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New Insights from Michigan State University Transition Cow Research

Barry Bradford and Turner Swartz

Michigan State University

1

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How do we get the next 5 pounds of milk?

1. Refine feeding strategies to better meet metabolic needs and equip the mammary gland with the necessary nutrients for milk.

2. Prevent the clinical + subclinical transition cow problems that impact productivity of 20-40% of our cows. (5 lb/d x 30%)

2

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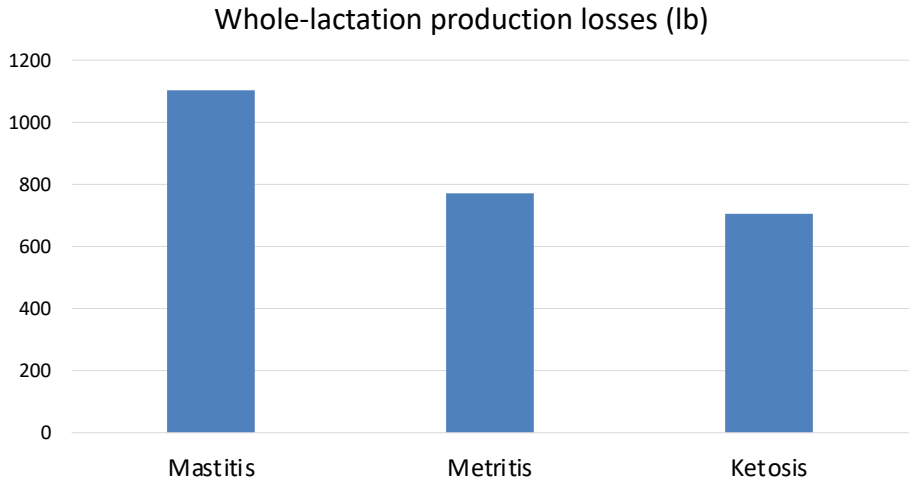
Long-term consequences of transition problems



Seegers 2003; Deluyker 1991; Wittrock 2011; Ospina 2010; Seifi 2011

3

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How do we get the next 5 pounds of milk?

1. Refine feeding strategies to better meet metabolic needs and equip the mammary gland with the necessary nutrients for milk.
2. Prevent the clinical + subclinical transition cow problems that impact productivity of 20-40% of our cows. (3 lb/d x 30%)
3. Reduce culling to increase average productive life and decrease the fraction of first-lactation cows in our herds

4

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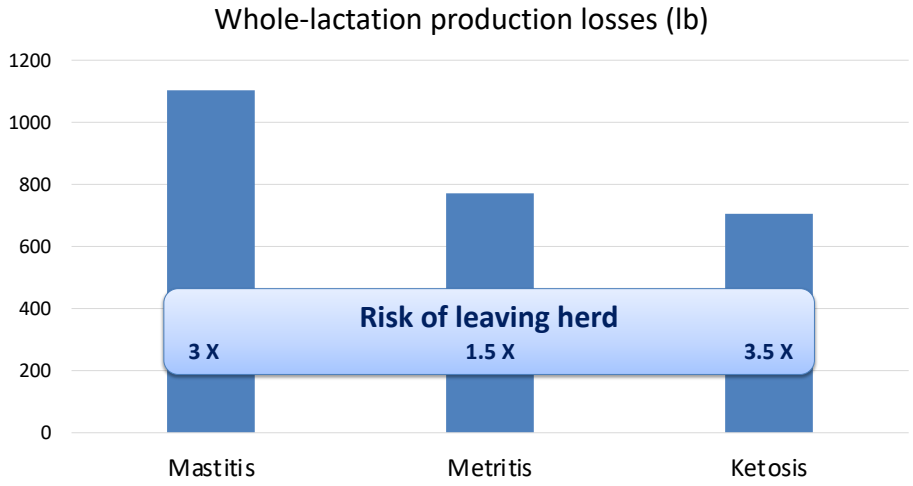
Long-term consequences of transition problems



Seegers 2003; Deluyker 1991; Wittrock 2011; Ospina 2010; Seifi 2011

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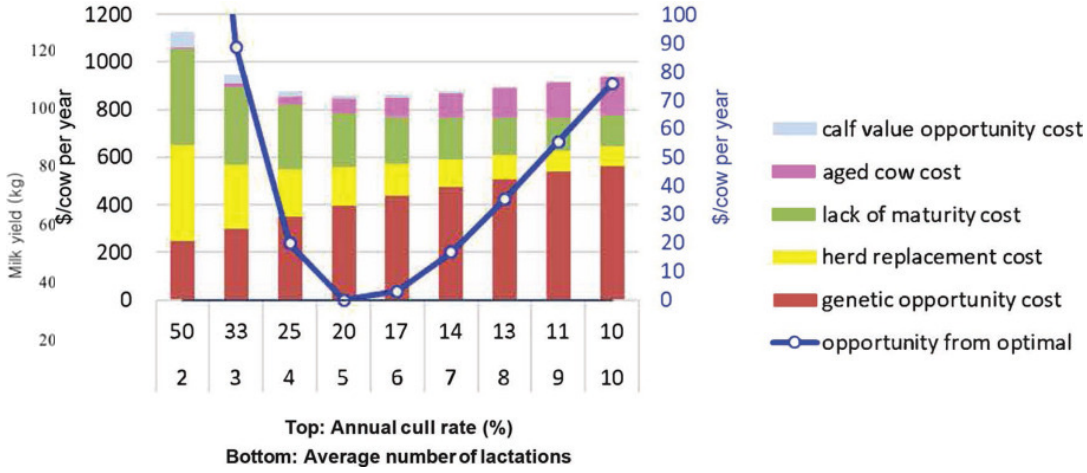
Productivity & profitability increase until lactation 4-5

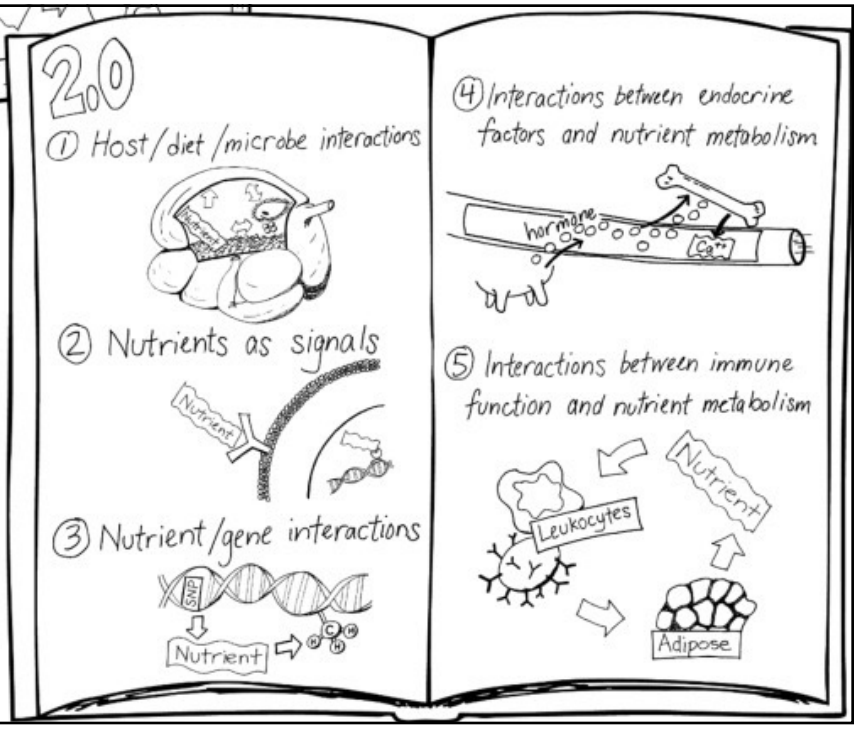


Lee and Kim, 2006

De Vries, 2020

6

How to go about improving health and longevity?



