IMPACT OF ENZYMES AND FIBRE ON GUT HEALTH

Xavière Rousseau, AB Vista

Balchem Real Science-Lecture Series

08th June 2021

Extraordinary science brought to life

OUTLINES

1. Gut and health
2. Enzymes beyond nutritional matrix value
3. Fibre : what's new and how to optimise their inclusion to ensure good gut health

GUT AND HEALTH

FREE OF ILLNESS WITH HIGH ABILITY TO COUNTERACT ANY ENTERIC CHALLENGE
(gut epithelium = physical and chemical protection from the antigenic components)

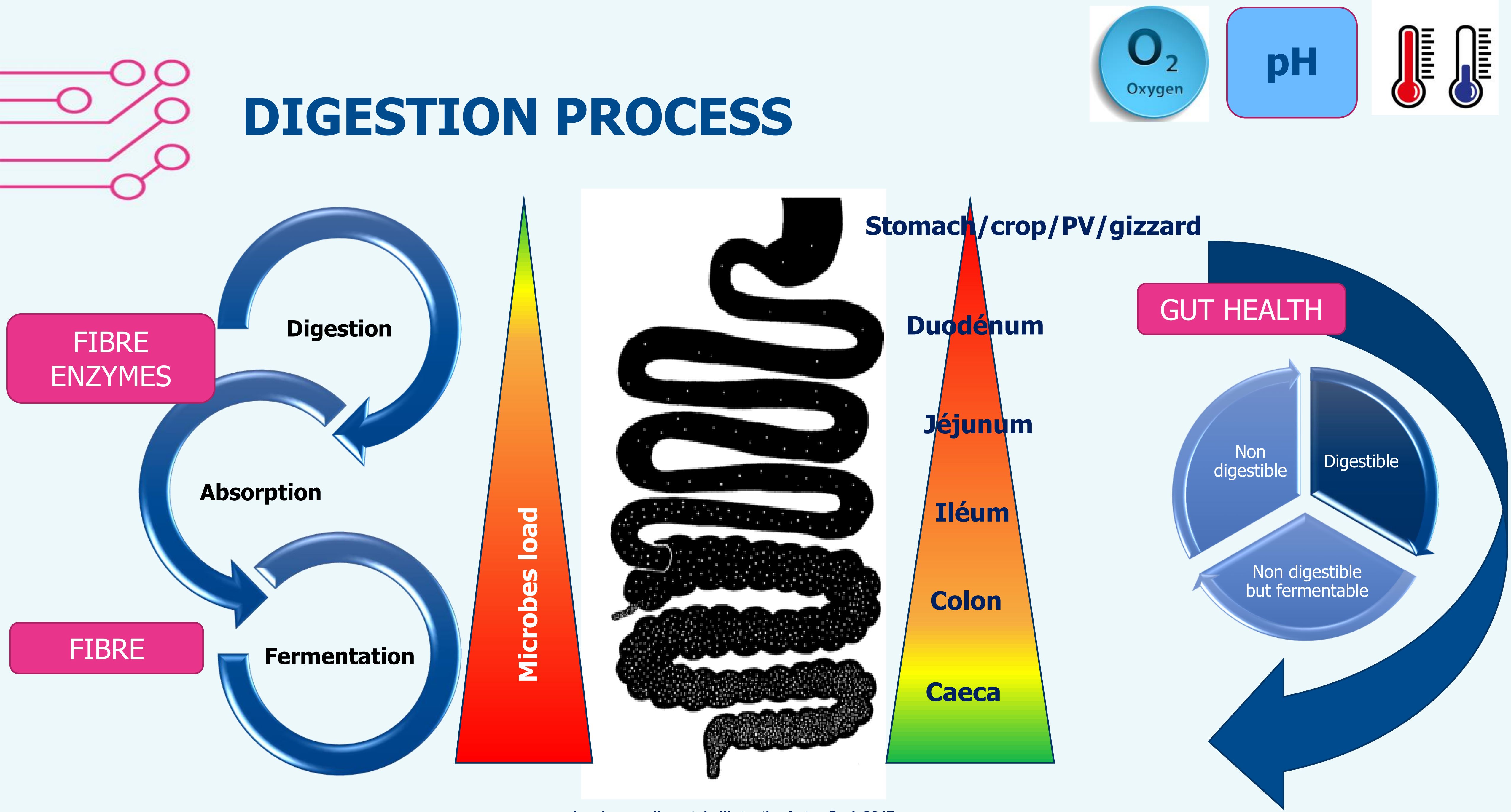
EVERYTHING THAT ALLOW EFFECTIVE NUTRIENT **DIGESTION – ABSORPTION - FERMENTATION**

GUT INTEGRITY
(absorption
- pathogens- homeostatic
balance)

GUT FUNCTIONALITY
(immunostimulation –
inflammatory
response)

1. Ensure Effective **digestion** and **absorption** (digestion-absorption process)
2. Having an optimal and **balanced microbiome** + Limit pathogens growth (gut integrity) + beneficial fermentation
3. Good **immune status** (innate and acquired mucosal immune response) **and low inflammatory response**

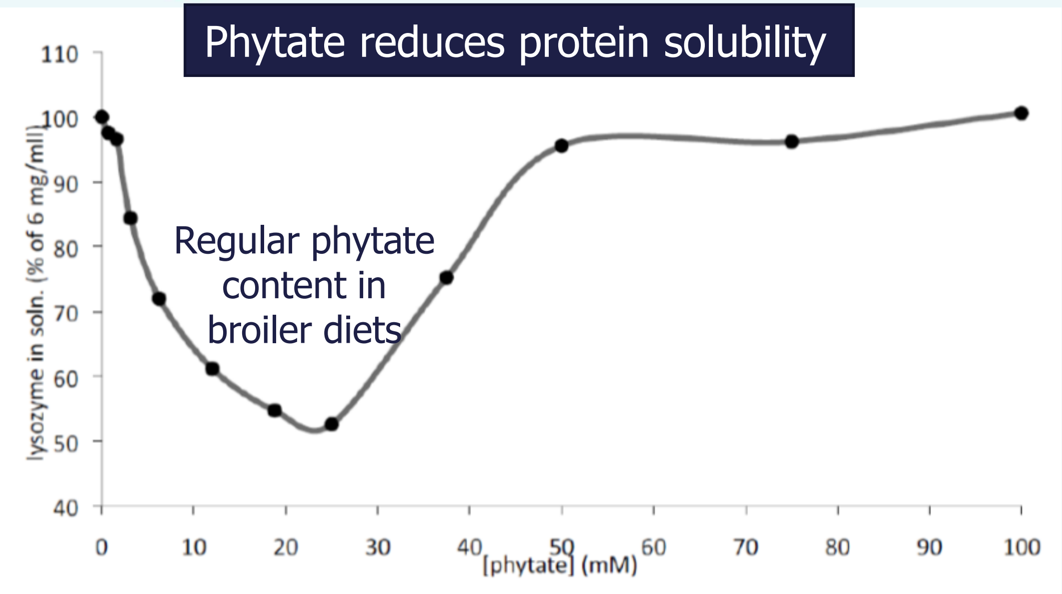
DIGESTION PROCESS



Le charme discret de l'intestin, Actes Sud, 2017

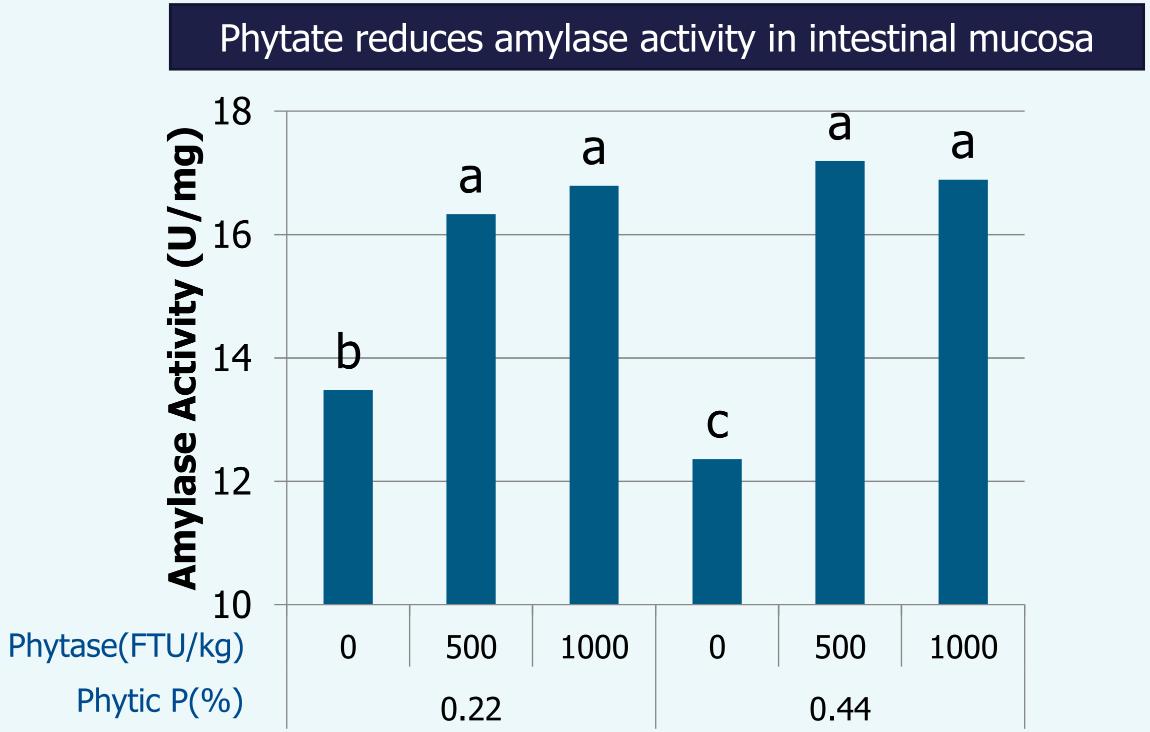
PHYTASE AND GUT HEALTH

PHYTASE & GUT HEALTH



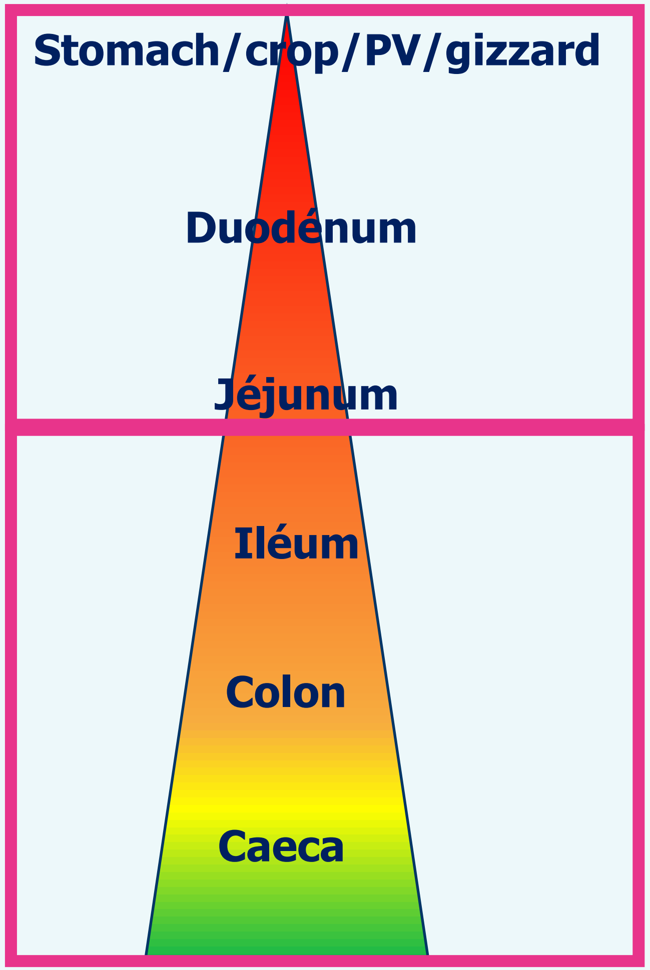
Cowieson et al., 2011

……..



