THE FATTY ACID FORUM

HOT TOPIC

Effects of Altering the Omega-6 to Omega-3 Ratio on Lactation Performance & Immune Response

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IFAS Extension

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Effect of Supplemental FA on Performance of Dairy Cows

	Control	SFA	EFA	P[1]		
				T*P	Fat	FA
DMI, kg/d	18.0 ± 0.7	19.3 ± 0.5	18.1 ± 0.6	0.01	0.42	0.12
Milk, kg/d	31.7 ± 1.0	31.8 ± 0.9	34.1 ± 0.9	0.07	0.27	0.06
Milk/DMI	1.83 ± 0.07	1.70 ± 0.06	1.95 ± 0.06	0.03	0.94	0.01

1 – T*P → Interaction between treatment and parity; Fat → Control vs. SFA + EFA; FA → SFA vs. EFA

Greco et al. (2010) J. Dairy Sci. 93 (E-Suppl. 1): 448 (Abstr.).

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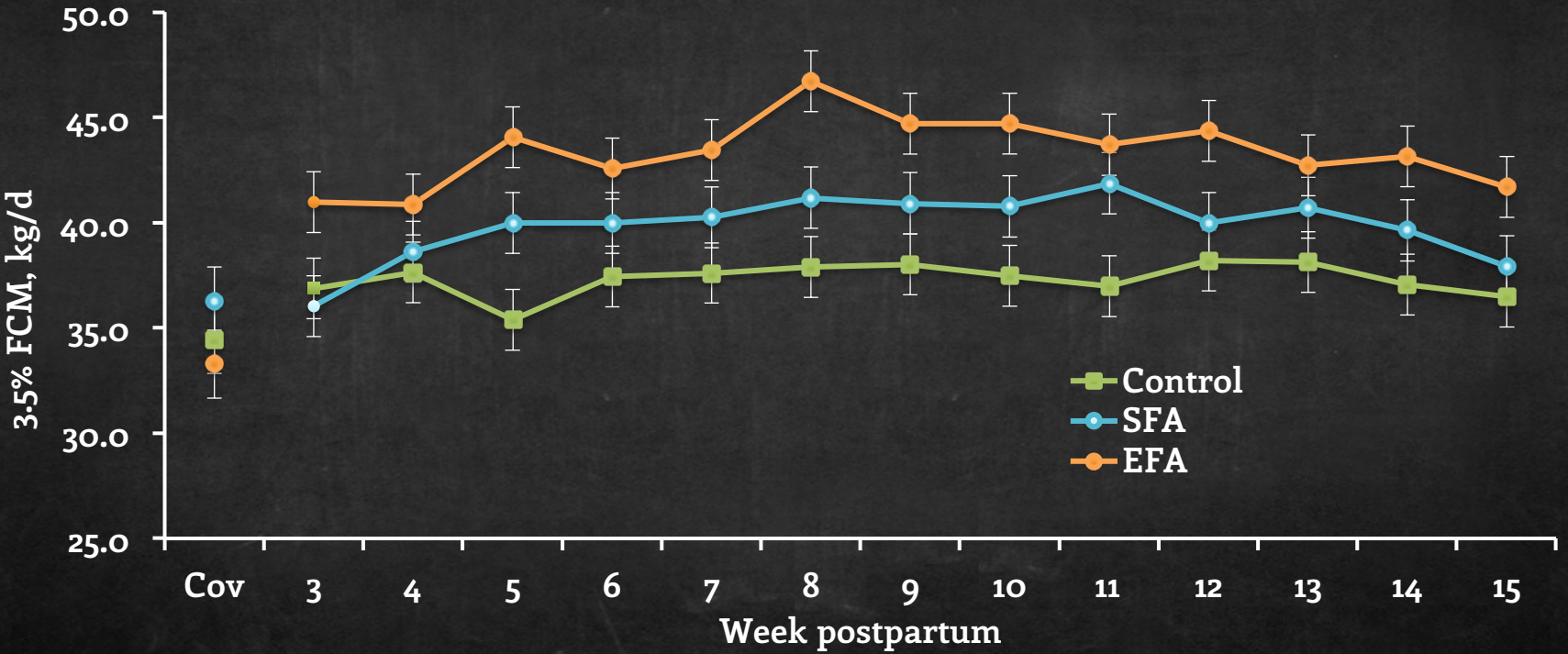
Effect of Supplemental FA on Performance of Dairy Cows



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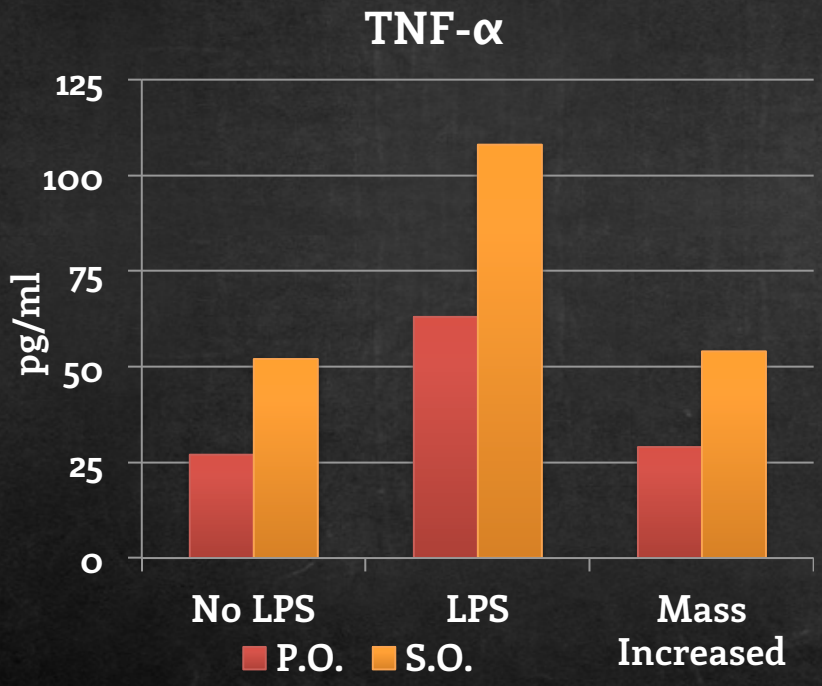

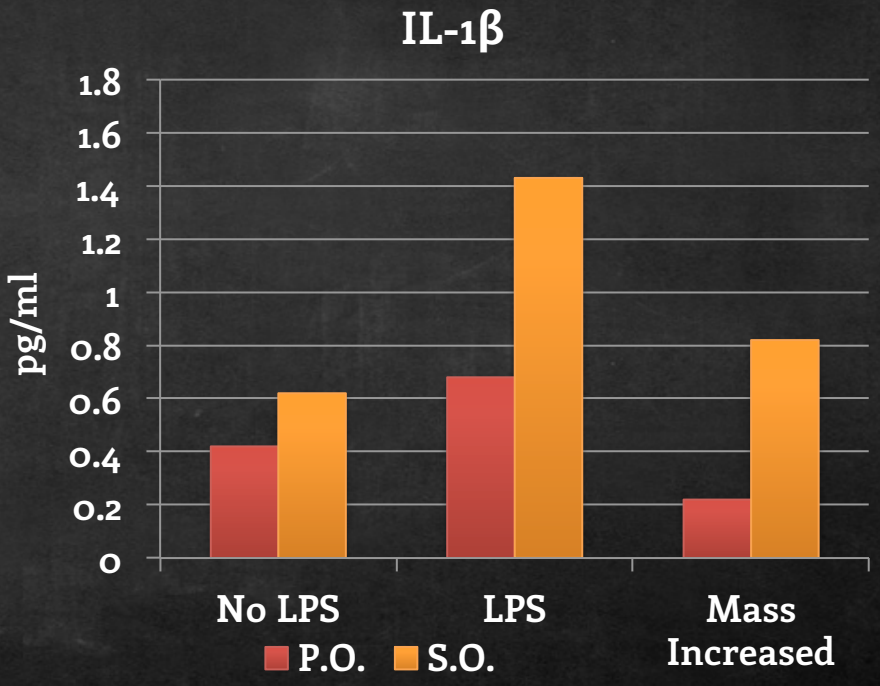

Silvestre et al. (2011) J. Dairy Sci. 94 :2285–2301

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Objective

Evaluate the impacts of altering the ratio of n-6 to n-3 FA of diets fed to early lactation cows on:

