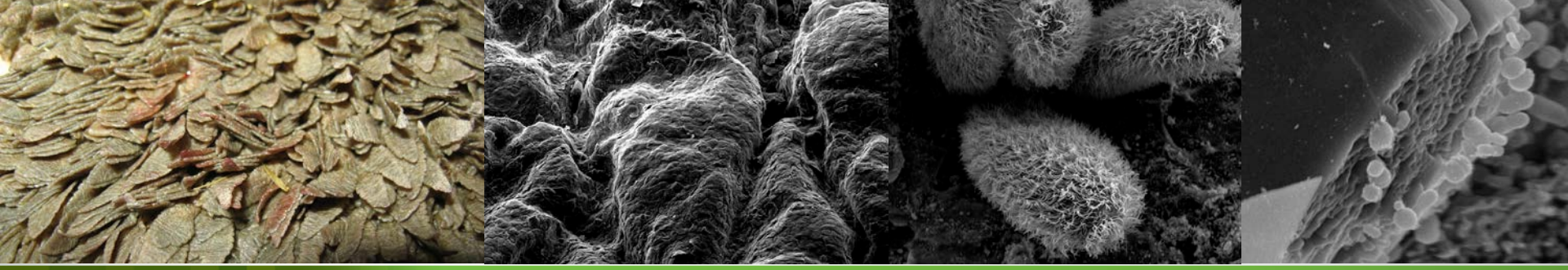


UNIVERSITY OF SASKATCHEWAN

Managing for gut health

Dr. Greg Penner
Associate Professor and Centennial Enhancement Chair in Ruminant Nutritional Physiology
University of Saskatchewan

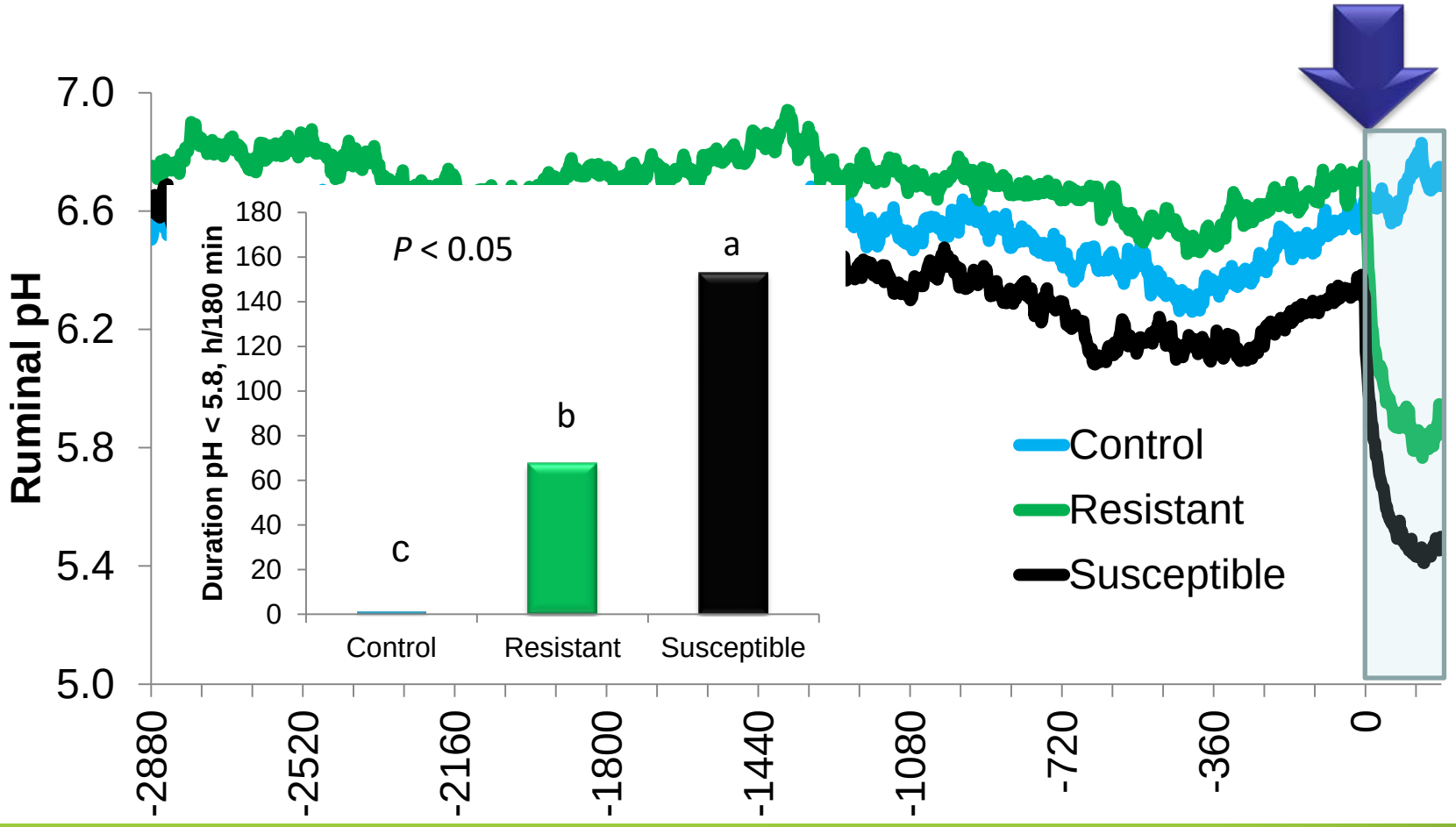
Take-home messages

- A consistent supply of DM and nutrients are required to maintain gut health
- Production responses have not been well characterized but can be extrapolated
- Management strategies to minimize variation in intake may yield greatest rewards
- Recovery following a challenge takes time, but can be accelerated

Requirements of the gastrointestinal tract

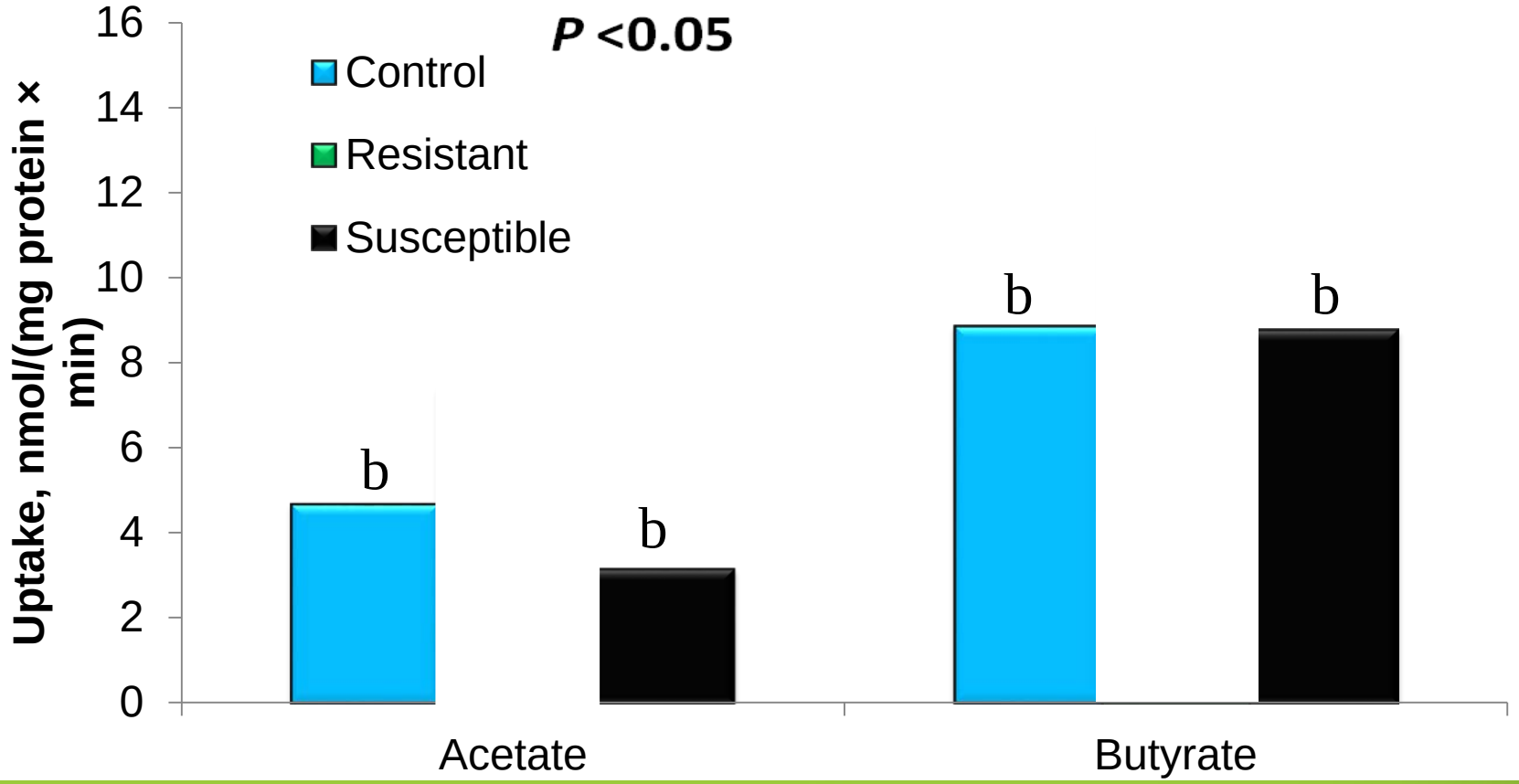
- Absorptive and secretory
  - Supply energy
  - Regulates ruminal pH
  - Urea recycling
- Barrier
  - First arm of the immune response
  - Prevents pathogen and antigen translocation
- Communicative
  - Facilitates cross-talk between host and microbiota
  - Nutrient sensing

Why is there variation in rumen pH?



Penner et al., 2009

Greater absorption reduces risk for low pH

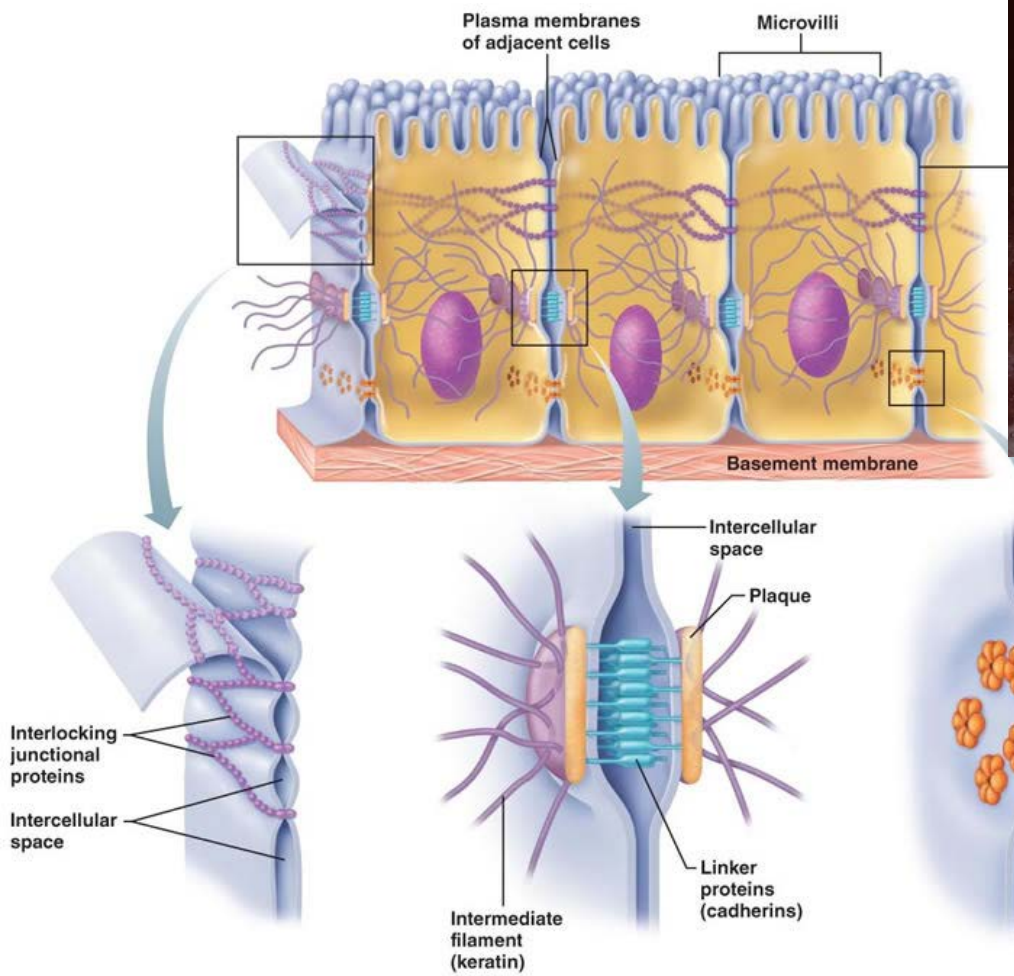


Penner et al., 2009

Barrier function

- Ability to promote selective permeability
  - Allow absorption of nutrients
  - Prevent movement of non-desired compounds, toxins, enteric flora
- Damage occurs in two forms
  - Lesions
  - Compromised tight-cell junctions