Liu et al., 2008

PHYTASE & GUT HEALTH



➡ # ***de novo*** **protein-phytate complex formation**
Refractory to pepsin digestion
Hyper-secretion of pepsin and HCl
Extra mucin secretion

➡ # Increased flows of endogenous amino acids
Pre-bound dietary protein less readily digested
Compromised amino acid uptakes
#Reduced absorption of dietary and endogenous amino acids

Protein fermentation

- Increase pH
- Toxic substances

PHYTASE & GUT HEALTH

CONSIDERING PHYTASE BEYOND MATRIX VALUE

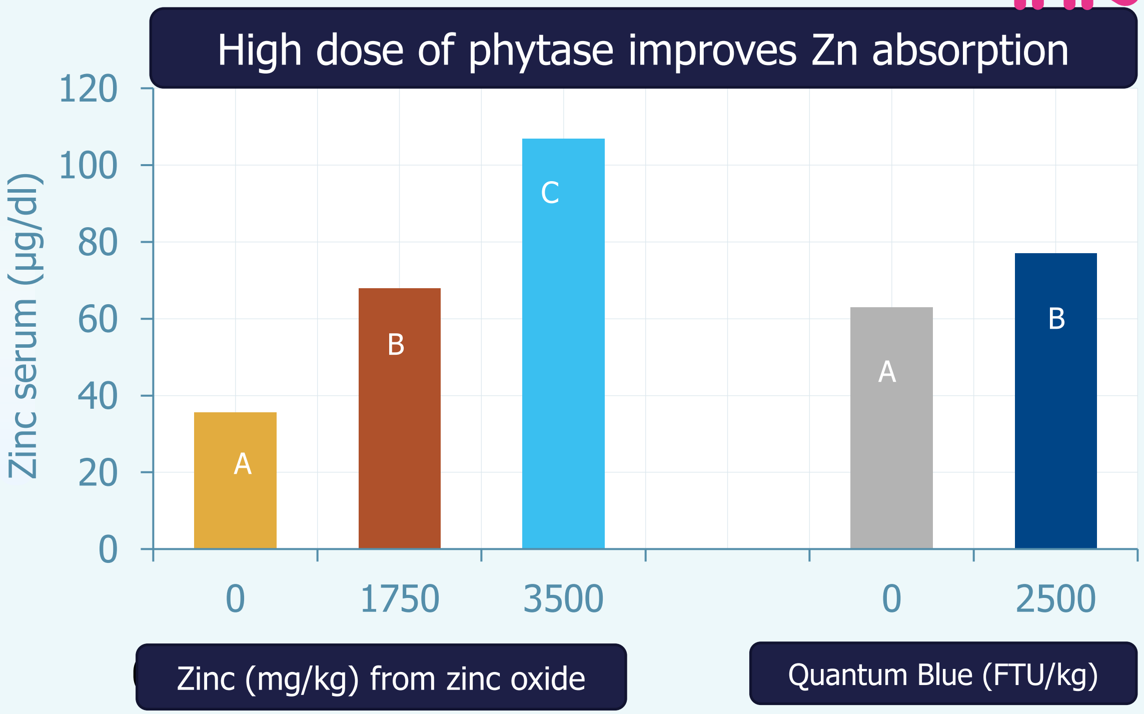
Release key nutrients : Zn, Fe, Cu
…

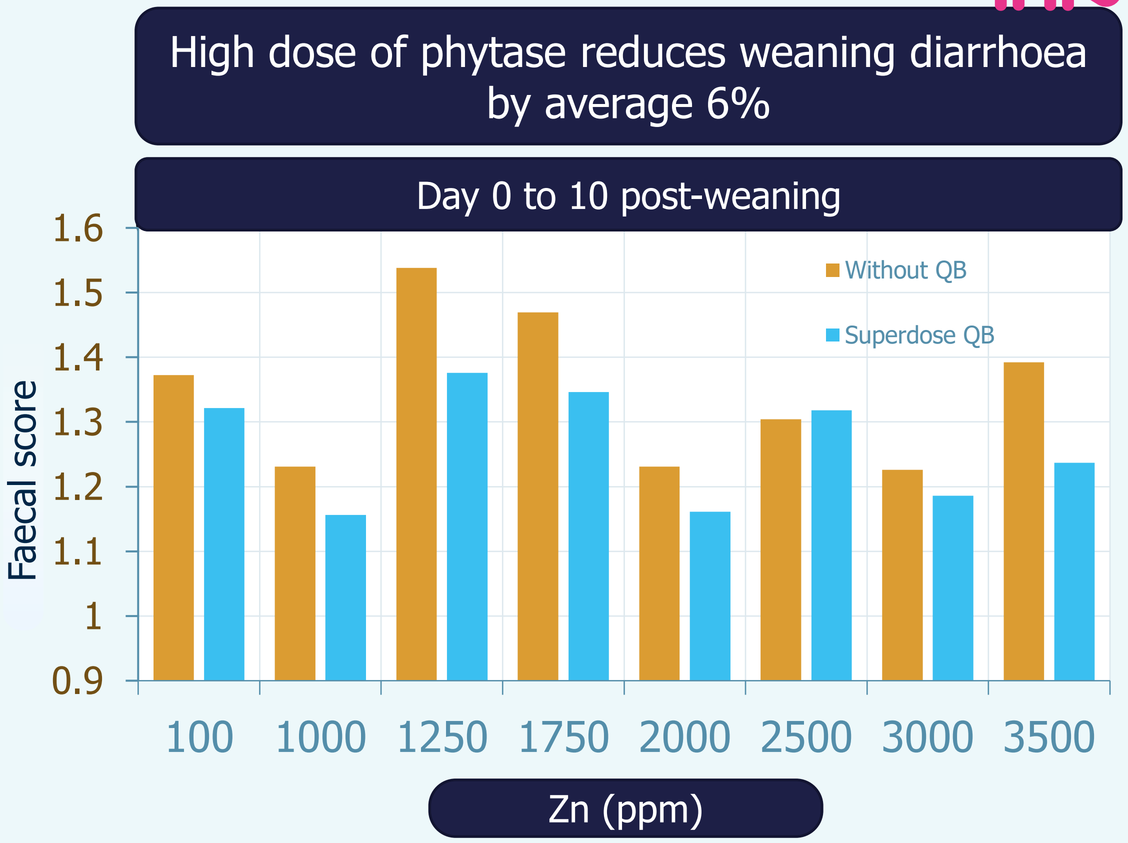
IP 6 to 1 hydrolysis to facilitate
ALP work
Inositol production

Phytate IP6 + ip5 +
IP4 + IP3+ IP2 down

HIGH DOSE OF PHYTASE AND ZINC_SWINE

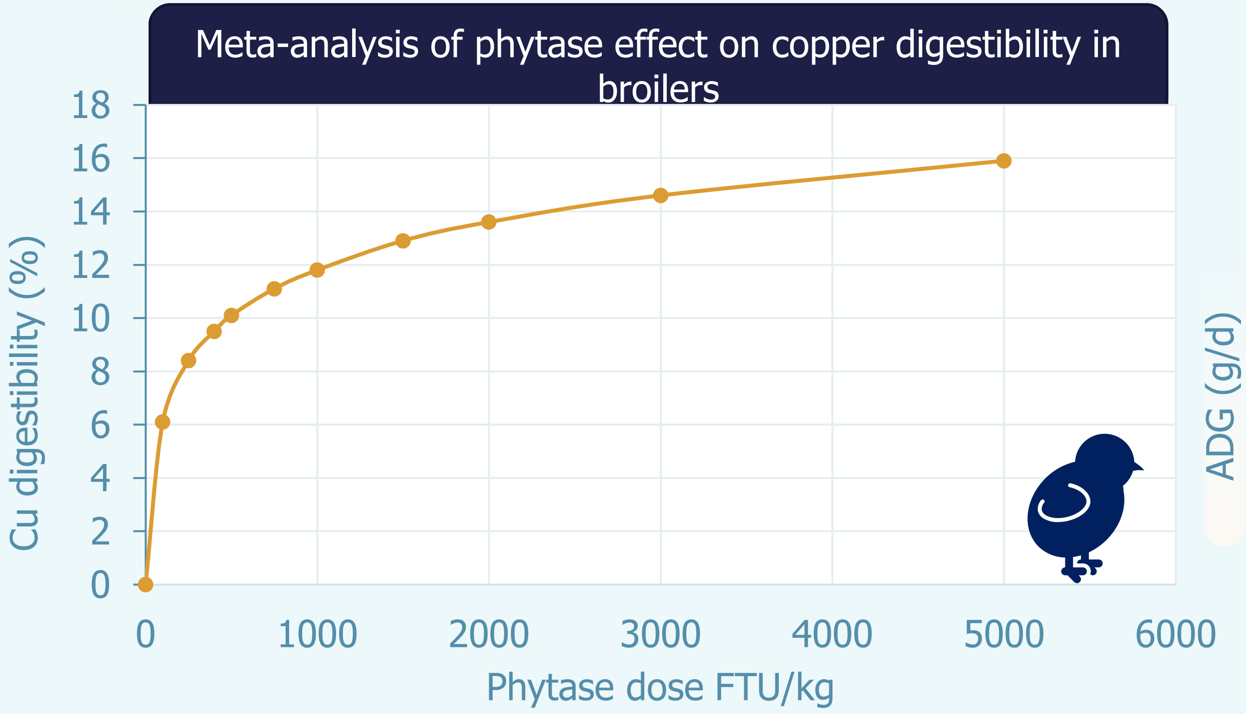
Release key nutrients : Zn, Fe, Cu …





AB Vista, Internal data

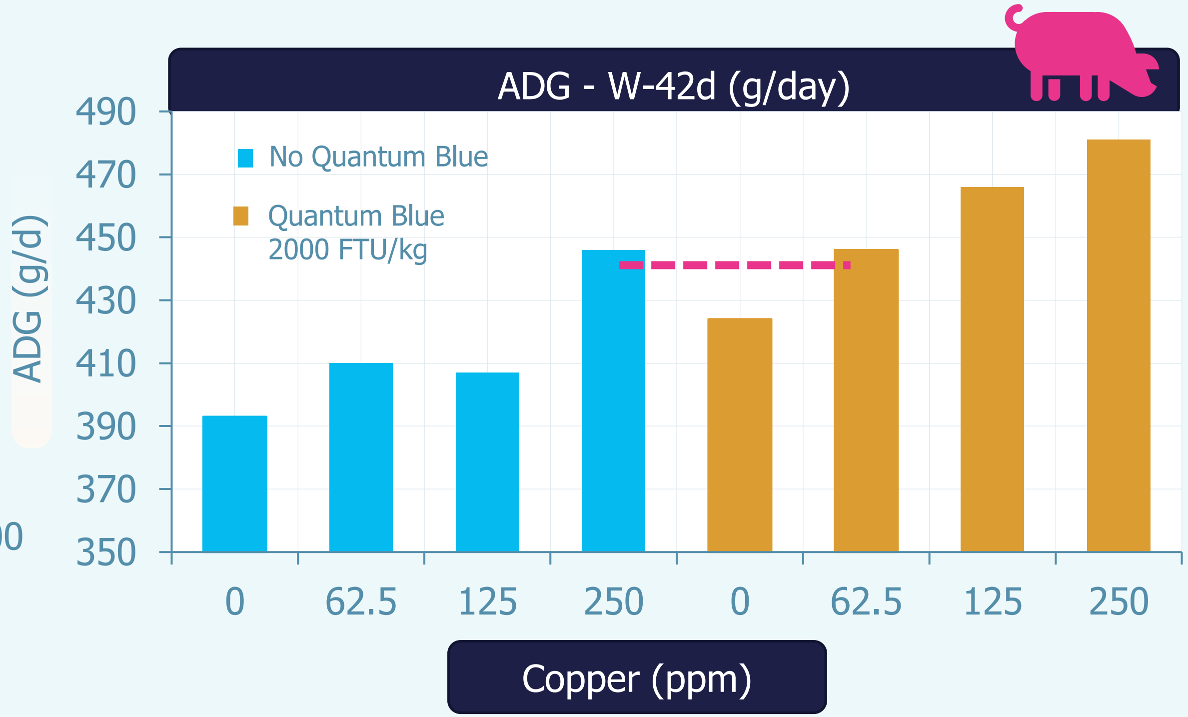
HIGH DOSE OF PHYTASE AND COPPER



Notes: 12 experiments; 80% with old Aspergillus phytase
Mean copper dose in trials 36 mg/kg diet

