Nutrition, Gut Microbiome, and Poultry Health

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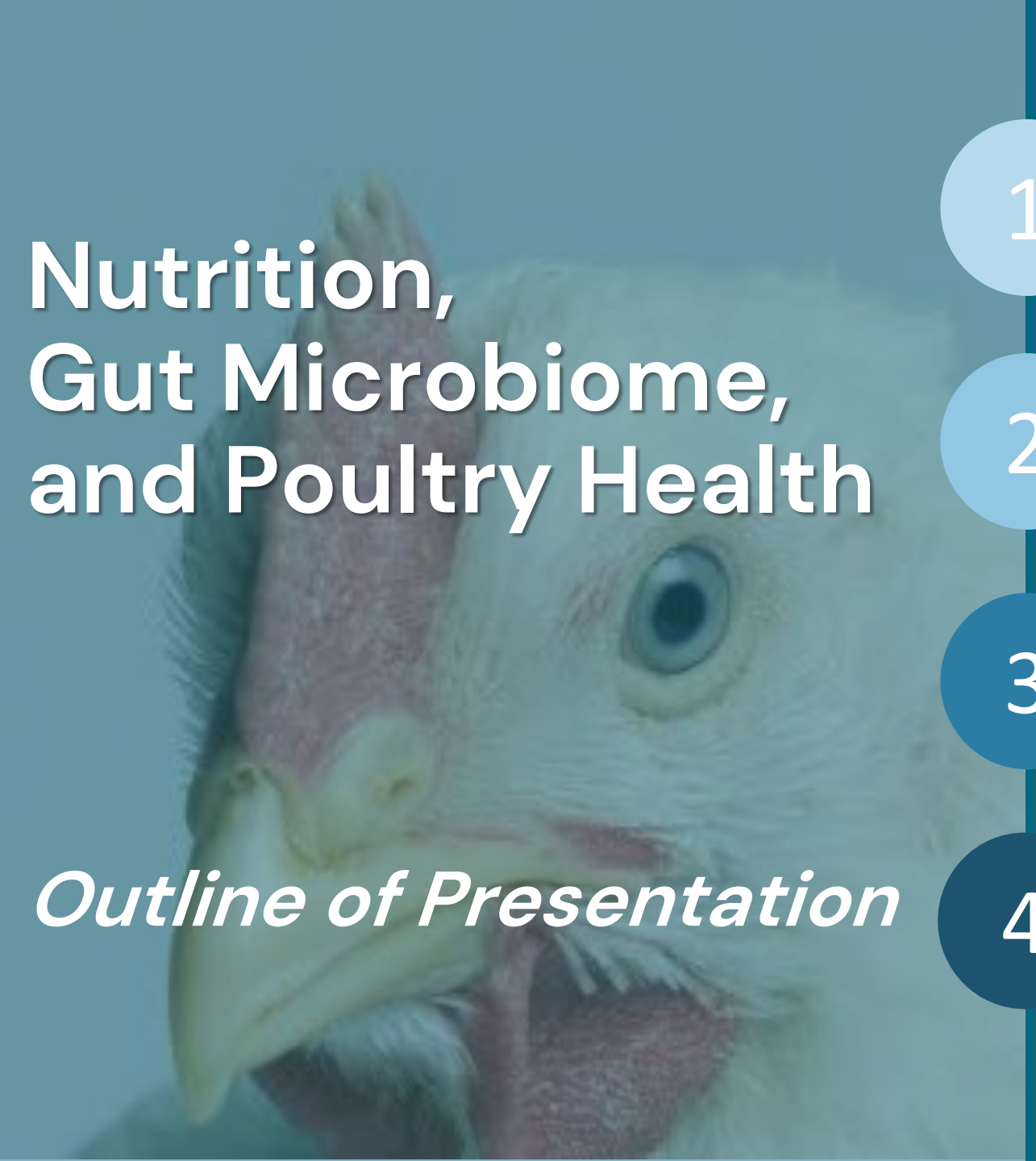

Nutrition, Gut Microbiome, and Poultry Health

Outline of Presentation

1. Formulating diets
2. *Conventional approach* in influencing gut microbiome
3. *Novel approach* in influencing gut microbiome
4. Key takeaways

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Nutrition, Gut Microbiome, and Poultry Health

1

Formulating diets

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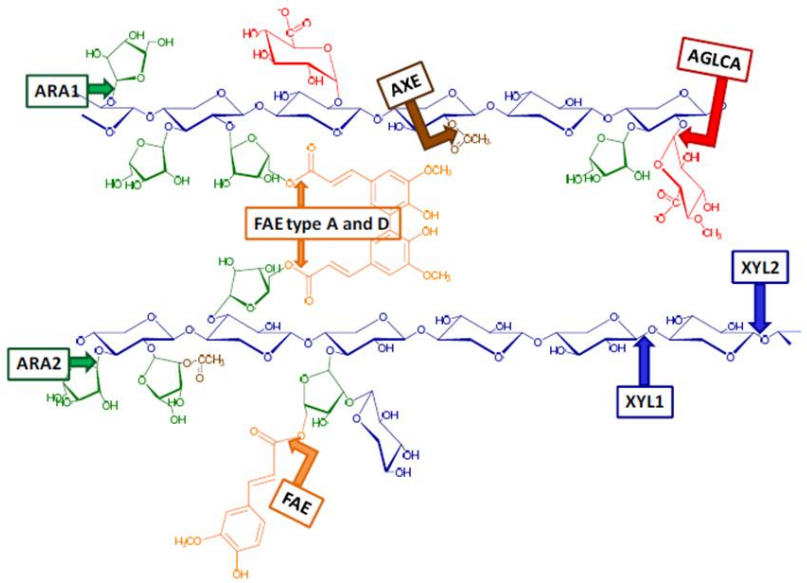
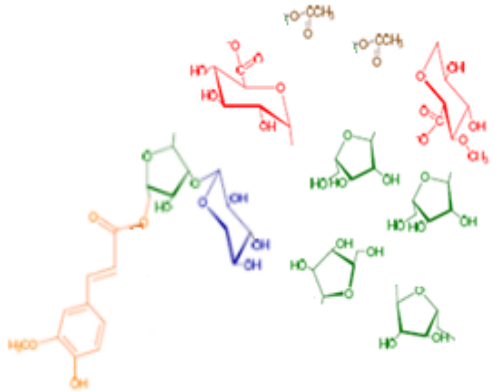
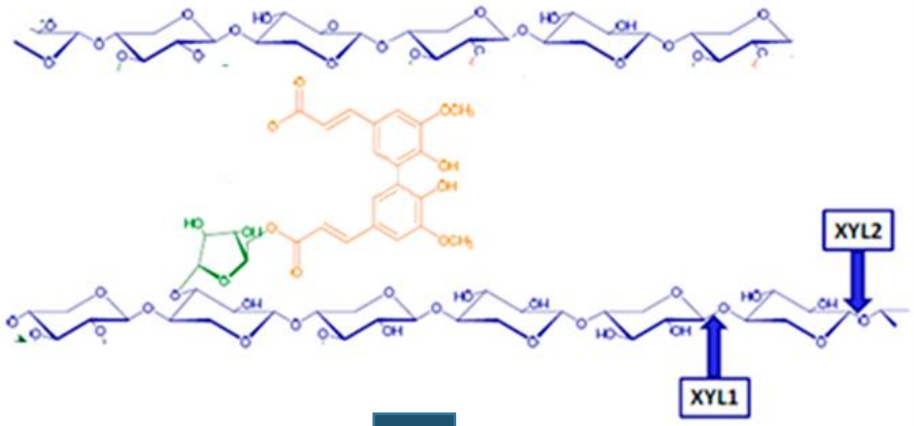
1 Formulating diets

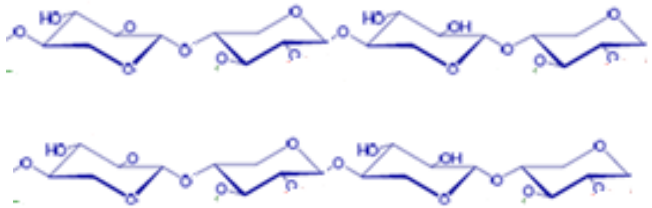
1 Formulating diets

Raw materials can be a source of prebiotics









Xylan oligomers
(known to be prebiotic)

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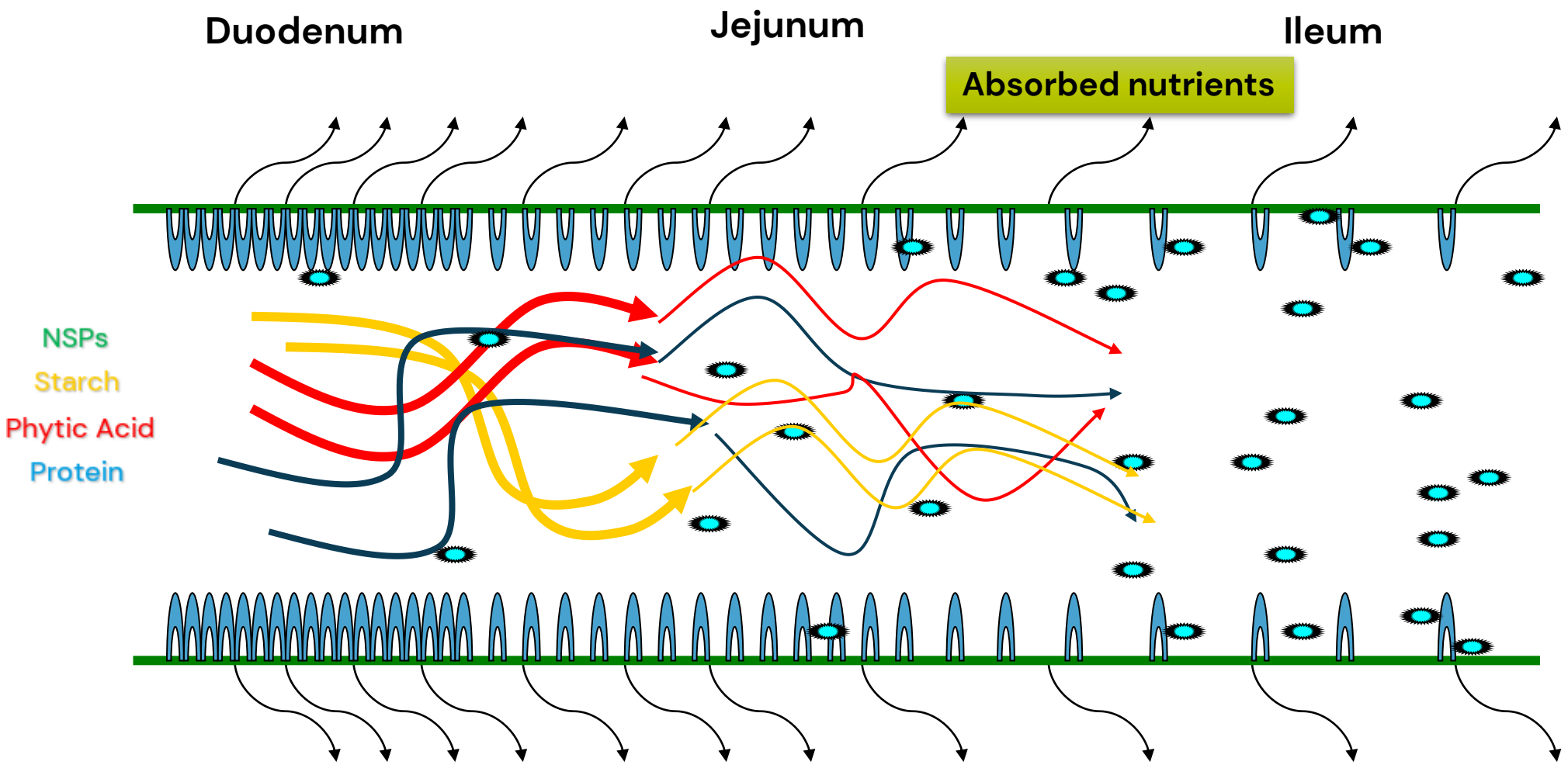
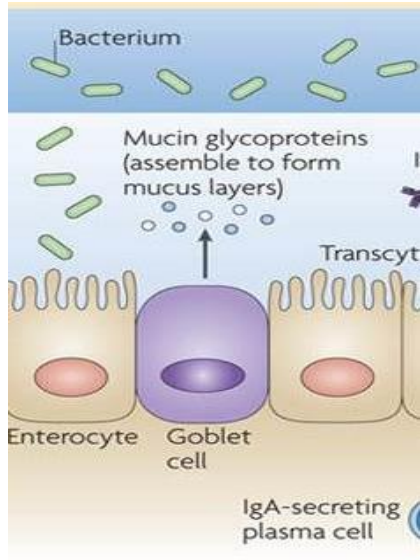
What happens when the digestion is **OPTIMAL?**





