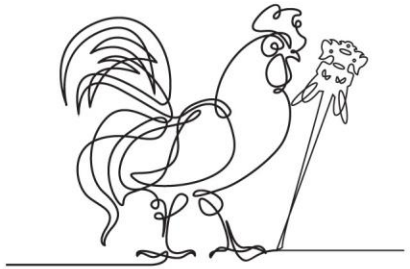


23rd European Symposium on Poultry Nutrition

ESPN 2023

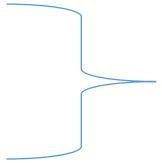
RIMINI/ITALY JUNE 21 - 24

Improving the nutritional value of ingredients through the use of feed enzymes

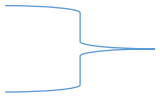
Michael Bedford, AB Vista, Marlborough, Wiltshire, UK

Ingredient issues for monogastrics that can be enzyme targetted

- Phytate
- Fibre
- Protease inhibitors/Lectins
- Mycotoxins
- Starch
- Protein
- Lipid



Major targets in commercial feeds



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- Phytate
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Major targets in commercial feeds

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Fibre

- Unhelpful term describing an heterogenous group of structures
  - Antinutritive
    - Viscous
    - Nutrient binding
    - Encapsulating
  - Inert
    - Diluent
  - Beneficial
    - Fermentable
    - Structural

Ingredient fibre content and composition varies

		Total (g/kg)			Soluble (% of total)			g/kg	g/kg
	n	A+X[1]	B-glucans	Mannan	A+X	B-glucans	Mannan	Uronic acids	Cellulose
Barley	8	77	47	4	13%	52%	30%	4	28
Rye	20	85	20	5	36%	33%	43%	3	12
Triticale	20	55	7	4	23%	14%	30%	3	19
Wheat	20	64	6	2	22%	33%	25%	3	14
Maize	3	52	1	3	10%	10%	67%	7	22
SBM	6	45		13	24%		38%	48	62
RSM	4	60		6	27%		17%	61	52

Adapted from (Rodehutscord *et al.*, 2016) and (Knudsen, 1997).
[1]Arabinose + xylose residues

Main issues with ingredients targeted mostly with xylanase and glucanase enzymes

		Total (g/kg)			Soluble (% of total)			g/kg	g/kg
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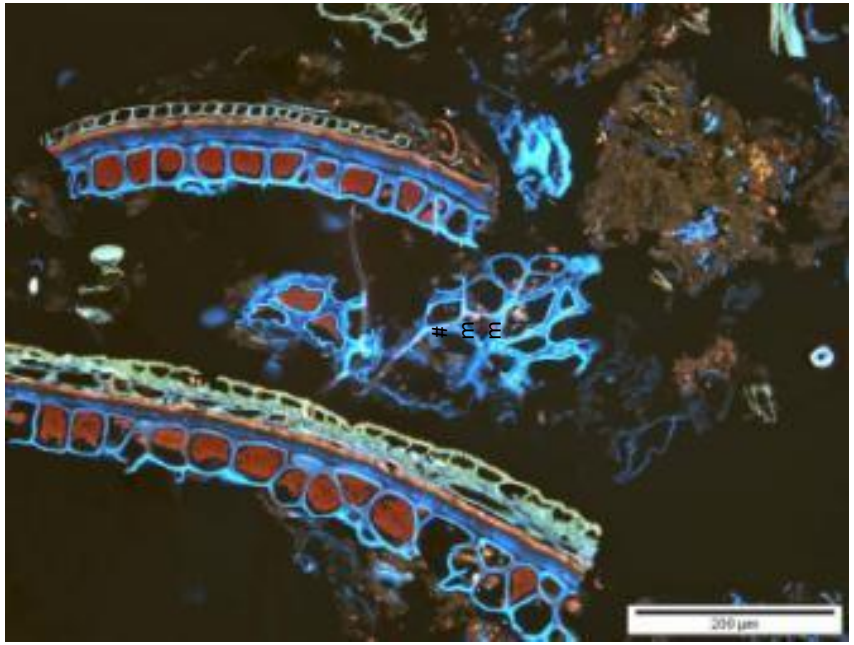
[1]Arabinose + xylose residues

Mode of action of fibre-degrading enzymes

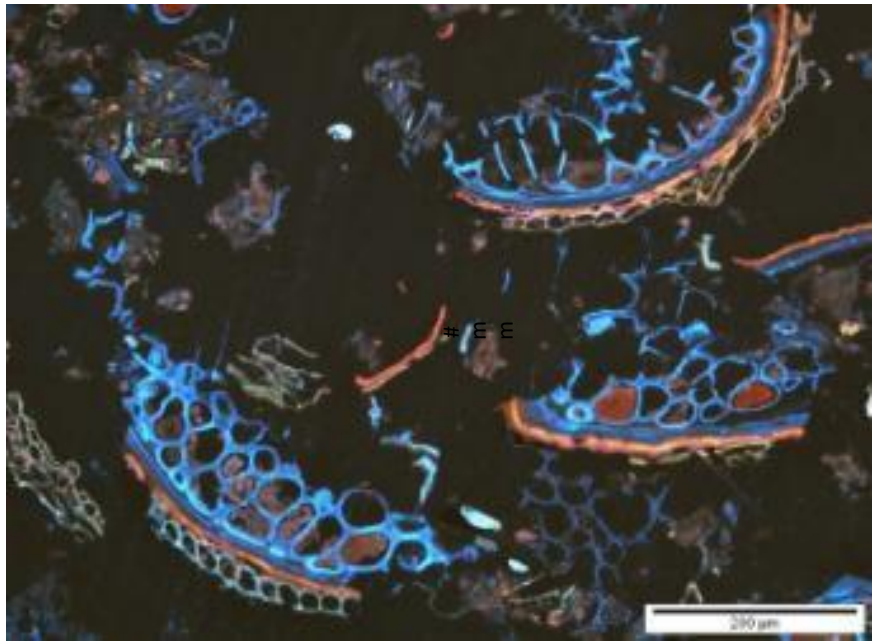
	Relevance over time
1. Opening up cell walls and exposing contents (insoluble fibre)	No change but small effect
2. Reducing intestinal viscosity	Decreasing
3. Producing fermentable fibre from insoluble fibre and further depolymerisation to prebiotics	Increasing

Cell wall effect

Samples taken from terminal ileum



Wheat diet, no enzyme



Wheat diet, xylanase added

NOTE – this *in vivo* micrographs taken from a bird fed a monocomponent xylanase

Bedford and Autio, 1996

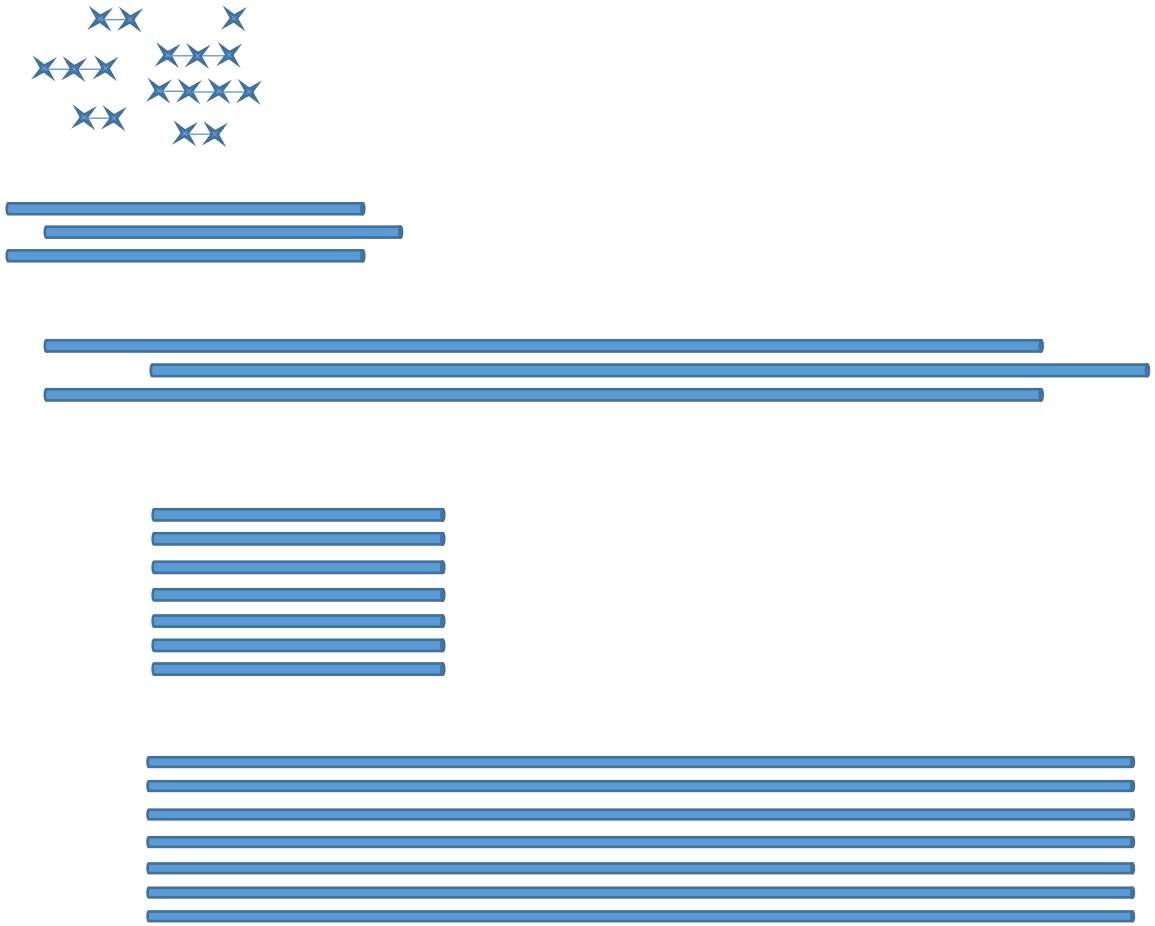
Viscosity effect

Fermentable Fibre – what defines its effects?