Bradford et al., 2016

7

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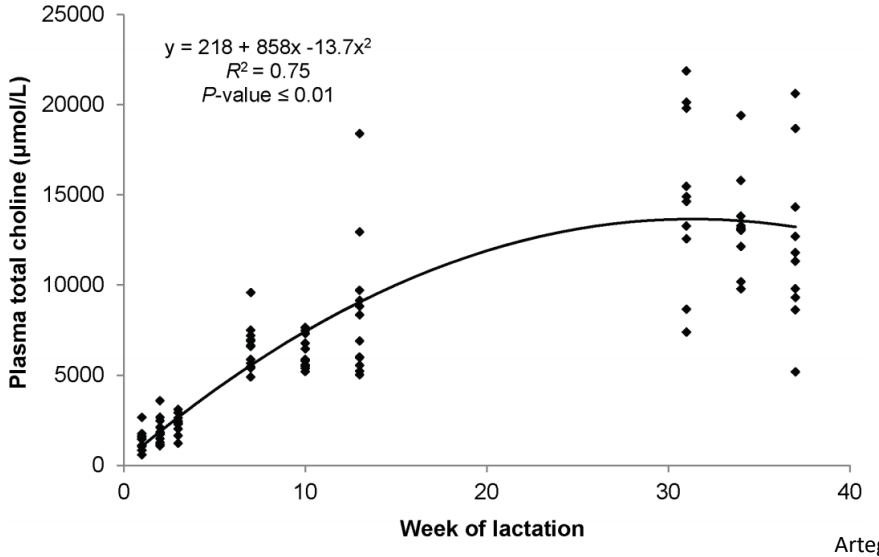
Choline in lactating cows



Artegoitia et a., 2014

8

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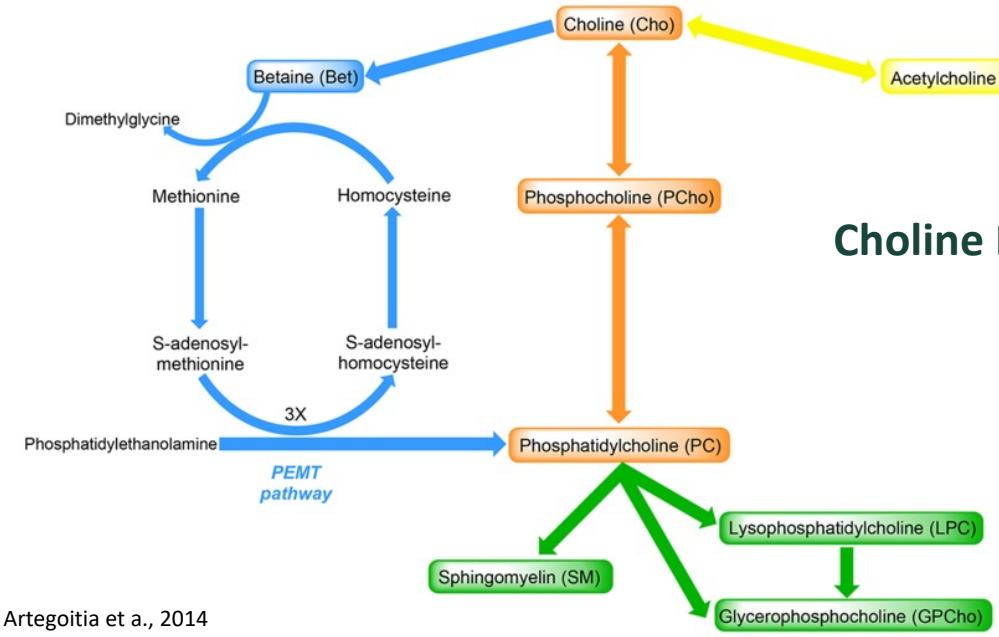

Choline Metabolism

Artegoitia et a., 2014

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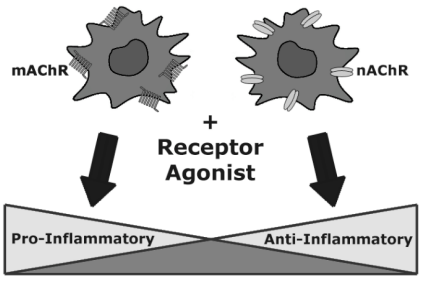
The Cholinergic System and Immune Response

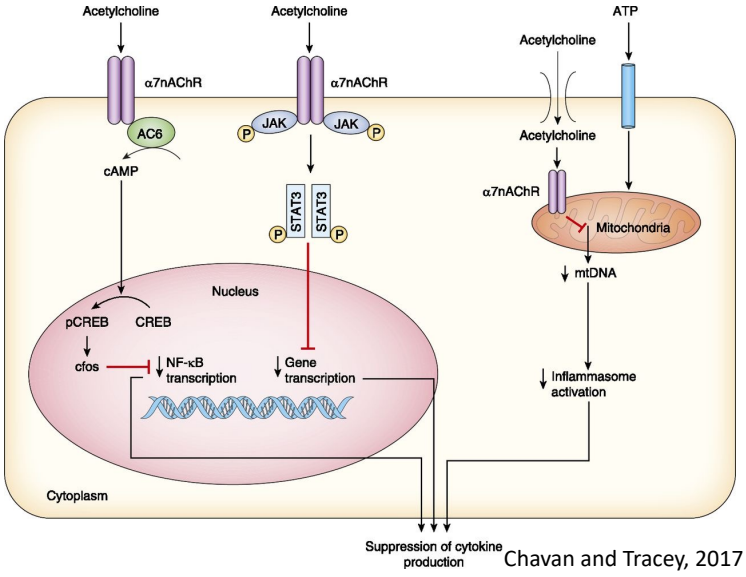
Acetylcholine Receptors

mAchR = Muscarinic

nAchR = Nicotinic



Di Bari et al., 2016



Chavan and Tracey, 2017

10

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What impacts does choline have on bovine immune cells apart from *in vivo* complexities?

frontiers in Immunology

ORIGINAL RESEARCH
published: 25 October 2018
doi: 10.3389/fimmu.2018.02448

Choline Regulates the Function of Bovine Immune Cells and Alters the mRNA Abundance of Enzymes and Receptors Involved in Its Metabolism *in vitro*

Miriam Garcia[1], Laman K. Mamedova[1], Barbara Barton[2] and Barry J. Bradford[1]**

[1] Department of Animal Sciences and Industry, Kansas State University, Manhattan, KS, United States, [2] Balchem Corporation, New Hampton, NY, United States

Dietary choline can impact systemic immunity, but it remains unclear whether this is primarily via direct impacts on immune cells or secondary effects of altered metabolic function. To determine whether increased choline concentrations (3.2, 8.2, 13.2 μM) in cell culture alter the function of bovine innate and adaptive immune cells, we isolated