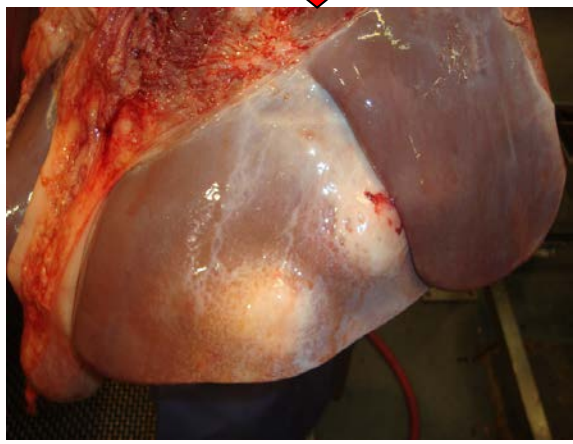
Barrier function



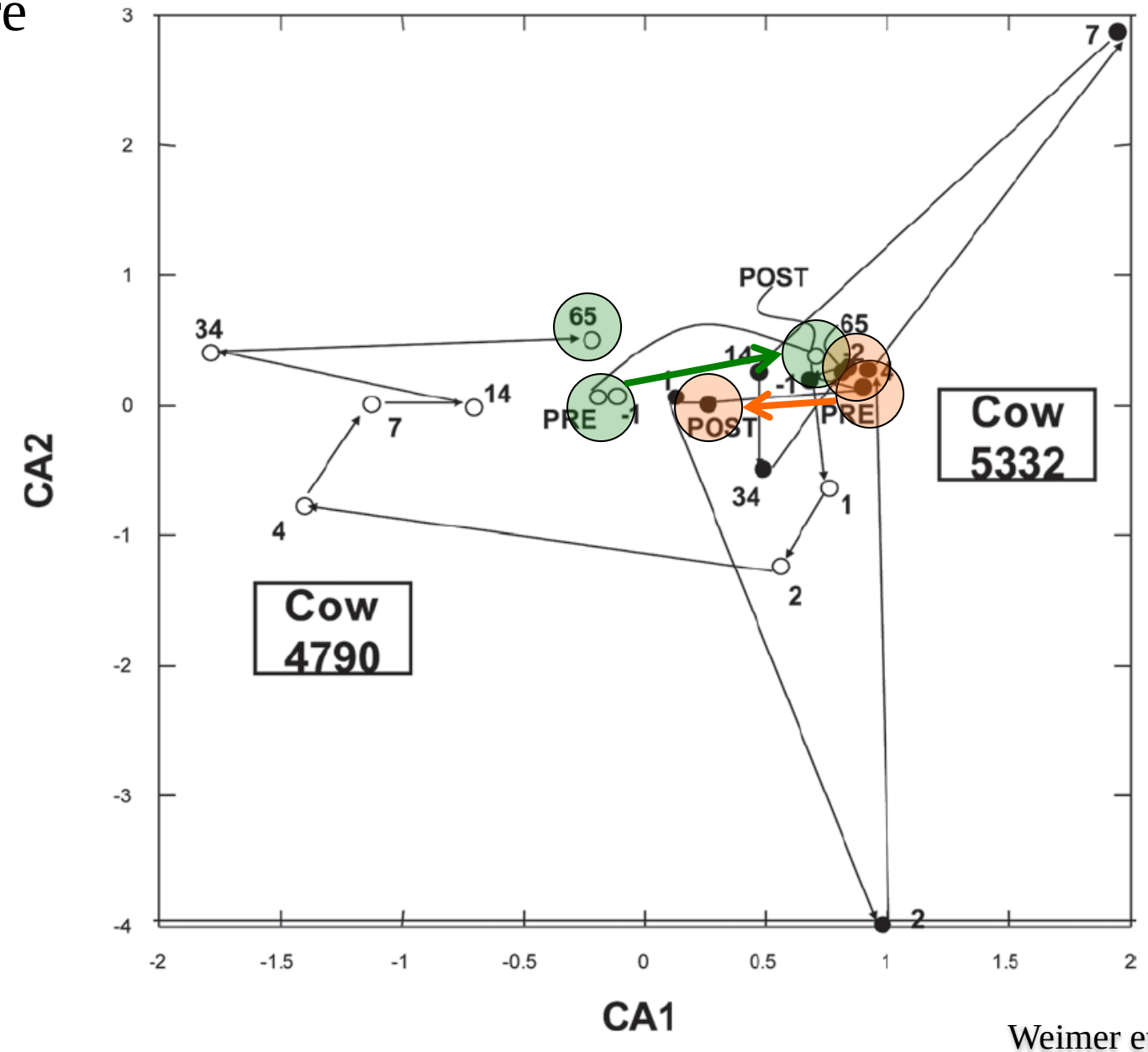
(a) Tight junctions: Impermeable junctions prevent molecules from passing through the intercellular space.

(b) Desmosomes: Anchoring junctions bind adjacent cells together like a molecular "Velcro" and help form an internal tension-reducing network of fibers.

(c) Gap junctions: Communicating junctions allow ions and small molecules to pass for intercellular communication.

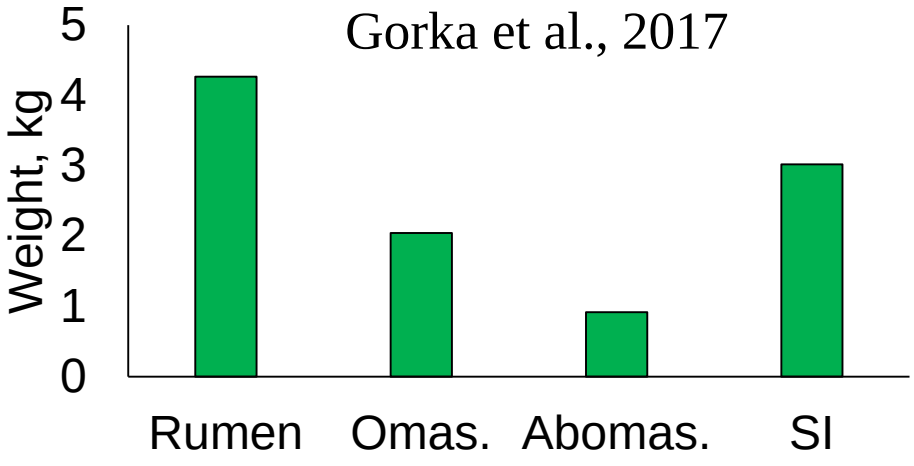


Evidence supporting stability in the rumen microbial community structure



Weimer et al., 2010; JDS

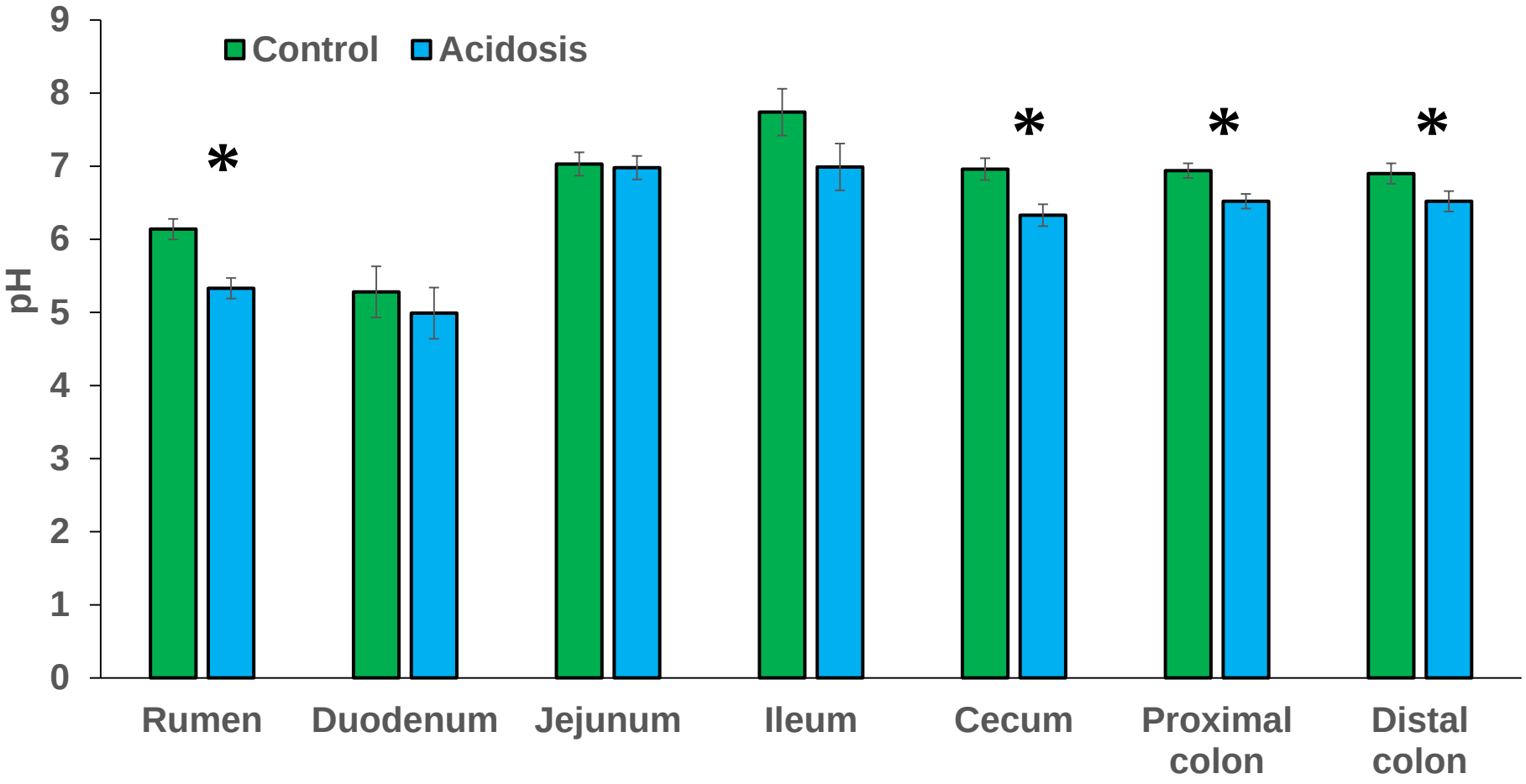
Gut health is more than just the rumen



Region	Length, m
Duodenum	0.53
Jejunum	21.62
Ileum	0.80
Cecum	0.22
Colon	4.63
Total	27.80
Length in ft	91.2

Watanabe et al., unpublished

Rumen acidosis: more than just the rumen!



Pederzolli, unpublished

What is gut health?

Efficient nutrient absorption

Good barrier function

Good types of microbes

Regulated pH

Good fibre digestion capability

Optimal bacterial protein production

Large rumen papillae

Adequate capacity

Balanced residence time and passage rate

What is gut health?

Forage-based

Attributes

- Active and regulated microbial community (fibre digestion)
- Nutrient absorption
- Barrier function

Requirements

- Consistent supply of dry matter and nutrients

Concentrate-based

Attributes

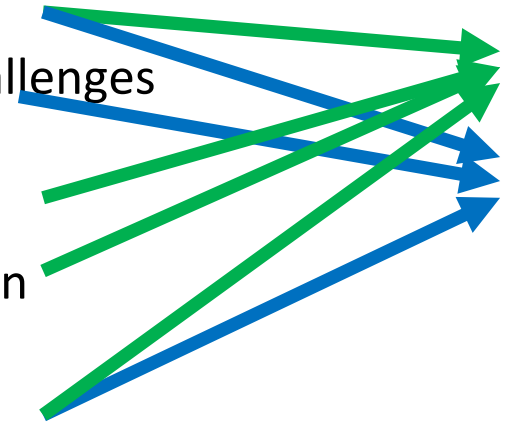
- Active and regulated microbial community (starch digestion)
- Nutrient absorption
- Barrier function

Requirements

- Consistent supply of dry matter and nutrients

Challenges to gastrointestinal function?

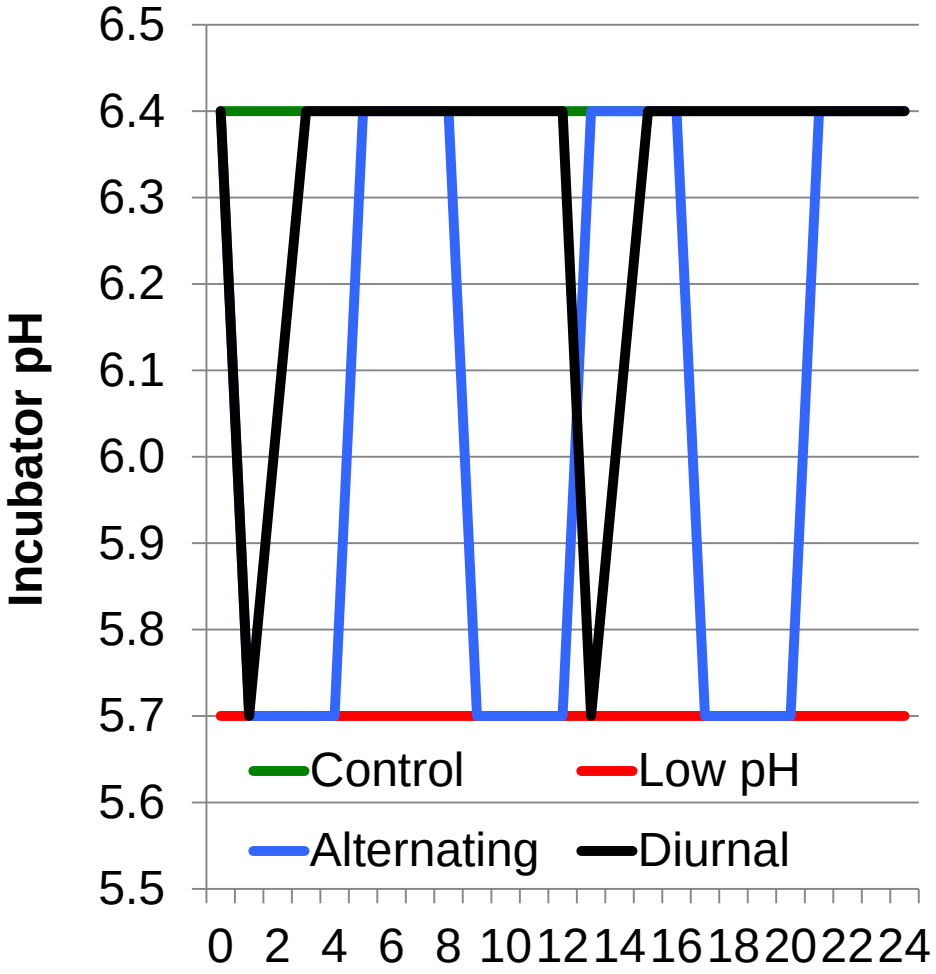
- Inherent challenges within current production settings
  - Management
    - Weaning
    - Dietary challenges
  - Environment
    - Heat stress
    - Competition
  - Physiological
    - Parturition