- Molecular Size
- Particulate size
- Solubility
- Sugar composition / complexity

- Age of animal
- Section of intestinal tract

Molecular Size and solubility



Oligosaccharides – rapidly fermented AND Stimbiotics

Soluble moderate size polysaccharides – moderate fermentation rate

Soluble large polysaccharides – moderate to slow fermentation rate.
Viscous

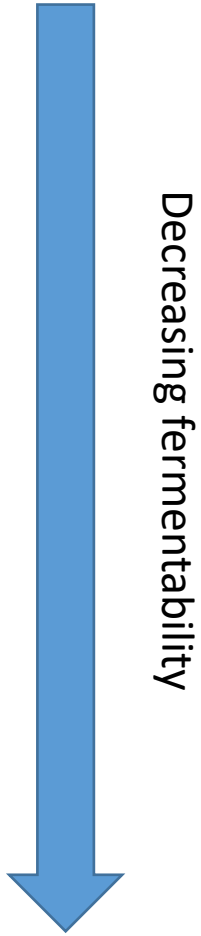
Very small particulate insoluble polysaccharides – Slow fermentation rate

Large particulate insoluble polysaccharides – Very slow to zero fermentation rate
Entraps nutrients

Decreasing fermentability

Sugar composition

Monosaccharides
Starch
Protein
Fructans
FOS/GOS
B glucans
Mannans/Galactans
Pectins
Xylans
Cellulose



Complexity

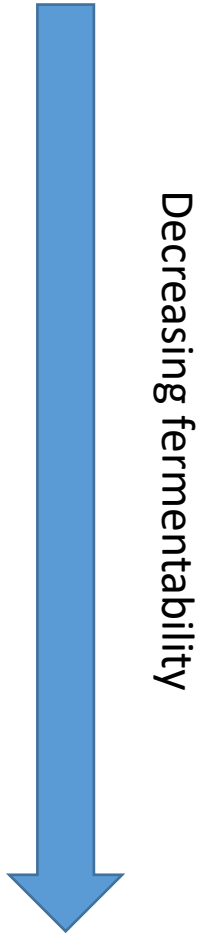
Single backbone

Low level of Substitution of backbone

Multiply substituted backbone

Complex multiple backbones linked together

Highly complex lignified material

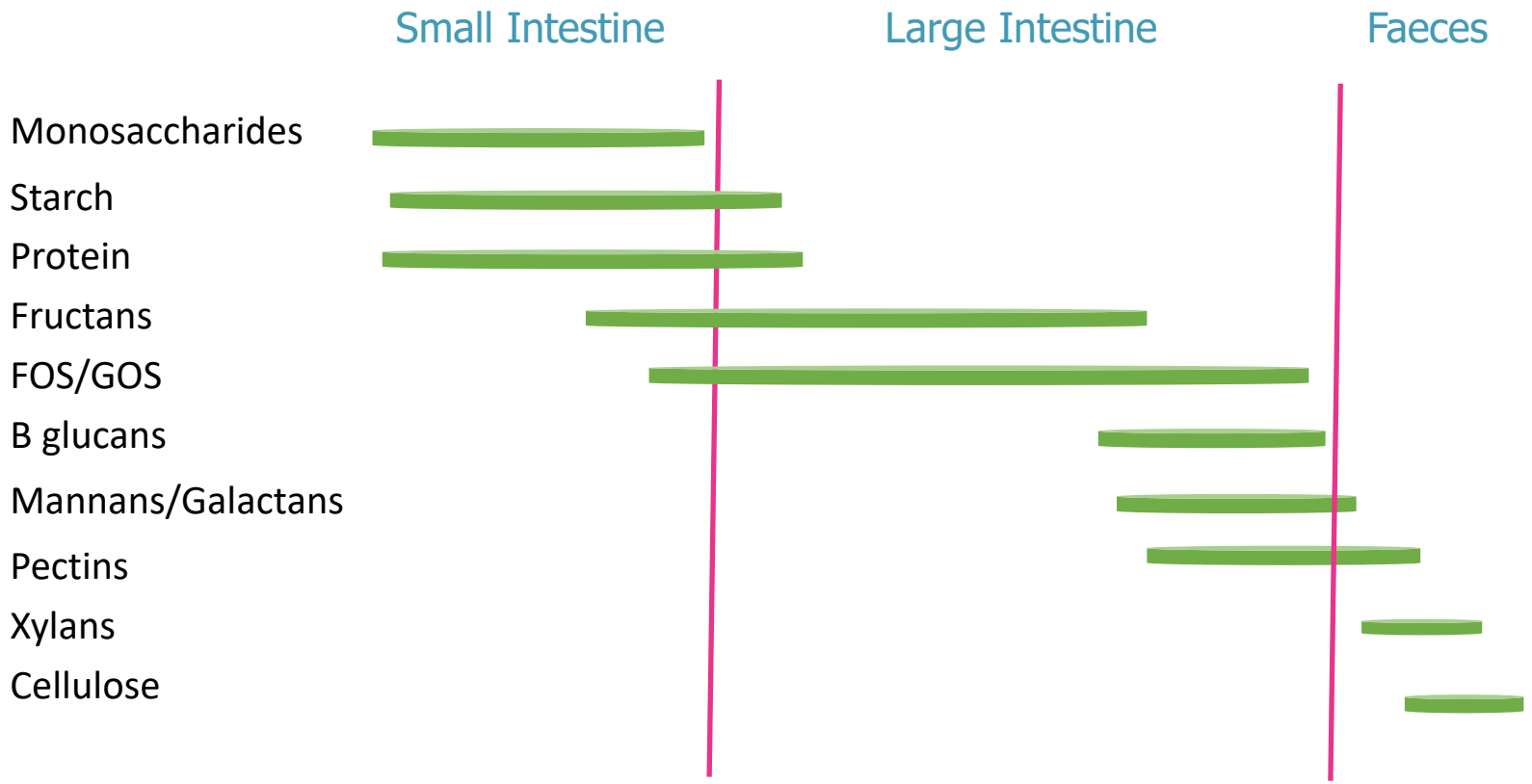


Section of the GIT also influences fermentation capacity

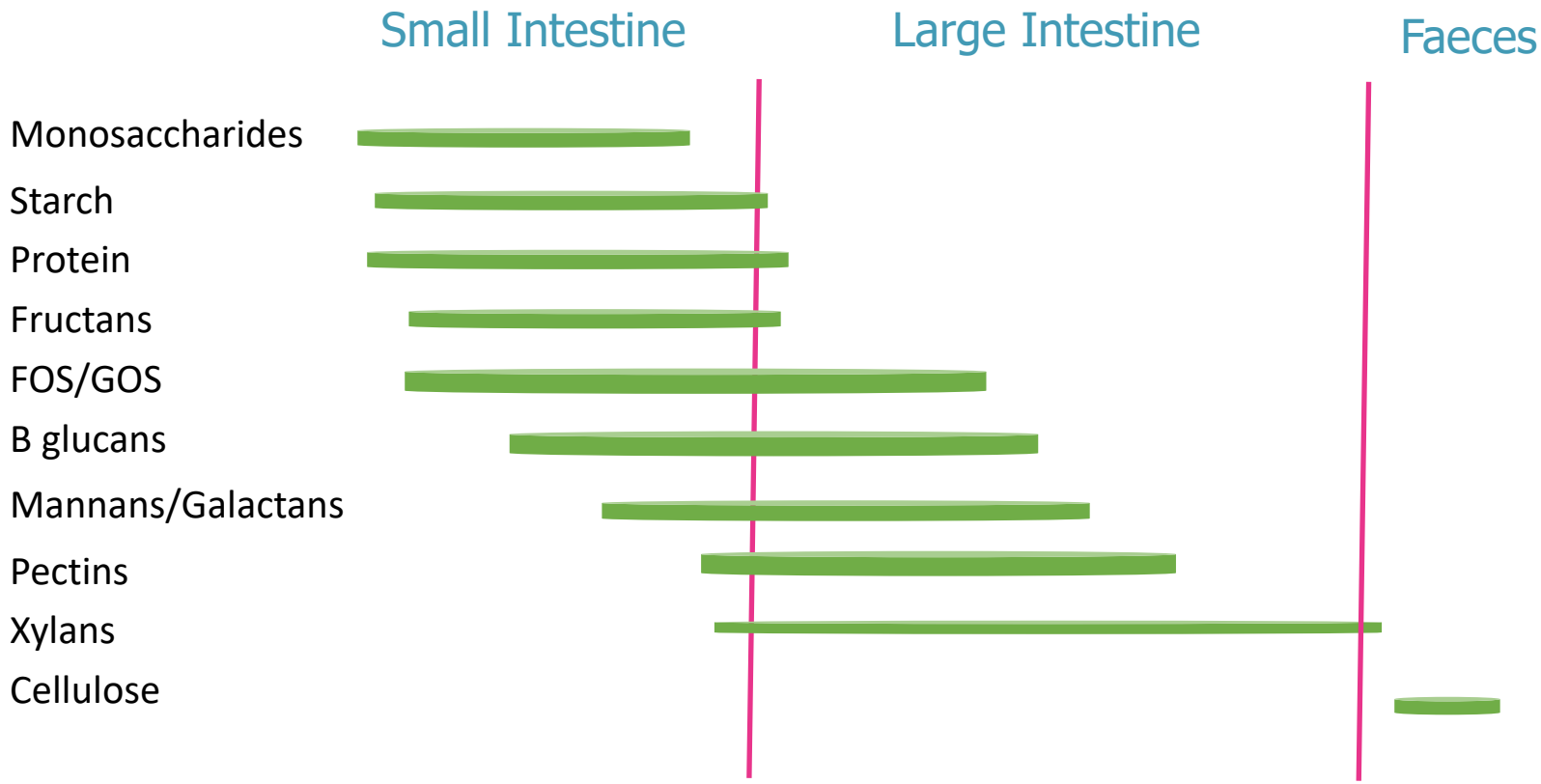
Crop	++
Gizzard	
Duodenum	=
Jejunum	++
Ileum	+++
Caecum	++++++++++
Colon	++

Capability of all sections increases with age

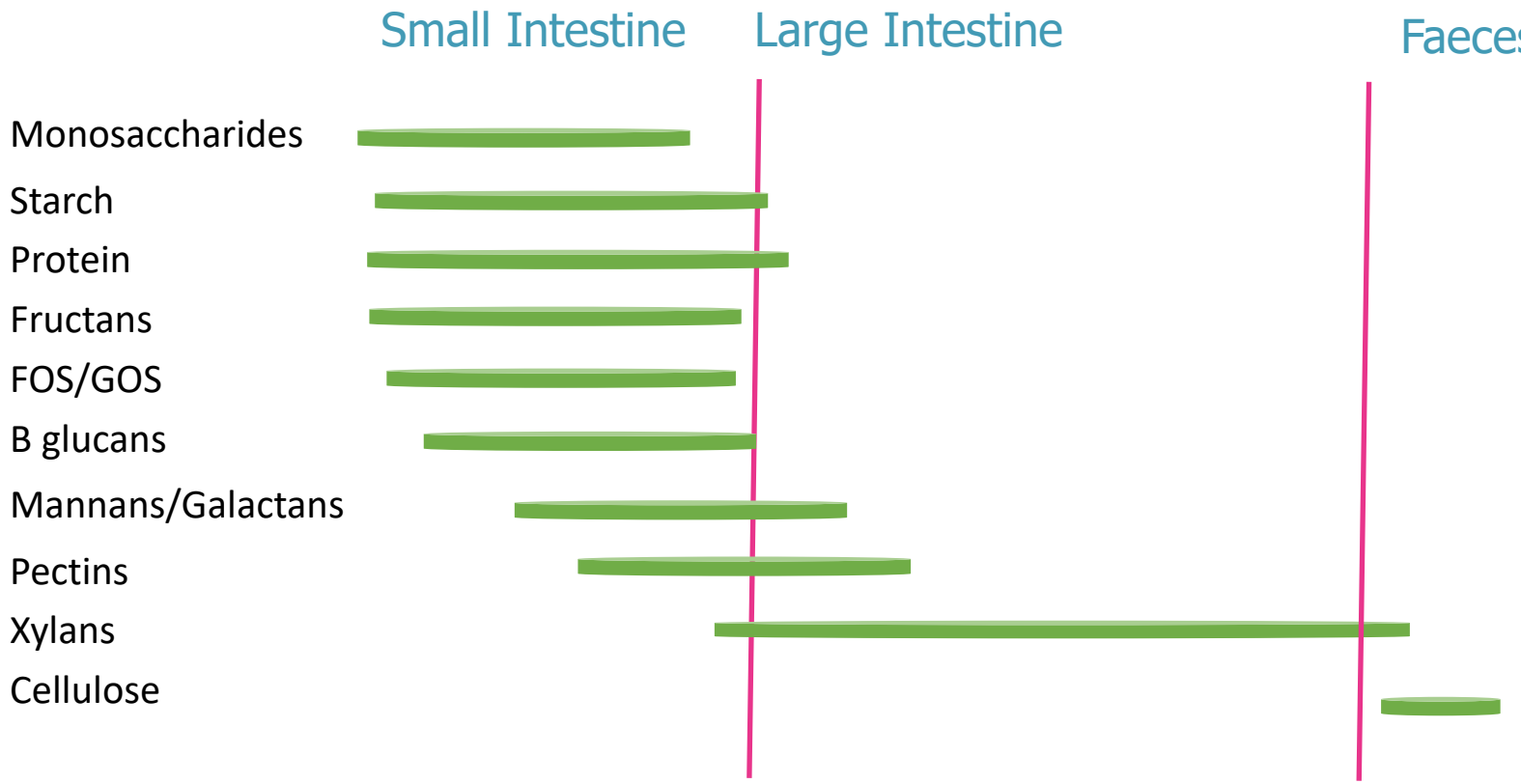
Age influences where the fibre is fermented Neonate