- Lactational performance
- Acute phase response to an intramammary LPS challenge

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Materials and Methods

- 45 multiparous cows blocked by parity (2 vs. > 2) and milk yield between 6 and 10 DIM and, within each block, randomly assigned to 1 of 3 treatments
  - TMR with a ratio of n6:n3 FA of 4:1 – R4
  - TMR with a ratio of n6:n3 FA of 5:1 – R5
  - TMR with a ratio of n6:n3 FA of 6:1 – R6
- The FA profile of diets was altered by incorporating Ca salts of fish oil (Strata), safflower oil (Prequel) and palm oil (EnerGII)
- Cows were fed a common diet for the first 14 DIM

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Materials and Methods

- Lactation performance evaluated from day 15 to 106 postpartum (13 weeks)
  - Cows were milked twice daily and no bST was used
  - Yields of milk, fat, protein and lactose measured daily and averaged weekly
  - BW was measured twice daily and averaged weekly

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Dietary Ingredients

Ingredients, % DM	R4	R5	R6
Corn Silage	18.7	18.7	18.7
Bermuda Grass Silage	9.0	9.0	9.0
Alfalfa Hay	6.1	6.1	6.1
Corn Grain, Finely Ground	13.8	13.8	13.8
Citrus Pulp	10.1	10.1	10.1
Soybean Hulls	20.3	20.3	20.3
Soybean Meal	10.1	10.1	10.1
Cooker-Processed SBM	5.7	5.7	5.7
Molasses	1.6	1.6	1.6
MinVit Premix	3.0	3.0	3.0
Ca Salts of Palm Oil	0.73	0.65	0.53
Ca Salts of Safflower Oil	0	0.37	0.70
Ca Salts of Fish Oil	0.70	0.41	0.20

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Chemical Composition of Diets

Nutrient Content, DM Basis (± SD)	R4	R5	R6
NE_L, [1] Mcal/kg	1.62	1.62	1.62
CP, %	16.6 ± 0.8	16.6 ± 0.8	16.5 ± 0.8
Starch, %	17.3	17.3	17.3
Non-Fibrous Carbohydrates, %	35.4 ± 1.9	35.4 ± 2.0	35.5 ± 1.9
Acid Detergent Fiber, %	16.0 ± 0.9	15.9 ± 0.9	15.6 ± 0.9
Neutral Detergent Fiber, %	38.4 ± 2.3	38.4 ± 2.3	38.1 ± 2.3
NDF from Forage, %	17.1 ± 0.7	17.1 ± 0.7	17.1 ± 0.7
Fatty Acids, %	3.66 ± 0.15	3.82 ± 0.17	3.88 ± 0.16

[1] Estimated based on nutrient analysis of ingredients and adjusted for 24kg DM intake (NRC, 2001)

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Intramammary LPS Challenge

- On d 75 postpartum, cows with SCC < 300,000/mL in the preceding 10 d and negative CMT on the day of challenge were used (n = 39 cows).
- Approximately 3 h after the morning milking, 10 μg of LPS (E. coli O111:B4; Sigma) diluted in 10 mL of sterile PBS was infused via teat canal.
- Milk samples were collected at 0, 2, 4, 6, 8, 14, 24, 48, 72 and 96 h after the infusion.
  - Infused quarter
  - Composite of 3 non-infused quarters

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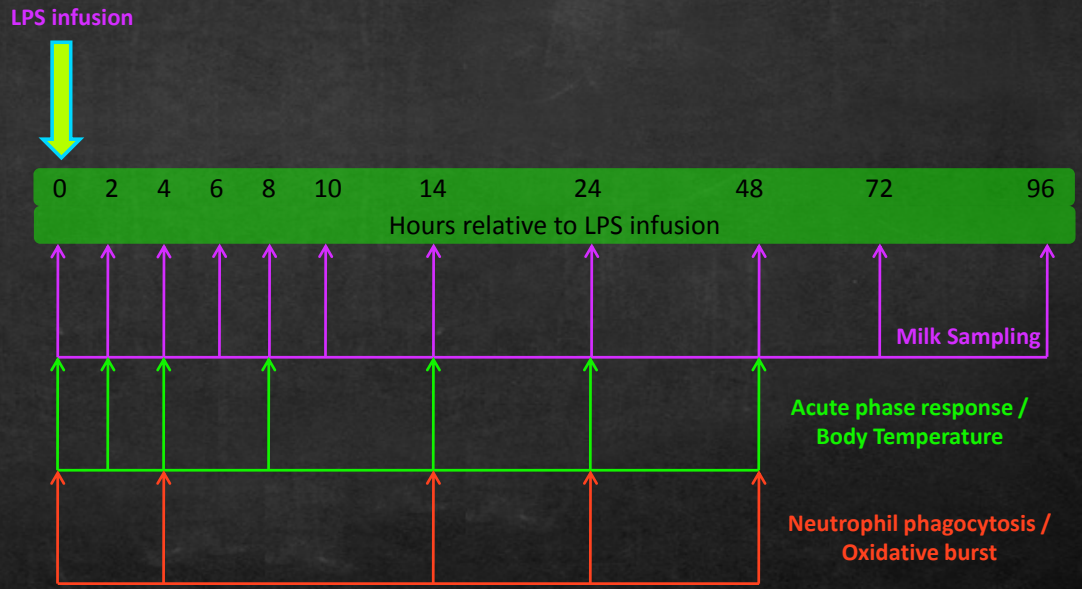
Intramammary LPS Challenge

- Blood was sampled multiple times
  - Acute phase proteins
  - Cytokines
  - Insulin, glucose
  - Neutrophil function
- Rectal temperature measured



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Statistical Analyses

- Data were analyzed by the GLIMMIX procedure of SAS fitting either a normal or Poisson distribution
- Data were evaluated for normality of residuals and transformed if needed. Back-transformed values are presented.
- Repeated measures
  - Fixed effects: Pre-treatment covariate value + Treatment + Time + Treatment x Time
  - Random effect: Cow(Treatment)
- Orthogonal polynomial contrasts were used to test
  - Linear (R4 vs. R6)
  - Quadratic (R4+R6 vs. R5)

