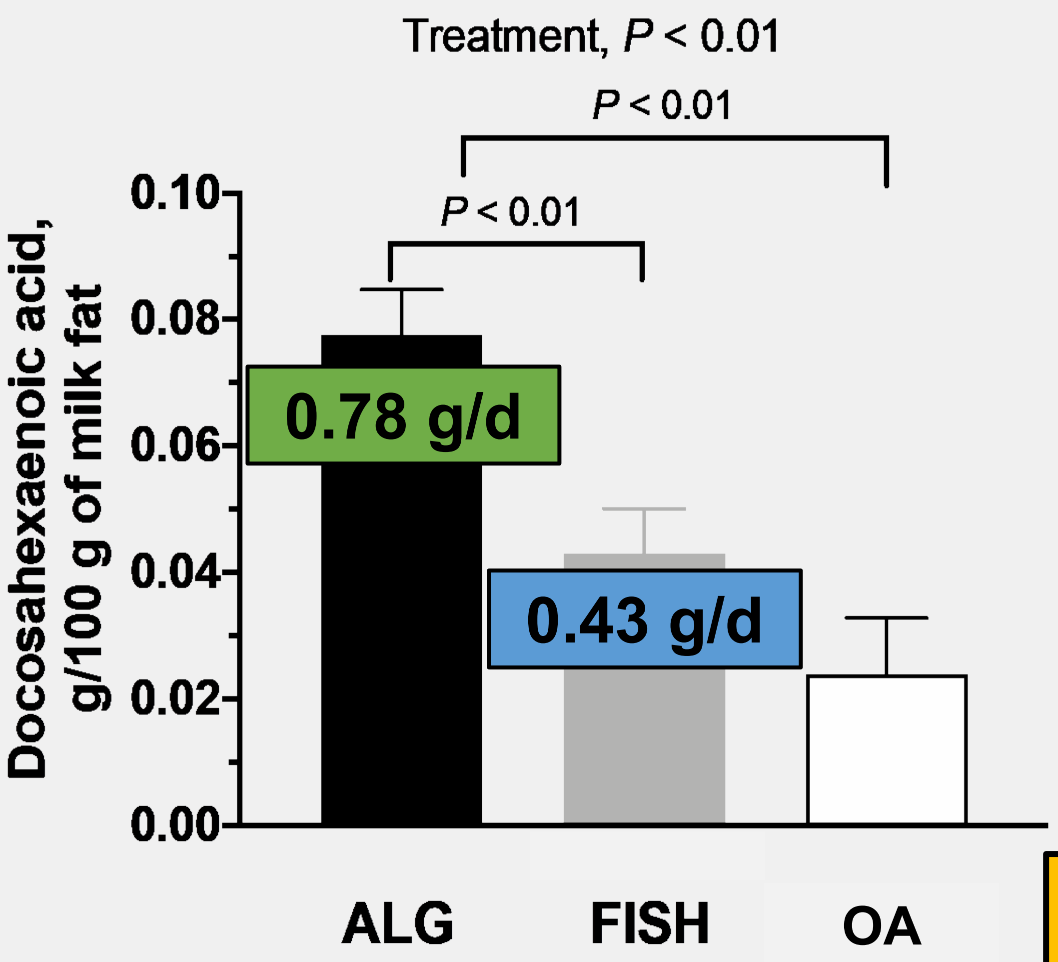
Transfer of dietary DHA into milk



Sáinz de la Maza-Escolà et al., (unpublished)

DHA transfer efficiency
RP ALG → 3.13 %

DHA transfer efficiency
RP FISH → 4.45 %

Treatment	Type of FA	EPA supply (g/d)	DHA supply (g/d)
RP Fish oil	n3	15.33	**9.69**
RP Algae	n3	0.17	**24.83**
RP Oleic acid	OA	0.00	0.00

Omega-3 fatty acids are mostly routed into **phospholipids** and cholesteryl esters in plasma (Limited incorporation in milk TG)

Rico et al., 2024 (Submitted)

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Discussion and future steps

1. **Differences in production parameters** between algae and fish oil **are complex to be attributed to their FA profile -** there is no evidence that DHA and EPA may have a different effect on milk and energy-corrected milk yield.

2. Lactating dairy cows fed rumen-protected **algae oil outperformed against an immune challenge** compared to rumen-protected fish oil.

3. **Evidence for transfer into milk** in agreement with dietary FA composition.

→ FA digestibility/absorption, *in situ* rumen degradation, and Oxylipids in response to immune challenge

Sáinz de la Maza-Escolà et al., (unpublished)

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- **Dr. Kevin Harvatine (Penn State Univ.)**
  - Fatty acid analyses

Thank you for your attention

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