THE FATTY ACID FORUM

RESEARCH REVIEW

Effects of Dietary Methionine and Calcium Salts Enriched in Omega-3 Fatty Acids on Lactation and Liver Function in Periparturient Dairy Cows

Tanya L. France, MS
PhD Candidate
Department of Animal Science
Cornell University

Effects of dietary methionine and calcium salts enriched in omega-3 fatty acids on lactation and liver function in periparturient dairy cows

Tanya L. France, A. Javaid, K. S. Juarez-Leon, M. G. Vogellus, and J. W. McFadden

Take-home message: Diets adequate in methionine (>1.13 g/Mcal of ME) or with omega-3 fatty acids derived from fish oil (EPA and DHA, 3-7 g) enhanced energy-corrected milk and milk protein yield, increased postpartum dry matter intake, reduced body weight loss, increased postpartum liver functionality index, modified hepatic methyl donor metabolism, and modified nutrient partitioning at calving in transition cows.

tlf54@cornell.edu

Cornell CALS College of Agriculture and Life Sciences

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

Methionine (Met) feeding in dairy cows

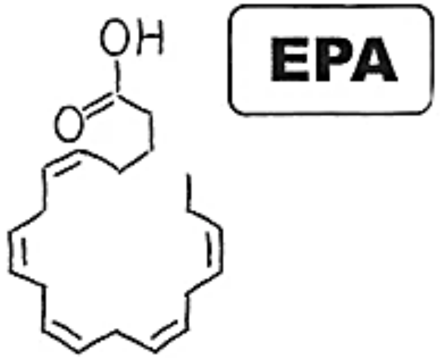
- Rumen-protected (RP)-Met is fed to enhance Met bioavailability
  - Increases milk production
  - Reduces oxidative stress
  - Improves liver function

- 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

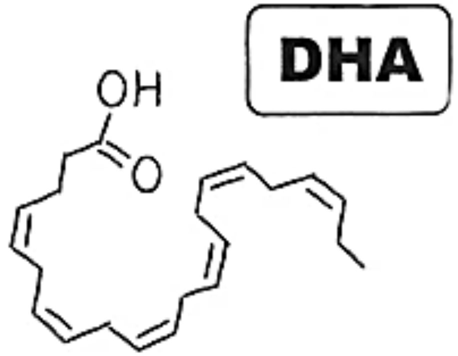
Zhou et al., 2016; Batistel et al., 2018

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

- Fed as calcium salts to reduce biohydrogenation
- Beneficial for immune function
  - Activate anti-inflammatory response
  - Inhibit pro-inflammatory response
- No established feeding rate in dairy cows



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

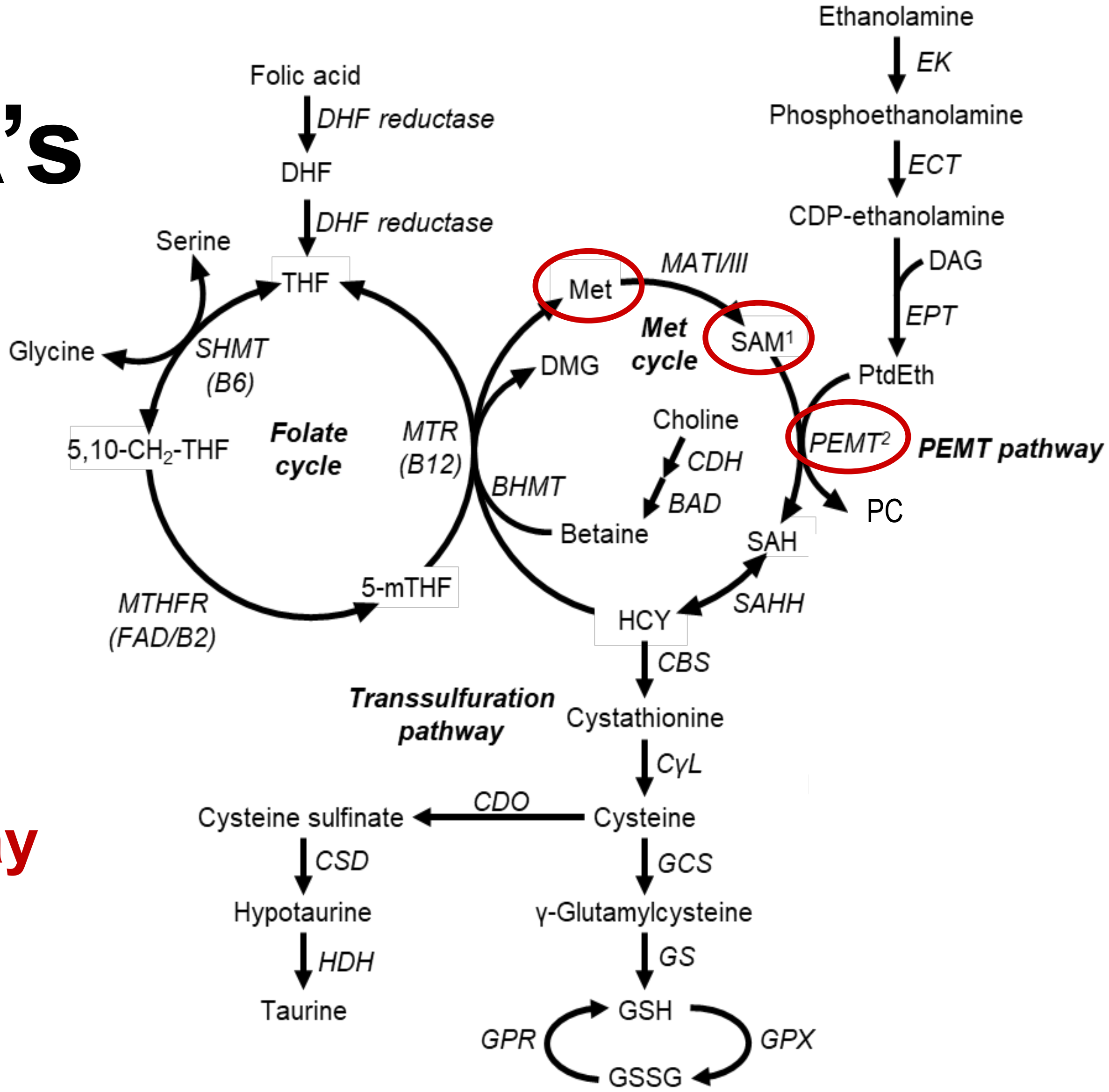


Docosahexaenoic Acid (DHA) (22:6, n-3)

