

UNIVERSITY OF SASKATCHEWAN

Gut Health for Beef Cattle

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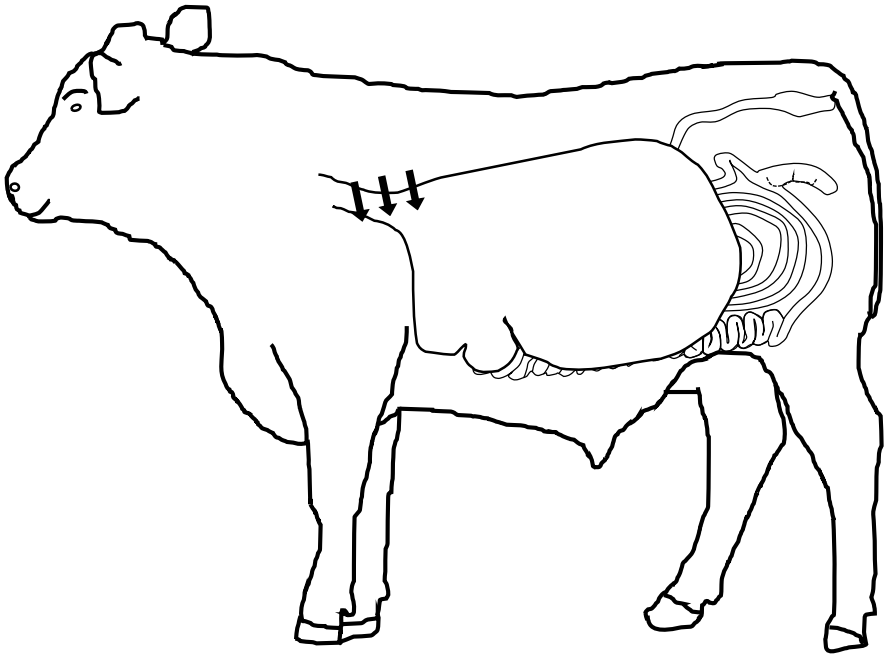
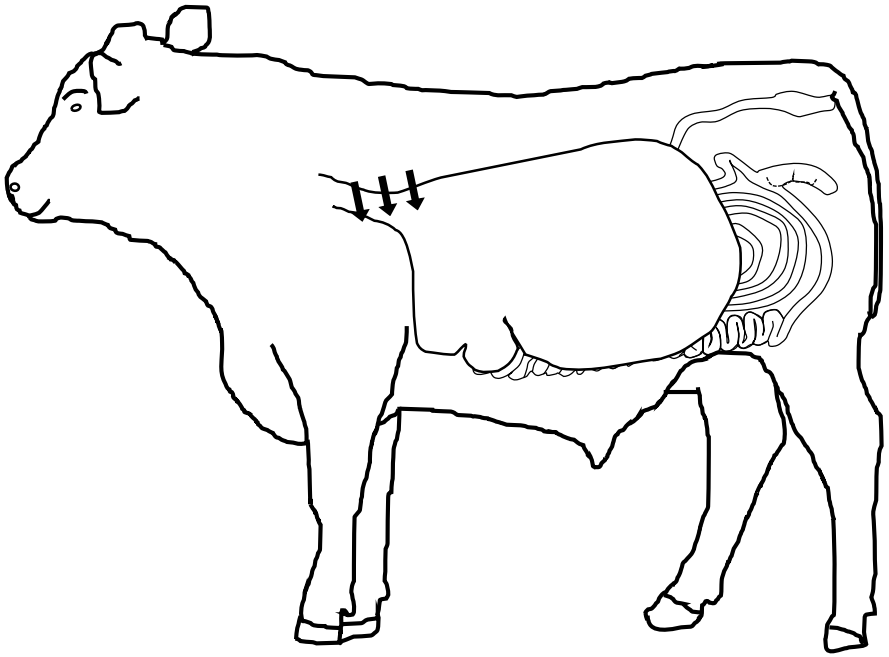
The gut as a central organ system



- Absorptive and secretory
  - Feed digestion
  - Digesta passage
  - Regulates luminal pH
  - Nutrient absorption
  - Urea recycling
- Barrier
  - First arm of the immune response
  - Prevents pathogen and antigen translocation
- Communicative
  - Facilitates cross-talk between host and microbiota
  - Nutrient sensing and signaling

The gut as a central organ system



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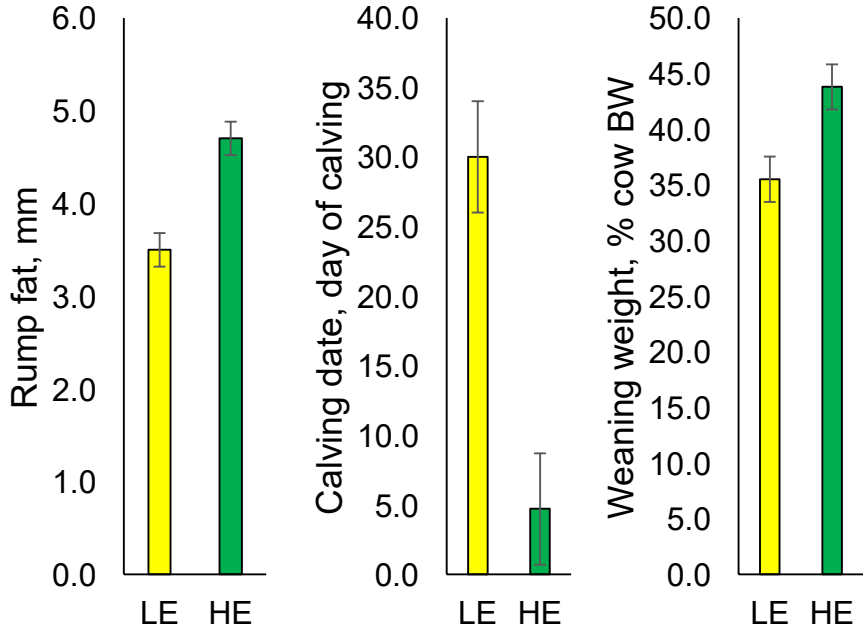
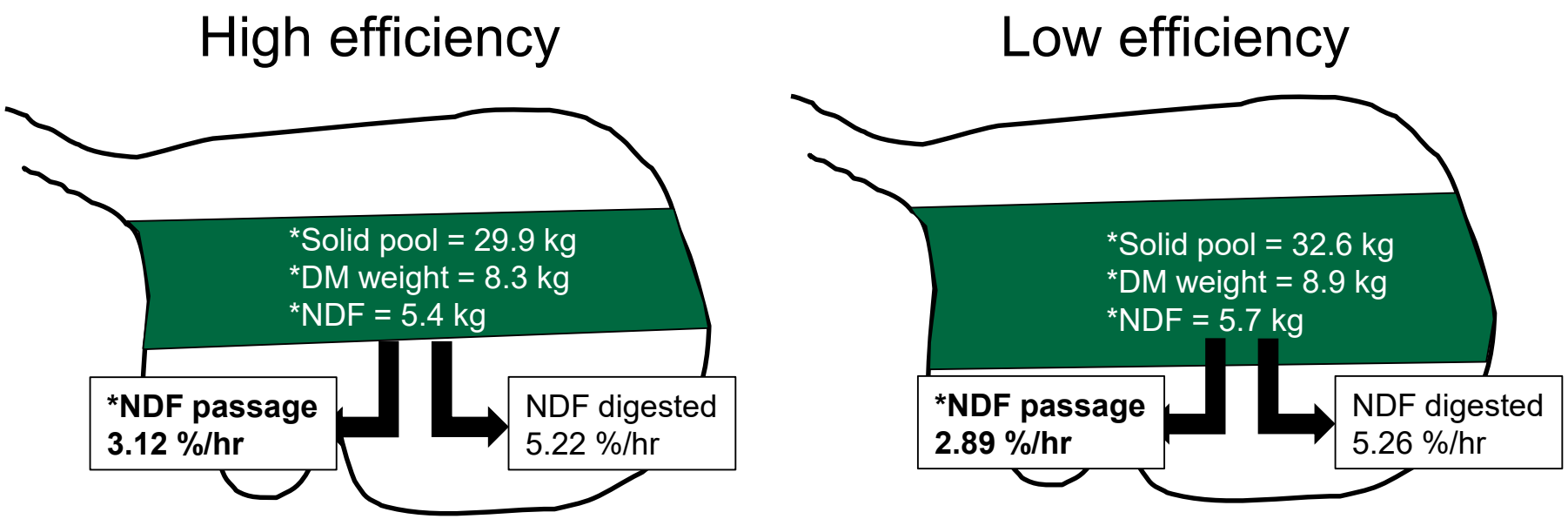
  - Digesta passage
  - Feed digestion



Delver et al. unpublished

Delver et al. unpublished

Cow's differing in efficiency process fibre differently

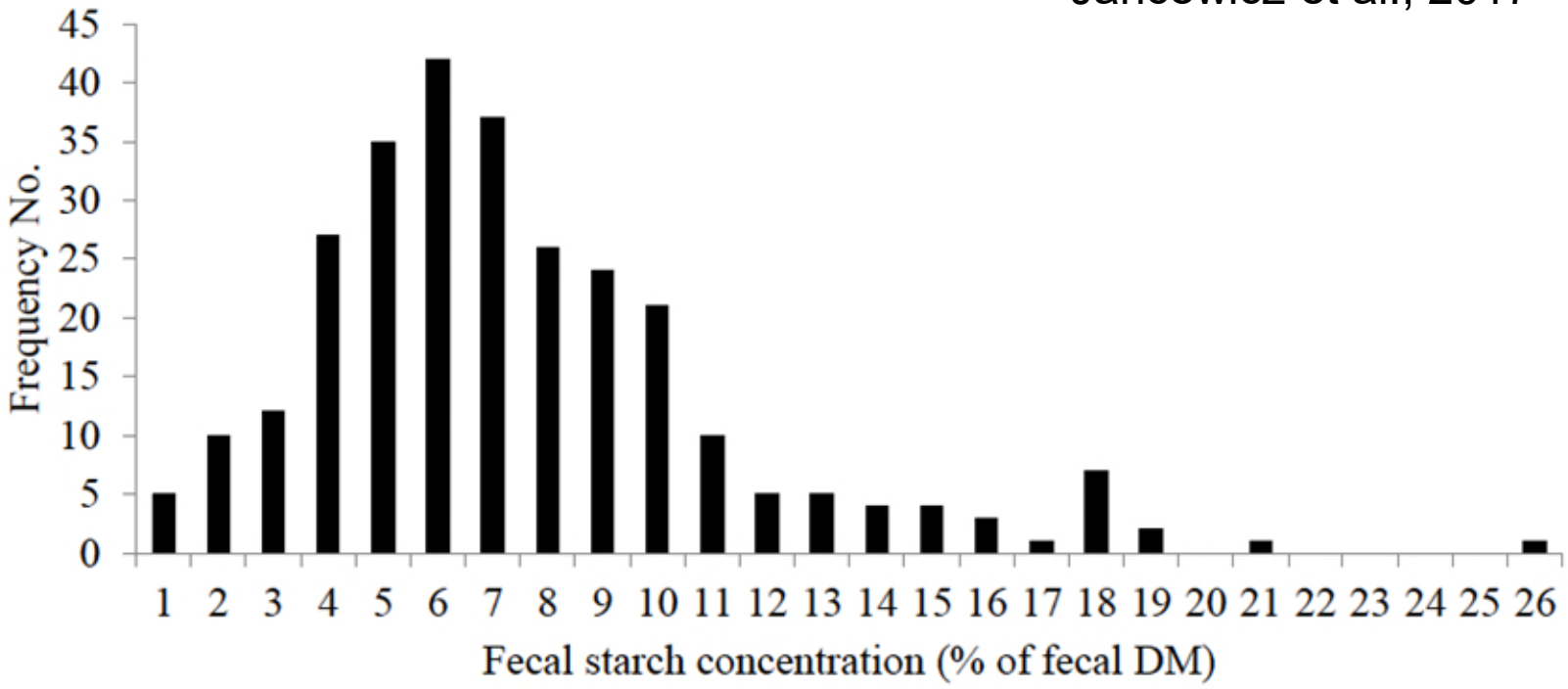


*values with an asterisk differ ($P < 0.05$)


Acid
Production
Acid
Removal

Fecal starch = lost opportunity

Jancewicz et al., 2017



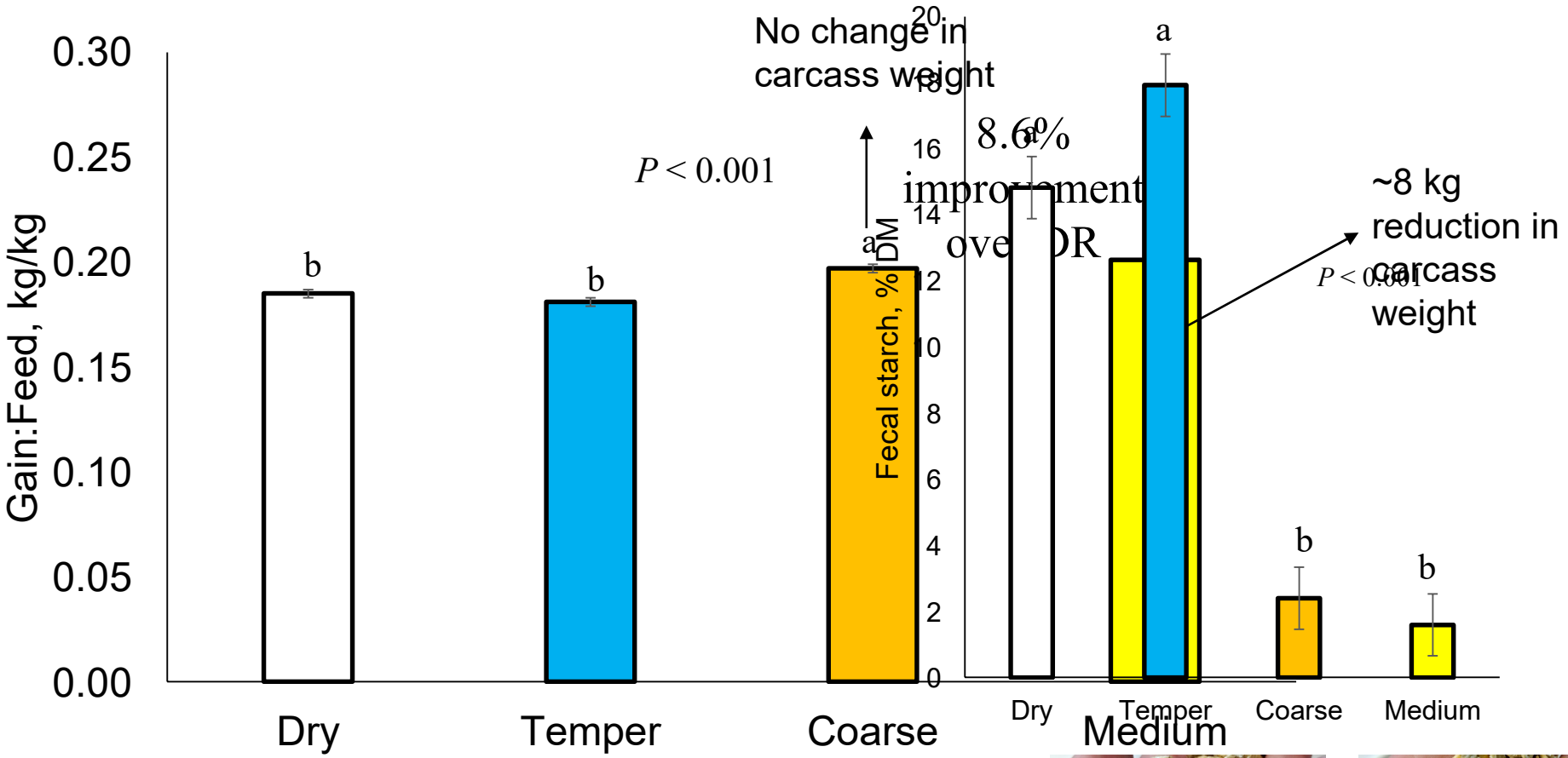
Direct cost of excreted starch, $/animal/d

Variable	Fecal starch, % DM			
	3%	6%	9%	12%
Daily starch excreted, kg/d	0.07	0.13	0.12	0.26
@ $200/tonne				
Cost, $/steer/d	0.01	0.03	0.04	0.05
@$300/tonne				
Cost, $/steer/d	0.02	0.04	0.06	0.08
@$400/tonne				
Cost, $/steer/d	0.03	0.05	0.08	0.11

Assuming 2.2 kg/d fecal DM output

Nixdorff et al., 2020; Appl. Anim. Sci.

