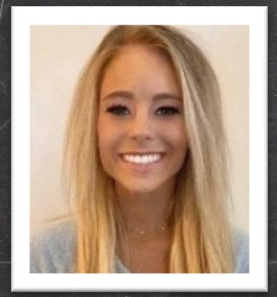
RESEARCH REVIEW

Feeding Rumen-Protected Methionine and Calcium Salts Enriched in Omega-3 Fatty Acids Increase Plasma Methionine Concentrations, Modify Milk Fatty Acid Profiles, and Modify Plasma and Liver Phospholipid Concentrations in Transition Dairy Cows



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SMART SOLUTIONS FOR INNOVATIVE DAIRIES

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The challenge for transition cows

- Diminished dietary nutrient supply but increased energy demand during late gestation and early lactation
- Nutrients are partitioned to support milk synthesis
- Systemic inflammatory response occurs at parturition, increasing risk of metabolic disease and lower milk production

Bobe et al., 2004

Methionine (Met) feeding in dairy cows

- Rumen-protected (RP)-Met is fed to enhance Met bioavailability
  - Increases milk production
  - Reduces oxidative stress

- Past recommendation: RP-Met fed at ~0.08% ration DM (~14 g/d prepartum and ~16 g/d postpartum); however, new data suggests that Met feeding should be on the basis of metabolizable energy supply

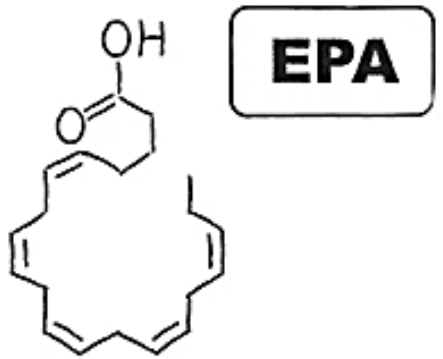
Zhou et al., 2016; Batistel et al., 2018

Omega-3 fatty acid (n-3 FA) feeding in dairy cows

- Fed as calcium salts to reduce rumen biohydrogenation

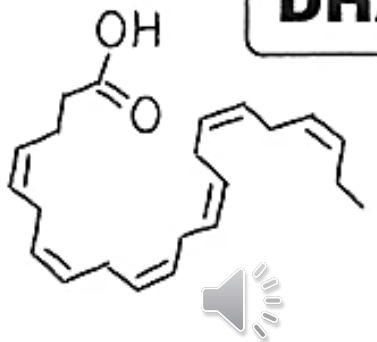
- Beneficial for immune function
  - Activate anti-inflammatory response
  - Inhibit pro-inflammatory response

- No established feeding rate in dairy cows



EPA

Eicosapentaenoic Acid (EPA) (20:5, n-3)