Potential interaction between Met and n-3 FA's

- Met donates methyl groups to SAM
  - Provides precursors for transsulfuration
  - Increases phosphatidylcholine (PC) synthesis via PEMT pathway
- PEMT pathway prefers very-long chain FA such as DHA in non-ruminants

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



[1] *S*-adenosylmethionine
[2] Phosphatidylcholine *N*-methyltransferase

DeLong et al., 1999; Watkins et al., 2003

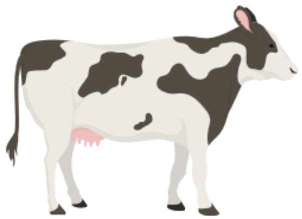
Hypothesis

Feeding adequate Met and n-3 FA's during the transition period will increase milk production and enhance activity of the PEMT pathway

Experimental approach

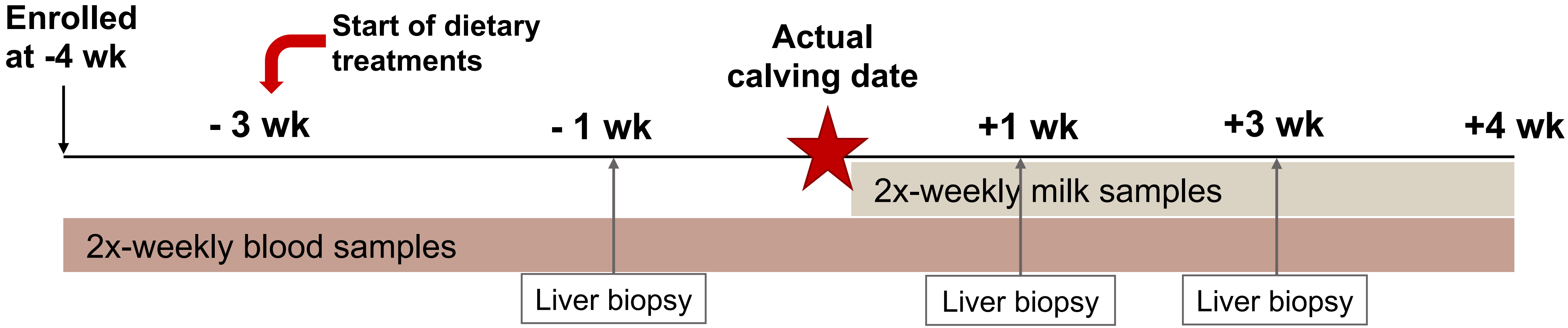
- Randomized complete block study design
  - Balanced by parity and 305ME

N = 79



n = 19/treatment

Weekly:
- Body weight
- Body condition score



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
- Covariates: 305 ME, parity, acclimation intake

Diet nutrient composition

A

Ingredient (% of DM)	Prepartum	Postpartum
Corn silage	47.1	42.5
Haylage	—	15.2
Wheat straw	27.0	—
Corn meal	—	15.6
Soybean meal	—	10.4
Concentrate mix A	25.9	—
Concentrate mix B	—	16.4