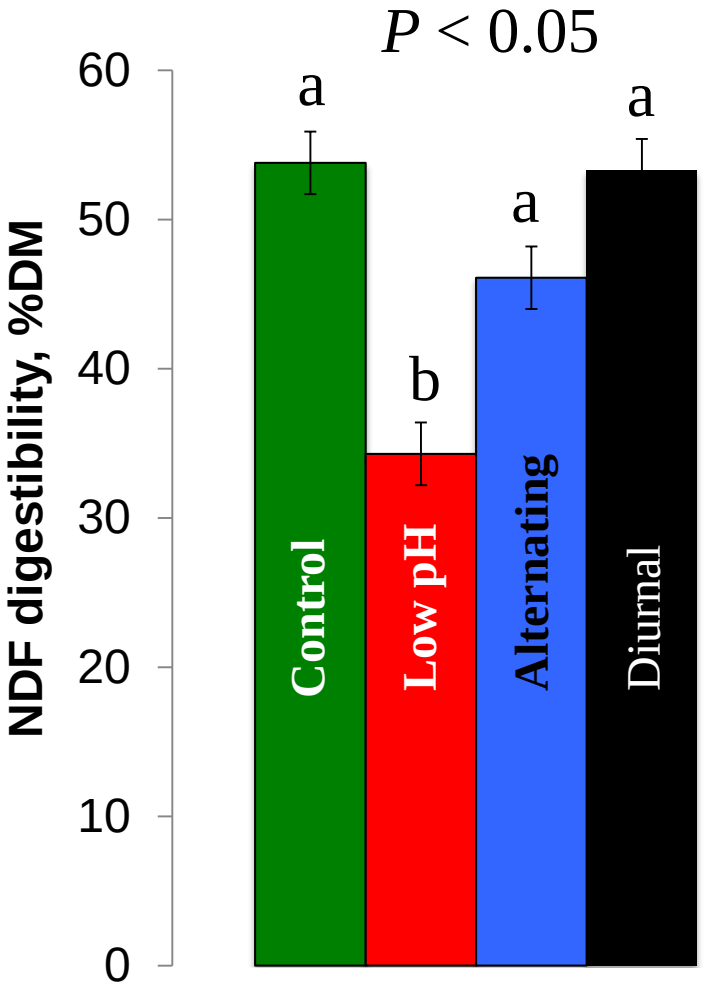


Low/transient low feed intake

Rapid dietary change / induction of rumen acidosis

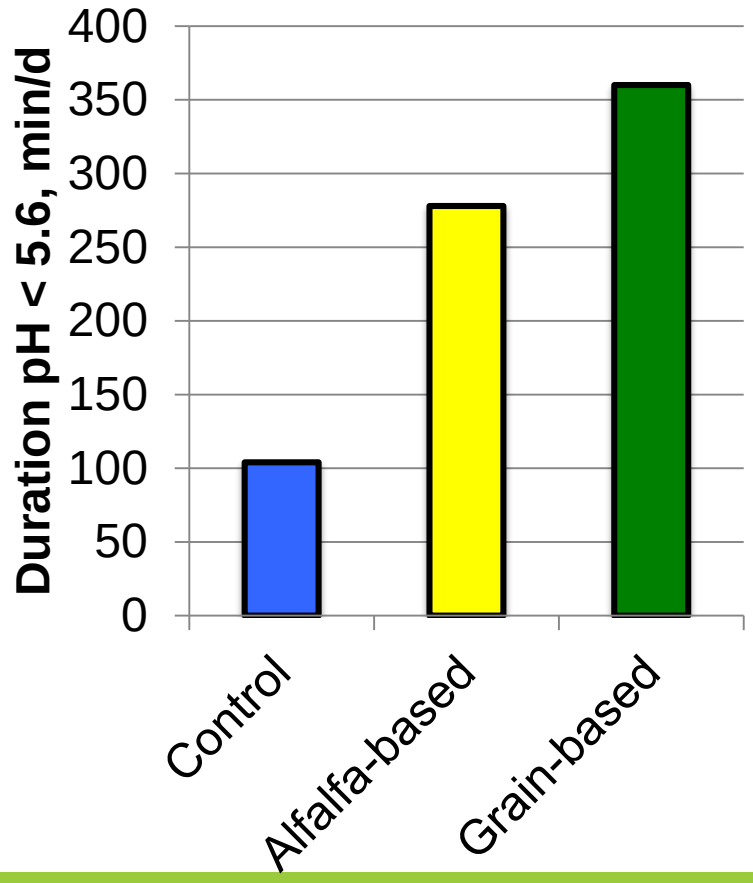
Direct effects of ruminal acidosis

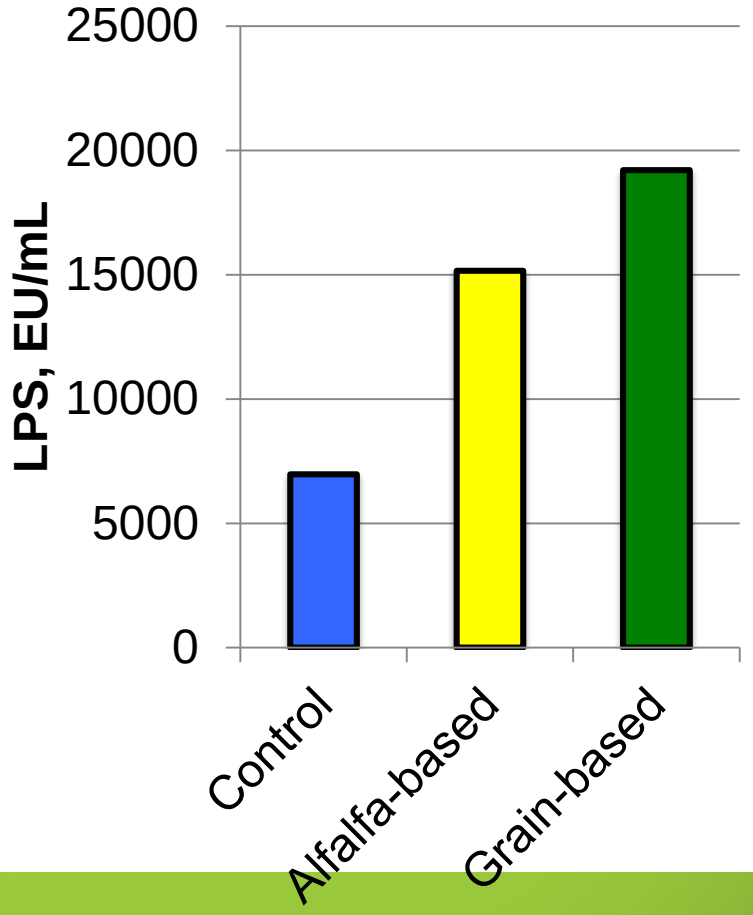




Calsamiglia et al., 2002; JDS

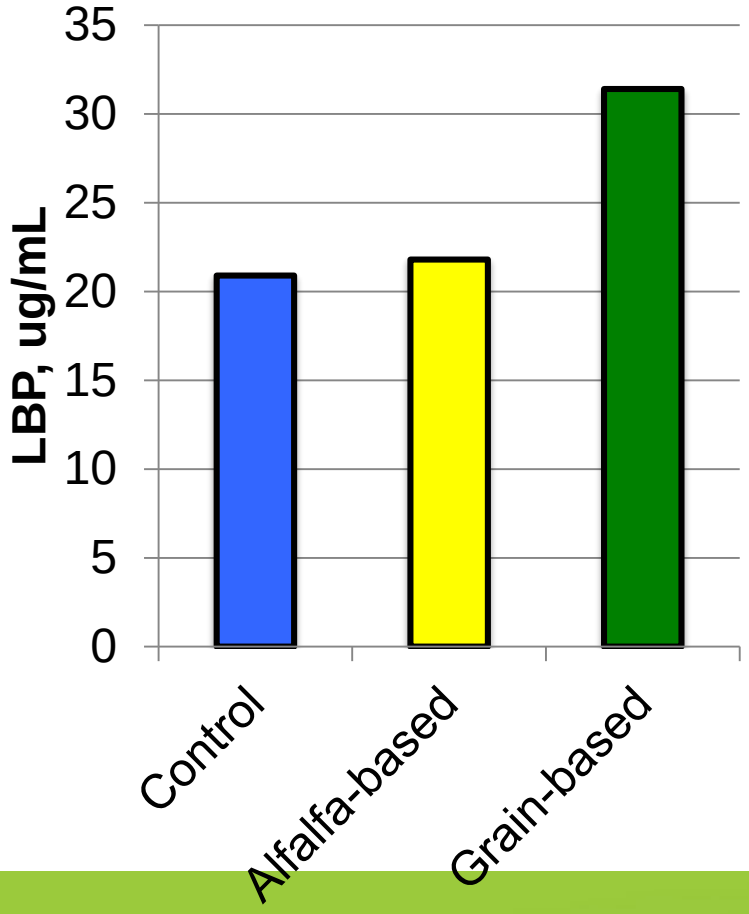
Low pH induces an inflammatory response

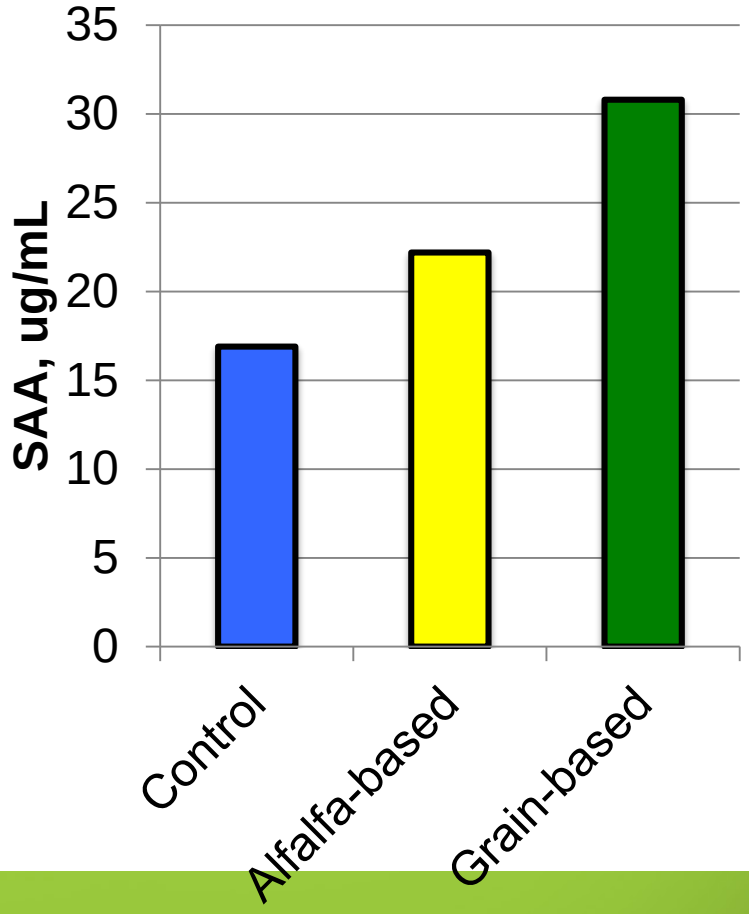




Khafipour et al., 2012: CJAS

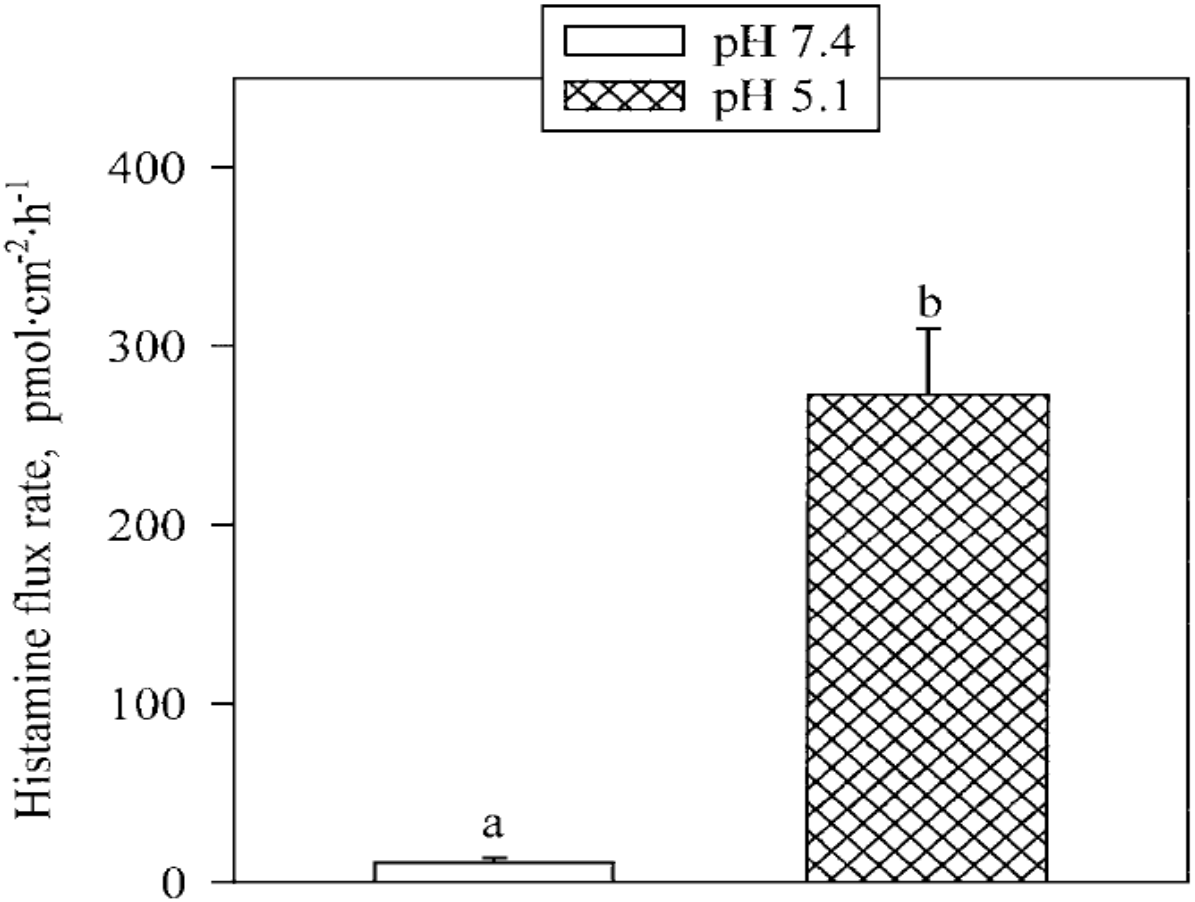
Low pH induces an inflammatory response





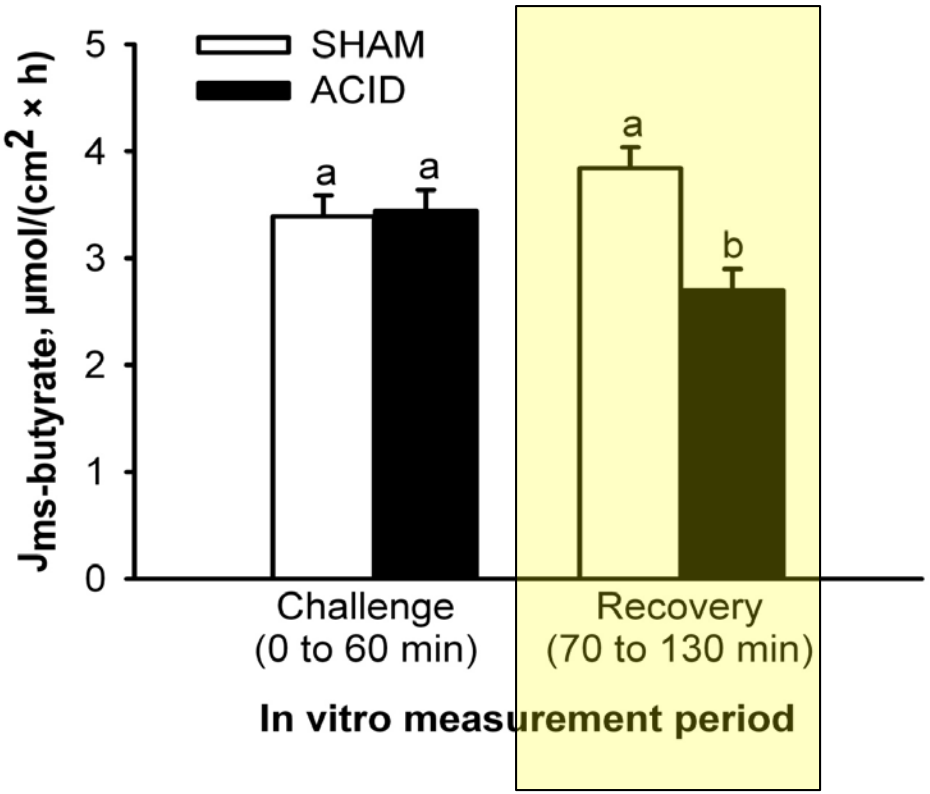
Khafipour et al., 2012: CJAS

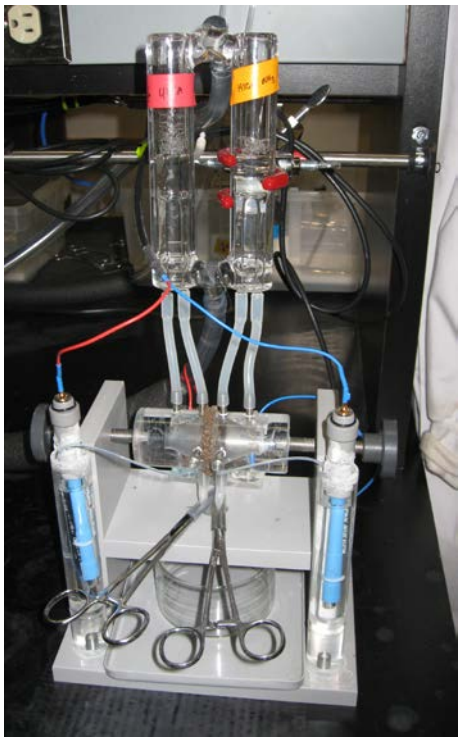
Barrier function of the rumen epithelium