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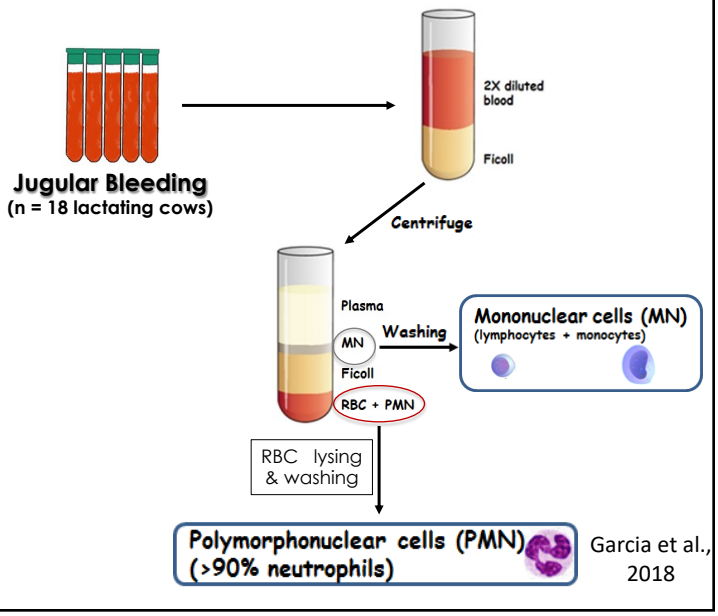
Approach

- Blood samples from early lactation (n = 9) and mid-lactation (n = 9) cows
- Isolated PMN (mostly neutrophils), monocytes, and lymphocytes
- Incubated with different choline concentrations and stimuli



Garcia et al., 2018

12

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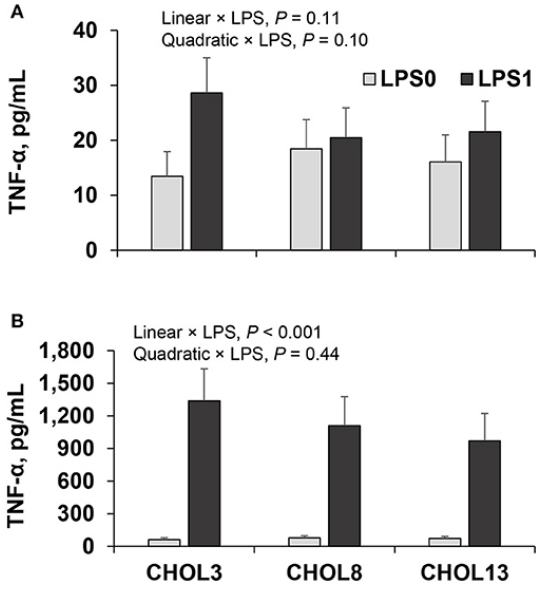
Choline in vitro effects

- Monocytes: tended to reduce TNFα release, significant reduction in *TLR4*, *NFKB1* mRNA

- Neutrophils: significant reduction of TNFα release, oxidative burst



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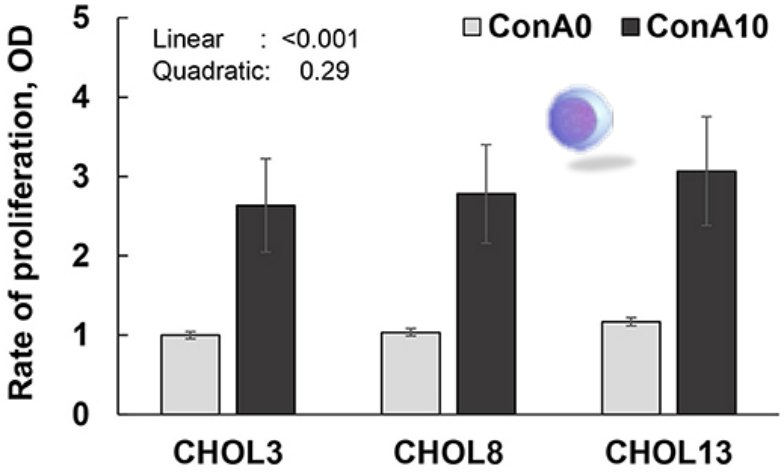
Choline enhances lymphocyte response in vitro

- Stimulated cell replication was linearly increased with increasing choline concentration



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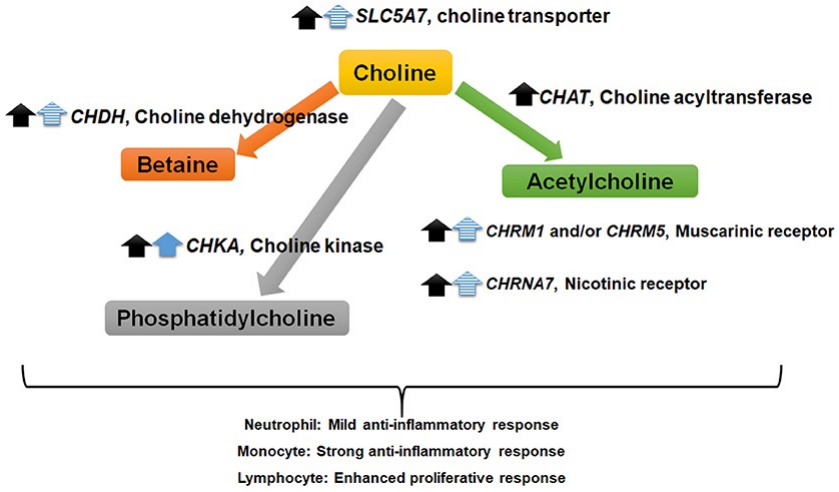
Choline promoted downstream pathways



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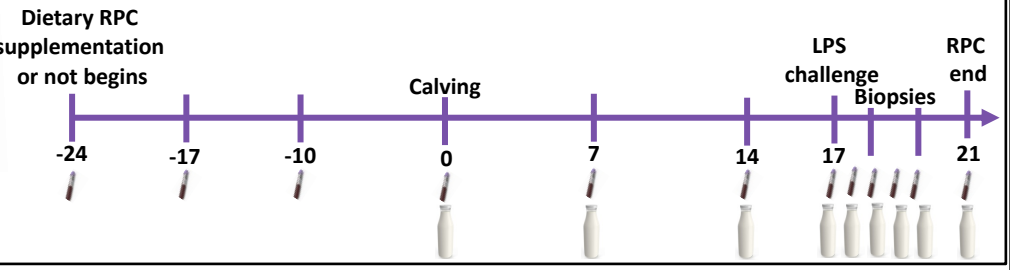
Does choline improve cow and calf immuno-metabolic status?