DHA

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

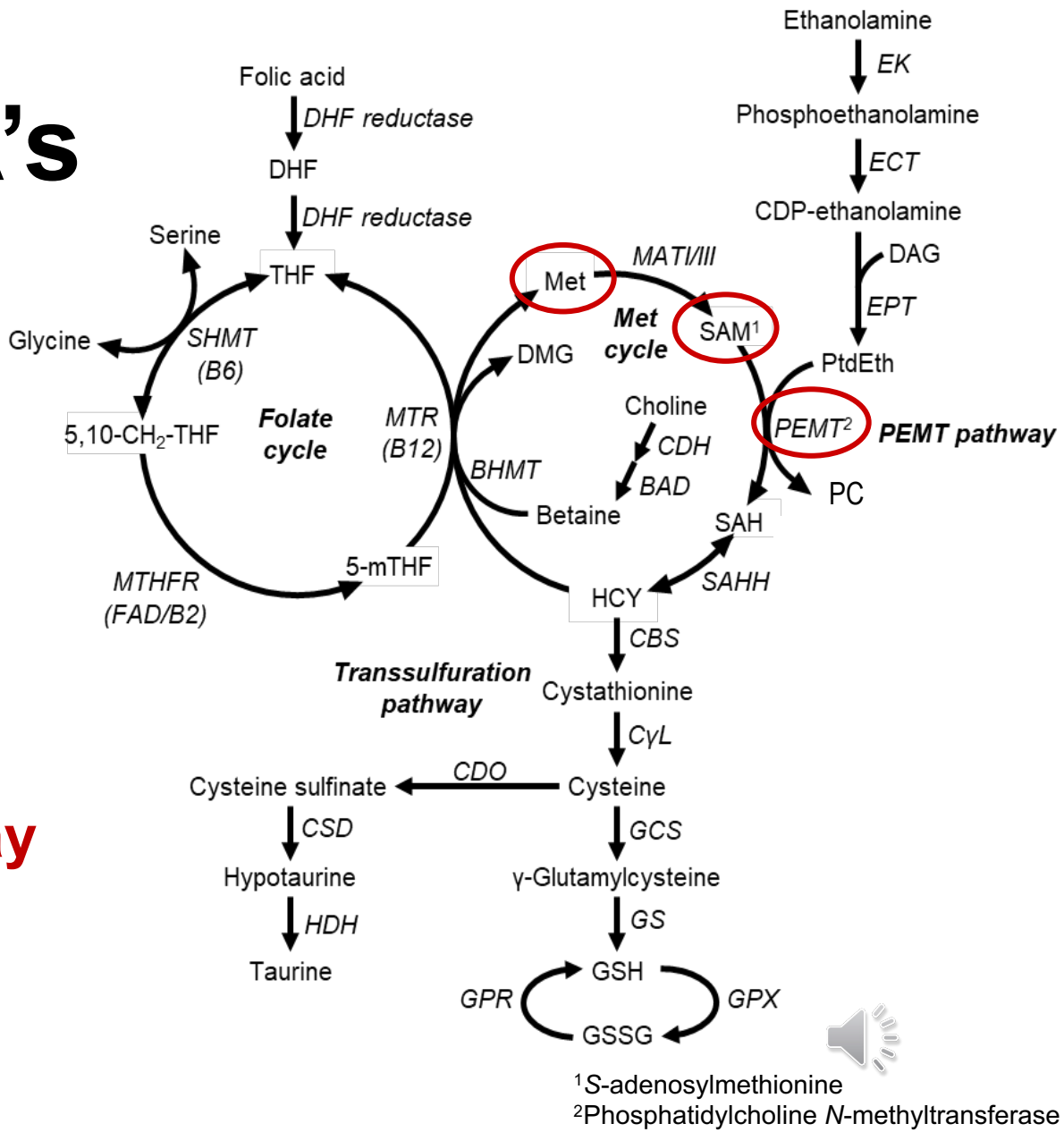
Greco et al., 2015; Moallem, 2018

Potential interaction between Met and n-3 FA's

- Met increases phosphatidylcholine (PC) synthesis via phosphatidylethanolamine *N*-methyltransferase (PEMT) pathway

- PEMT pathway prefers phosphatidylethanolamine (PE) enriched with EPA and DHA.

Possible downregulation of this pathway in transition period due to insufficient dietary supply of Met and n-3 FA



