Calf Nutrition Program for Long-Term Health

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Topics to be covered

- Why do pre-weaned calves get sick?
  - Development of gastrointestinal immunity
- Why do post-weaned calves get sick?
  - Development of active immunity
- Nutrition and immunity of calves
  - Reduce interaction of potential pathogens with calf
  - Stimulate gastrointestinal immunity
  - Stimulate adaptive immune development

Why do so many calves get sick?

- Risk of mortality greatly decreases after the first few weeks of life
- What changed in the calf during this period?

Gastrointestinal Maturation

- Some components of the GI immune system develop after birth
- Catch-22 Situation
  - Passive absorption of macromolecules but increases risk for translocation of microorganisms
- Ideal situation
  - Absorb adequate antibodies
  - No absorption of microorganisms
  - Rapid maturation of the GI tract

Gastrointestinal Maturation

- Many components to the GI immune system
  - Physical barrier
  - Chemical barrier
  - Immunological barrier
  - Microbial barrier

Strategies to improve immunity

- What role can nutrition play in reducing enteric disease?

Strategies to improve immunity

- Putative nutrition supplements added to milk replacer and/or calf starter
  - Post-day 1 colostrum
  - Bovine serum/plasma proteins
  - Yeast cell walls
    - *Whole cell wall extract*
    - *MOS and β-glucan fractions*
  - Live yeast
  - Yeast cultures
  - Direct fed microbials
  - Butyric acid
  - Hyper immunized egg proteins
  - Adsorbents

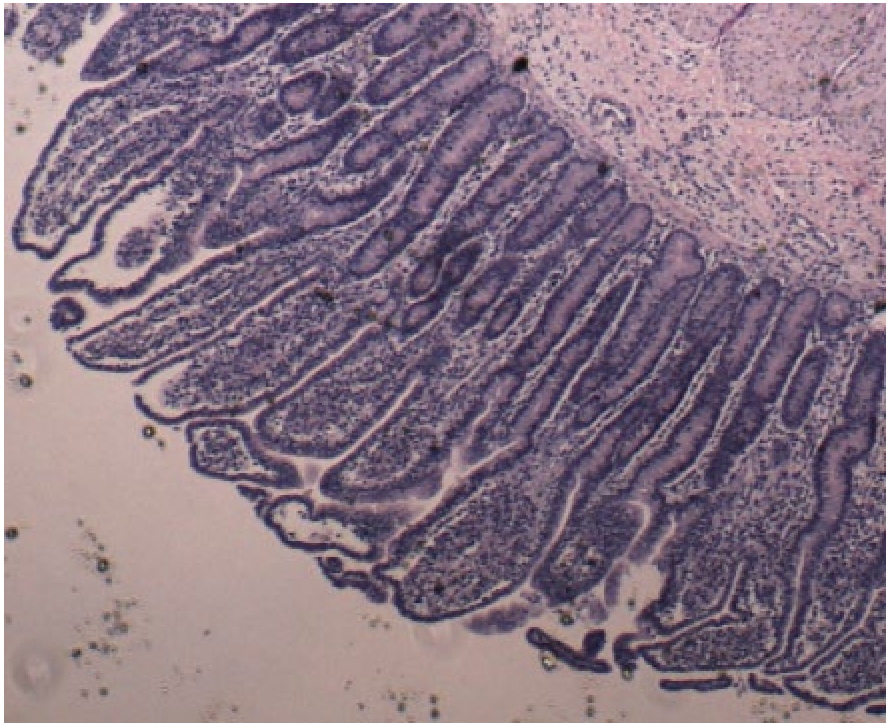
Strategies to improve immunity

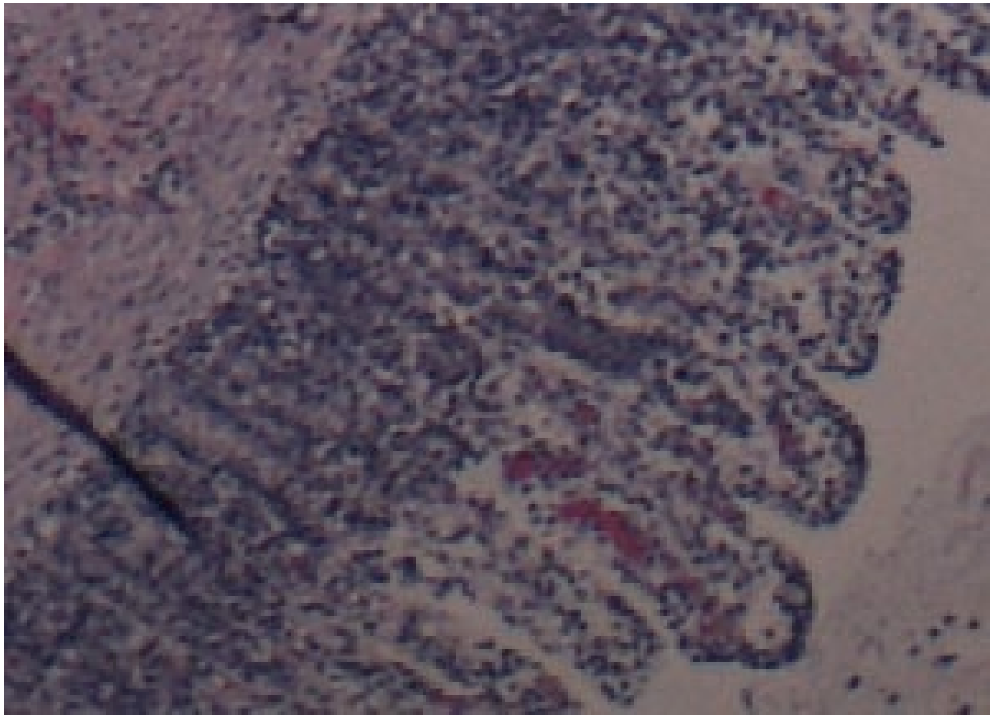
General Mechanisms of Action

- Competitive inhibition
- Binding/Adsorption
- Antimicrobial factors
  - Low pH, Bacteriocins, Organic Acids
- Stimulate other mucosal immune defenses
  - Epithelial growth, mucin production, host defense peptides, secretory IgA, T regs
- Alter systemic immune defenses

Colostrum

- Colostrum – Non-Immunoglobulin





Post-Day 1 Colostrum

supplementation (control group; n = 100), received 454 g of a commercial milk replacer (28% CP, 20% crude fat; Land O'Lakes Milk Replacer, Shoreview, MN), mixed according to label directions to a final volume of 3 L, twice daily until weaning (d 56). Calves fed milk replacer supplemented with colostrum replacer powder (treatment group; n = 102), received 150 g of dried bovine colostrum powder containing 32 g of IgG (>40% CP, >20% crude fat; Calf's Choice Total Hi-Cal, The Saskatoon Colostrum Co. Ltd., Saskatchewan, Canada) added to 304 g of Land O'Lakes Milk Replacer powder and then mixed according to label directions to a final volume of 3 L, twice daily for the first 14 d of life. Fol-

- 64 g of IgG per day
- Low Mortality - 2/202 calves died
- $0.20 - $0.30 / g IgG

Chamorro et al., 2017

Post-Day 1 Colostrum

Post Day 1 Colostrum

Table 1. Descriptive statistics of serum IgG, BW, and ADG by group (CS vs. MR)[1]

Variable, unit	Treatment	n	Mean	Median	SD[2]	Minimum	Maximum
Mean BW (d 0), kg	CS	102	40.6	40.4	4.8	27.7	51.3
	MR	100	39.2	39.7	4.8	20.4	50.3
Mean BW (d 14), kg	CS	101	45.1	44.9	3.8	34.9	54.4
	MR	98	44.4	44.9	4.4	31.1	52.6
Mean BW (d 56), kg	CS	101	80.3	79.4	8.4	50.8	101.2
	MR	97	79.6	80.3	9.1	51.7	99.8
IgG (d 0), g/L	CS	102	25.2	24.8	9.4	8.6	52.7
	MR	100	24.5	25.3	9.3	10.1	50.2
ADG	CS	100	0.7	0.7	0.1	0.1	1.1
(Birth to weaning), kg	MR	98	0.7	0.7	0.4	0.2	1.2

[1]CS = dried bovine colostrum powder + milk replacer; MR = milk replacer.