- Multiparous cows randomly assigned to receive one of three treatments: dietary supplementation of rumen-protected choline (RPC) at either 45 (**CHOL45**; 20.4 g/d choline), 30 (**CHOL30**; 13.6 g/d choline), or 0 (**CON**) g/d
- Intramammary LPS challenge at 17 DIM or left unchallenged

Transition cow study



Swartz et al., 2022 and unpublished data

16

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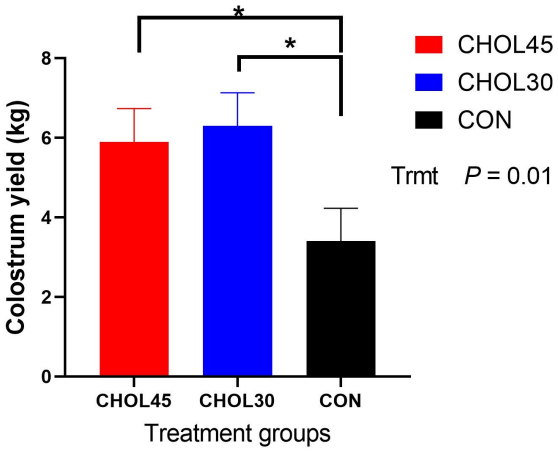
Dietary choline (CHOL) supplementation increased colostrum yield



- CHOL45 and CHOL30 produced greater colostrum protein yields than CON.
- CHOL30 produced greater colostrum fat yields relative to the CON.
- IgG content as assessed by Brix refractometry was not affected by treatment.

Swartz et al., 2022

17

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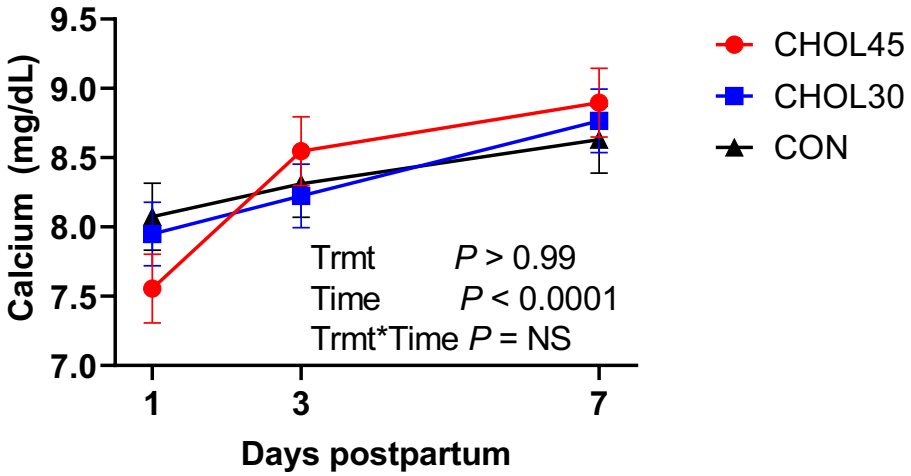
No apparent impact on blood calcium concentration



Swartz et al., *In preparation*

18

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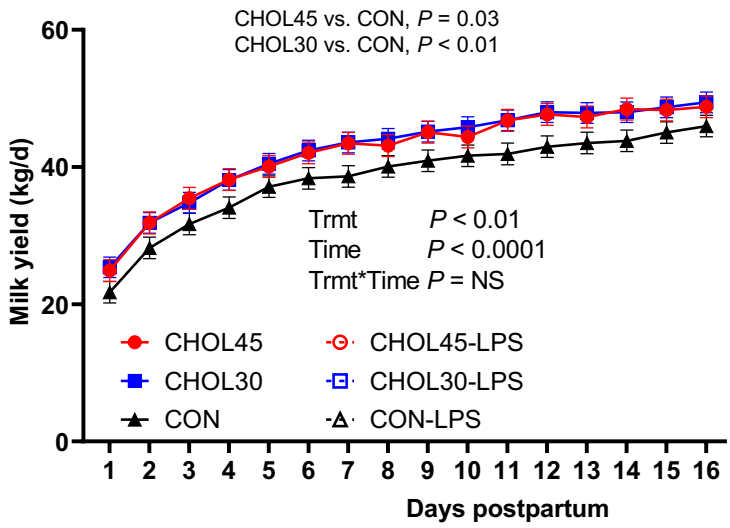
Dietary choline (CHOL) supplementation increased milk yield



Swartz et al., *In preparation*

19

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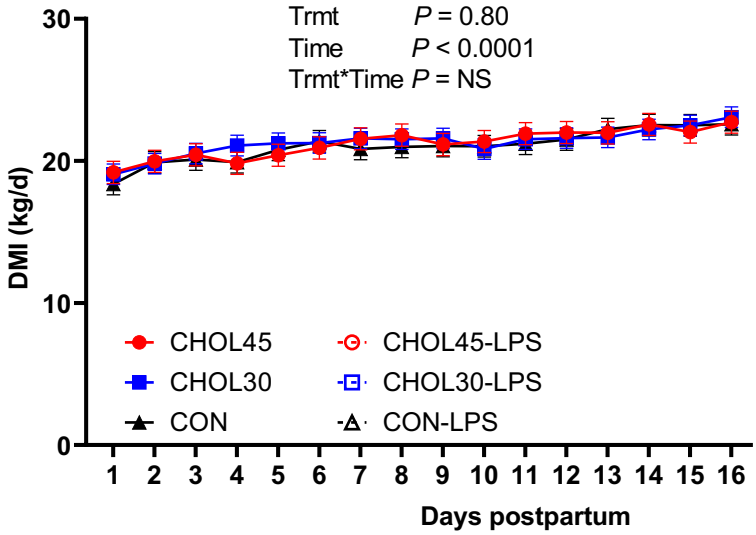
No choline effect on dry matter intake



Swartz et al., *In preparation*

20

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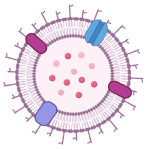
LPS – inflammatory response

Gram-negative
E. coli



21

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LPS – inflammatory response

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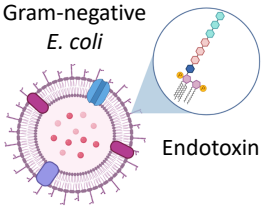
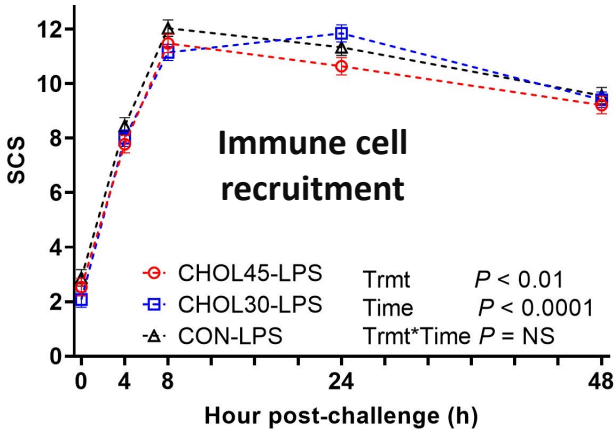


Endotoxin

Intramammary
challenge



Swartz et al., *In preparation*

22

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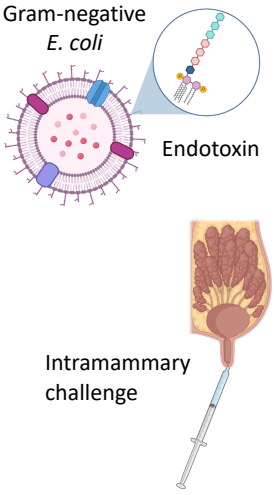