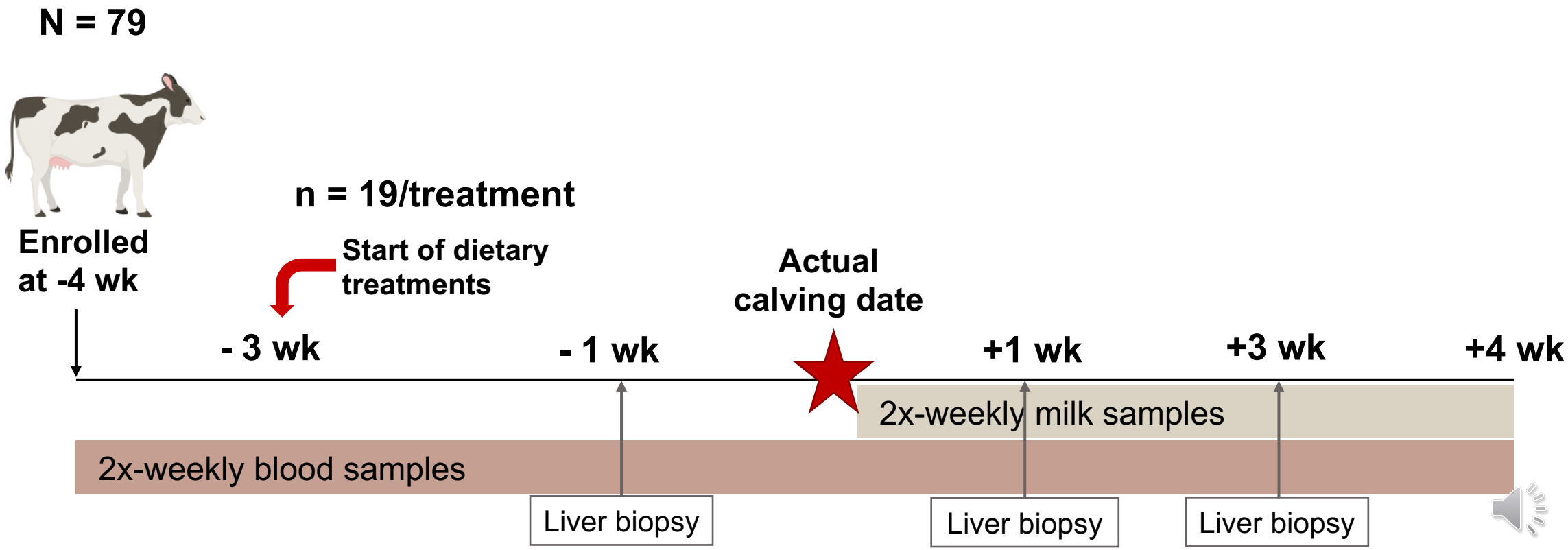
DeLong et al., 1999; Brosnan et al., 2006

Hypothesis

Feeding RP-Met and n-3 FA during the transition period will modify circulating AA concentrations, milk FA profile, and plasma and liver phospholipid concentrations in transition dairy cows.