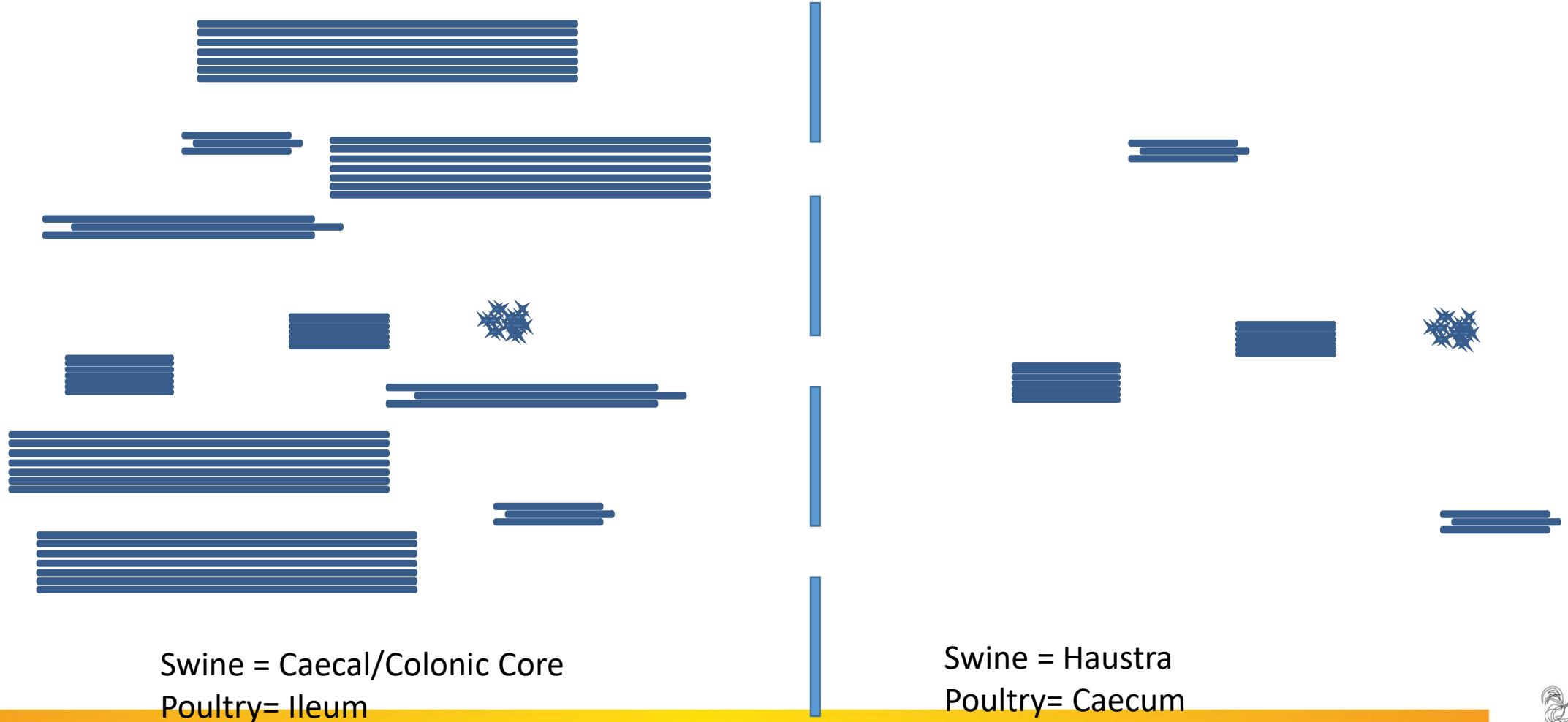
Age influences where the fibre is fermented adolescent



Age influences where the fibre is fermented adult



Caeca concentrates more fermentable material

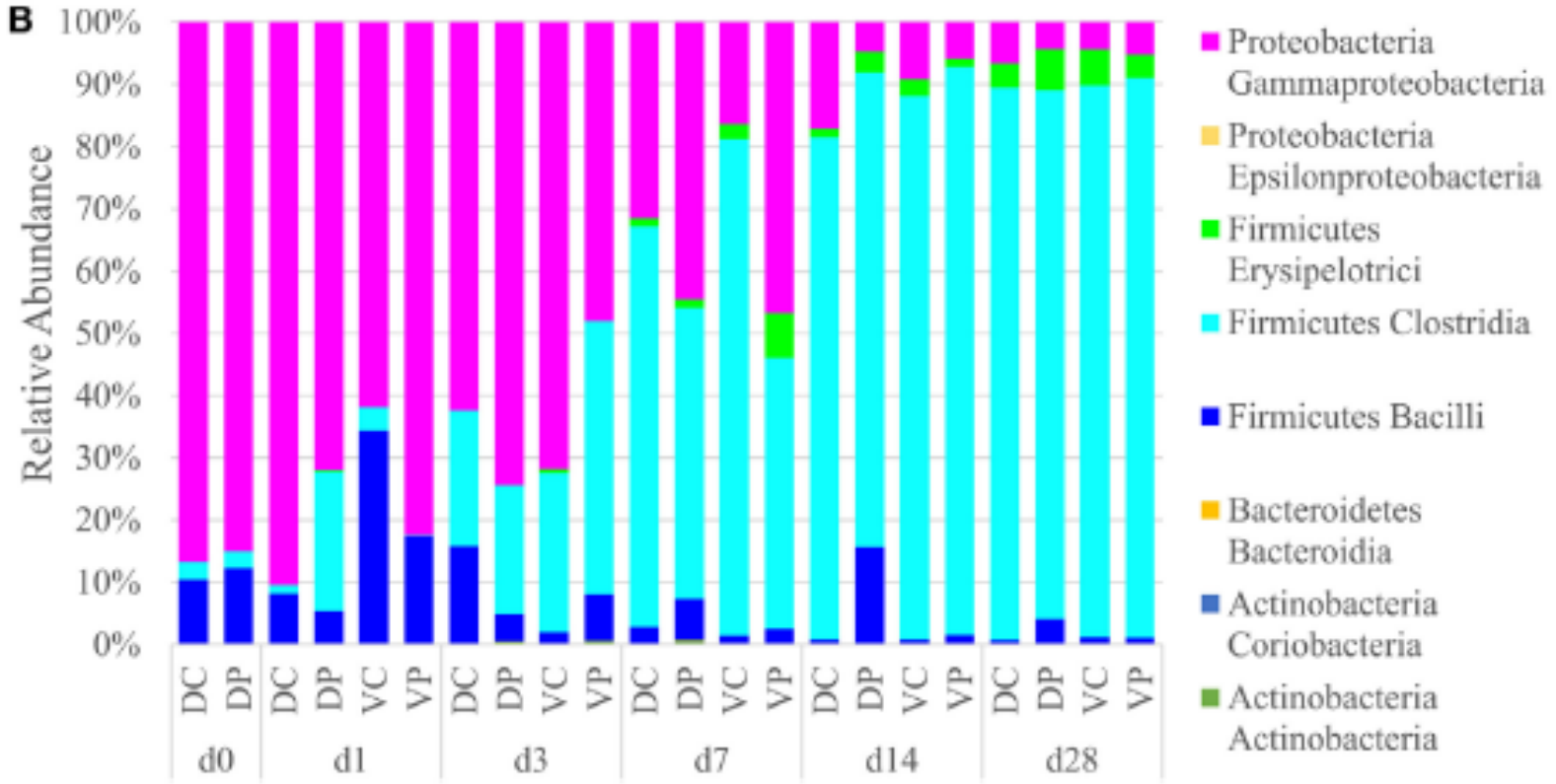


Swine = Caecal/Colonic Core
Poultry= Ileum

Swine = Haustra
Poultry= Caecum

Gut function changes over time

Shift from gram(-) to a Firmicute-dominated (Clostridia) community.