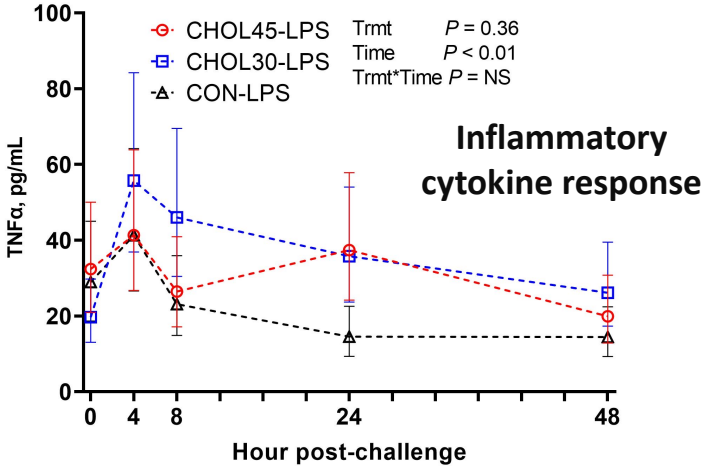

Swartz et al., *In preparation*

23

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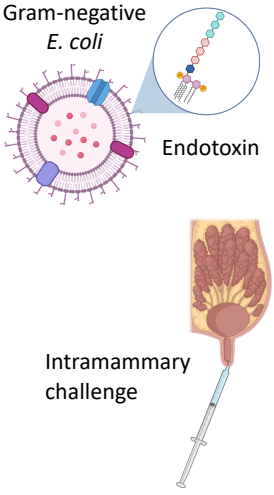
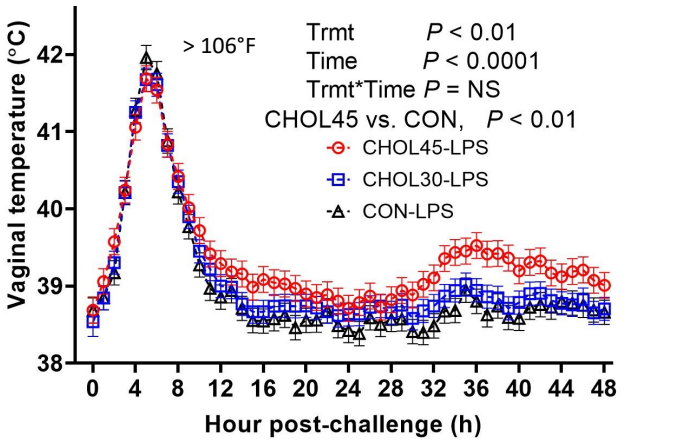
LPS – inflammatory response





Swartz et al., *In preparation*

24

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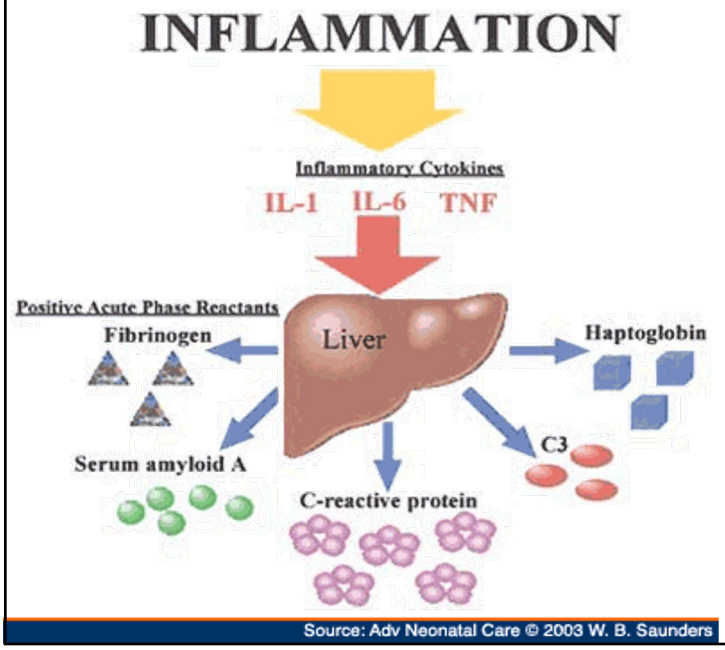

Acute phase proteins are stable blood markers of inflammation

25

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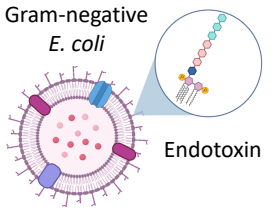
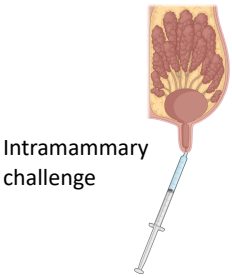
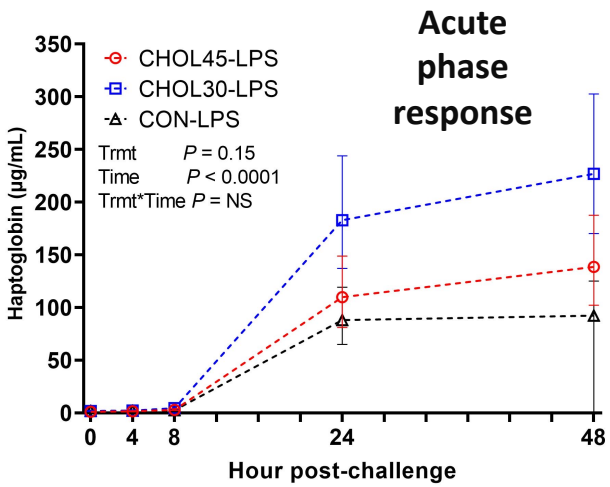
LPS – inflammatory response







Swartz et al., *In preparation*

26

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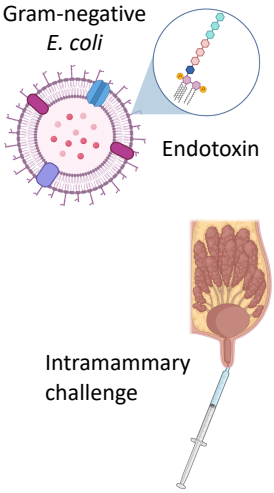
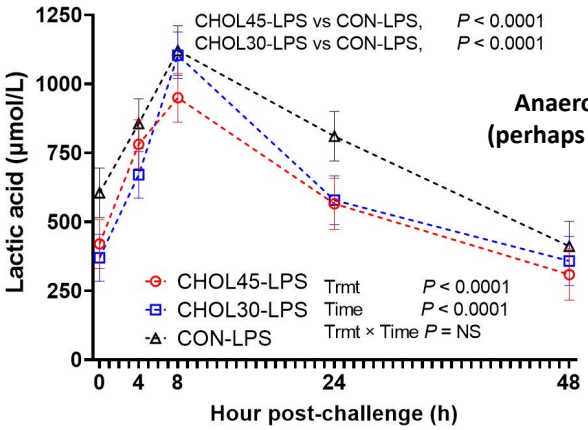
LPS – inflammatory response



Metabolic disruptions



Anaerobic glycolysis (perhaps oxidative burst)