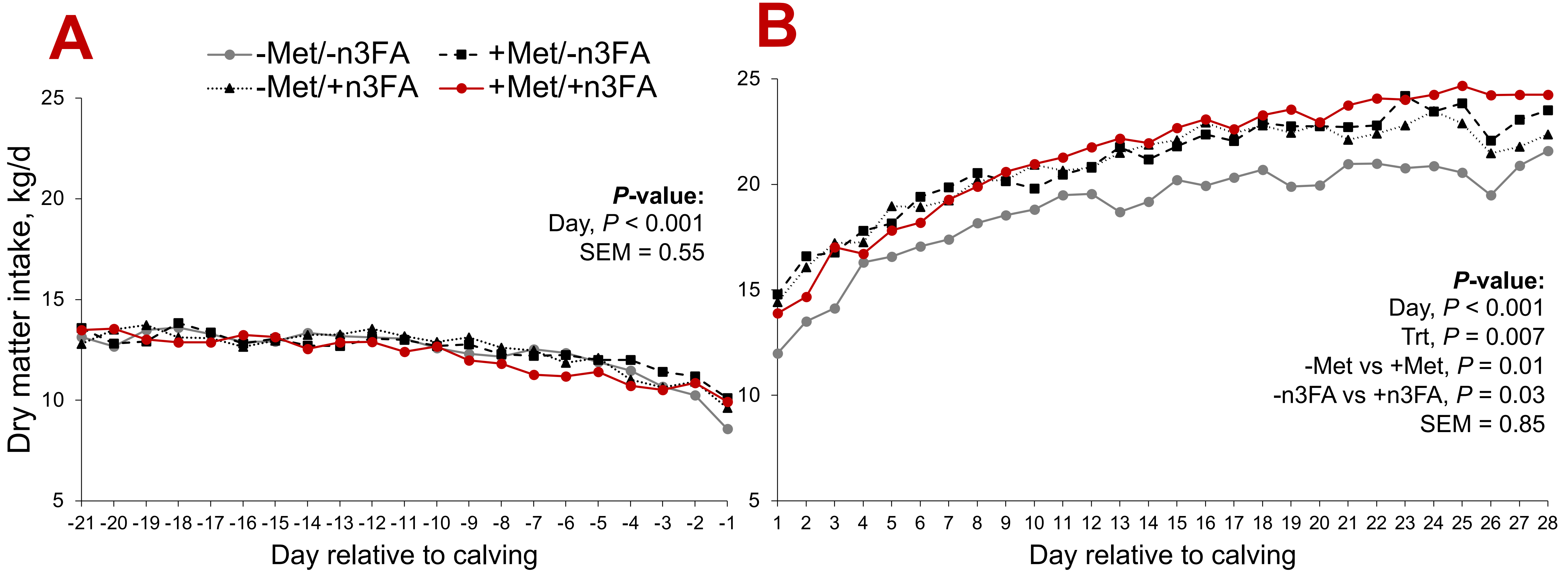
B

	Prepartum diet			
Nutrient, % of DM (±SD)	-Met/-n3FA	+Met/-n3FA	-Met/+n3FA	+Met/+n3FA
NE_L, Mcal/kg	1.46 ± 0.02	1.48 ± 0.02	1.44 ± 0.01	1.47 ± 0.03
CP	14.5 ± 0.92	14.5 ± 1.18	14.6 ± 0.92	15.0 ± 0.78
Starch	17.0 ± 1.44	17.0 ± 1.07	15.9 ± 1.83	16.0 ± 0.83
NFC	31.6 ± 1.43	32.7 ± 4.68	29.9 ± 1.90	29.9 ± 0.92
ADF	25.2 ± 2.12	27.1 ± 2.58	27.0 ± 1.20	26.1 ± 0.87
NDF	41.6 ± 1.32	40.1 ± 4.50	42.9 ± 0.56	41.6 ± 1.26
Ether extract	3.53 ± 0.68	3.59 ± 0.49	3.27 ± 0.50	3.89 ± 0.72
DCAD	-5.16 ± 3.11	-6.94 ± 2.28	-7.82 ± 2.46	-8.96 ± 2.01

C

	Postpartum diet			
Nutrient, % of DM (±SD)	-Met/-n3FA	+Met/-n3FA	-Met/+n3FA	+Met/+n3FA
NE_L, Mcal/kg	1.73 ± 0.01	1.73 ± 0.02	1.73 ± 0.02	1.72 ± 0.04
CP	16.6 ± 0.42	17.1 ± 0.48	16.8 ± 0.43	16.9 ± 0.21
Starch	24.9 ± 1.65	25.8 ± 1.31	24.1 ± 1.51	24.2 ± 2.43
NFC	42.0 ± 0.80	42.0 ± 0.90	43.0 ± 1.30	42.0 ± 1.60
ADF	18.4 ± 0.90	17.4 ± 0.88	17.6 ± 1.13	17.2 ± 1.12
NDF	28.4 ± 0.84	27.9 ± 0.94	28.3 ± 0.82	27.7 ± 0.72
Ether extract	5.37 ± 0.34	5.55 ± 0.34	5.17 ± 0.12	5.28 ± 0.41
DCAD	37.4 ± 3.91	36.8 ± 4.32	38.3 ± 5.57	35.4 ± 3.84

Dry matter intake



Prepartum

Postpartum

Fatty acid intakes

A

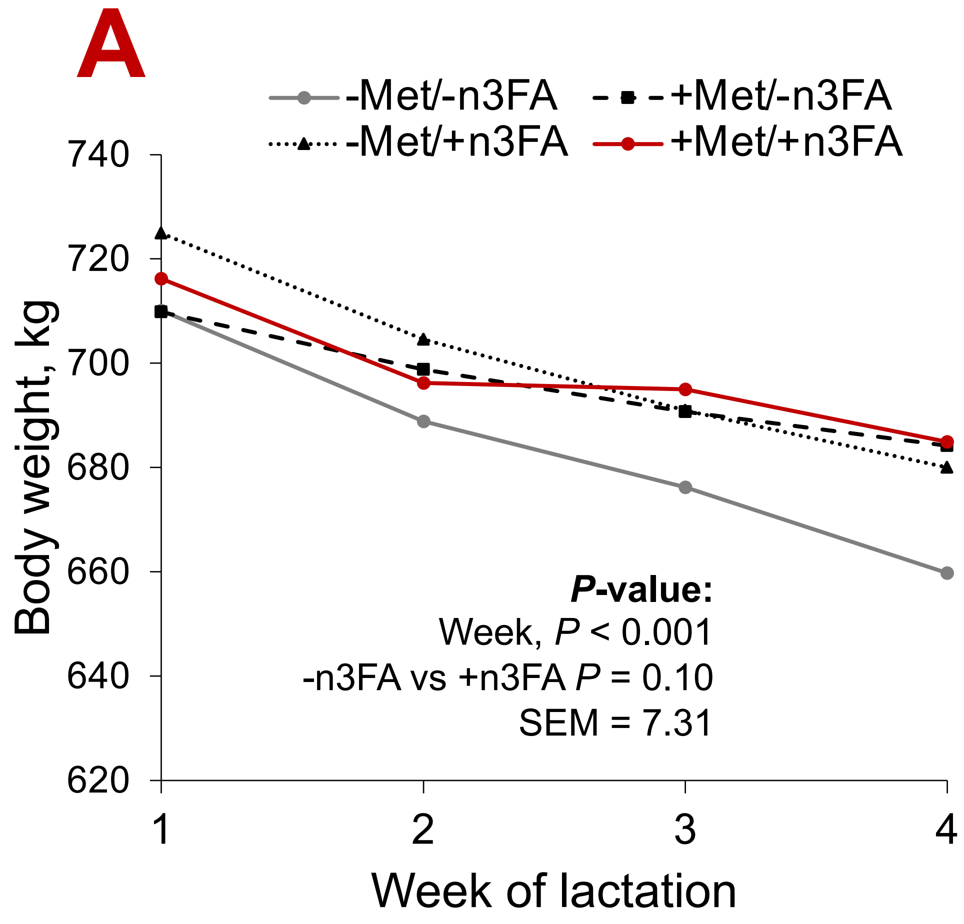
Prepartum diets						
	-Met/-n3FA	+Met/-n3FA	-Met/+n3FA	+Met/+n3FA	SEM	Treatment
Total FA	364	349	313	350	13.3	0.05
16:0	130	119	111	128	4.88	0.02
18:0	17.1	17.1	15.2	19.2	0.64	<0.001
18:1c9	92.5	88.6	66.6	73.6	3.16	<0.001
18:2	89.6	90.2	79.8	87.4	4.81	0.38
18:3n3	14.9	14.9	13.9	13.9	0.57	0.31
SFA	160	148	141	162	5.85	0.03
MUFA	100	94.9	76.7	84.5	3.62	<0.001
PUFA	104	106	96.0	103	5.51	0.58
RUFAL	197	193	161	175	8.13	0.01
EPA	-	-	0.84	1.09	0.07	<0.001
DHA	-	-	0.31	0.48	0.04	<0.001