Jongbloed et al, 2010; IPS3

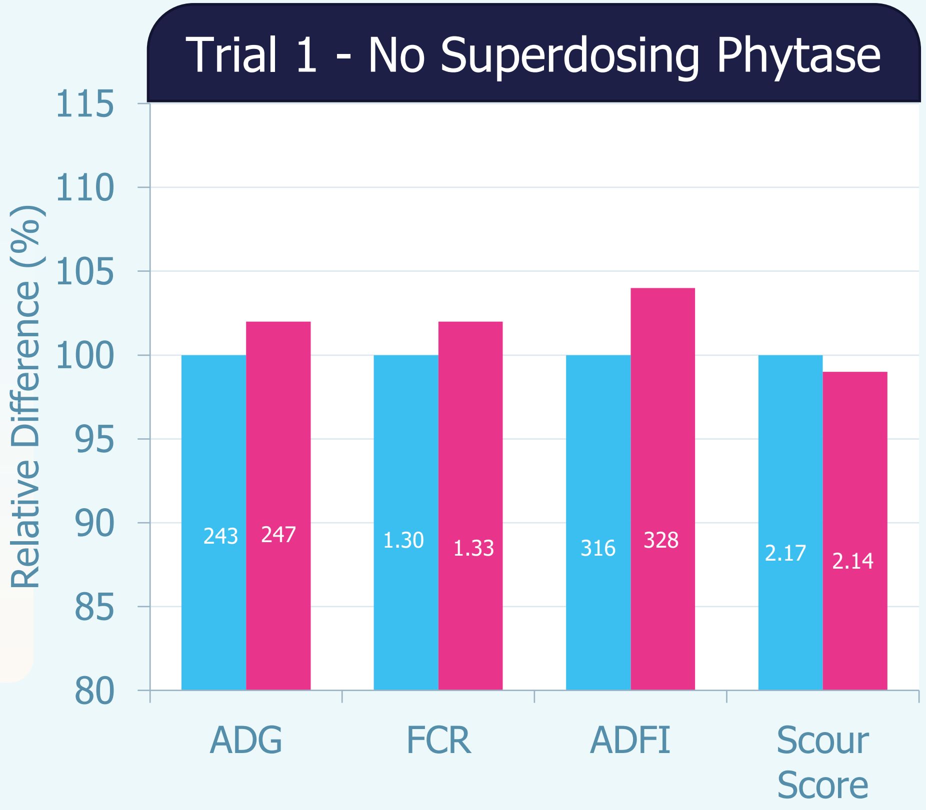
Release key nutrients : Zn, Fe, Cu ...

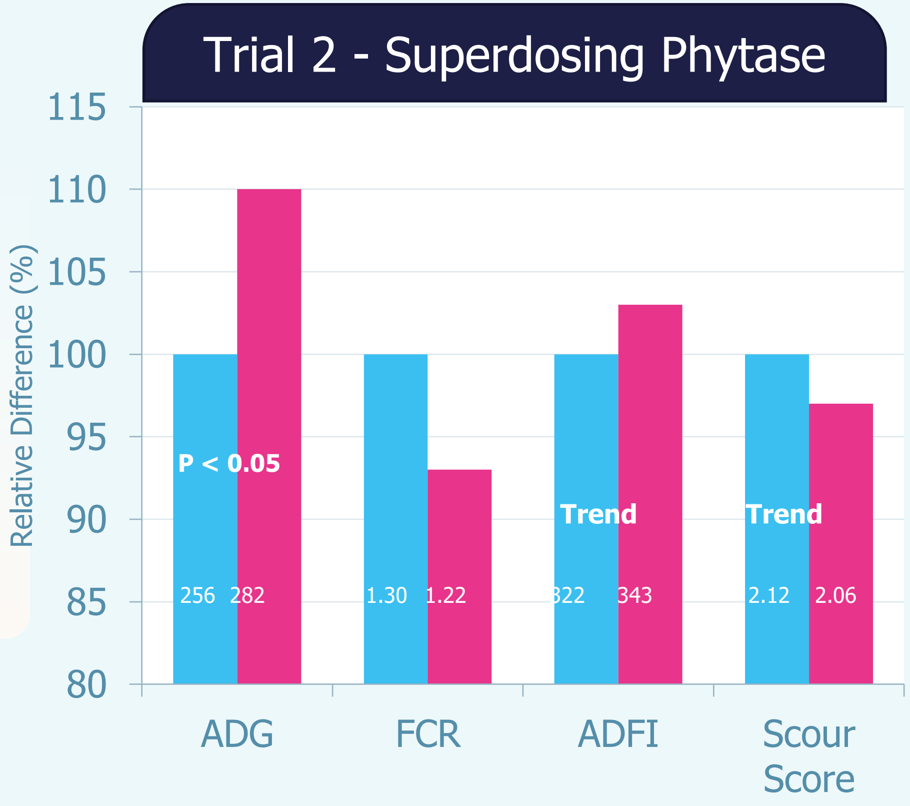


Cordero et al, 2017

HIGH DOSE OF PHYTASE AND IRON

Release key nutrients : Zn, Fe, Cu …





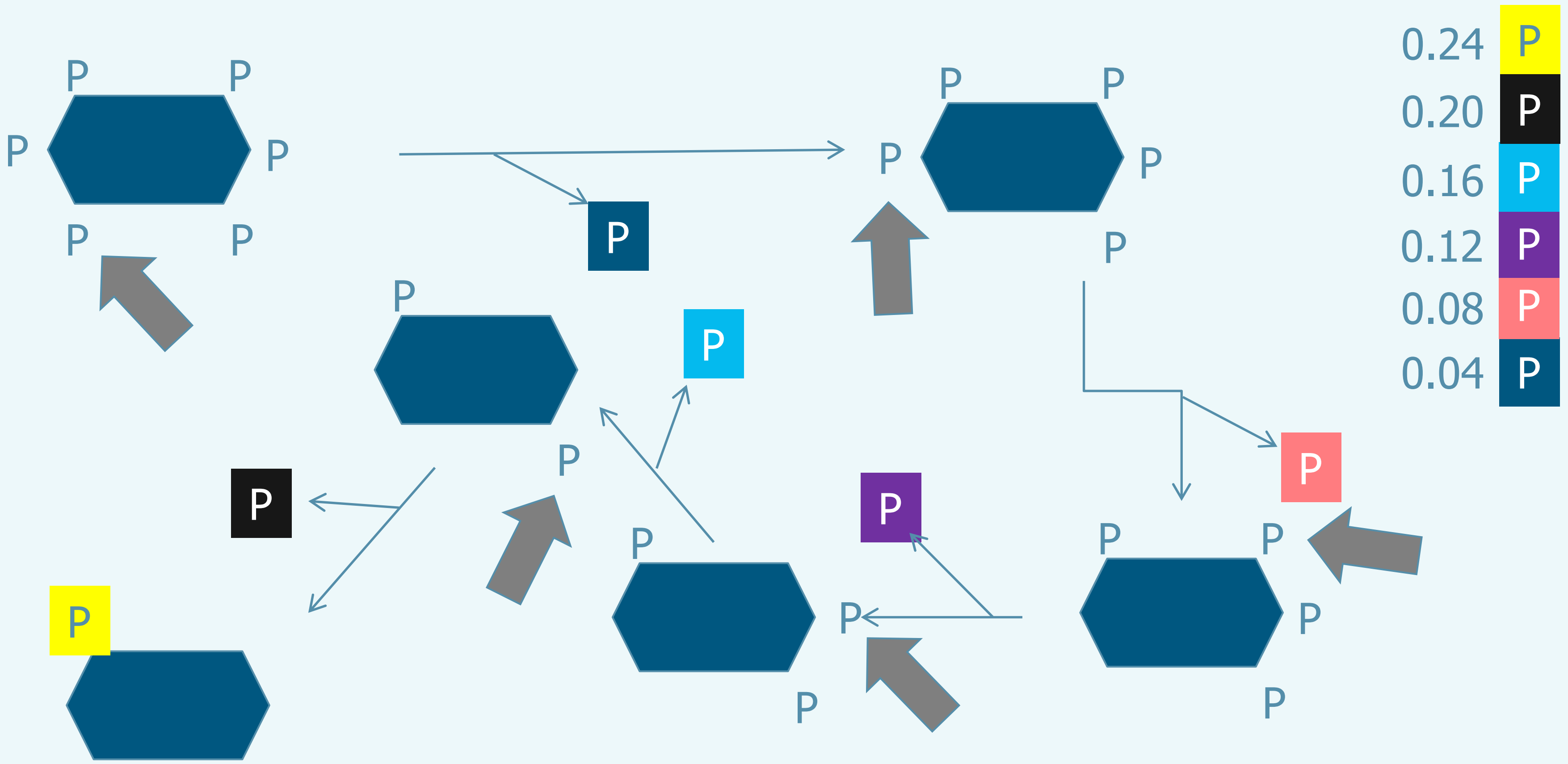
■ Std ■ Std + 150 ppm Organic Iron

Note: Standard Diet = 200 ppm Iron, All piglets were iron supplemented, weaned at 28 d

Ref: Customer Commercial Study

Iron supplementation improves performance and reduces scour when superdosing

INOSITOL RELEASE AND GUT HEALTH



Release key nutrients : Zn, Fe, Cu …

IP 6 to 1 hydrolysis for ALP work to produce inositol

INOSITOL

99.8 % of free inositol can be absorbed

Co-transported by:

SMIT1

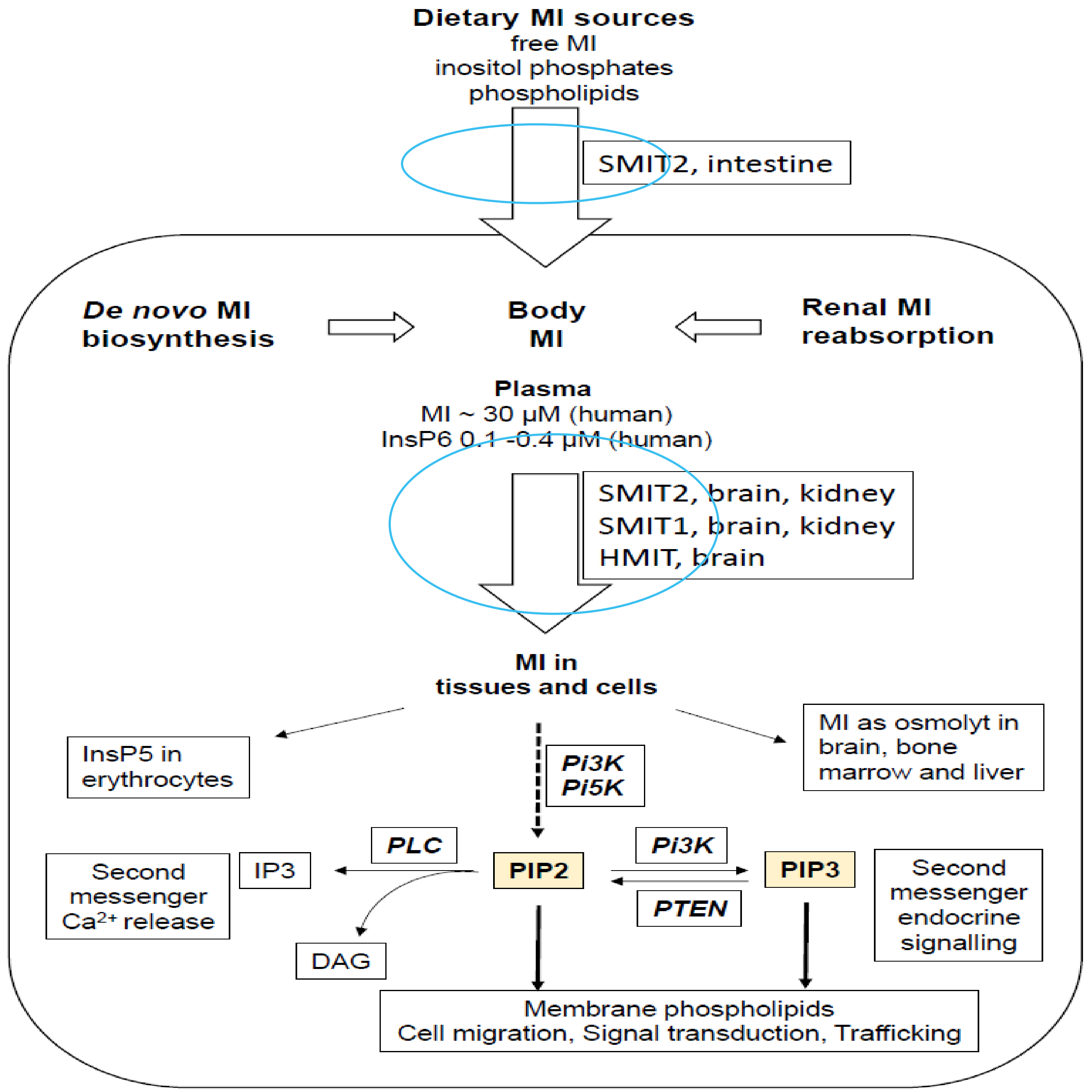
SMIT2

HMIT

Once in the cells inositol acts as a building block for:

2^{nd} messengers (IP3, PIP_2, PIP_3)

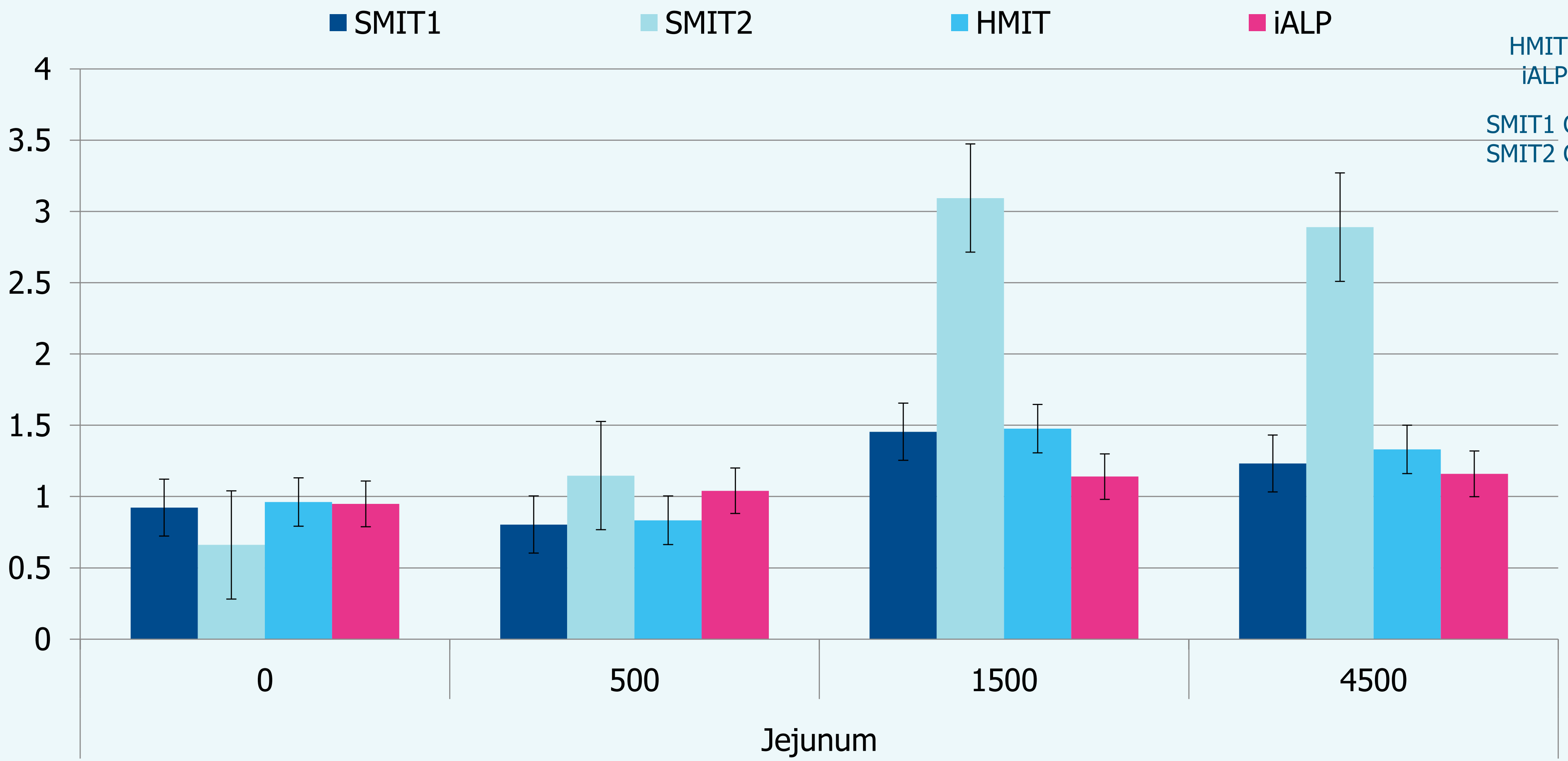
Phytate (IP5)



Huber, 2016; Croze and Soulage, 2013

HIGH OF PHYTASE INCREASE EXPRESSION OF INOSITOL TRANSPORTERS IN JEJUNUM

Greater transport of inositol in the jejunum may indicate greater phytate breakdown

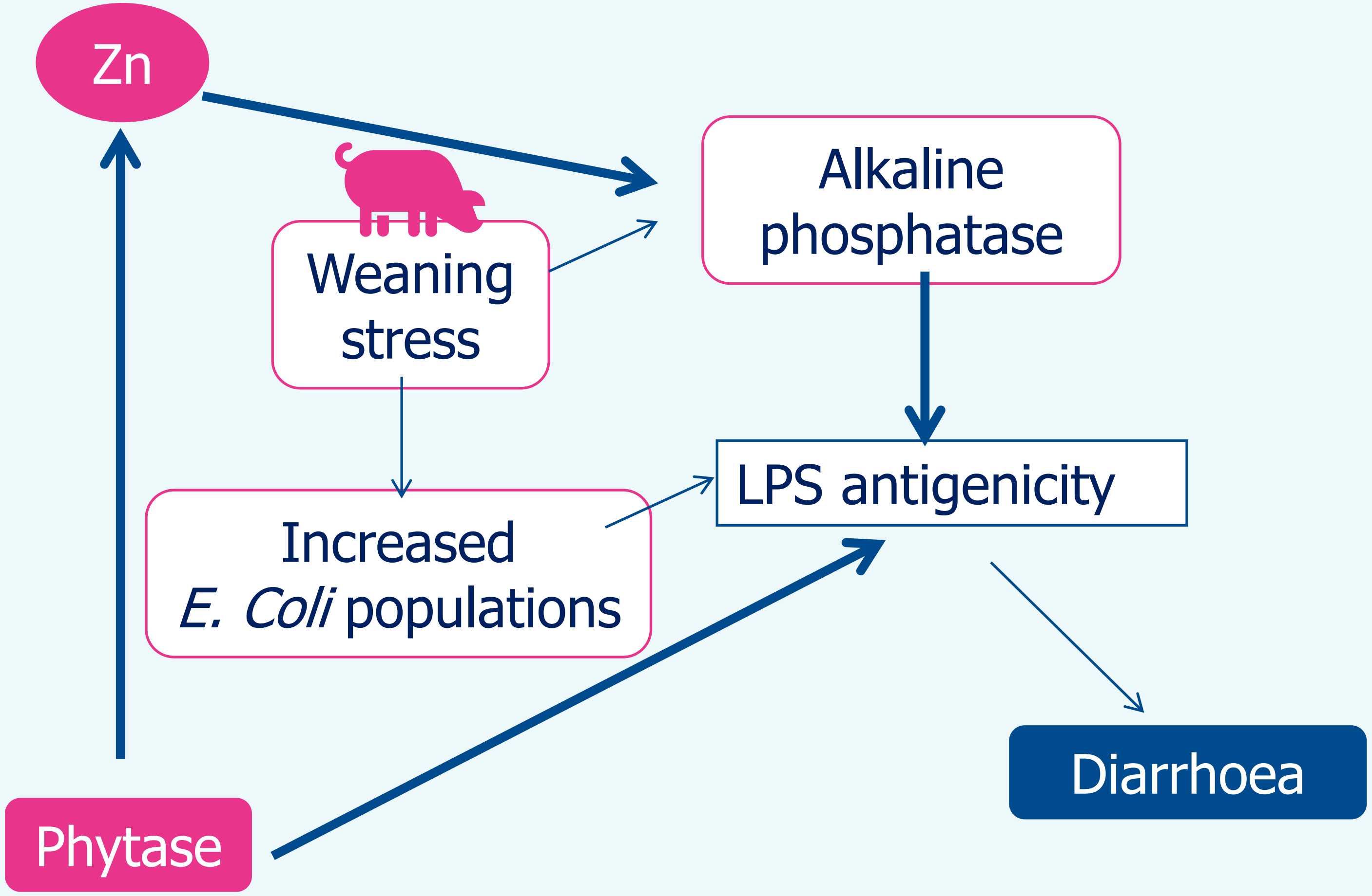


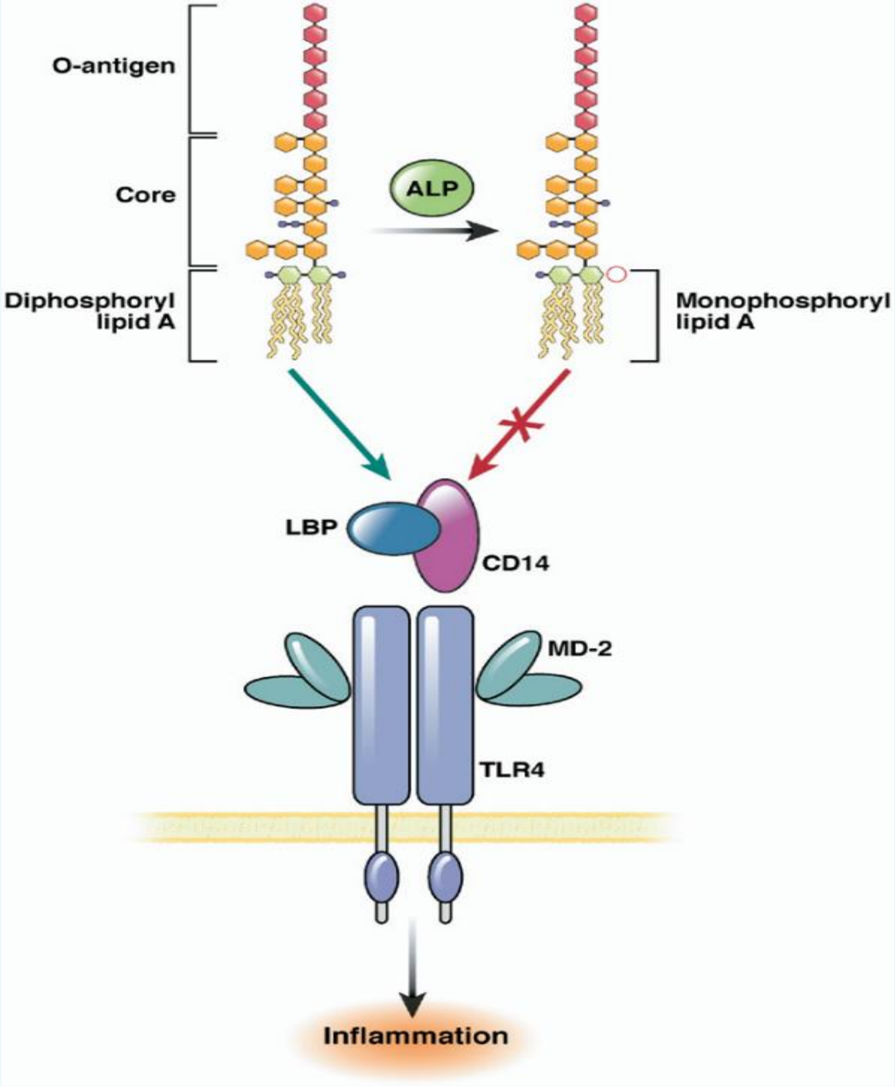
HMIT Linear P < 0.05
iALP Linear P < 0.05