Aschenbach and Gäbel, 2000; JAS

Acidification impairs absorption

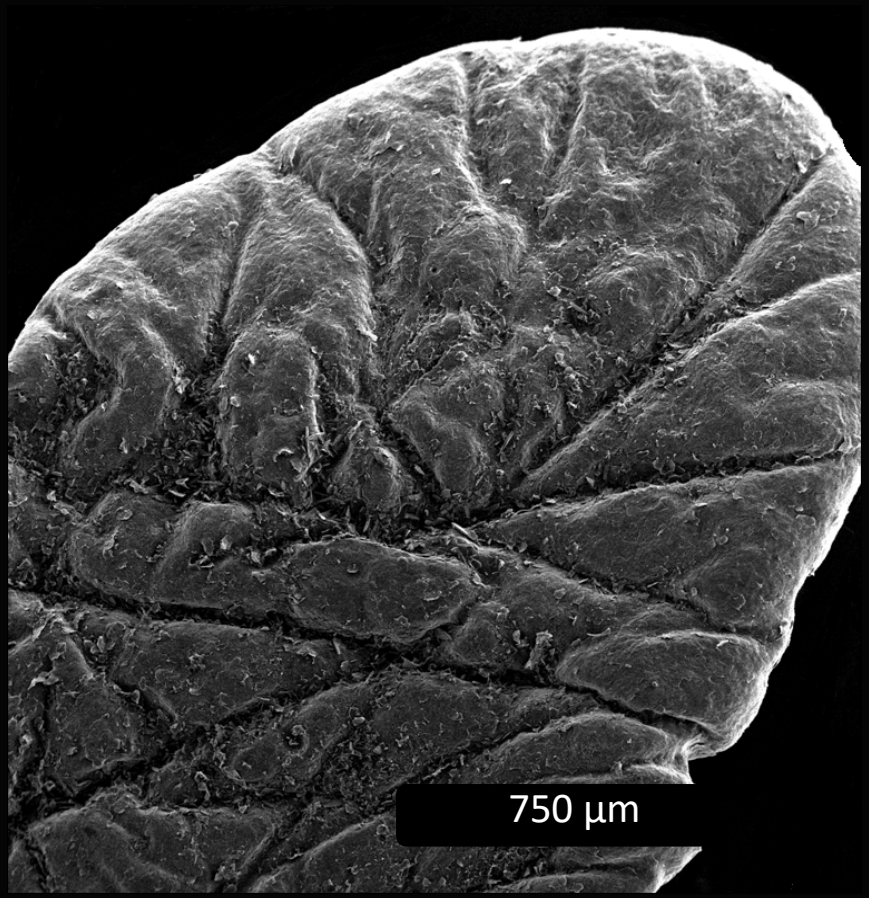


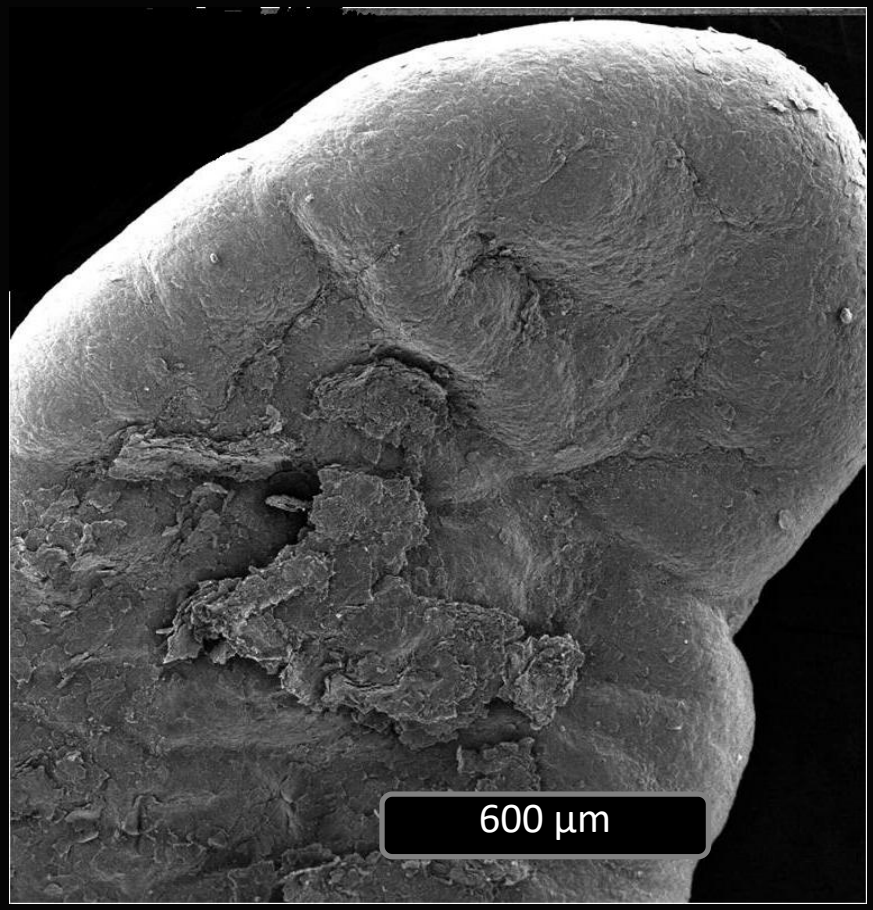


Wilson et al., 2012; JAS

CONTROL

ACIDOSIS

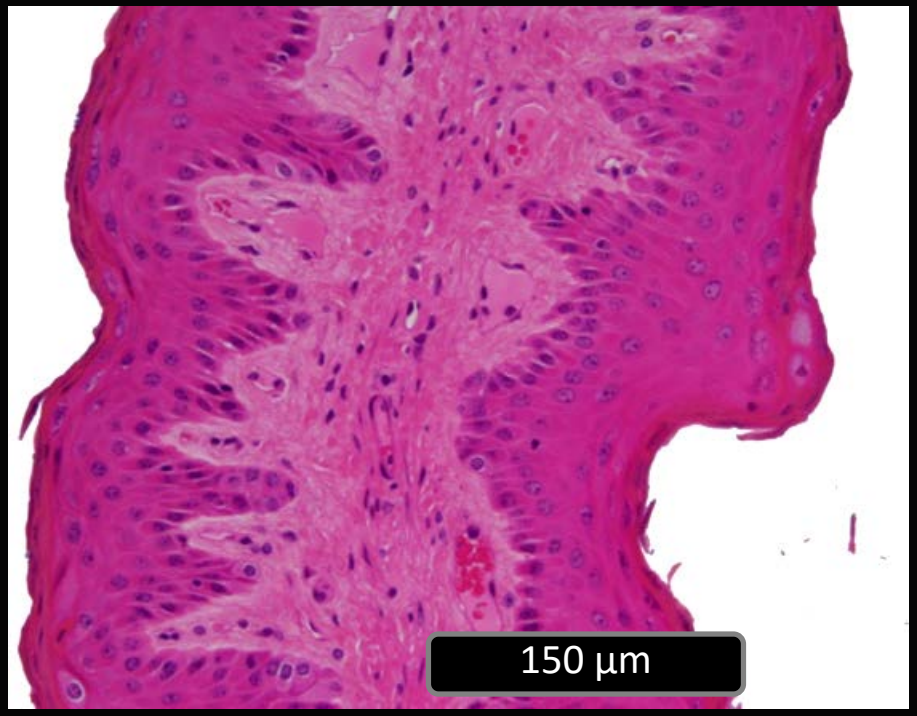




Steele et al., 2009

CONTROL

ACIDOSIS



Steele et al, 2009

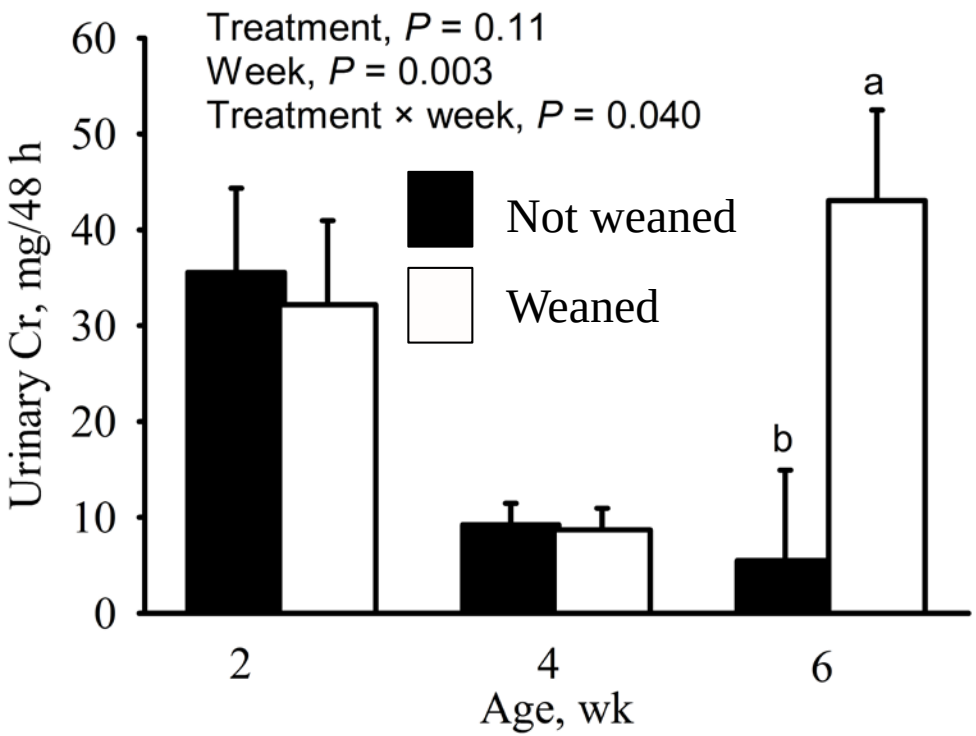
Inconsistent nutrient supply: the real challenge for gut health

- Variation in DMI and nutrient intake alters:
  - Nutrient supply for microbes
  - Growth response and antigen release
  - Nutrients available for cattle
  - Function of the rumen and whole gut

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

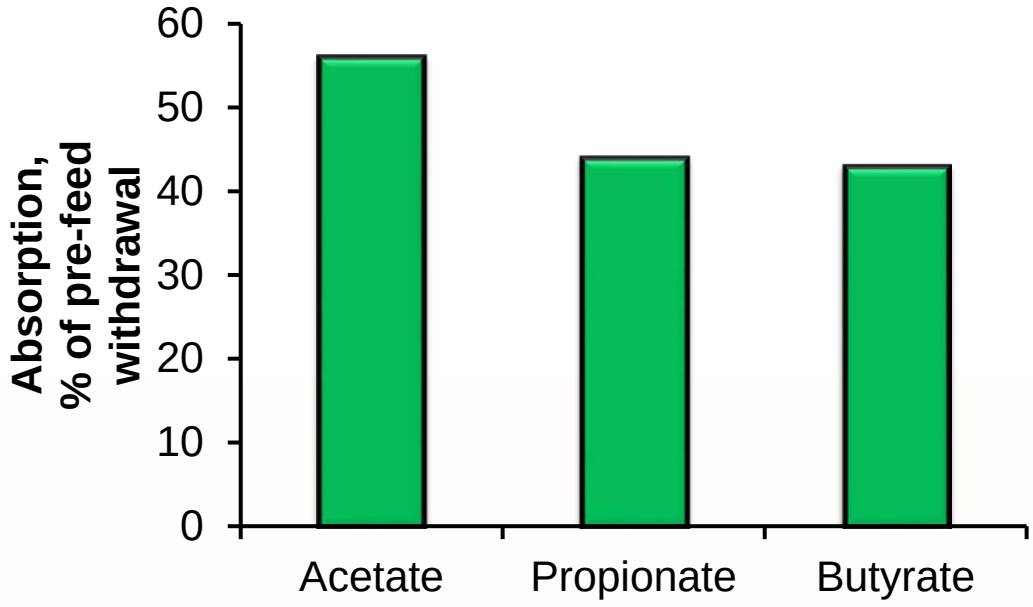


Wood et al., 2015: JDS

Low feed intake for newly received feedlot cattle

	Week relative to arrival		
Variable	**1st week**	**2nd week**	**3rd and 4th weeks**
DMI (% of BW)	**0.5% to 1.5%**	**1.5% to 2.5%**	**2.5% to 3.5%**