Mucin: by GC : mucus blanket of granular HMW glycoprotein assemble to form protective barrier (Bacteria, viruses and parasites: dehydration & mechanical damaged. However permeable to LMW components:> Intestinal nutrient absorption

Courtesy of R. Torbeyns

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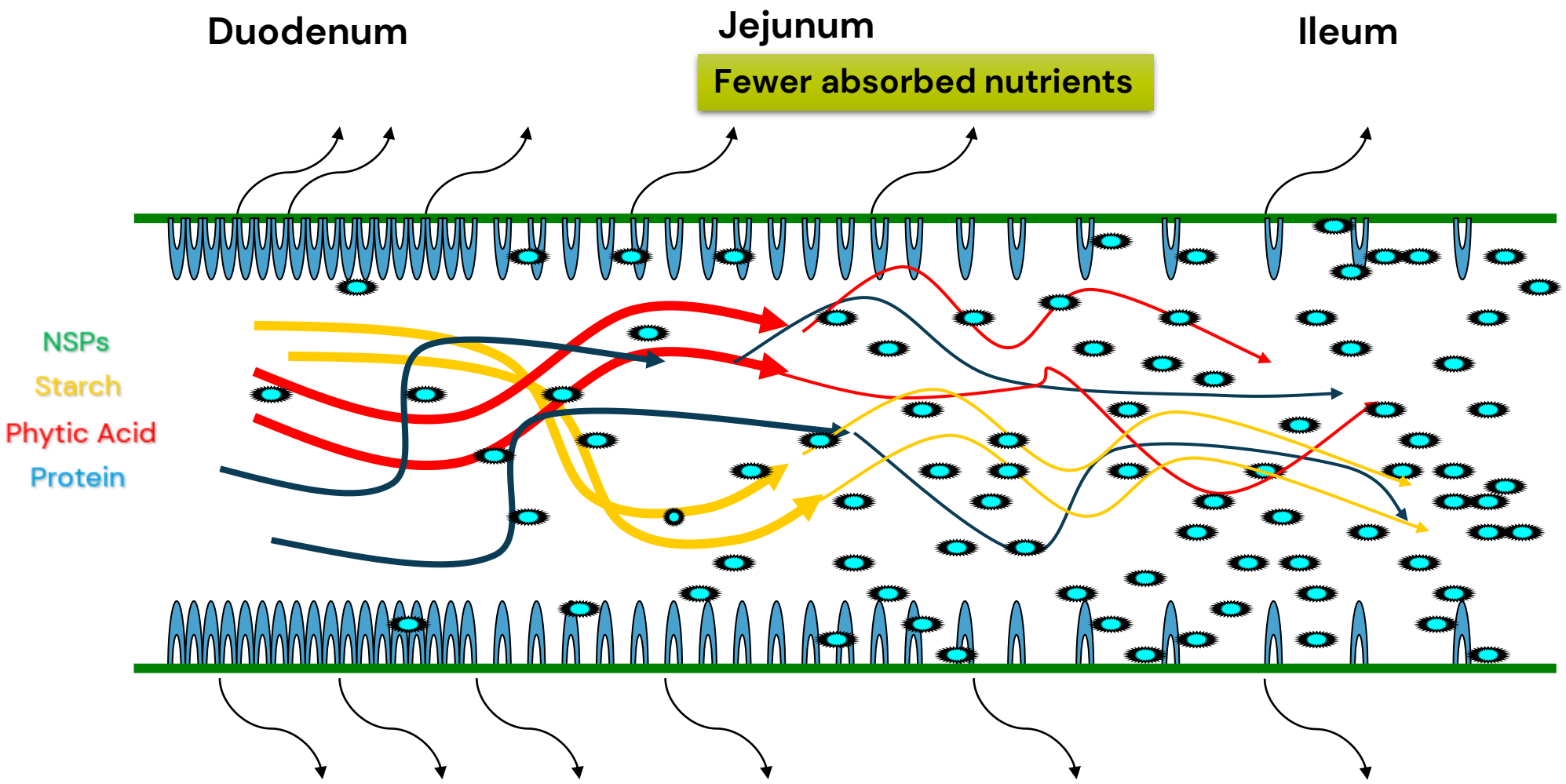
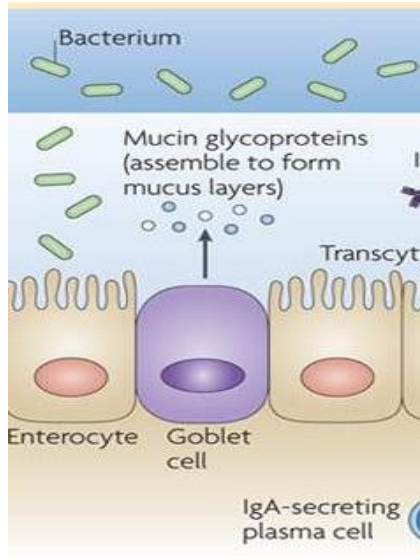
What happens when the digestion is SUB-OPTIMAL?





Mucin (MUc2 Muc3) glycoprotein: branched oligosaccharide attached to protein core (OH):> (Ser, Thre. (41%) , Pro, Asp, Glu. OLS (Fu, Gal, GalNAc, GlcNAc, SialicAcid), Glycosilation; Respond to infections, inflammatory conditions

Courtesy of R. Torbeyns

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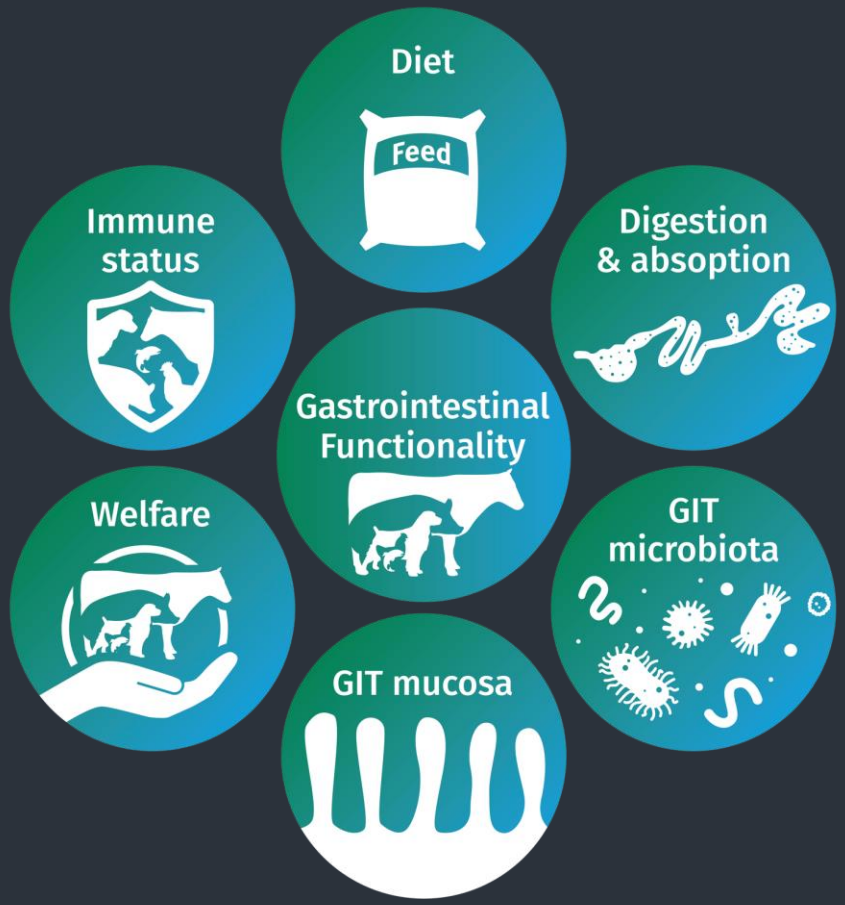
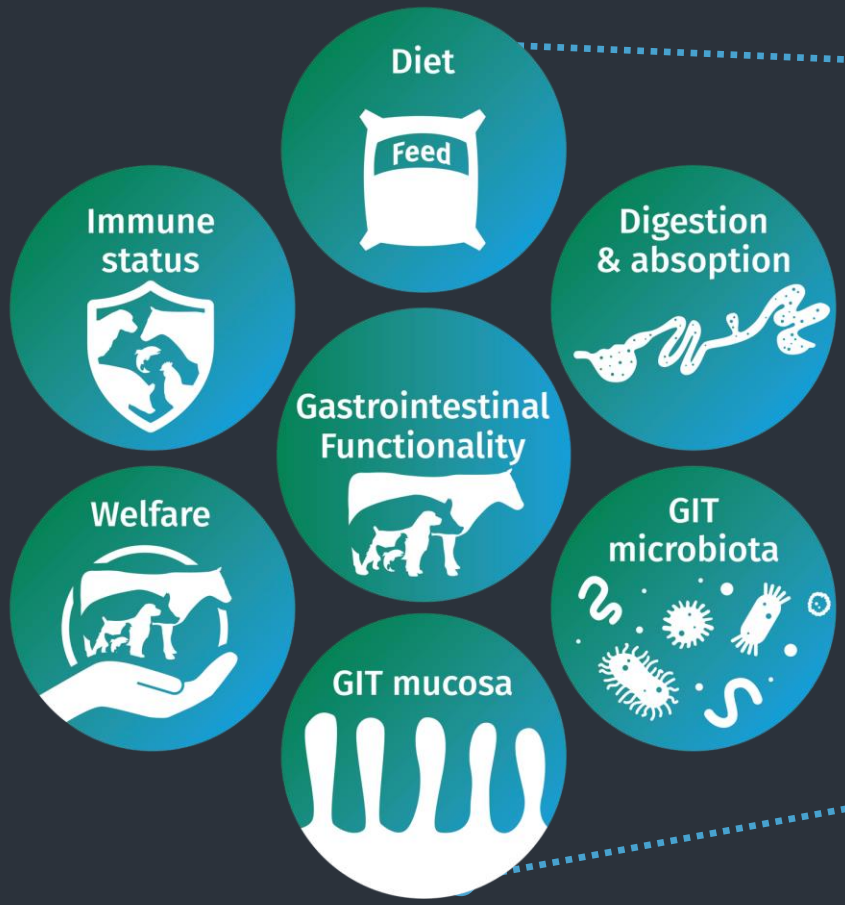
Optimal Gastrointestinal Functionality



OPTIMUM GASTROINTESTINAL FUNCTIONALITY:

'a steady state where the microbiome and the intestinal tract (host) exist in symbiotic equilibrium and where the welfare and performance of the animal is not constrained by intestinal dysfunction' (modified from *Celi et al. 2017*)

Optimal Gastrointestinal Functionality



THE MICROBIOME IS RECOGNIZED AS A KEY PLAYER IN ACHIEVING OPTIMAL GASTROINTESTINAL FUNCTIONALITY

OPTIMUM GASTROINTESTINAL FUNCTIONALITY:
'a steady state where the microbiome and the intestinal tract (host) exist in symbiotic equilibrium and where the welfare and performance of the animal is not constrained by intestinal dysfunction'
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2