Improvements in G:F with flaking



Evaluating adequacy of processing on farm

- Visual inspection
- Processing index
- Percent fines

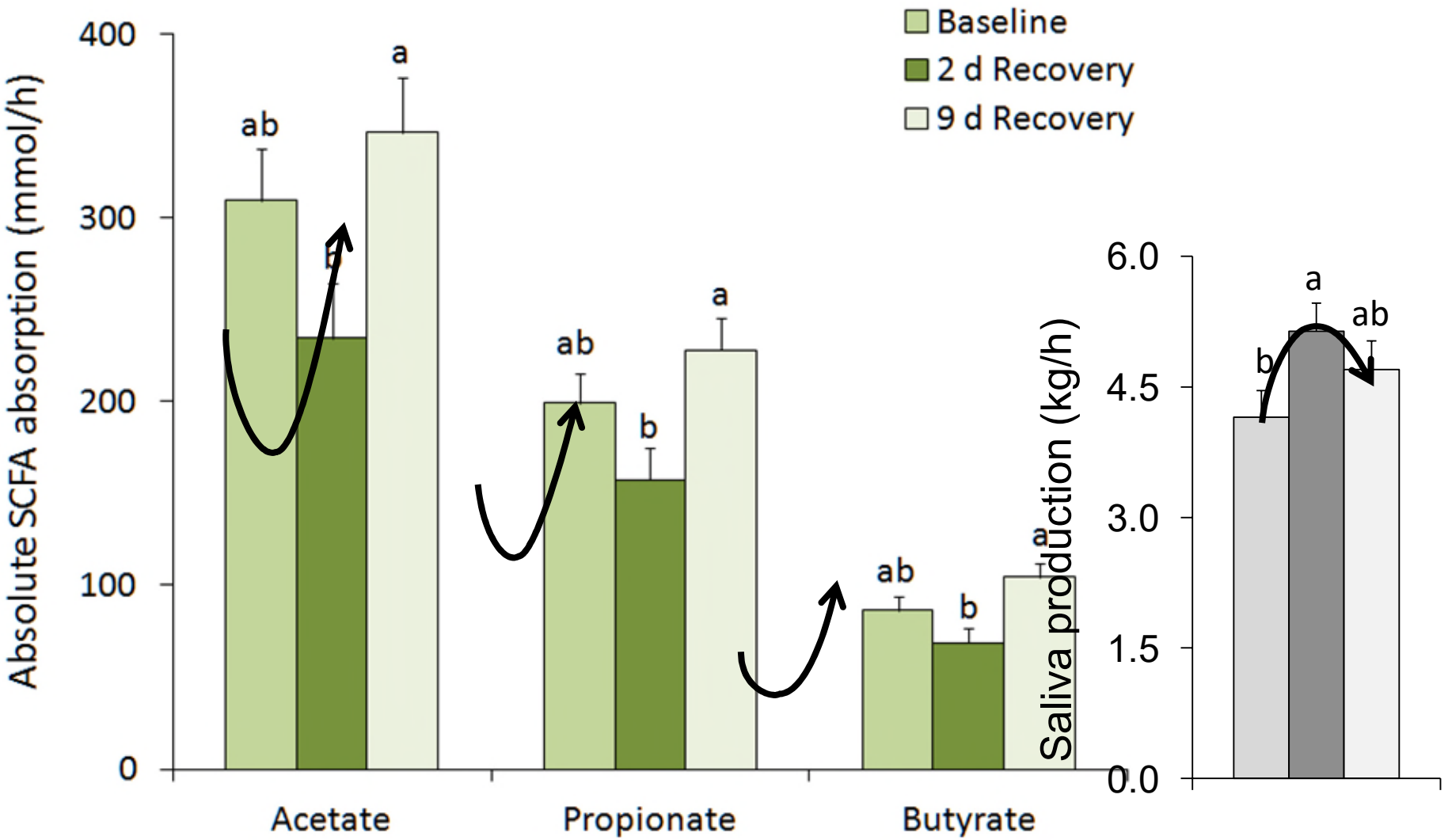
} Subjective, lack precision, and limited decision ability

- Laboratory based approaches } Starch reactivity, in vitro -requires re-grinding, time, and doesn't help make decisions
- NIR } Re-processing + what should be predicted?
- Fecal starch } Probably the best measure, but part of the opportunity is lost


Acid
Production
Acid
Removal

Schwaiger et al., 2013

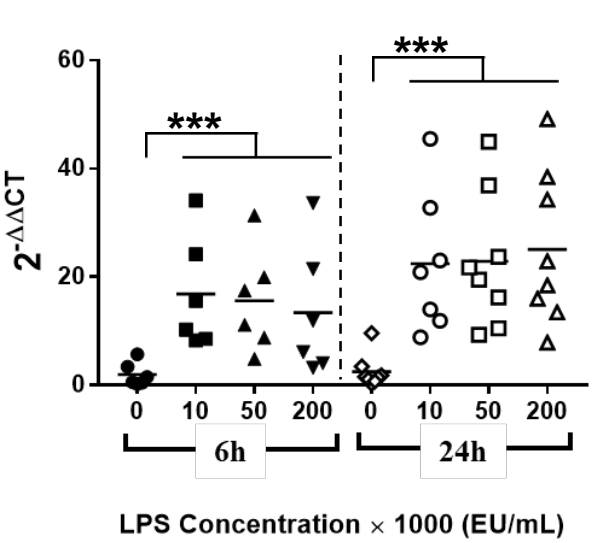
Ruminal acidosis decreases absorption



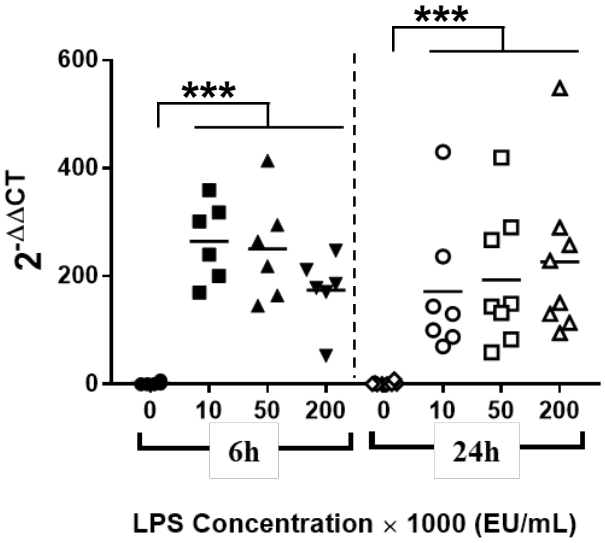
Kent-Dennis and Penner, 2019

In vitro LPS exposure induces a proinflammatory response

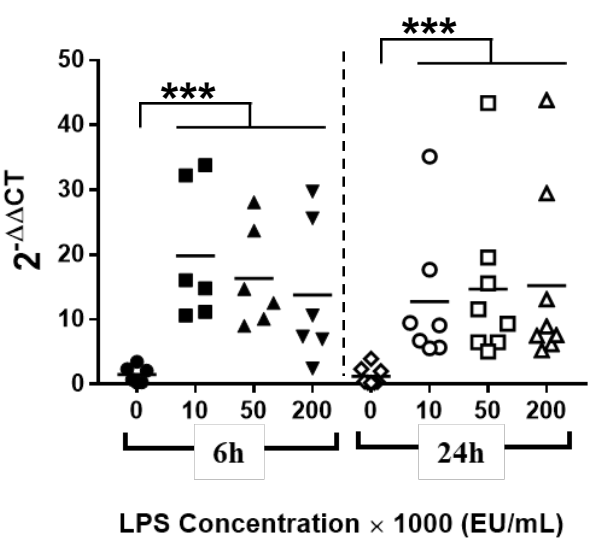
TNF-α
Treatment: $P < 0.001$
Time: $P < 0.001$
Treatment ×Time: $P = 0.42$



IL-1β
Treatment: $P < 0.001$
Time: $P = 0.42$
Treatment ×Time: $P = 0.44$



CSF2
Treatment: $P < 0.001$
Time: $P = 0.22$
Treatment ×Time: $P = 0.27$

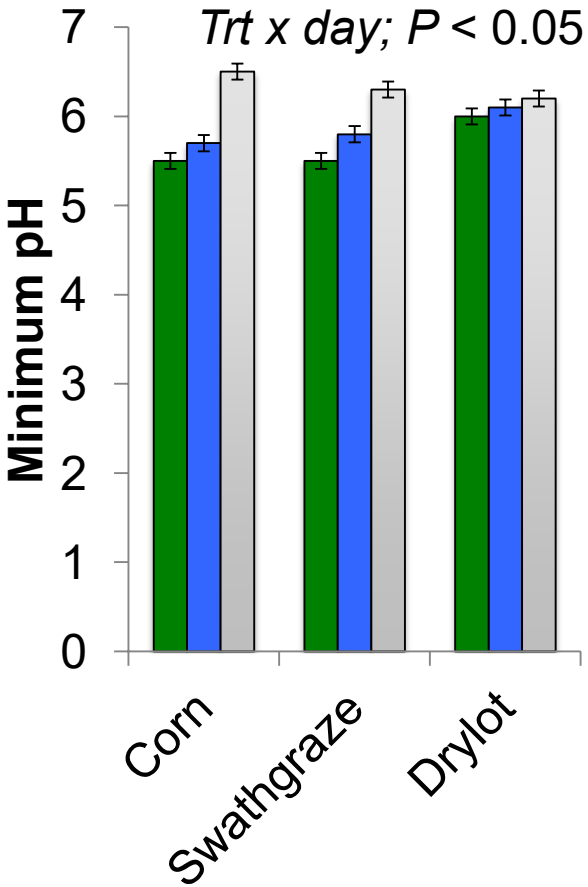


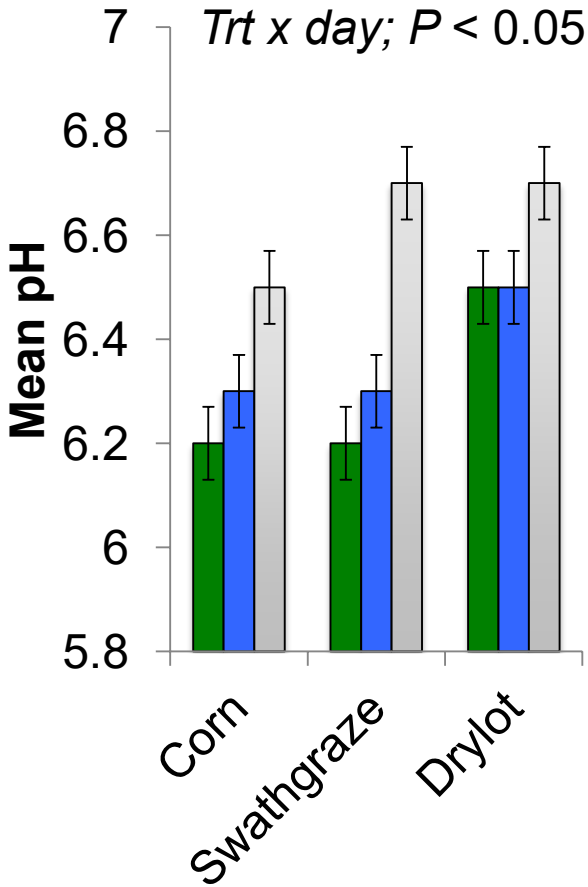
TNFa and IL1b: Key cytokines for induction of inflammatory response[6,7]
CSF2: Acts locally in response to LPS[8]

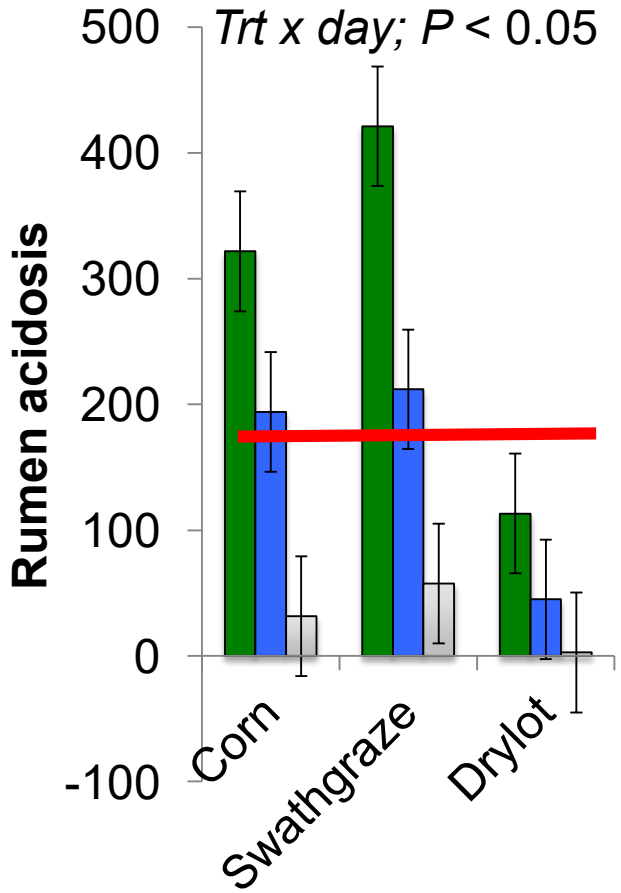
[6]Bradley, 2008; [7]Wojdasiewicz et al., 2014; [8]Becher et al., 2016

Jose et al., 2020; AAS

Rumen acidosis: Not just dairy and feedlot cattle!







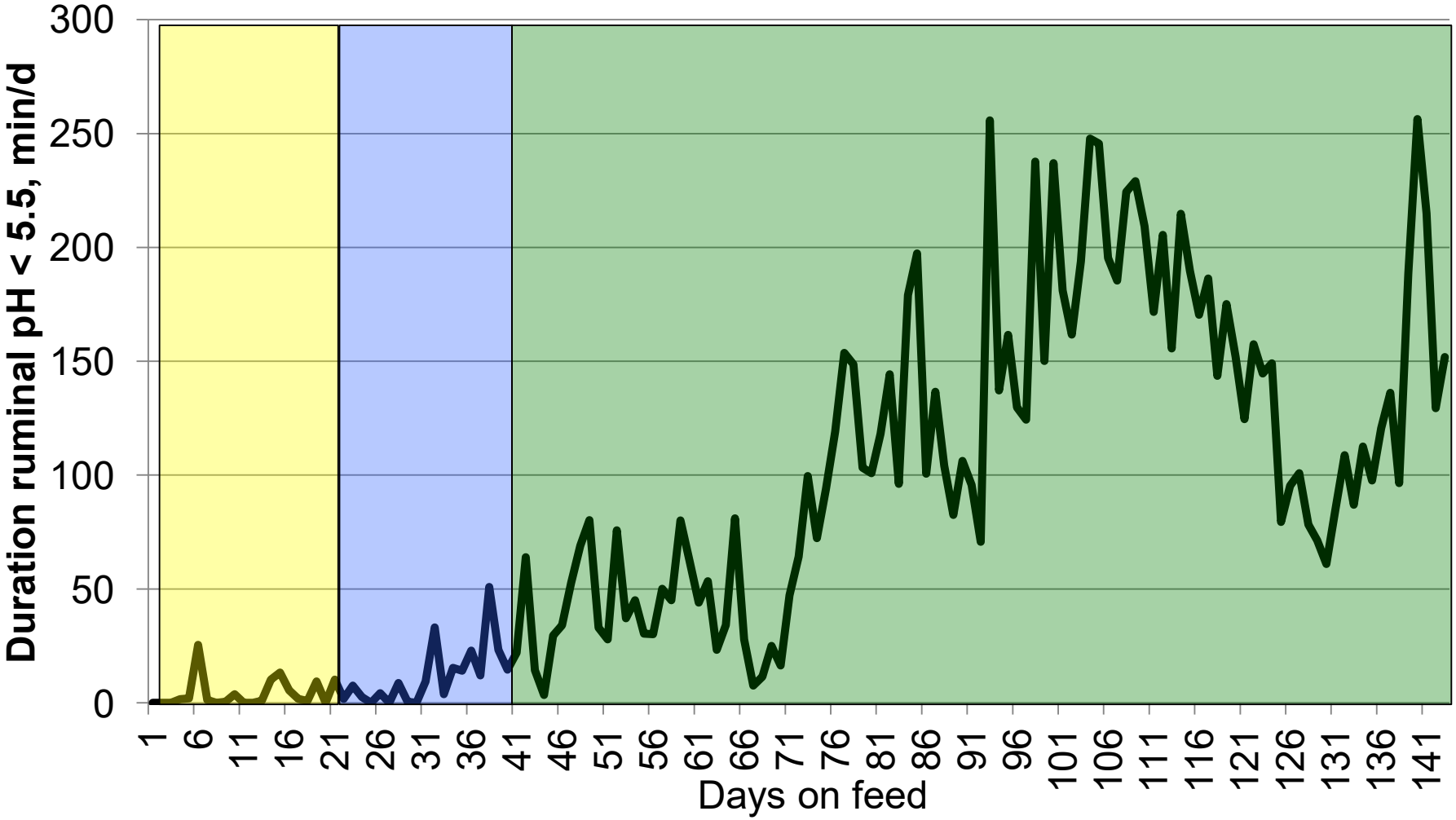
Prevalence and Severity of Ruminal Acidosis

