Benefits of probiotic supplementation in cow-calf herds

2024 Ona Highlight

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Range Cattle Research & Education Center - University of Florida, Ona, FL

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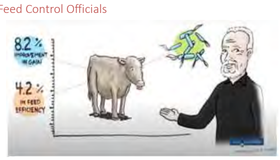
Definition: Probiotics vs. direct-fed microbials (DFM)

Probiotics and DFM are not synonymous (McAllister et al., 2011; Can. J. Anim. Sci. 91:193-211)

Probiotics = "live microorganisms, which when administered in adequate amounts, confer a health benefit to the host" (FAO-WHO 2001).
- Some also contain enzymes and/or crude extracts in addition to live microbes (Yoon and Stern 1995)

DFM = contain only a source of live or naturally occurring micro-organisms (Brashears et al. 2005).
- Defined by the Office of Regulatory Affairs of the US FDA and The Association of The American Feed Control Officials



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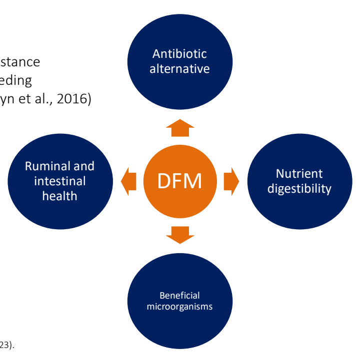
Direct-fed microbials (DFM)

- Growing concern with antibiotic resistance
- Alternative to low-dose antibiotic feeding
- Research for the past 30 years (Buntyn et al., 2016)



(Krehbiel et al., 2003; Pan et al., 2022; Cappellozza et al., 2023).

3

Most common microorganisms of DFM

- **Bacteria**
  - *Bacillus*
  - *Lactobacillus*
  - *Pediococcus*
  - *Enterococcus*
  - *Propionibacterium*
  - *Megasphaera*
  - *Bifidobacterium*
  - *Bacteroides*
- **Fungus**
  - *Saccharomyces*
  - *Aspergillus*

Buntyn et al. (2016) Annu. Rev. Anim. Biosci. 4:335-355
McAllister et al. (2011) Can. J. Anim. Sci. 91:193211

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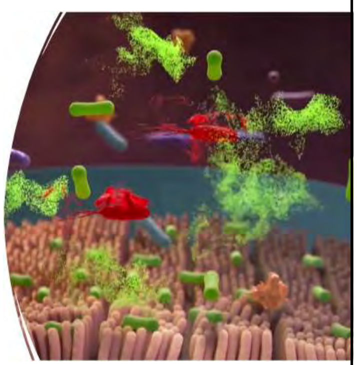
Modes of action



Courtesy of B. I. Cappellozza

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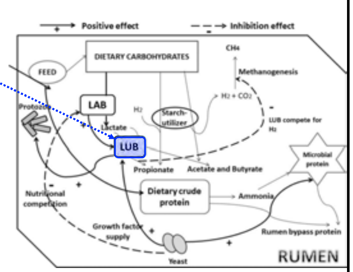
DFM & Rumen fermentation

Most studies: Enhance ruminal lactic acid metabolism after inoculation with lactic acid-utilizing bacteria (**LUB**)

Megasphaera elsdenii (Klieve et al. 2003)
Selenomonas ruminantium (Wiryawan and Brooker 1995)
Propionibacterium freudenreichii (Raeth-Knight et al. 2007)



Kulkarni et al. (2022) Trop. Anim. Health. Prod. 54:110
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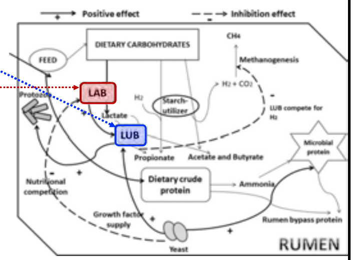
LAB
Lactic-acid producing bacteria

Streptococcus bovis
Lactobacillus spp.
Enterococci

Proliferate in low-pH conditions



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Reduce lactic acid production after
Inoculation with Prevotella bryantii 25A
to utilize starch but produce other end products (Chiquette et al. 2008).