Experimental approach

- Randomized complete block study design
  - Balanced by parity and 305ME



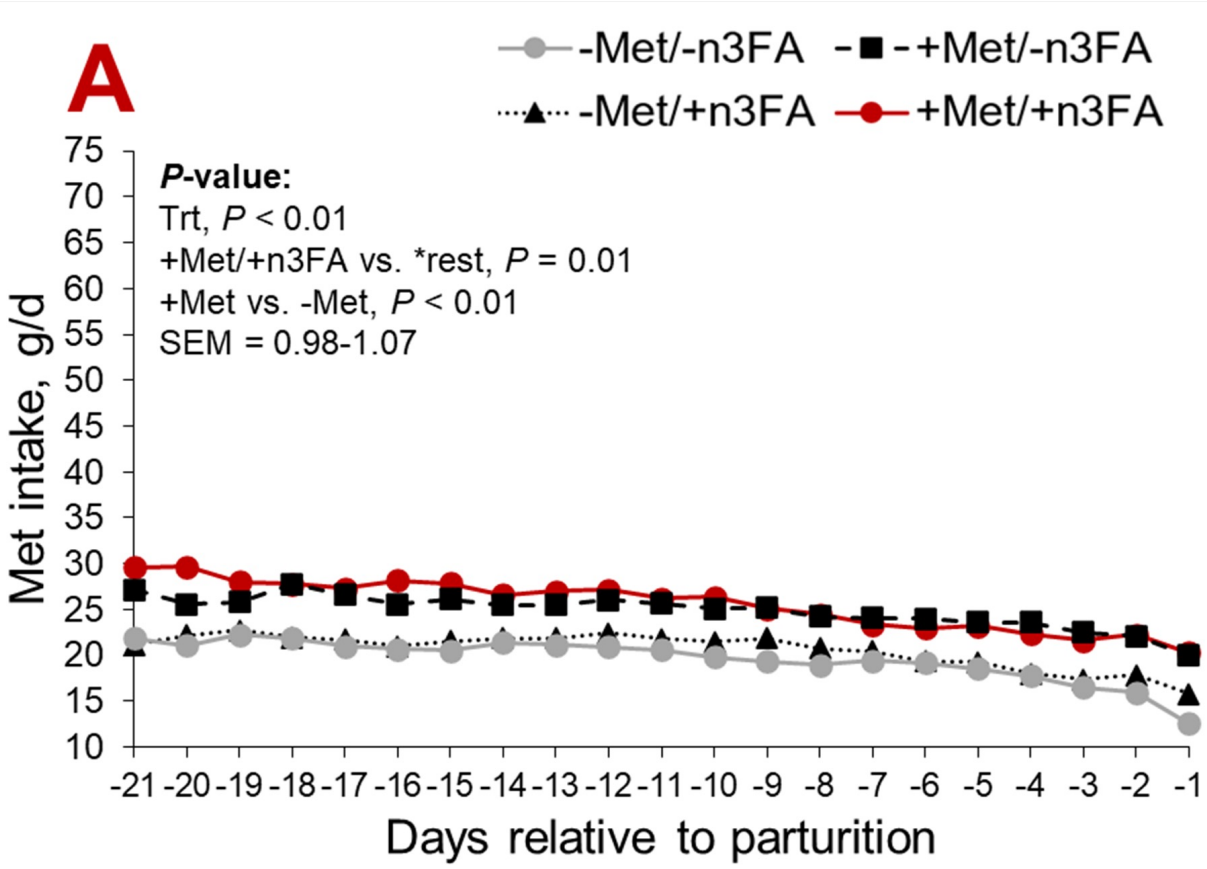
Pre- and postpartum dietary treatments

-Met/-n3FA	+Met/-n3FA	-Met/+n3FA	+Met/+n3FA
≤0.96 g Met/Mcal metabolizable energy *No RP-Met*	≥1.13 g Met/Mcal metabolizable energy *RP-Met added* **Smartamine M**	≤0.96 g Met/Mcal metabolizable energy *No RP-Met*	≥1.13 g Met/Mcal metabolizable energy *RP-Met added* **Smartamine M**
Long chain FA without n3 FA as Ca-salts at 1.5% ration DM *No n3 FA* **EnerGII**	Long chain FA without n3 FA as Ca-salts at 1.5% ration DM *No n3 FA* **EnerGII**	Long chain FA enriched with EPA and DHA as Ca-salts at 1.5% ration DM *With n3 FA* **EnerG3**	Long chain FA enriched with EPA and DHA as Ca-salts at 1.5% ration DM *With n3 FA* **EnerG3**