Conventional approach in influencing gut microbiome

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2

Conventional approach
in influencing gut microbiome

Conventional Perspective on Microbiome Science

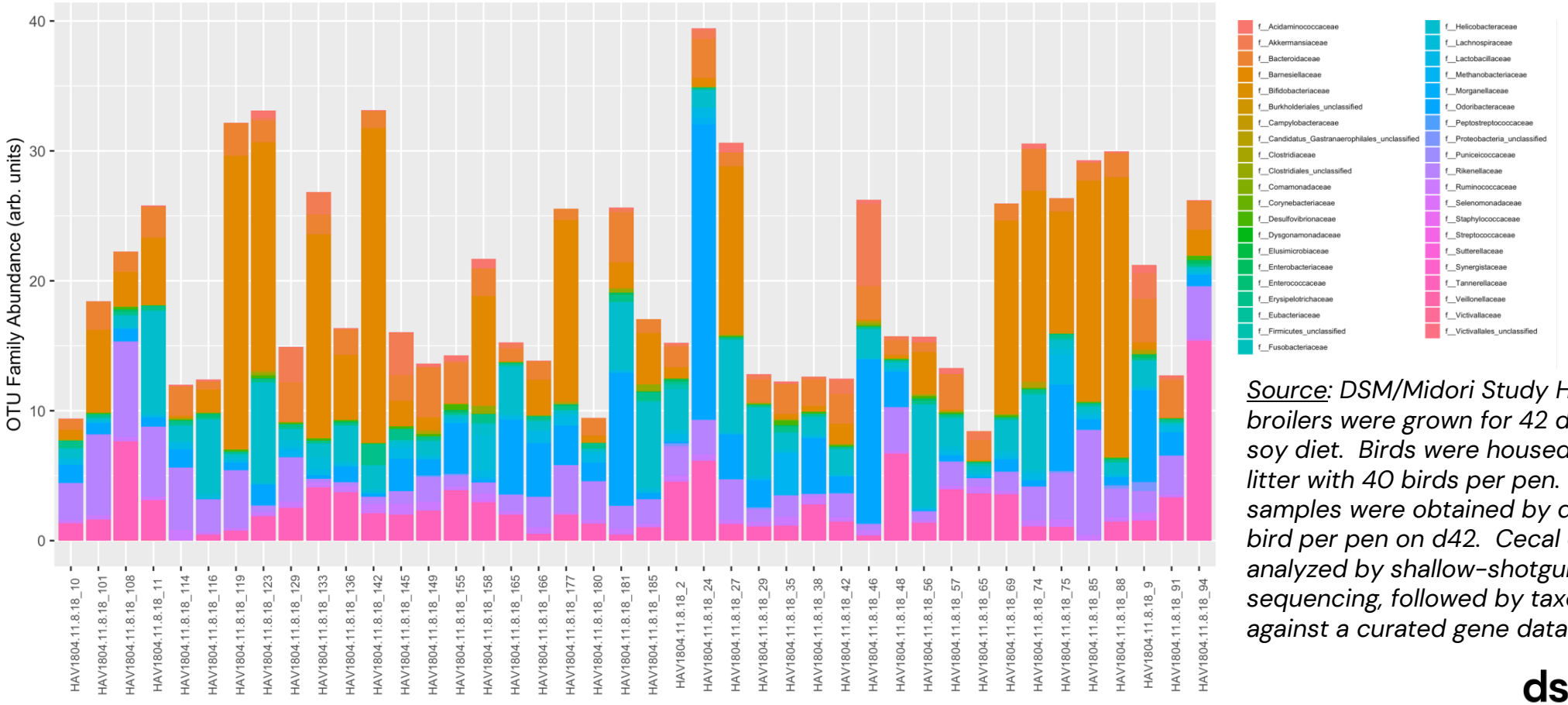
Who is there?

2

Conventional approach
in influencing gut microbiome

Conventional Perspective on Microbiome Science

Who is there?



Source: DSM/Midori Study HAV1804. Cobb 500 broilers were grown for 42 days on a standard corn-soy diet. Birds were housed in floor pens on used litter with 40 birds per pen. Cecal microbiome samples were obtained by dissection of 1 healthy bird per pen on d42. Cecal digesta samples were analyzed by shallow-shotgun whole genome sequencing, followed by taxonomic assignments against a curated gene database.

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1 Antibiotics

2 Raw Materials

3 Enzymes

4 Acidifiers & Phytogenics

5 Direct Fed Microbials and Prebiotics

6 Other Feed Additives

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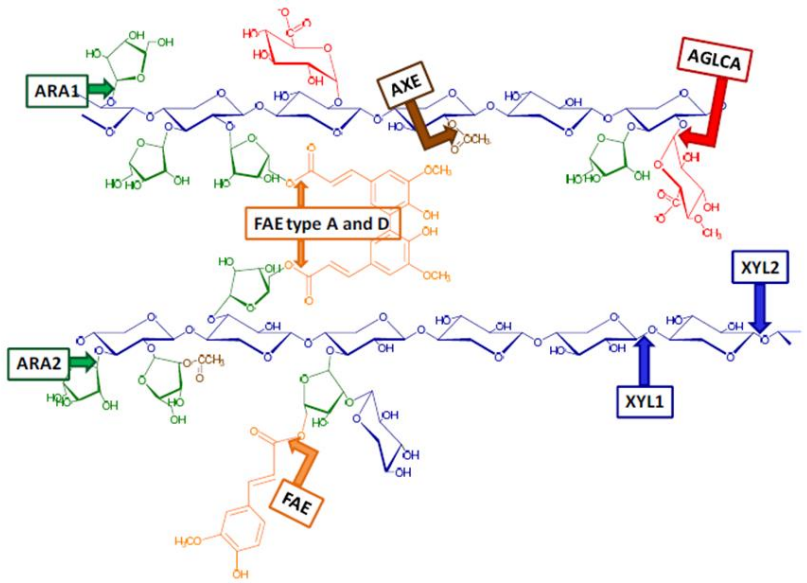
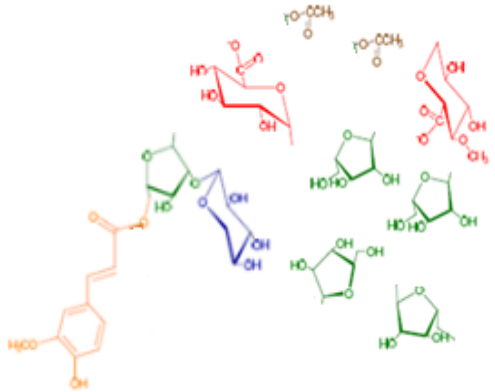
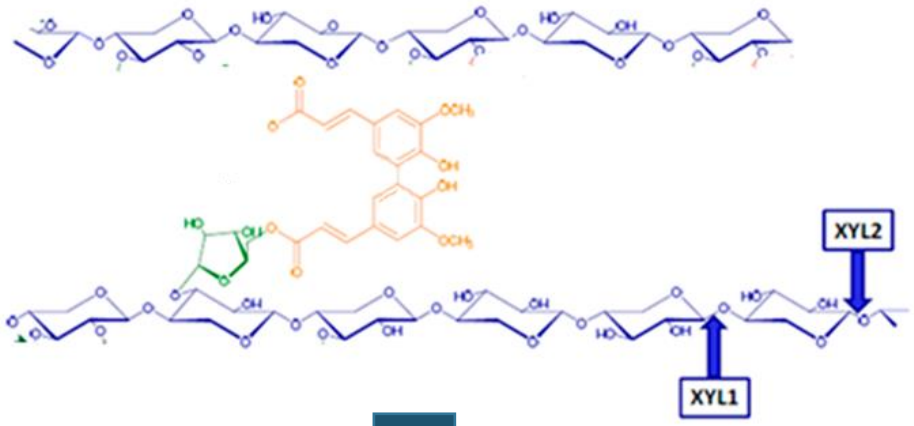
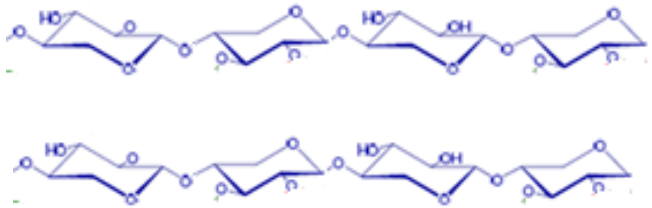
Raw materials can be a source of prebiotics









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Animal Feed Science and Technology 236 (2018) 159–169

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Combined *endo*-β-1,4-xylanase and α-L-arabinofuranosidase increases butyrate concentration during broiler cecal fermentation of maize glucurono-arabinoxylan

J.L. Ravn[a,b,*], V. Glitsø[a], D. Pettersson[a], R. Ducatelle[b], F. Van Immerseel[b], N.R. Pedersen[a]

[a] *Novozymes A/S, Krogshoejvej 36, 2880 Bagsværd, Denmark*
[b] *Department of Pathology, Bacteriology and Avian Diseases, Faculty of Veterinary Medicine, Ghent University, Salisburylaan 133, B-9820 Merelbeke, Belgium*

Total xylan solubilisation (g/kg dry matter) from four replicates of maize fibre incubated in sodium acetate buffer (0.1 M, pH 5) for 3 h at 40 °C without or with xyl and araF dosed at 10 mg EP/kg and 5 mg EP/kg, respectively.

Treatment	Total xylose release (g/kg DM)	SEM[1]
Blank	0.4[c]	0.06
araF	0.4[c]	0.02
xyl	6.2[b]	1.14
xyl + araF	26.1[a]	1.09

[1] SEM = standard error of mean. abc: Mean values within a column not sharing a common letter index differ significantly ($P < .05$; Tukey-Kramer HSD).

Effects of xyl and araF supplementation on broiler villi length[1] in the duodenum.

	Day14		Day29		
Treatment	Villi length (µm)	*P* value[2]	Villi length (µm)	*P* value[2]	Pooled SEM[3]
Control (n = 24)	1644	–	1918	–	56.6
xyl + araF (n = 24)	1667	.47	2039	< .01	40.4

[1] Random measurements of 10 villi per duodenum section (24 sections) was performed by a computer-based LAS v.4 software (Leica) analysis system.
[2] *P* value[1]. Pairwise comparison of means (Tukey-Kramer HSD test) for control and enzyme supplementation at days 14 and 29, respectively.
[3] SEM = Standard error of mean.

Animal Feed Science and Technology 226 (2017) 113–123

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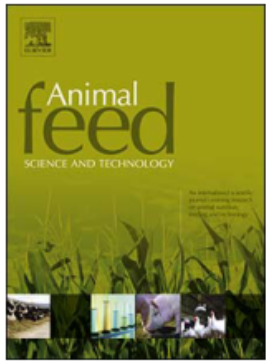


GH11 xylanase increases prebiotic oligosaccharides from wheat bran favouring butyrate-producing bacteria *in vitro*

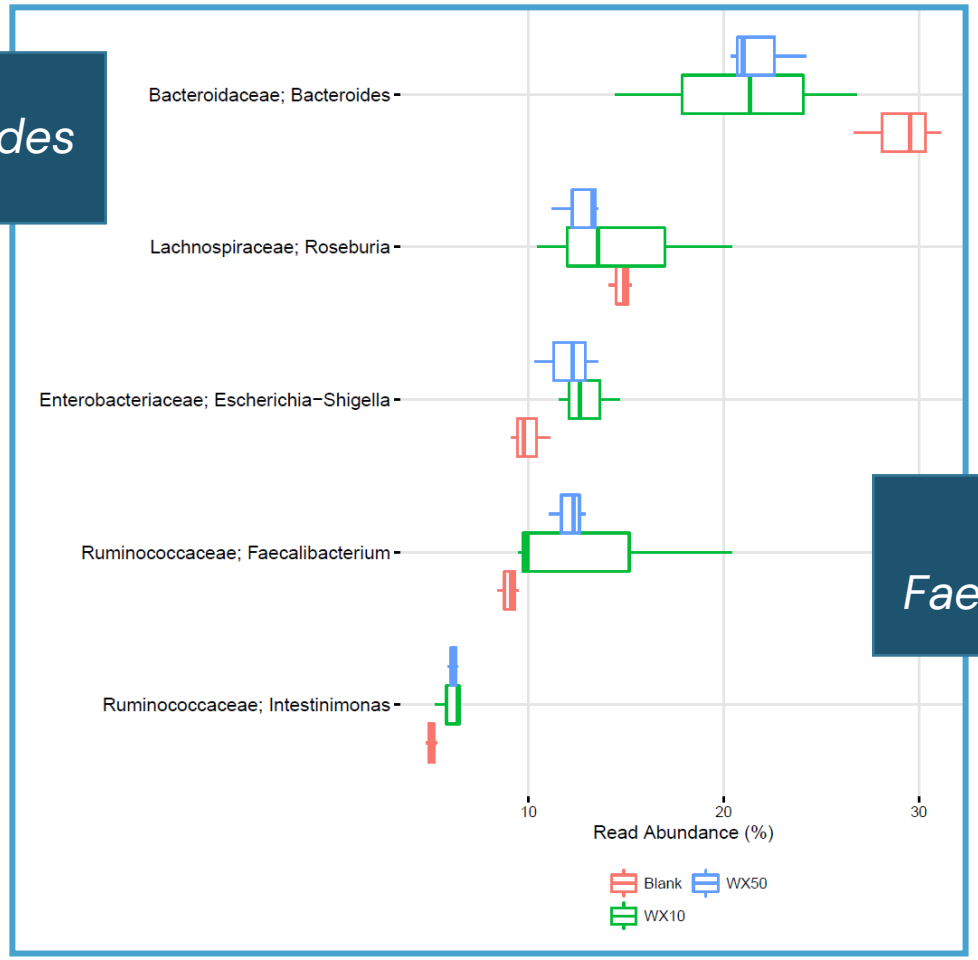
Jonas Laukkonen Ravn[a,*], Juliane Charlotte Thøgersen[a], Jens Eklöf[a], Dan Pettersson[a], Richard Ducatelle[b], Filip van Immerseel[b], Ninfa Rangel Pedersen[a]