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Lactation Performance

	Treatment[1]				P		
	R4	R5	R6	SEM	TRT	Lin	Quad
DM Intake, kg/d	26.1	24.6	24.7	0.5	0.07	0.05	0.17
Fatty Acid Intake[3], g/d							
Linoleic	298.1	329.5	369.4	8.6	<0.01	<0.01	0.69
EPA + DHA	20.3	14.9	10.0	0.3	<0.01	<0.01	0.65
Total n-6	300.6	332.0	371.9	8.6	<0.01	<0.01	0.69
Total n-3	76.3	67.3	62.8	1.7	<0.01	<0.01	0.27
Ratio of n-6 to n-3	3.9	4.9	5.9				

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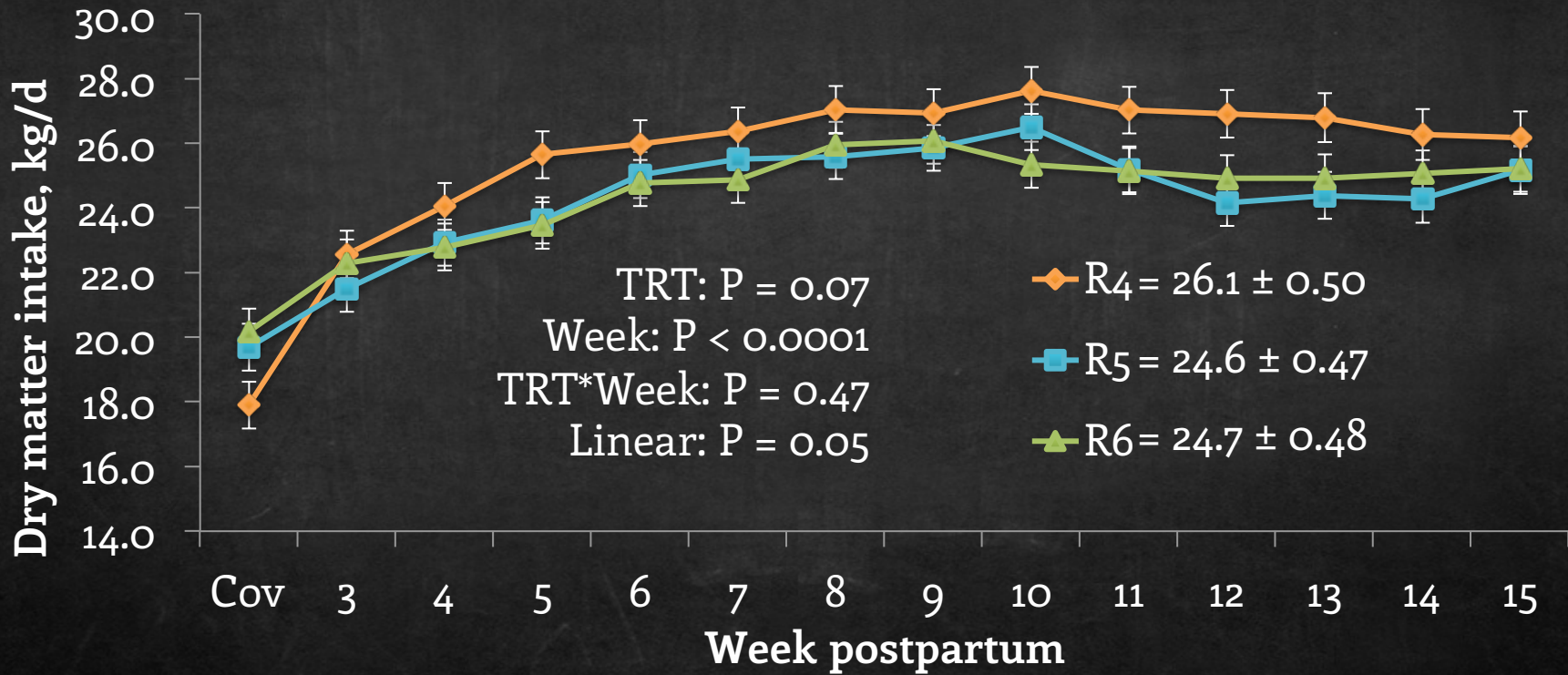
DM Intake



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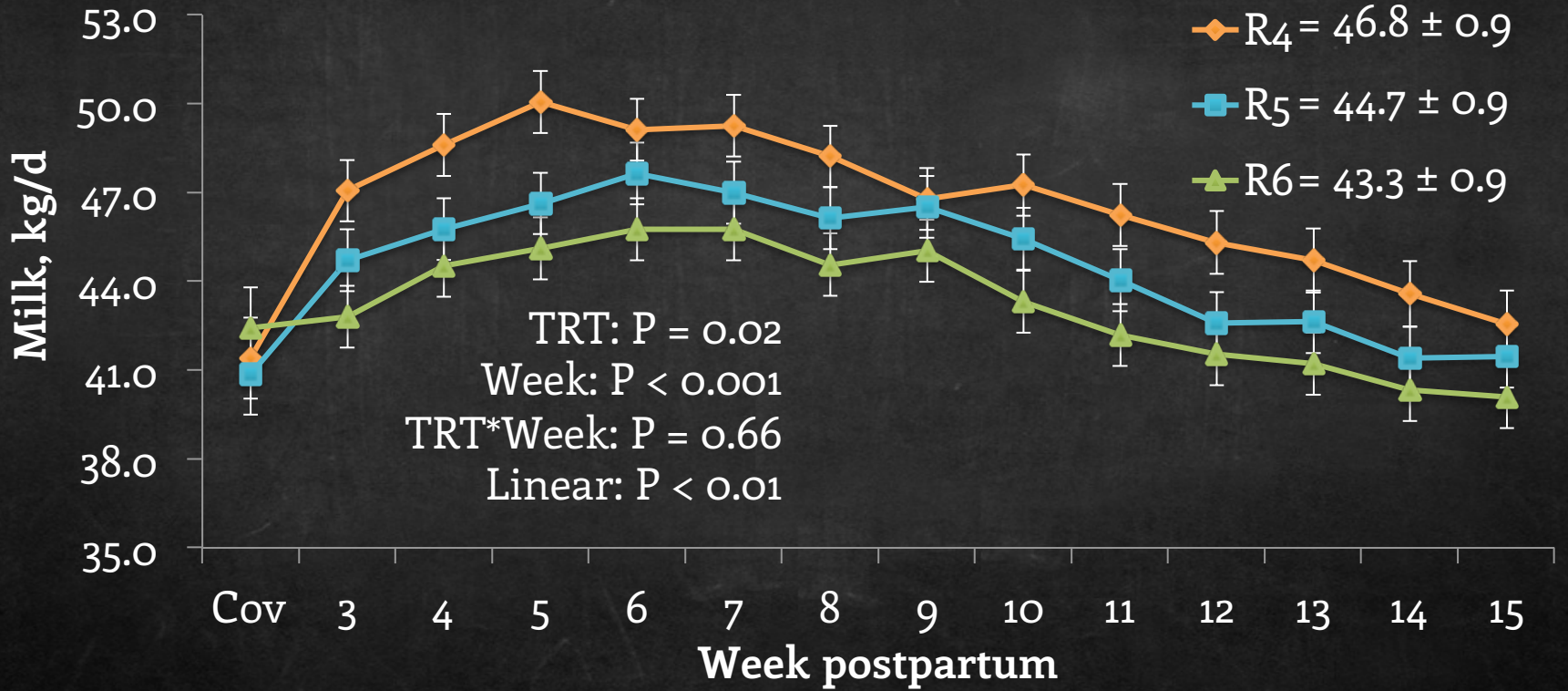
Milk Yield