SMIT1 Quadratic P = 0.10
SMIT2 Quadratic P < 0.05

Walk et al., 2018

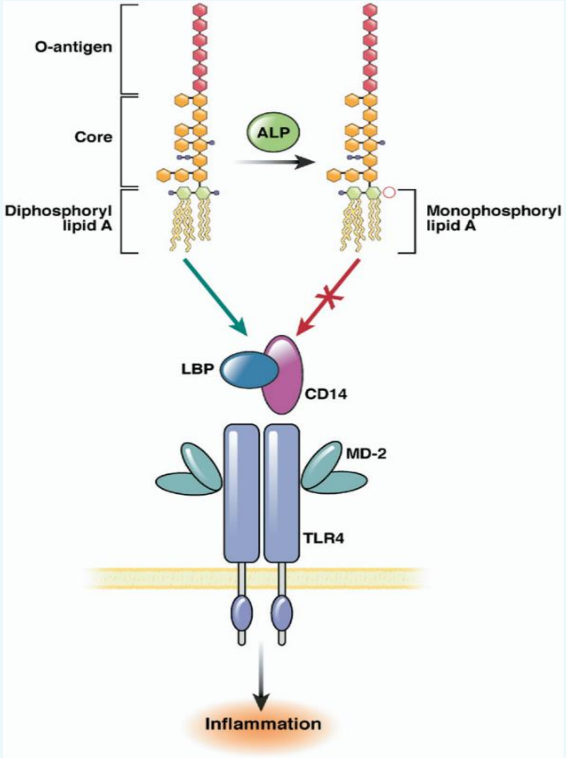
WEANING DIARRHOEA - PROPOSED MECHANISM

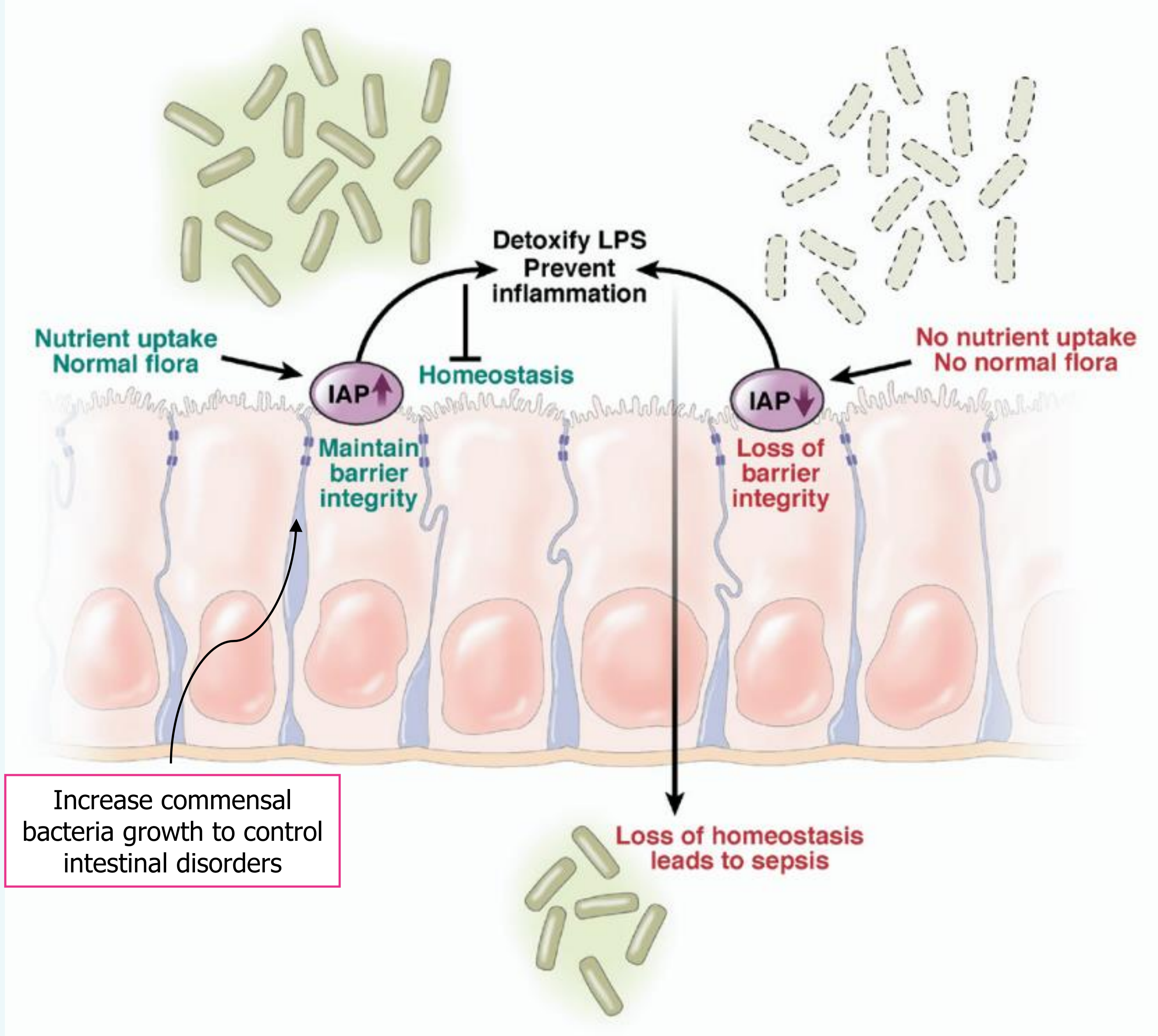




Bedford, personal communication

AP - LPS





Increase commensal bacteria growth to control intestinal disorders

AP REDUCES E. COLI INFLAMMATION

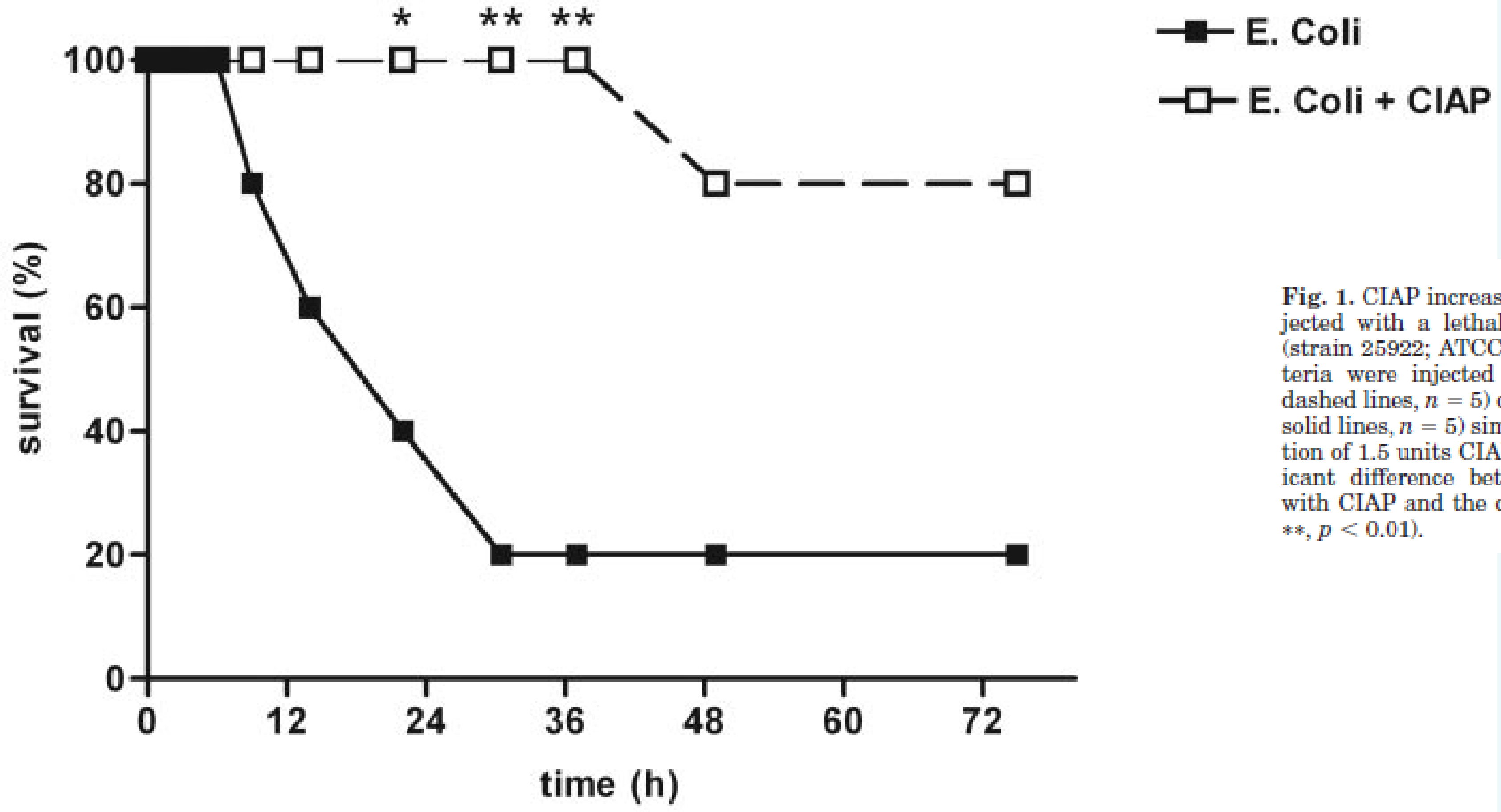
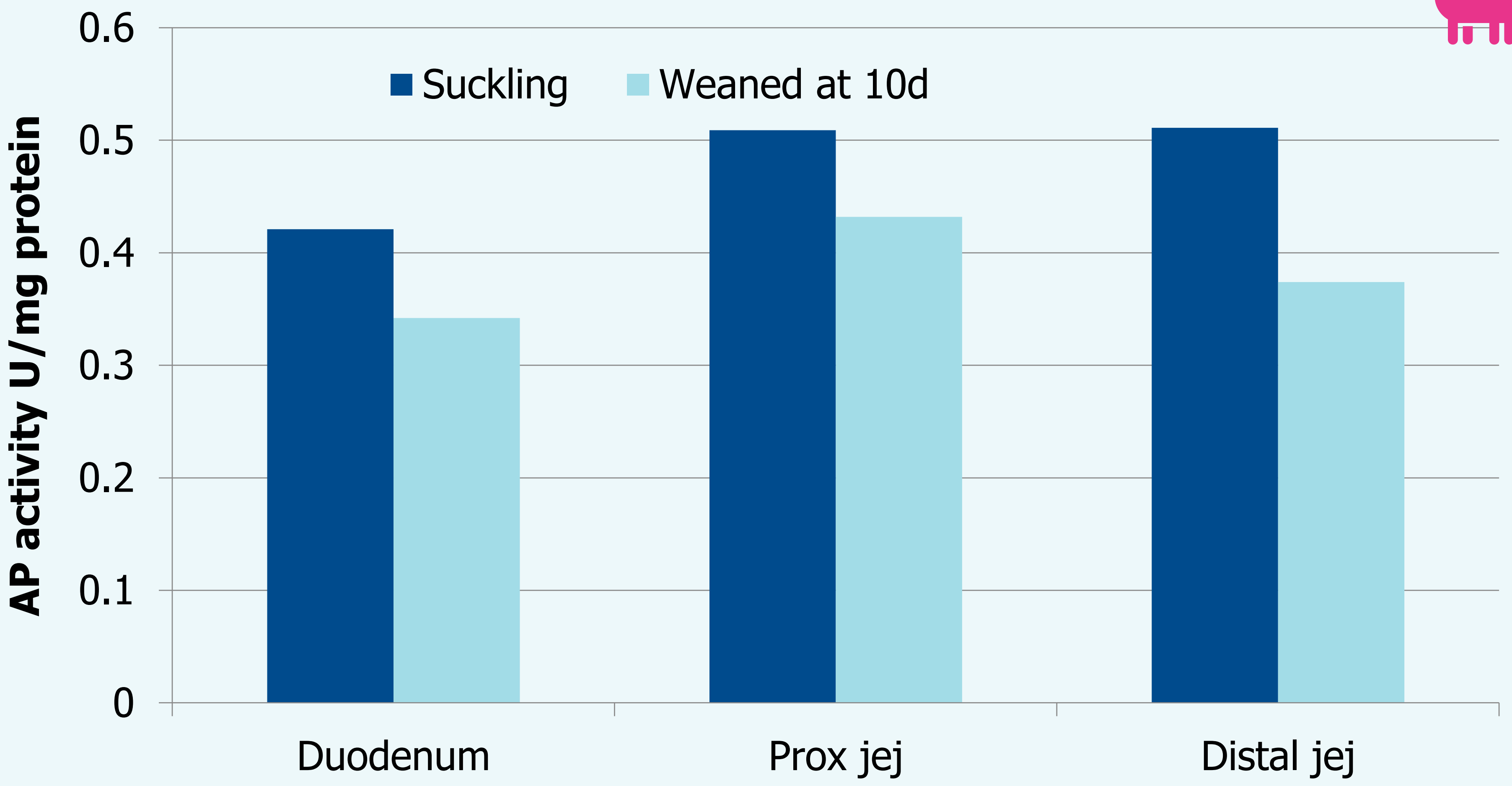


Fig. 1. CIAP increases the survival of mice injected with a lethal dose of *E. coli* bacteria (strain 25922; ATCC). At $t = 0$, 2.3×10^7 bacteria were injected i.p. with (open symbols, dashed lines, $n = 5$) or without (closed symbols, solid lines, $n = 5$) simultaneous i.v. administration of 1.5 units CIAP. Asterisks denote significant difference between the group injected with CIAP and the control group ($*$, $p < 0.05$; $**$, $p < 0.01$).