Swartz et al., *In preparation*

27

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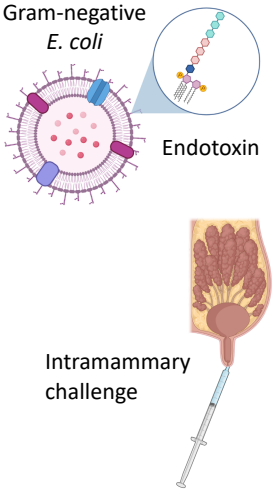
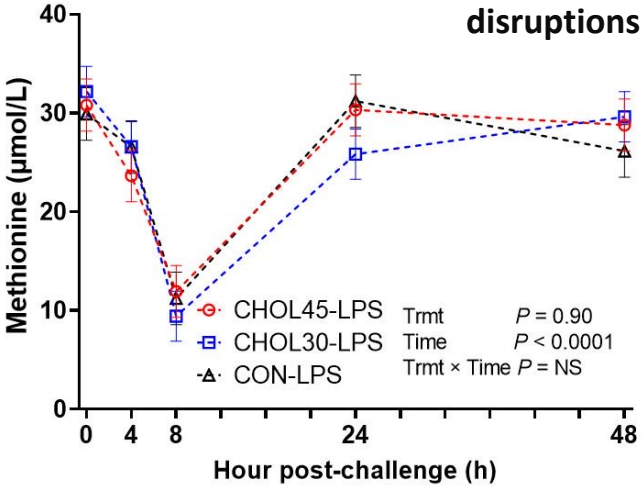
LPS – inflammatory response



Metabolic disruptions



Swartz et al., *In preparation*

28

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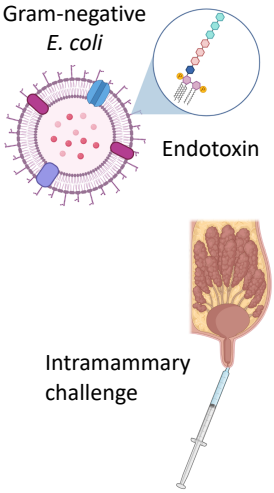
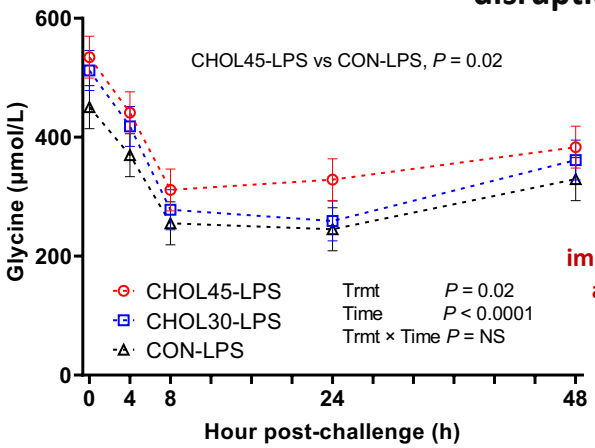
LPS – inflammatory response



Metabolic disruptions



Possible improvement in antioxidant defenses

Swartz et al., *In preparation*

29

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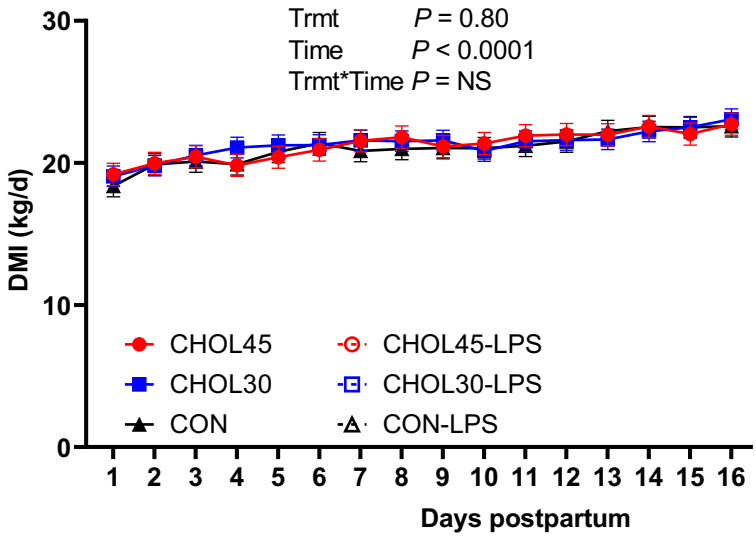
Dry matter intake through challenge



Swartz et al., *In preparation*

30

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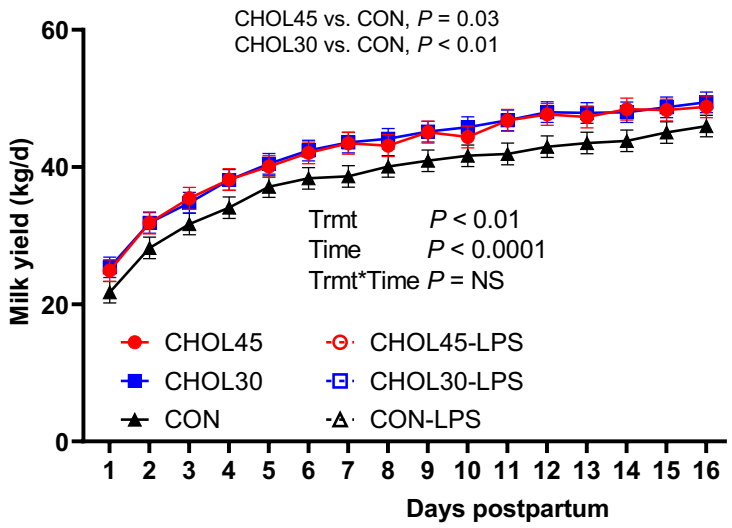
Milk yield response to challenge



Swartz et al., *In preparation*

31

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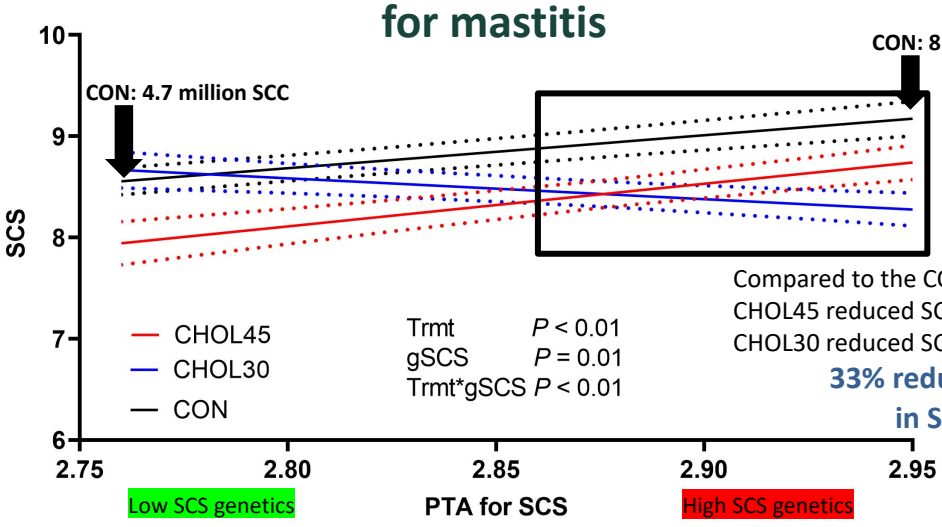
LPS challenge – RPC interacted with the genetic propensity for mastitis



Compared to the CON:
CHOL45 reduced SCC by 1.8 million
CHOL30 reduced SCC by 2.5 million