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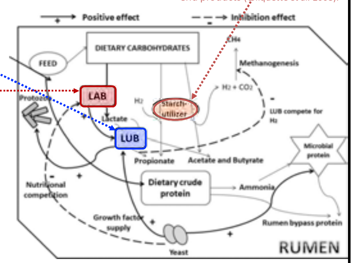

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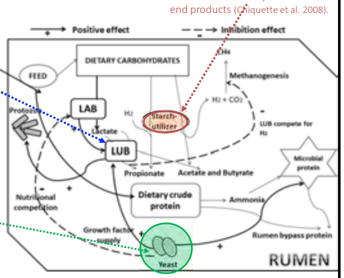
Yeast
Saccharomyces cerevisiae

Metabolize lactic aid



Kulkarni et al. (2022) Trop. Anim. Health. Prod. 54:110
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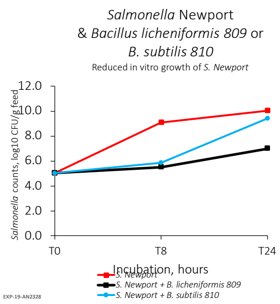
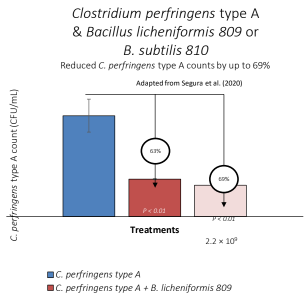
Inhibition of pathogen growth via production of anti-bacterial factors and competition for dietary ingredients (growth substrates)





Courtesy of B. I. Cappellozza

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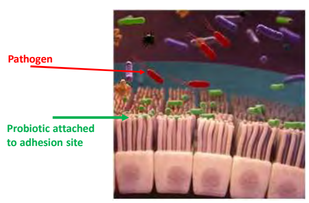
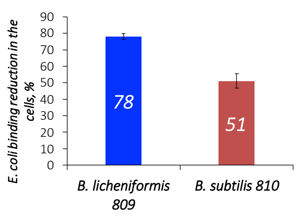
Inhibition of pathogen growth via competition for binding sites





Courtesy of B. I. Cappellozza

Copani et al. (2020)

Adhesion of *Lactobacillus acidophilus* strain R0052 and *L. rhamnosus* strain R0011 to intestinal epithelium cells (T84) reduced subsequent colonization by both E. coli O157:H7 and E. coli O127:H6 (Sherman et al., 2005).

Lactobacillus acidophilus strain NP51 reduced shedding of *E. coli* O157:H7 in cattle by 48 to 80% (Brashears et al. 2003; Younts-Dahl et al. 2004, 2005; Stephens et al. 2007a,b).

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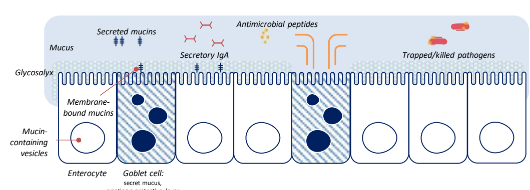
Intestine protection = Mucus production

Reservoir of antibodies (IgA), mucins, and antimicrobial peptides

Selective barrier for trapping pathogens and unwanted substances



Courtesy of B. I. Cappellozza

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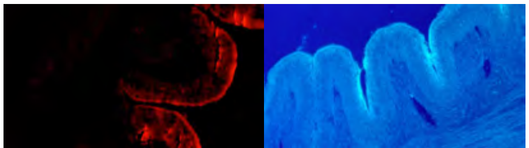
Biofilm formation

Biofilm = ordered and arranged group of microorganisms over a surface.