[a] *Novozymes A/S, Krogshoejvej 36, 2880 Bagsværd, Denmark*

[b] *Department of Pathology, Bacteriology and Avian Diseases, Faculty of Veterinary Medicine, Ghent University, Salisburylaan 133, B-9820 Merelbeke, Belgium*

GH11 xylanase increases prebiotic oligosaccharides from wheat bran

LESS *Bacteroides*



MORE *Faecalibacterium*

A shift in the microbiota is observed upon treatment with WX10 and WX50

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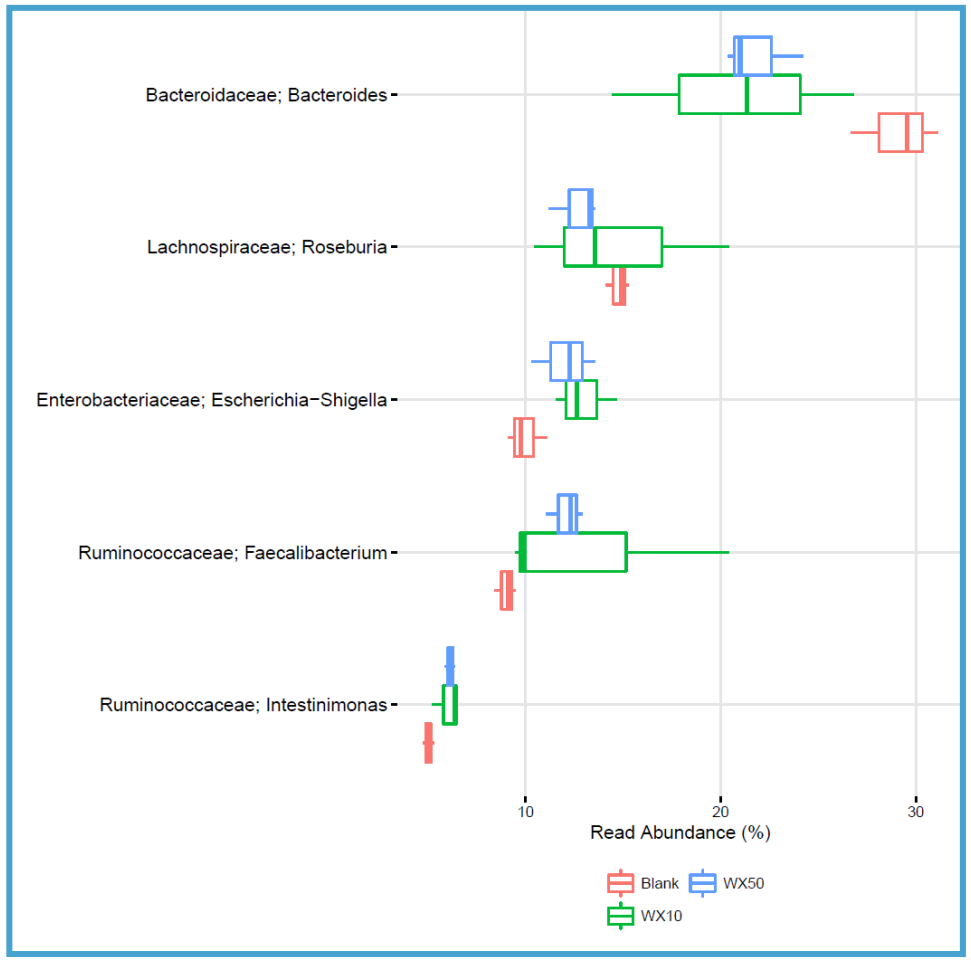
GH11 xylanase increases prebiotic oligosaccharides from wheat bran



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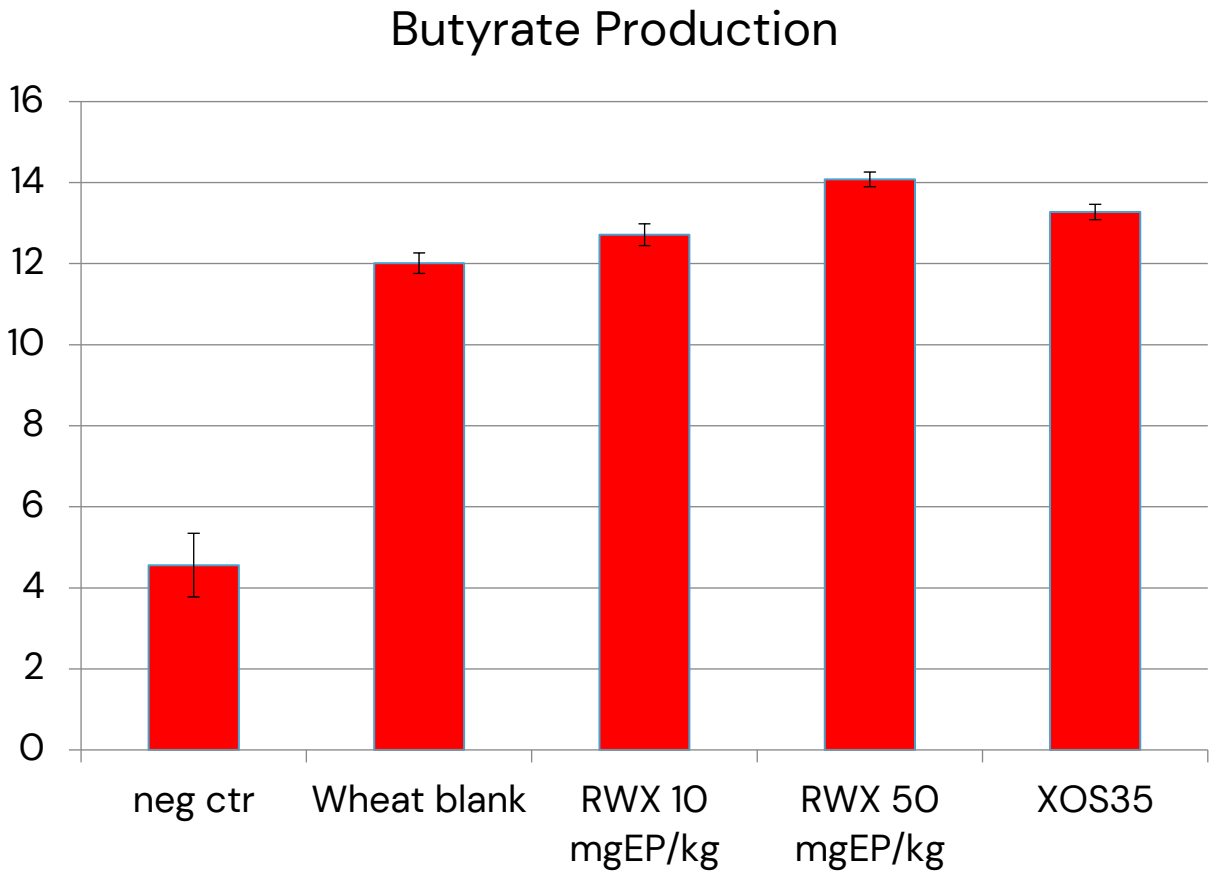

Fermentation metabolite formation by ceacal content

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When broilers are fed the same diets using different digestive enzymes, **do the bacterial populations and type differ between groups?**

Are exogenous enzymes the same?

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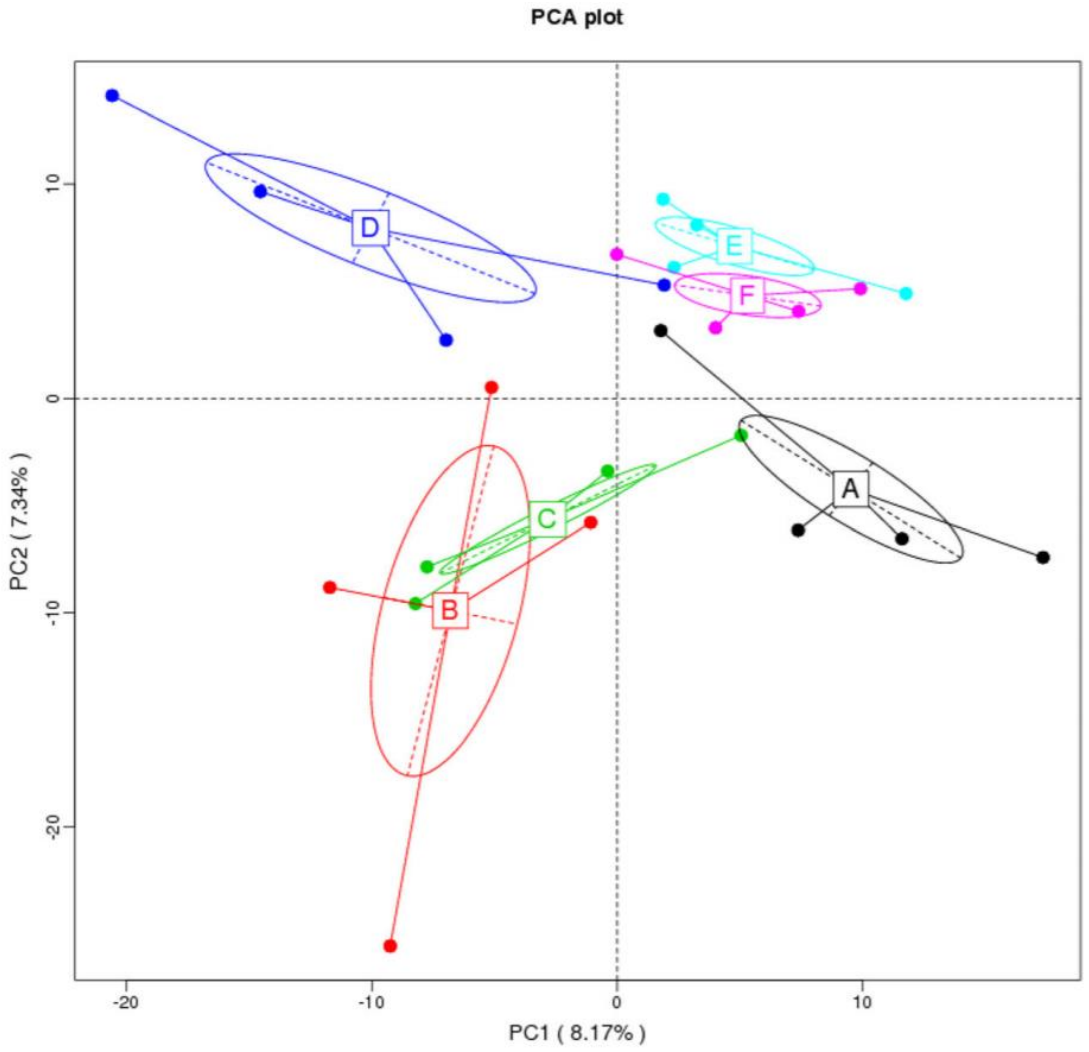
Are Exogenous Enzymes the Same?