33% reduction in SCC

Swartz et al., *In preparation*

32

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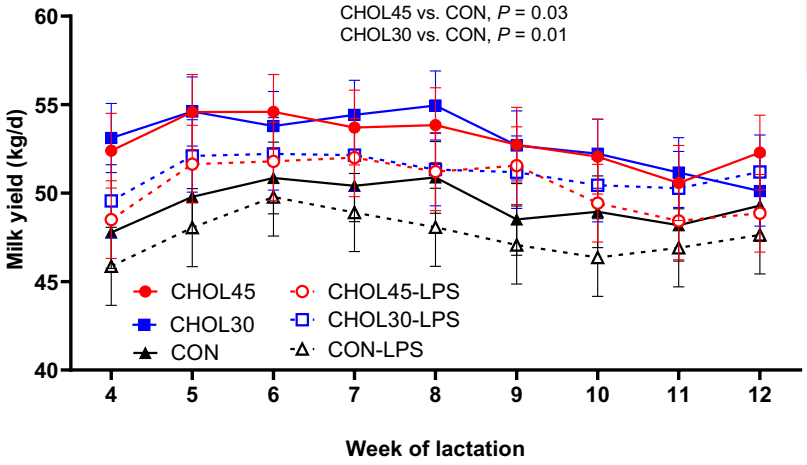
Dietary CHOL supplementation increased milk yield in the carry-over period (22-84 DIM)



LPS "hangover" of about 5 lb/d for at least 2 months post-challenge

Trmt	*P* = 0.02
LPS	*P* = 0.05
Trmt*LPS	*P* = NS
Week	*P* < 0.0001
LPS*Week	*P* = NS
Trmt*Week	*P* = NS
Trmt*LPS*Week	*P* = NS

Swartz et al., *In preparation*

33

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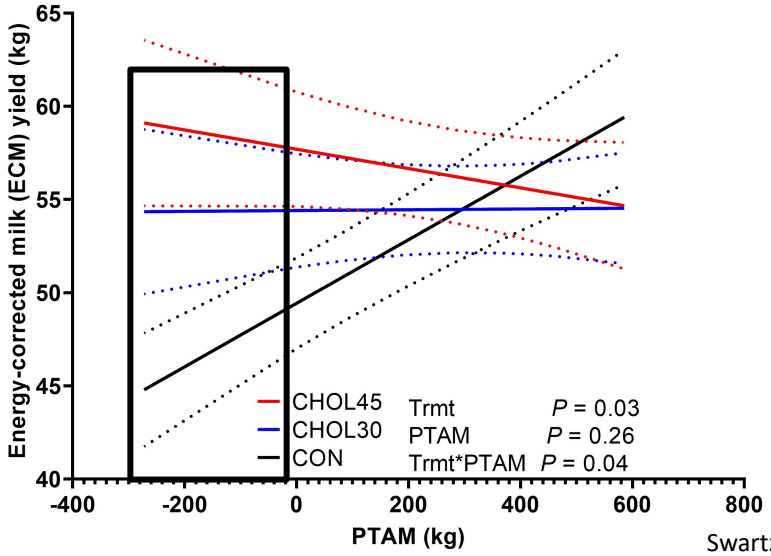
Choline increased ECM yields in cows with inferior genetics



Swartz et al., *In preparation*

34

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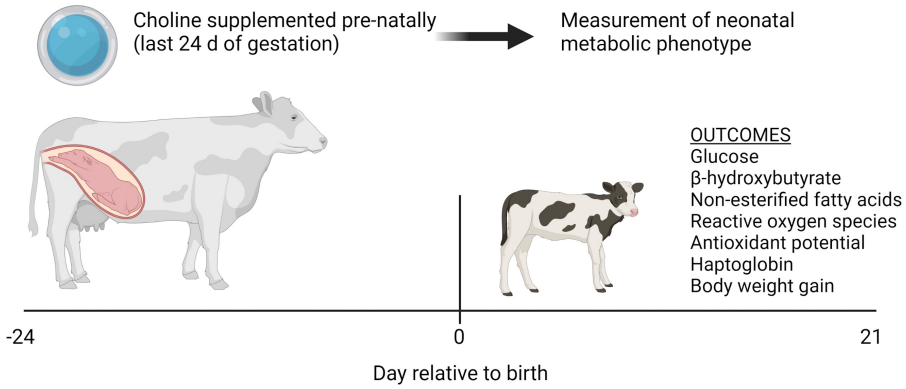
What about the calves??

- Key factor: all calves fed commercial colostrum replacer, NOT dam's colostrum



35

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What about the calves??

ARTICLE IN PRESS

J. Dairy Sci. 105
https://doi.org/10.3168/jds.2022-22239

Effects of prenatal dietary rumen-protected choline supplementation during late gestation on calf growth, metabolism, and vaccine response

T. H. Swartz,[1]* B. J. Bradford,[1] M. Lemke,[1] L. K. Mamedova,[1] R. Agnew,[1] J. Fehn,[1] E. Owczarzak,[1] J. L. McGill,[2] and K. A. Estes[3]
[1]Department of Animal Science, Michigan State University, East Lansing 48824
[2]Department of Veterinary Microbiology and Preventive Medicine, Iowa State University, Ames 50011
[3]Balchem Corporation, New Hampton, NY 10958

ABSTRACT

The objective of this study was to examine the effects of prenatal supplementation and dose of rumen-protected choline (RPC) on neonatal calf growth, metabolism, and vaccine response. Parous Holstein cows

dam's prepartum NEFA concentration interacted with treatment. When dam NEFA was minimal, calves from CHOL45 and CHOL30 dams had greater or tended to have greater NEFA, respectively. Conversely, when dam NEFA was greater, calves from CHOL30 and CHOL45 dams had lesser or tended to have lesser NEFA, than

36

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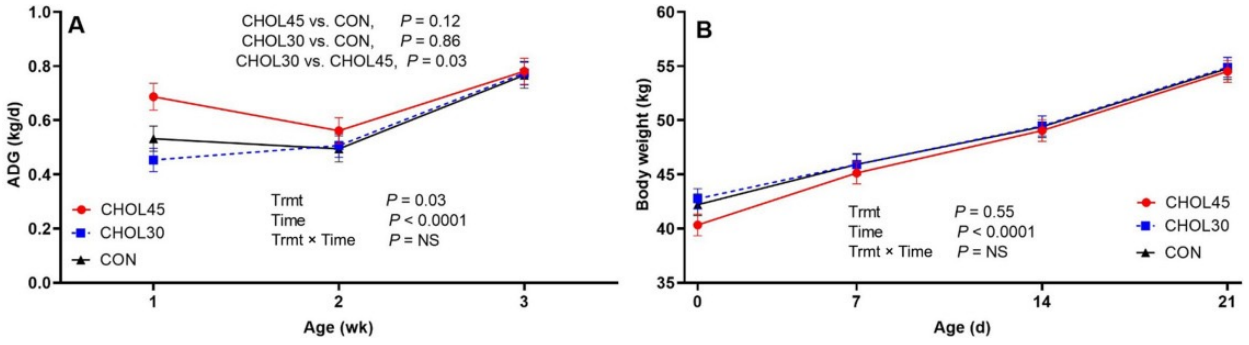
Minimal effects on growth through day 21