Table 2. Descriptive statistics of antibiotic treatment by group (CS vs. MR)[1]

Item		CS	MR	Total
Antibiotic treatment (ATB) by treatment group	ATB Yes	19	70	89
	ATB No	83	30	113
	Total	102	100	202
Number of antibiotic treatments (ATB n) by treatment group	ATB n	n (%)	n (%)	Total
	0	83 (81.4)	32 (32.0)	115
	1	13 (12.8)	38 (38.0)	51
	2	4 (3.9)	13 (13.0)	17
	3	2 (1.9)	12 (12.0)	14
	4	0 (0.0)	3 (3.0)	3
	5	0 (0.0)	2 (2.0)	2
	Total	102 (100)	100 (100)	202

[1]CS = dried bovine colostrum powder + milk replacer; MR = milk replacer.

Chamorro et al., 2017

Post-Day 1 Colostrum

gain of preweaned calves. Ninety 1-d-old calves on each of 3 commercial calf ranches were randomly allocated to 1 of 3 groups. Treatment-group calves received 10 g of supplemental immunoglobulin G (IgG) in the form of 70 g of colostrum powder in the milk replacer twice daily for 14 d. The placebo-group calves received a nutritionally equivalent supplement lacking IgG in the milk replacer twice daily for 14 d. Control calves received milk replacer without supplements twice daily. Calves were housed in individual hutches and were

- 10 g of IgG per day
- $0.20 - $0.30 / g IgG

Berge et al., 2009

Post-Day 1 Colostrum

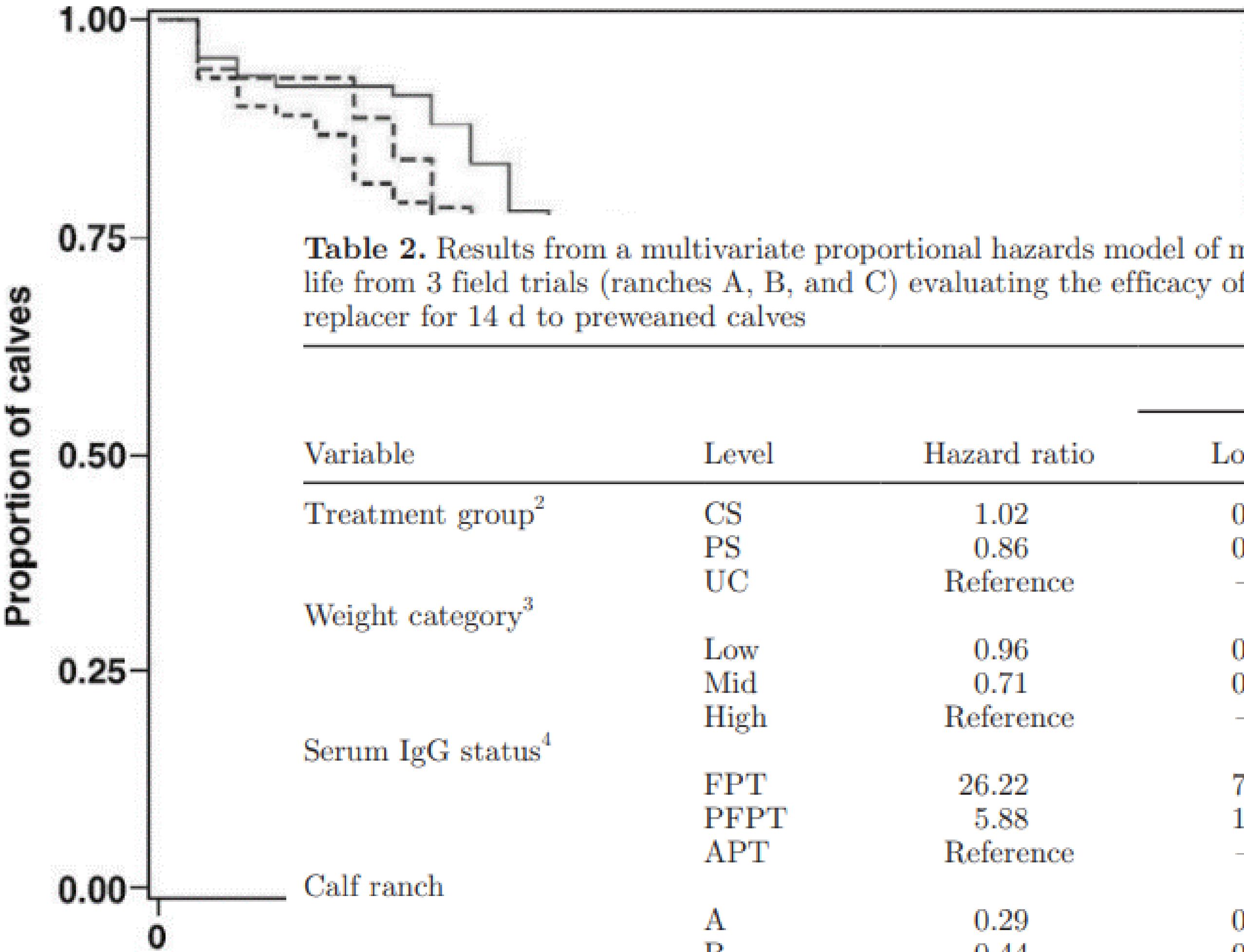


Table 2. Results from a multivariate proportional hazards model of mortality in calves during the first 28 d of life from 3 field trials (ranches A, B, and C) evaluating the efficacy of feeding a colostrum supplement in milk replacer for 14 d to preweaned calves

			90% CI[1]		
Variable	Level	Hazard ratio	Lower	Upper	Wald's *P*-value
Treatment group[2]	CS	1.02	0.52	1.98	0.96
	PS	0.86	0.44	1.69	0.72
	UC	Reference	—	—	—
Weight category[3]					
	Low	0.96	0.44	2.07	0.93
	Mid	0.71	0.33	1.52	0.46
	High	Reference	—	—	—
Serum IgG status[4]					
	FPT	26.22	7.60	90.38	<0.01
	PFPT	5.88	1.68	20.52	0.02
	APT	Reference	—	—	—
Calf ranch					
	A	0.29	0.14	0.60	<0.01
	B	0.44	0.21	0.95	0.08
	C	Reference	—	—	—

Berge et al., 2009

Post-Day 1 Colostrum

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Short communication: Effects of transition milk and milk replacer supplemented with colostrum replacer on growth and health of dairy calves

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Table 1. Chemical composition of milk replacer, transition milk, and a 1:1 mix of milk replacer and colostrum replacer fed to calves from 2 to 4 d of age, nutrient intake, and predicted ADG

	Diet[1]		
Variable	MR	TM	MCR
Fat (% on DM basis)	10.3	25.9	14.6
Protein (% on DM basis)	27.8	41.8	38.6
IgG (g/kg of DM)	0	10	98
ME (Mcal/kg of DM)	4.03	5.40	4.47
DMI[2] (g/d)	770	862	864
CP intake[2] (g/d)	214	360	332
ME intake[2] (Mcal/d)	3.10	4.65	3.86
Expected ADG[2] (kg/d)	0.59	1.02	0.78

Post-Day 1 Colostrum

Table 2. Biomarkers of inflammation and health scores (scores averaged by calf for the first 21 d of age)

	Diet[1]				*P*-value	
Variable	MR	TM	MCR	SEM	MR vs. TM and MCR[2]	TM vs. MCR[3]
Eye[4]	0.60	0.31	0.30	0.16	0.13	0.9
Feces[4]	6.8	7.8	7.2	0.83	0.4	0.6
Ear[4]	2.4	2.3	2.6	0.42	0.9	0.6
Haptoglobin[5] (µg/mL)	7.5	4.6	3.6	1.40	0.05	0.6
LBP[6] (µg/mL)	5.8	5.5	5.3	0.45	0.4	0.7

[1]Diets contained milk replacer (MR), pooled and pasteurized transition milk (TM), or milk replacer supplemented at a ratio of 1:1 with colostrum replacement powder (MCR).

[2]Contrast of MR and treatments TM and MCR.

[3]Contrast of TM and MCR.

[4]Daily health scores averaged by calf for the first 21 d.

[5]Haptoglobin samples from d 14 and 21.

[6]LBP = LPS binding protein samples from d 14 and 21.