Item	Backgrounding	Step 1	Step 2	Step 3	Step 4	Finishing
Duration, d	21	5	5	5	5	102
Ingredient inclusion rates, % DM						
Barley silage	45.7	34.3	25.5	17.0	10.5	5.0
Barley grain	41.6	51.3	60.8	69.3	75.7	81.2
Canola meal	4.2	5.9	5.1	5.0	5.0	4.9
Pellet	8.0	8.0	8.0	8.0	8.0	8.0
Limestone	0.5	0.5	0.6	0.7	0.8	0.9

All diets contained Monensin (33 mg/kg) and Tylan (11 mg/kg)

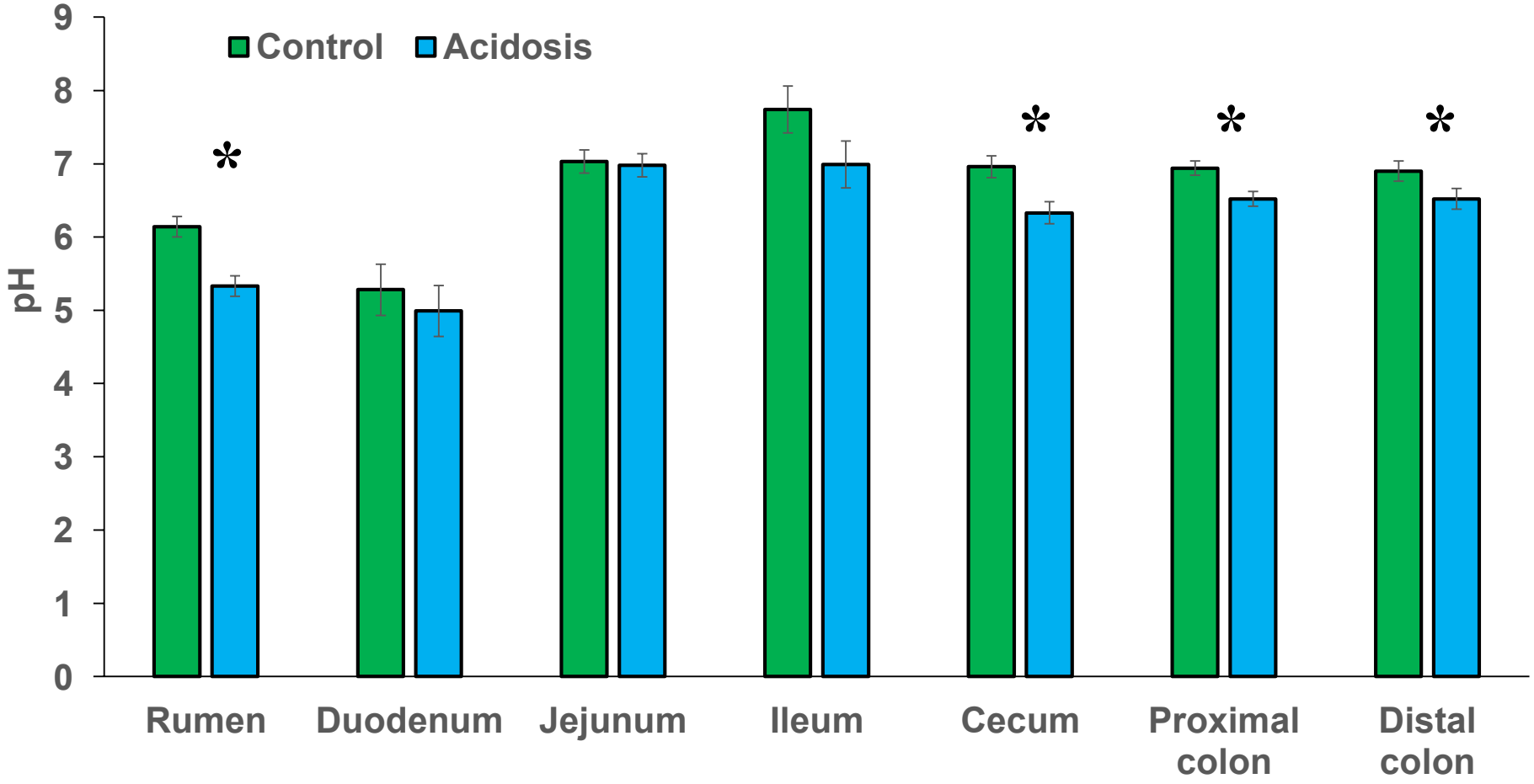
Castillo-Lopez et al., 2014; JAS

Severity of Ruminal Acidosis



Castillo-Lopez et al., 2014; JAS

Rumen acidosis affects more than ruminal pH



Pederzolli et al., 2018; JAS

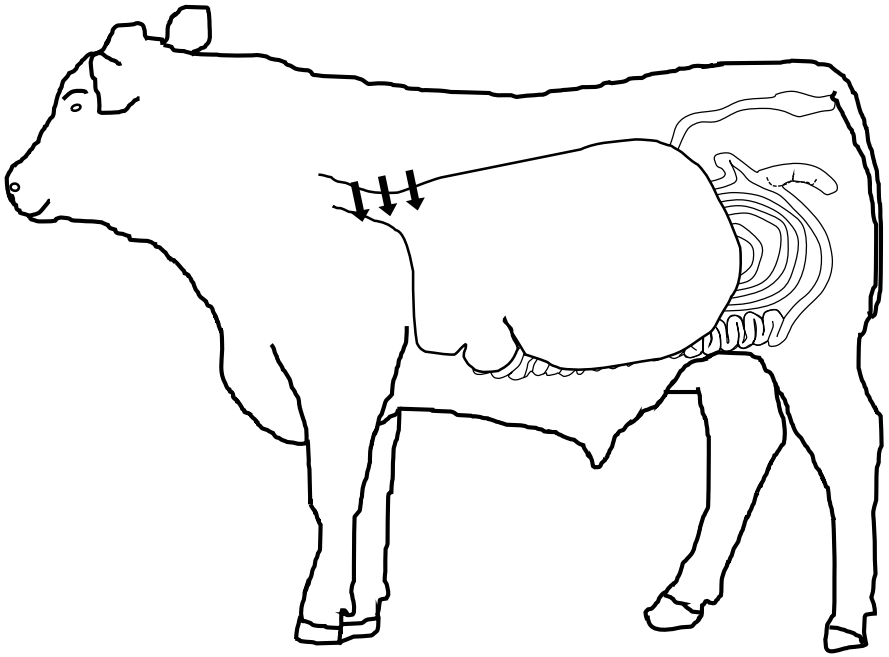
Risk for inflammation

Wiese et al., 2017; CJAS

	Case definition[1]		
	PATH	NOPATH	*P* value
n	20	8	
Ruminal pH			
Minimum	5.38 ± 0.05	5.40 ± 0.14	0.89
Mean	5.99 ± 0.05	6.12 ± 0.06	0.12
Duration pH < 5.2, min/d	**62.0 ± 26.7**	**8.31 ± 5.81**	**0.03**
Serum[3], µg/mL			
SAA	**45.12 ± 3.47**	**31.04 ± 3.05**	**0.02**
Hp	**4.91 ± 0.78**	**2.28 ± 0.18**	**0.08**

[1]Rumen and liver pathology were used to create a case definition. Steers with rumen scores of 0 or 1 and liver scores of 0 were categorized as NOPATH. Steers with liver scores of A-, A, or A+, or with rumen scores of 2 or 3, were categorized as PATH. Data are reported as means ± SEM.

The gut as a central organ system



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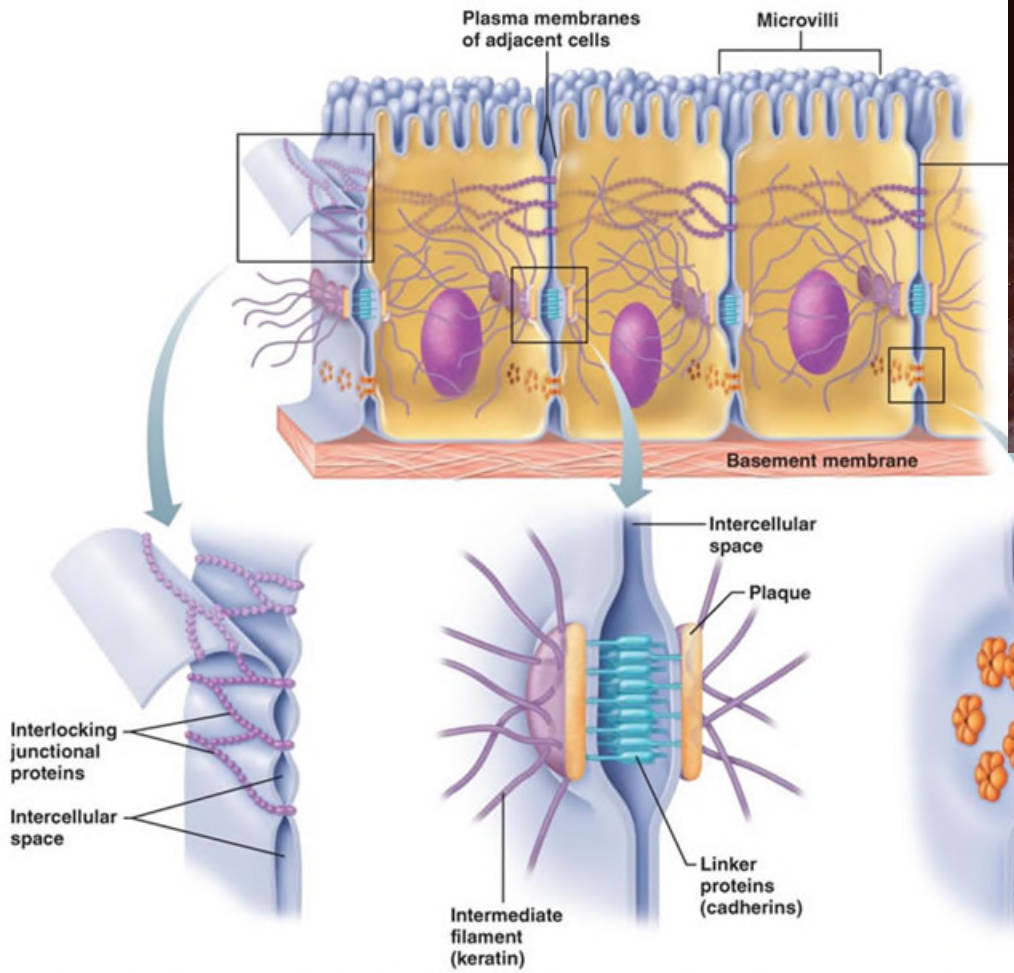
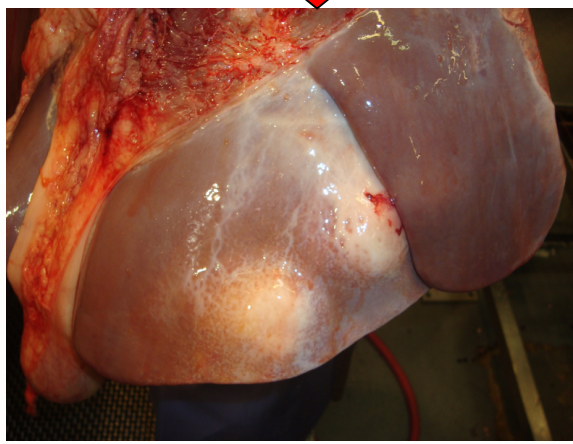
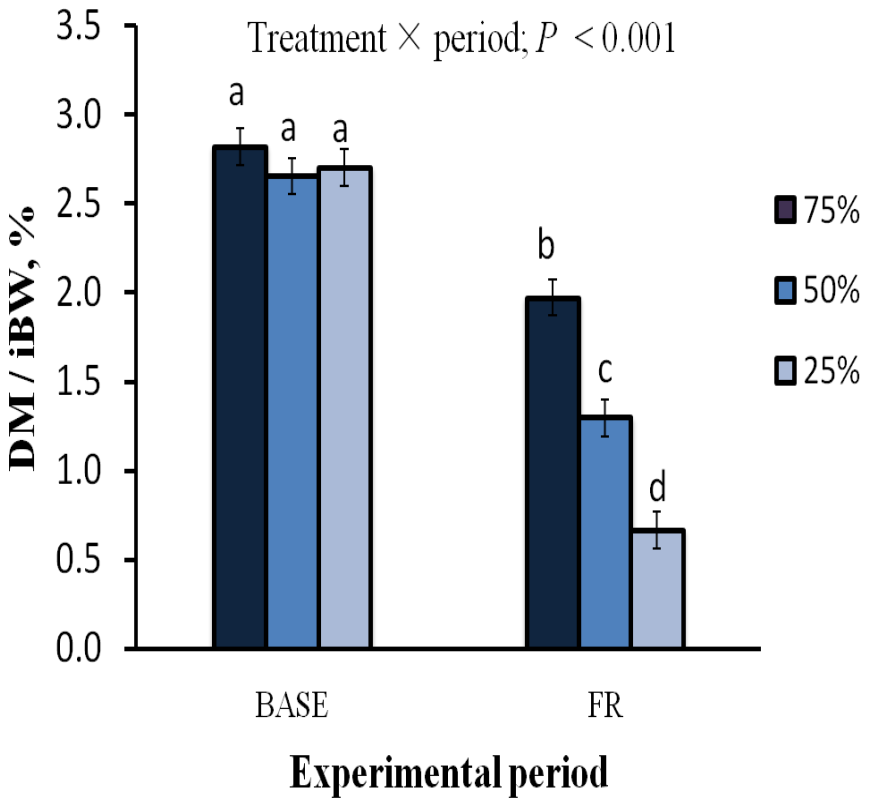
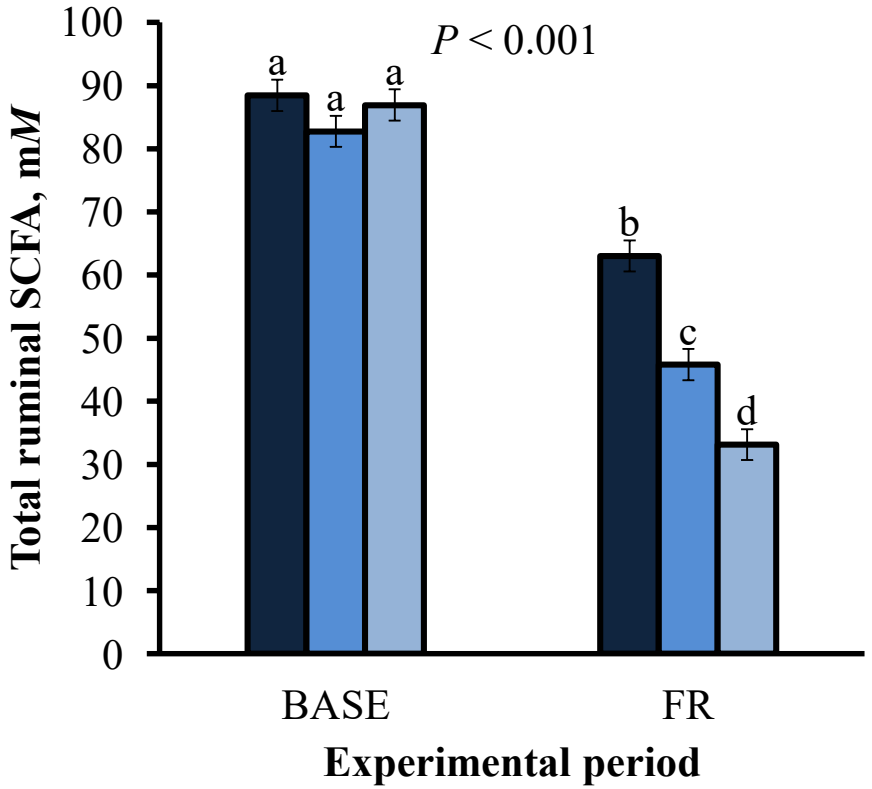
Barrier function