Swartz et al., in press

37

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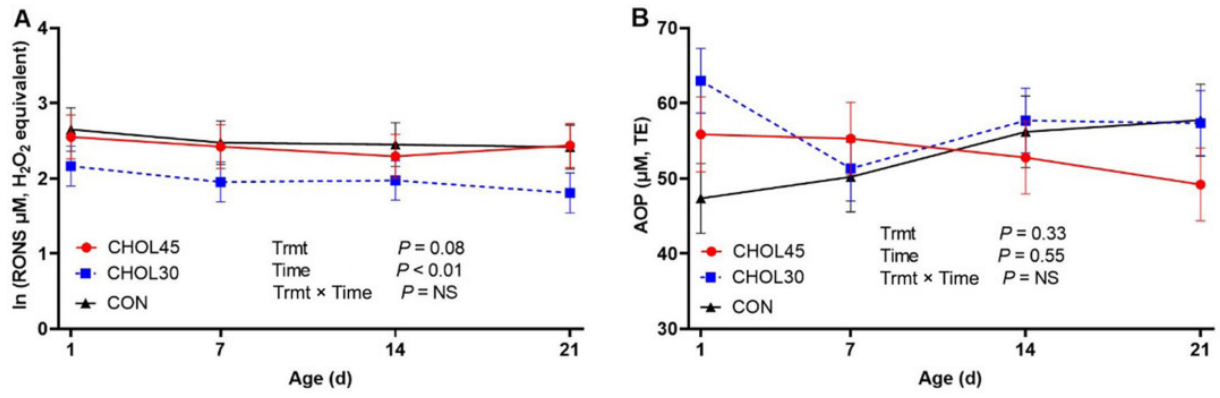
Neonatal oxidative stress index



Swartz et al., in press

38

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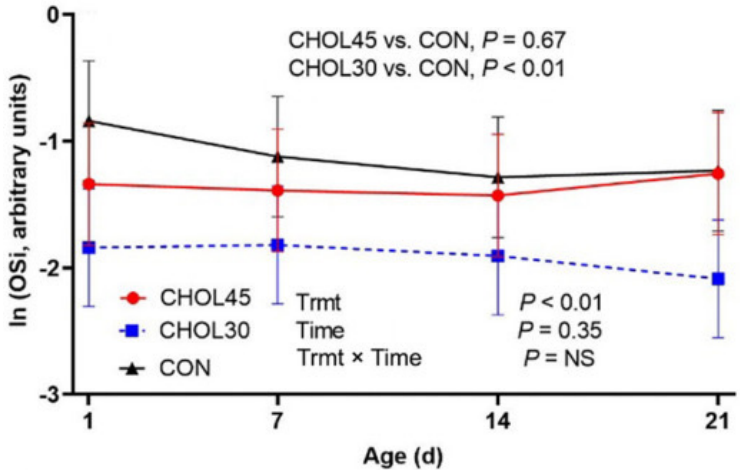
Neonatal oxidative stress index



Swartz et al., in press

39

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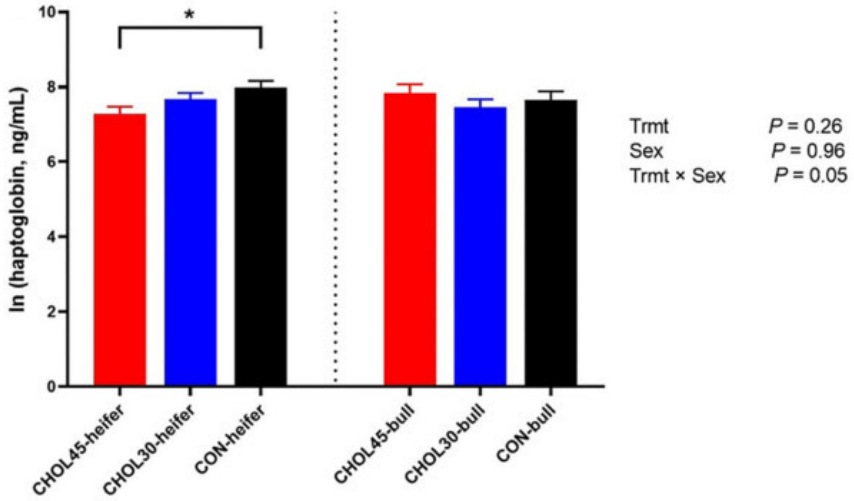
Neonatal inflammatory marker



et al., in press

40

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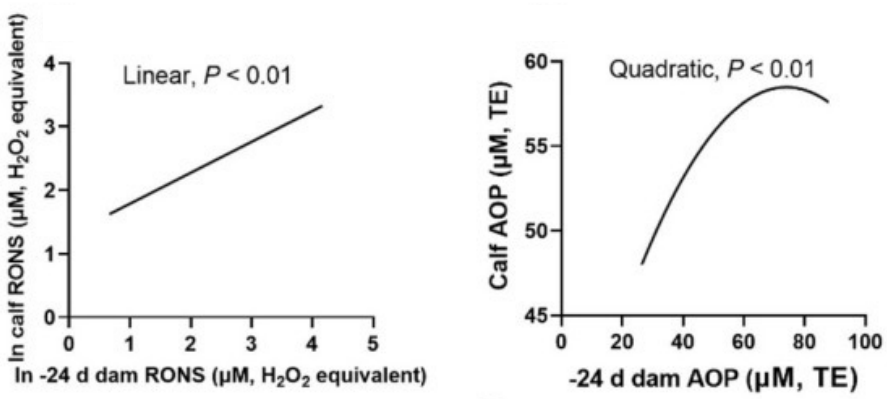
Some evidence of maternal imprinting



Swartz et al., in press

41

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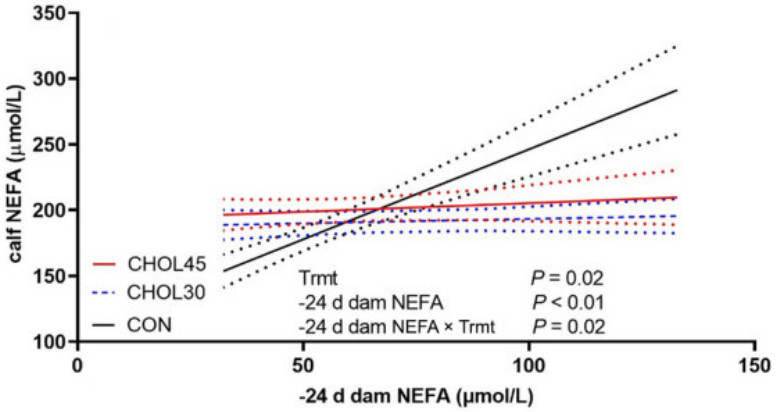

Swartz et al., in press

42

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Highlights from MSU transition choline study

- 80% increase in colostrum yield is surprising and worth exploring
- Choline increased milk & ECM yield substantially, but not by diminishing the hit from LPS
- Genetic interactions point to potential for precision feeding
- This study is the first to demonstrate in a randomized design that early lactation intramammary LPS substantially reduces peak milk yield (~5 lb/d)
- Lots to learn about gestational imprinting and neonatal immunity

43

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How do we get the next 5 pounds of milk?

1. Refine feeding strategies to better meet metabolic needs and equip the mammary gland with the necessary nutrients for milk.

2. Prevent the clinical + subclinical transition cow problems that impact productivity of 20-40% of our cows. (3 lb/d x 30%)

3. Reduce culling to increase average productive life and decrease the fraction of first-lactation cows in our herds

44

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Questions/comments:

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45