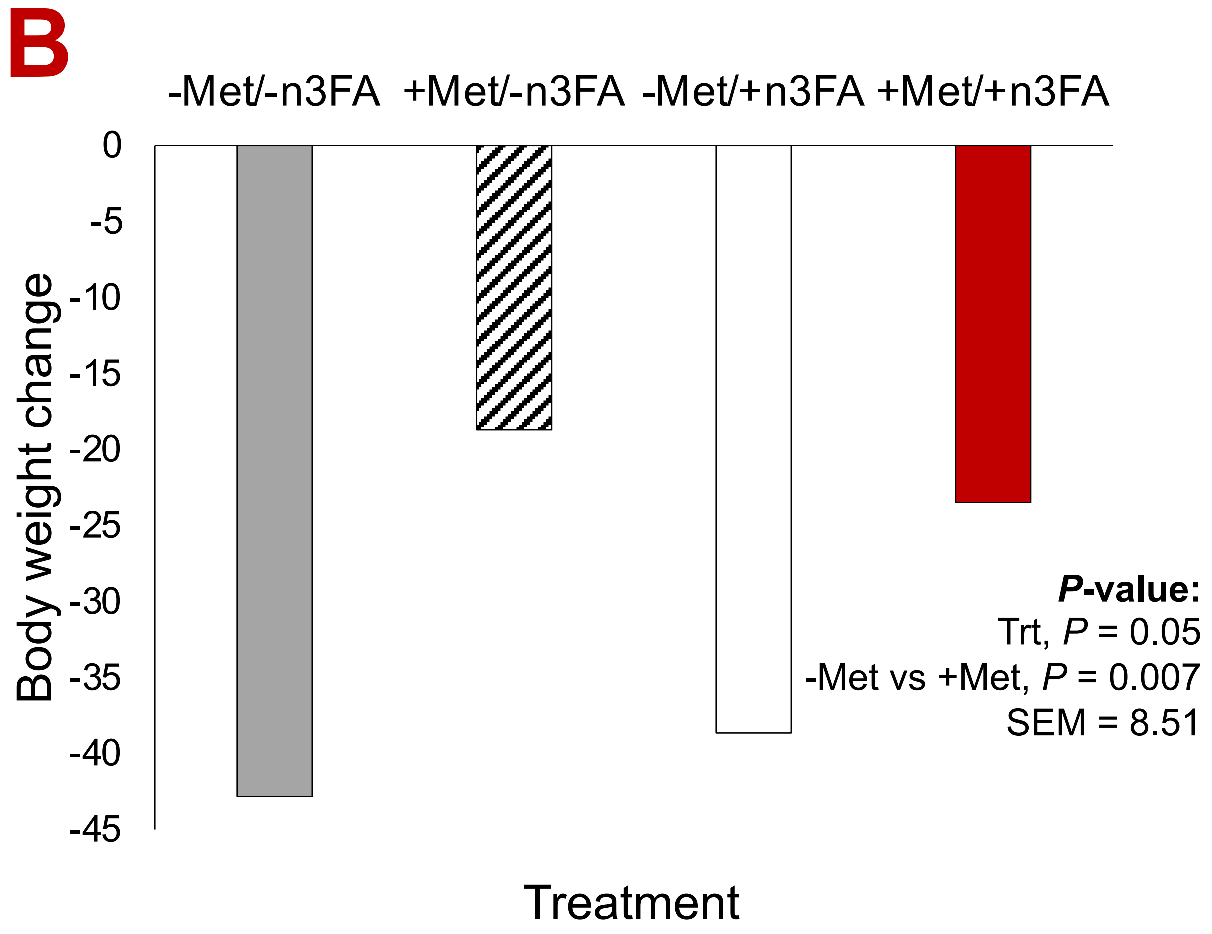
B

Postpartum diets						
	-Met/-n3FA	+Met/-n3FA	-Met/+n3FA	+Met/+n3FA	SEM	Treatment
Total FA	875	978	967	999	26.6	0.01
16:0	362	405	414	429	10.9	<0.001
18:0	42.5	50.1	48.6	56.6	1.49	<0.001
18:1c9	180	204	169	174	5.22	<0.001
18:2	209	228	224	229	6.41	0.10
18:3n3	46.9	52.3	49.4	51.2	1.44	0.05
SFA	425	478	491	514	1.30	<0.001
MUFA	194	219	192	196	5.93	0.01
PUFA	257	282	283	289	7.84	0.02
RUFAL	437	485	443	455	13.0	0.04
EPA	-	-	4.63	4.13	0.12	<0.001
DHA	-	-	2.07	2.39	0.07	<0.001

