Intestinal microbiota and health in piglets

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Wageningen Livestock Research

Nutrition seminar SEGES, April 2018

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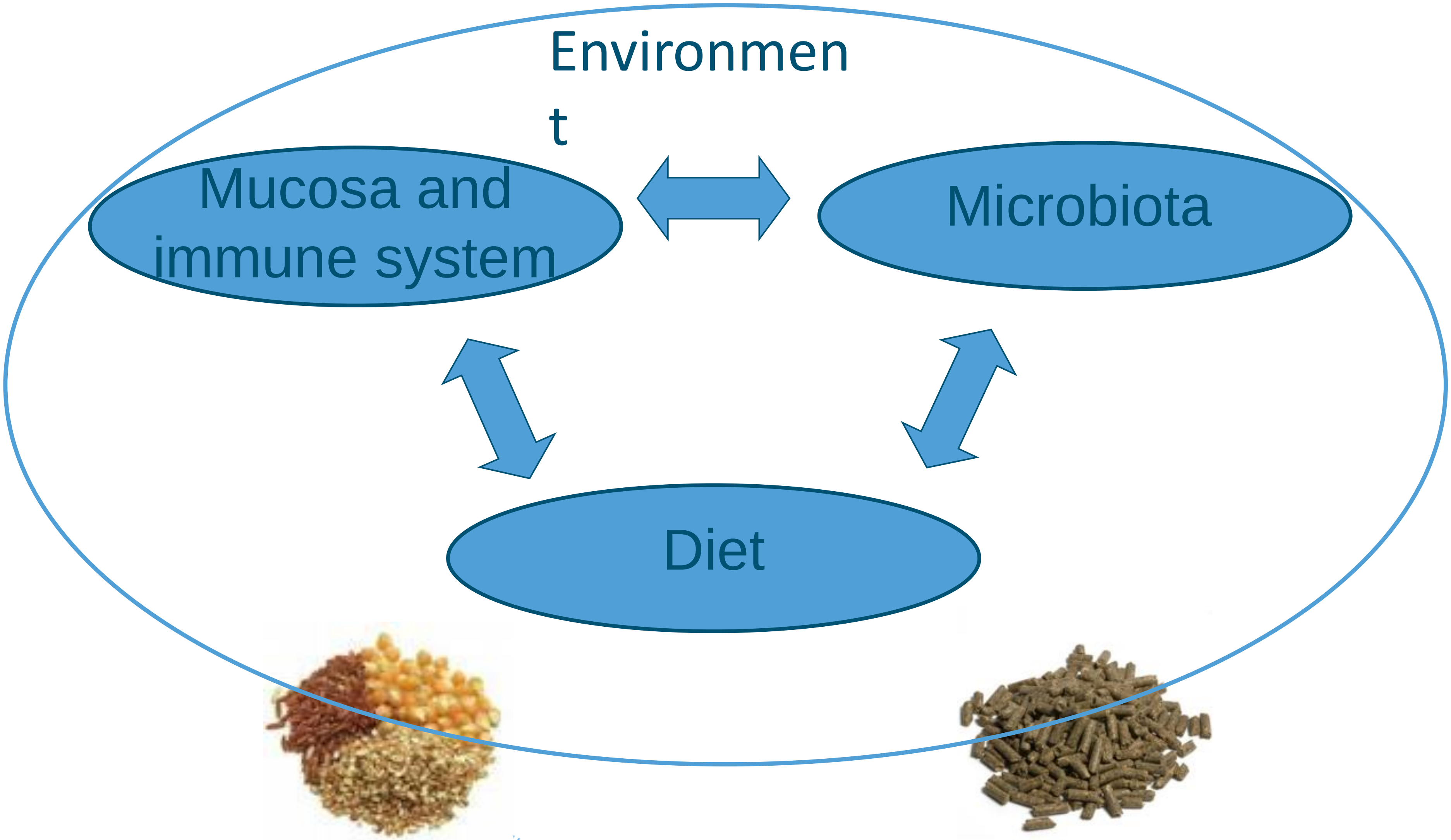
Introduction

- What is gut health and what are functions of the gut?
- Early development of gut function and the local immune system
- Effects of ingredient-, nutrient composition and feed additives on gut health
- Take home messages

Intestinal health



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Functions of the gut

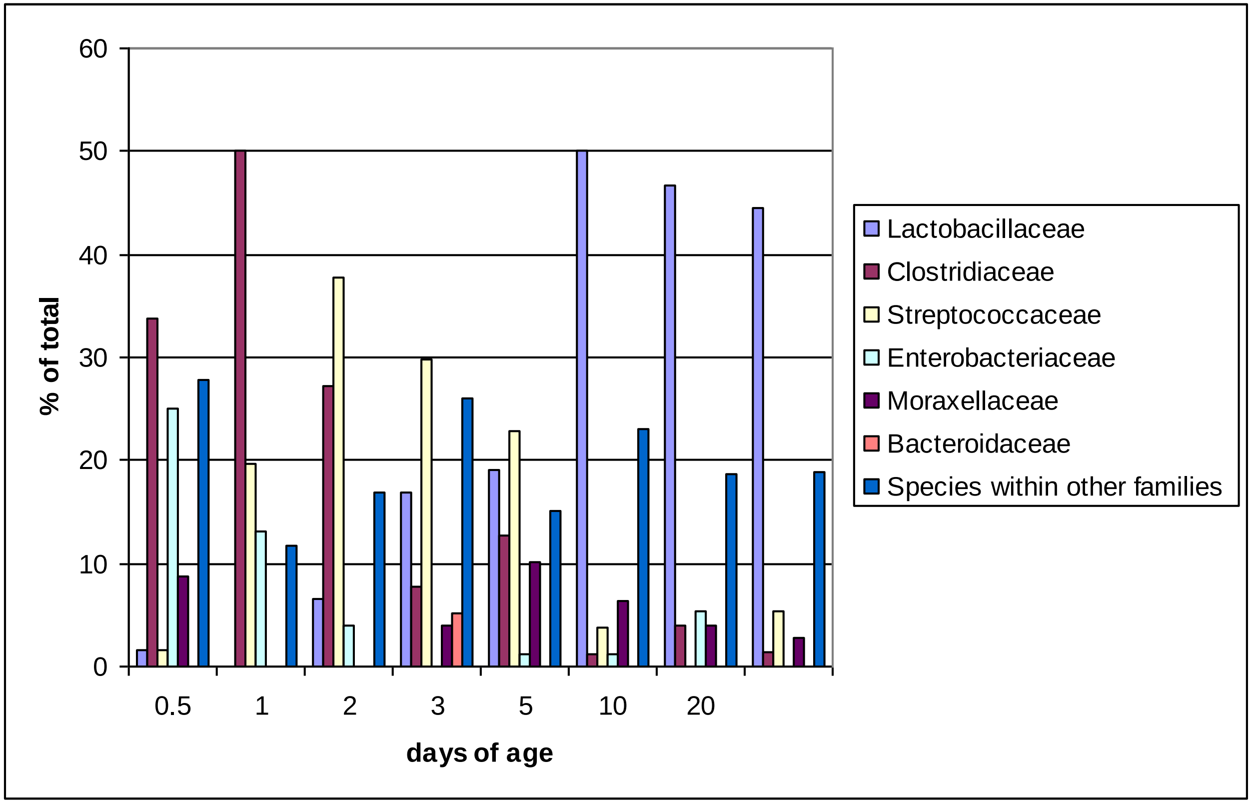
Nutrient digestion

Barrier function

- Enzymatic digestion
- Fermentative digestion

- Microbiota in the gut ↕
- Immune system and its programming
  - **10^{13} cells in the body**
  - **10^{14} GI bacteria**

Microbial succession in the digestive tract of piglets after birth



In total 604 species identified using ^{16}S rRNA gene sequencing

Petri et al. (2010)