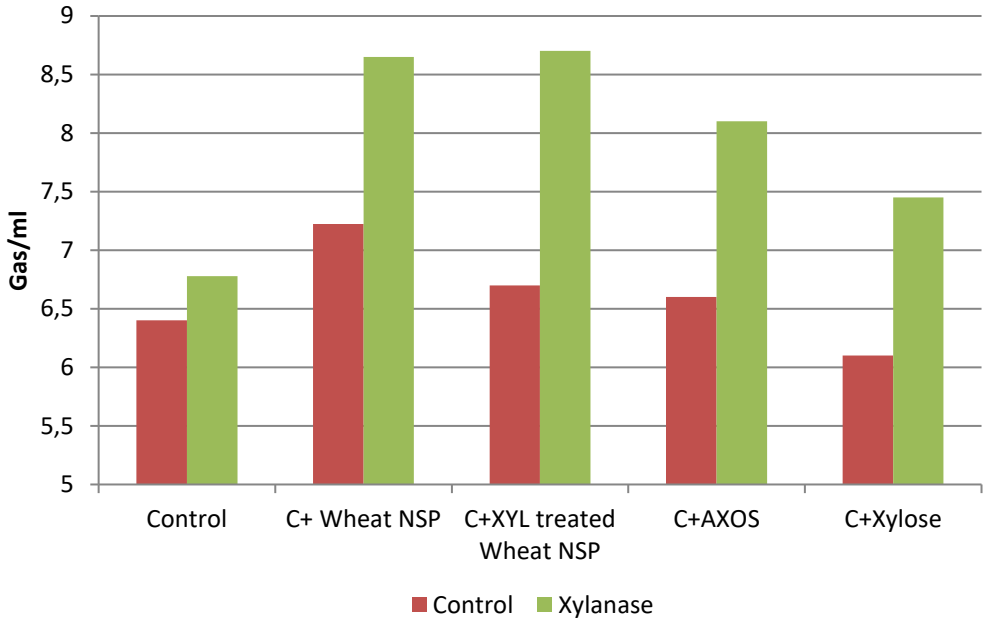


Ballou et al., 2016; poultry

Additional benefits – oligosaccharide stimbiotic effect

- Small DP XOS are absorbed and stimulate resident microbiota to degrade fibre
- Quantity needed to create this effect is very low – not a traditional prebiotic
- Effect seems to accelerate fibre degrading ability of the caecal microbiome
- Enzyme evolution should concentrate on end products

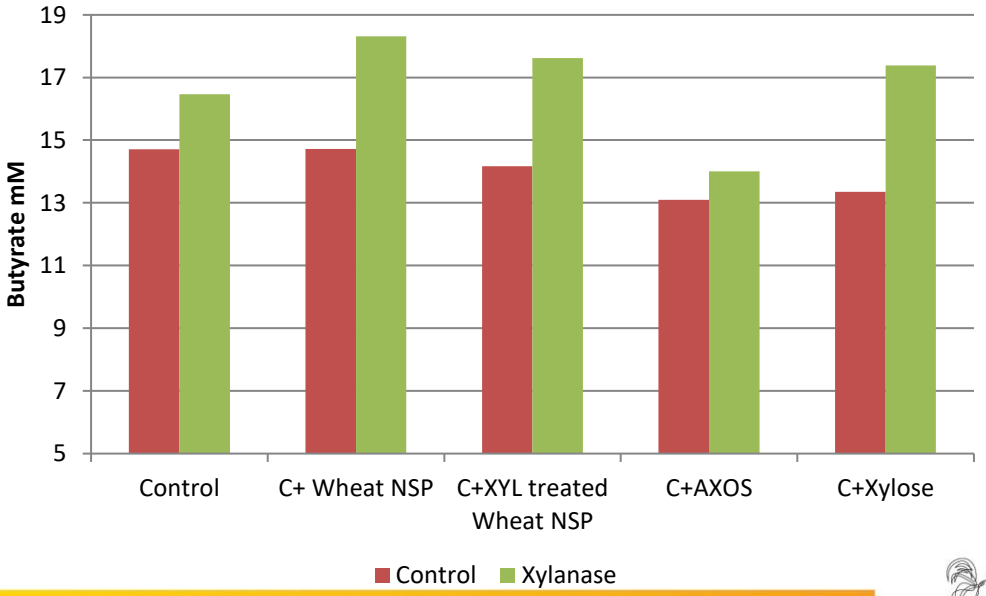
Feeding NSPases activates the microbiota



Birds fed wheat diet with or without xylanase

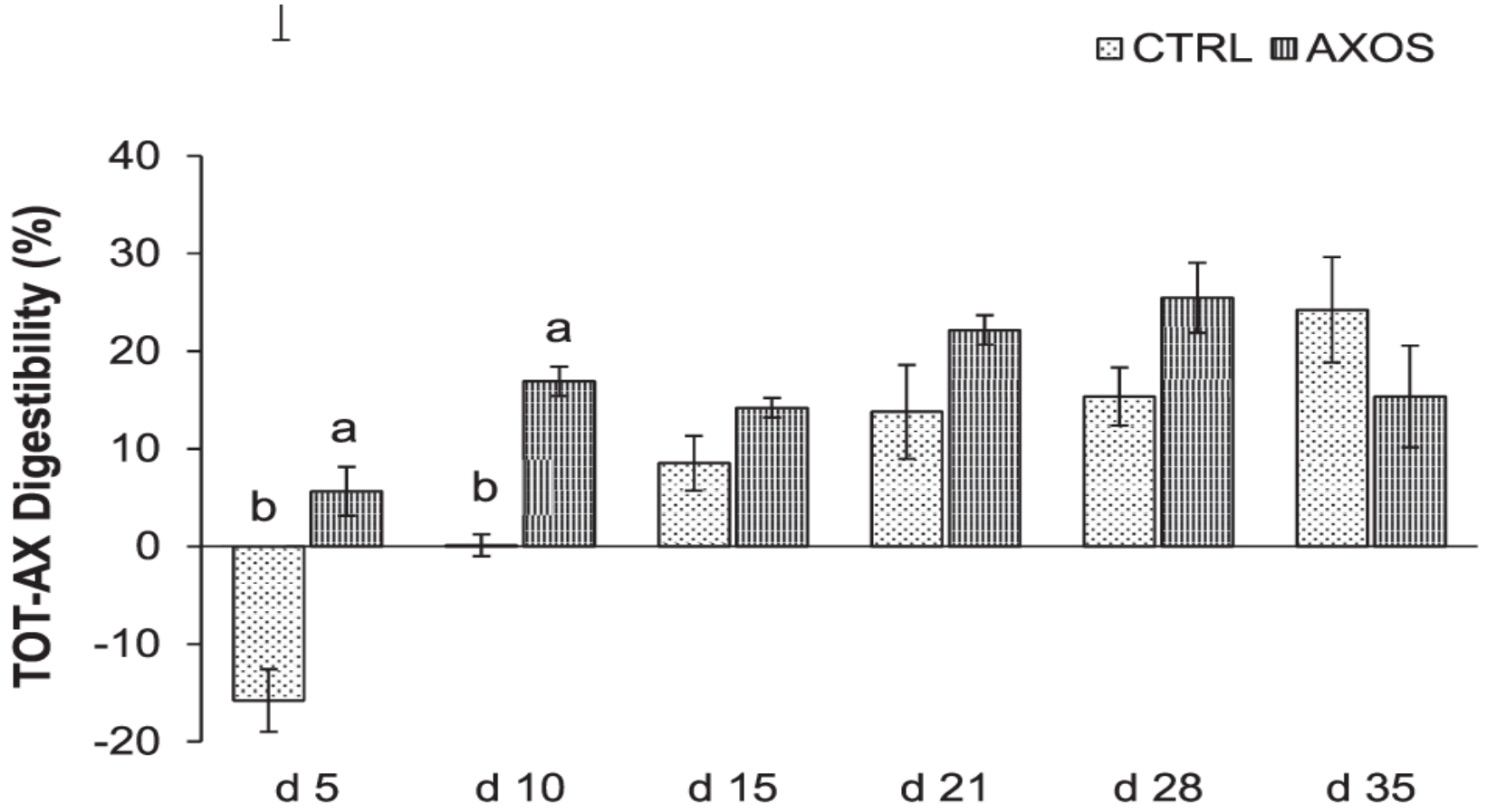
Caecal flora used as innoculum

NSP added to each to determine if adaptation had occurred



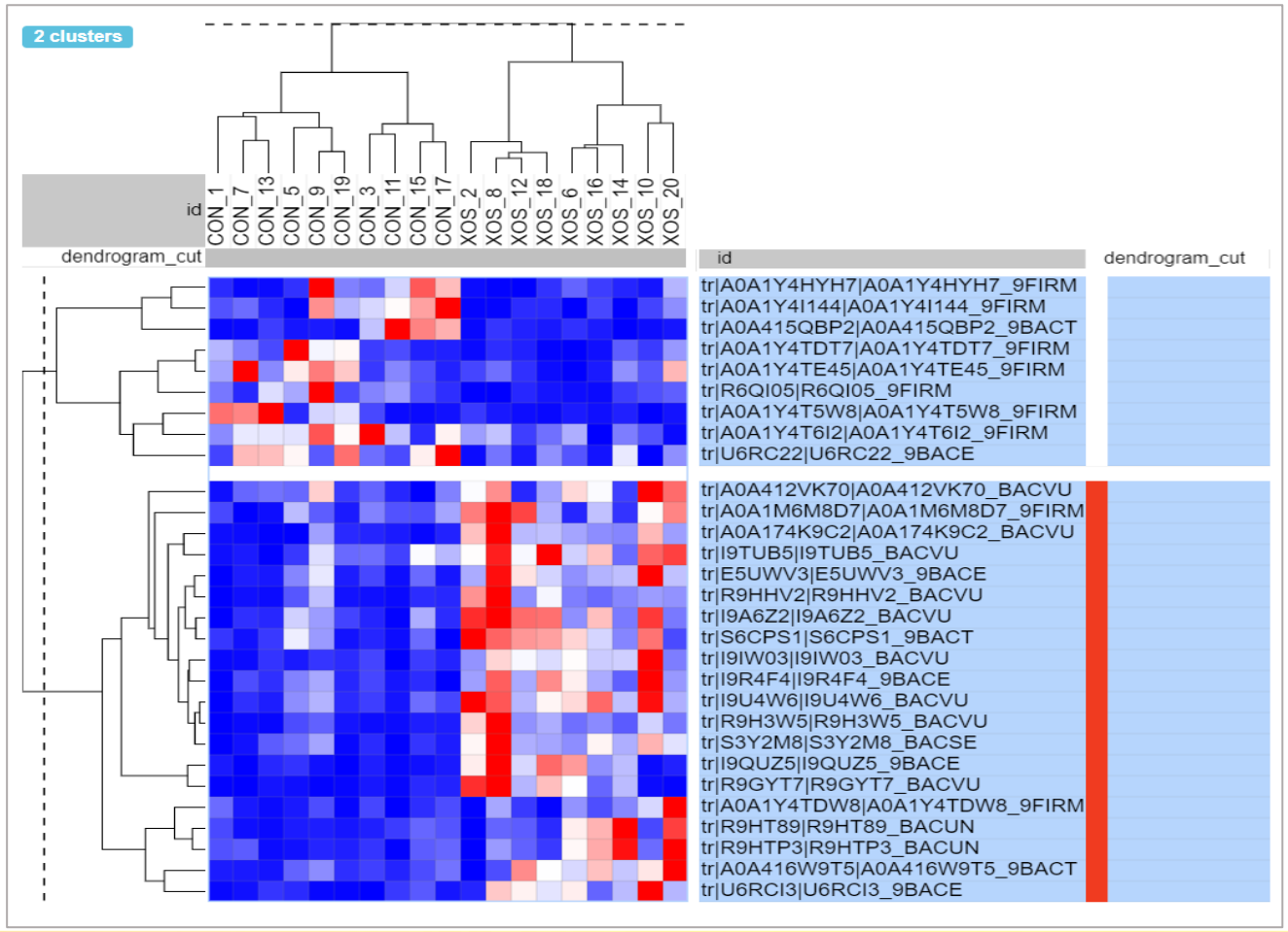
Bedford and Apajalahti, 2018

Feeding AXOS activates the microbiota



Bautil et al 2020

Microbiota response to signals is dramatic



PhD Thesis, Saba Amir, NTU, 2021

9 of these 20 upregulated proteins are SuSC Oligo transport proteins

Target is to continue supply of fermentable fibre to large intestine

- Bacteria with both saccharolytic and putrefactive metabolic potential preferentially use carbohydrates
- Putrefaction intensifies in the distal intestine when carbohydrates are depleted
- Ideal fibres are present in quantity to keep fermentation running into distal large intestine

Quantity of fermentable fibre is of interest

		Total (g/kg)			Soluble (% of total)			g/kg	g/kg
	n	A+X[1]	B-glucans	Mannan	A+X	B-glucans	Mannan	Uronic acids	Cellulose
Barley	8	77	47	4	13%	**52%**	30%	4	28
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Adapted from (Rodehutscord *et al.*, 2016) and (Knudsen, 1997).