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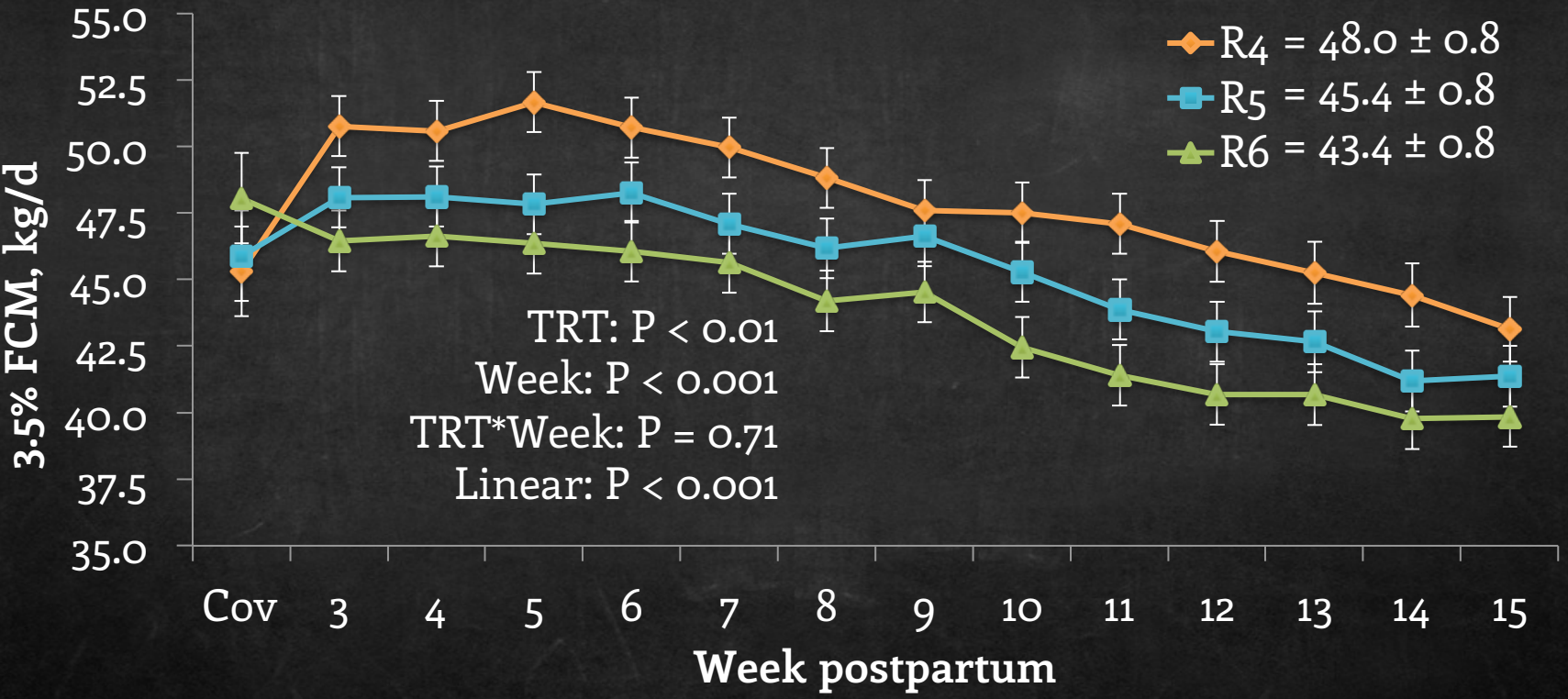
3.5% FCM



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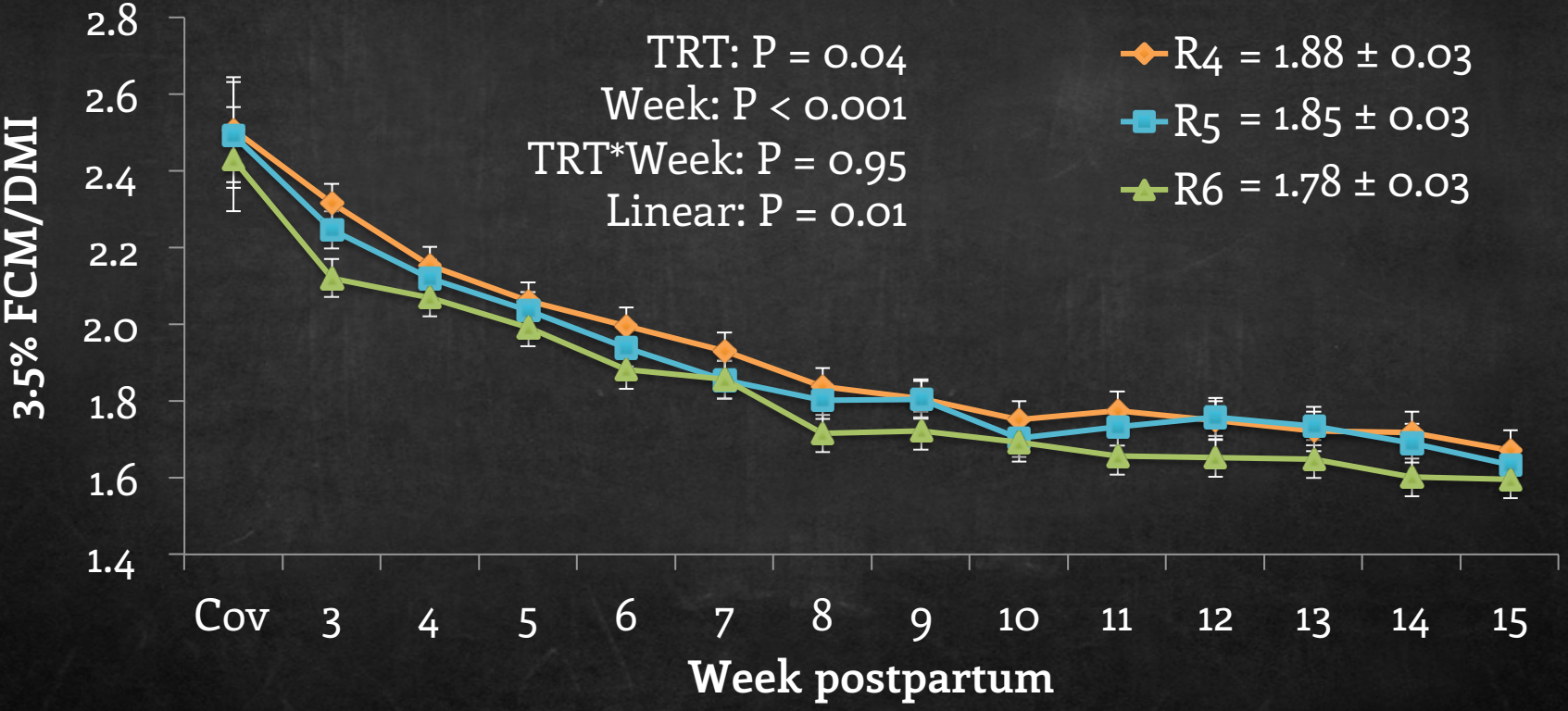
Feed Efficiency