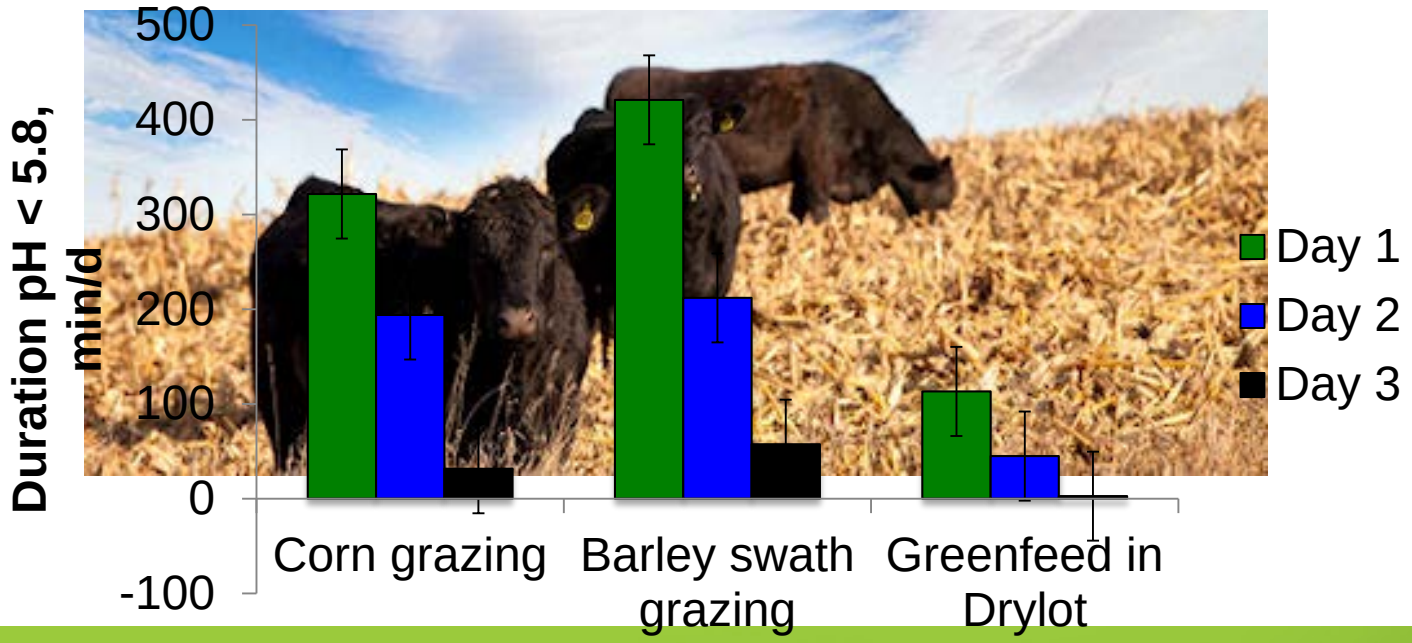
Hutcheson and Cole, 1986; JAS



Gäbel et al., 1993

Variation in nutrient supply: beef cow example

- Swathgrazing – forage allocation cycle
  - 3 d/paddock or longer



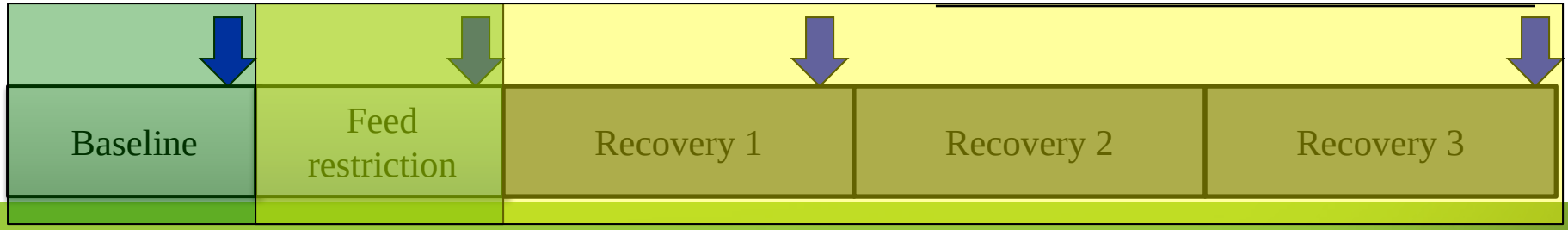
Jose, Penner, McKinnon, Lardner, unpublished

Information Required

- Does the severity of short-term feed restriction affect the absorptive and barrier functions of the gastrointestinal tract?
- Does the severity of short-term feed restriction affect recovery of absorptive and barrier function?
- Can we manipulate the diet to mitigate the response?

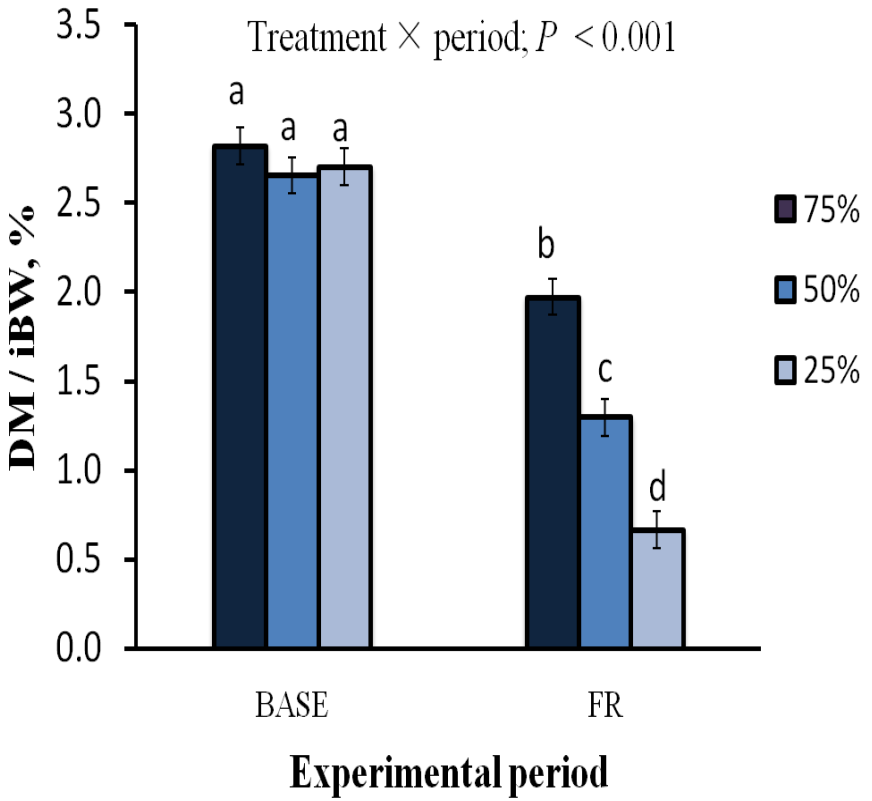
- 18 cannulated Angus heifers
  - 3 treatments
    - 75% of feed ad libitum
    - 50% of feed ad libitum
    - 25% of feed ad libitum
- 5 periods

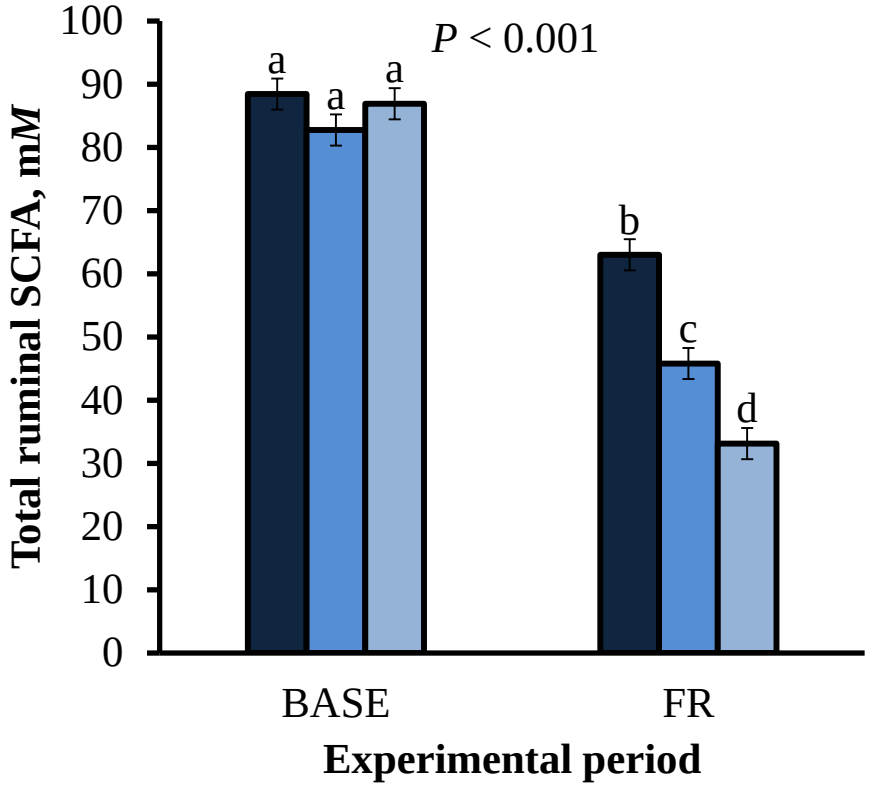
Ingredient , % of DM	
Barley silage	30
Grass-Alfalfa hay	30
Barley grain (rolled)	32
Pellet	8
Nutrient composition	
DM,%	65.8 ± 1.9
OM,% of DM	92.3 ± 1.2
CP,% of DM	11.2 ± 0.4
Fat, % of DM	1.8 ± 0.0
NDF,% of DM	40.1 ± 0.4



Zhang et al., 2013; JAS

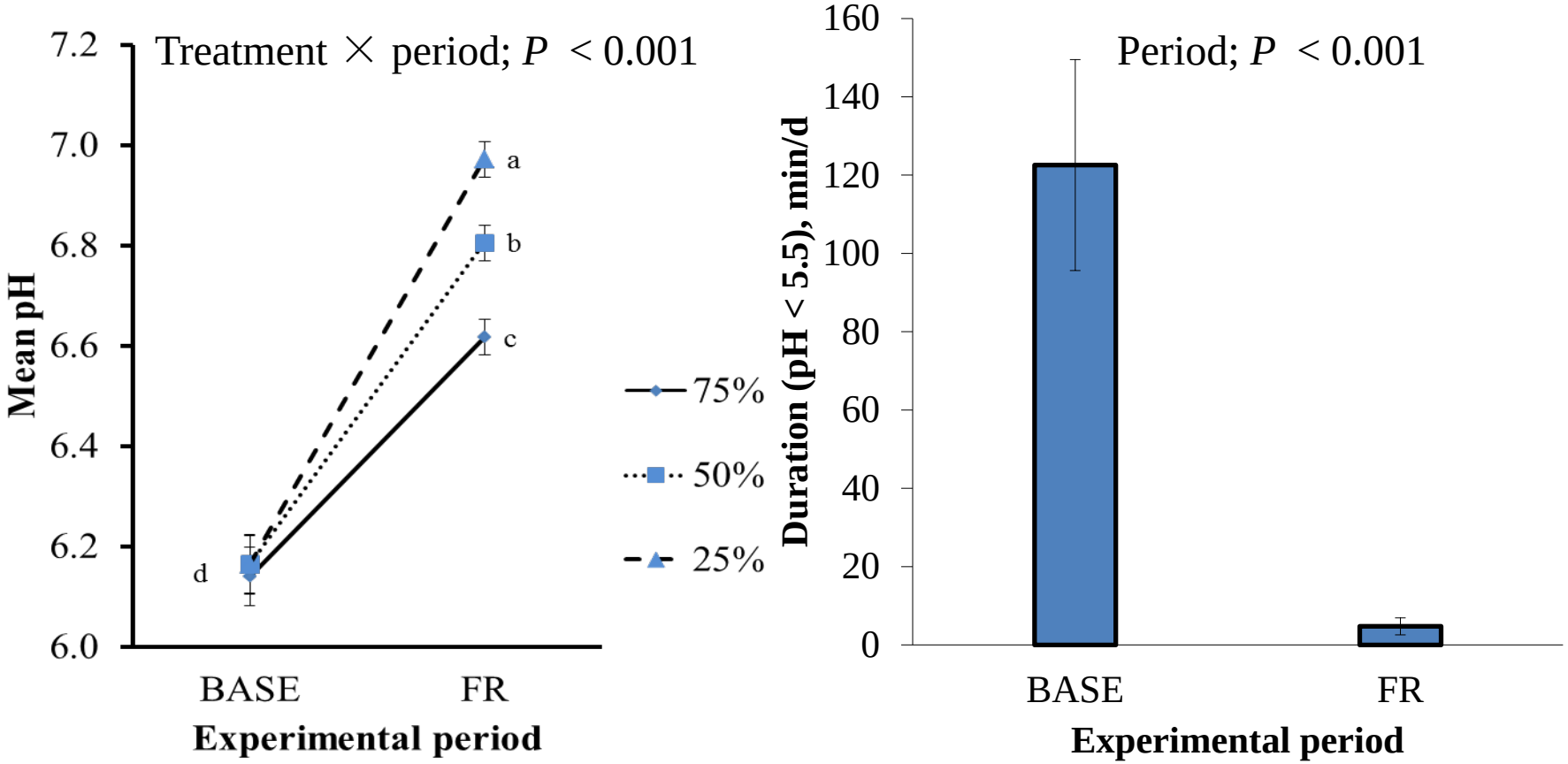
Feed restriction decreases the VFA (nutrients for cows) in the rumen





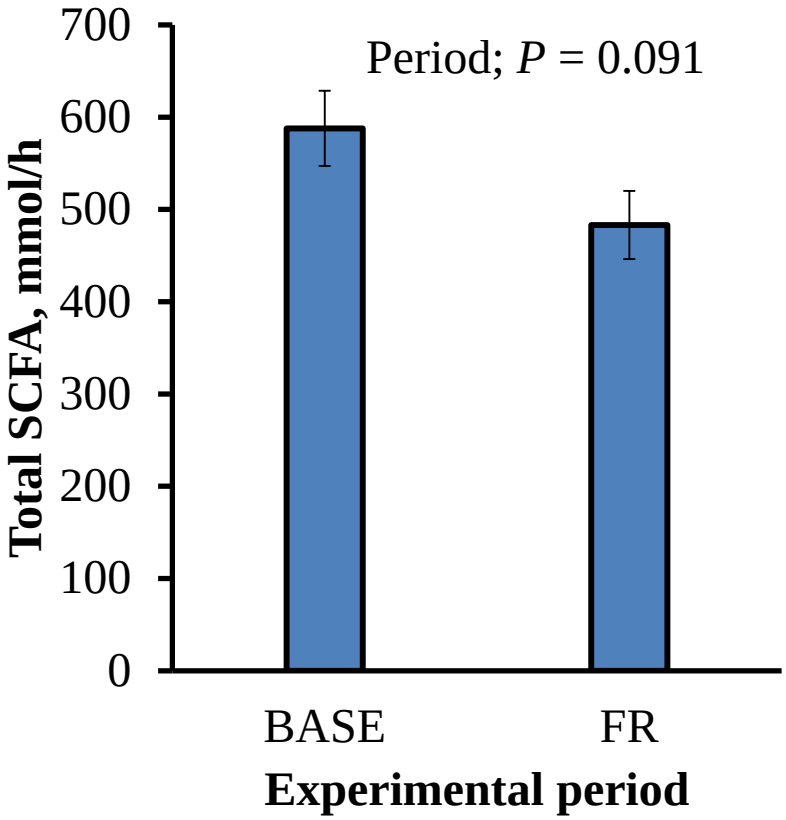
Zhang et al., 2013

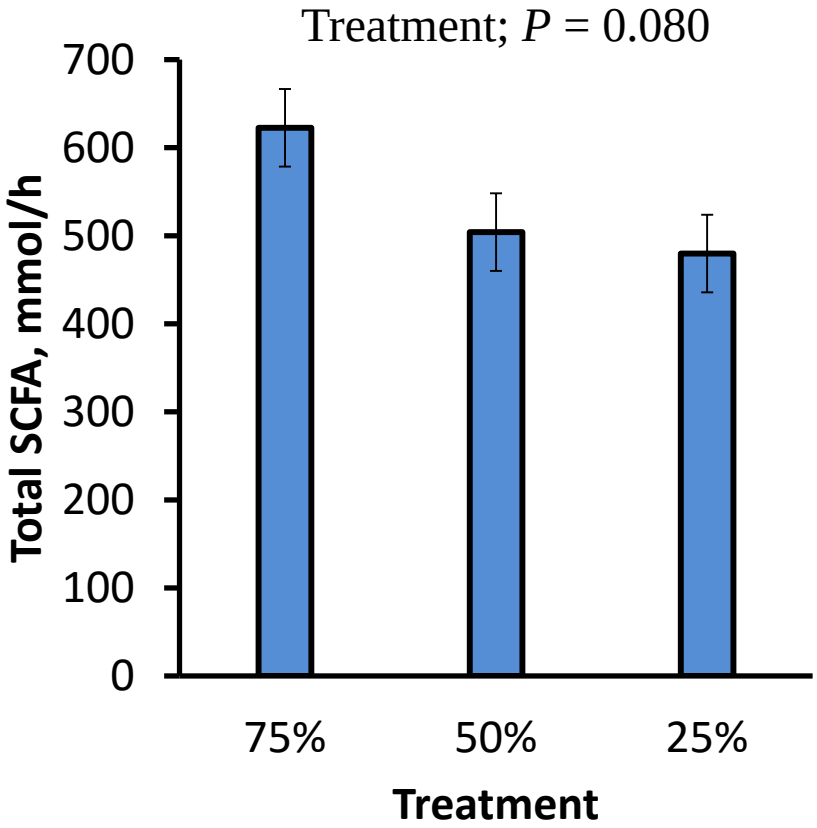
Rumen pH increases during feed restriction