[1]Arabinose + xylose residues

Points on application of fibre degrading enzyme to ingredients

- Most cereals have appreciable quantities of AX. BUT;

• Maize / Sorghum	Limited sol AX and intransigent to NSPases
• Wheat /Barley *	Moderate sol AX and responsive to NSPases
• Triticale/Rye	Significant sol AX and highly responsive to NSPases

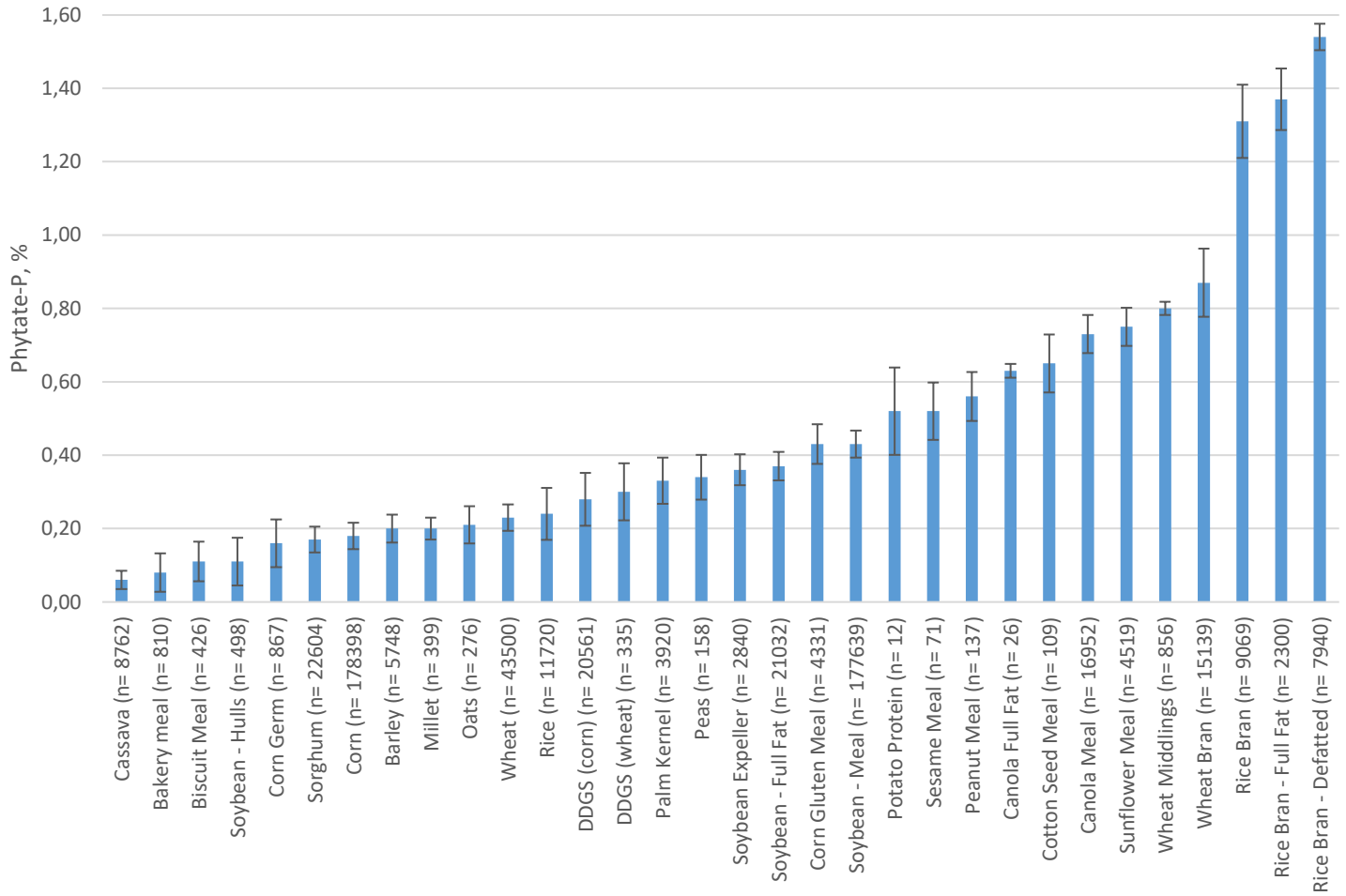
Challenge : Do older birds always have enough fermentable fibre supply to the caeca?

- Targetting xylans makes sense for the bird as it ages

Phytate

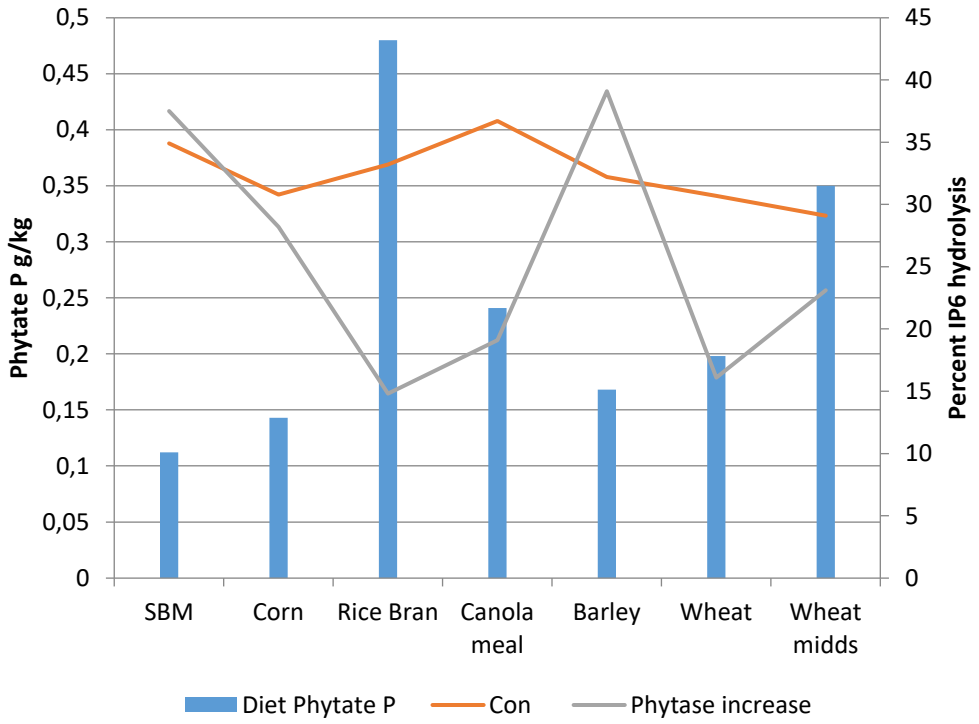
- Content varies with ingredient
- Susceptibility of phytate varies between ingredients
- Efficacy of phytase varies with Ca, P, Na, Vit D levels and with age and fibre content
- Variation can be reduced with increased dosages
- Additional benefits accrue with increased dosages

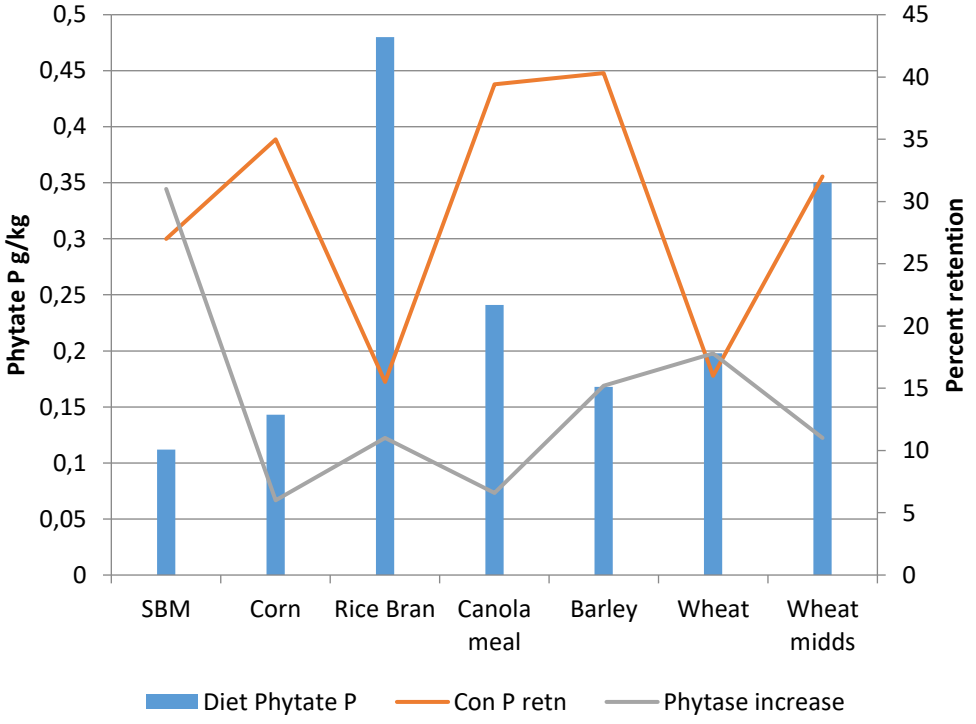
Phytate content of ingredients



- Ingredients vary markedly in phytate content
- Ingredients vary markedly in where this phytate is stored
- Phytate location and processing of ingredients may influence its availability to interact with nutrients and phytase