Table 3. Initial BW, weaning weight, and gain for calves fed experimental diets

	Diet[1]				*P*-value	
Variable	MR	TM	MCR	SEM	MR vs. TM and MCR[2]	TM vs. MCR[3]
Birth weight (kg)	36.8 ± 3.7	37.6 ± 5.3	38.7 ± 4.0	0.75	0.13	0.24
Weaning weight (kg)	68.1 ± 6.8	71.8 ± 5.3	73.0 ± 6.6	1.01	<0.01	0.7
Weight gain (kg)	31.3 ± 5.8	34.2 ± 6.0	34.3 ± 6.2	0.98	0.02	0.9
Preweaning ADG (kg/d)	0.562 ± 0.10	0.616 ± 0.14	0.620 ± 0.11	0.017	0.01	0.9

Post-Day 1 Colostrum

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Transition milk stimulates intestinal development of neonatal Holstein calves

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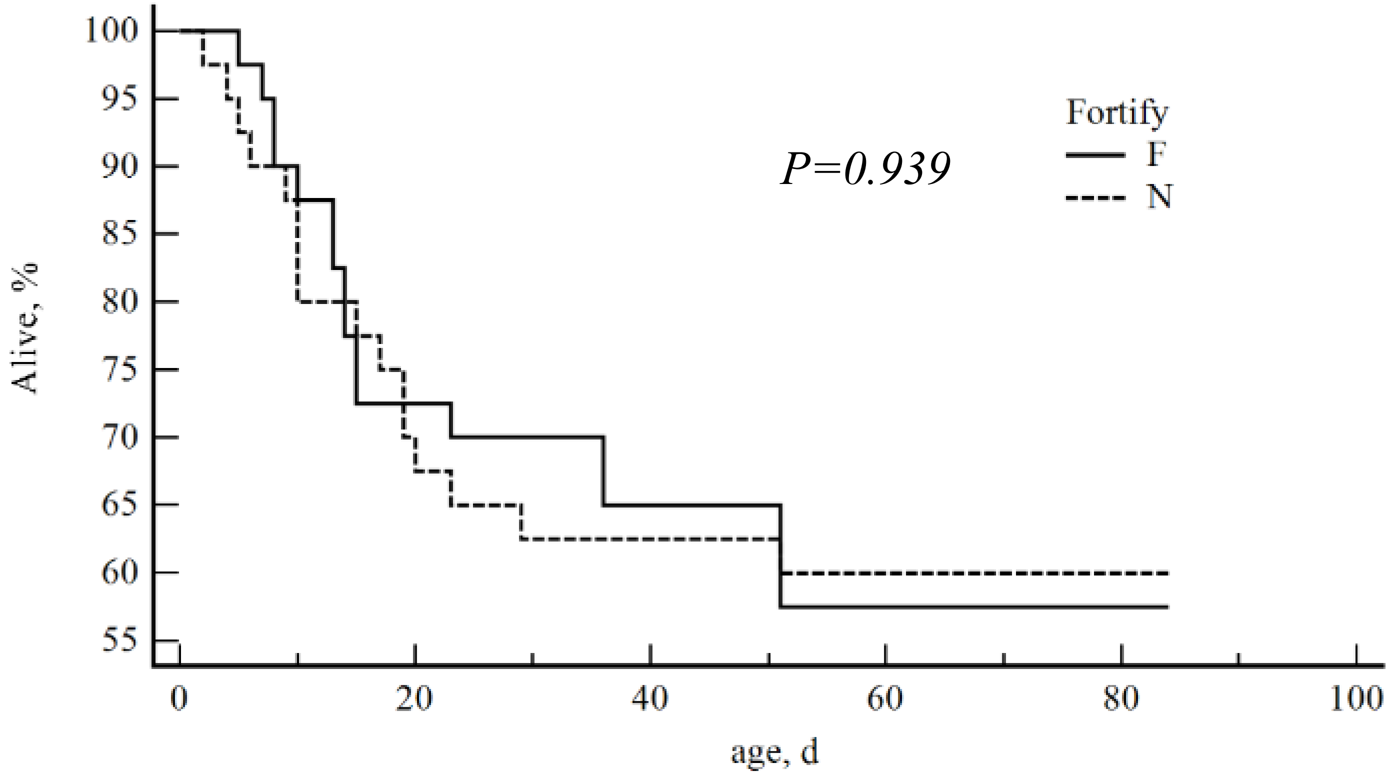
Table 3. Small intestine morphology (mean ± SE)

	~20g/L IgG Treatment[1]		
Item	TM	MR	*P*-value
Villus length (mm)			
Duodenum	0.824 ± 0.060	0.504 ± 0.058	0.003
Proximal jejunum	1.190 ± 0.048	0.609 ± 0.047	<0.001
Mid jejunum	1.004 ± 0.059	0.568 ± 0.058	<0.001
Ileum	0.812 ± 0.045	0.536 ± 0.044	0.001

Plasma

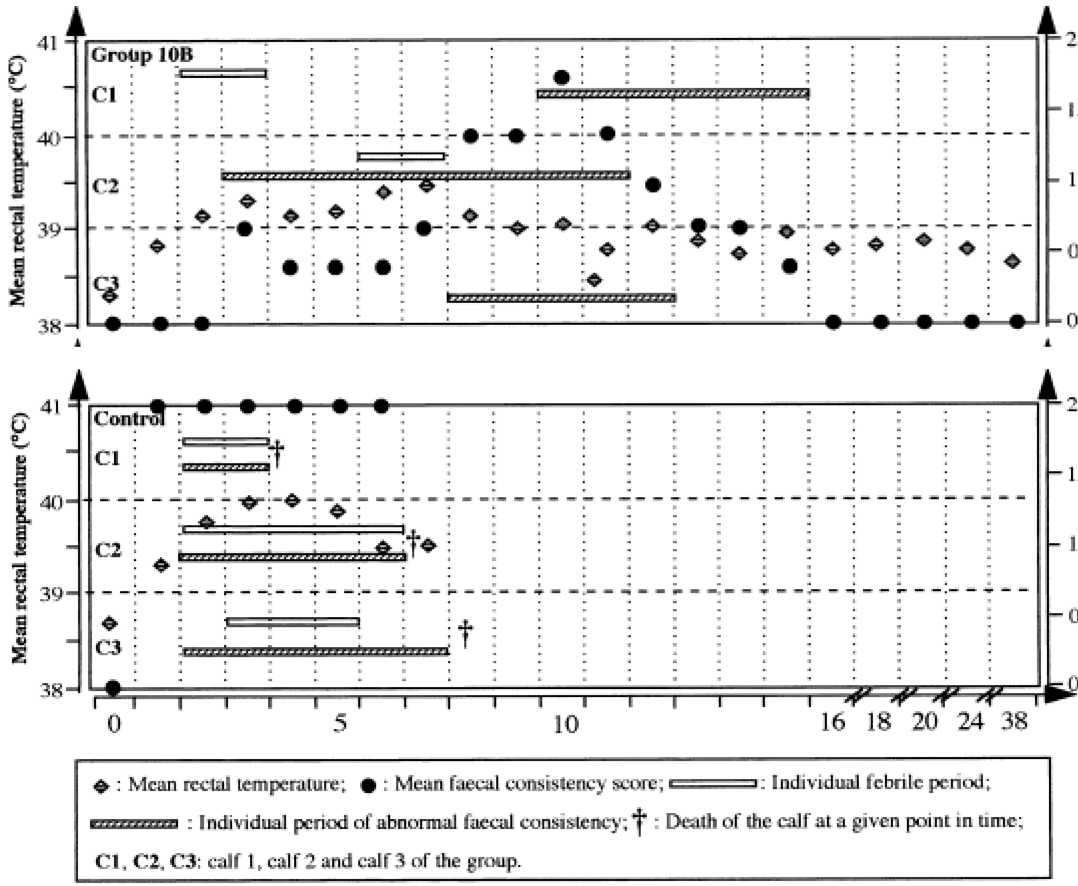
- Spray Dried Plasma
  - Fed a plasma-based colostrum supplement
    - *454 in total volume of 2L first feeding in calf ranch*



Langenkamp & Ballou (ongoing)

Plasma

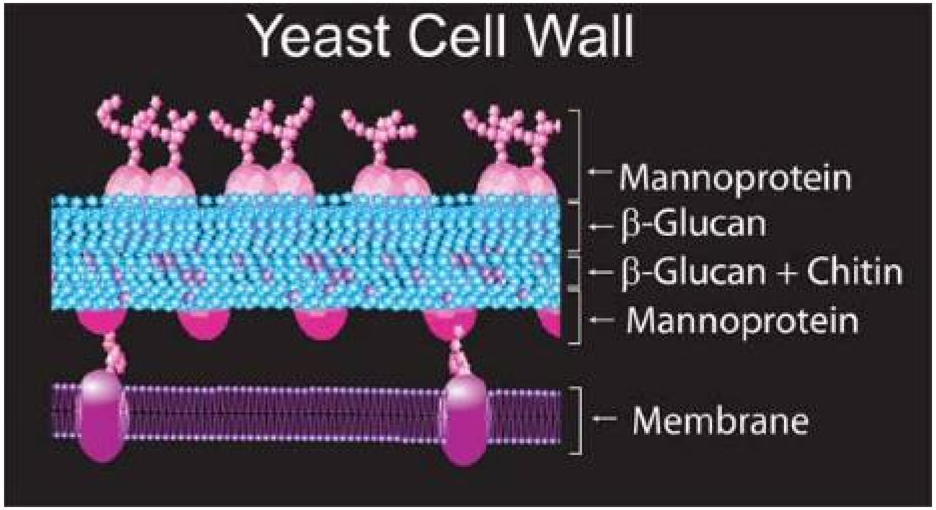
- Spray Dried Plasma
  - Approximately 22.2% IgG