Zhang et al., 2013

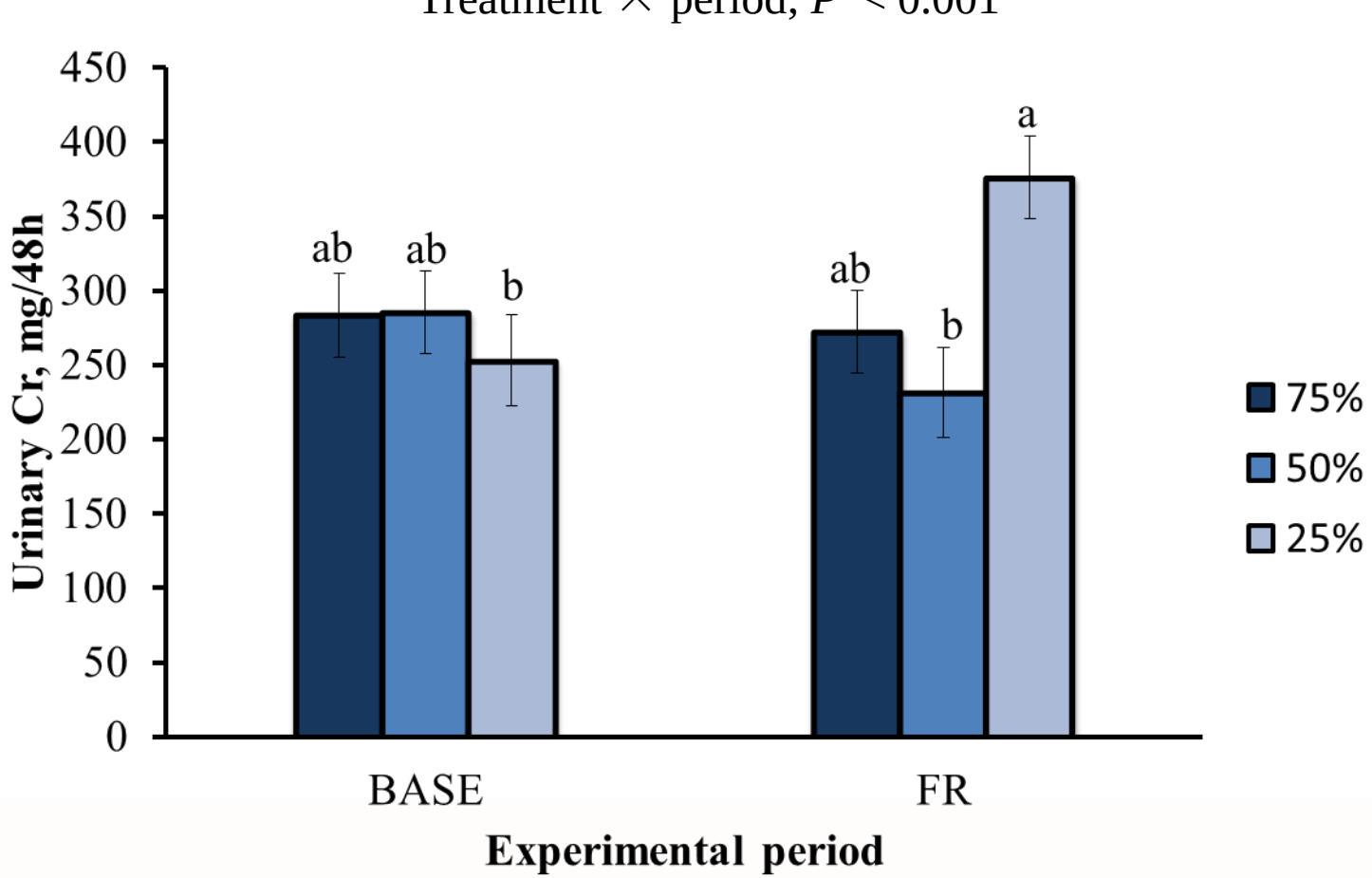
Nutrient absorption is reduced with feed restriction





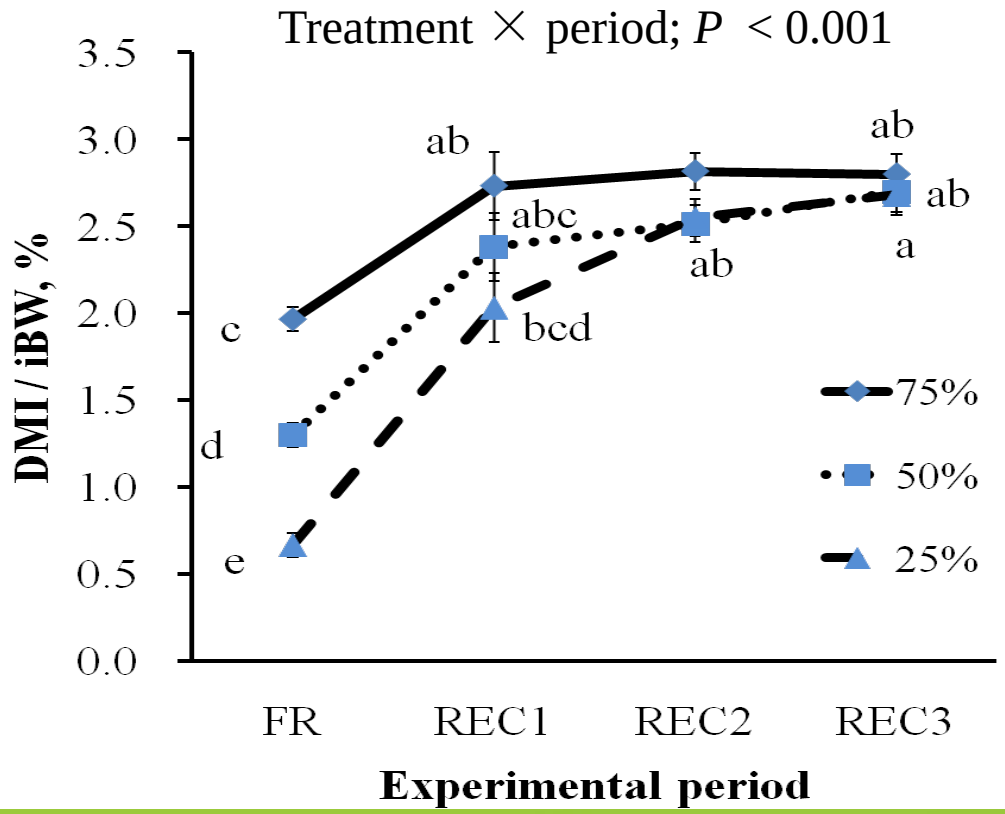
Zhang et al., 2013

Barrier function of the gut is reduced with feed restriction



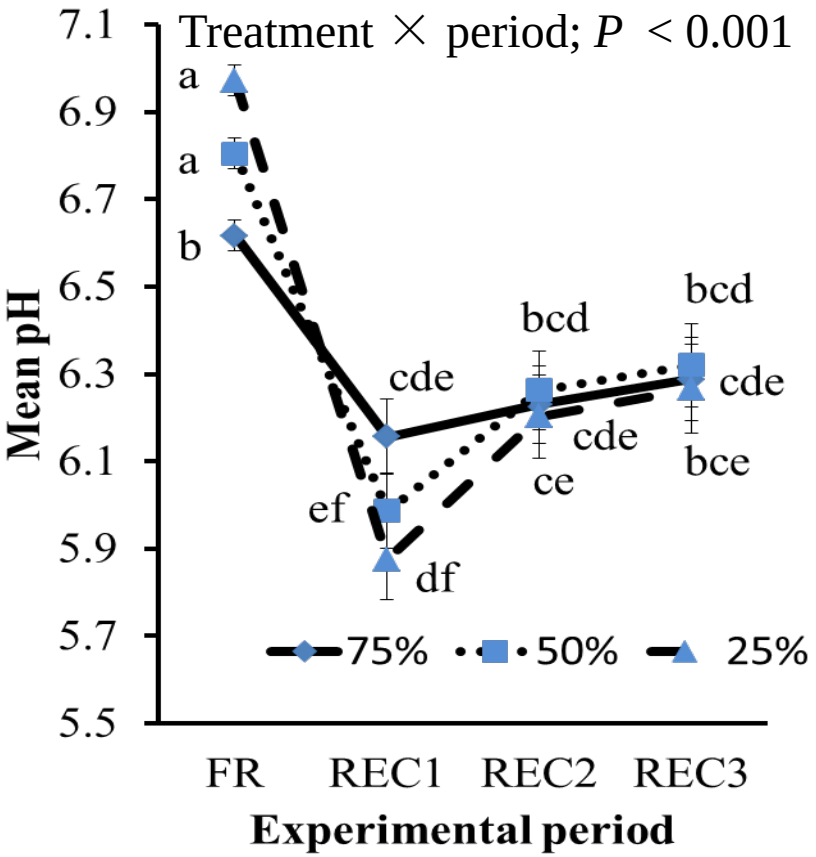
Zhang et al., 2013

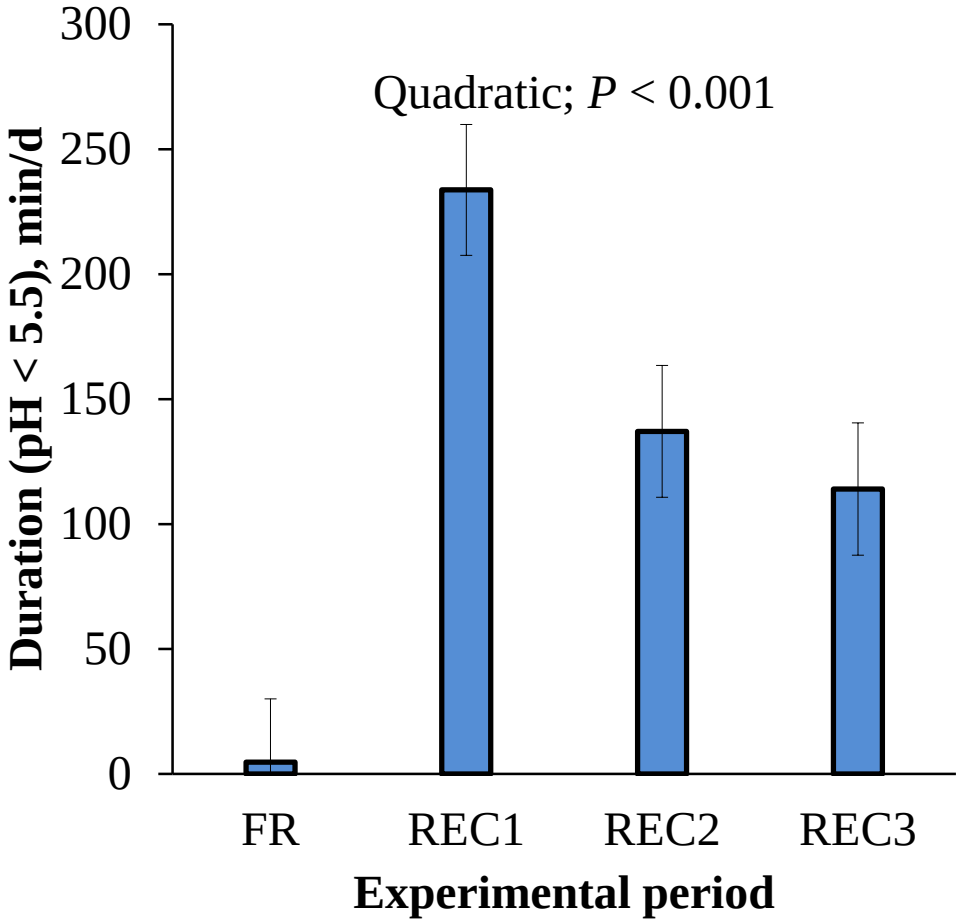
Feed restriction impacts cattle when they return to full feed conditions