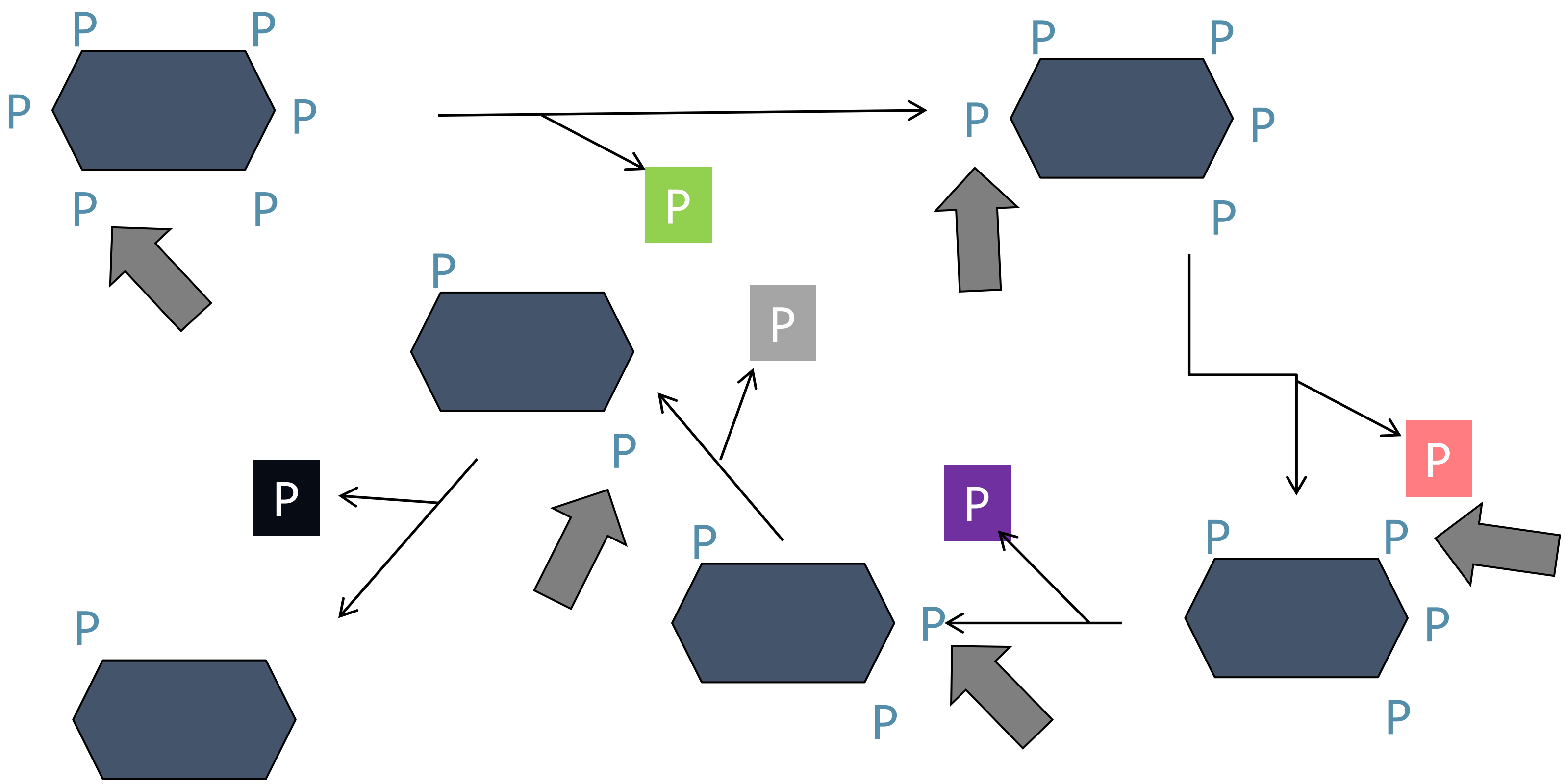
Phytin location may influence “availability”