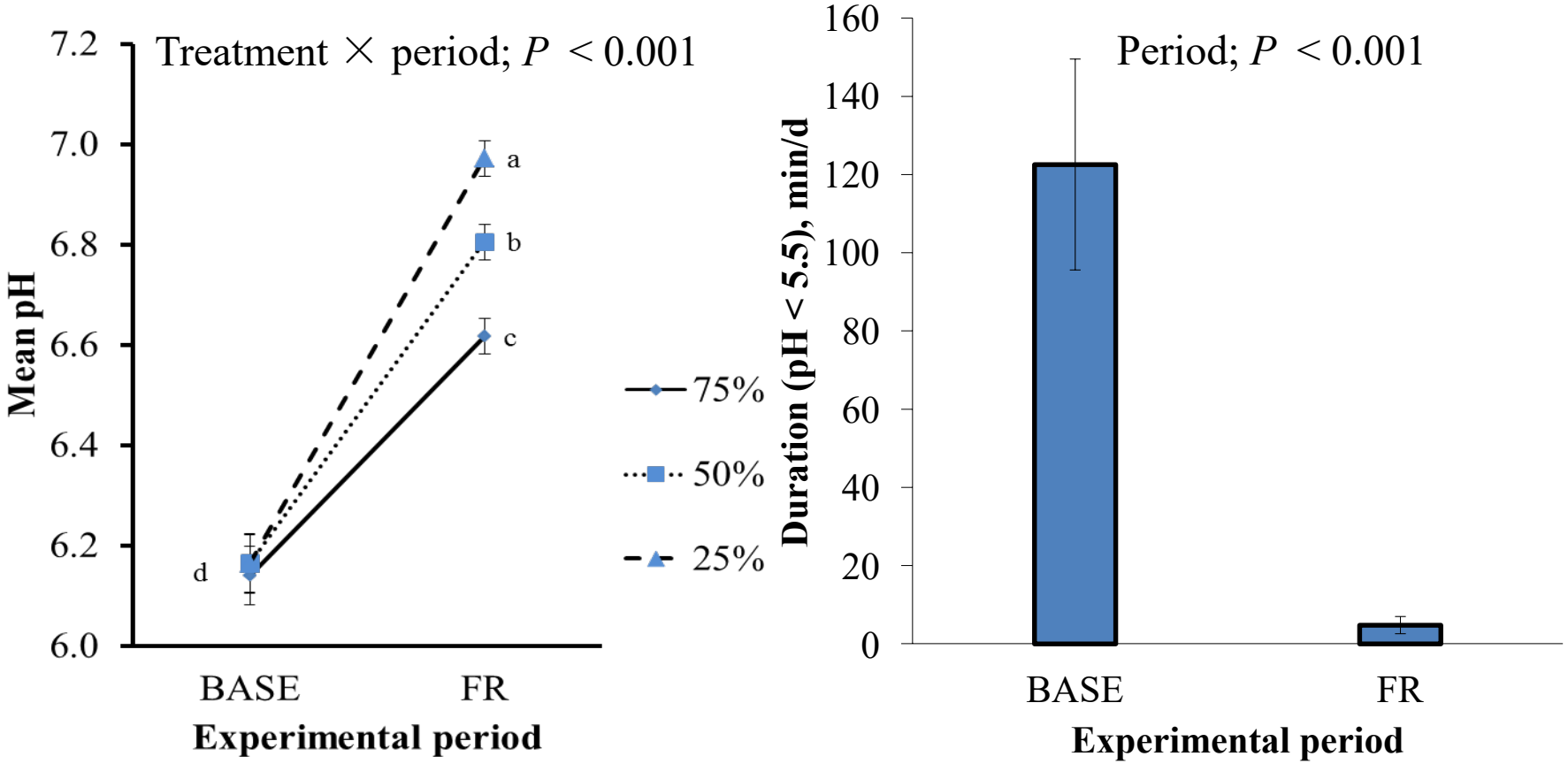
Low feed intake decreases ruminal SCFA concentration





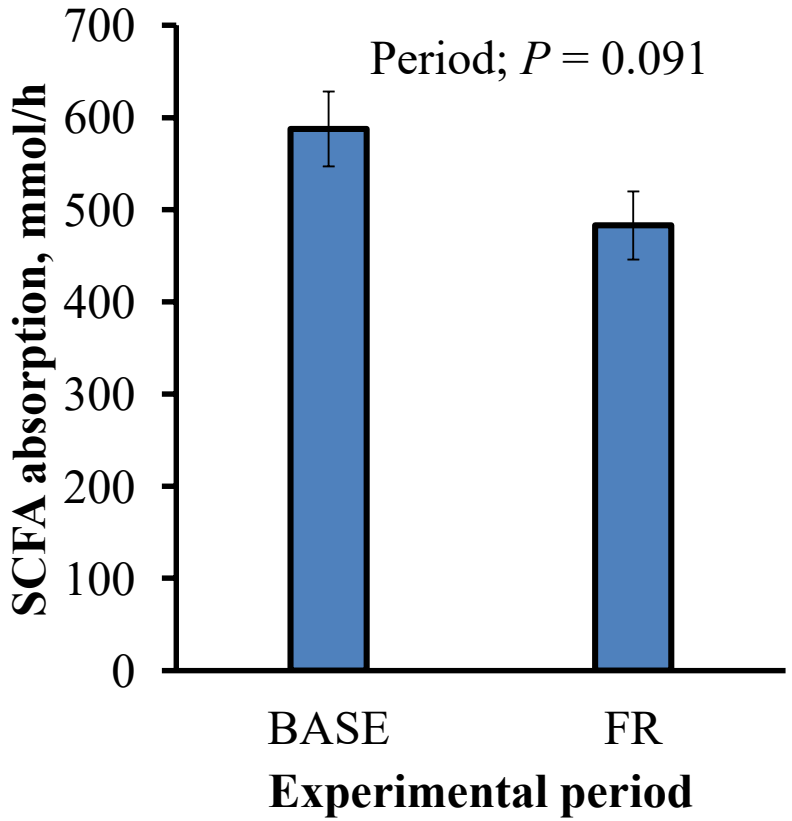
Zhang et al., 2013

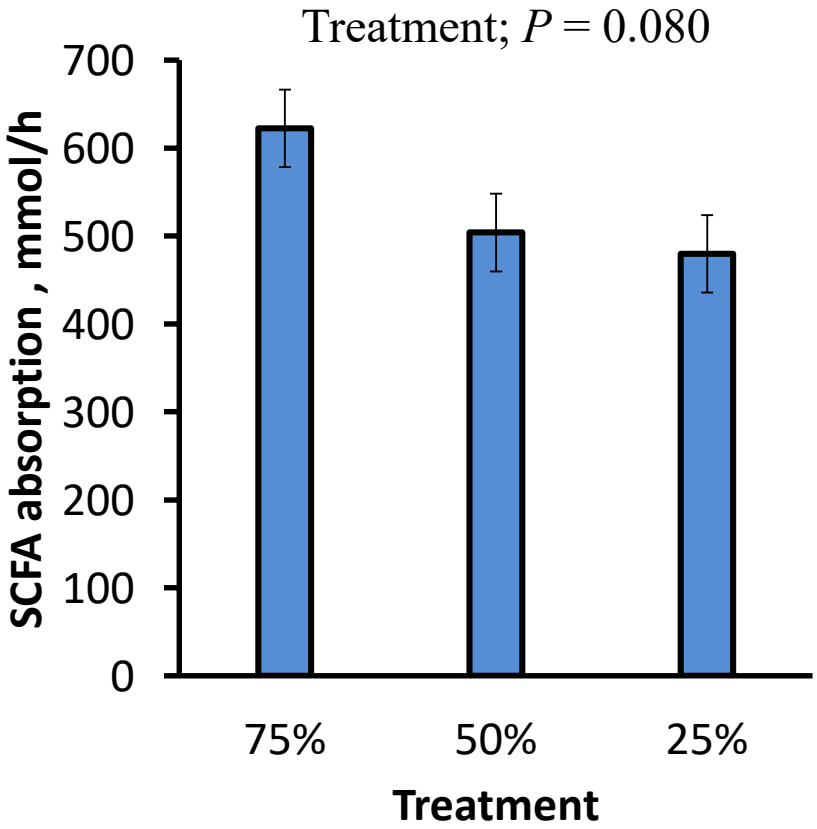
Ruminal pH increases with low feed intake



Zhang et al., 2013

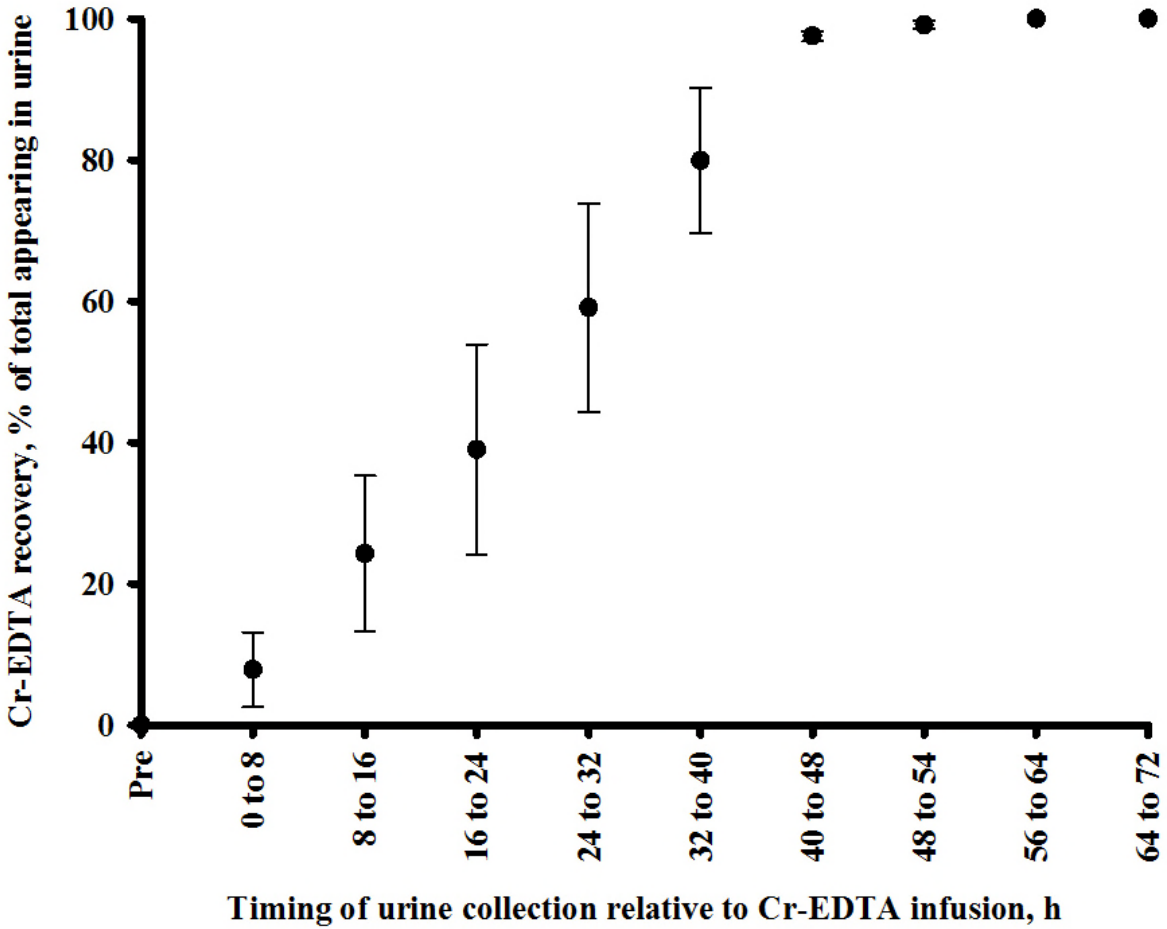
SCFA absorption is reduced with low feed intake





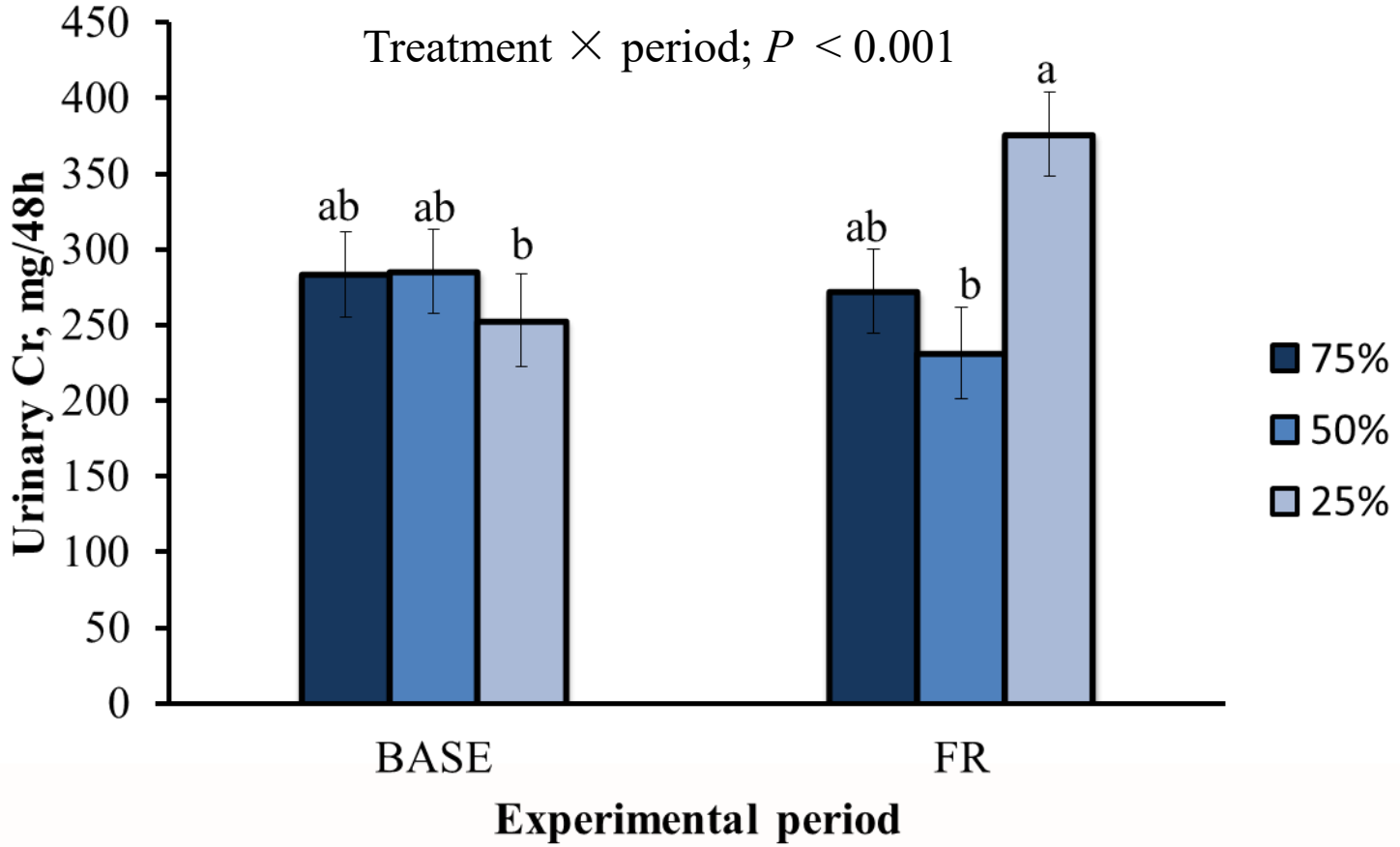
Zhang et al., 2013

Timeline of Cr-EDTA Appearance



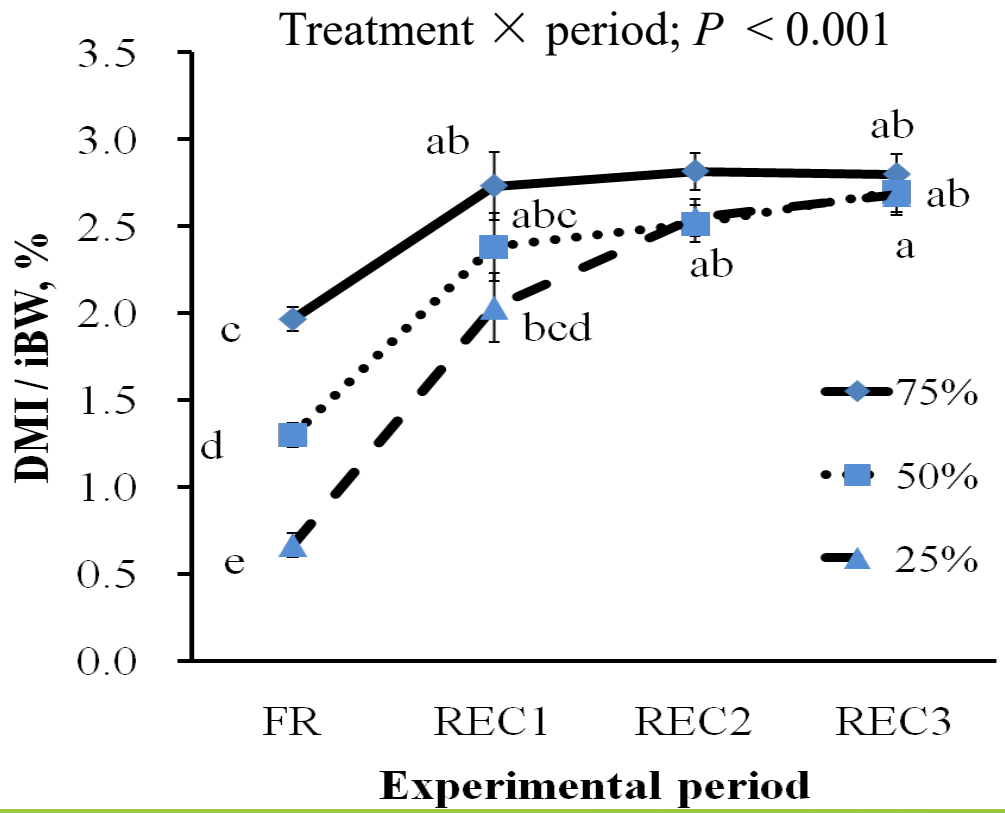
Zhang et al., 2013

Barrier function of the gut is reduced with severe low feed intake (d 3 and 4)