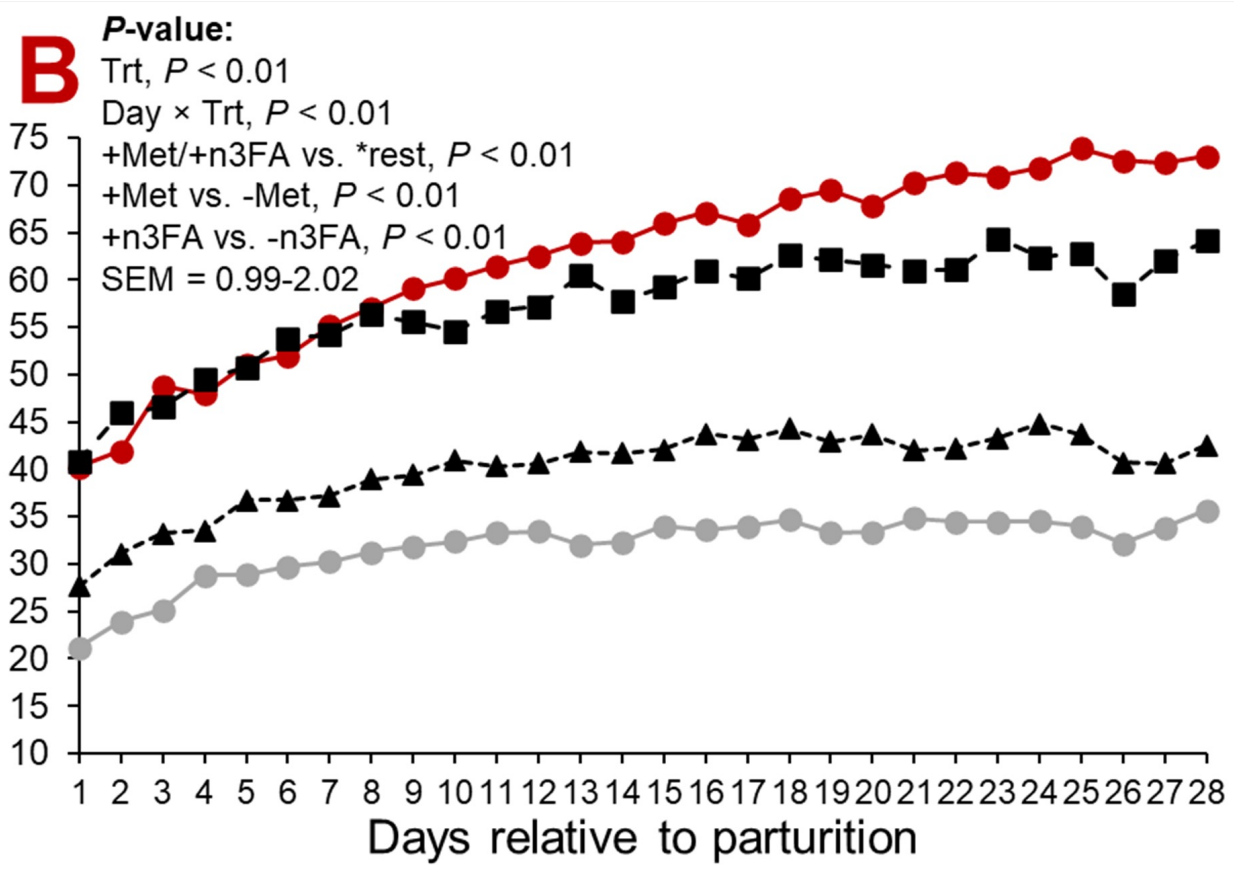
Statistical analysis

- MIXED procedure of SAS
- Fixed effects: treatment, time, time × treatment
- Random effect: cow nested within treatment
- Repeated effect: time
- Pre-planned contrasts
  - +Met/+n3FA vs +Met/-n3FA and -Met/+n3FA
  - -Met vs +Met
  - -n3FA vs +n3FA
- CORR procedure of SAS used to measure correlations between liver PC and PE and liver triglyceride (TAG) %.