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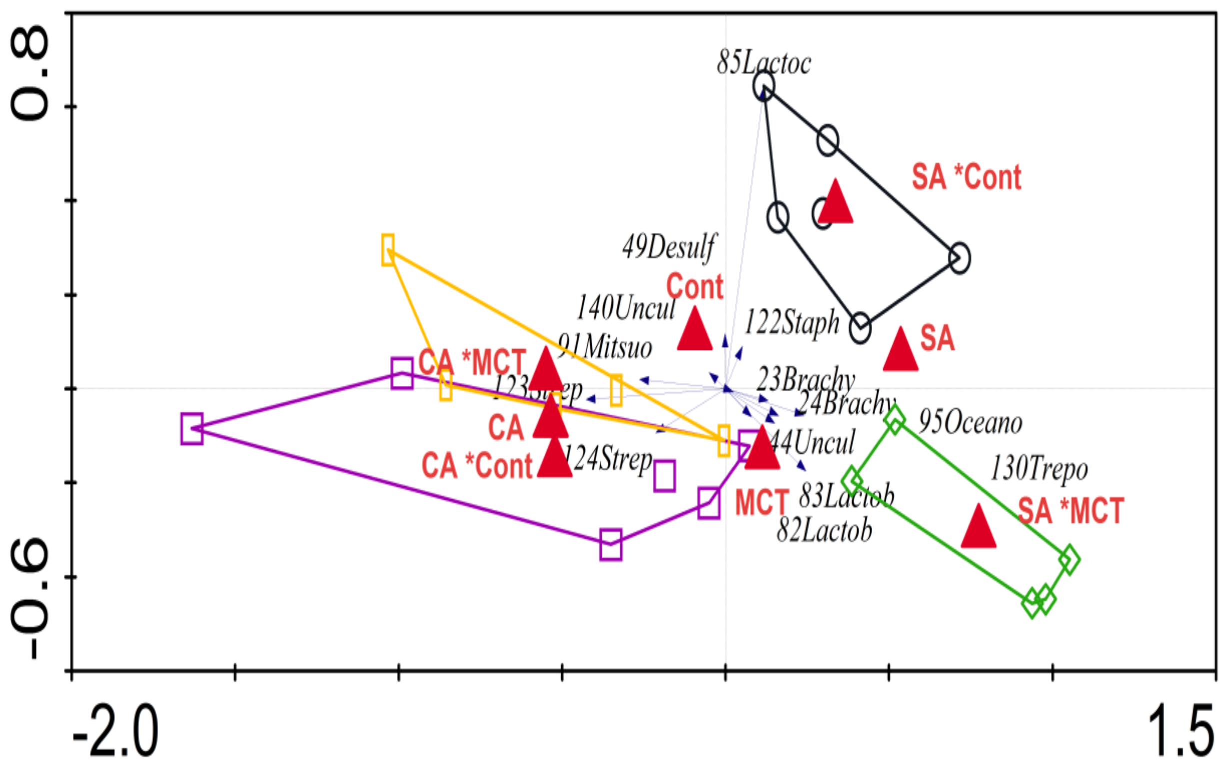
Jejunal microbiota composition as affected by oral association and diet composition in piglets (20 and 21 of age)



A mix of soya oil (50 g/kg) and palm oil (30 g/kg) was exchanged with coconut oil (70 g/kg + 10 g/kg other fat sources)

Jansman et al. (2014)

Gene set enrichment analysis (GSEA)[1] for multiple comparisons between treatments in jejunal tissue

Comparison		Enriched	Im-mune	Putative immune	Immune or metabolic	Metabolic	Generic process	Protein
1	SA.Con vs SA.MCT	SA.Con						
		SA.MCT						
2	CA.Con vs CA.MCT	CA.Con	14					
		CA.MCT						
3	SA.MCT vs CA.MCT	SA.MCT	35					1
		CA.MCT						
4	CA.Con vs SA.Con	CA.Con						
		SA.Con						
5	CA.Con vs SA.MCT	SA.MCT						
		CA.Con	3					
6	SA.Con vs CA.MCT	SA.Con	15					
		CA.MCT				2		

CA CON vs CA MCT:

LEUKOCYTE_ACTIVATION

INFLAMMATORY_RESPONSE

DEFENSE_RESPONSE

CELLULAR_DEFENSE_RESPONSE

SA MCT vs CA MCT:

KEGG_CYTOKINE_CYTOKINE_RECEPTOR_INTERACTION

IMMUNE_SYSTEM_PROCESS

T_CELL_ACTIVATION

CYTOKINE_ACTIVITY

REGULATION_OF_IMMUNE_SYSTEM_PROCESS

CELLULAR_DEFENSE_RESPONSE

[1] Number of gene sets (False Discovery Rate < 25%)

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Recent papers on role intestinal microbiota

REVIEWS

The gut microbiota shapes intestinal immune responses during health and disease

June L. Round and Sarkis K. Mazmanian

Abstract | Immunological dysregulation is the cause of many non-infectious human diseases such as autoimmunity, allergy and cancer. The gastrointestinal tract is the primary site of interaction between the host immune system and microorganisms, both symbiotic and pathogenic. In this Review we discuss findings indicating that developmental aspects of the adaptive immune system are influenced by bacteria ... of the gut. We also highlight the molecular pathways that mediate host–s... that regulate proper immune function. Finally, we present recent e... in the bacterial microbiota result in dysregulation of ... underlie disorders such as inflammatory bowel dis... the mammalian immune system, which seems to b... is in fact controlled by microorganisms.

The ISME Journal (2008) 2, 739–748

www.nature.com/ismej

ORIGINAL ARTICLE

The immediate environment during postnatal development has long-term impact on gut community structure in pigs

Claire L Thompson, Bing Wang and Andrew J Holmes
School of Molecular and Microbial Biosciences, University of Sydney, Sydney, New South Wales, Australia

Pediatric Allergy and Immunology

ORIGINAL ARTICLE

Direct experimental evidence that early-life farm environment influences regulation of immune responses

Marie C. Lewis[1]*, Charlotte F. Inman[1]*, Dilip Patel[1], Bettina Schmidt[2], Imke Mulder[2], Bevis Miller[1], Bhupinder P. Gill[3], John Pluske[4], Denise Kelly[2], Christopher R. Stokes[1] & Michael Bailey[1]

[1]Infection and Immunity, School of Veterinary Science, University of Bristol, Langford, Somerset, UK; [2]Gut Immunology Group, University of Aberdeen, Rowett Institute, Aberdeen, UK; [3]DEFRA, London, UK; [4]School of Veterinary and Biomedical Sciences, Murdoch University, Perth, Western Australia

JOURNAL OF HUMAN BIOLOGY 24:350–360 (2012)

...nents,

ELSEVIER

Available online at www.sciencedirect.com
ScienceDirect
Current Opinion in Pharmacology

Interplay between obesity and associated metabolic disorders: new insights into the gut microbiota

Patrice D Cani and Nathalie M Delzenne

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Available online at www.sciencedirect.com
ScienceDirect
Current Opinion in Biotechnology

Programming infant gut microbiota: influence of dietary and environmental factors

Tatiana Milena Marques[1,2,3], Rebecca Wall[1], R Paul Ross[1,2], Gerald F Fitzgerald[1,3], C Anthony Ryan[4] and Catherine Stanton[1,2]

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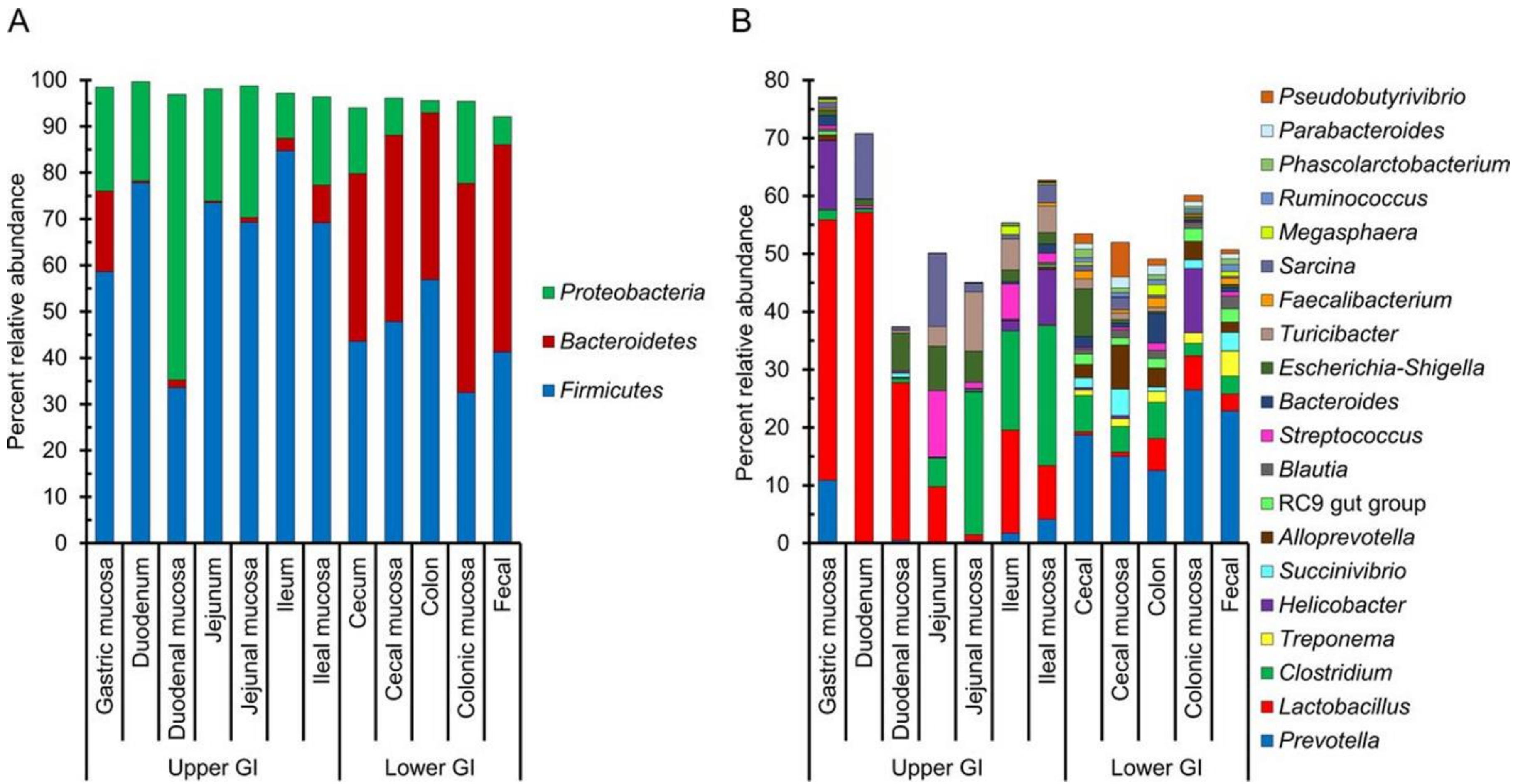
Microbiota composition in the pig gut