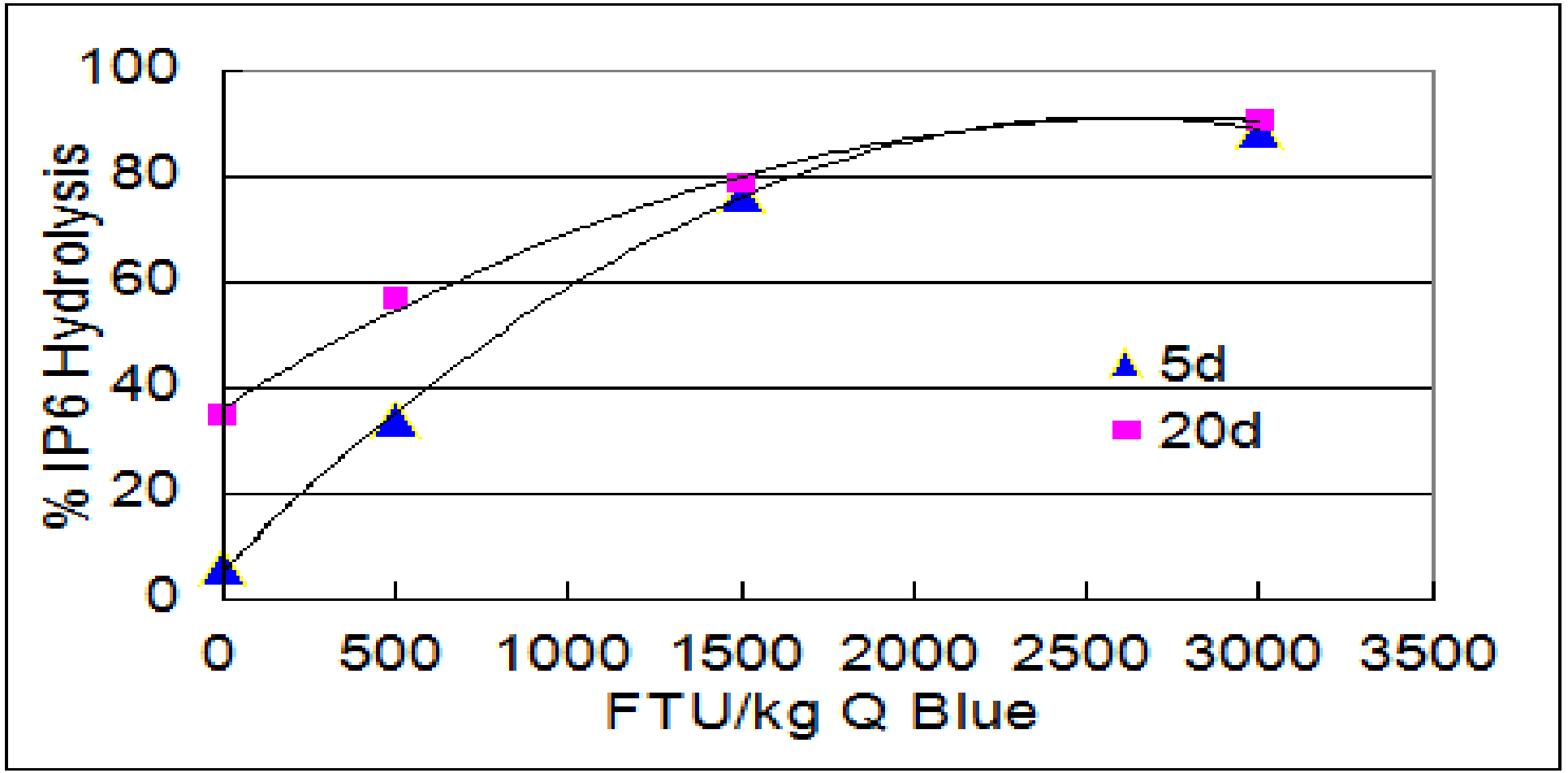


Leske and Coon 1999

Phytase has 5 separate substrates

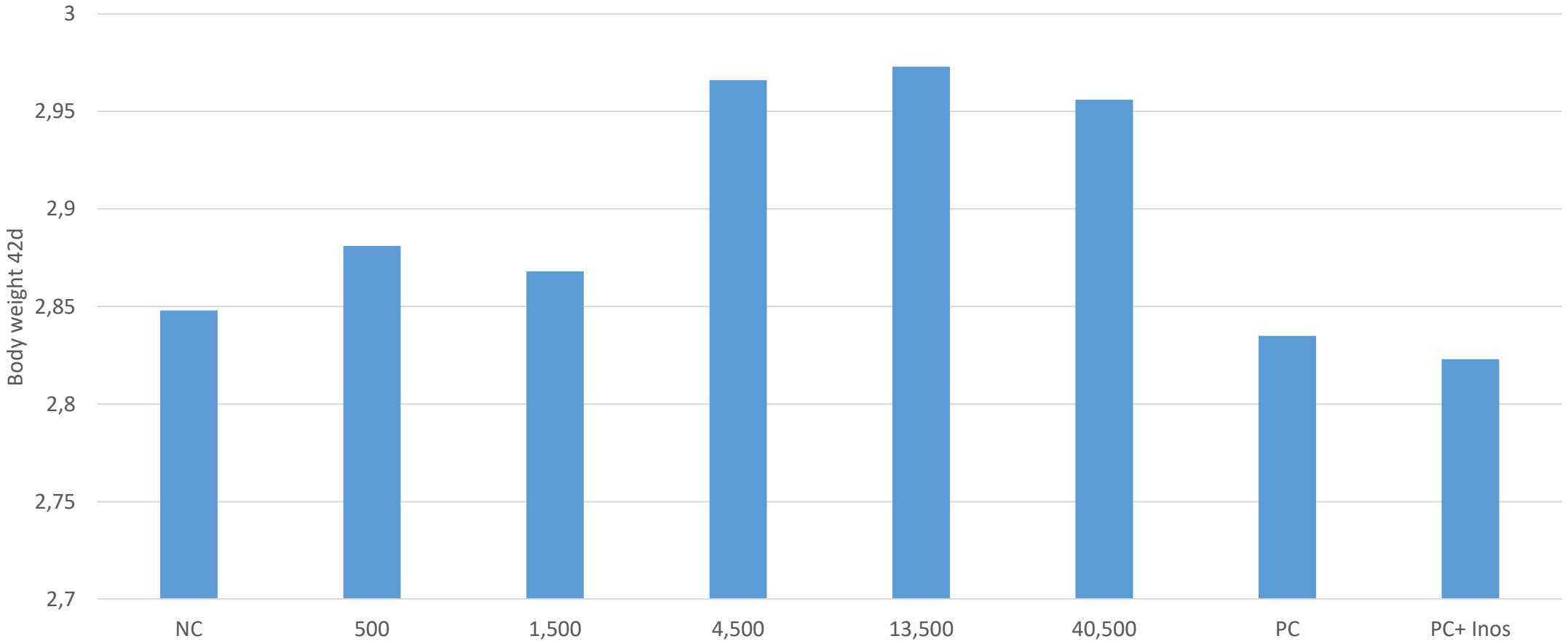


Age differences removed by higher phytase dose



Beaulac 2016

Higher dosages accrue additional benefits



Kriseldi et al 2021

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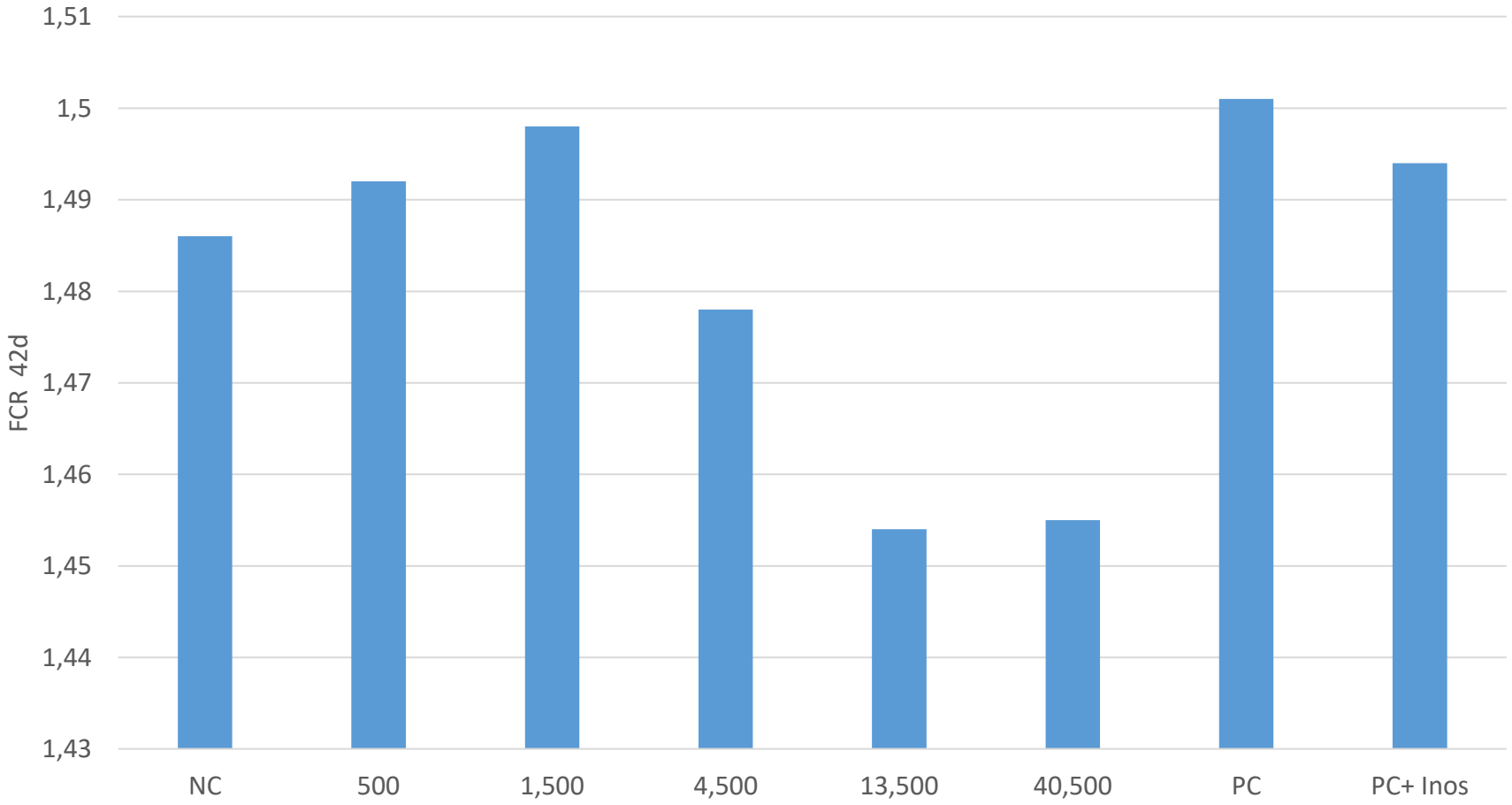

Kriseldi et al 2021

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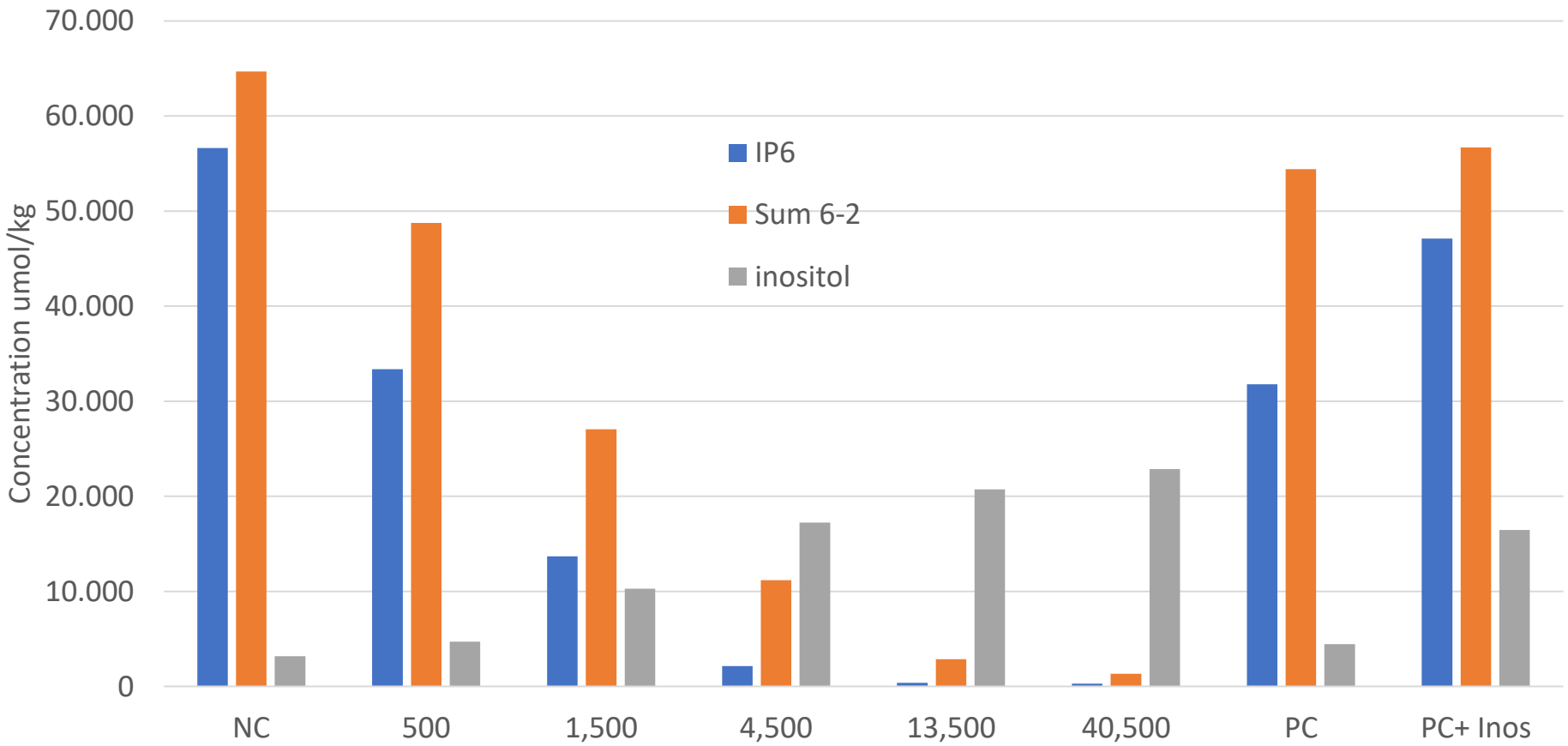
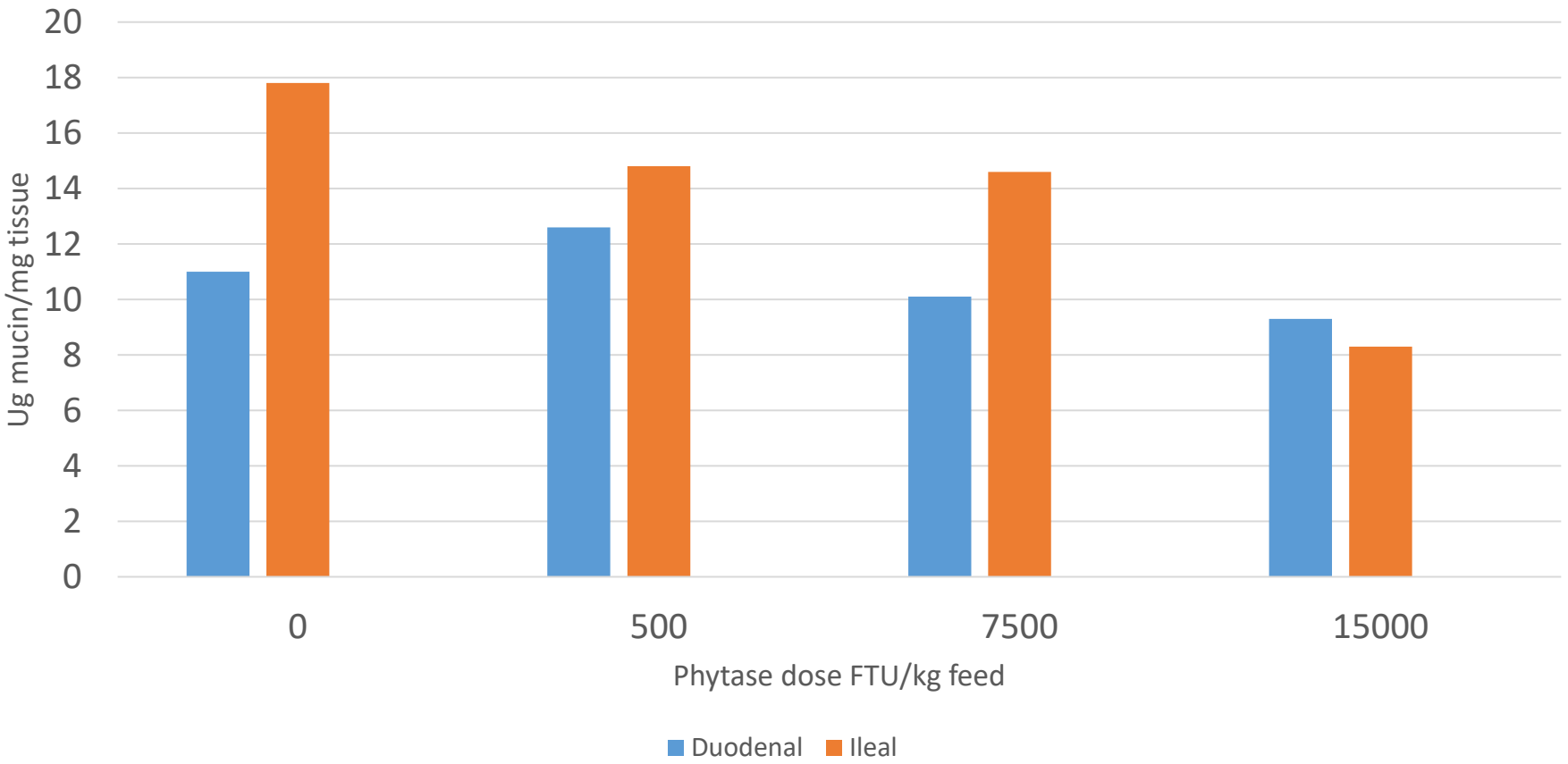