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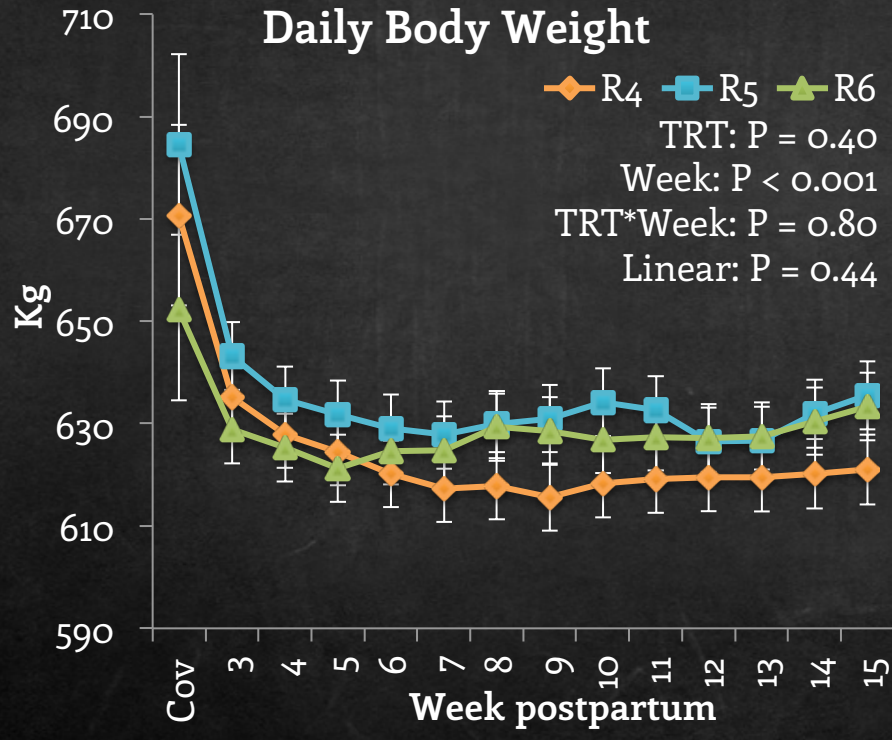
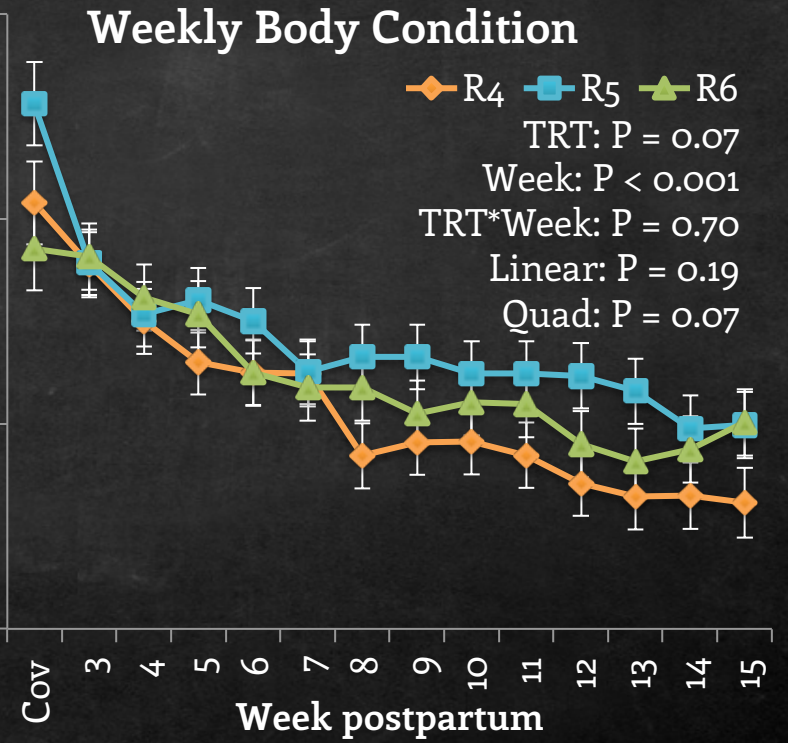
Body Weight and BCS





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Milk Composition

	Ratio n6:n3 FA in the Diet				P			
	R4	R5	R6	SEM	TRT	Wk	TRT*Wk	Linear
Milk Fat, %	3.64	3.58	3.55	0.05	0.42	<0.01	0.23	0.19
Milk Fat, kg/day	1.71	1.60	1.53	0.03	<0.01	<0.01	0.69	<0.01
True Protein, %	2.82	2.86	2.86	0.02	0.23	<0.01	0.99	0.13
True Protein, kg/day	1.32	1.28	1.24	0.02	0.03	<0.01	0.75	<0.01
Lactose, %	4.90	4.88	4.88	0.01	0.37	<0.01	0.82	0.23
Lactose, kg/day	2.29	2.19	2.12	0.04	0.01	<0.01	0.46	<0.01
Mcal/kg	0.69	0.69	0.68	0.01	0.68	<0.01	0.18	0.38
Mcal/day	32.3	30.8	29.5	0.6	<0.01	<0.01	0.74	<0.01

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Concentrations of Hormones & Metabolites in Plasma

	Treatment				P		
	R4	R5	R6	SEM	TRT	Lin	Quad
Glucose, mg/dL	65.7	67.5	66.1	1.1	0.46	0.81	0.22
Urea N, mg/dL	12.4	11.0	12.4	0.4	0.04	0.93	0.01
NEFA[3], μM	310.8	256.7	247.9	22.5	0.10	0.06	0.46
BHBA[3], mg/dL	6.51	6.34	6.11	0.47	0.83	0.55	0.94
Insulin, ng/mL	0.47	0.50	0.52	0.05	0.73	0.44	0.89
IGF-I[3], ng/mL	35.7	37.0	36.5	1.9	0.88	0.75	0.69

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Plasma & Milk Fatty Acid Composition

	Treatment				P		
FA (g/100g)	R4	R5	R6	SEM	TRT	Lin	Quad
Plasma							
Total n-6	50.85	52.66	53.30	0.54	0.01	<0.01	0.38
Total n-3	7.09	5.46	4.76	0.34	<0.001	<0.001	0.27
n-6 to n-3 Ratio	7.60	9.84	11.33	0.40	<0.001	<0.001	0.45
Milk							
Total n-6	2.90	3.13	3.45	0.14	0.03	0.01	0.79
Total n-3	0.62	0.60	0.54	0.03	0.23	0.10	0.66
n-6 to n-3 Ratio	4.74	5.41	6.37	0.16	<0.001	<0.001	0.29