Zhang et al., 2013

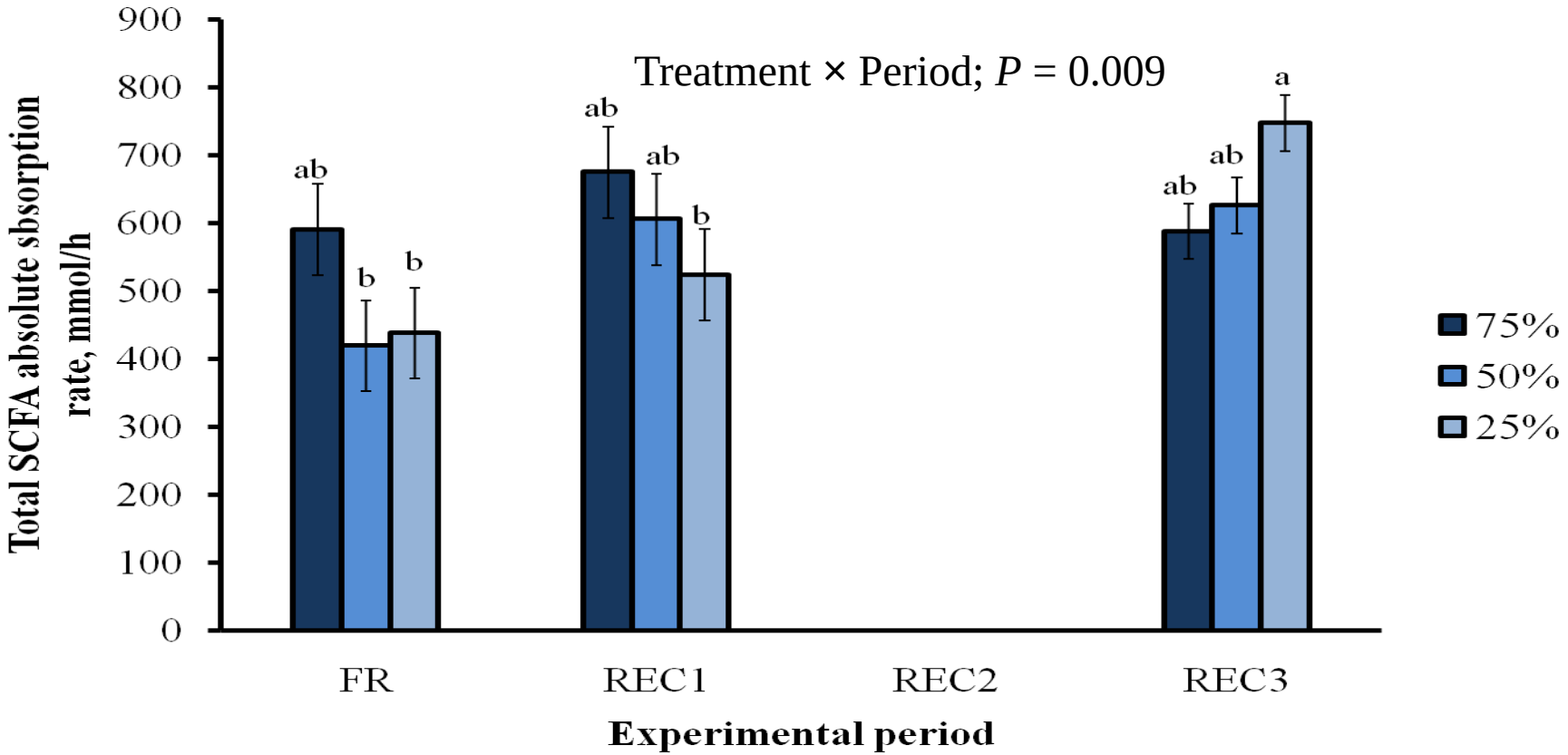
Ad libitum feeding after feed restriction induces rumen acidosis





Zhang et al., 2013; JAS

Absorption capability did not recover until about 3 wk after feed restriction

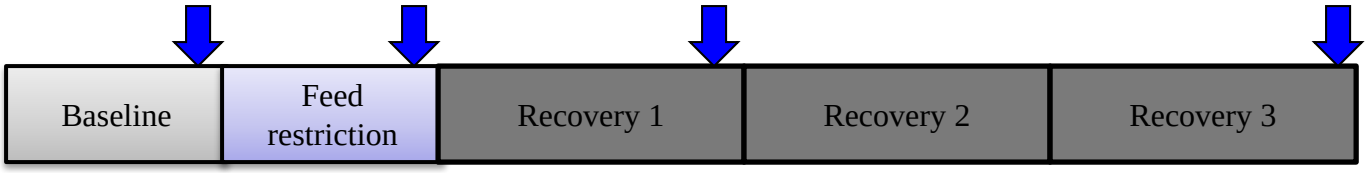


Management strategies to improve gut health

- Consistent feed supply that meets nutrient requirements
  - Good husbandry, bunk management, grain processing
- Feed additives that help to stabilize rumen fermentation
  - Ionophores, yeast, probiotics, essential oils, etc.
- Can we predict the low feed intake event?
  - Recovery diets?

Can We Mitigate the Response by Changing the Forage-to-Concentrate Ratio?

- Animals and Experimental Design
- 20 cannulated Angus heifers
  - 4 treatments
    - High forage/High forage
    - High forage/Moderate forage
    - Moderate forage/High forage
    - Moderate forage/Moderate forage



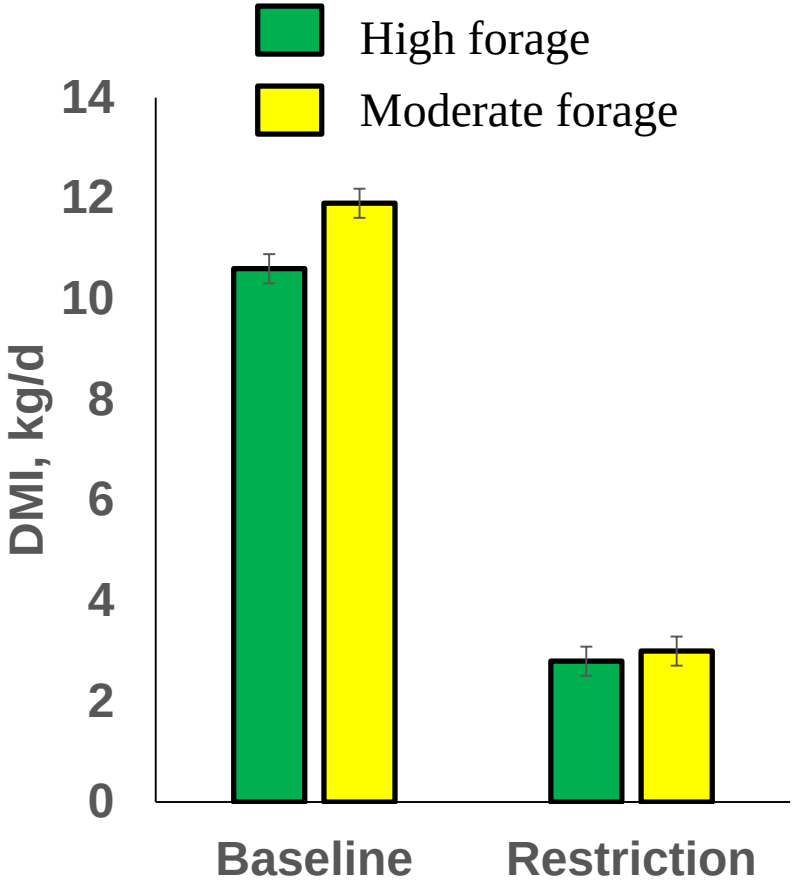
Albornoz et al., 2013

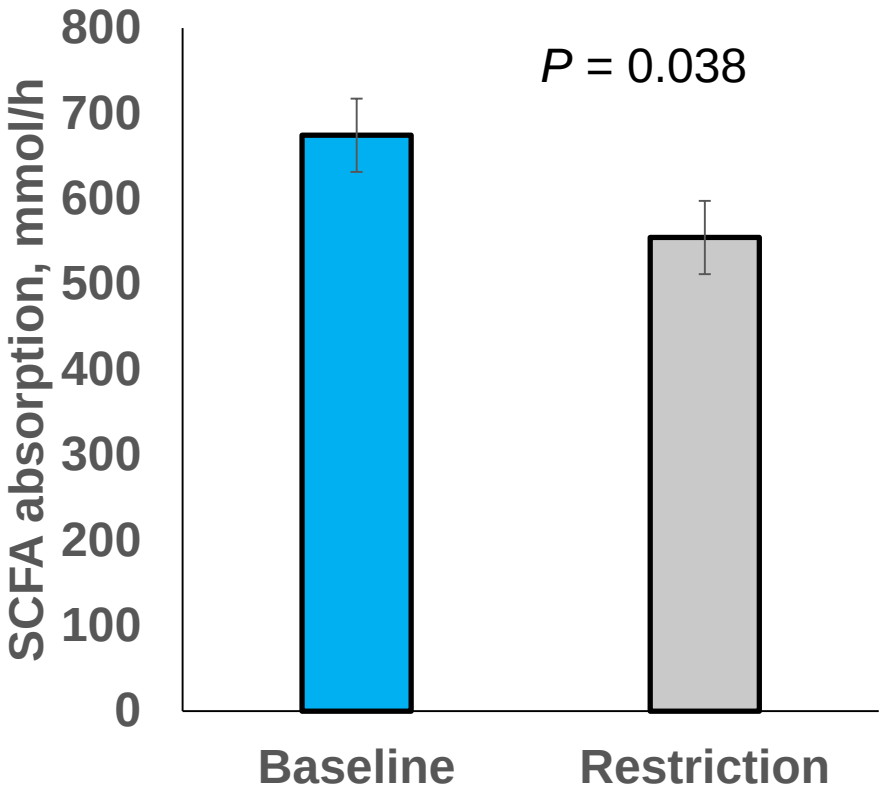
Role of forage in recovery after low feed intake

	Treatment[1]	
	HF	MF
Ingredient, % of DM		
Grass hay	46	30
Barley silage	46	30
Barley grain	0	32
Pellet[2]	8	8
Chemical composition,[3] g/kg ± SD		
DM	584 ± 69.7	557 ± 47.3
OM	907 ± 2.3	925 ± 1.9
CP	107 ± 5.7	111 ± 5.4
Crude fat	21 ± 0.4	19 ± 0.7
NDF	527 ± 4.6	405 ± 1.4
ADF	291 ± 5.4	209 ± 4.5
NEm,[4] MJ/kg	4.61	6.09
NEg,[4] MJ/kg	2.03	2.21

Albornoz et al., 2013; JAS

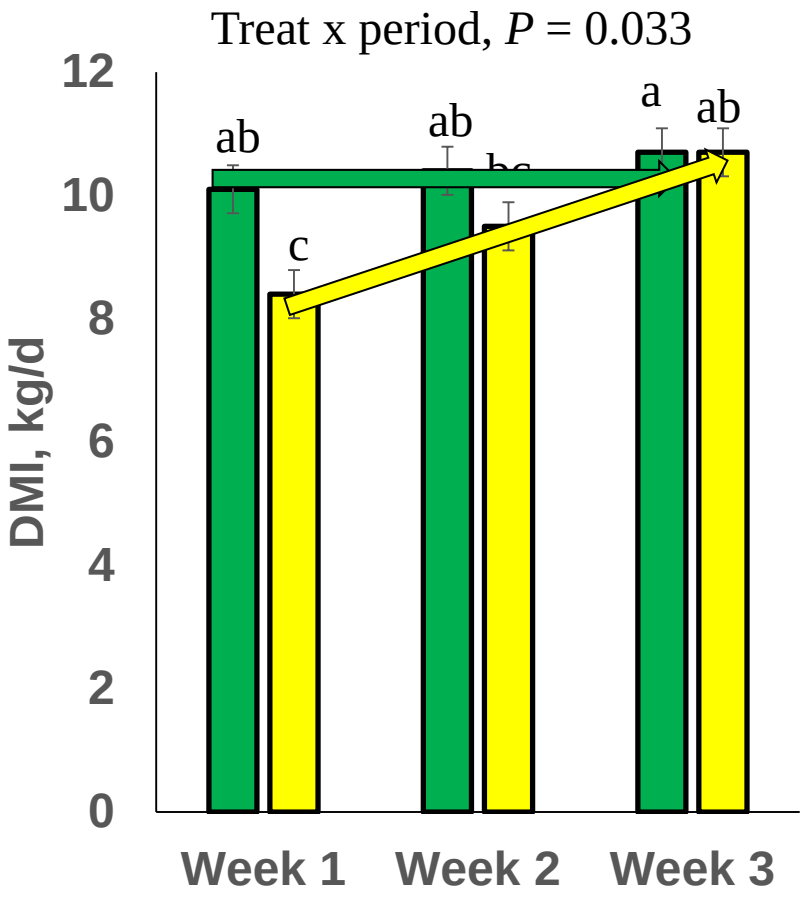
Low feed intake decreases SCFA absorption

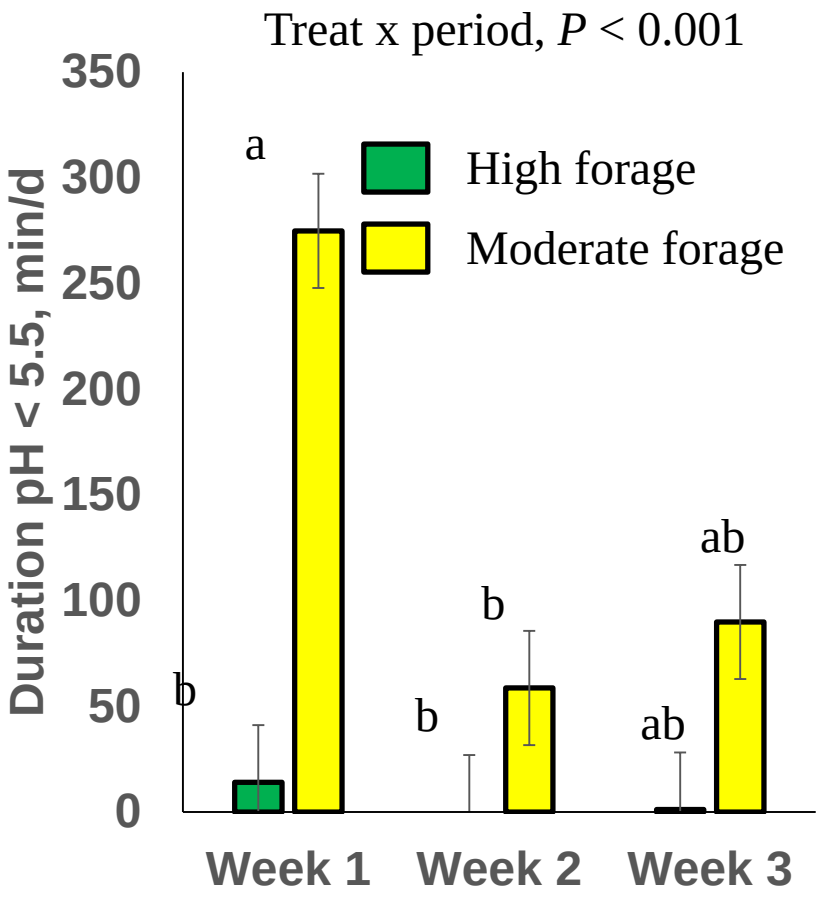




Albornoz et al., 2013; JAS

Feeding a high forage diet improves recovery





Albornoz et al., 2013; JAS

Nutritional strategies to accelerate recovery of the gastrointestinal tract (GIT)

- Several nutrients may help promote GIT function
  - Butyrate Gorka et al., 2013; Kawalski et al., 2015
  - Betaine
    - Coccidia infection Kettunen et al. 2001; Fetterer et al. 2003
  - Antioxidants
    - Superoxide dismutase benefits GIT in mice Vouldoukis et al. 2004
    - May counteract hypoxic conditions Dengler et al., 2015