Supports competitive exclusion of pathogenic bacteria and influence nutrient transport (McAllister et al. 2011)



Bacillus biofilm covering caecum villi surface

Bacillus visible between caecum villi (DAPI) - the lighter colour

Courtesy of B. I. Cappellozza

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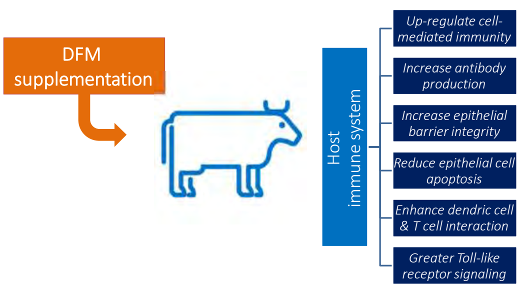
Immune system modulation



McAllister et al. (2011) Can. J. Anim. Sci. 91:193211

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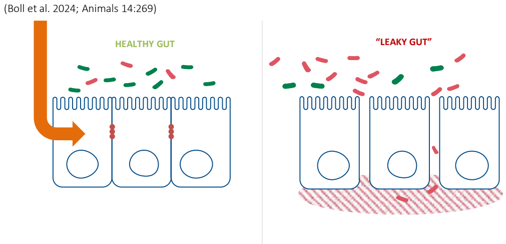
Intestinal permeability

Tight junctions consist of transmembrane proteins, including occludin and claudins, and peripheral membrane proteins, such as zona occludens (ZO)-1.
(Boll et al. 2024; Animals 14:269)



Courtesy of B. I. Cappellozza

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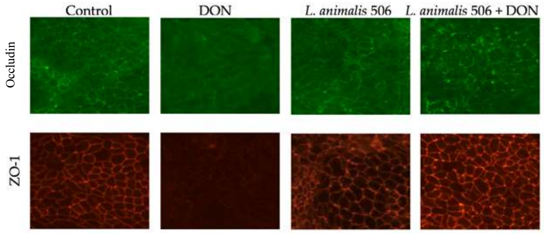
Intestinal integrity

Mycotoxins, such as deoxynivalenol (DON), impair intestinal barrier integrity and trigger inflammation.
Lactobacillus animalis 506 ameliorates the damaging effect of DON on gut barrier integrity.



Caco-2 cell monolayers were exposed to DON in the presence or absence of *L. animalis* 506.
After 14 h, cells were stained with occludin (green) and ZO-1 (red).

Boll et al. (2024) Animals 14:269.

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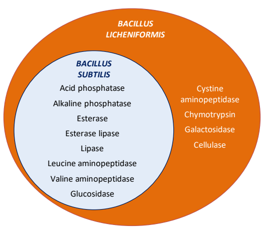
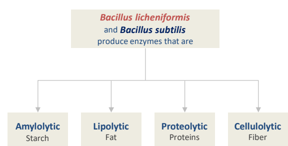
Production of a cascade of enzymes that improves digestibility of starch, fat, protein, and fiber in the gastrointestinal tract.





Schallmey et al. (2004)

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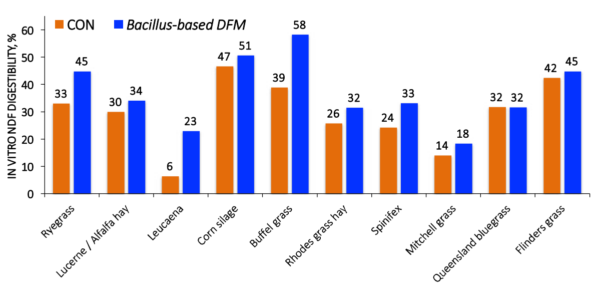

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Pan et al. (2022) Trans. Anim. Sci. 6:1-9