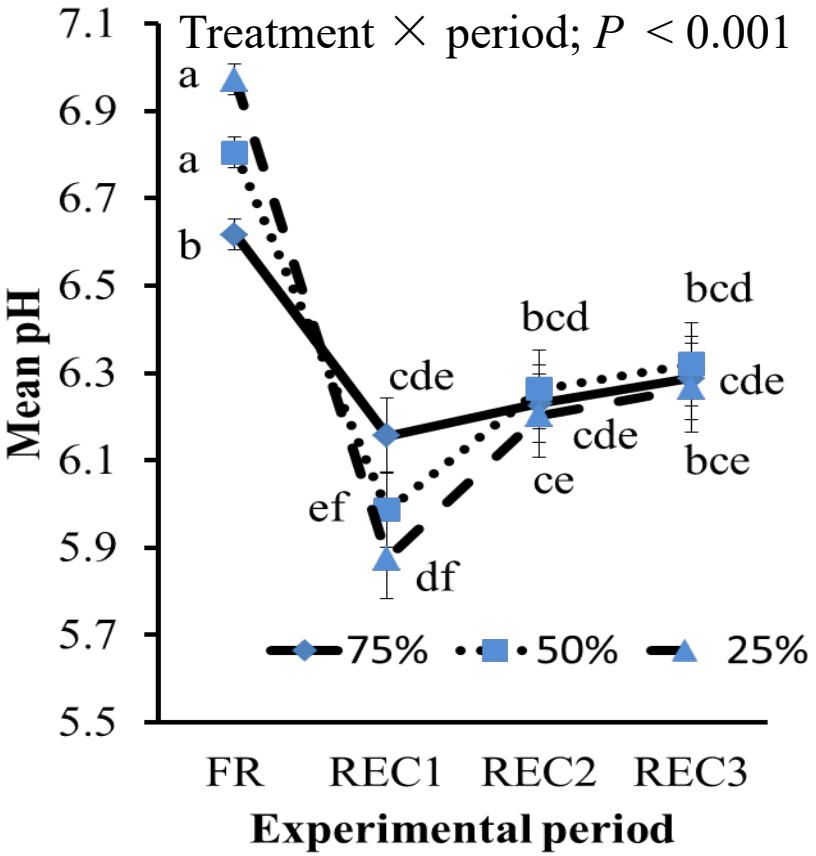
Zhang et al., 2013

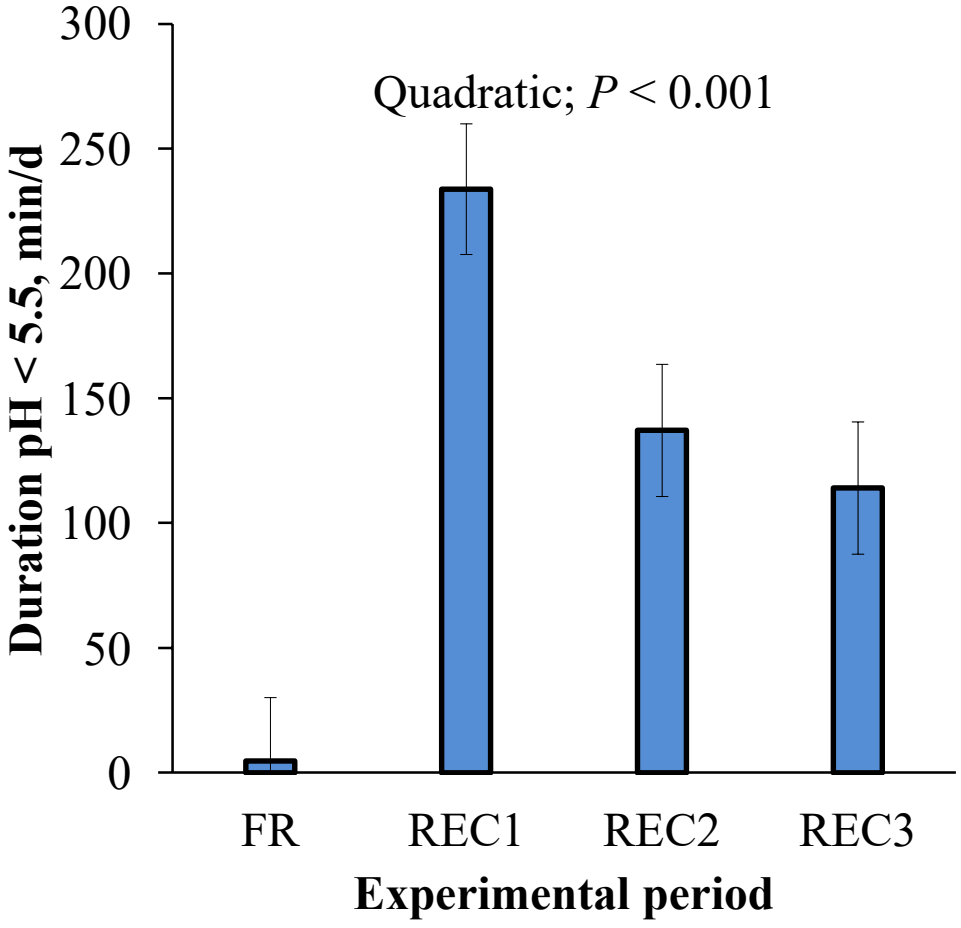
Severity of low feed intake impacts the recovery response



Zhang et al., 2013

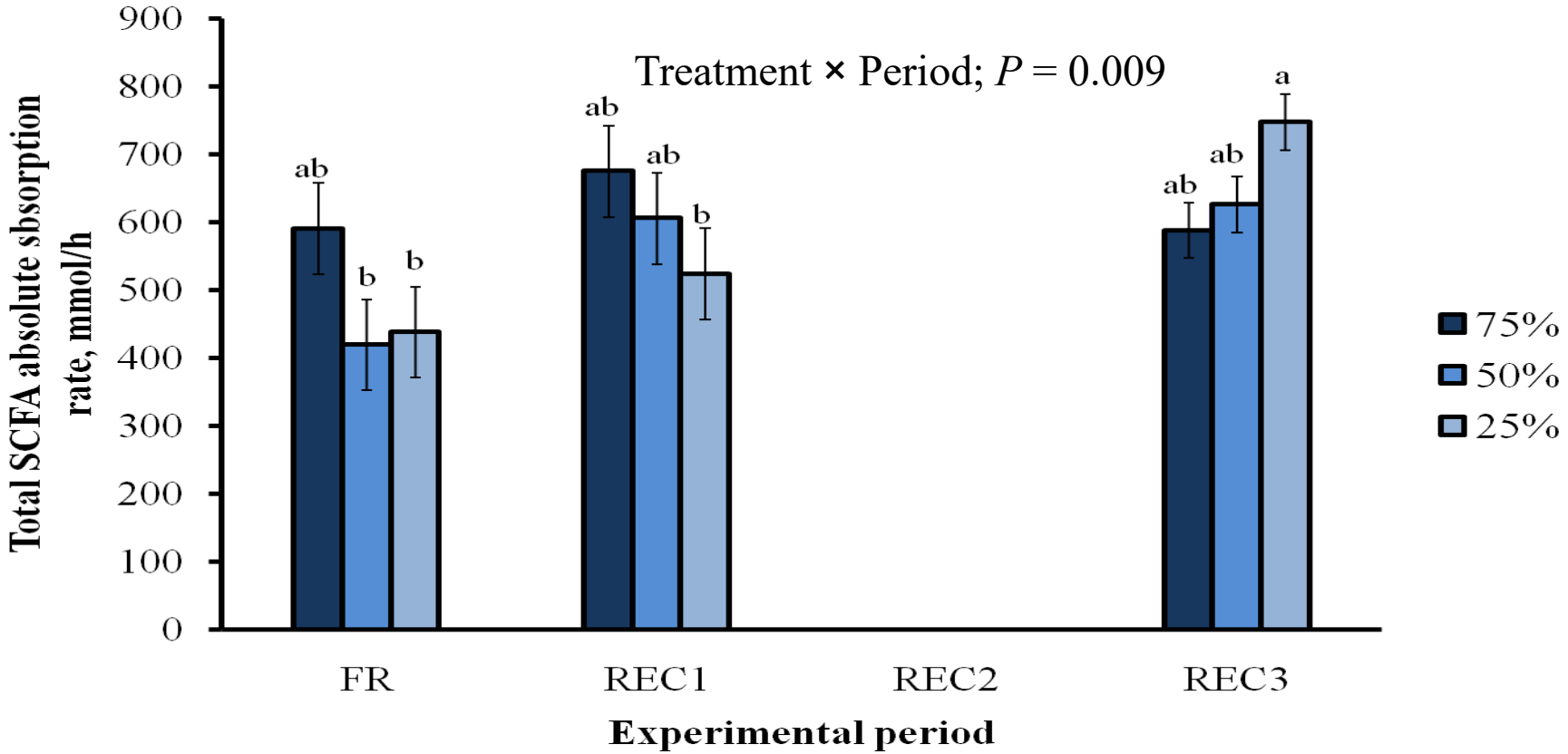
Ad libitum feeding after low feed intake induces low ruminal pH





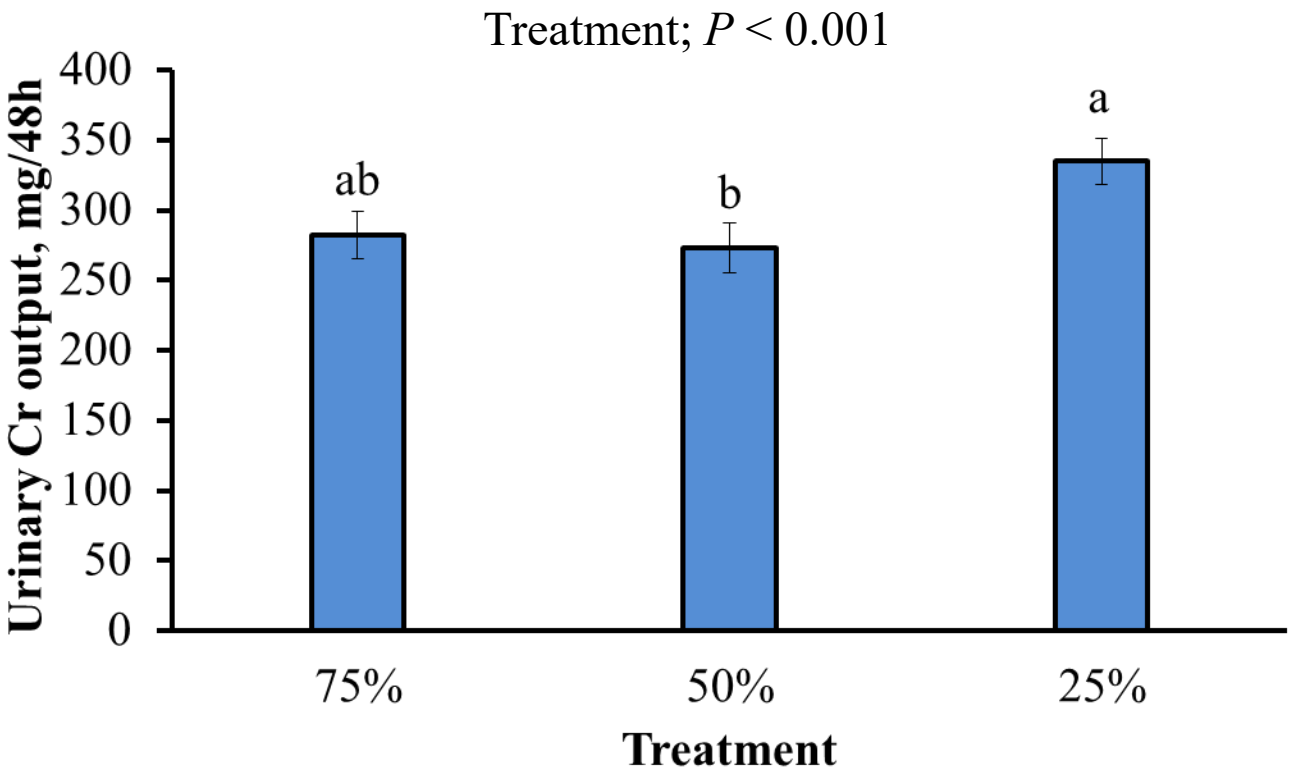
Zhang et al., 2013; JAS

Delayed response for recovery of SCFA absorption with low feed intake



Zhang et al., 2013; JAS

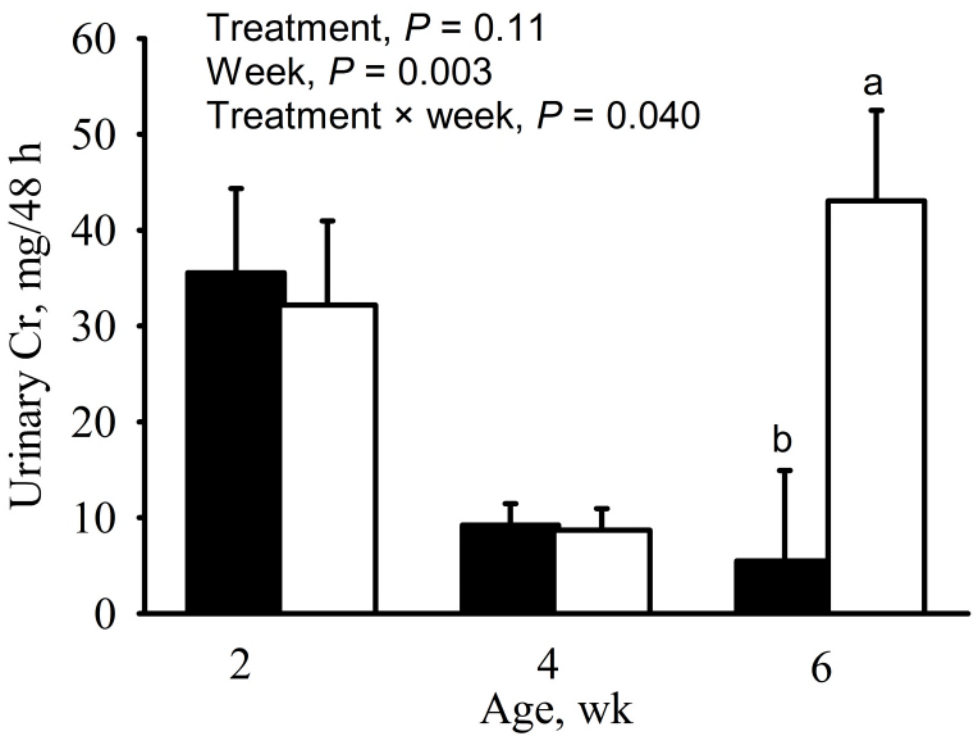
Total tract barrier function was still compromised 3 wk after severe low feed intake