Methionine intake



Prepartum



Postpartum

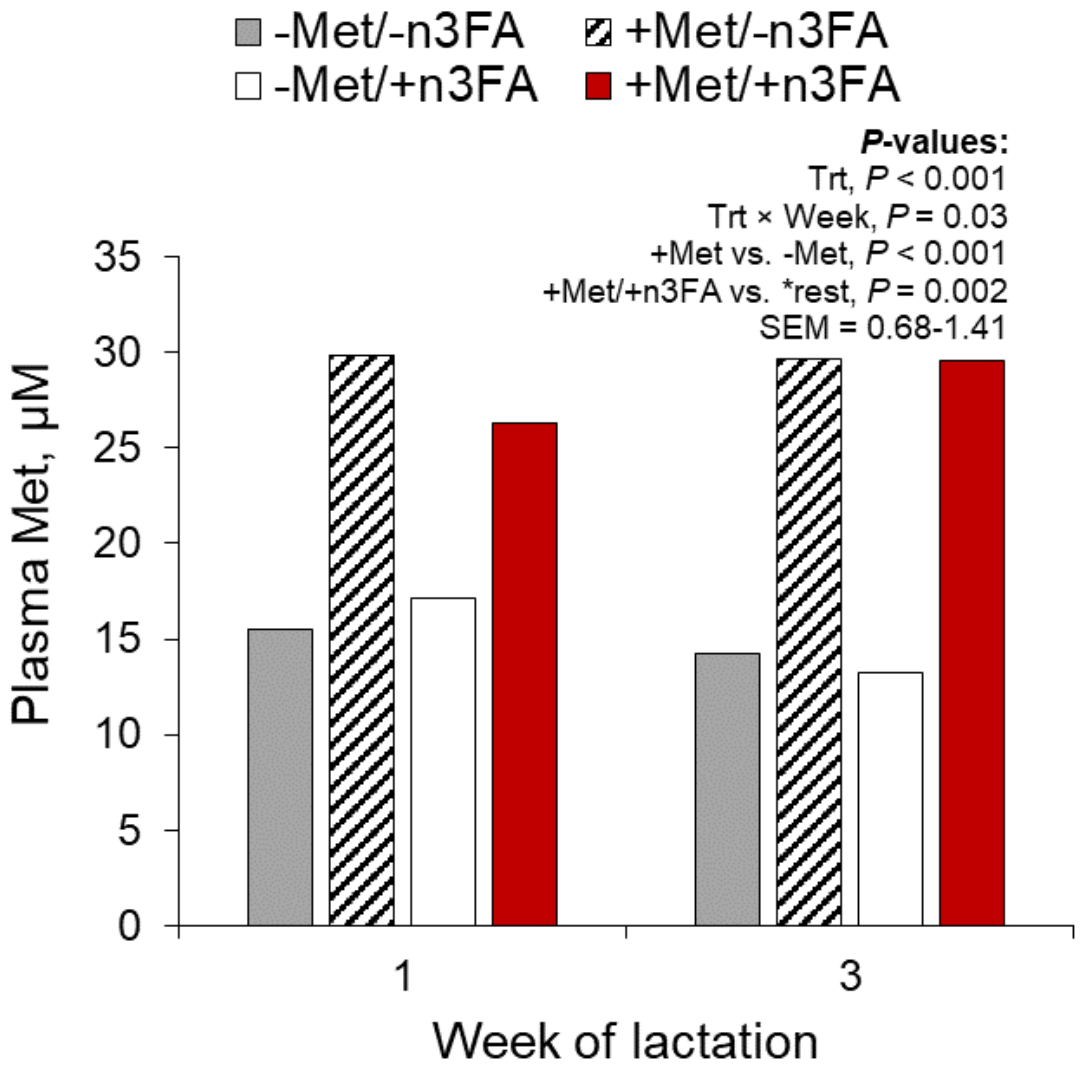
*rest = +Met/-n3FA and –Met/+n3FA

Pre- and postpartum fatty acid intakes

	Treatment					*P*-value		
FA intakes, g/d	-Met/-n3FA	+Met/-n3FA	-Met/+n3FA	+Met/+n3FA	SEM	+Met vs. -Met	+n3FA vs. -n3FA	+Met/+n3FA vs. +Met/-n3FA and -Met/+n3FA
Prepartum								
20:5n3	0	0	0.84	1.09	0.07	0.08	**<0.001**	**<0.001**
22:5n3	0.60	0.66	2.15	2.91	0.13	0.01	**<0.001**	**<0.001**
22:6n3	0	0	0.31	0.48	0.04	0.02	**<0.001**	**<0.001**
n3 total	15.7	15.3	17.0	18.4	0.73	0.51	**0.01**	**0.02**
Postpartum								
20:5n3	0	0	4.63	4.13	0.12	0.04	**<0.001**	**<0.001**
22:5n3	3.54	3.72	11.5	11.6	0.26	0.65	**<0.001**	**<0.001**
22:6n3	0	0	2.07	2.39	0.07	0.02	**<0.001**	**<0.001**
n3 total	50.5	54.9	67.2	68.8	1.85	0.09	**<0.001**	**0.01**