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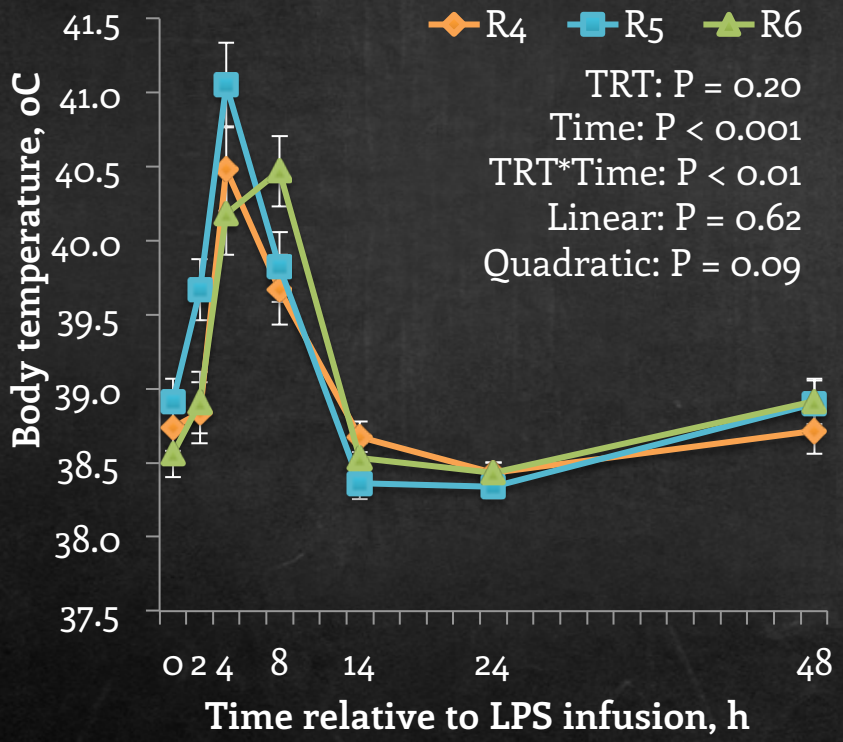
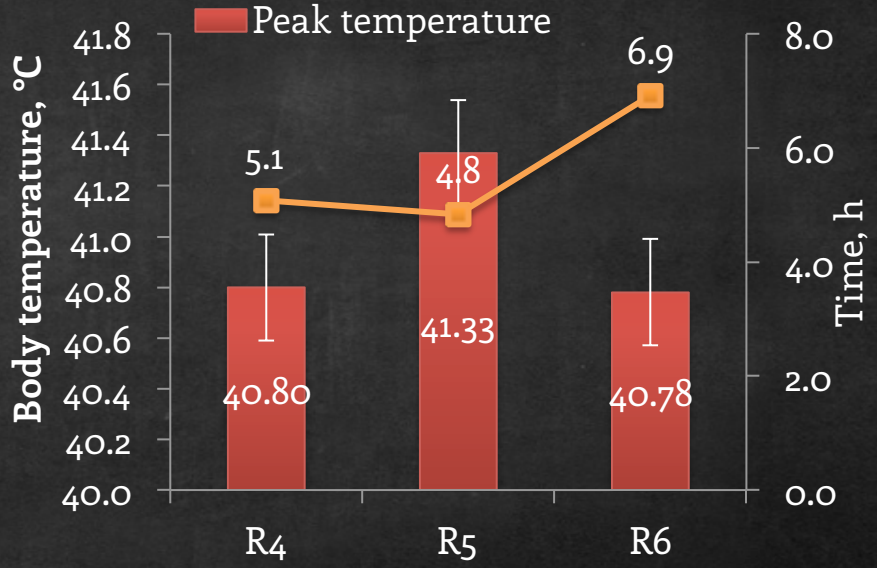
Body Temperature After a LPS Challenge





Peak temperature
TRT: P = 0.14
Linear: P = 0.96
Quadratic: P = 0.05

Time to peak temperature
TRT: P = 0.07
Linear: P = 0.08
Quadratic: P = 0.28

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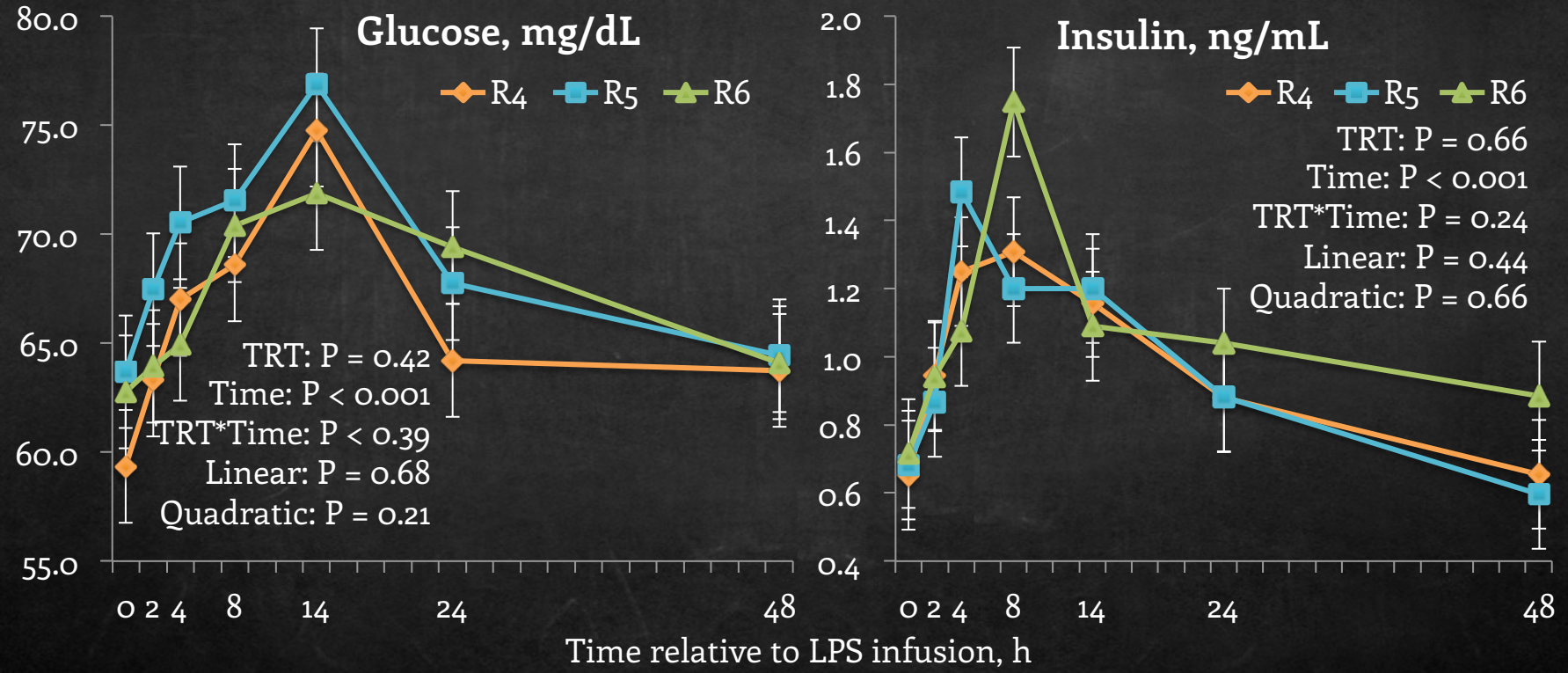
Plasma Glucose and Insulin After a LPS Challenge