Holman et al. (2017)

Intestinal microbiota and gut barrier

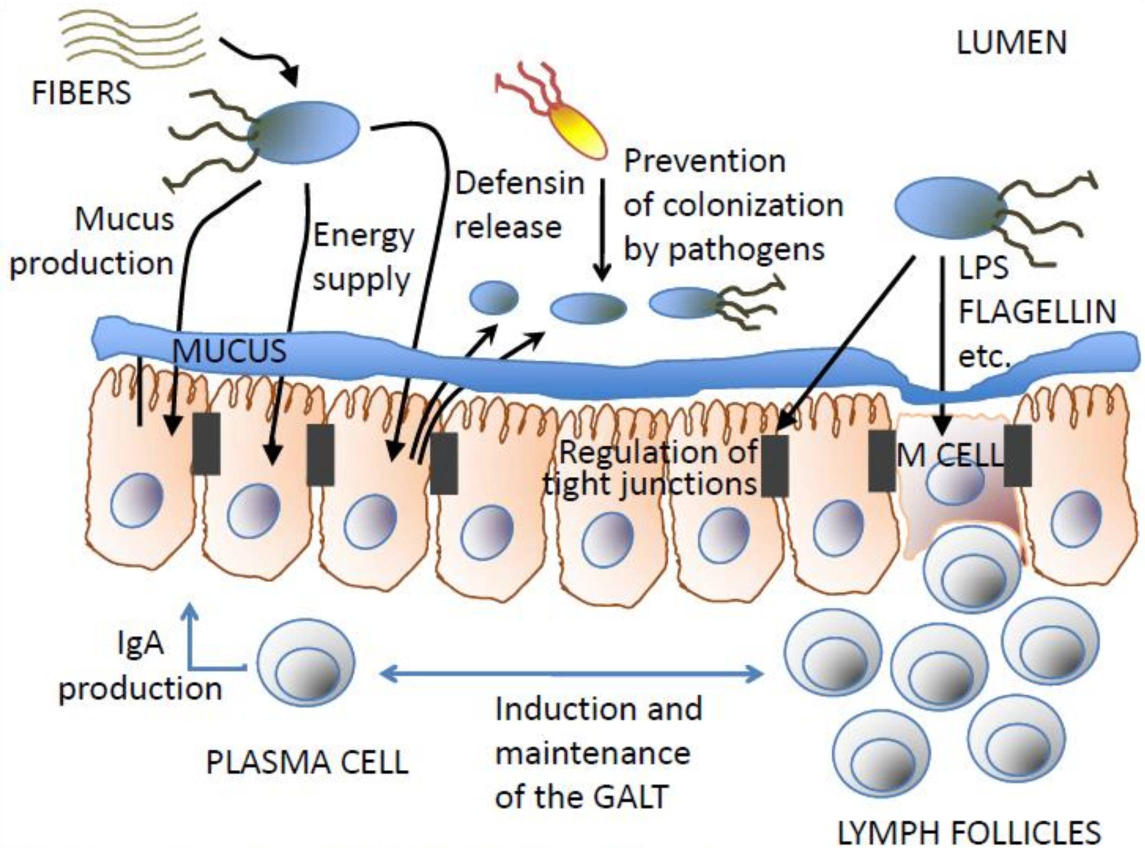
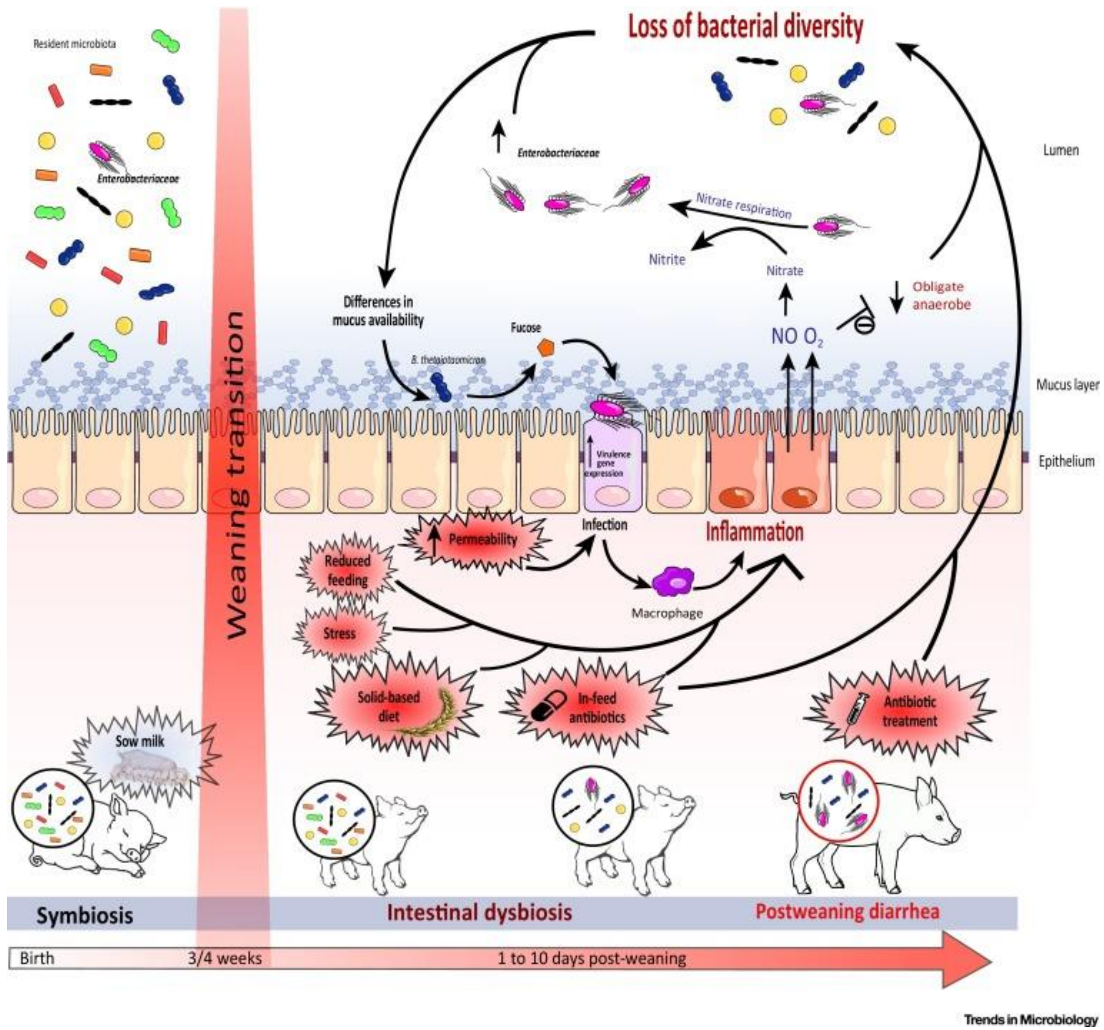


Figure 2 Mechanisms of action of the intestinal microbiome on the gastrointestinal barrier. Commensal bacteria support the digestion of fibres and other nutrients, thereby contributing to energy and substrate supply. They regulate epithelial functions such as mucus production in goblet cells, defensin release from Paneth cells and tight junction protein synthesis in normal epithelial cells. They prevent colonisation of pathogens in the gut and regulate the mucosal immune system, for example, by inducing and maintaining gut-associated lymphoid tissue and by stimulating mucosal immunoglobulin A production. For details and references, see text 'Underlying mechanisms'.