Use of a compound feed additive to accelerate recovery of the GIT

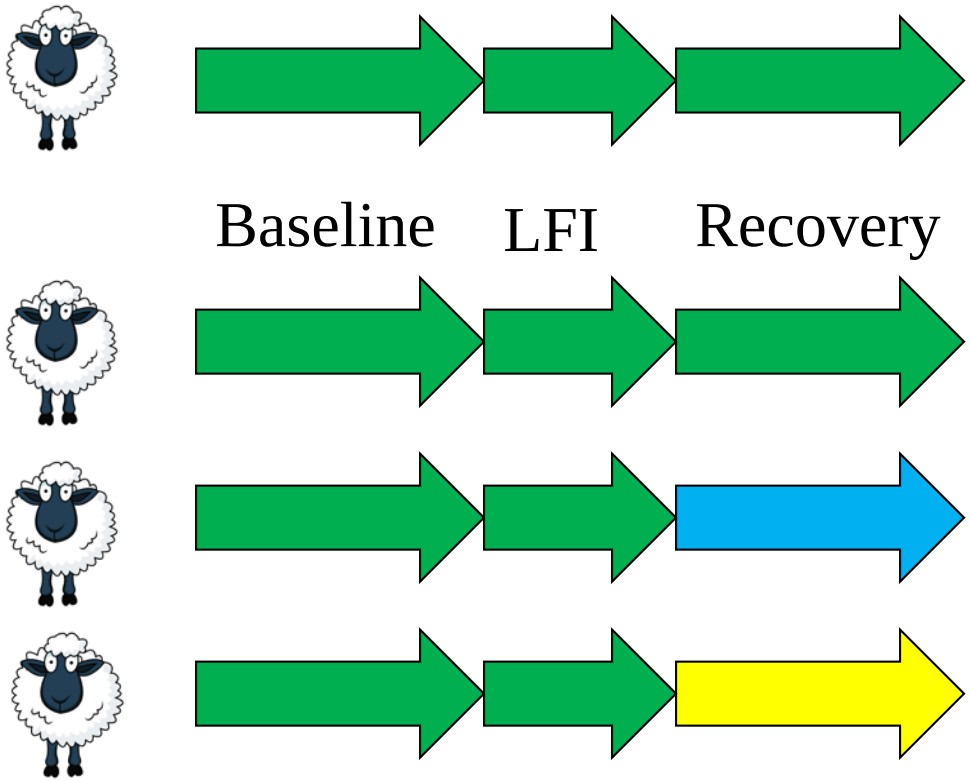
- n = 32

- Fed 'High'
- 3 d low feed intake at 50%

	Treatment		
Ingredient, % DM	High	Storm	Storm+
Barley silage	9	20	20
Barley grain	79	67.5	66.6
Min/vit	12.5	12.5	12.5
RP betaine			0.7
Antioxidant			0.01
Butyrate			0.2

Penner et al., unpublished

Use of a compound feed additive to accelerate recovery of the GIT

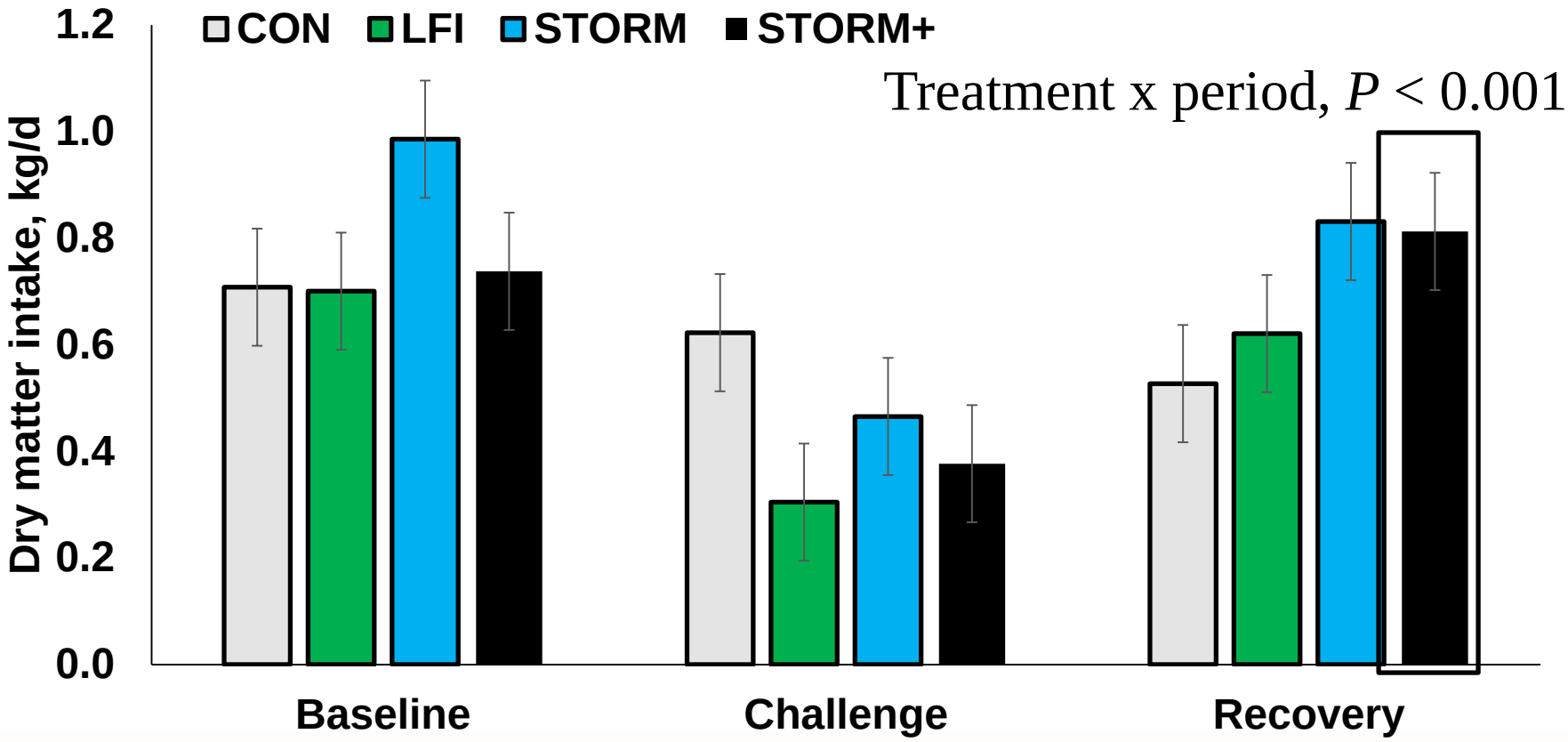


CON = no LFI

	Treatment		
Ingredient, % DM	High	Storm	Storm+
Barley silage	9	20	20
Barley grain	79	67.5	66.6
Min/vit	12.5	12.5	12.5
RP betaine			0.7
Antioxidant			0.01
			0.2

Penner et al., unpublished

Increasing the F:C ratio and use of a compound supplement stabilized DMI

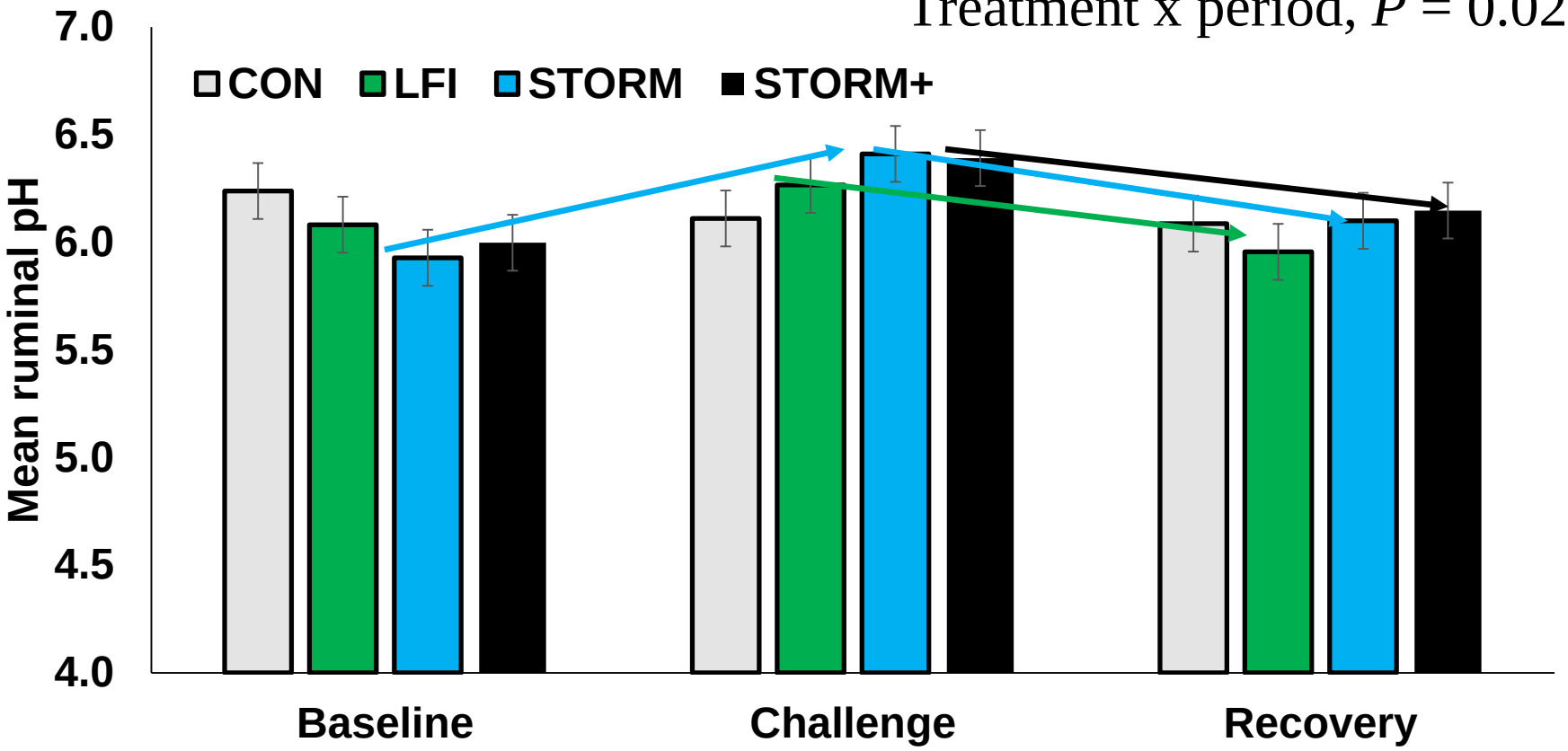


Only STORM+ recovered to baseline DMI after low feed intake

Penner et al., unpublished

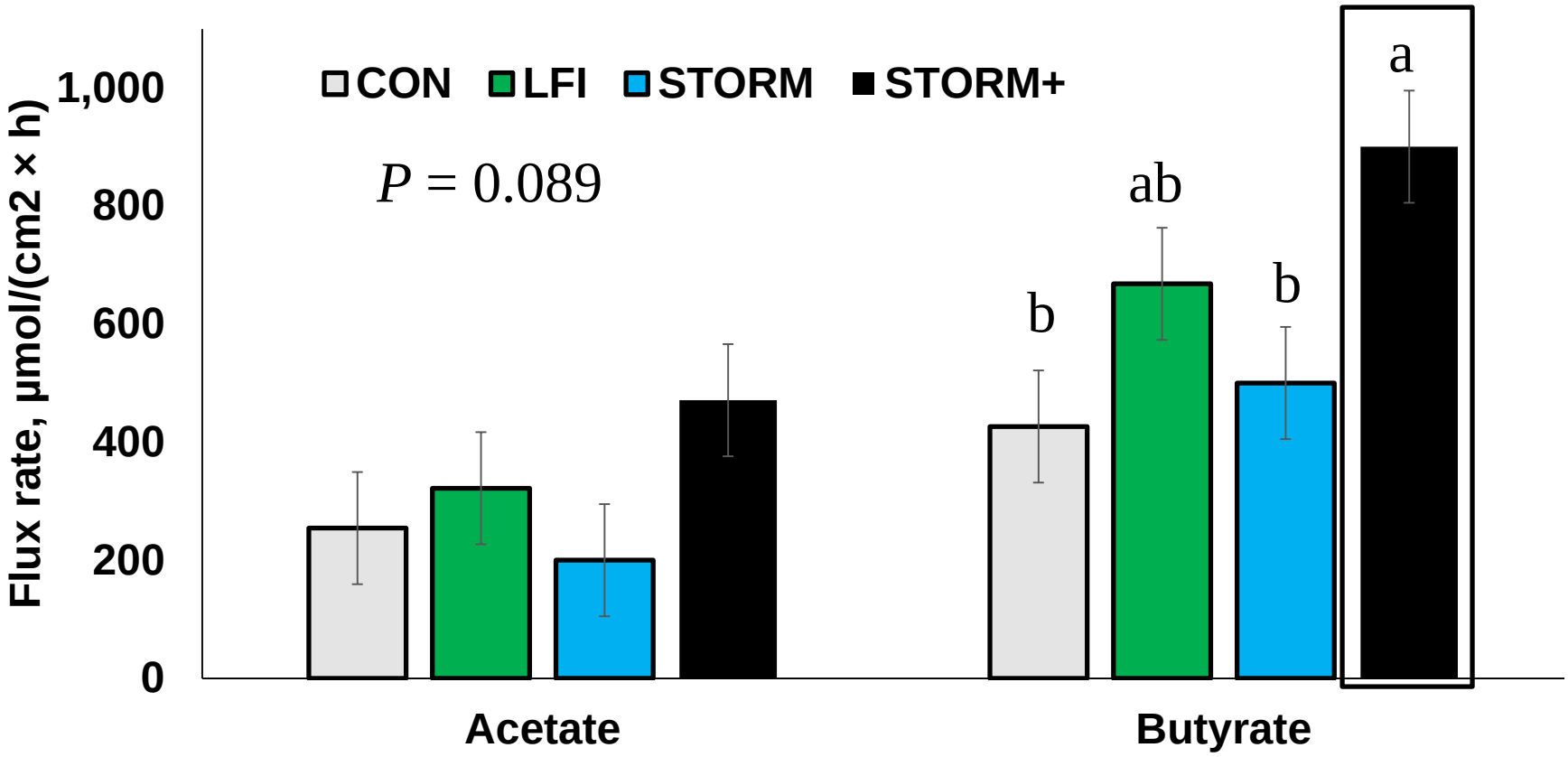
Increasing the F:C ratio and use of a compound supplement stabilized pH

Treatment x period, $P = 0.022$



Penner et al., unpublished

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



Penner et al., unpublished

Take-home messages

- A consistent supply of DM and nutrients are required to maintain gut health
- Production responses have not been well characterized but can be extrapolated
- Management strategies to minimize variation in intake may yield greatest rewards
- Recovery following a challenge takes time but can be accelerated

University of Saskatchewan

Thank you

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