A: Control
B: Amylase
C: B + amylopectase + glucoamylase
D: C + protease
E: D + xylanase
F: E + cellulase + pectinase

When broilers are fed the same diets using different digestive enzymes, **do the bacterial populations and type differ between groups?**

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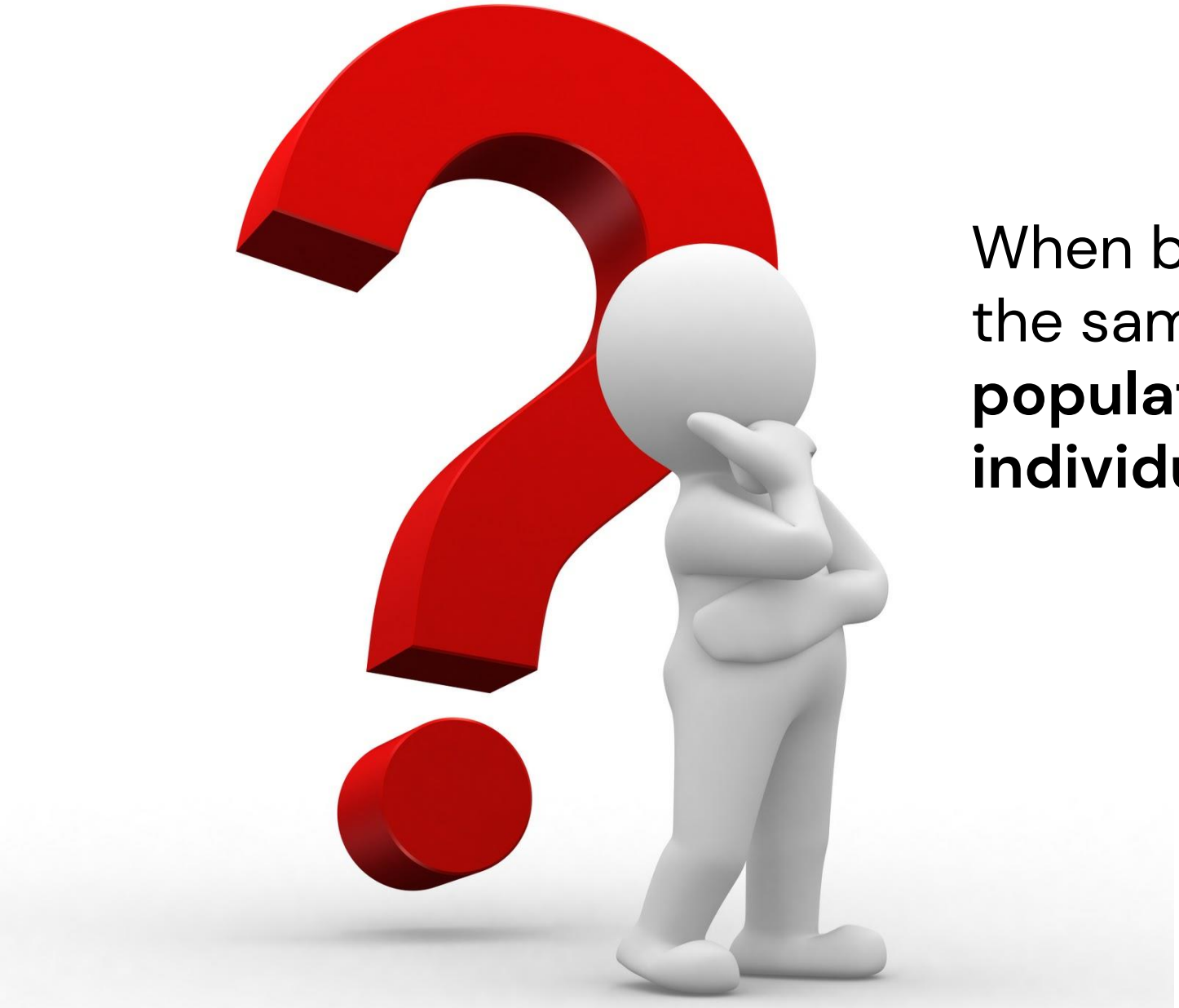

When broilers are in same shed fed the same diet, **do the bacterial populations and type differ between individuals?**

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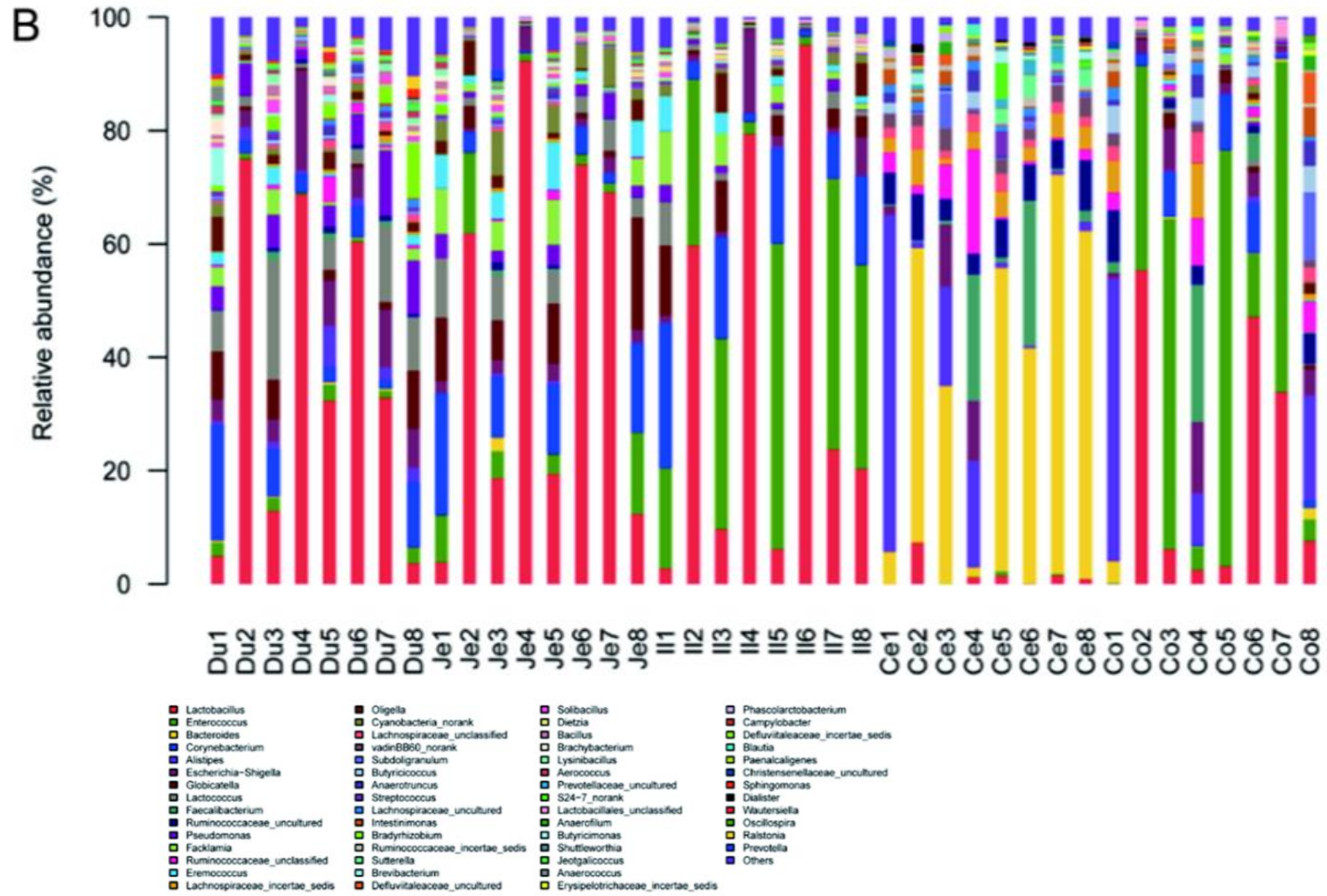
Diets and Microbiota Relationship

When broilers are in same shed fed the same diet, **do the bacterial populations and type differ between individuals?**



Yingping, et.al., 2017

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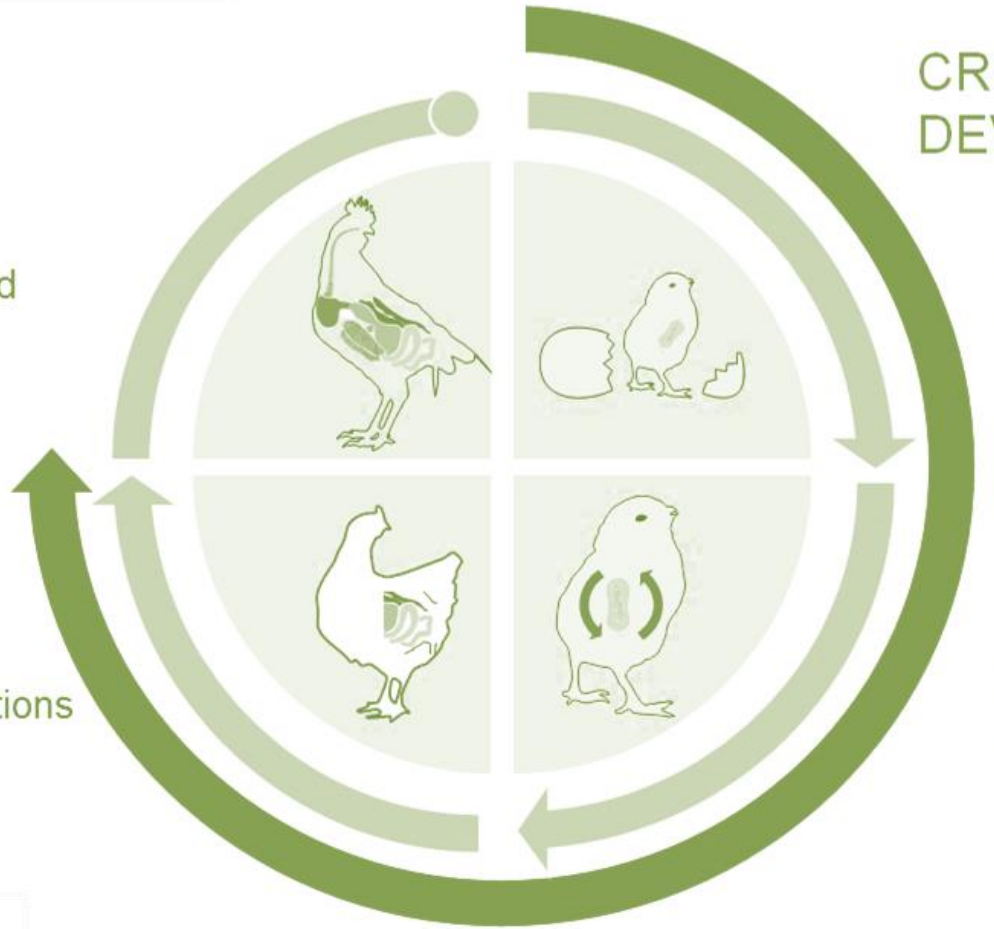
First 21 days are critical for microbial developement



CRITICAL TIME IN DEVELOPMENT

Hatch
Colonisation begins

7 days
Rapid microbial turnover

14 -21 days
Small intestine populations established

>30 days
Cecal populations established

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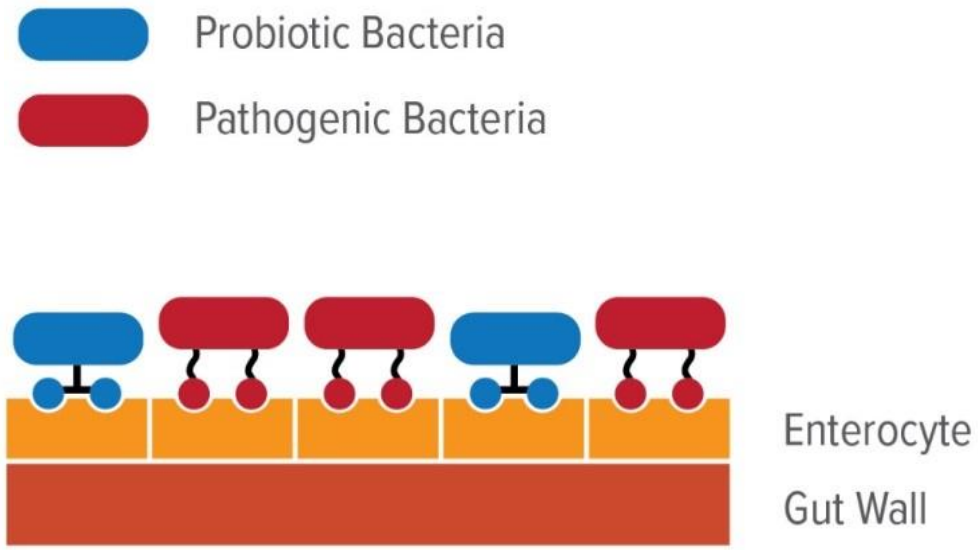
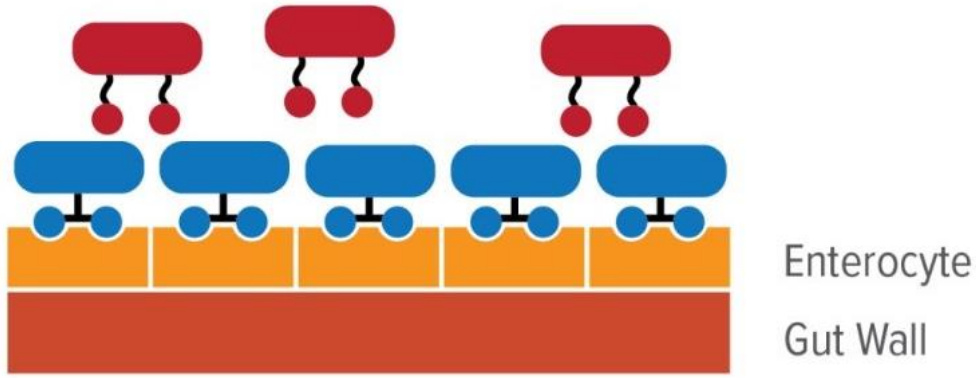
Seeding the gut as early as hatching with probiotic bacteria is important