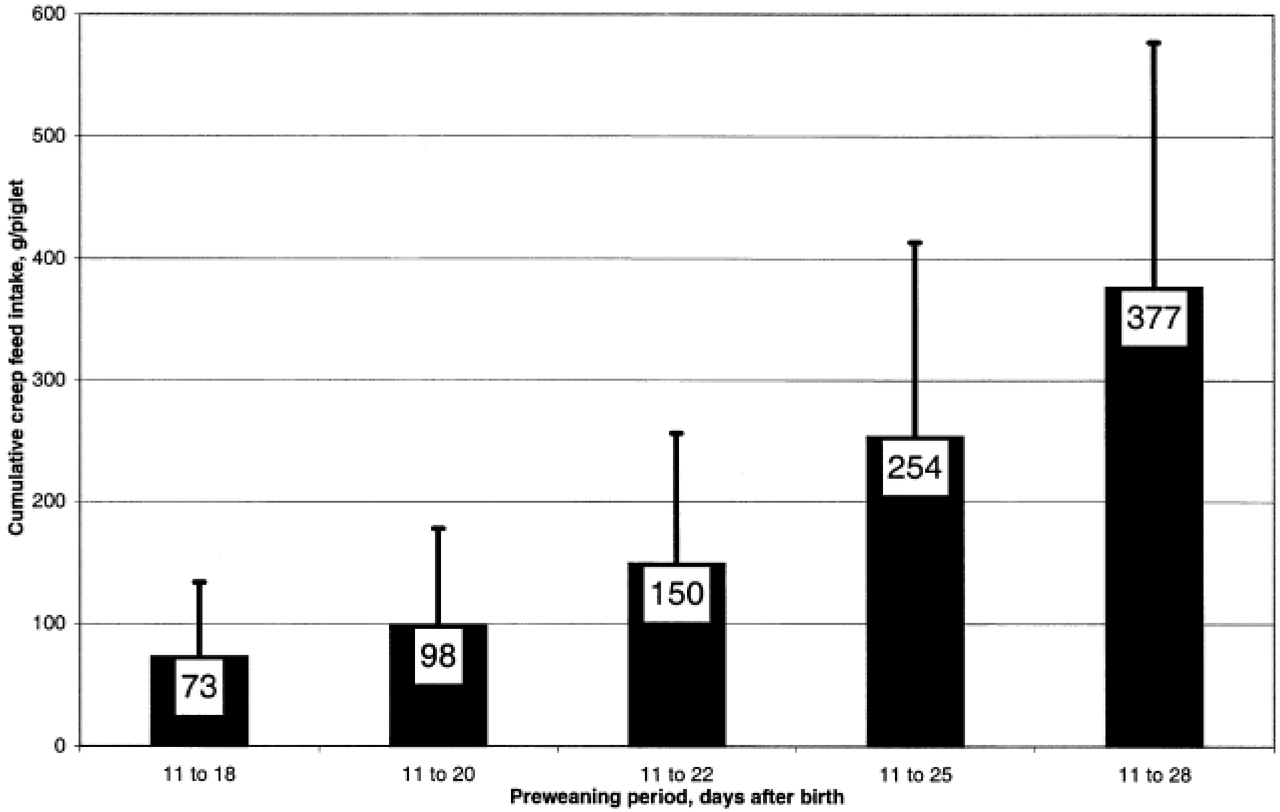
Bisschof (2011)

Impact of Weaning Transition on Piglet Gut Microbiota and Expansion of Infectious Agents



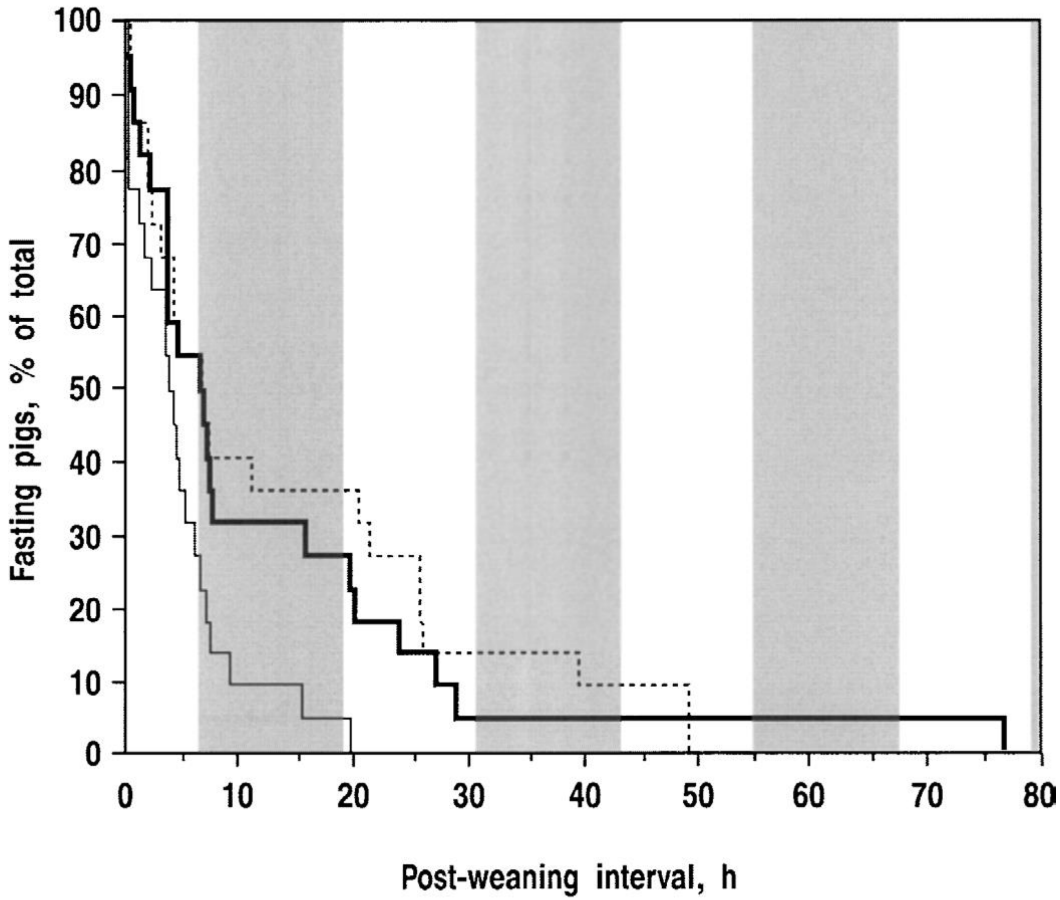
Gresse et al. (2017)

Average cumulative creep feed consumption (g/piglet + sd) per period during nursing.



Bruininx et al. (2002)

Post weaning feed intake as affected by and pre-weaning creep feed intake



Bruininx et al. (2002)