Weaning compromises total tract barrier function

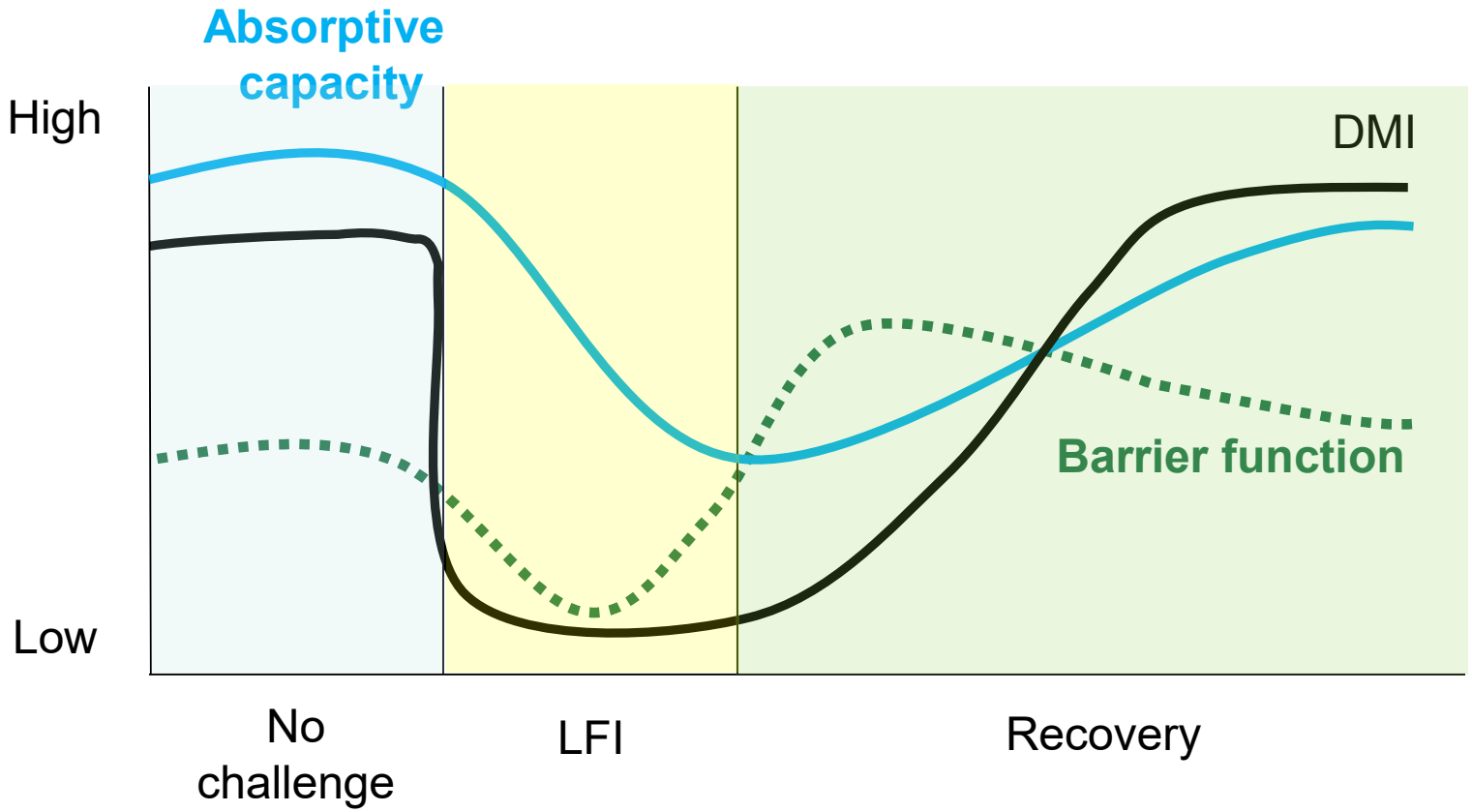
- 14 newborn Holstein bull calves
- Weaned on d 42 after a 7-d step-down program vs. or not weaned
- Cr-EDTA used as an indicator of barrier function

Greater urinary Cr = reduced barrier function



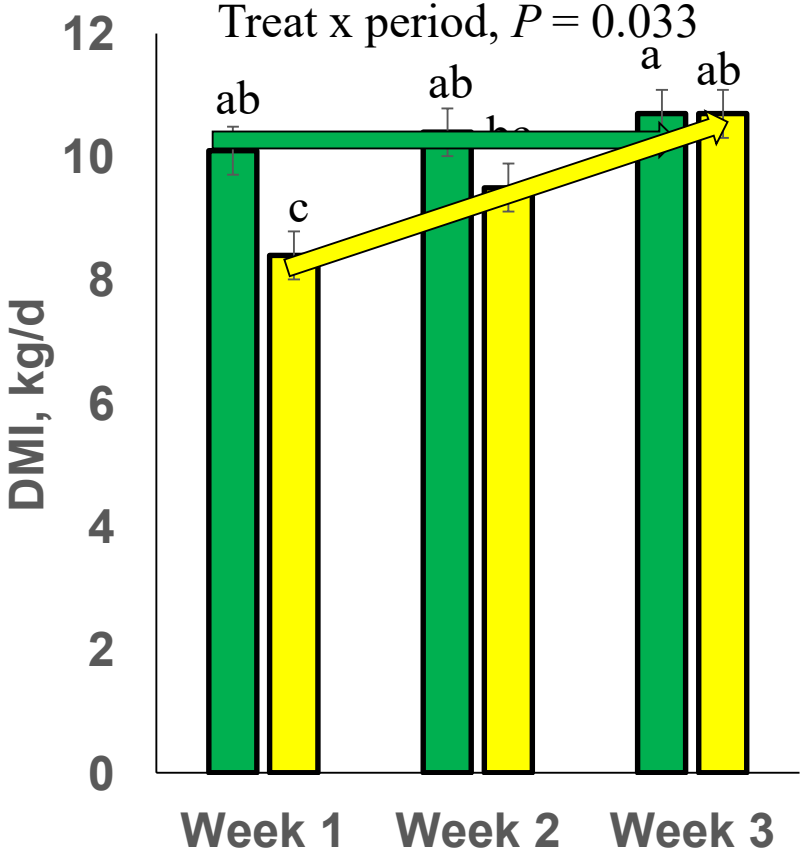
Wood et al., 2015: JDS

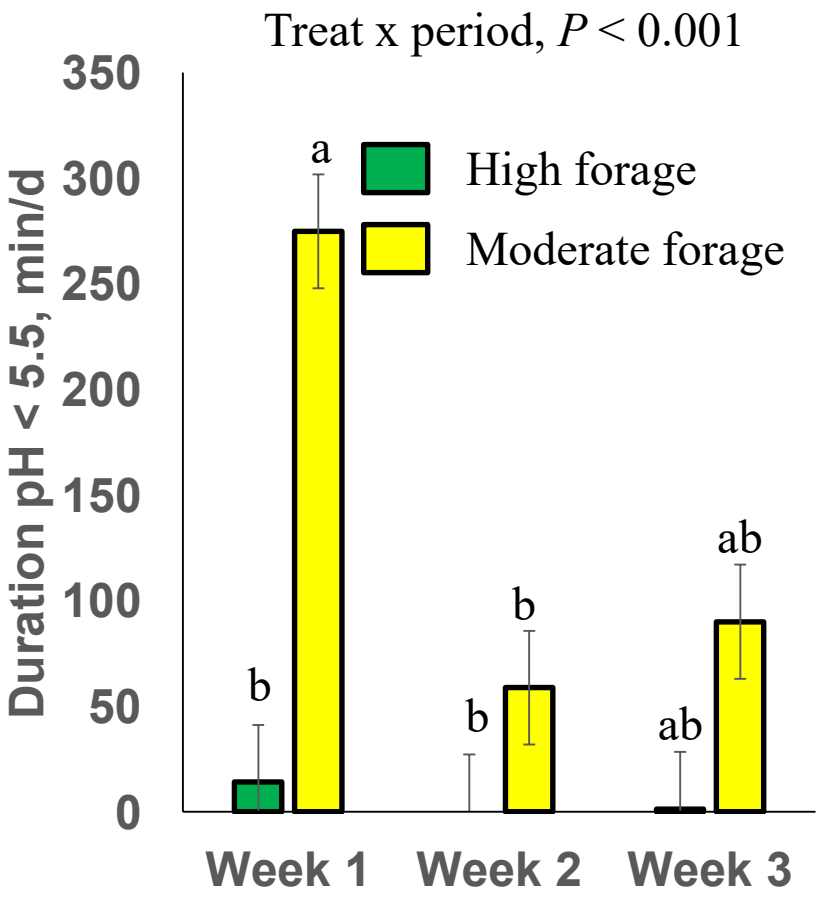
Integration of the data for LFI



Aschenbach et al., 2019

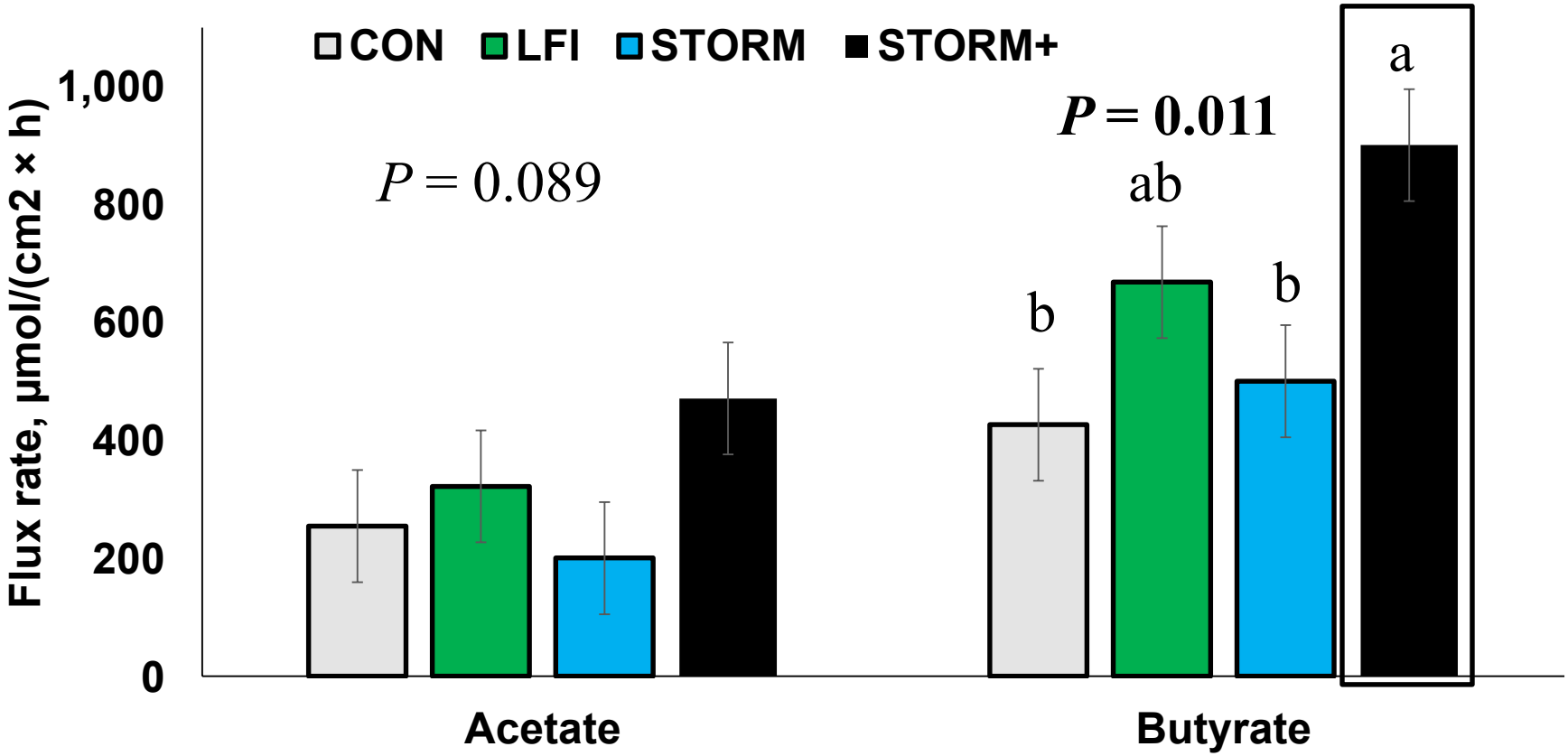
Feeding a high forage diet after low feed intake improves recovery





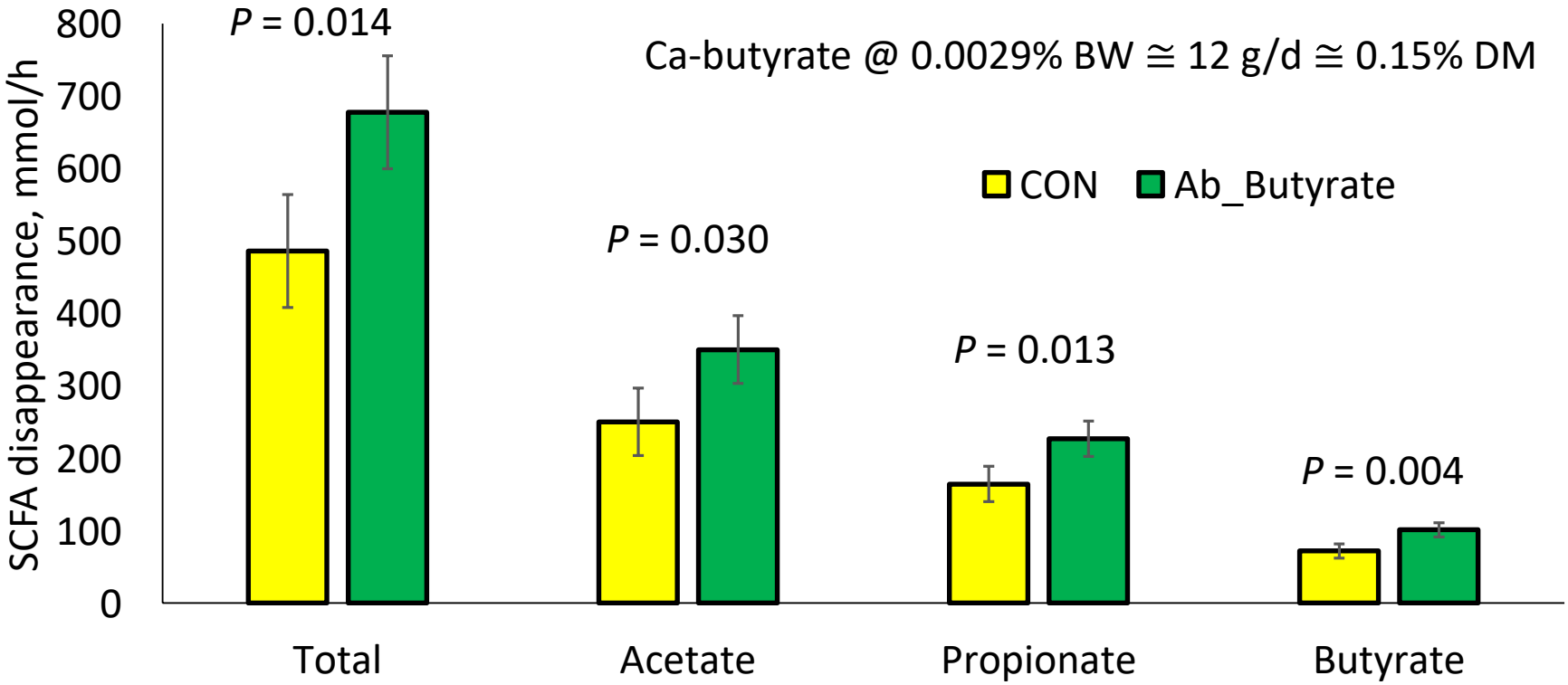
Albornoz et al., 2013; JAS

Increasing the F:C ratio and use of a compound supplement improved absorption



Penner et al., unpublished

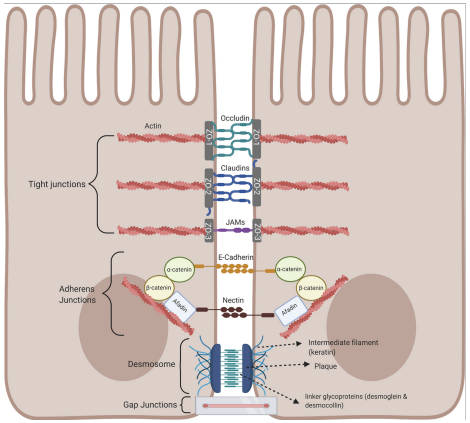
Abomasal butyrate supply stimulates ruminal SCFA absorption

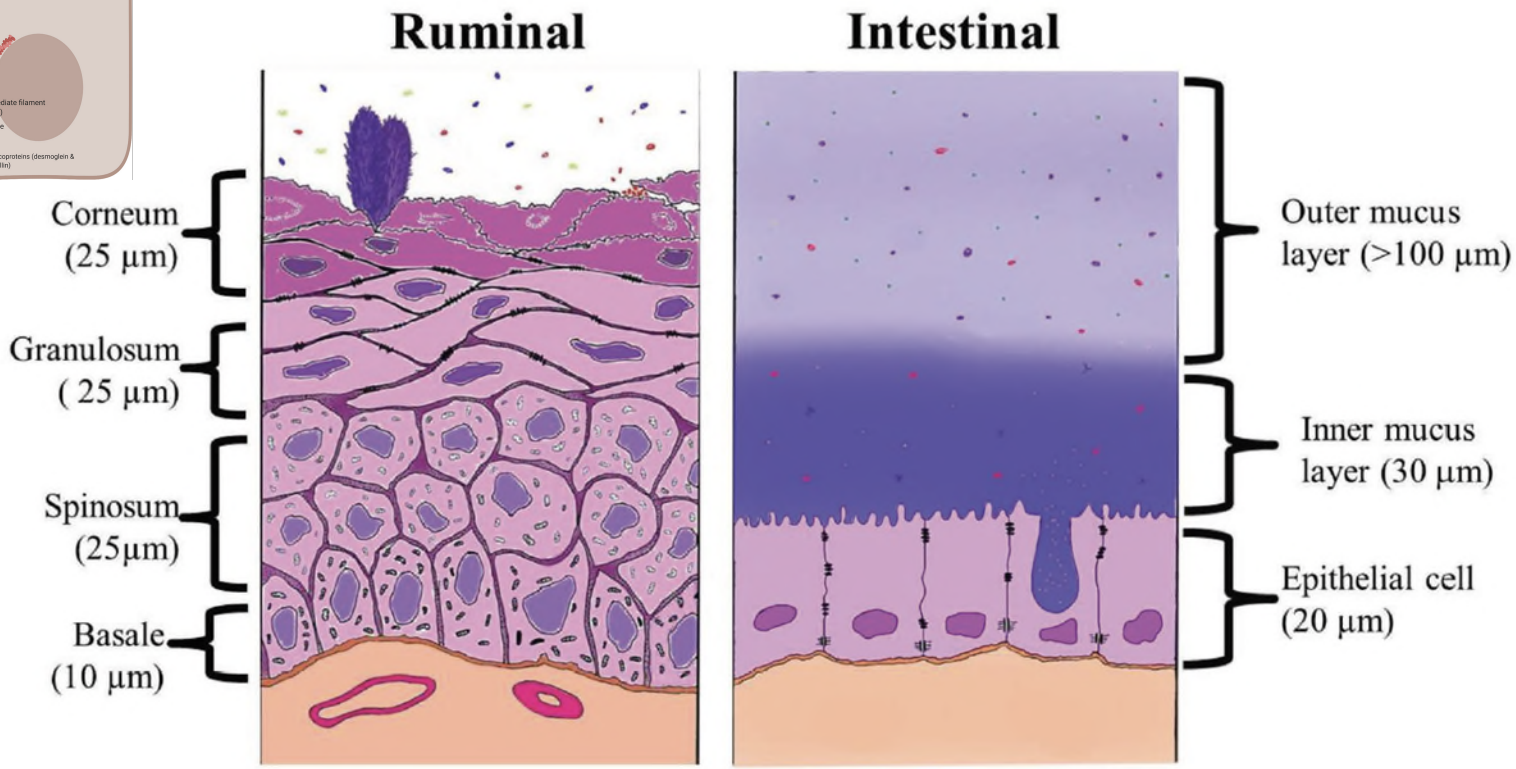


Watanabe et al., in review

Mohammed and Thiermermann, 2021; Front. Immunol.