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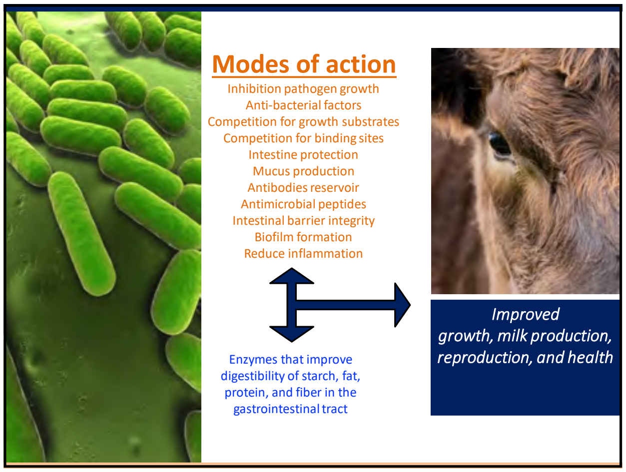
Modes of action
Inhibition pathogen growth
Anti-bacterial factors
Competition for growth substrates
Competition for binding sites
Intestine protection
Mucus production
Antibodies reservoir
Antimicrobial peptides
Intestinal barrier integrity
Biofilm formation
Reduce inflammation
Enzymes that improve digestibility of starch, fat, protein, and fiber in the gastrointestinal tract
Improved growth, milk production, reproduction, and health

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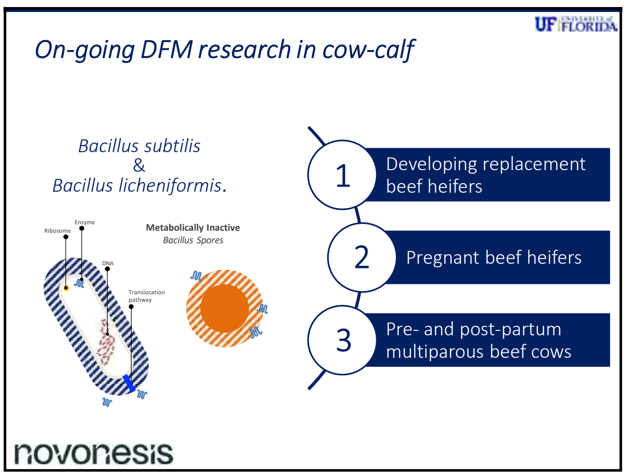
UF UNIVERSITY of FLORIDA
On-going DFM research in cow-calf
Bacillus subtilis & Bacillus licheniformis.
Ribosome
Enzyme
DNA
Translocation pathway
Metabolically Inactive Bacillus Spores
1 Developing replacement beef heifers
2 Pregnant beef heifers
3 Pre- and post-partum multiparous beef cows
novonesis

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1239
1301
Replacement heifers

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A new supplementation strategy for beef heifers in Florida

Funded by Florida Cattlemen Enhancement Board - 2023/2024

Sep. 2023 to Nov. 2024 (Year 1)   To be repeated 2024/2025 (Year 2)

- 64 Brangus heifers/year
- 16 bahiagrass pastures/year
- 8 pastures/treatment/year

All heifers supplemented with concentrate at 1.5% of their body weight from September until pregnancy diagnosis (April of the following year)

NOBAC = No probiotic addition

BAC = Probiotic inclusion at 3 g/heifer daily

Bacillus subtilis and Bacillus licheniformis (6.6 × 10^9 CFU)

240 days of supplementation

3.5 cents per heifer daily = $8.40/heifer

Estrus synchronization late-November and AI early-December

Bulls 10 days after timed-AI. Natural breeding for 90 days

22

Heifers supplemented with concentrate at 1.5% of their body weight from September until pregnancy diagnosis (April of the following year)