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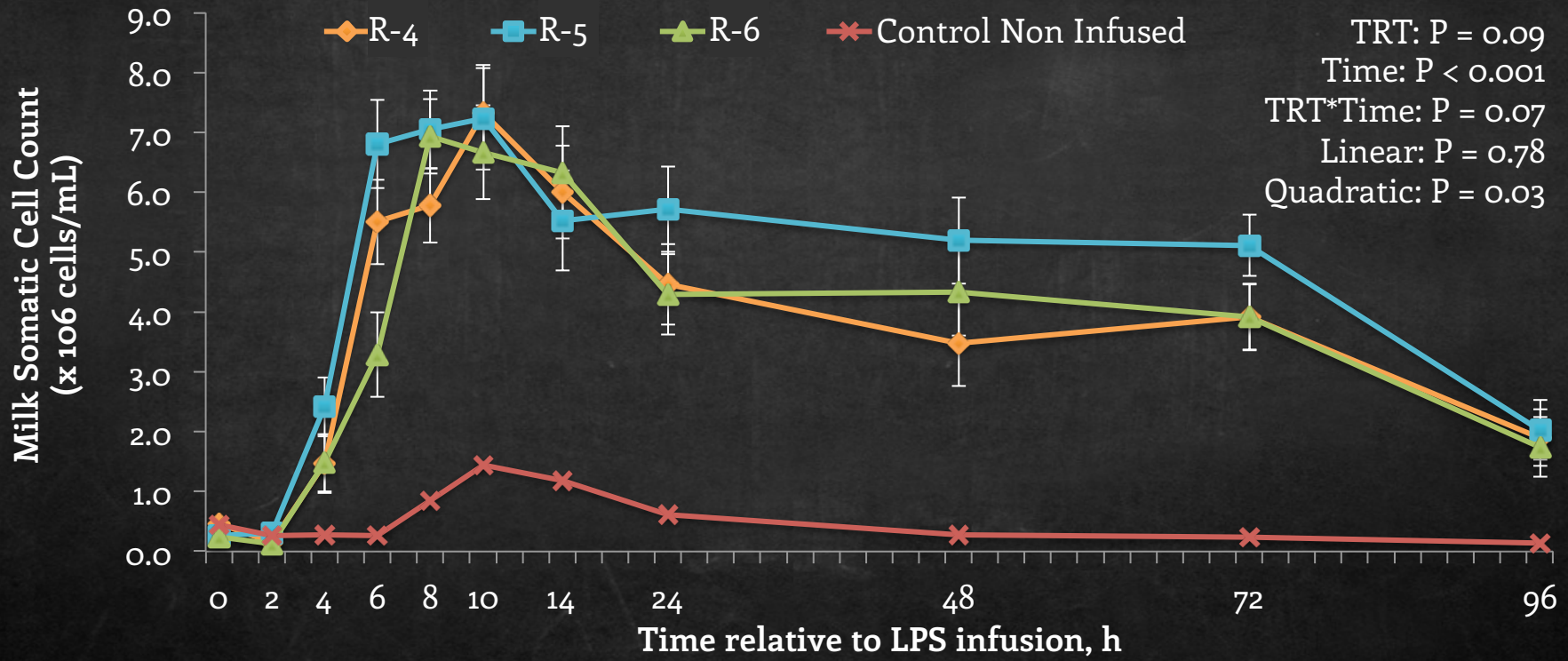
Milk Somatic Cell Count After a LPS Challenge



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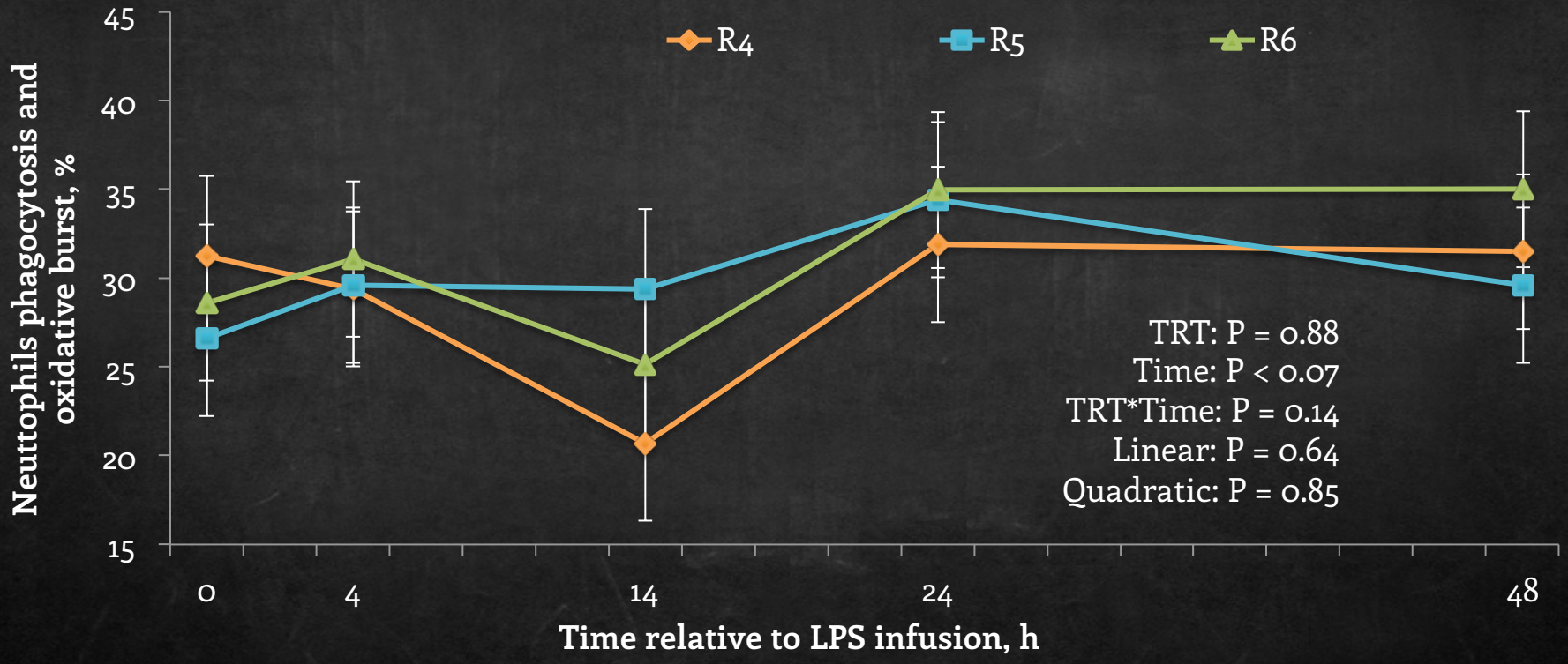
Neutrophils Phagocytosis and Oxidative Burst