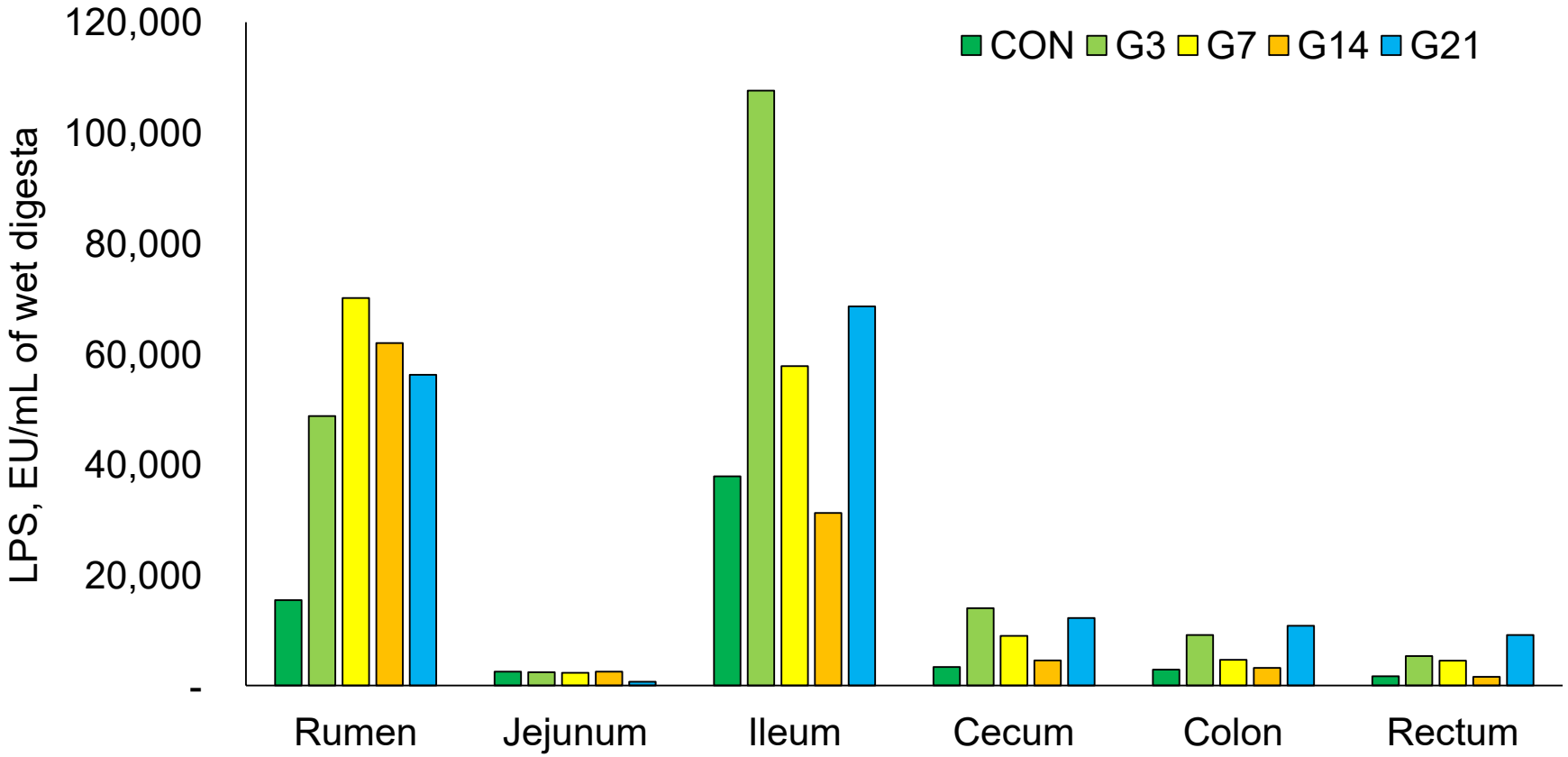
Barrier function: junctional complexes





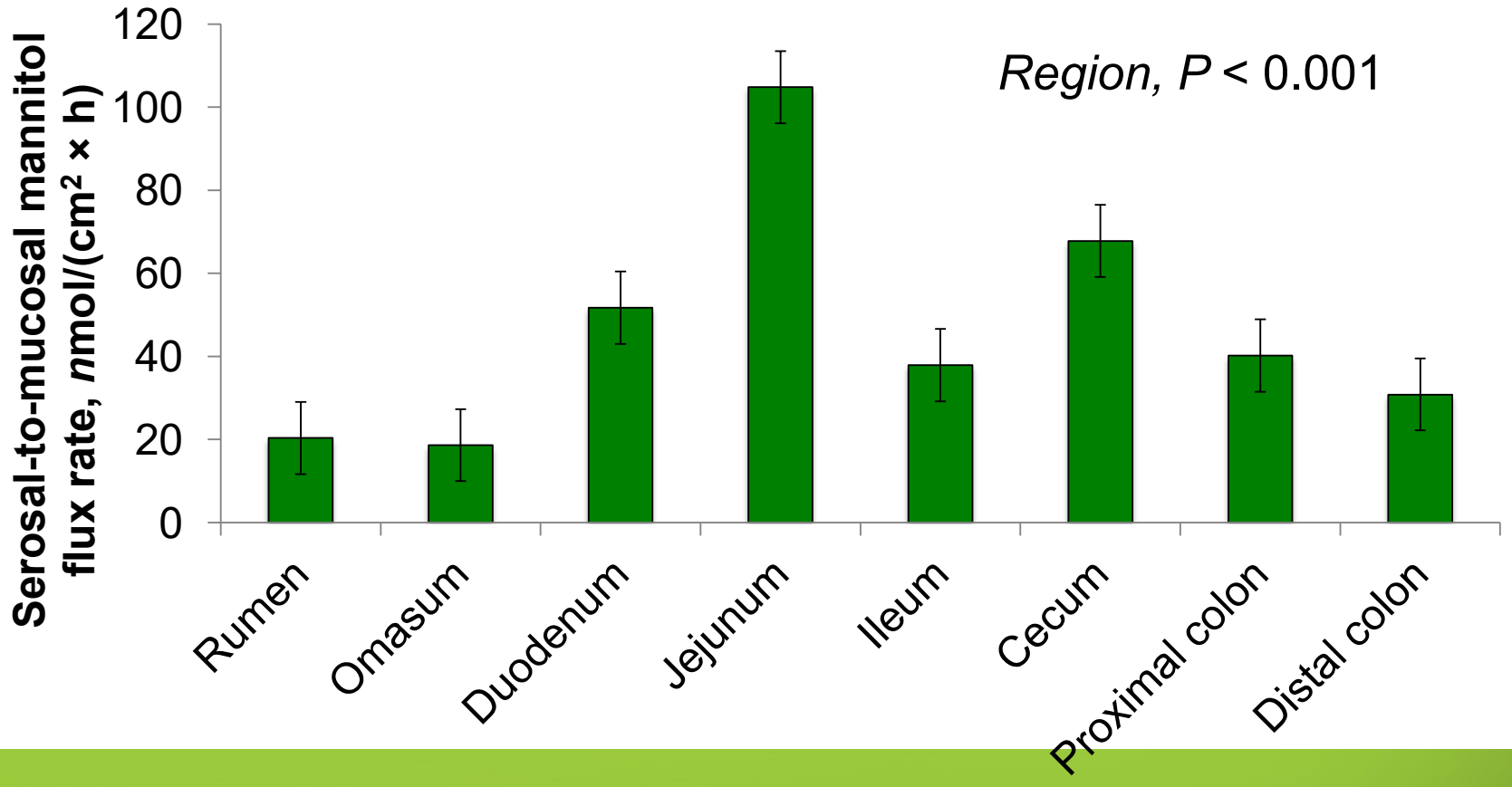
Steele et al., 2016

Antigens occur throughout the GIT



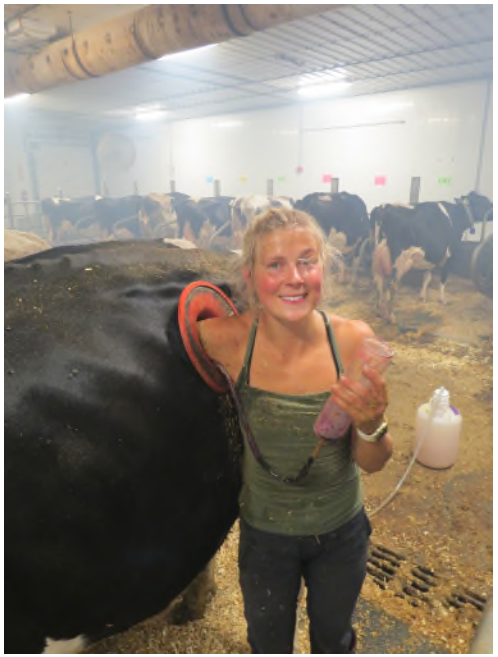
Plaizier et al., 2014; JDS

There are regional differences in barrier function



Penner et al., 2014; Anim. Prod. Sci.

Total and post-ruminal gastrointestinal tract barrier function "leaky gut"



Cobalt-EDTA

Chromium-EDTA

Urine collection

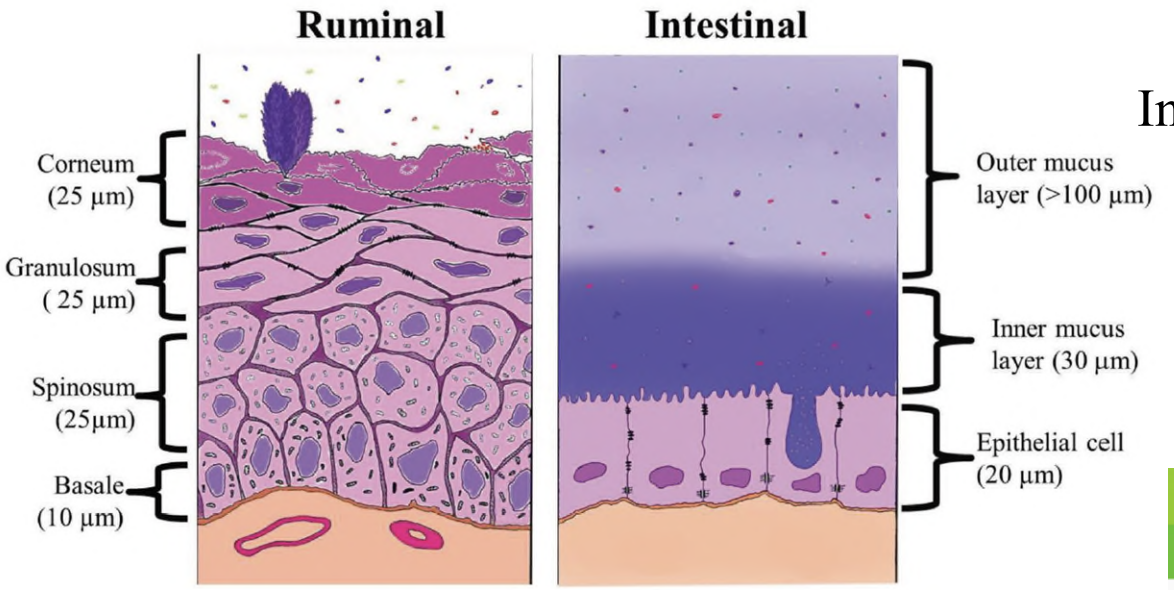
Bertens et al., unpublished

Total and post-ruminal gastrointestinal tract barrier function as affected by Ca/Mg-carbonate

- **Buffer reduced intestinal permeability by 27%**

Bertens et al., unpublished

	Treatment					*P* value		
Variable	HB-HD	HB-LD	LB-HD	LB-LD	SEM	Buffer	DCAD	Buffer*DCAD
Chromium excreted, mg	139.2	150.0	155.0	166.9	12.11	0.098	0.24	0.96
Cobalt excreted, mg	**99.8**	**82.9**	**126.9**	**122.7**	**8.38**	**<0.01**	**0.22**	**0.45**

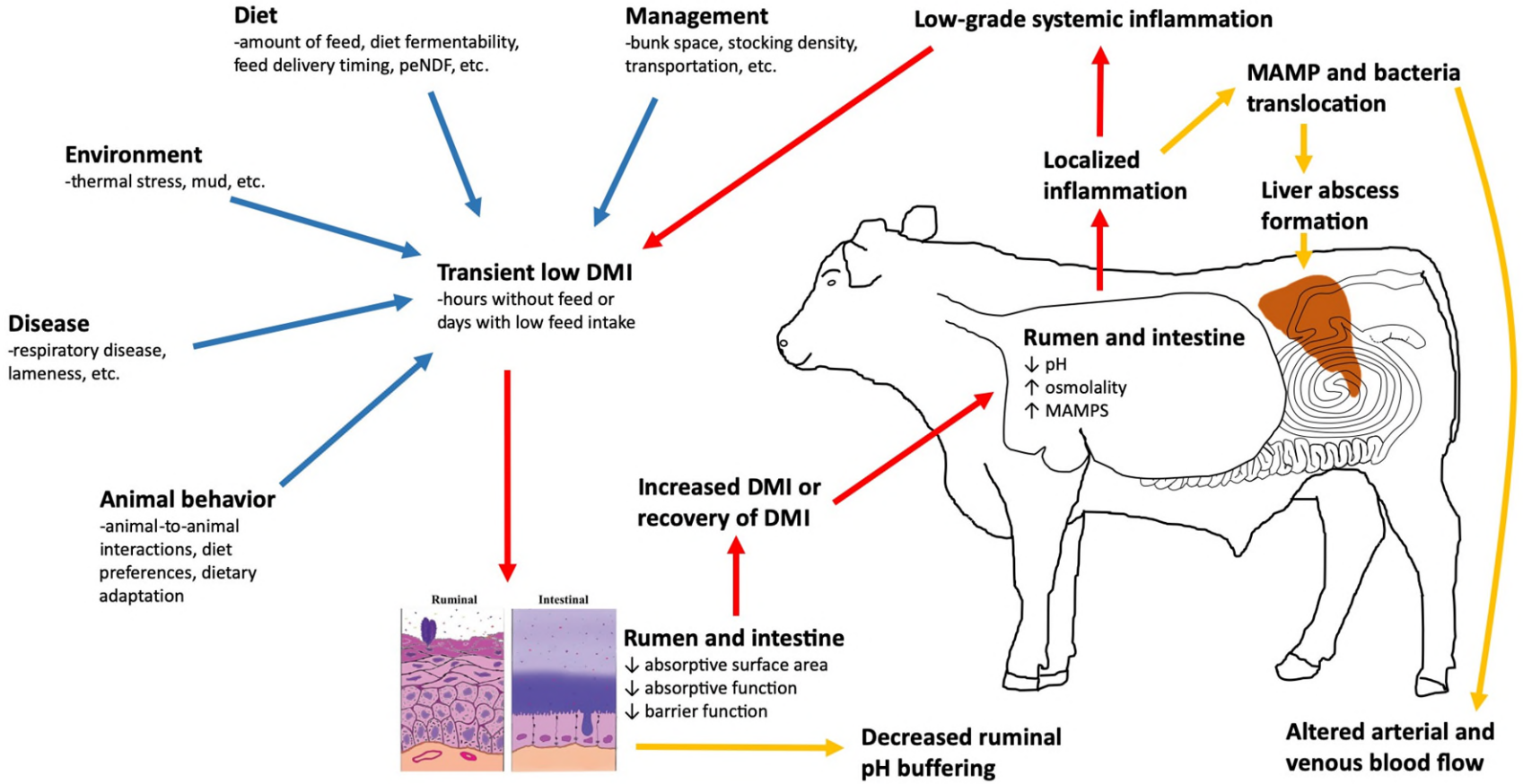


Steele et al., 2016; JDS

Increased risk of inflammation

- glucose utilization ~1 kg/12 h (Kvidera et al., 2017)
- liver amino acid uptake