NOBAC = No probiotic addition   BAC = Probiotic inclusion at 3 g/heifer daily

Heifer growth performance

	Supplement treatment			
Item	NOBAC	BAC	SEM	*P-value*
Heifer BW, lb				
Day 0 (Sep)	571	571	6.7	0.97
Day 109 (Start of AI and breeding season)	774	770	6.7	
Day 211 (End of breeding season)	866	865	6.7	
Day 244 (Pregnancy diagnosis)	969	967	6.7	
Mature body weight (start of breeding season), %	70.3	70.0	0.7	0.77
ADG, lb/day				
Day 0 to 109 (Start of study to start of breeding)	1.81	1.78	0.07	0.76
Day 109 to 244 (Breeding season)	1.49	1.48	0.05	0.88
Day 0 to 244 (overall)	1.63	1.62	0.04	0.92

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Heifers supplemented with concentrate at 1.5% of their body weight from September until pregnancy diagnosis (April of the following year)

NOBAC = No probiotic addition   BAC = Probiotic inclusion at 3 g/heifer daily

Heifer reproductive performance

	Supplement treatment			
Item	NOBAC	BAC	SEM	*P-value*
Pubertal, % of total				
Day 60	6.7	24.1	6.6	0.06
Day 90 (Start of synchronization)	17.2	26.7	7.8	0.39
Repro Tract Score, 1 to 5 scale				
Day 60	3.55	3.87	0.17	0.21
Day 90 (Start of synchronization)	3.72	4.00	0.12	0.12
Detected in estrus, % of total	32.7	44.5	9.0	0.35
Pregnant, % of total				
AI	37.5	52.5	9.1	0.24
AI + Bull	73.3	72.4	8.4	0.94
Pregnancy loss, % of total				
AI	6.7	6.8	4.7	0.97
AI + Bull	Nov 2024	Nov 2024		
Calved, % of total	Nov 2024	Nov 2024		
Calving distribution, % of total	Nov 2024	Nov 2024		

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Pregnant heifers

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Experimental Design

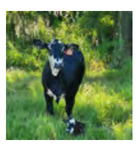
Maternal Treatment

	May day 0	August day 90	November day 190	January day 242
		CALVING SEASON		Start Breeding Season; Early weaning
CON	2.2 lb/day of soybean hulls DM			
BAC	2.2 lb/day of soybean hulls DM added with 3g of a *Bacillus*-based DFM mixture			

(Bovacillus™; Chr. Hansen A/S, Hørsholm, Denmark)

Bacillus subtilis and *Bacillus licheniformis*

Target: 6.6×10^9 CFU



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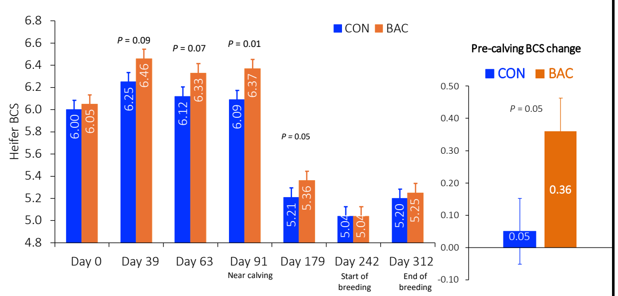
Cow Body Condition Score (BCS)

BAC = 3g of *Bacillus* DFM from day 0 to 242
CON = No *Bacillus* DFM from day 0 to 242



Izquierdo et al. (2024) J. Anim. Sci. 102:skae110 doi:10.1093/jas/skae110

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BAC = 3g of *Bacillus*-based DFM from day 0 to 242
CON = No *Bacillus* supplementation from day 0 to 242

Cow Reproductive Data

	Maternal treatment			*P*-value
	CON	BAC	SEM	Treatment
First offspring (Calves in utero when treatments were provided)				
Calving, % of total	96	91	4.22	0.45
Calving date, day of the study	142	135	4.10	0.22
Male calves at birth, % of total	48	54	9.21	0.63
Calf birth BW, lb	62	65	0.99	0.34
Second offspring (Calves conceived from day 242 to 312)				
Pregnant, % of total	89	89	5.35	0.97
Calving, % of total	84	88	7.83	0.76
Calving date, day of the study	554	556	4.60	0.61
Male calves, % of total	52	52	12.00	0.94