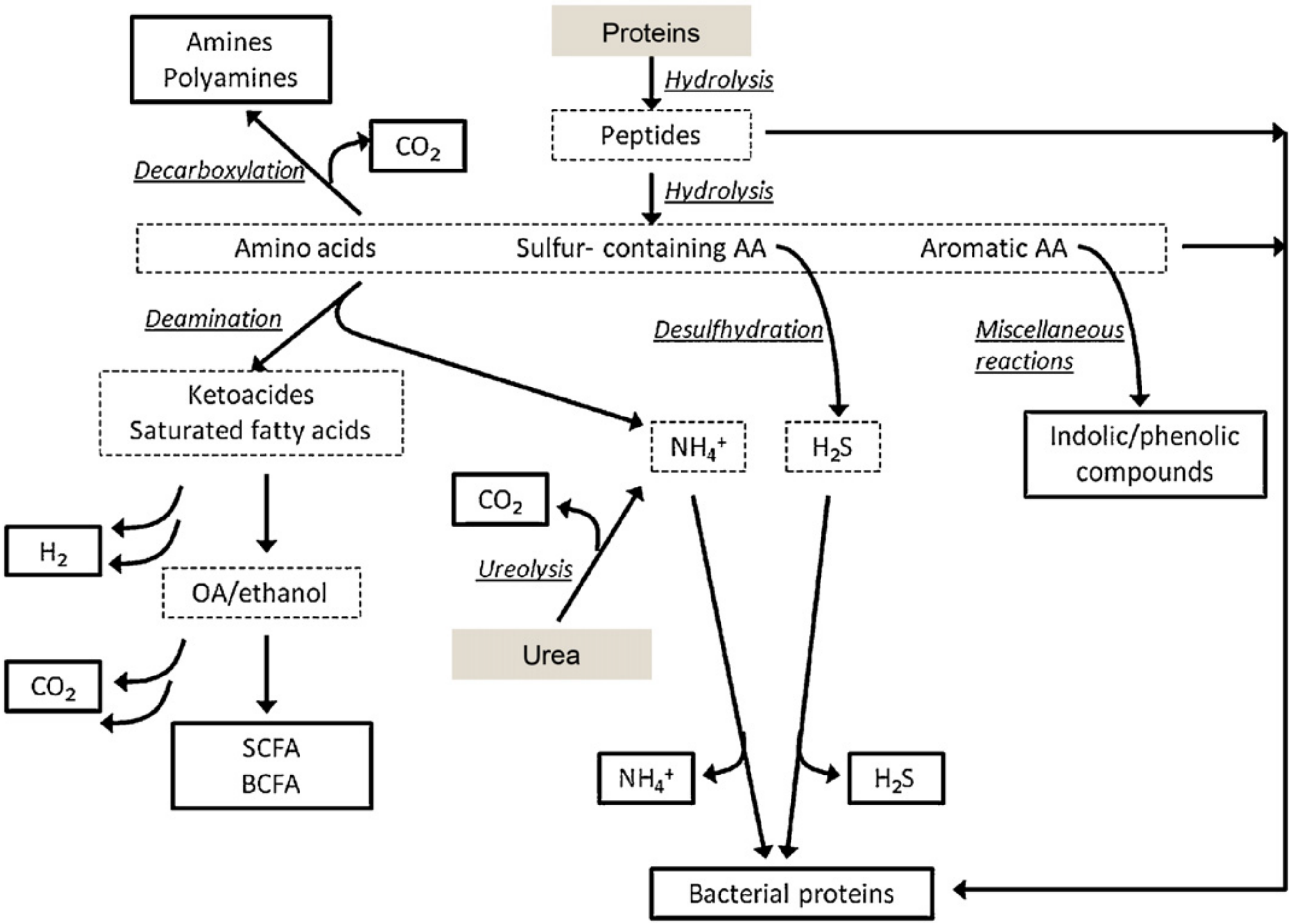
Effect of dietary protein level on performance and health in piglets

CP[1]	23%	21%	19%	17%	Sign. Diet
Intake, g/d	528	522	464	414	*
BWG, g/d	353	340	288	232	*
Water intake, l/d	3.83	3.01	3.24	3.22	Ns
Faecal consistency score (0-3)	0.36	0.20	0.18	0.29	Ns
pH, ileum	6.7	6.0	6.1	6.3	*
Ammonium, jejunum, mg/l	35	34	27	22	*
Ammonium, ileum, mg/l	72	49	42	38	*

[1]Diets balanced for Lys, M+C, Thr and Trp (but not for Val, Ile and other AA)

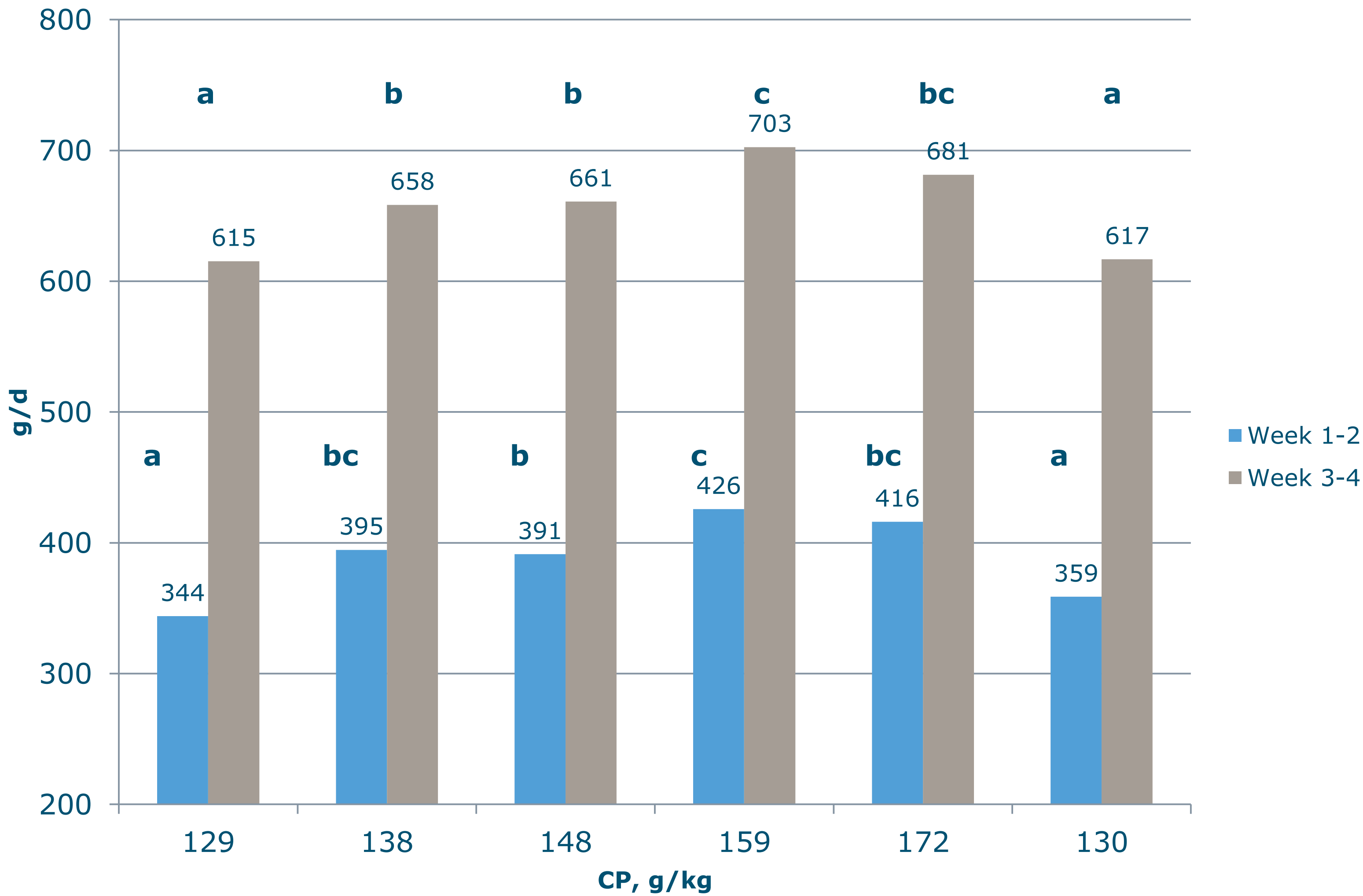
Nyachoti et al. (2006)

Protein fermentation in the GIT



Davilaa et al. (2013)

Further reduction of dietary CP in piglets



a,b,c P<0.05

Jansman et al. (2016)