Not all gut bacterial receptors are specific

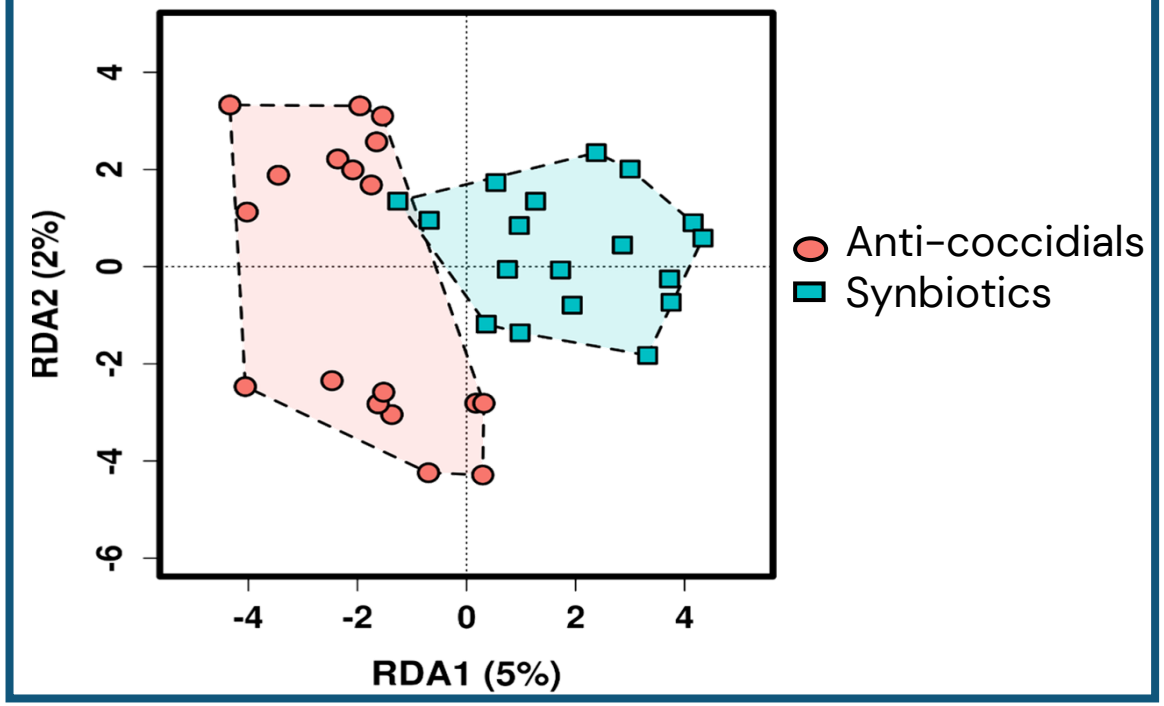




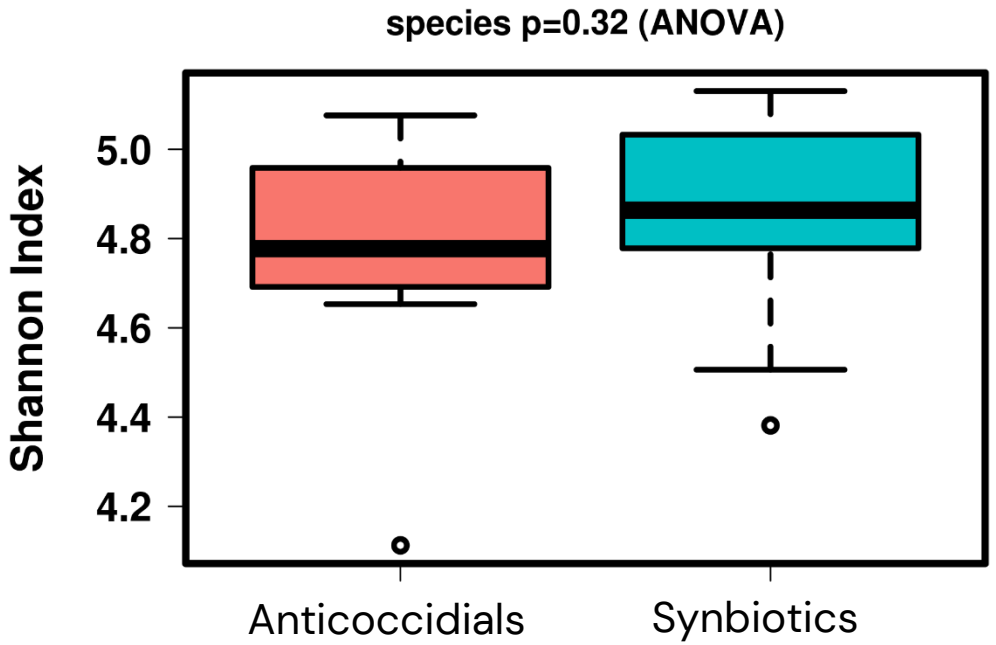
Probiotics adhere and block intestinal receptors, inhibiting adherence and colonization by pathogens.

Synbiotics vs. Anticoccidials

Exploratory analysis in the gut



Diversity analysis in the gut



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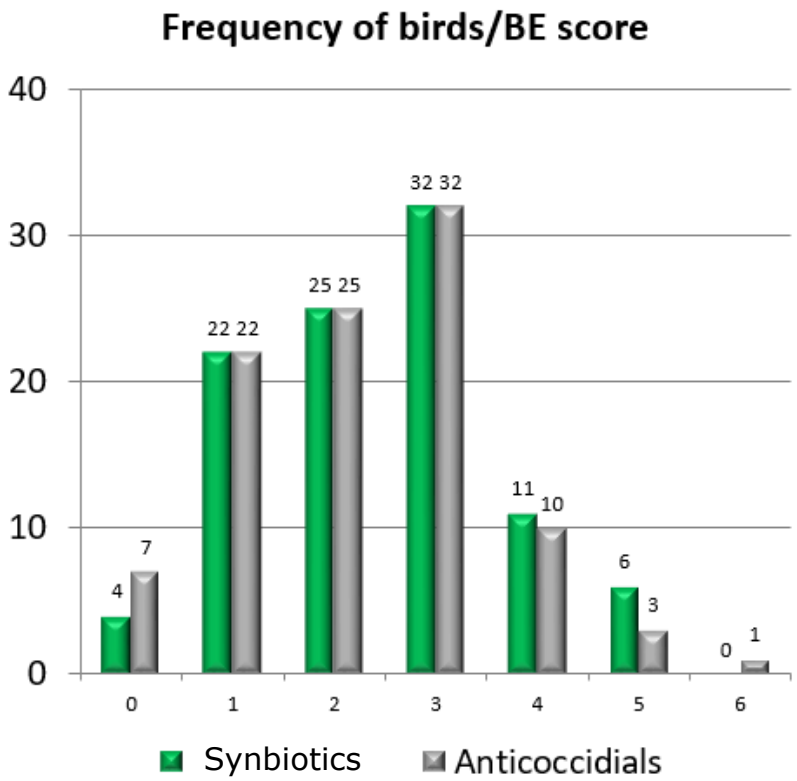
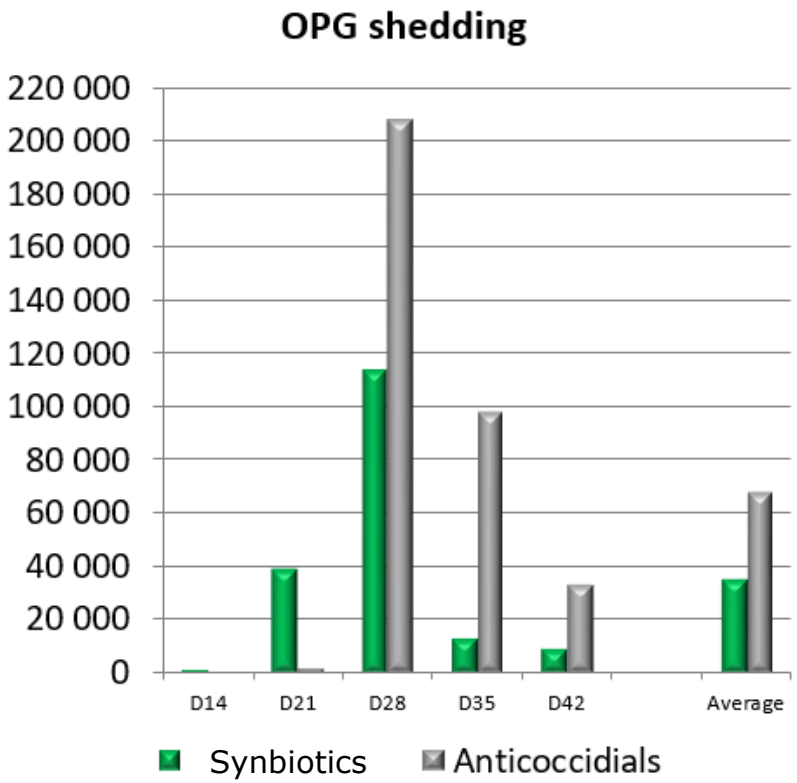
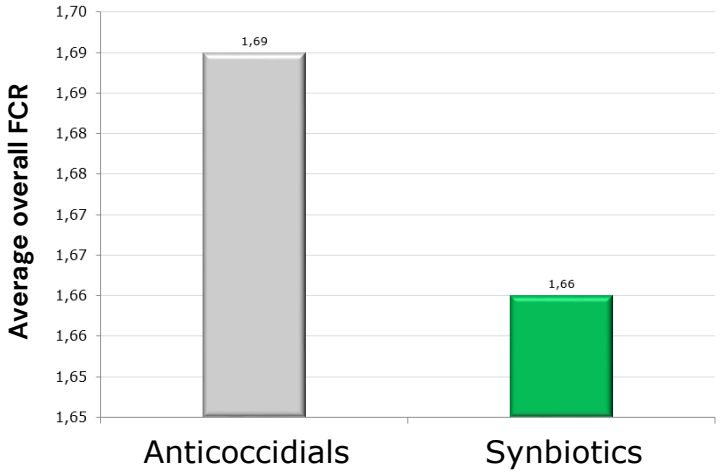
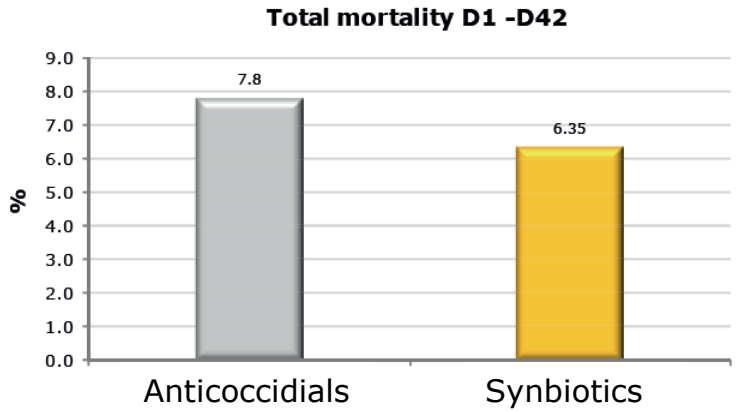
Synbiotics vs. Anticoccidials

	Starter 1-20 days	Grower 21-28 days	Finisher
Control	Anti-coccidial drug	Anti-coccidial drug	
Program	Synbiotics (1kg/MT)	Synbiotics (0.5kg/MT)	Synbiotics (0.5kg/MT)









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Nutrition, Gut Microbiome, and Poultry Health

3

Novel approach in influencing gut microbiome

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3

Novel approach
in influencing gut microbiome

What if we look at the gut microbiome beyond just a collection of microbiome but as an organ?