Nollet et al. (1999)

Yeast cell wall fractions

- **Yeast cell wall (MOS)**
  - **Whole yeast cell wall** – insoluble cell wall is extracted from a culture of yeast.
    - ***Polysaccharides (30 -60%)*** *– β-Glucan and Mannan Polymers. Yeast cell wall contains typically between 5 to 30% of each.*
    - ***Proteins (30%)*** *– Most of the protein is linked to the Mannan Polymers*



Yeast cell wall fractions

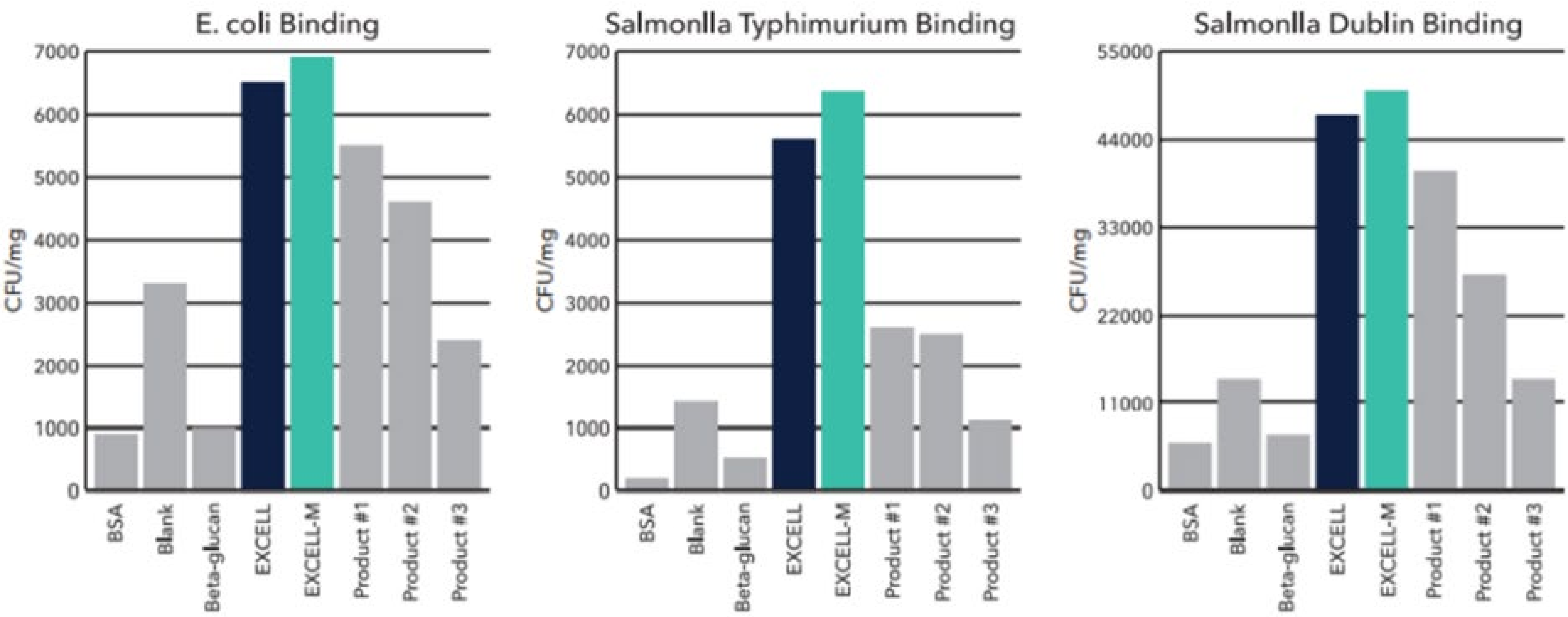


Figure 1. A comparison of the binding efficacy of an enteropathogenic *E. coli, Salmonella Typhimurium,* and *Salmonella Dublin* by CEREVIDA® EXCELL and EXCELL-M when compared against 3 leading commercial products.

Yeast cell wall fractions

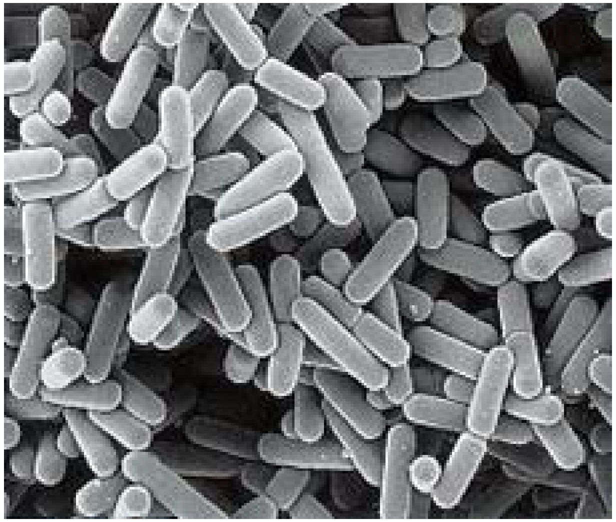
Table 1. Performance of high-risk Holstein calves supplemented with either CEREVIDA® EXCELL - M or PROVIDA® Calf probiotics (n=20 calves per treatment).

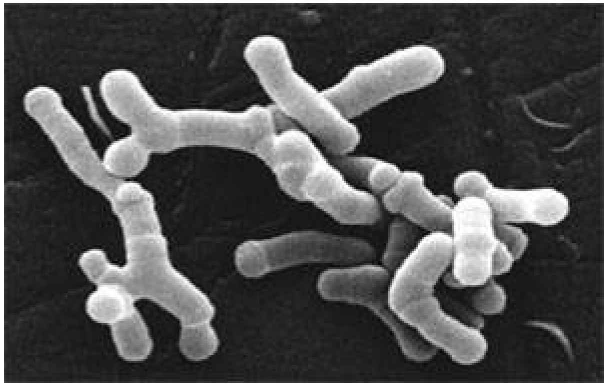
Variable	Control	CEREVIDA EXCELL-M	PROVIDA Calf	SEM	Trt
Initial BW, lbs	91.7	91.7	91.7	2.5	…
Weaned body weight, lbs	146.5	151.5	155.3	7.99	0.664
Preweaned starter intake, lbs	30.7	38.3	40.7	8.9	0.413
age 1 to 28 days, lbs	2.2[a]	3.9[b]	3.0[ab]	0.6028	0.016
age 29 to 56 days, lbs	27.1	34.6	36.1	8.2	0.32
Preweaned ADG, lbs/d	0.97[a]	1.06[ab]	1.12[b]	0.073	0.081

Means with different superscripts differ $P \leq 0.05$.

Direct fed microbials

- Direct fed microbials
  - Probiotics – are live microorganisms that are thought to be beneficial to the host organism
    - *Include lactobacillus sp, bifidobacterium sp, saccharomyces sp, enterococcus, bacillus sp*





Direct fed microbials

J. Dairy Sci. 103:7351–7363
https://doi.org/10.3168/jds.2019-17480

Supplementing neonatal Jersey calves with a blend of probiotic bacteria improves the pathophysiological response to an oral *Salmonella enterica* serotype Typhimurium challenge

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[2]Department of Veterinary Science, Texas Tech University, Lubbock 79409