Data presented as LS Means, grams/d

Plasma Met concentrations

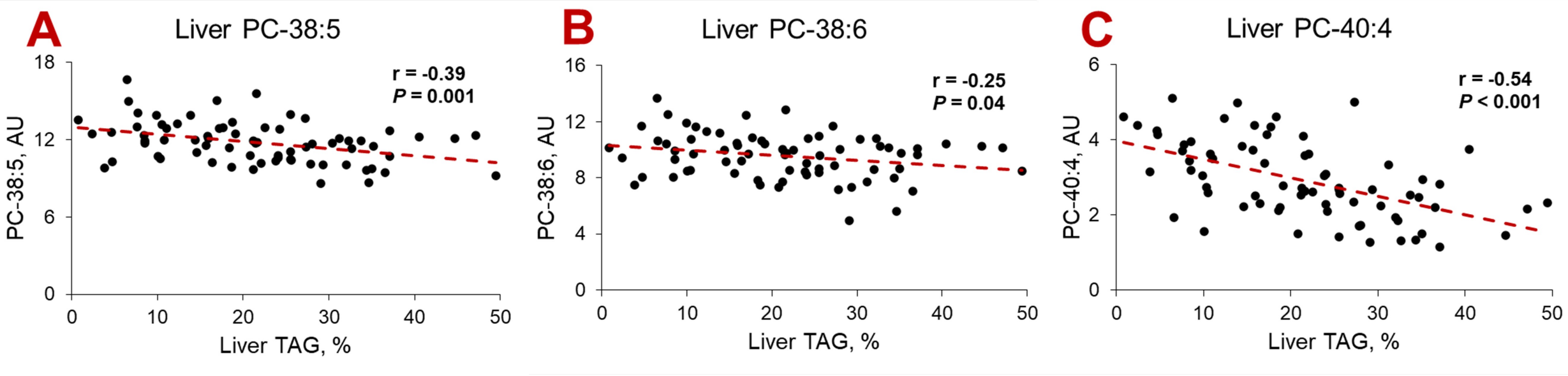


*rest = +Met/-n3FA and –Met/+n3FA

Milk FA content and yield

	Treatment					*P*-value		
Milk FA	-Met/-n3FA	+Met/-n3FA	-Met/+n3FA	+Met/+n3FA	SEM	+Met vs. -Met	+n3FA vs. -n3FA	+Met/+n3FA vs. +Met/-n3FA and -Met/+n3FA
Composition, %								
16:0	29.6	29.9	29.9	30.1	0.38	0.52	0.41	0.59
18:0	10.3	9.76	9.32	9.17	0.27	0.20	**0.004**	0.25
18:3n3	0.32	0.31	0.34	0.33	0.01	0.18	**0.01**	0.56
20:5n3	0.03	0.03	0.07	0.06	0.003	0.18	**<0.001**	**0.01**
22:5n3	0.04	0.05	0.08	0.07	0.004	0.57	**<0.001**	0.11
22:6n3	0.00	0.00	0.03	0.03	0.003	0.49	**<0.001**	**0.001**
n6:n3	4.92	4.88	3.95	4.04	0.09	0.80	**<0.001**	**0.001**
De novo	13.5	14.9	14.4	15.7	0.65	**0.04**	0.19	0.17
Preformed	38.8	37.5	37.6	36.2	0.95	0.17	0.18	0.26
Total FA	88.6	88.6	88.6	88.6	0.03	0.47	0.13	0.35
SFA	57.9	58.9	58.5	59.1	0.80	0.30	0.59	0.64
PUFA	2.62	2.54	2.91	2.79	0.06	0.14	**<0.001**	0.44
Yield,g/d								
16:0	627	664	662	702	23.8	0.10	0.12	0.18
18:0	215	220	204	211	10.0	0.54	0.33	0.97
18:3n3	6.58	6.82	7.53	7.51	0.27	0.68	**0.003**	0.30
20:5n3	0.62	0.67	1.66	1.45	0.06	0.20	**<0.001**	**0.001**
22:5n3	0.90	1.01	1.72	1.57	0.08	0.78	**<0.001**	**0.04**
22:6n3	0.03	0.01	0.63	0.67	0.05	0.80	**<0.001**	**<0.001**
n6:n3	4.92	4.89	3.95	4.07	0.09	0.62	**<0.001**	**0.002**
De novo	284	332	320	364	15.6	**0.004**	**0.03**	**0.05**
Preformed	819	852	835	850	42.3	0.91	0.91	0.91
Total FA	1,843	1,964	1,938	2,038	71.1	0.12	0.23	0.32
SFA	1,213	1,303	1,275	1,363	44.3	**0.04**	0.17	0.17
PUFA	54.7	56.8	63.0	63.3	2.03	0.55	**<0.001**	0.17