Beumer et al .,2003

WEANING REDUCES AP

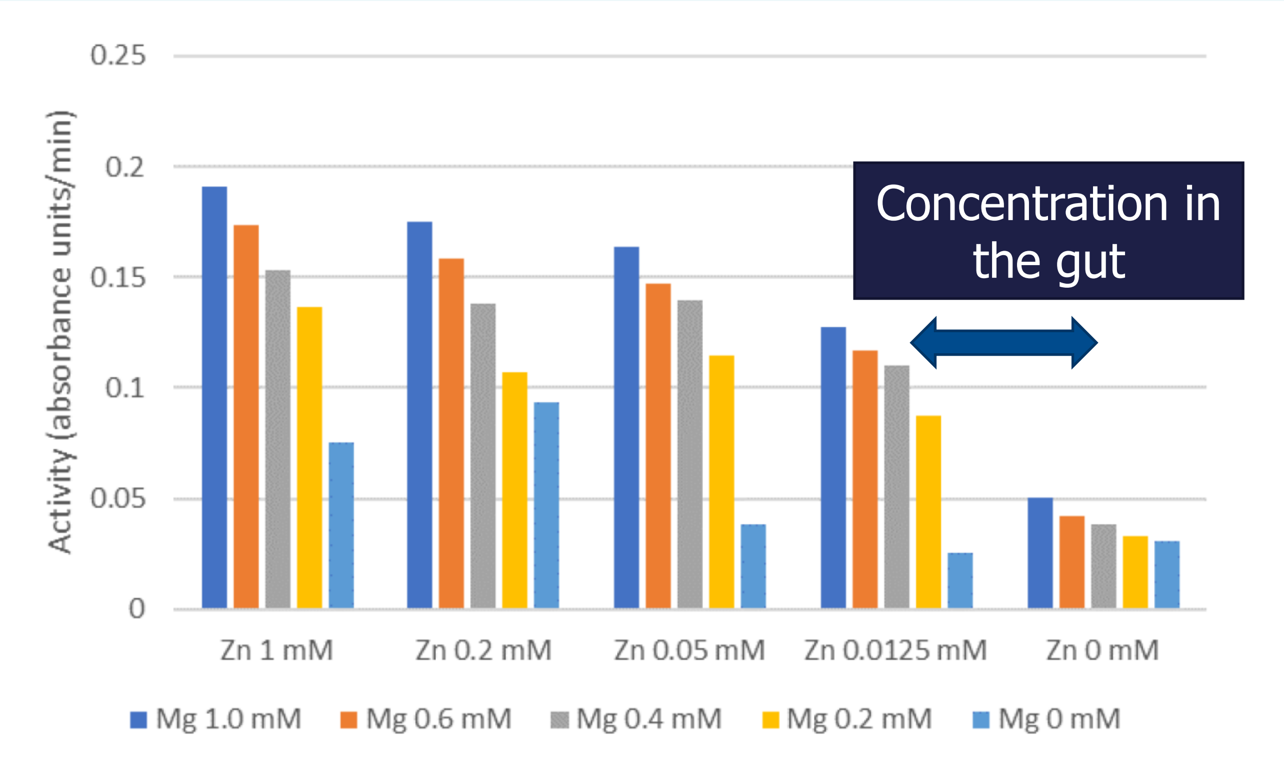


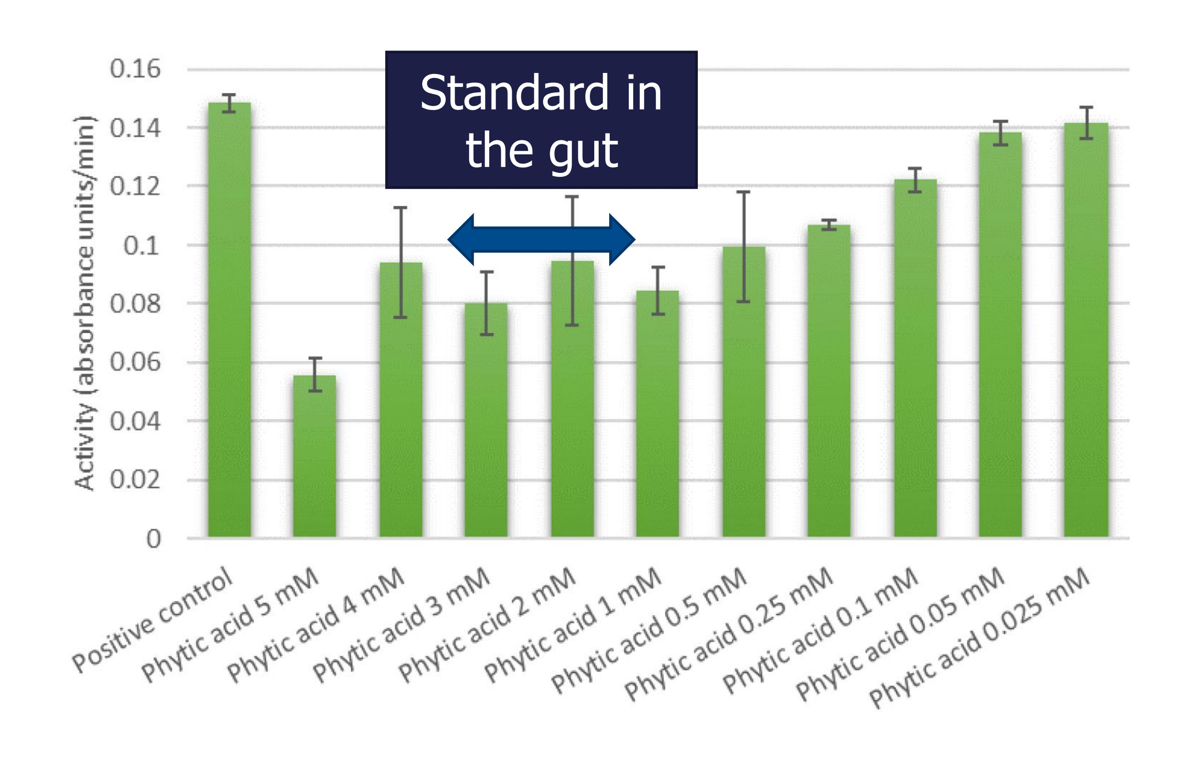
early weaning decreased small intestinal IAP V(cap), IAP catalytic affinity, and IAP gene expression, and this may in part contribute to the susceptibility of early-weaned piglets to increased occurrence of enteric diseases and growth-check.

Lackeyram et al., 2010

10d weaned pigs fed weaner for 12d or suckled till 22d

CHICK ALP ACTIVATED BY ZN AND MG

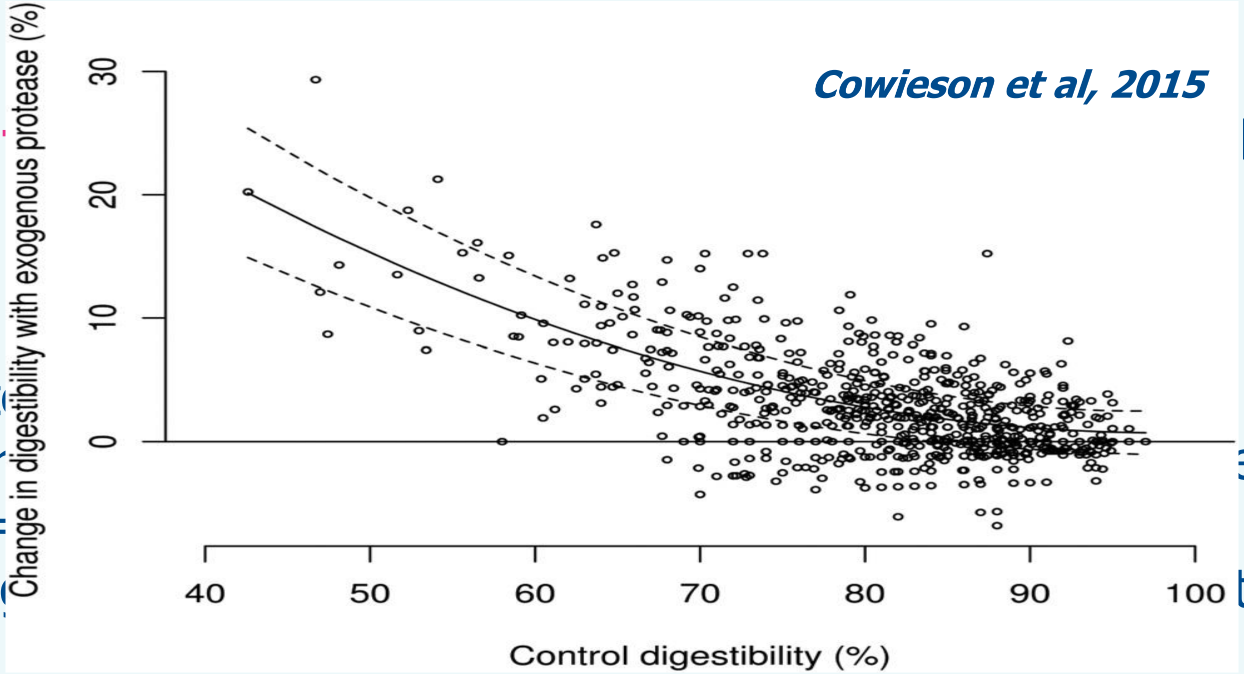




Chick ALP inhibited by phytate

PHYTASE APPLICATION IN GUT HEALTH

Increase **digestibility of protein** => lowering putrefaction in the hindgut



Releasing **key nutrien** ... lth

Increase **ALP activity**

- Reduction of ent...
- Need to consider ... entrations of inositol antioxydant effect = ...
- Better blood oxy... tion