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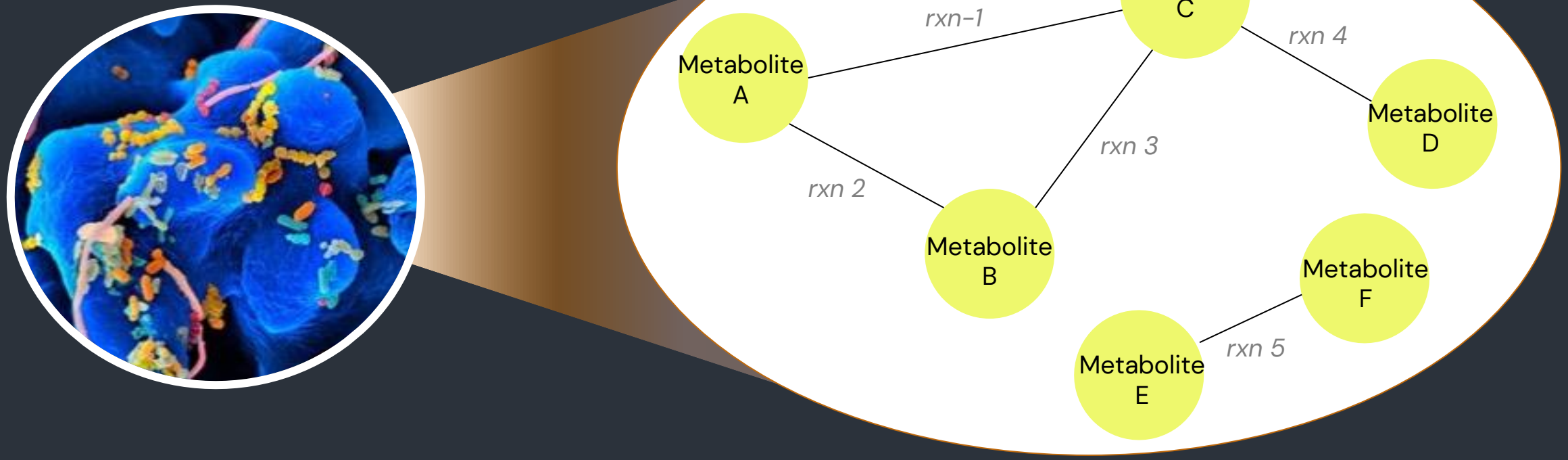
....like other organs, we need to view the microbiome via its functions, not cells...



The ***Functional Metagenome*** refers all the metabolic pathways of the microbiome organ as a whole

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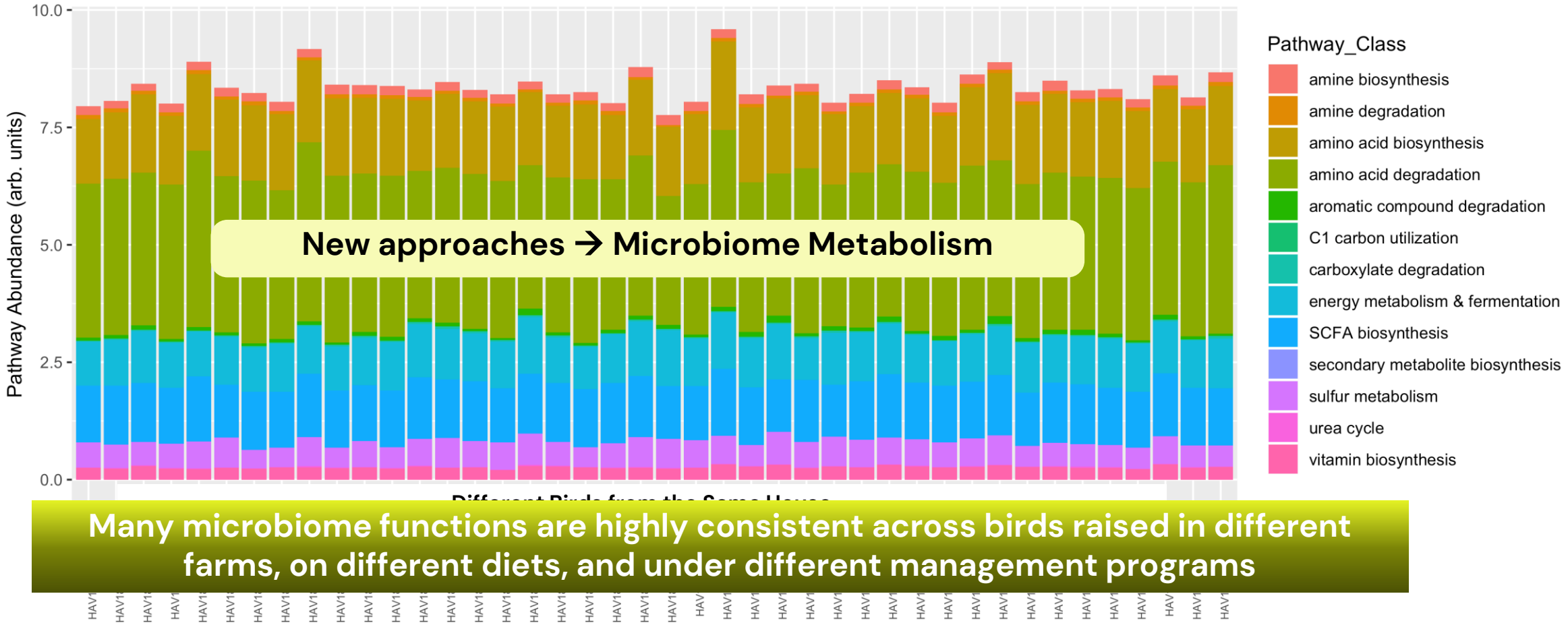
Novel Perspective on Microbiome Science

What are they doing?

Novel Perspective on Microbiome Science

What are they doing?



Source: DSM/Midori Study HAV1804. Cobb 500 broilers were grown for 42 days on a standard corn-soy diet. Birds were housed in floor pens on used-litter with 40 birds per pen. Cecal microbiome samples were obtained by dissection of 1 healthy bird per on d42. Cecal digesta samples were analyzed by shallow-shotgun whole genome sequencing, followed by functional metagenomic assignment against a proprietary function-annotated gene catalog and pathway groupings according to MetaCyc pathway ontology.

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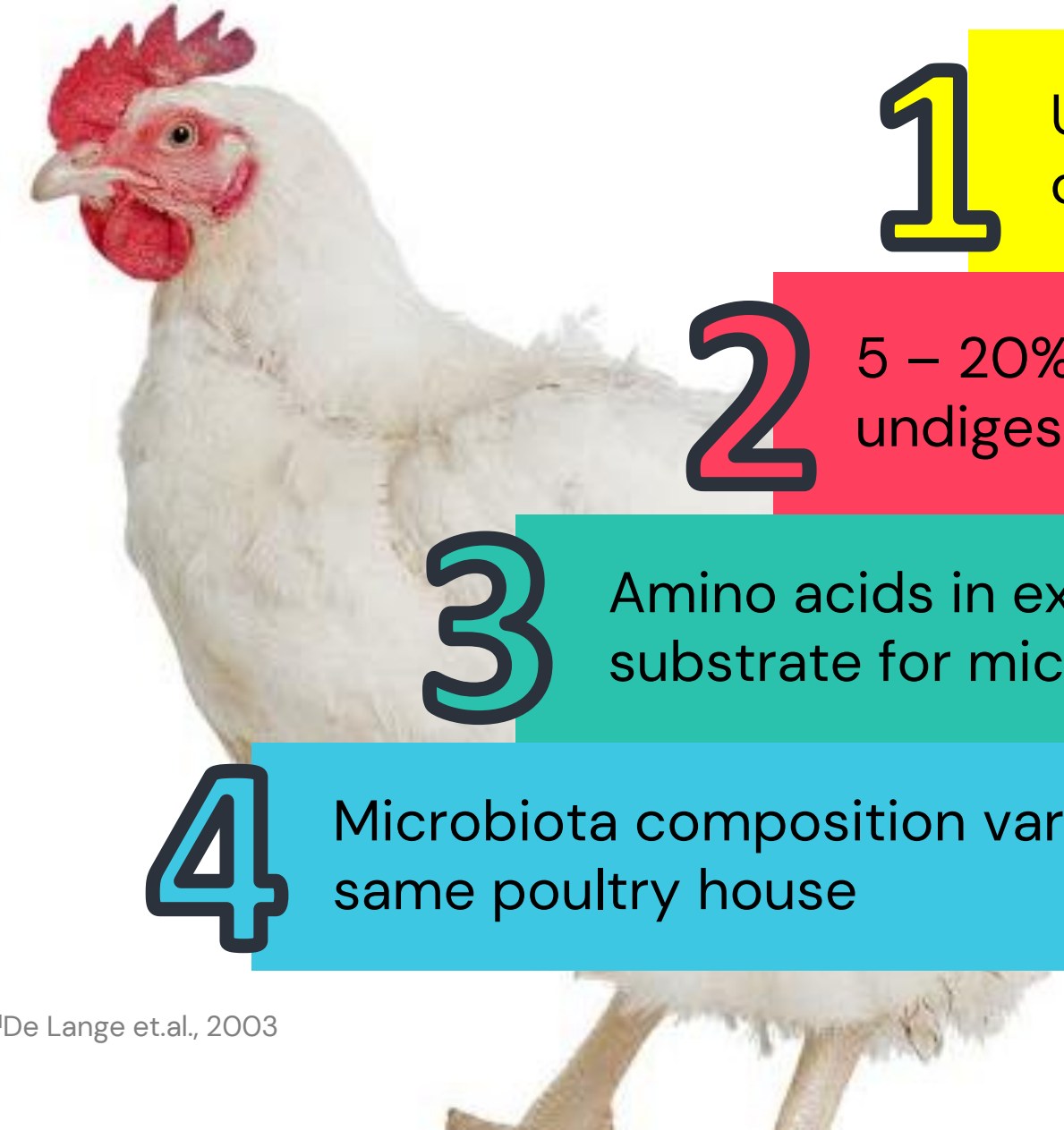
Poultry gut health challenges in relation to proteins



1. Undigestible protein has a negative effect on broiler performance
2. 5 – 20% of the protein used in the diet is undigestible[1]
3. Amino acids in excess of the birds' requirements are a substrate for microbiome
4. Microbiota composition varies dramatically between birds in the same poultry house

[1]De Lange et.al., 2003

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Shifting the microbiome protein metabolism influences host health, performance, welfare, and sustainability via microbial metabolites.

Beneficial Microbiome Protein Metabolism

Assimilation Pathways to:

- Branched & short-chain fatty acids
- Polyamines
- Other amino acids

- Improve performance[1,3,4]
- Stimulate immune function[5] and homeostasis [1]
- Control inflammation[3]

Undesirable Microbiome Protein Metabolism

Putrefactive pathways to:

- NH_3 / NH_4^+, H_2S radicals, and reactive sulfur
- Uric acid
- Skatole & other indoles

- Increase luminal pH and feed pathogens [1]
- Cause epithelial damage [6,7]
- Reduce energy metabolism[8] and performance
- Cause undesirable litter & odor emissions[9]

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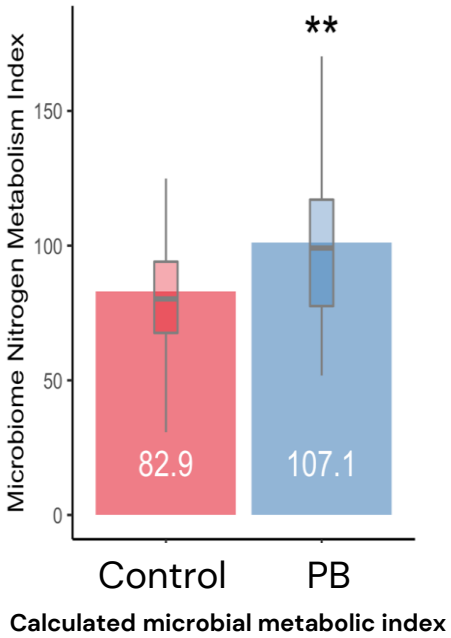
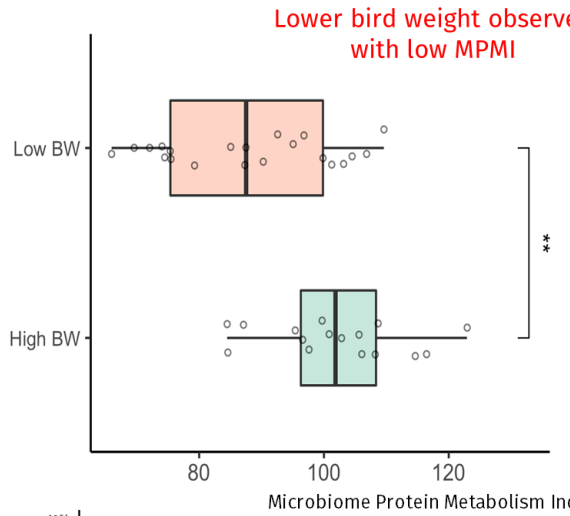
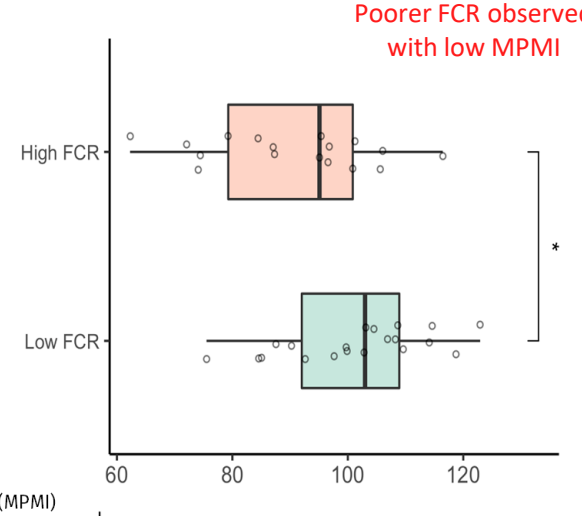
Poor microbiome protein metabolism is associated with higher gastric disease, performance loss, and poor welfare