Direct fed microbials

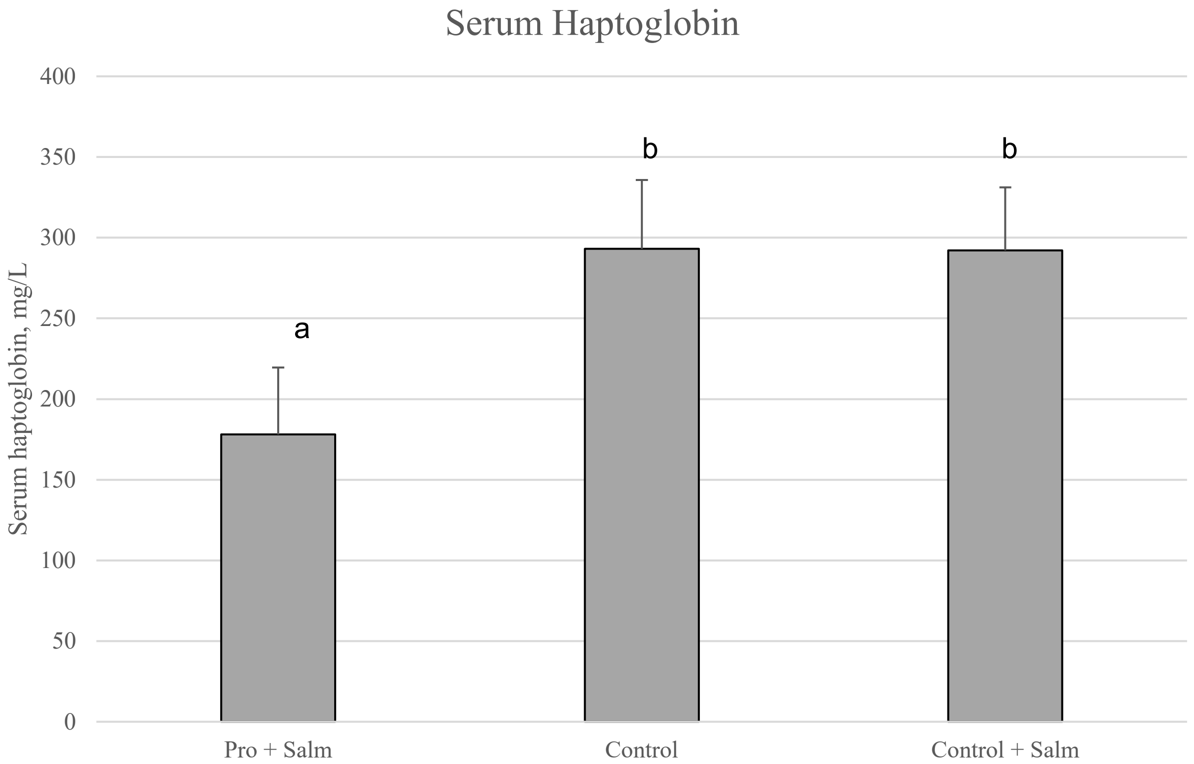
Materials and Methods

- Challenged with log-growth *Salmonella enterica* in morning milk replacer
- BW collected on d 0, 7, 14, and 21
- Blood collected on d 0, 7, 10, 14, and 21
- Histology d 21
  - *Duodenum and Ileum*

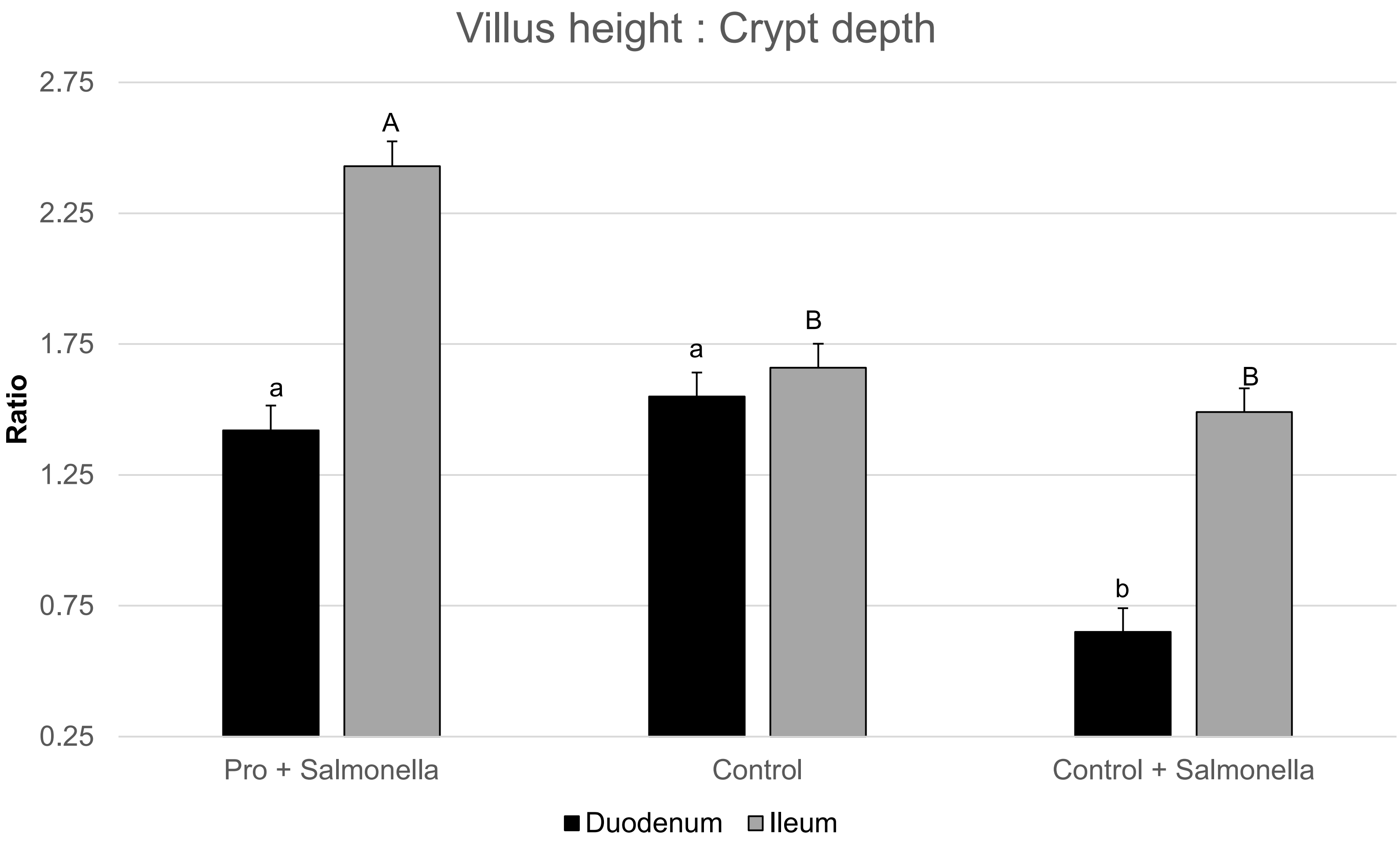
Direct fed microbials

Results

- Probiotic supplemented calves had reduced systemic inflammation throughout the entire study period