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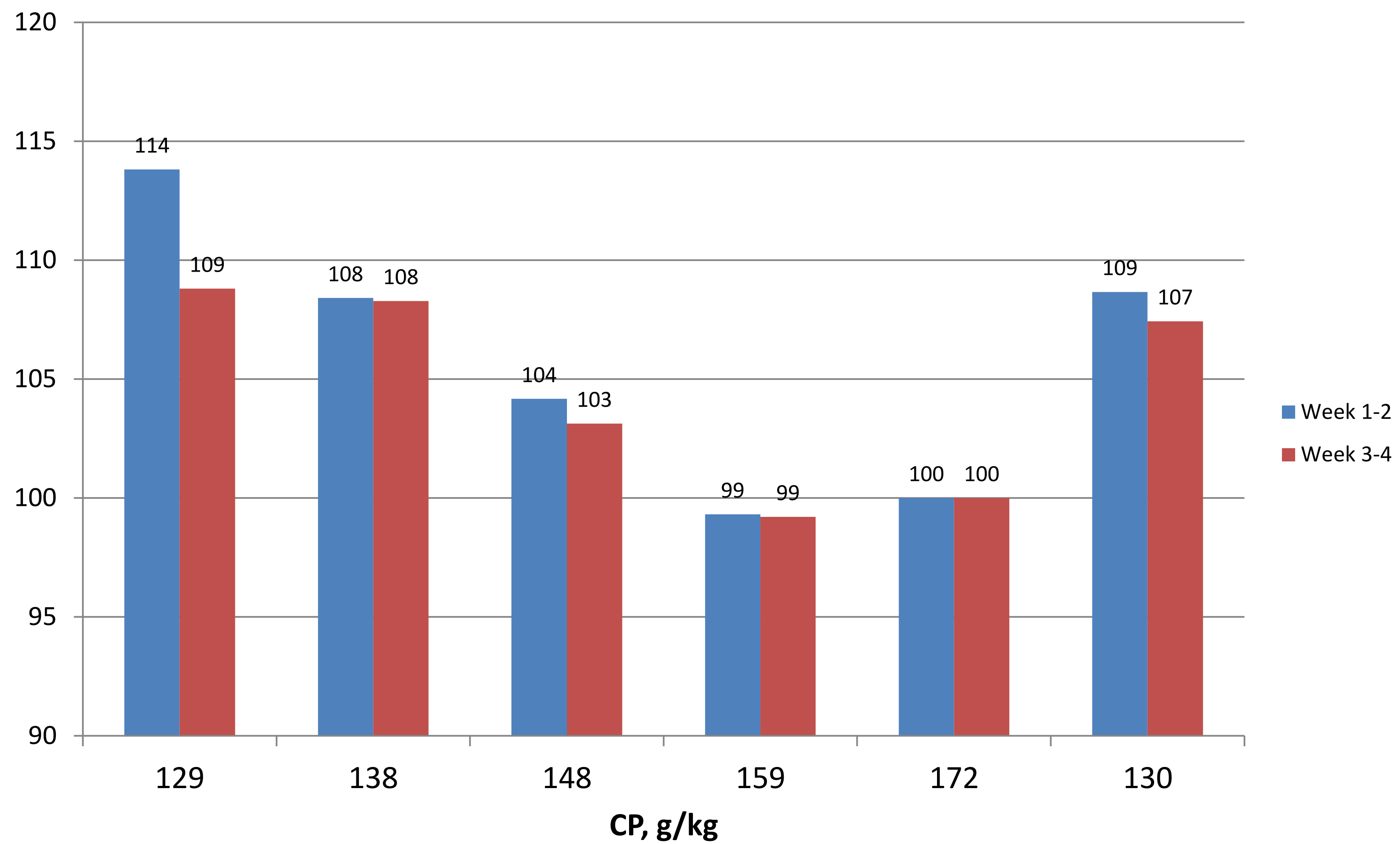
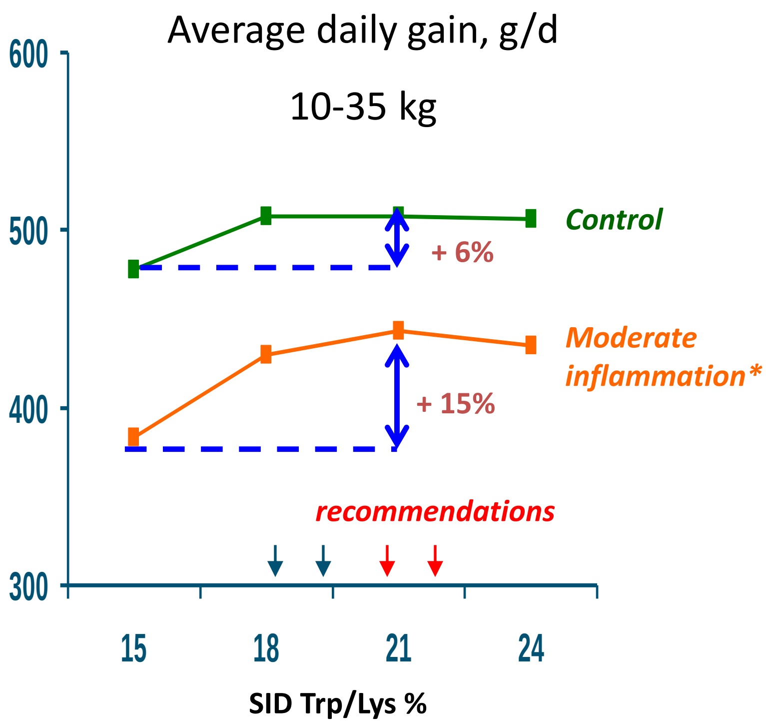
Further reduction of dietary CP in piglets; FCR relative to a diet with 17% CP (=100)



Jansman et al. (2016)

Effect of TRP and health status on growth performance



** Inflammation caused by low hygiene of housing*

In pigs suffering from inflammation :

- ➚ Trp : no growth restoration
- greater impact of low TRP supply on growth rate

➔ *greater response of growth to additional TRP*

LeFloc'h et al. (2010)

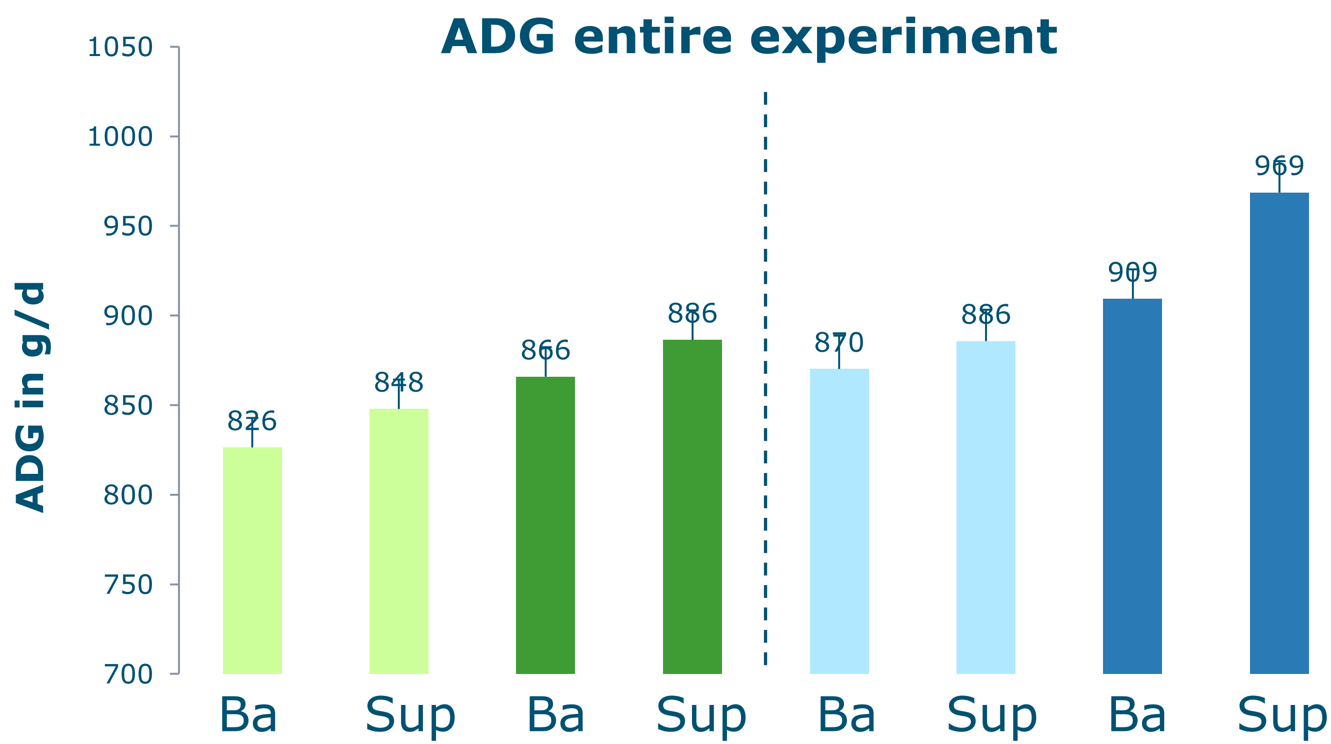
Sanitary status of pigs and performance

- Low or high sanitary status
- Four different diets (*ad lib*)
- Normal or low CP supply (100 or 80%)
- Two different AA-profiles (AID)

	Basal	Supplemented
Lys	100	
M+C	51	61
Thr	59	71
Trp	18	22
Arg	87	
His	43	
Ile	53	
Leu	101	
Phe	54	
Val	69	

Developed from Bikker et al., 1994; Le Bellego et al., 2002; Jansman et al., 2002; NRC 2012, Moughan et al., 1998

Response to protein and AA supply and health status



Sanitary conditions:	$P < 0.0001$
CP level:	$P = 0.0001$
AA-profile:	$P = 0.02$

= low sanitary conditions
= high sanitary conditions

v.d. Meer et al. (2016)