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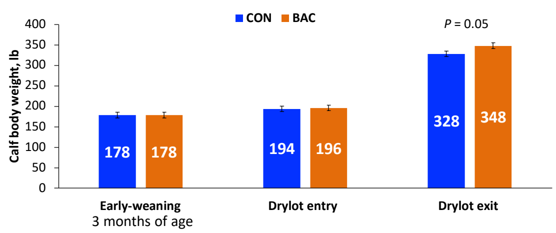
Calf Growth Performance



	Maternal treatment			*P*-value
	CON	BAC	SEM	Treatment
Calf ADG, lb/day				
Birth to drylot entry (day 242)	0.97	0.93	0.046	0.61
Drylot entry to exit (day 258 to 319)	2.22	2.44	0.077	0.04
Total DMI, % of BW	3.24	3.27	0.038	0.73
Gain:Feed	0.25	0.27	0.004	0.05

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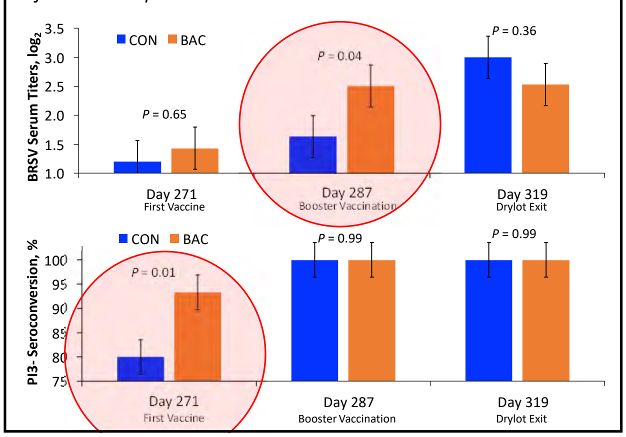
Calf Immune Response



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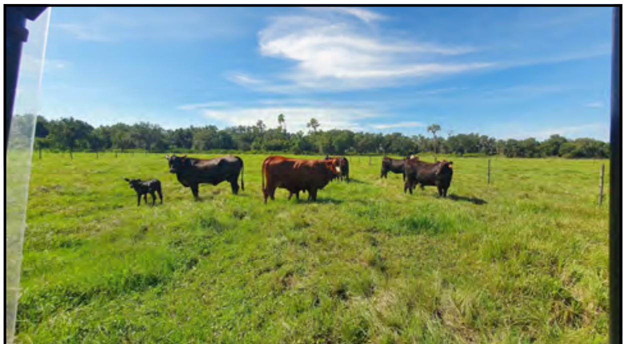

Multiparous cows

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Year-round Bacillus supplementation for multiparous beef cows

August 2023 to July 2024
- n = 296 multiparous Brangus cows
- 90 days precalving until calf weaning at 8-9 months of age
- 2 herds (10 pastures with 12 cows/pasture & 16 pastures with 11 cows/pasture)
- 13 pastures/treatment

Ad libitum trace mineral supplementation (target intake = 50 g/cow/day) offered once weekly (Mondays)

Added with:

CON = No DFM addition

BAC = DFM inclusion at 3 g/cow daily

Bacillus subtilis and *B. licheniformis* (6.6 × 10^9 CFU)

320 days of supplementation

Natural breeding from Jan to April 2024

Pregnancy diagnosis in May 2024

Calf weaning July 2024

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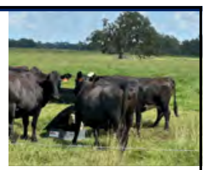
Average daily trace mineral intake, g/cow/day