Phospholipid correlations



Liver phospholipids on d +21

	Treatment					*P*-value		
Liver phospholipids	-Met/-n3FA	+Met/-n3FA	-Met/+n3FA	+Met/+n3FA	SEM	+Met vs. -Met	+n3FA vs. -n3FA	+Met/+n3FA vs. +Met/-n3FA and -Met/+n3FA
LPC-20:5	0.002	0.002	0.004	0.003	0.001	0.42	**0.003**	0.85
LPC-22:5	0.71	0.60	0.85	0.72	0.09	0.17	0.16	0.92
LPC-22:6	0.11	0.07	0.49	0.32	0.03	0.01	**<0.001**	0.35
PC-38:5	10.9	11.4	12.6	12.1	0.37	0.89	0.001	0.81
PC-38:6	8.69	8.57	10.7	10.3	0.33	0.38	**<0.001**	0.12
PC-40:4	3.13	3.14	2.64	2.76	0.24	0.79	0.08	0.66
PC-40:6	4.74	4.57	10.5	9.74	0.42	0.27	**<0.001**	<0.001
PE-38:5	1.49	1.41	1.67	1.70	0.06	0.70	**0.001**	**0.05**
PE-38:6	1.46	1.27	3.28	2.94	0.12	0.03	**<0.001**	<0.001
PE-40:6	0.15	0.16	0.56	0.61	0.02	0.15	**<0.001**	**<0.001**
Ratios								
PC:PE-38:6	6.04	6.67	3.34	3.63	0.20	0.02	**<0.001**	**<0.001**
PC:PE-40:6	3.40	3.19	2.83	2.81	0.08	0.18	<0.001	0.06
Sum								
LPC	0.83	0.68	1.30	1.02	0.12	0.07	**0.001**	0.87
PC	107	108	117	114	4.45	0.78	0.07	0.83
PE	10.5	9.89	12.3	12.2	0.40	0.39	**<0.001**	**0.02**

Plasma phospholipids on d +21

	Treatment					*P*-value		
Plasma phospholipids	-Met/-n3FA	+Met/-n3FA	-Met/+n3FA	+Met/+n3FA	SEM	+Met vs. -Met	+n3FA vs. -n3FA	+Met/+n3FA vs. +Met/-n3FA and -Met/+n3FA
LPC-22:5	0.04	0.04	0.05	0.05	0.004	0.79	**0.003**	0.26
LPC-22:6	0.01	0.01	0.04	0.04	0.002	0.71	**<0.001**	<0.001
PC-38:5	5.38	4.52	7.21	6.84	0.21	0.004	<0.001	0.001
PC-38:6	0.11	0.13	0.09	0.12	0.01	0.21	0.44	0.91
PC-40:6	1.24	1.05	3.48	3.59	0.12	0.74	**<0.001**	**<0.001**
PE-38:5	0.09	0.09	0.15	0.13	0.01	0.61	0.004	0.82
PE-38:6	0.05	0.06	0.10	0.10	0.01	0.50	<0.001	0.21
PE-40:6	0.01	0.01	0.02	0.02	0.002	0.82	**0.001**	0.31
Sum								
LPC	0.07	0.07	0.11	0.12	0.01	0.81	**<0.001**	**0.01**
PC	79.0	74.2	79.5	78.8	2.27	0.23	0.29	0.50
PE	0.57	0.59	0.72	0.69	0.07	0.93	0.10	0.72

Summary and conclusions

Diets RP-Met or with n-3 FA in transition cows:

Proof of concept

↑ Met intake and n-3 FA intakes

↑ Pre- and postpartum plasma Met concentrations

Modified milk FA content and yield

↑ Milk EPA and DHA content and yield

↑ De novo FA synthesis

Modified plasma and liver phospholipid profiles

↑ plasma and liver PC, LPC, and PE concentrations

↑ select PC and PE concentrations

Blue = RP-Met or EPA/DHA

Green = co-supplementation

Acknowledgements

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- Cornell University Dairy Research Center

Thank you!

Questions? email: tlf54@cornell.edu

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