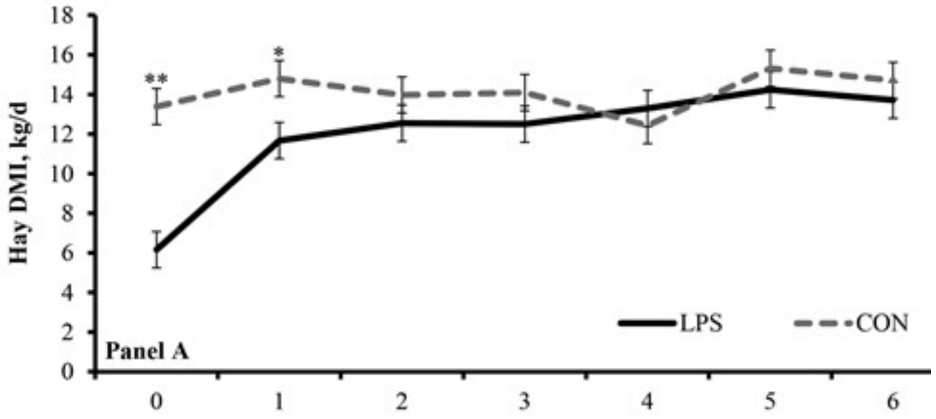
Linking the gut and disease states

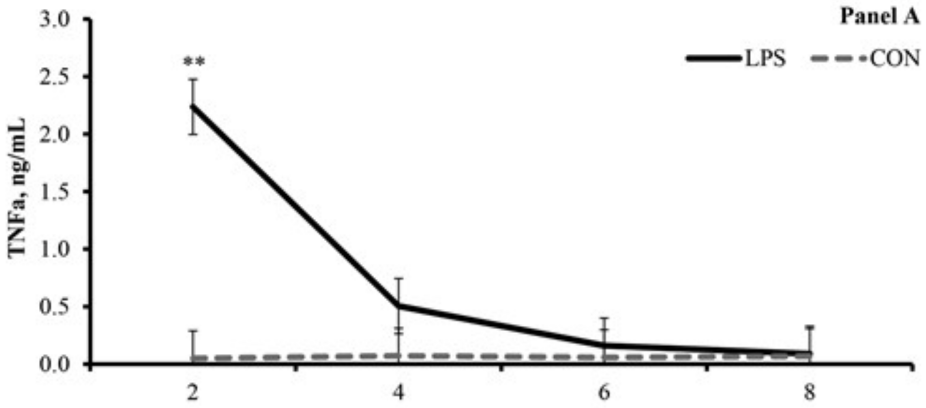


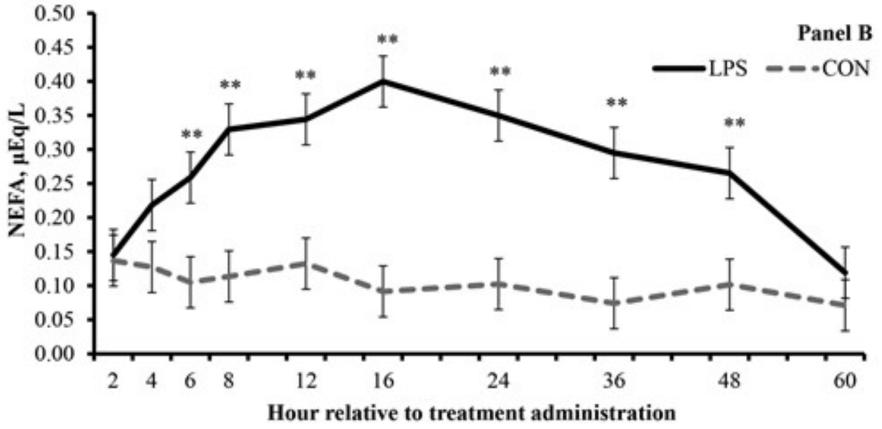
Penner, 2020; Rumen Health Compendium

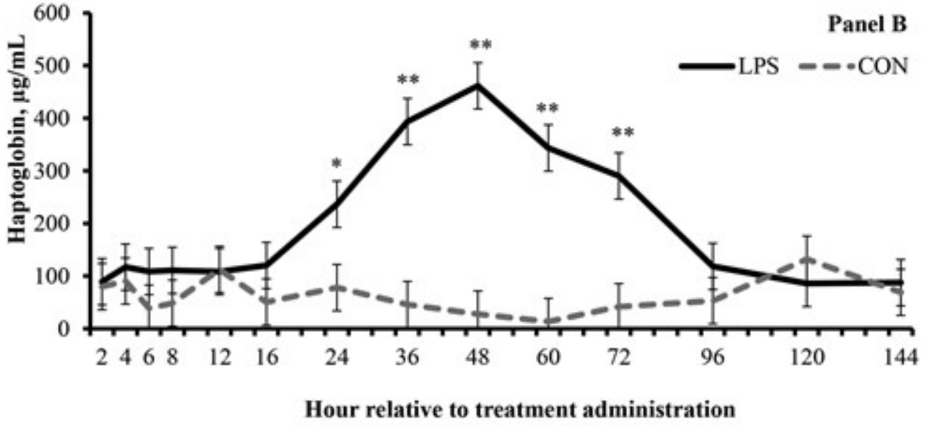
Lippolis et al., 2017; JAS

Diseased states induce systemic inflammation



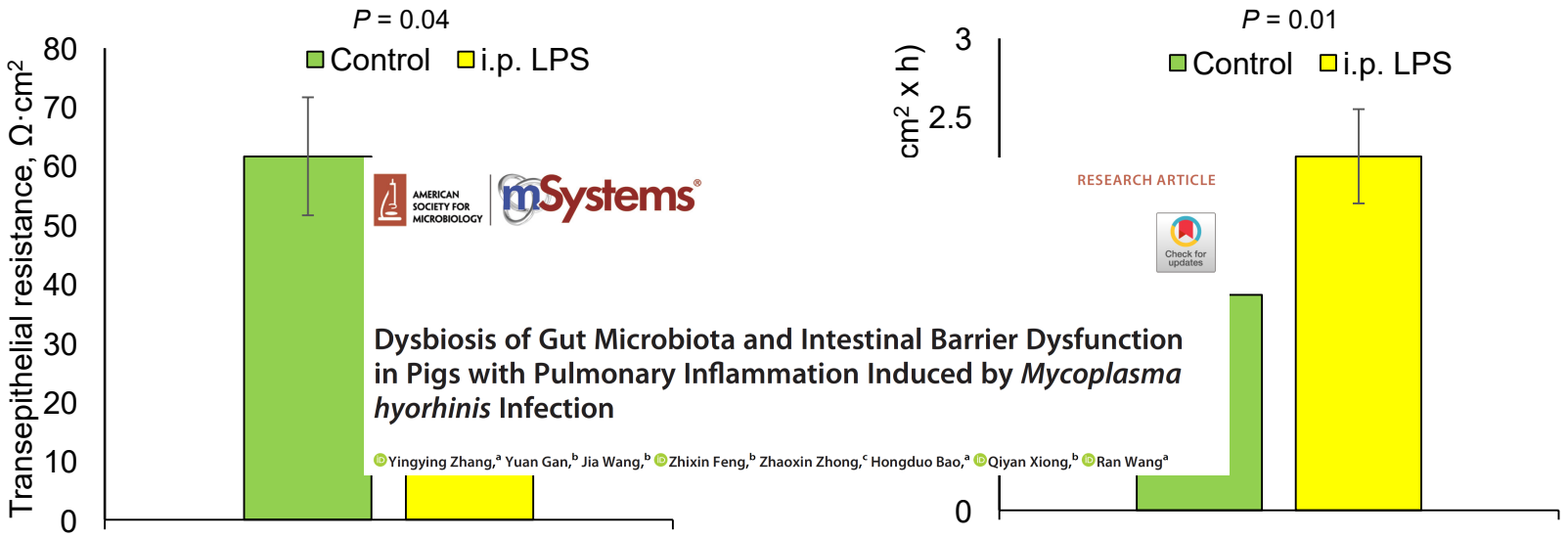






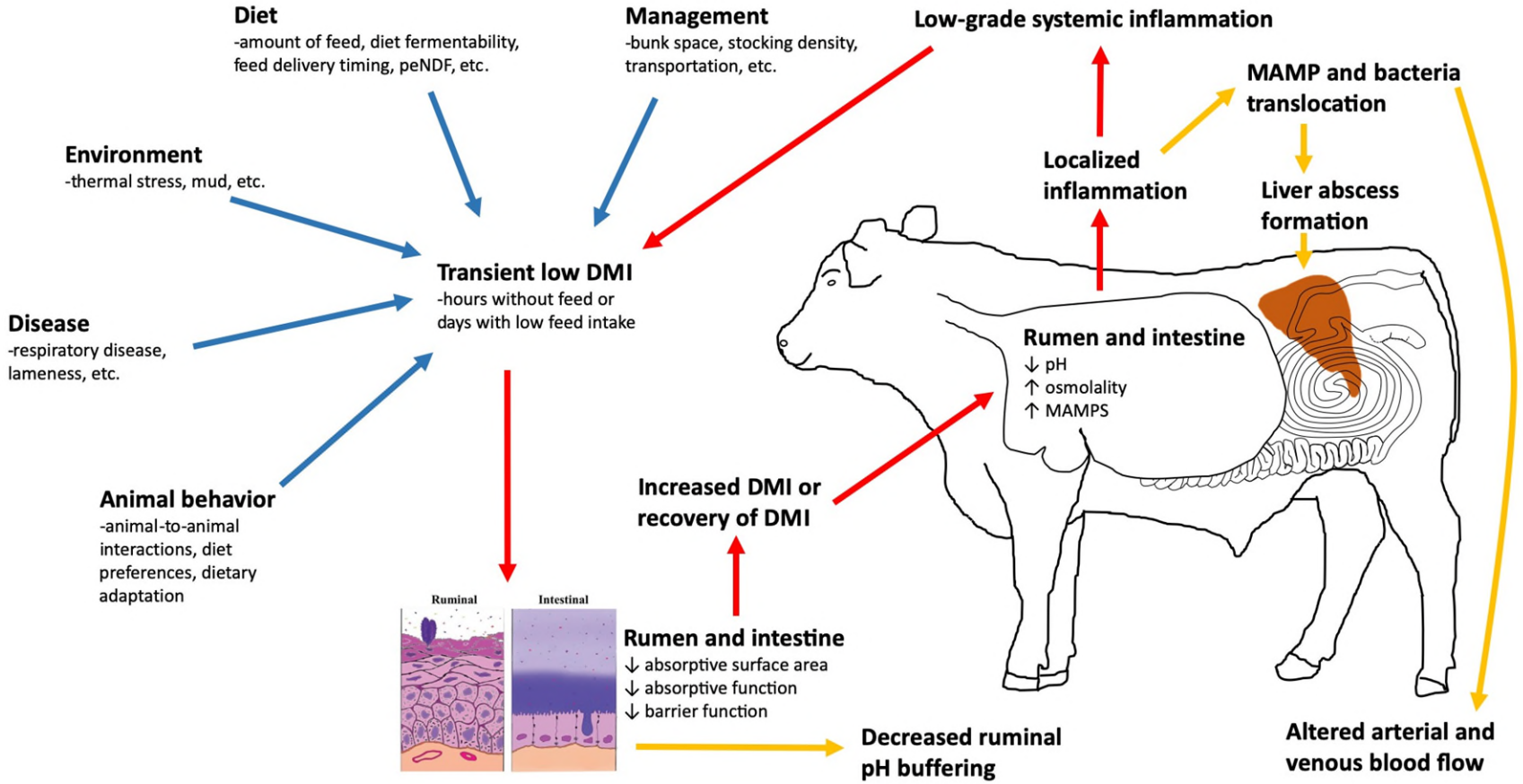
Systemic inflammation affects multiple epithelia and endothelia

- Manheima haemolytica challenge stimulated PDV oxygen consumption (Burciaga-Robles, 2006)
- i.p. LPS in pigs (100 ug/kg BW) increased intestinal permeability



Cao et al., 2018; Inn. Immun.

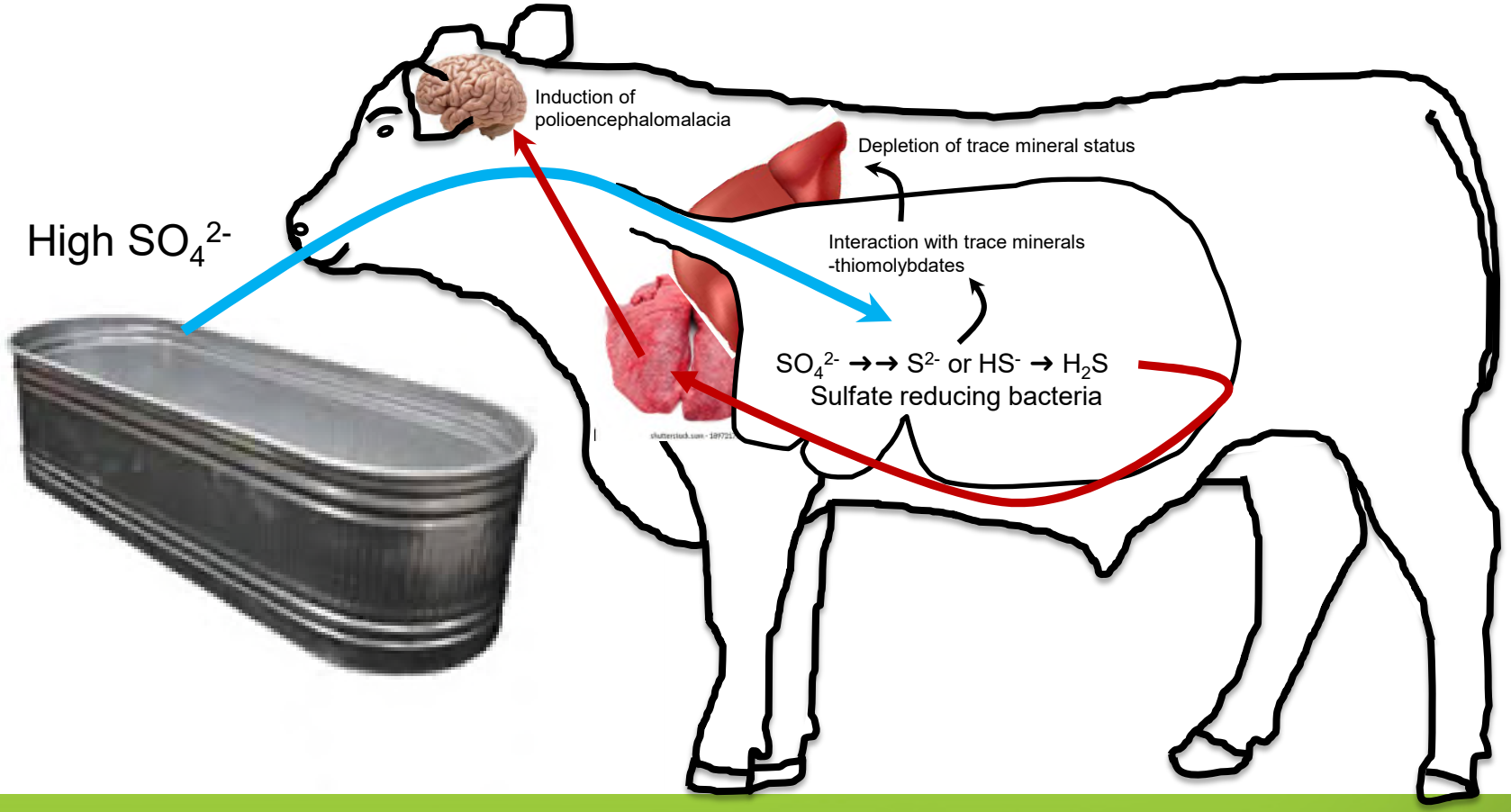
Linking the gut and disease states



Penner, 2020; Rumen Health Compendium

~43% of cattle in SK have copper deficiency (Waldner, 2016)

Managing water quality



Questions

Saskatchewan Ministry of Agriculture
SaskBarley Development Commission
ACIDF Alberta Crop Industry Development Fund Ltd.
ALMA Alberta Livestock and Meat Agency Ltd.
BCRC Beef Cattle Research Council
SCA Saskatchewan Cattlemen's Association
Alberta Beef Producers
Alberta Milk
Saskmilk
SaskCanola Saskatchewan Canola Development Commission
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