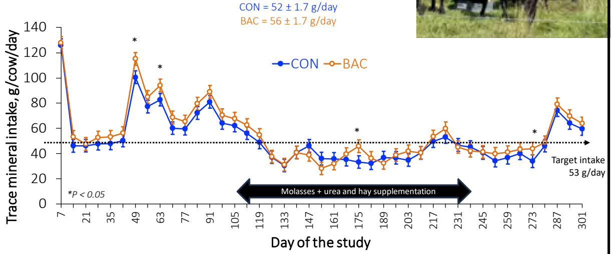
Trt x day

P = 0.10

On average supplement DMI (*P* = 0.10)

CON = 52 ± 1.7 g/day

BAC = 56 ± 1.7 g/day



Breeding season = day 150 to 240

Average calving date = day 90 of the study

Molasses+urea and hay = day 112 to 238

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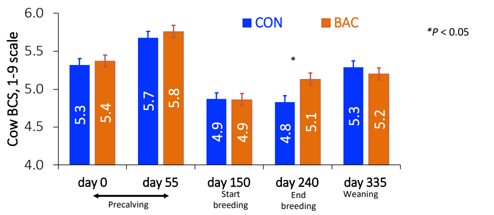
Cow performance

CON = trace mineral + 0 g of *Bacillus*-based DFM
BAC = trace mineral + 3 g of *Bacillus*-based DFM



Item	Treatment NOBAC	BAC	SEM	*P*
Cow BCS change				
day 0 to 55 (precalving)	0.39	0.39	0.08	0.99
day 55 to 150 (post-calving)	-0.77	-0.90	0.08	0.29
day 150 to 240 (breeding season)	-0.04	0.27	0.08	0.03
day 240 to 335 (breeding to weaning)	0.45	0.06	0.08	0.01
Calving date, day of the study	93	95	1.6	0.32
Pregnant, % of total	94.6	90.4	2.17	0.17

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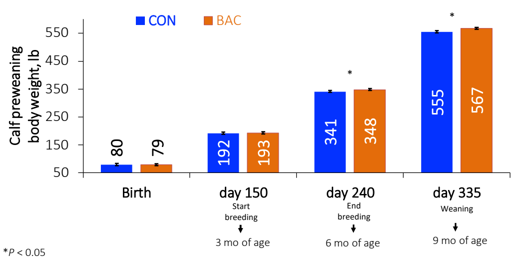
Calf performance

CON = trace mineral + 0 g of *Bacillus*-based DFM
BAC = trace mineral + 3 g of *Bacillus*-based DFM



Item	Treatment NOBAC	BAC	SEM	*P*
Calf average daily gain, lb/day				
Birth to day 150	2.03	2.05	0.07	0.95
Day 150 to 240 (breeding season)	1.74	1.83	0.04	0.02
Day 240 to 335	2.33	2.38	0.04	0.42
Birth to day 335 (weaning)	1.98	2.07	0.04	0.10

On-going analyses…

Heifer calves post-weaning growth and repro

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Summary – Direct-fed microbials (DFM)

UF FLORIDA

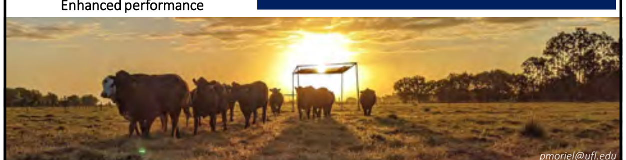
Multiple species and strains, and modes of action
Modulate nutrient utilization, intestinal health, and immune function.

Enhanced performance

Cow-calf

Limited number of published studies.
Multiple opportunities for research.

Benefits to both maternal and offspring performance.
Promising results in heifer development.



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Acknowledgement

Thank you

Florida Cattlemen's Association

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CHR HANSEN

Dr. B. Cappellozza (Novonesis)
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Dr. N. Ashrafi (Beaumont Research Institute & Oakland)
Dr. R. Mimi (Beaumont Research Institute & Oakland)
Dr. S. Graham (Beaumont Research Institute & Oakland)

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