Direct fed microbials

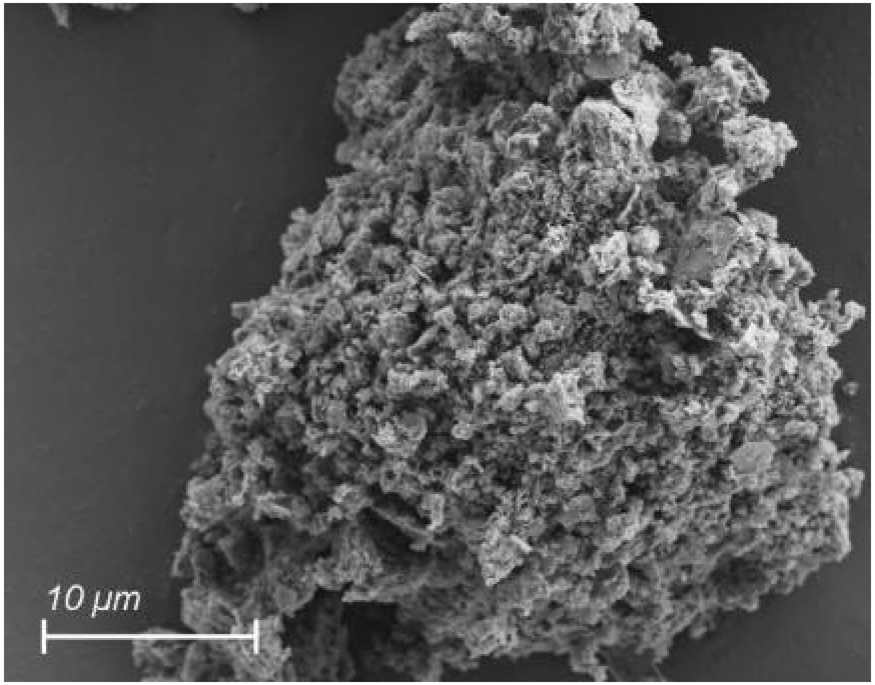


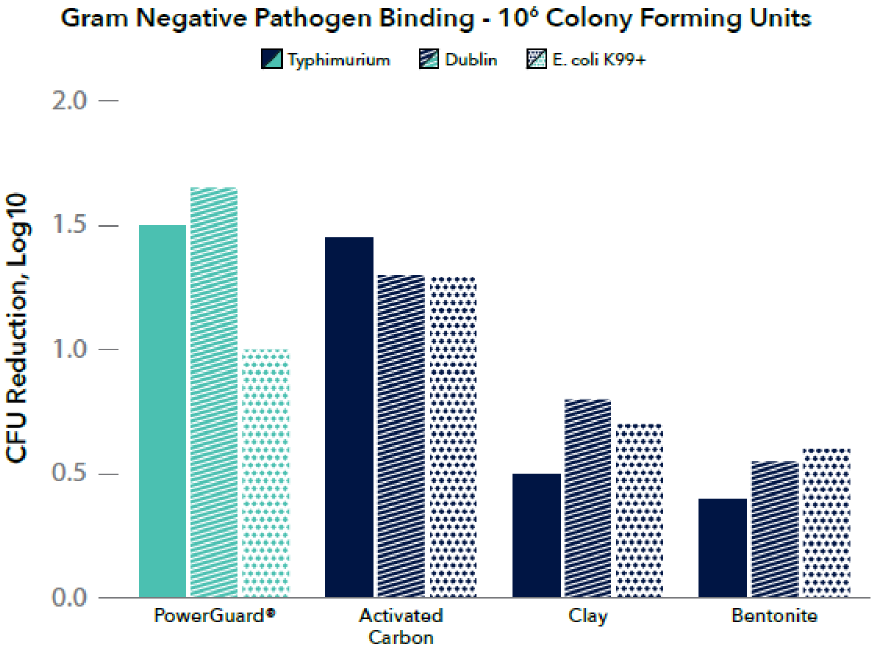
Adsorbents

A Dose-Response Investigation of a Micronized Porous Ceramic Particle to Improve the Health and Performance of Post-weaned Pigs Infected With *Salmonella enterica* Serotype Typhimurium

frontiers | Frontiers in Animal Science

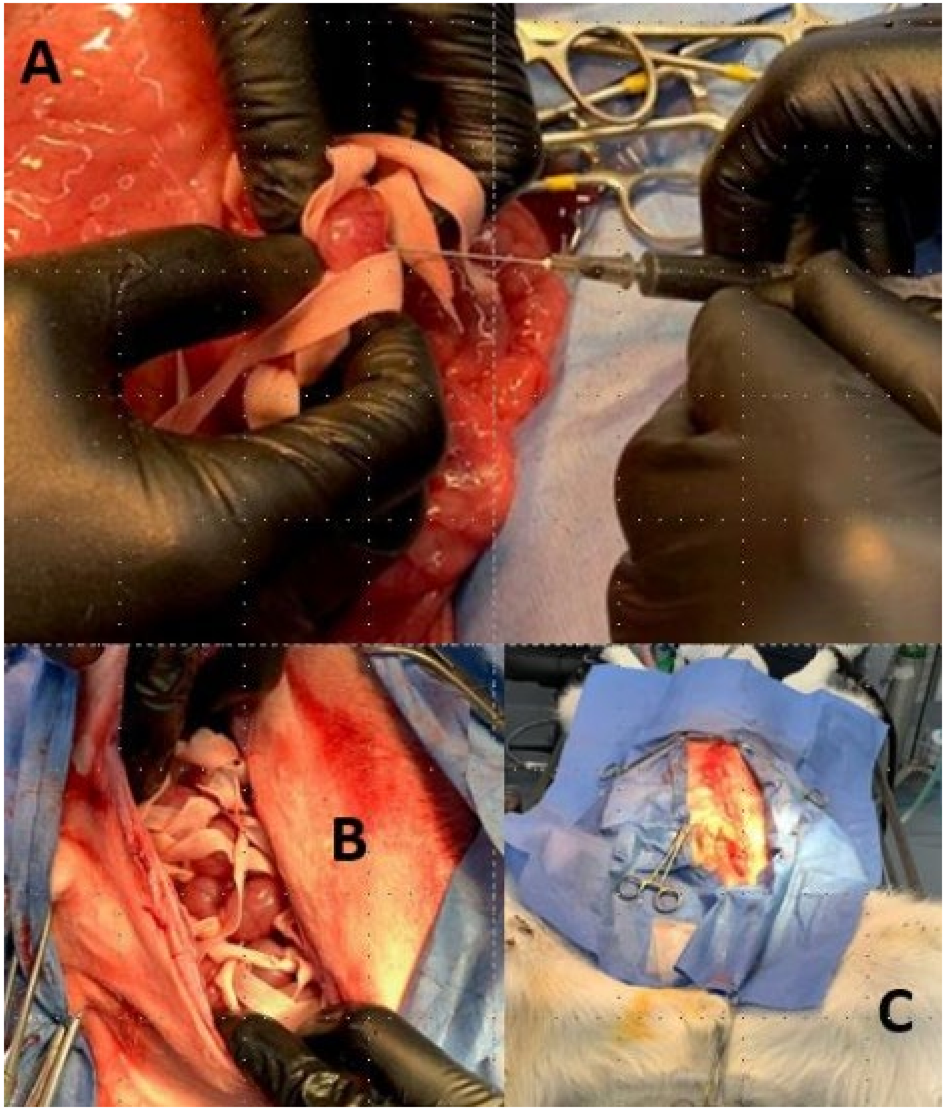
Emily M. Davis[1], *Kayla P. Wallace*[2], *Michael J. Cruz Penn*[2], *Amy L. Petry*[3], *Rand Broadway*[4], *Nicole C. Burdick Sanchez*[4], *Jeffery A. Carroll*[4] *and Michael A. Ballou*[1*]

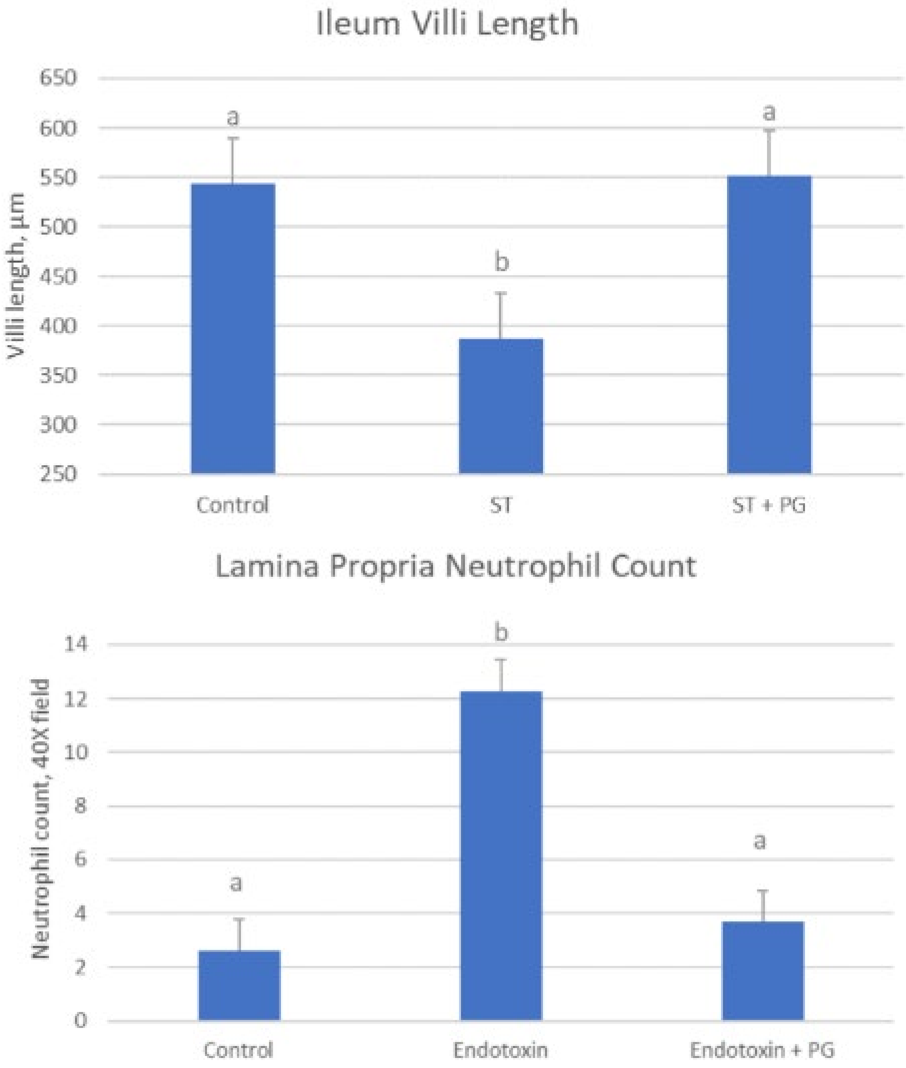




PowerGuard is able to bind pathogenic gram negative bacteria, such as *E. coli* and *Salmonella enterica* sp. better than commercial clay absorbents.