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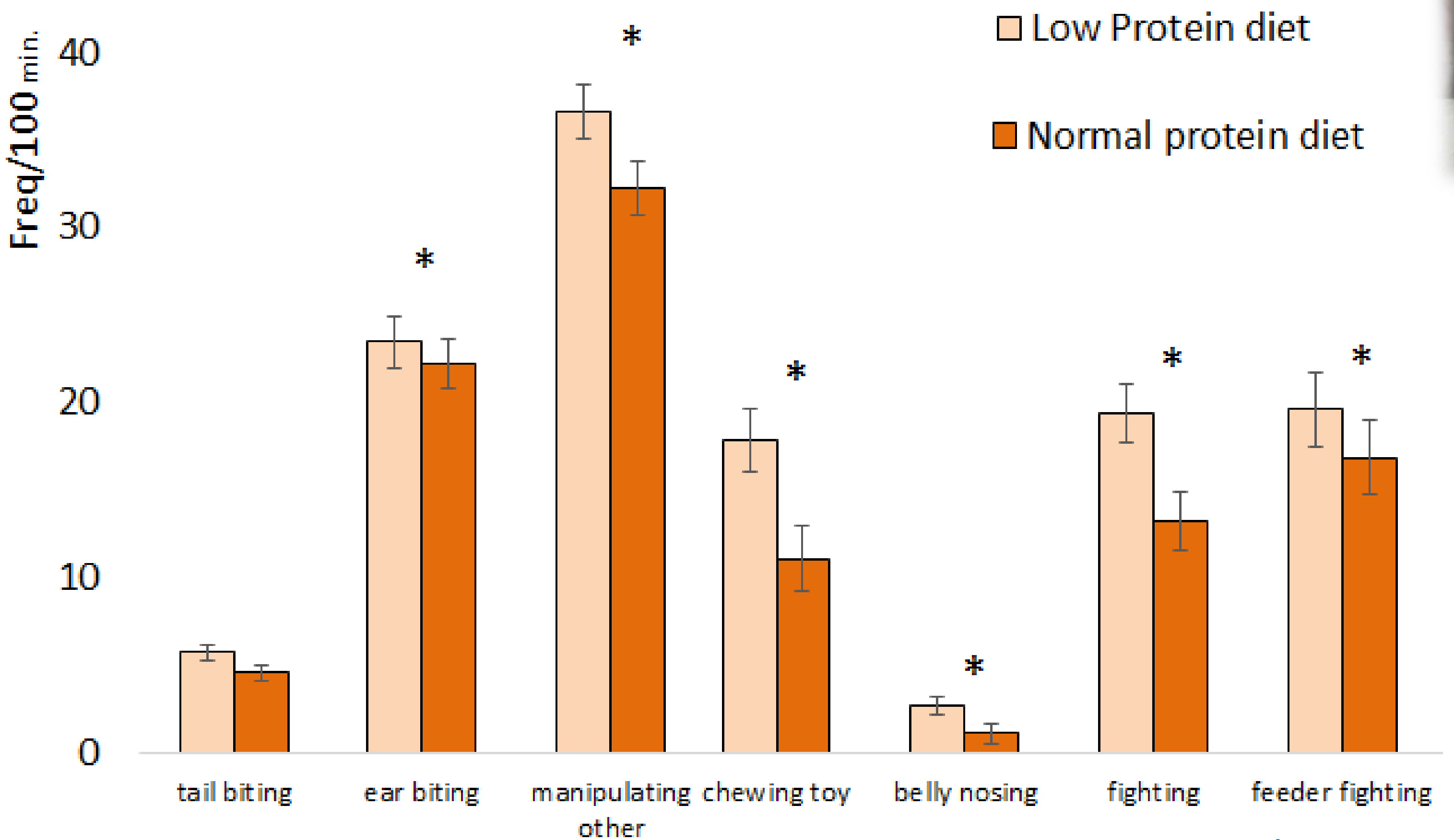
Effect of dietary CP on behaviour in pigs

Risk on behavioural problems higher when protein level is low?



v.d. Meer et al. (2017)

Plasma proteins in piglet diets

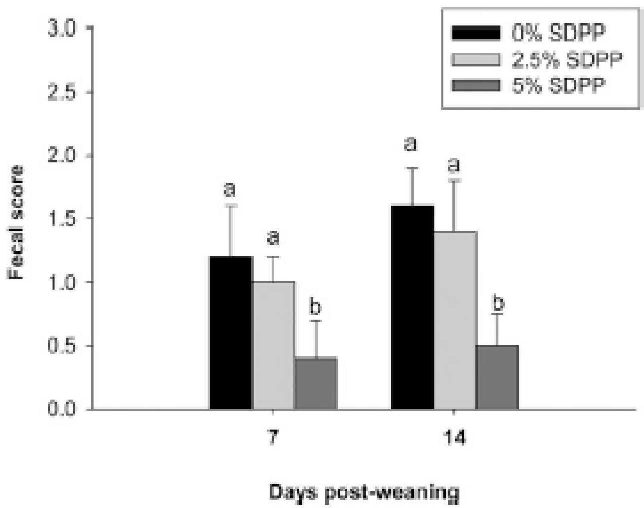


FIGURE 1 Fecal scores in weaned pigs fed different dietary levels of spray-dried porcine plasma (SDPP) for 7 or 14 d. Values are mean ± SE, n = 8. Means at a time without a common letter differ, $P < 0.05$. *Different from d 7, $P < 0.05$.

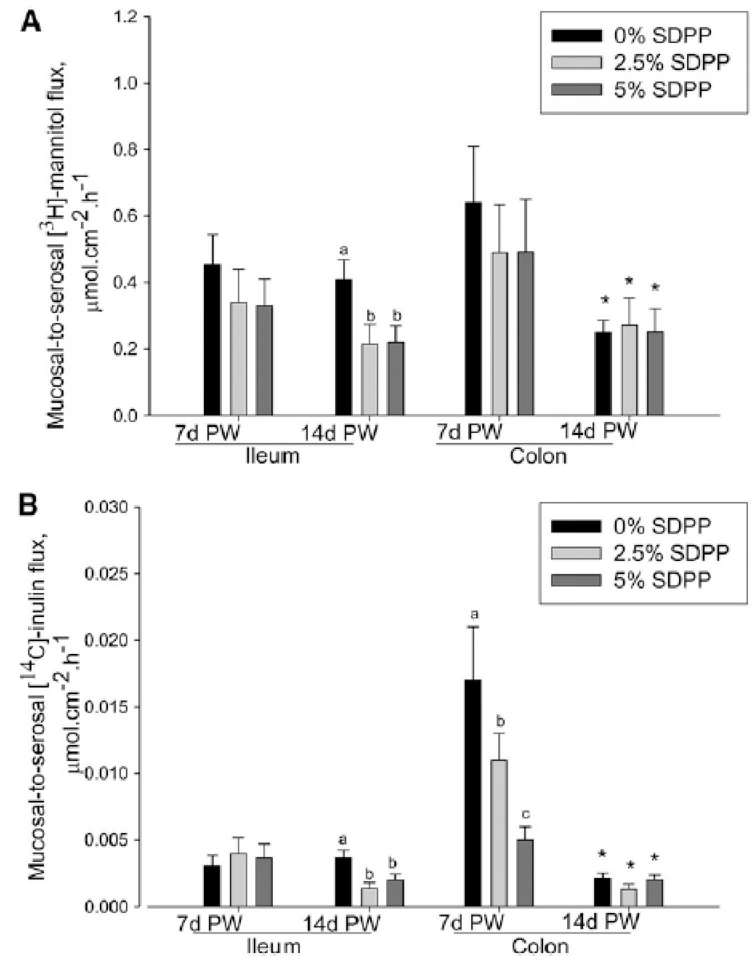


FIGURE 3 Effects of spray-dried porcine plasma (SDPP) on mucosal-to-serosal ^{3}H-mannitol (*A*) and ^{14}C-inulin (*B*) flux in the ileum and colon of weaned pigs fed different dietary levels of SDPP for 7 or 14 d. Values are mean ± SE, n = 8. Means at a time without a common letter differ, $P < 0.05$. *Different from d 7, $P < 0.05$.