NSP ENZYMES AND GUT HEALTH

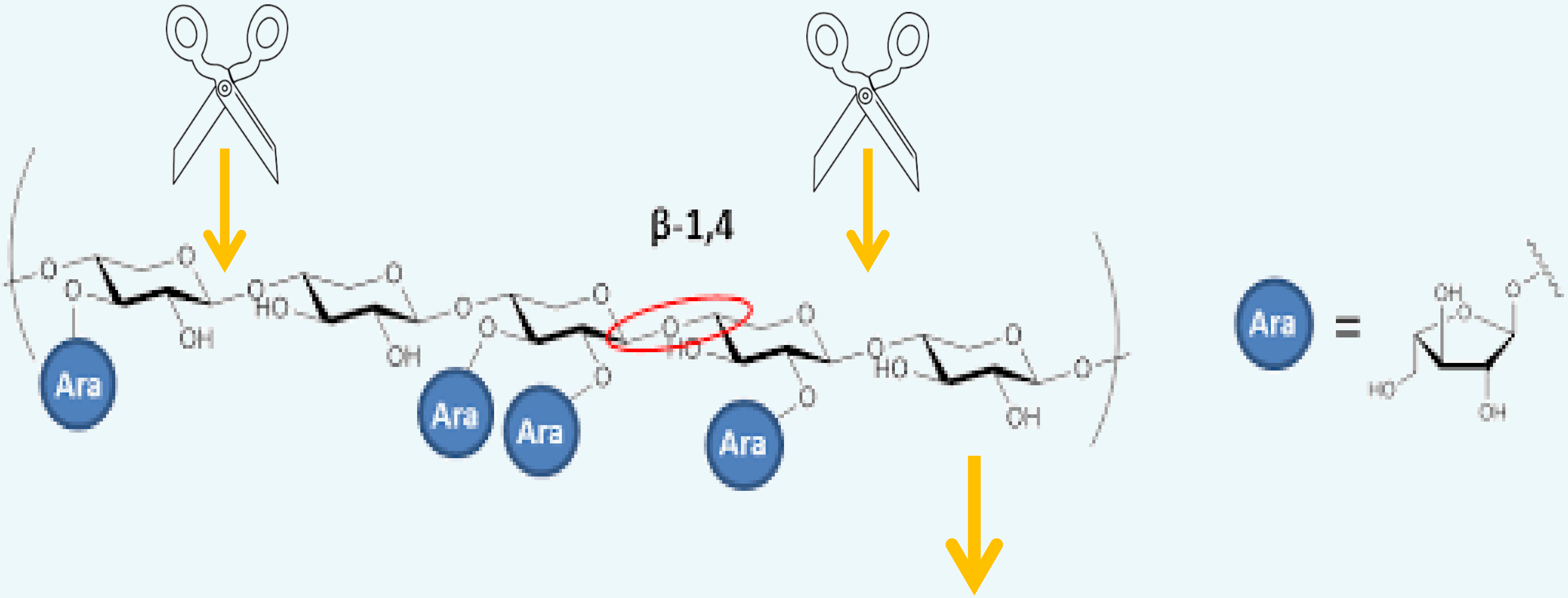
NSP ENZYMES

1. Opens up feedstuff cell walls (insoluble fibre)
   May also provide energy from constituent sugars

2. Reduces intestinal viscosity (soluble fibre)
   Wheat and barley diets

3. Produces oligosaccharides (prebiotics)

ARABINOXYLANES



Xylo-oligosaccharides

NSP ENZYMES

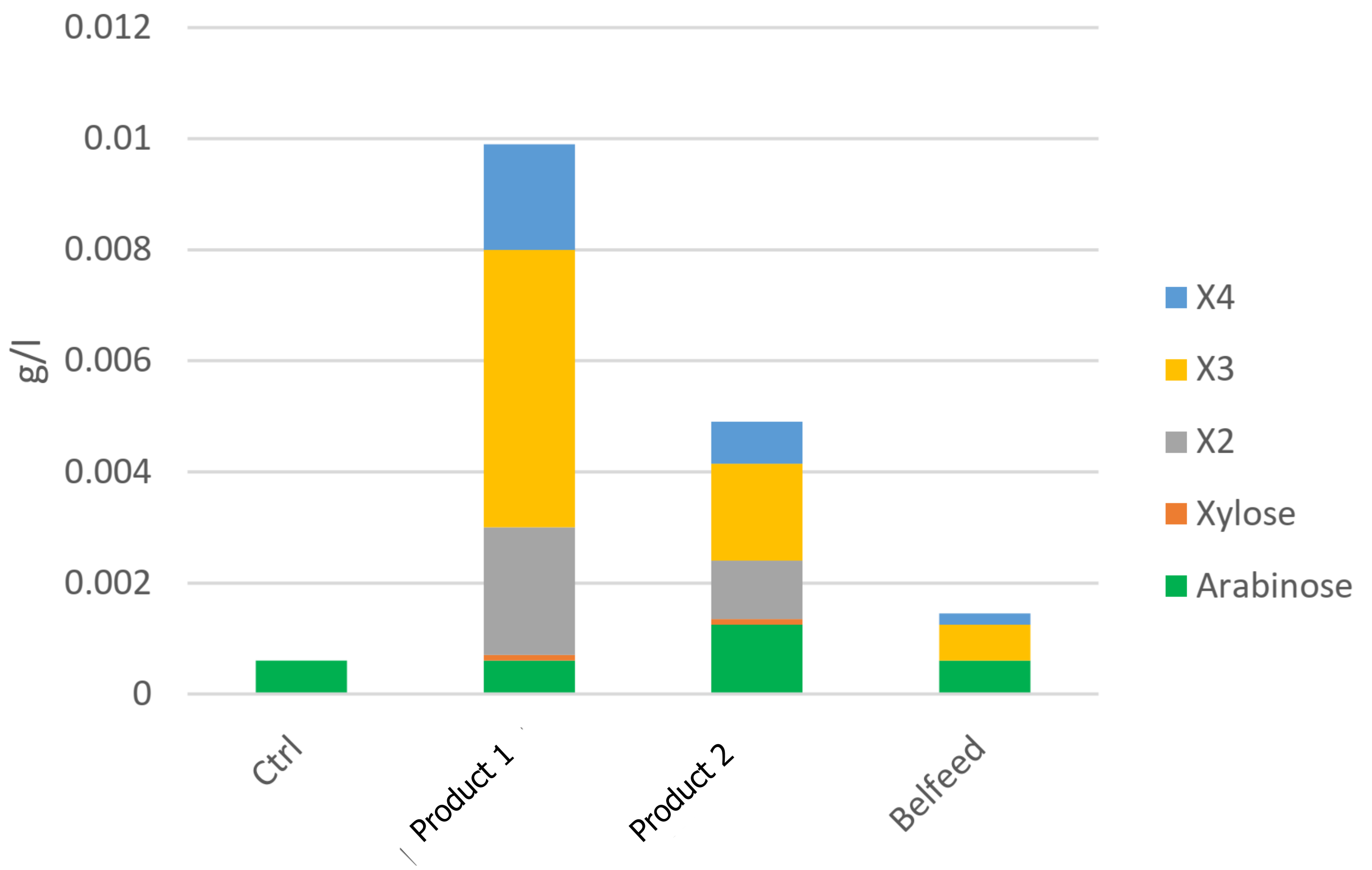
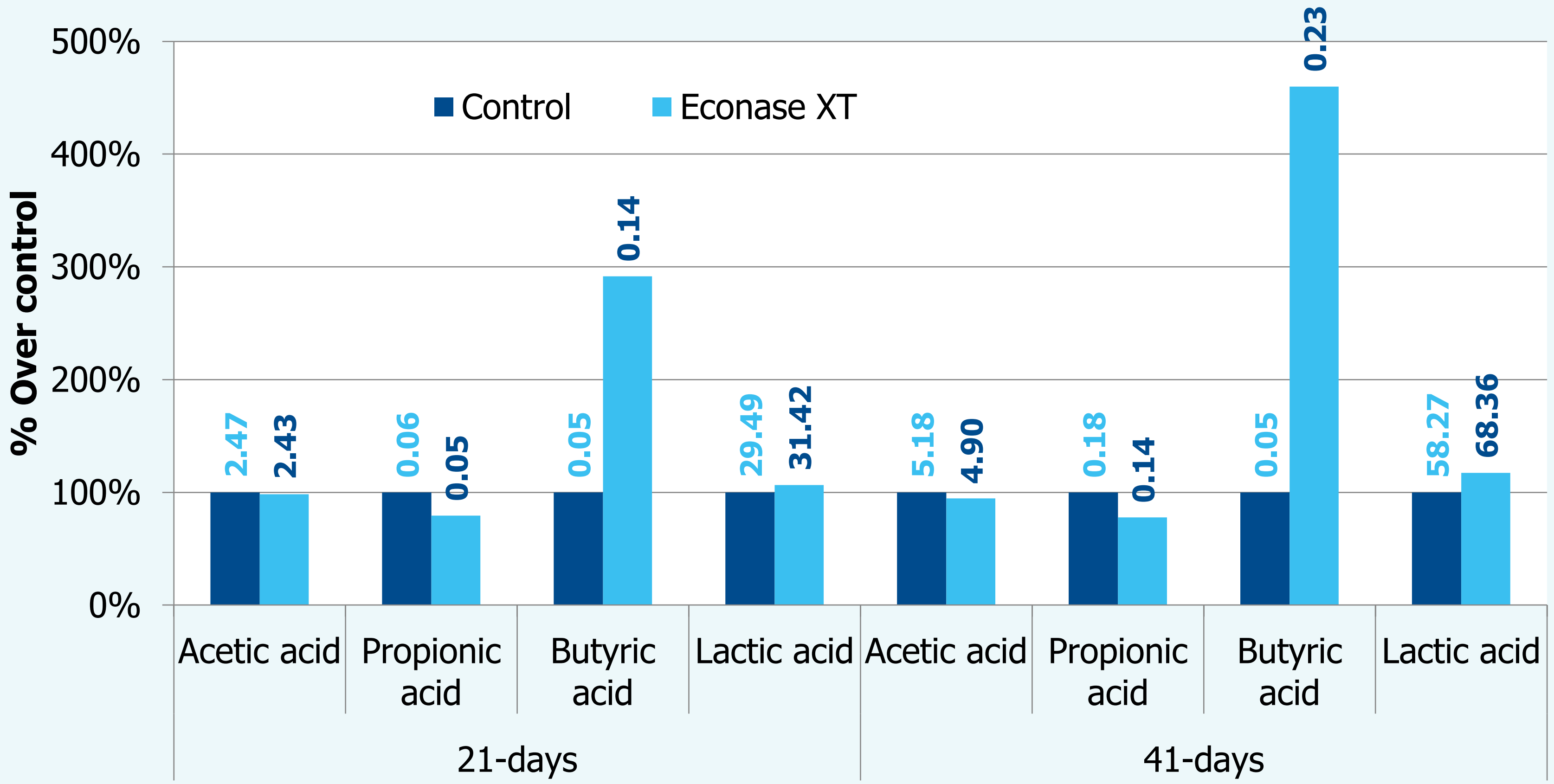


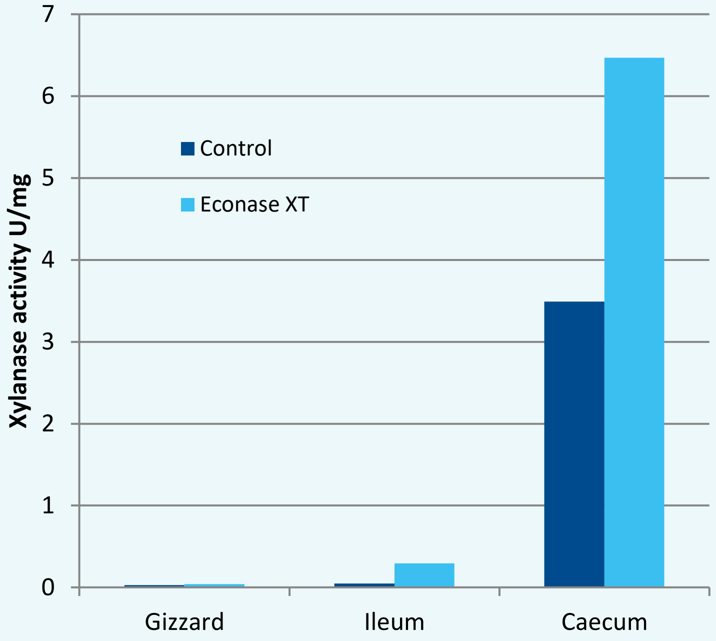
Figure 1 HPAEC-PAD results.