Adsorbents





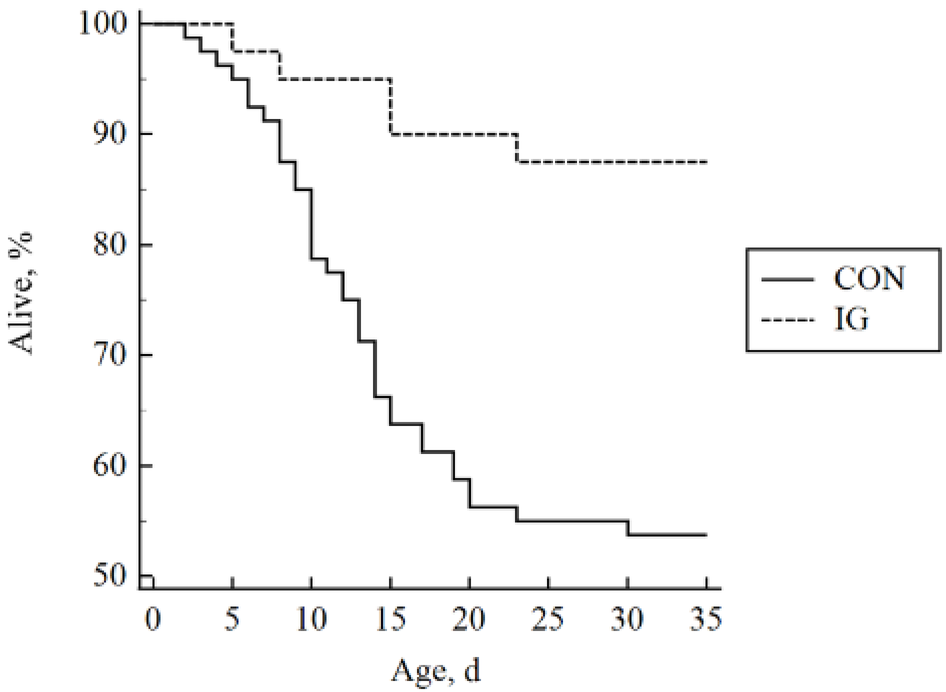
Davis et al. (ongoing)

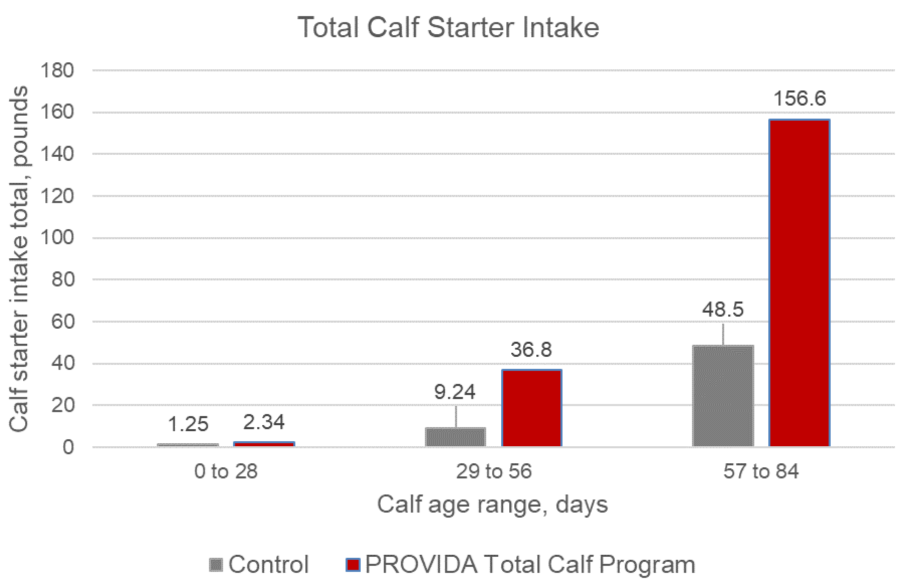
Take Home Messages / Discussion Points

- Many holes in G.I. immune system and undergoing rapid maturation
- Many interactions among host, pathogens, and environment
- Nutrition attractive approach
- Primary strategies to improve enteric immunity
    - Reduce interaction of potential pathogen with calf
    - Improve G.I. immune system maturation

Combination Treatment

- Control calves fed 22-20 Component, Non-Med
  - Skim, 7-60 (or Liquid Fat), 99% Lactose
- IG supplemented with 45 g/calf/day
  - 21 days then 6 g/calf/day PROVIDA VTM
- IG = Plasma, PowerGuard, EXCELL-M, Whey, DFM, VTM, Lys/Met
- n=60/treatment; ~75% FPT





Langenkamp and Ballou, ongoing

Respiratory Disease

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https://doi.org/10.3168/jds.2018-15997

Pre-weaning plane of nutrition and *Mannheimia haemolytica* dose influence inflammatory responses to a bovine herpesvirus-1 and *Mannheimia haemolytica* challenge in post-weaning Holstein calves

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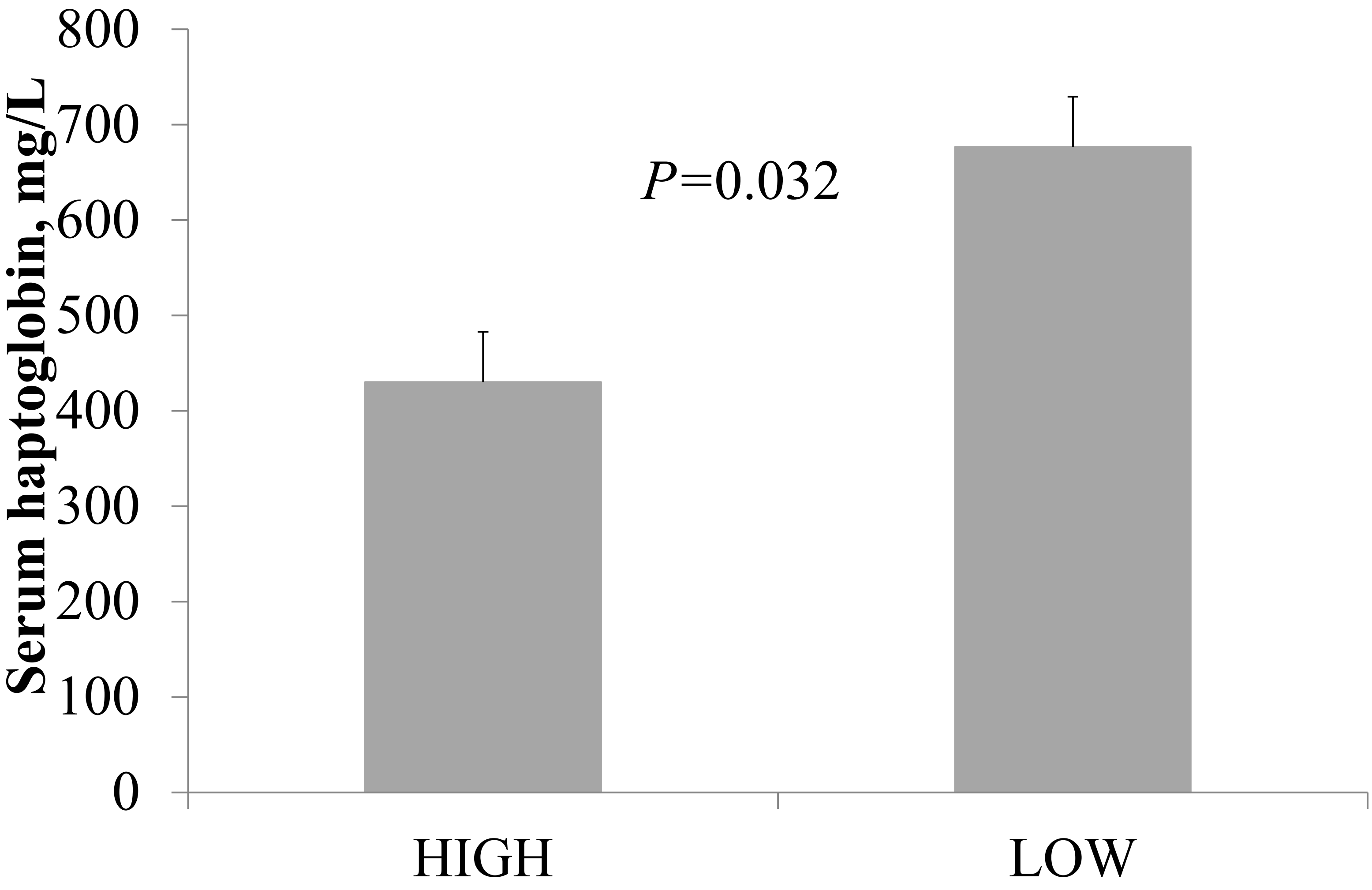
Quantity of milk solids