Data presented as LS Means, grams/d

Postpartum body weight



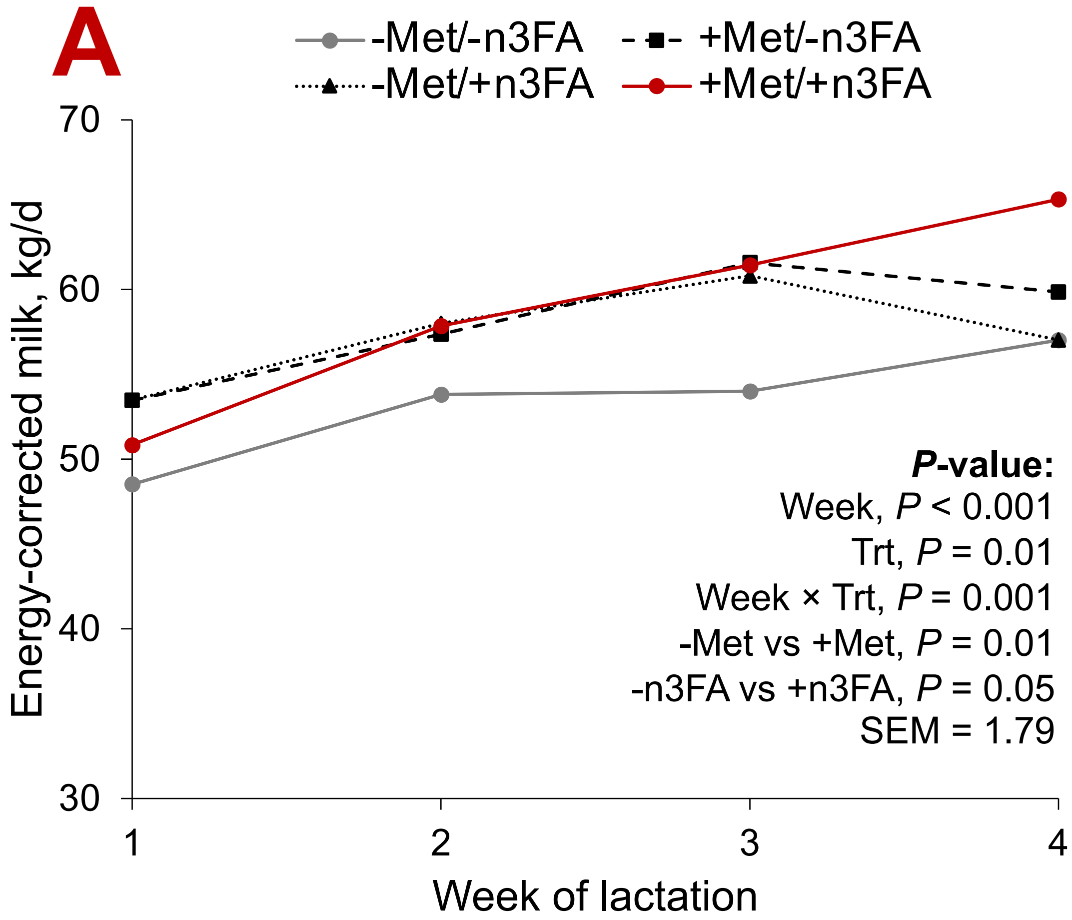


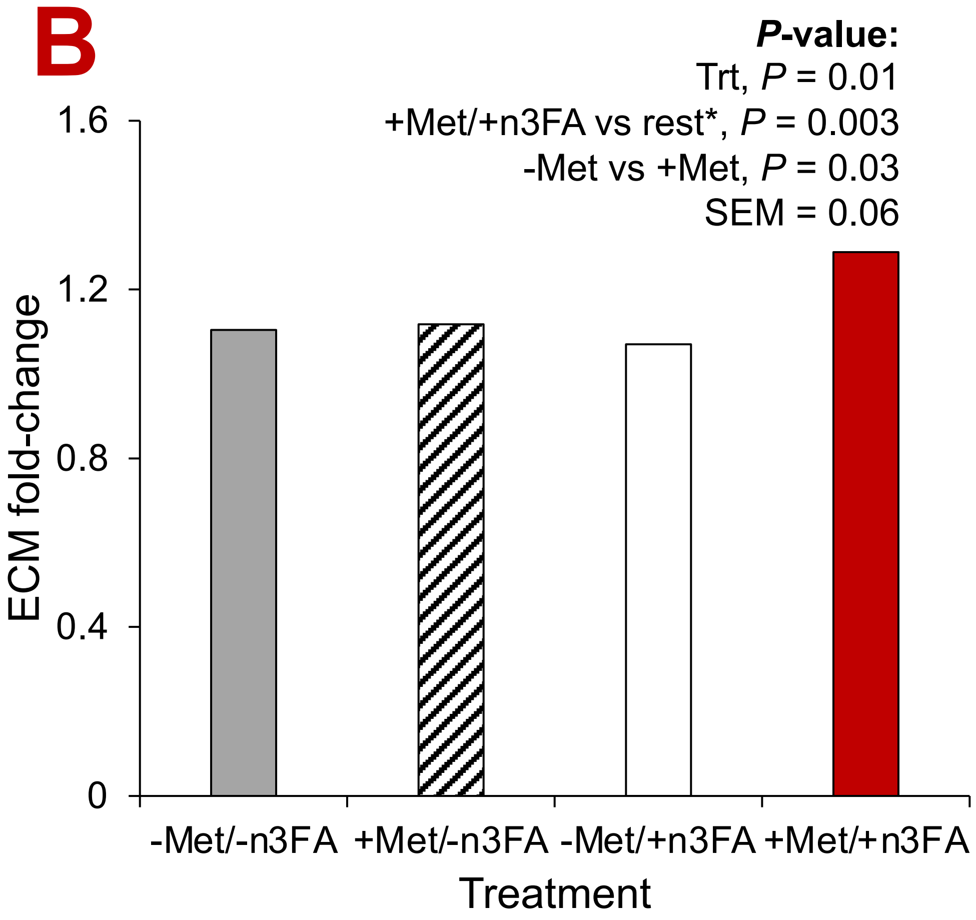
DMI and milk components

Variable	Treatment				SEM	P-value		
	-Met/-n3FA	+Met/-n3FA	-Met/+n3FA	+Met/+n3FA		-Met vs +Met	-n3FA vs +n3FA	+Met/+n3FA vs +Met/-n3FA and -Met/+n3FA
Fresh DMI, kg/d	18.8	21.0	20.8	21.4	0.64	**0.01**	**0.03**	0.53
Milk yield, kg/d	44.6	47.9	48.4	47.4	1.24	0.29	0.13	0.56
ECM, kg/d	53.3	58.1	57.3	58.9	1.43	**0.01**	**0.05**	0.45
FCM, kg/d	56.6	60.9	60.4	61.8	1.55	**0.03**	**0.08**	0.50