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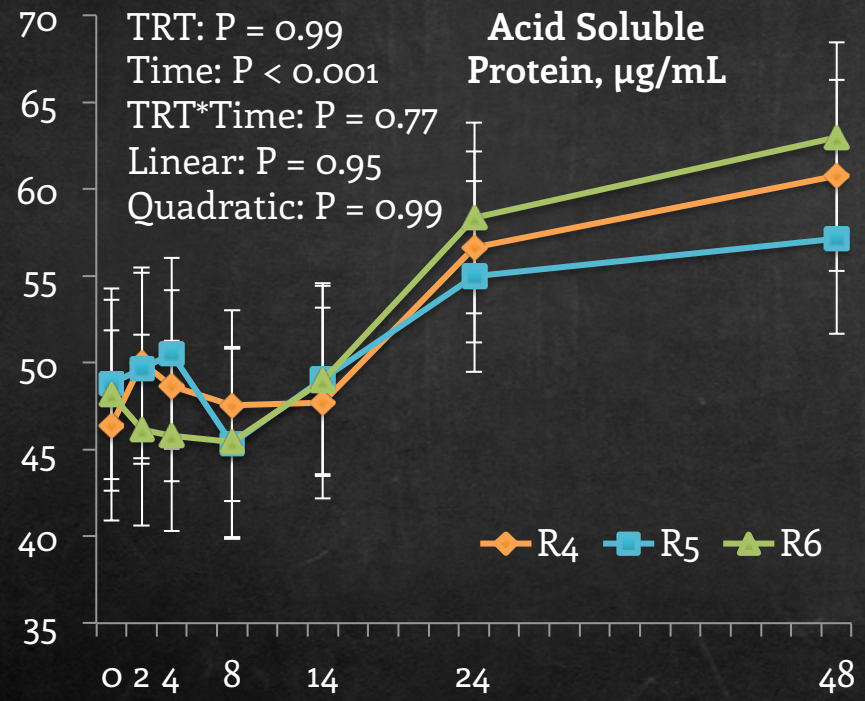
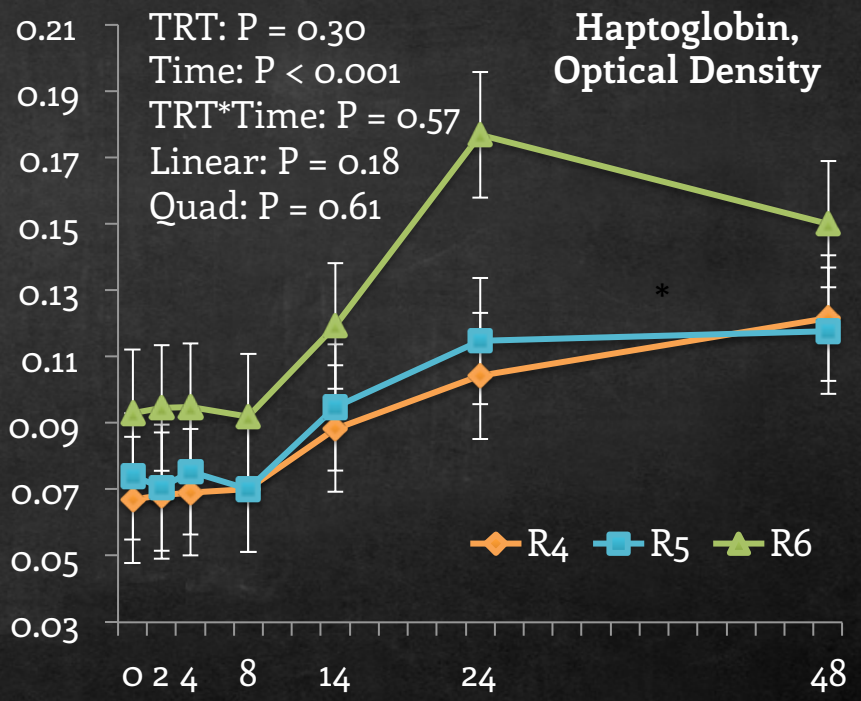
Plasma Acute Phase Proteins After a LPS Challenge





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Time relative to LPS infusion, h

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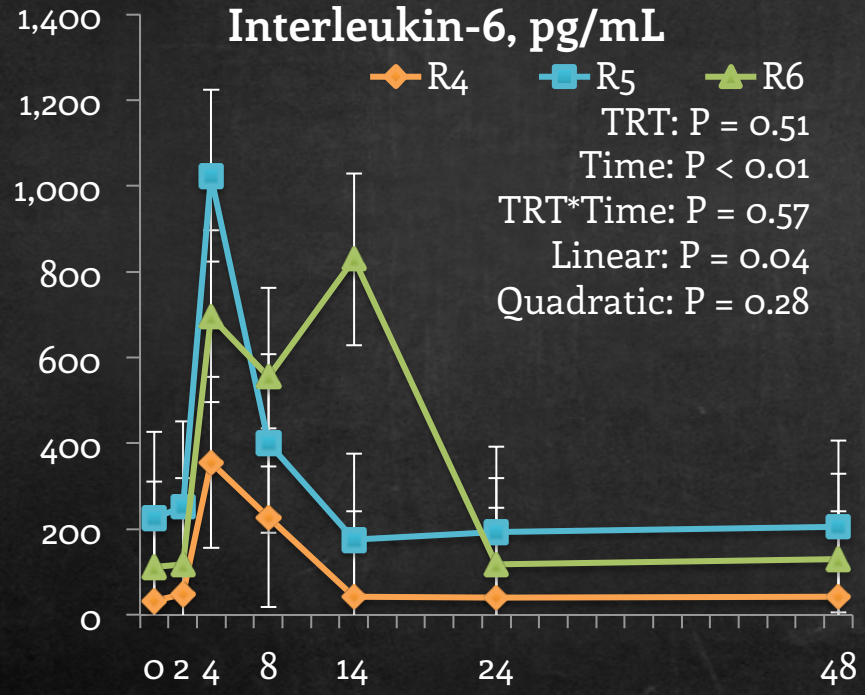
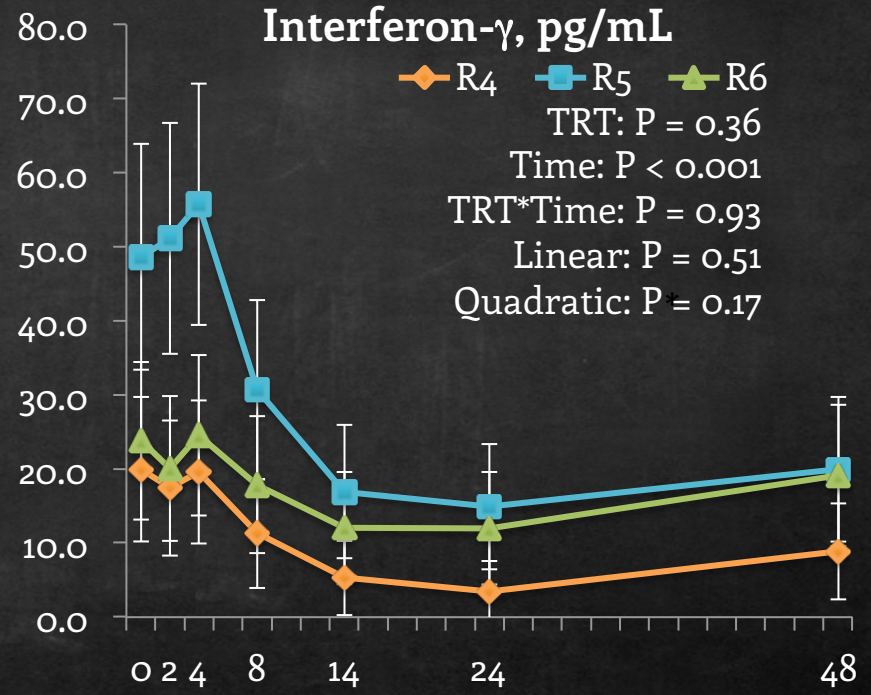
Plasma Acute Phase Proteins After a LPS Challenge





Time relative to LPS infusion, h

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Conclusions

Altering the FA profile of the diet fed to dairy cows by manipulating the n6 to n3 FA:

- Improved lactation performance;
  - Energetically, 1.3 kg of ECM could not be accounted for by the nutrient intake of cows when fed a diet in which EPA and DHA replaced linoleic acid
  - Efficiency of feed conversion into 3.5% FCM increased 5.6%
- Reducing the ratio of n6:n3 FA partially attenuated the acute inflammatory response to a LPS challenge
- R4 cows had the lowest SCC, haptoglobin, IL-6 and IFN- γ

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Questions & Answers

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