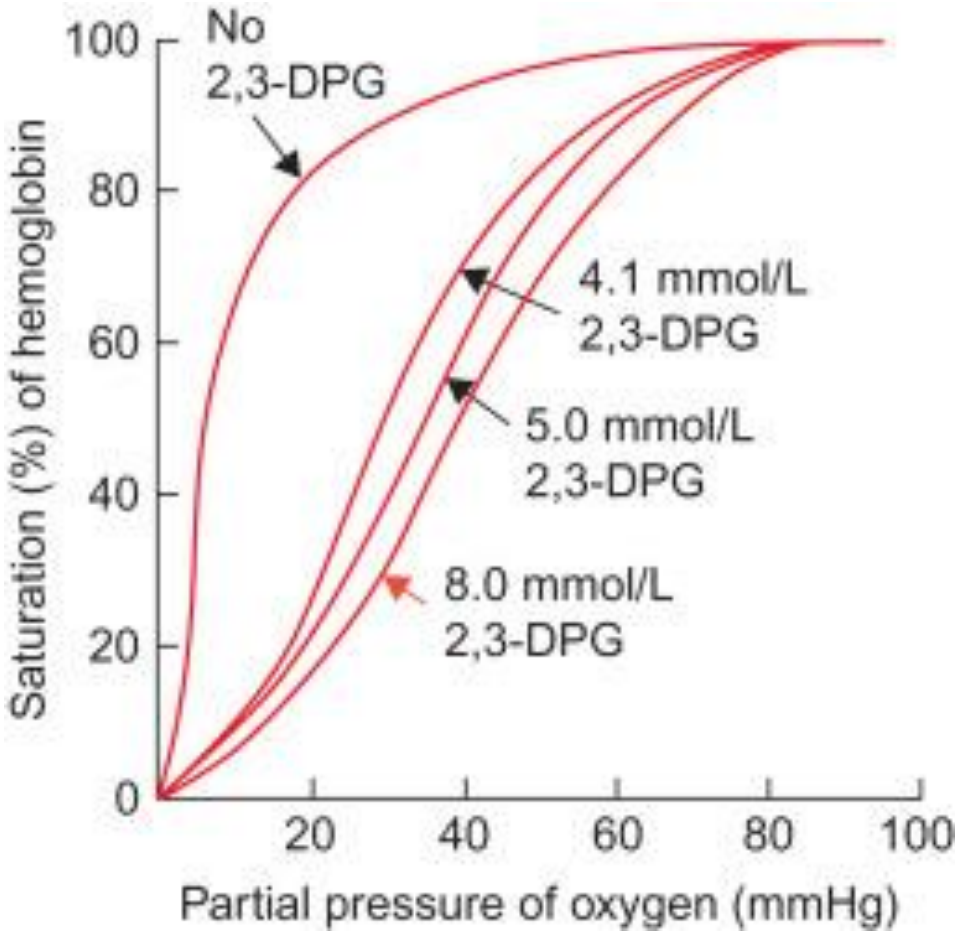
Kriseldi et al 2021

Very high doses of phytase continue to reduce mucin losses



Persia, 2010

Other effects – inositol contribution?



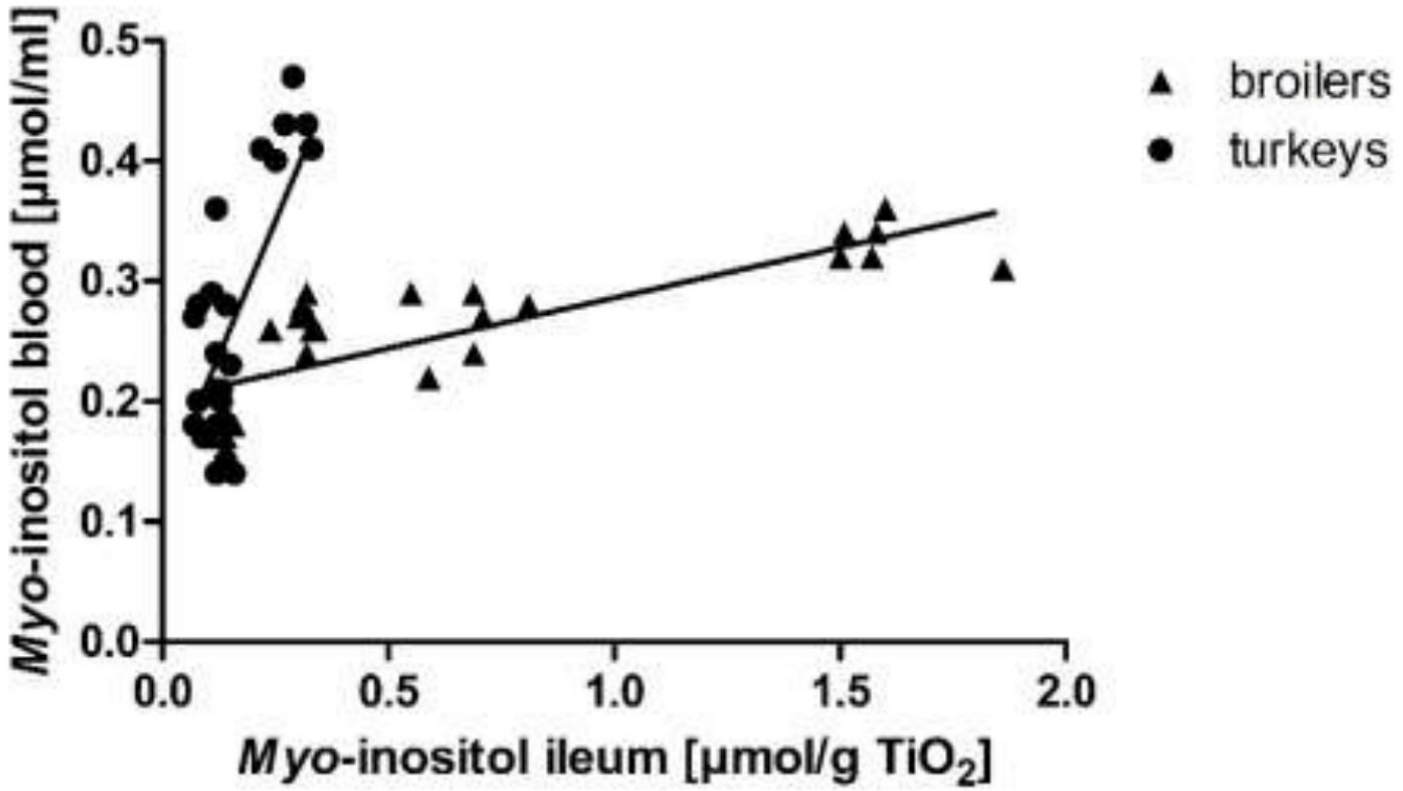
2,3 Diphosphoglycerate (DPG) pushes HB from high to low oxygen affinity in mammals enabling O2 release in active tissues

In avian species it is not 2,3 DPG **but InsP5 that performs this task, and it binds much tighter than 2,3 DPG**

Deeply anoxic tissues will produce lactate and free radicals and benefit most from IP5 levels being high

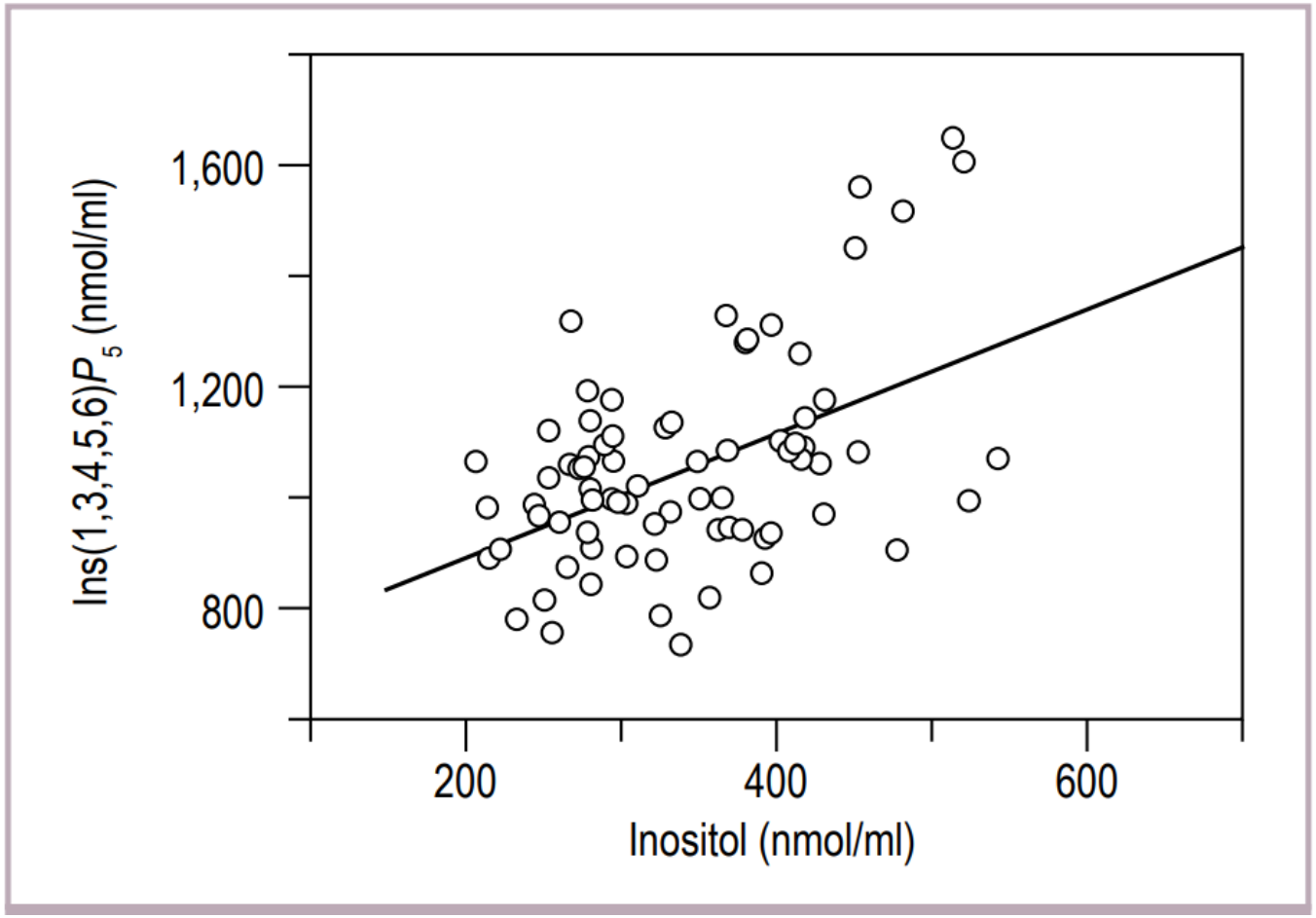
WOODY BREAST
WHITE STRIPING
BCO
ASCITES

Inositol levels in blood related to ileal concentrations



Novotny et al, 2023

Inositol levels in blood correlate with Erythrocyte IP5



Whitfield et al, 2022

Phytate conclusions

- There are differences between ingredients in phytate content and perhaps susceptibility to phytase activity
- These “susceptibility” differences can be markedly reduced by increased dosage
- Additional benefits accrue from very high phytase dosage that are unrelated to nutrient release
  - Anti-inflammatory effects
  - Nutrient utilisation/post absorptive effects
  - Improved tissue oxygenation effects

Conclusions

- Individual ingredients bring specific challenges with regards to fibre and phytate into the diet

Goals

Reduce variation as much as possible

Fibre – address the idiosyncrasies on an ingredient basis

Phytate – Take into account “availability” or remove with higher dosages