Milk fat, %	5.24	5.25	5.06	5.41	0.14	0.16	0.93	**0.10**
Milk fat, kg/d	2.26	2.43	2.45	2.49	0.07	**0.08**	**0.05**	0.50
Milk protein, %	2.91	3.11	2.95	3.15	0.05	**<0.001**	0.41	**0.03**
Milk protein, kg/d	1.28	1.45	1.4	1.45	0.03	**<0.001**	**0.05**	0.53
Efficiencies, kg								
MY/DMI	2.27	2.23	2.27	2.16	0.06	0.15	0.51	0.16
ECM/DMI	2.73	2.81	2.78	2.68	0.08	0.93	0.56	0.20
FCM/DMI	2.87	2.93	2.93	2.79	0.09	0.64	0.65	0.17

Energy-corrected milk

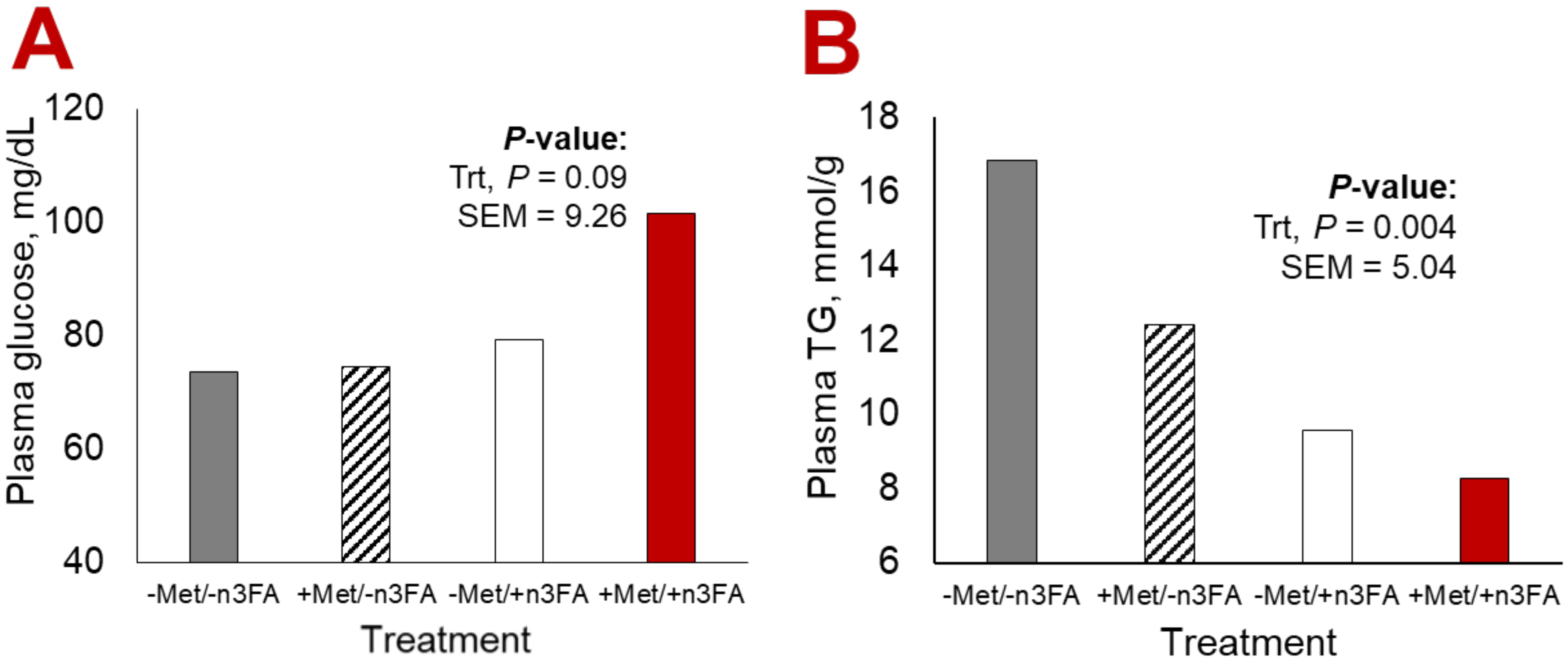
5.53 kg/d increase overall in +Met/+n3FA compared to -Met/-n3FA