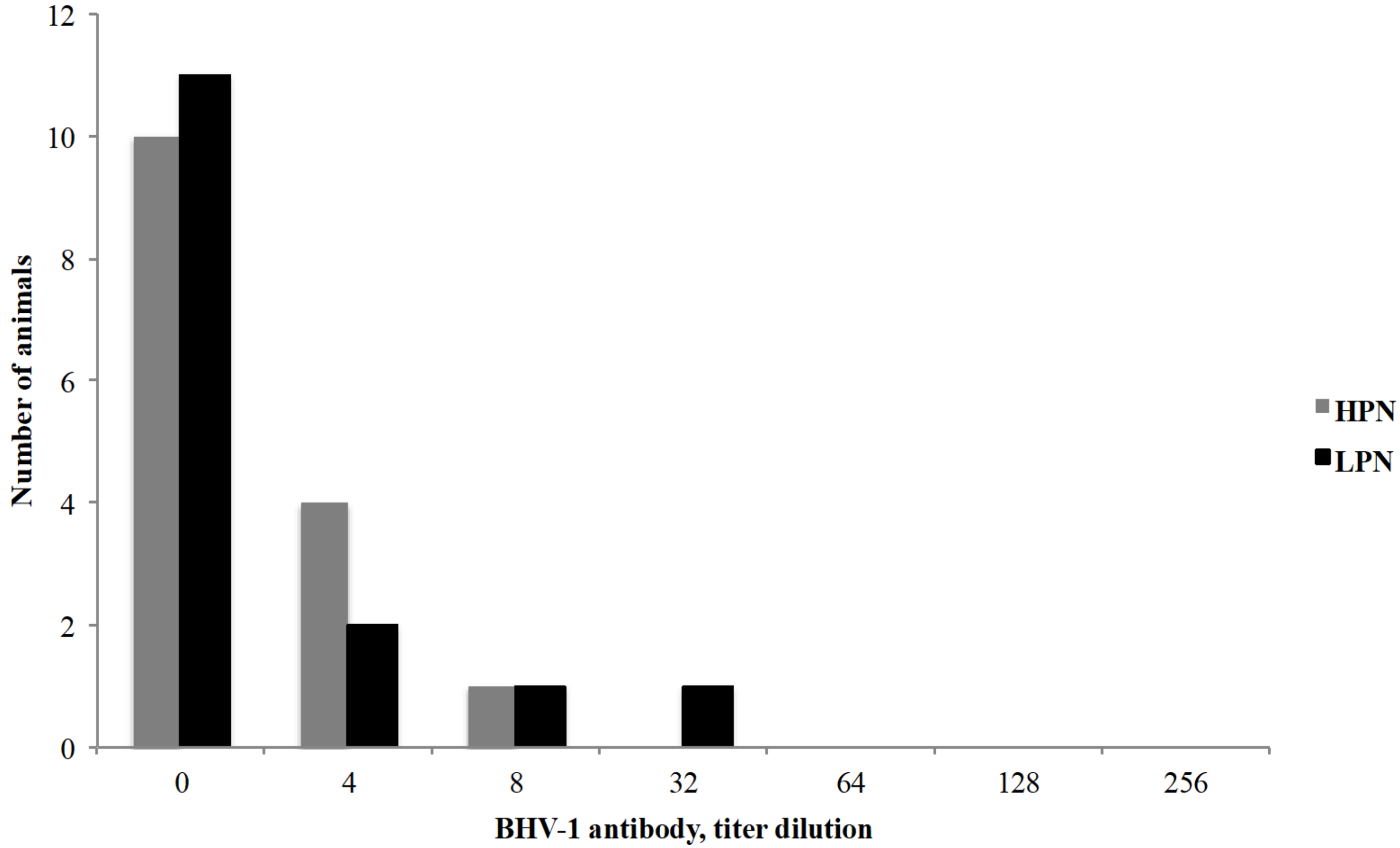
- 30 Holstein bull calves fed either **LOW** or **HIGH** and weaned at 54 d of age
- Challenged with 10^8 PFU/nostril with bovine herpesvirus-1 at 81 d of age
- Challenged with 10^6,10^7, or 10^8 CFU *Mannheimia haemolytica* at 84 d
  - Observation period through 94 d
  - 4/15 Low calves died consistent with respiratory disease
    - *1, 2, and 1 challenged with 10^6, 10^7 & 10^8, respectively*
  - 0/15 High calves died

Quantity of milk solids



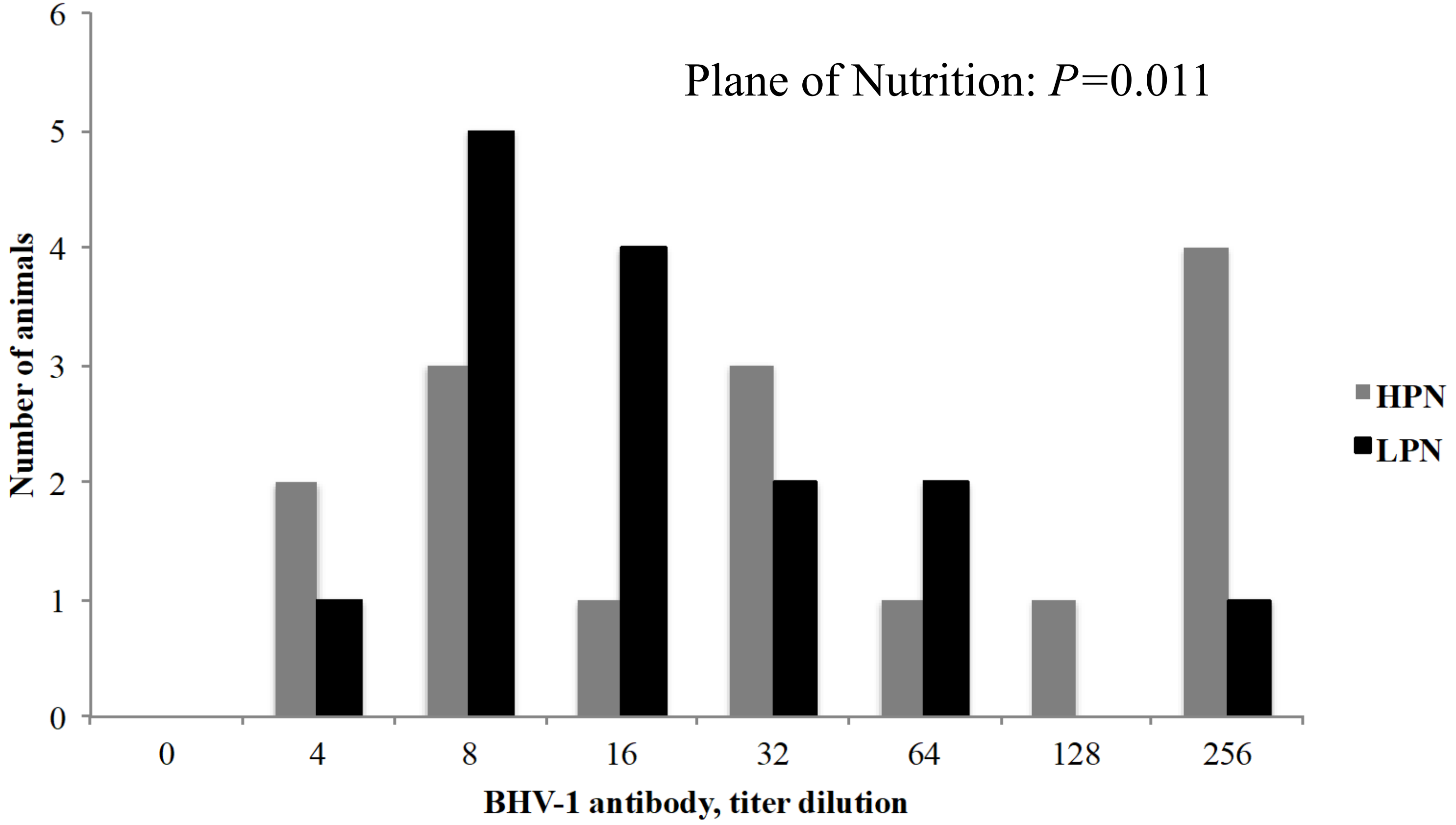
Quantity of milk solids

- BHV-1 Titers: Prior to Challenge



Quantity of milk solids

- BHV-1 Titers: 13 days Post-Challenge



Quantity of milk solids

- **TAKE HOME**
- Data indicate that post-weaned health was improved among calves that were previously fed a higher plane of milk replacer
- Was it due to an improved vaccination response during the pre-weaned period?
- Data indicate that early life performance can influence response to respiratory challenge.