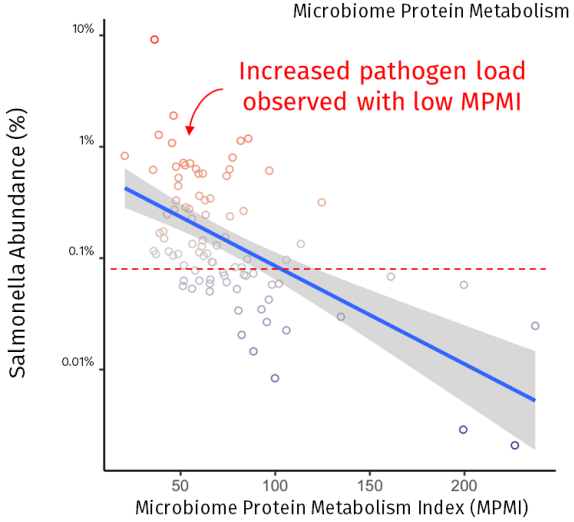
Improving Protein Metabolism

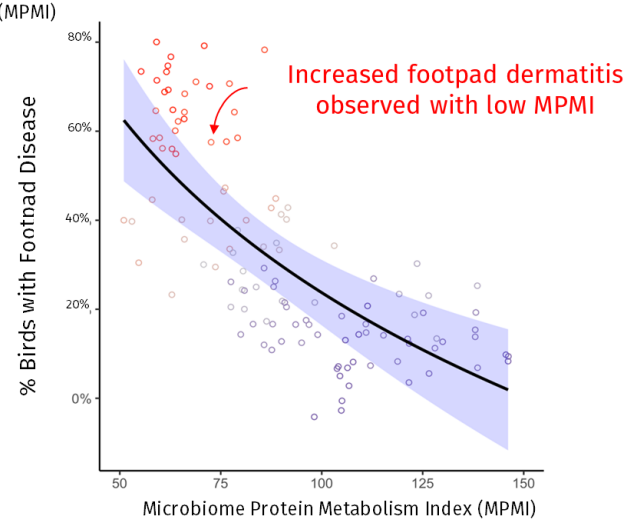


Calculated microbial metabolic index









Lower MPM index was positively correlated with poorer FCR, BWG , higher incidences of footpad lesions and higher *Salmonella* abundance.

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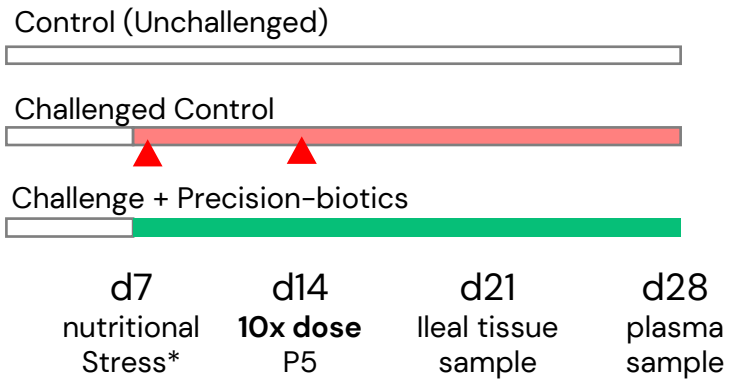
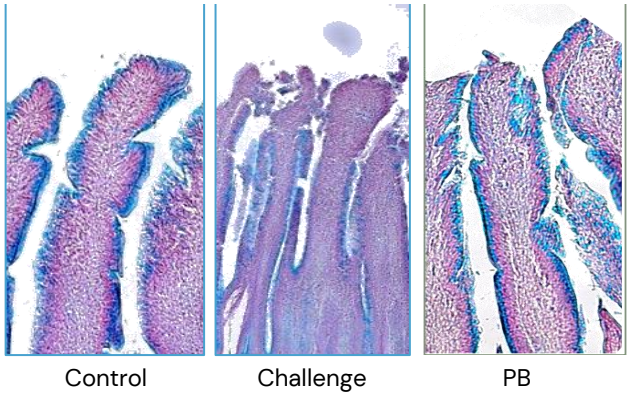
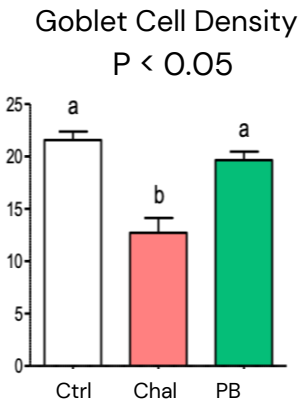
Precision-biotics support birds' resilience to enteric stress

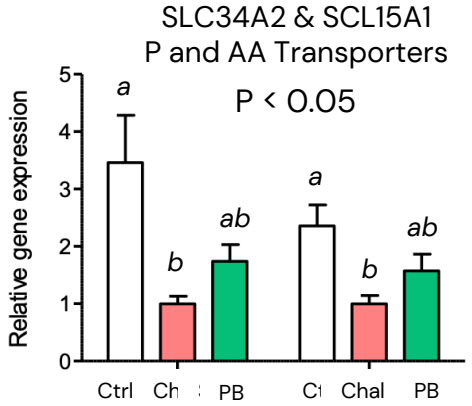
Study Design:



Precision-biotics maintained healthy epithelial histology, morphology, and goblet cell density, and helped maintain nutrient transport throughout the inflammatory challenge







- Cobb 500 broilers in battery cages
- Control: Conventional broiler diet
- ***Protein utilization stressor: No Soybean meal, 16% potato protein, 13% Rapeseed meal**
- 3 treatment groups with 20 replicates per d28 blood AGP to measure systemic inflammation

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Precision-biotics support birds' resilience to enteric stress

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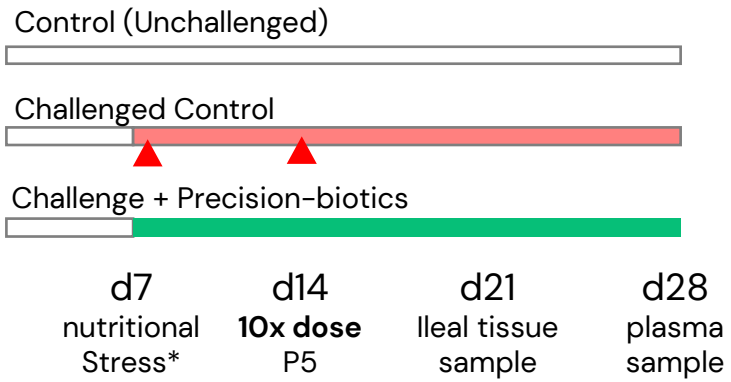

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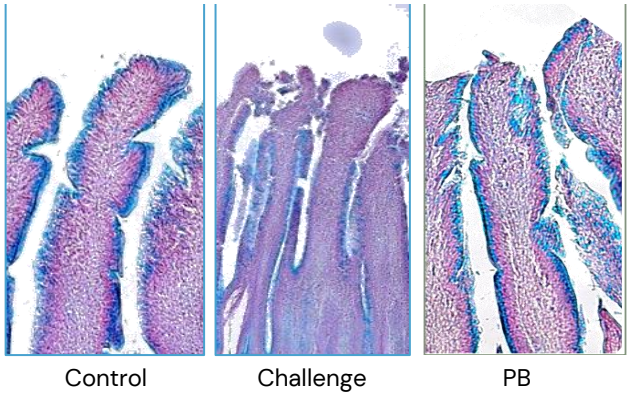
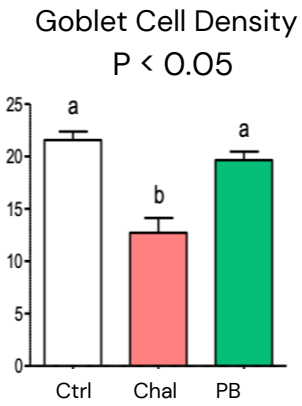
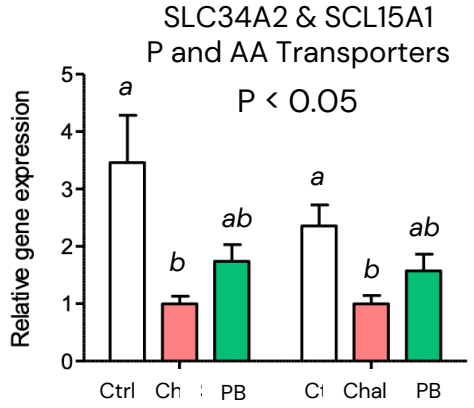
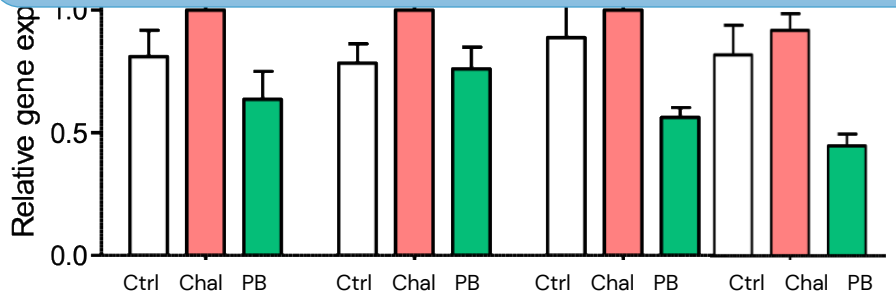
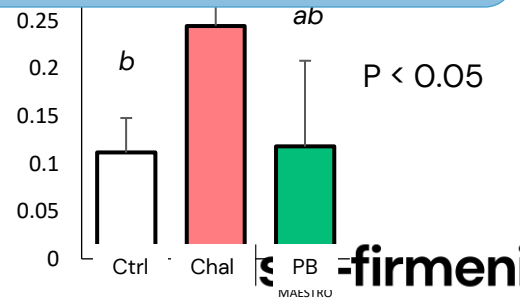






Precision-biotics maintained healthy cytokine and acute phase protein response, both locally and systemically throughout the inflammatory challenge





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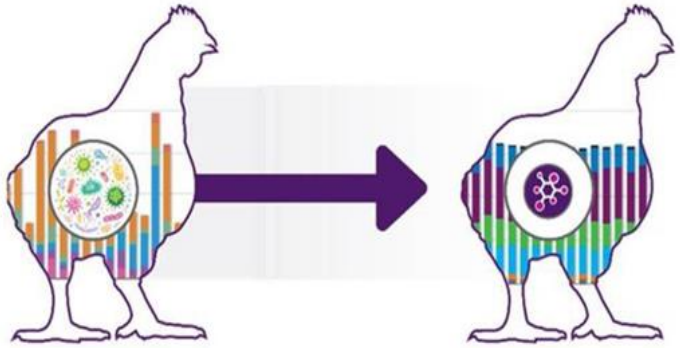
Key Message on precision-biotics



Focus beyond the composition of bugs
BUT to their functions

Precision-biotics modulate microbial metabolic pathways, promoting pathways associated with beneficial metabolites and suppressing pathways associated with undesirable metabolites

Improves resilience to gastric stressors, especially in flocks exposed to gastric challenges In antimicrobial removal, or reduction, cocci vaccination, during feed changes

Gut microbiome ferments unused proteins & excess amino in the hind gut to toxic metabolites

Beneficial metabolites:
Short-chain fatty acids (Butyrate), conversion of Nitrogen to amino acids.
Undesirable metabolites:
Ammonia, Hydrogen Sulfide

Precision-biotics
performance of challenged flocks back to potential ↑
Litter quality ↑
Incidences of foot pad lesions ↓
Pathogen load ↓
Environmental emissions ↓

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Nutrition, Gut Microbiome, and Poultry Health

4

Key takeaways

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4 Key takeaways

- Nutrition, together with management, has a great impact on the health and well-being of the animal

- When formulating diets, do not settle on meeting the minimum nutrient requirements alone, but should be considering:
  - Raw materials and digestibility
  - Feed additives
  - Formulating in excess of the animal's requirement

4 Key takeaways

- Not all feed additives are the same. A lot of considerations should be taken when choosing these types of additives.
- Utilizing the microbiome's functionality by modulating microbial metabolite output is an innovative strategy to improve the nutritional well-being, health, productivity and sustainability of broiler production.

We bring progress to life™

jean-marjorie.ensendencia@dsm.com

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