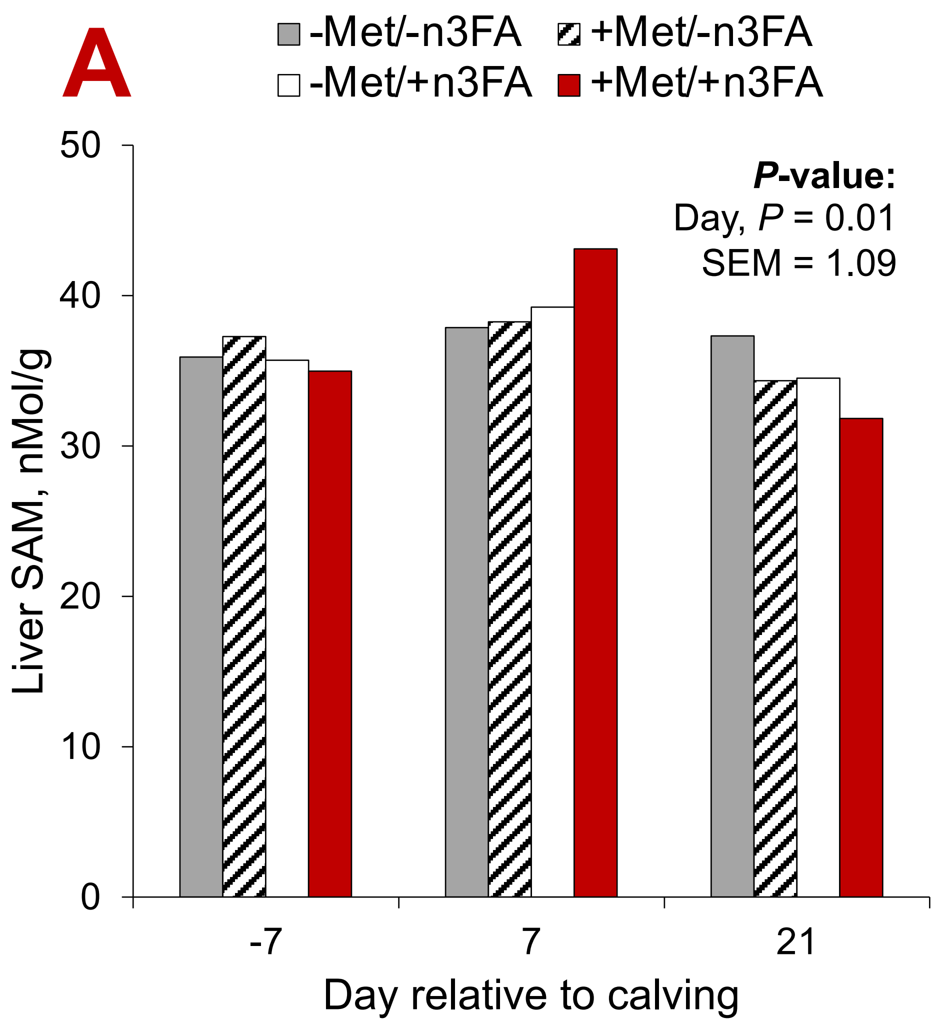


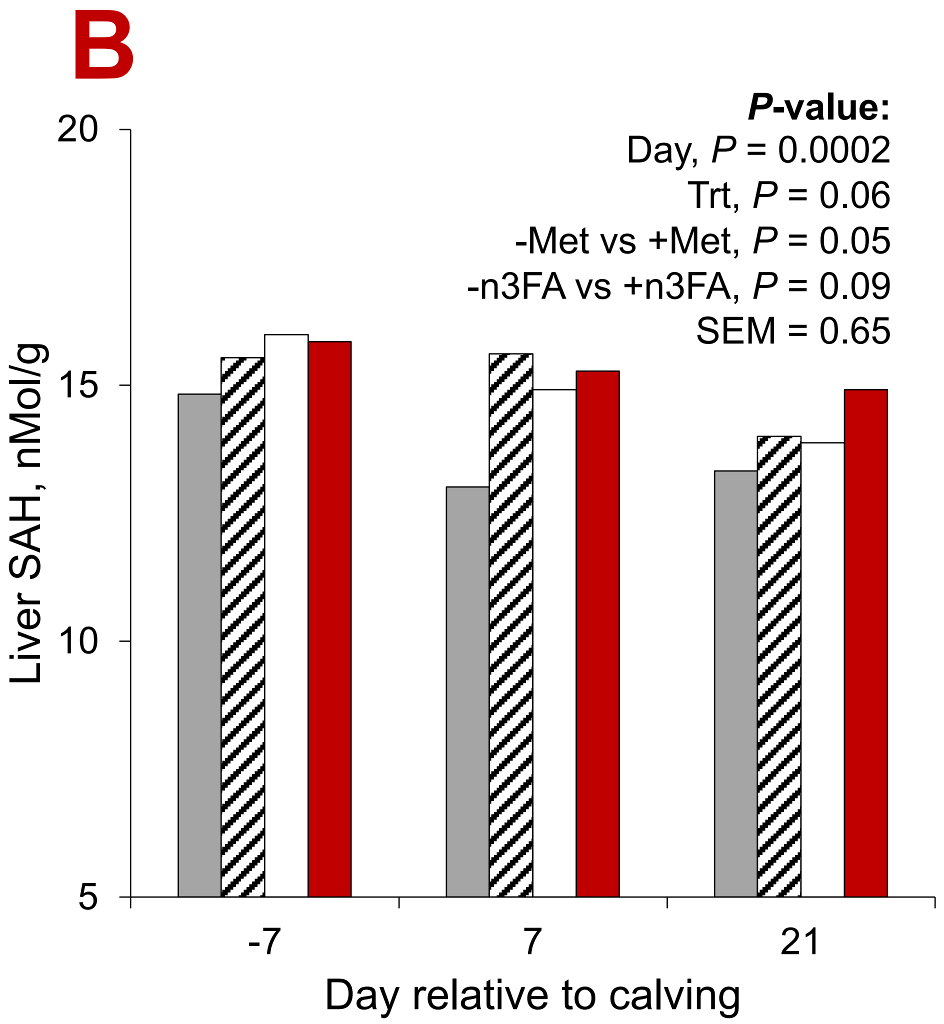
*rest = +Met/-n3FA and –Met/+n3FA

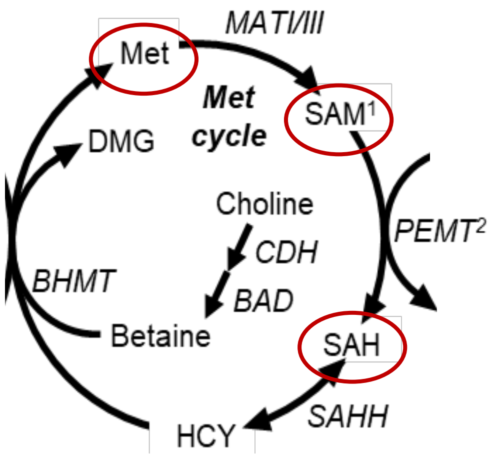
Plasma metabolites at calving



Liver SAM and SAH

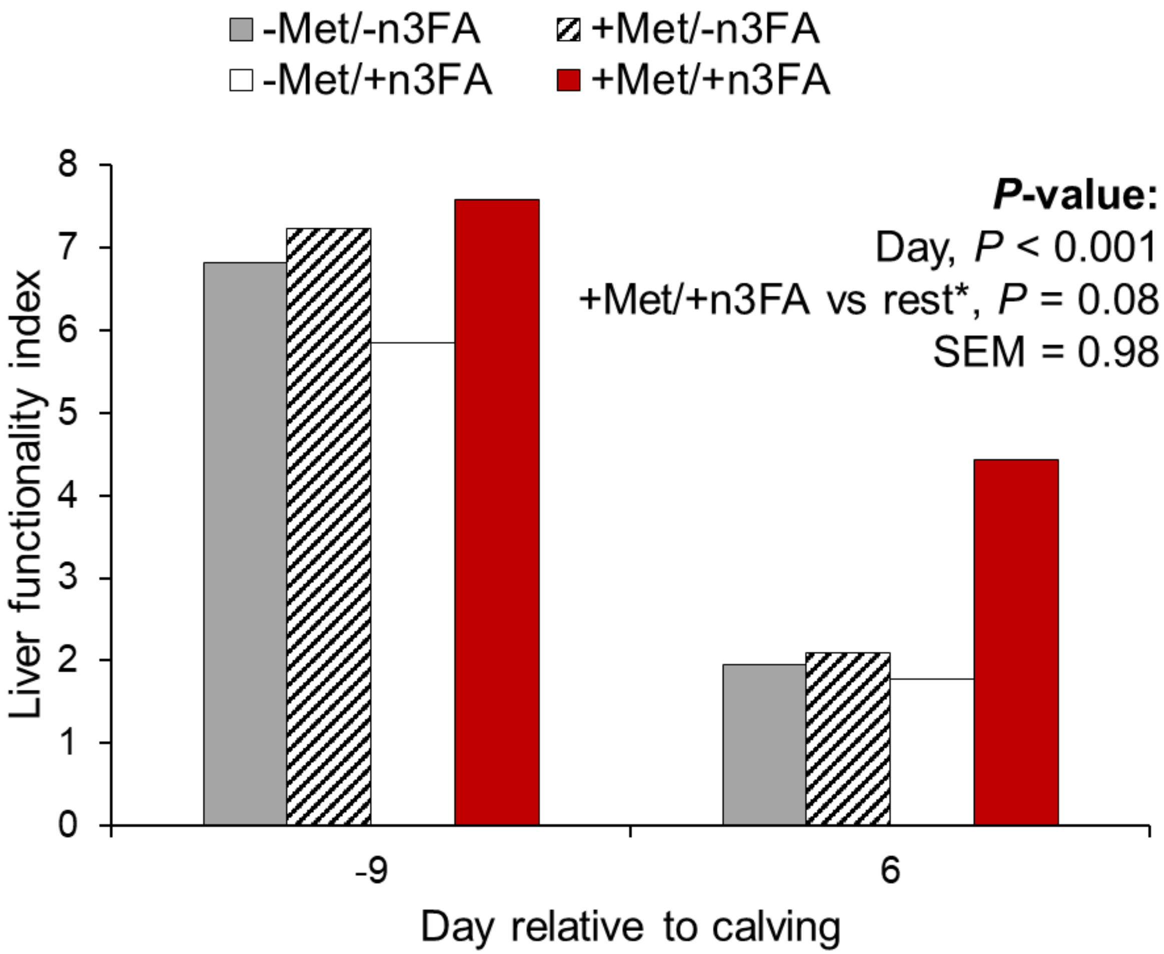






Liver functionality index

Calculated using serum albumin, total cholesterol, and total bilirubin concentrations (Trevisi et al., 2010)



*rest = +Met/-n3FA and –Met/+n3FA

Summary and conclusions

Diets adequate in Met (>1.13 g/Mcal ME) or with n-3 FA (EPA and DHA, 3-7 g) in transition cows:

Enhanced lactational performance

↑ ECM, FCM, milk protein % and yield, milk fat % and yield

Improved postpartum performance

↑ Postpartum DMI, liver functionality index

Reduced postpartum body weight loss

Modified hepatic methyl donor metabolism

↑ Liver SAH

Indirect measurement of ↑ activity of PEMT pathway

Modified nutrient partitioning at calving

↑ Plasma glucose concentrations

↓ Plasma triglyceride concentrations

Acknowledgements

- **Foundation for Food and Agriculture Research**
- **Virtus Nutrition**
- **Adisseo**
- McFadden Lab
- Undergraduate support
- Cornell University Dairy Research Center

Effects of dietary methionine and calcium salts enriched in omega-3 fatty acids on lactation and liver function in periparturient dairy cows

Tanya L. France, A. Javaid, K. S. Juarez-Leon, M. G. Vogellus, and J. W. McFadden

Take-home message: Diets adequate in methionine (>1.13 g/Mcal of ME) or with omega-3 fatty acids derived from fish oil (EPA and DHA, 3-7 g) enhanced energy-corrected milk and milk protein yield, increased postpartum dry matter intake, reduced body weight loss, increased postpartum liver functionality index, modified hepatic methyl donor metabolism, and modified nutrient partitioning at calving in transition cows.

tlf54@cornell.edu

Cornell CALS College of Agriculture and Life Sciences

THE FATTY ACID FORUM

SPONSORED BY

VIRTUS NUTRITION™