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Peace et al. (2011)

Feed additives and gut health

- Organic acids
- Enzymes
- Probiotics
- Prebiotics
- Herbs and plant extracts

Enzymes and ileal digestibility of carbohydrates of 20 kg pigs

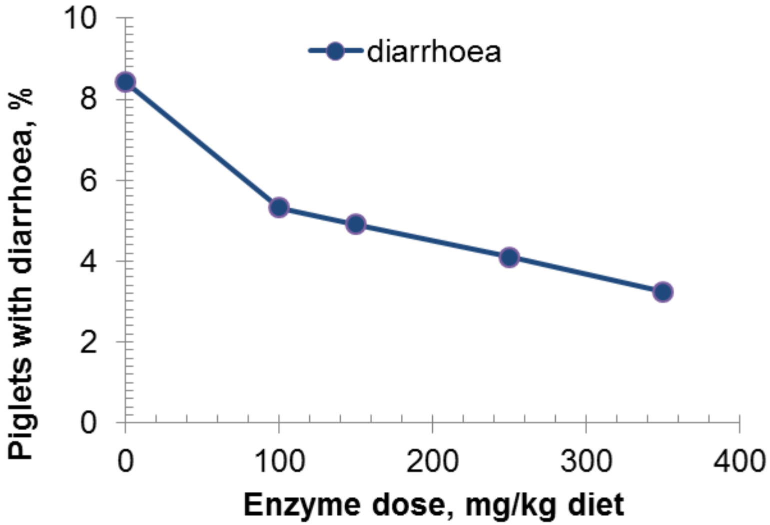
	Arabinose	Xylose	Pentosans	Mannose	Glucose	Galactose	Total NSP
Diet*							
R0	3.9	1.8	2.6	32.4	23.5	−29.0	11.3
R50	9.8	6.7	7.9	33.9	33.2	−27.6	18.2
R100	23.9	15.5	18.7	40.4	40.3	−9.5	27.6
R200	19.2	12.4	15.0	39.2	41.1	−13.9	25.8
Pooled SEM	5.5	3.9	4.2	2.1	2.3	6.4	3.2
p-value linear	0.021	0.026	0.015	0.008	<0.001	0.035	<0.001
quadratic	0.048	0.053	0.032	0.026	<0.001	0.104	0.002

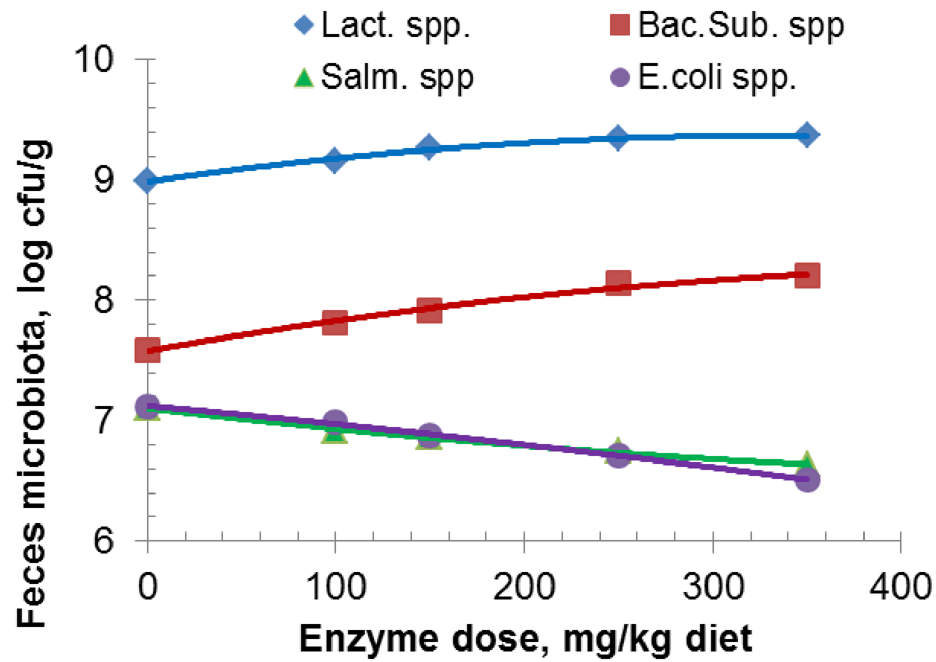
Notes: *Diet R0, control; diets R50, R100 and R200 contained 50, 100 and 200 mg xylanase/kg, respectively.

- 96% rye-based diet, supplemented with xylanase
- increase in ileal and faecal DE 2-3%

Nitrayova et al. (2009)

Influence of exogenous enzymes on GUT health





- 10-25 kg pigs; maize/SBM/WM diet;
- Activity: 4520 AMY, 8660 PROT, 6000 XYL/g product

Zhang et al. (2014)

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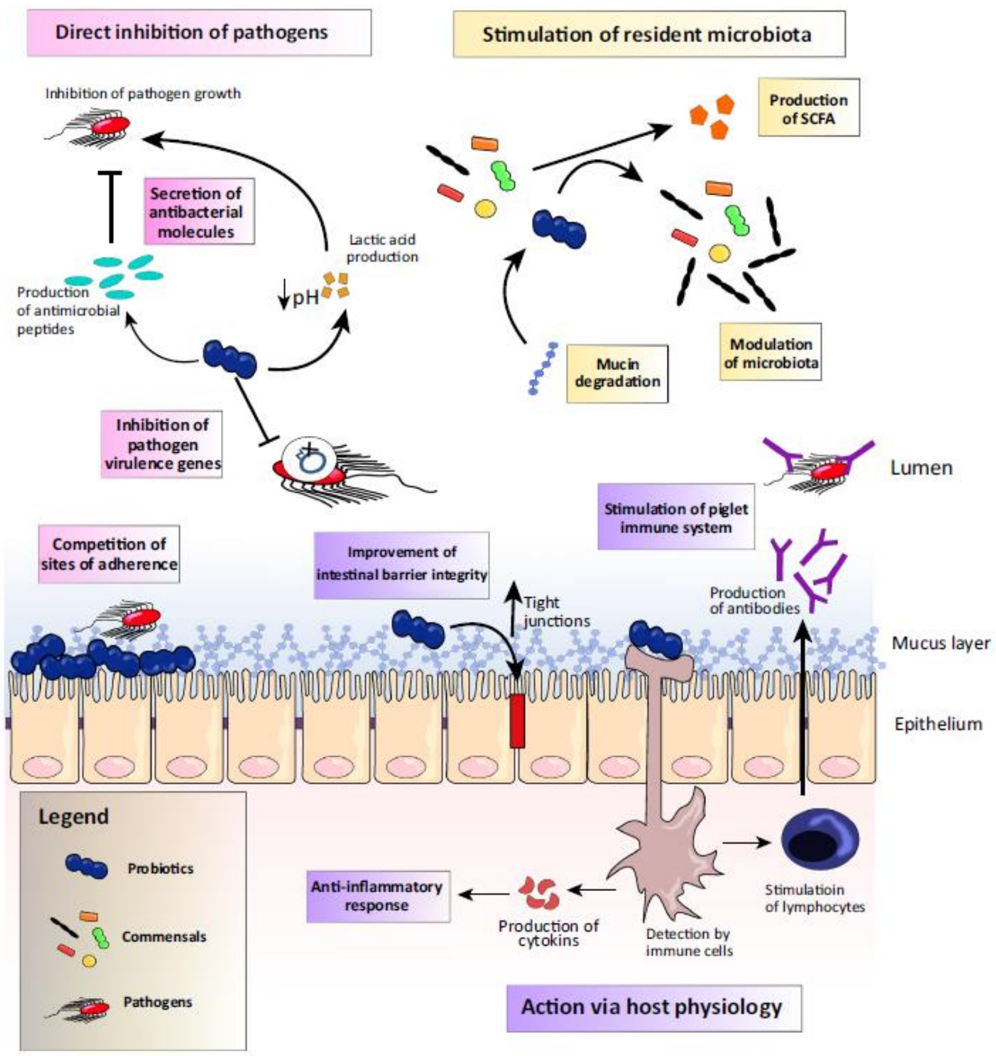
Organic acids

- Endogenously produced and supplemented in the diet

- Reduction of gastric pH and activation gastric pepsinogen (inhibition bacterial growth)
- Reduced rate of gastric emptying
- Inactivation of pathogenic bacteria in small intestine
- Increased pancreatic secretion
- pH reduction in GI tract (pathogen colonization reduced)
- Energetic substrate for mucosa or modulator of mucosal development
- Precursor for synthesis NEAA and DNA for intestinal development
- Increased intestinal blood flow

Mroz (2005)

Mechanisms of Action of Probiotic Strains



Gresse et al. (2017)

Low-diarrhoea weaning diets

- Consider feed intake in pre-weaning phase
- Consider functional value of feed ingredients (protein sources)
- Consider dietary ingredient and nutrient composition and use of additives in combination to support gut health in critical periods

Thank you for your attention!