Ab Vista 2020. Commercial doses of all enzymes used on 1% wheat AX.

oligosaccharides

ECONASE XT INFLUENCES INTESTINAL FERMENTATION IN BROILERS





Gonzalez et al., 2019

Gonzales-Ortiz et al., 2016

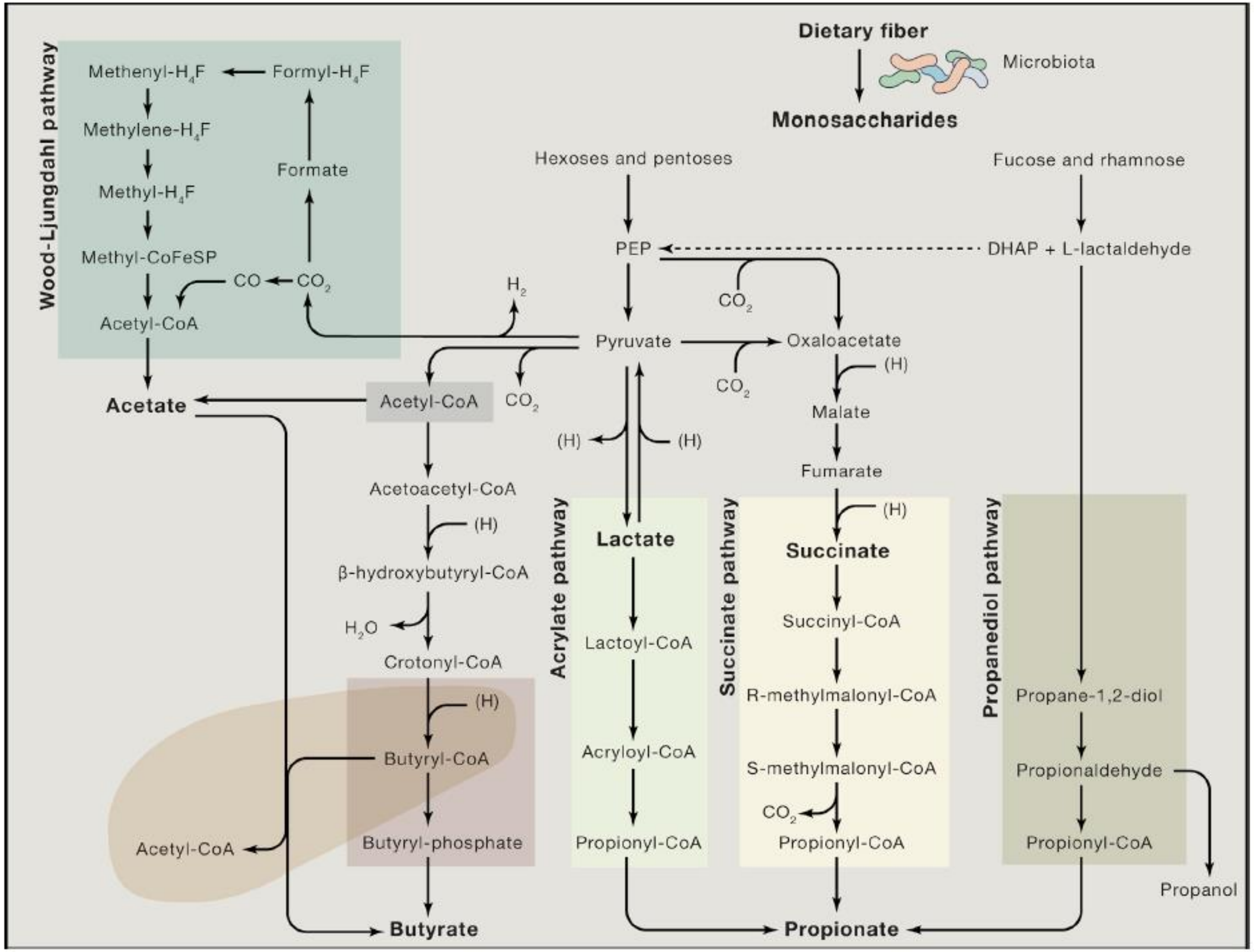
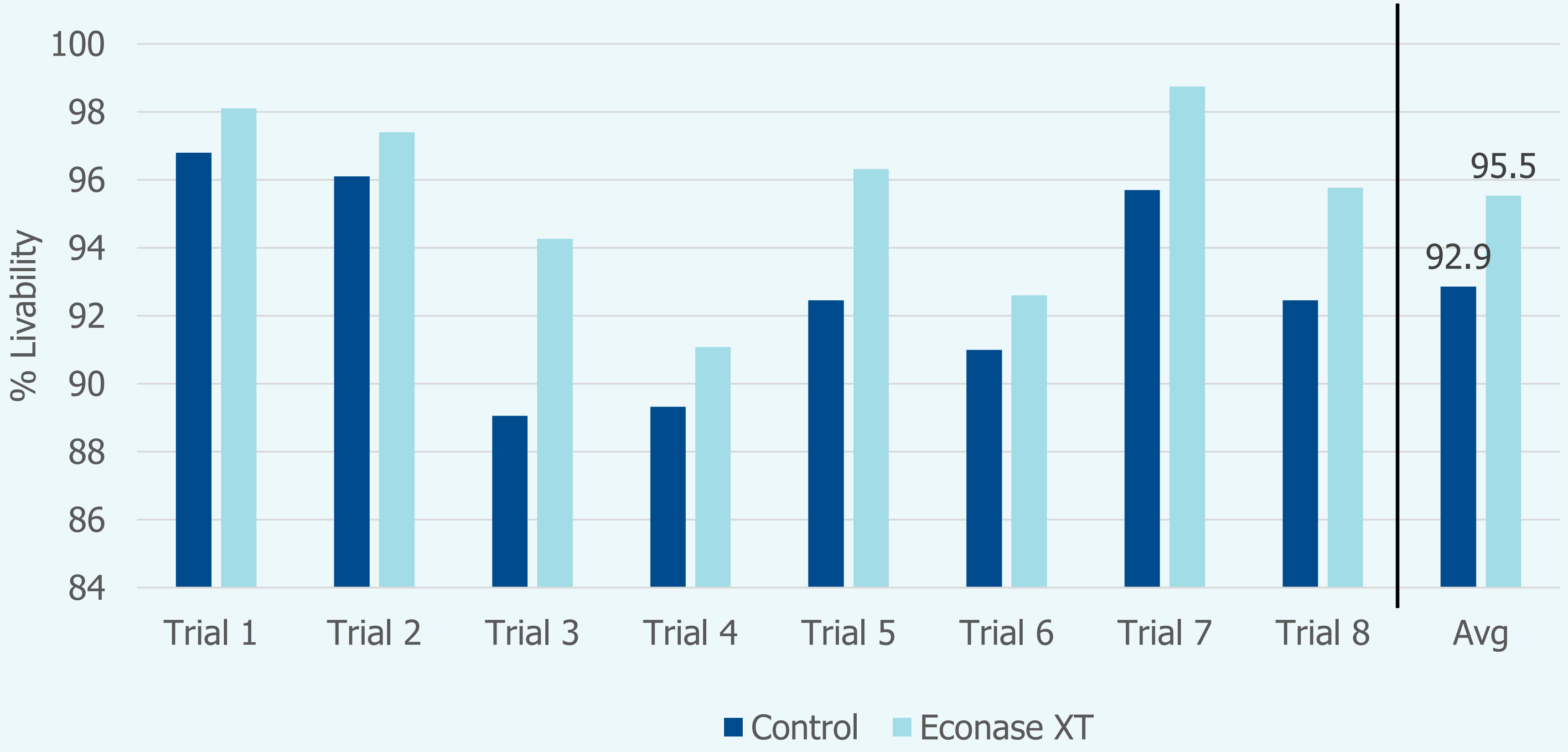


Figure 1. Known Pathways for Biosynthesis of SCFAs from Carbohydrate Fermentation and Bacterial Cross-Feeding

The microbial conversion of dietary fiber in the gut results in synthesis of the three major SCFAs, acetate, propionate, and butyrate. Acetate is produced from pyruvate via acetyl-CoA and also via the Wood-Ljungdahl pathway. Butyrate is synthesized from two molecules of acetyl-CoA, yielding acetoacetyl-CoA, which is further converted to butyryl-CoA via β-hydroxybutyryl-CoA and crotonyl-CoA. Propionate can be formed from PEP through the succinate pathway or the acrylate pathway, in which lactate is reduced to propionate. Microbes can also produce propionate through the propanediol pathway from deoxyhexose sugars, such as fucose and rhamnose. PEP, phosphoenolpyruvate; DHAP, dihydroxyacetonephosphate.

Koh et al., 2016

THE EFFECT OF ECONASE XT ON LIVABILITY (SWINE)

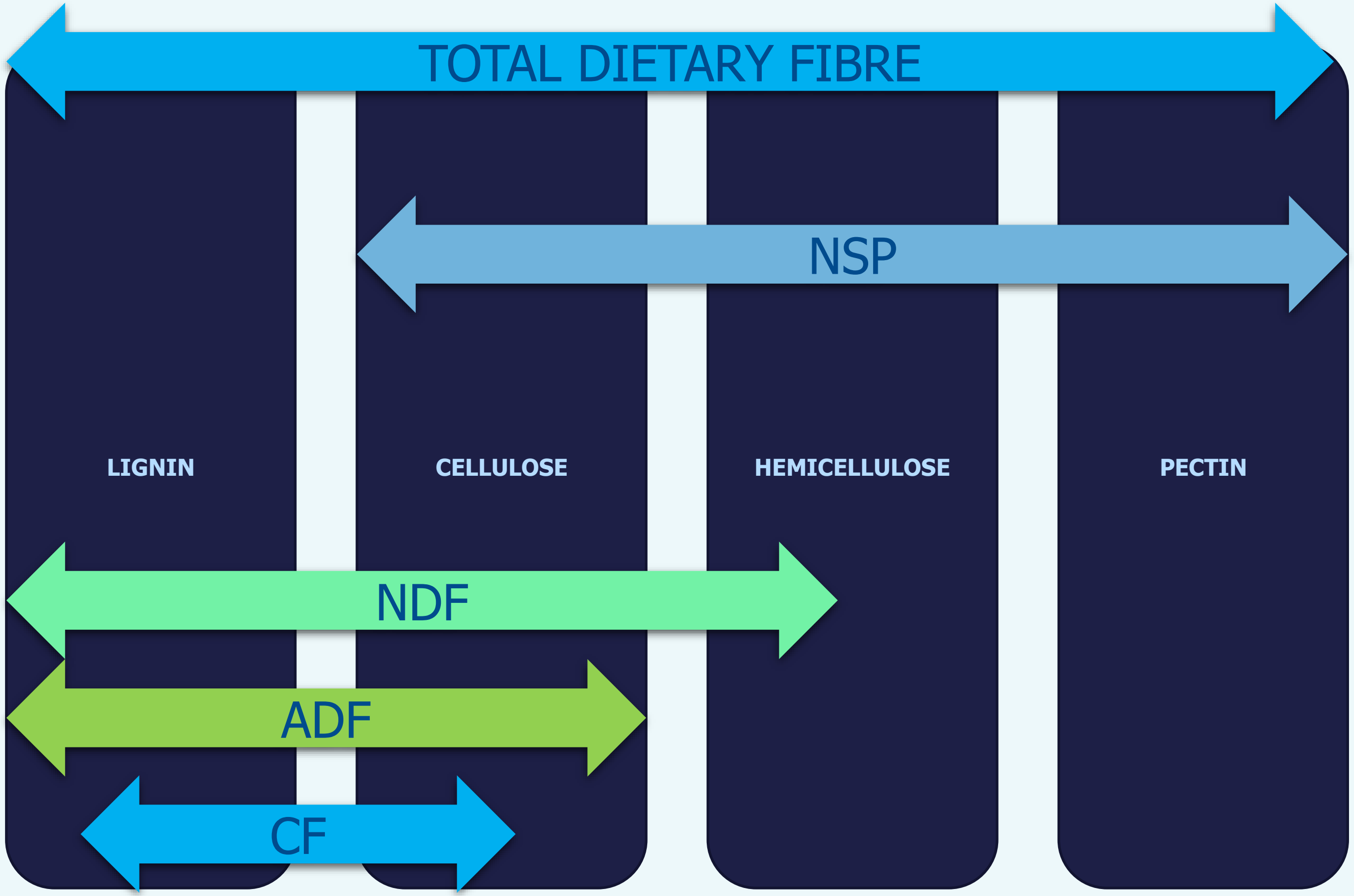


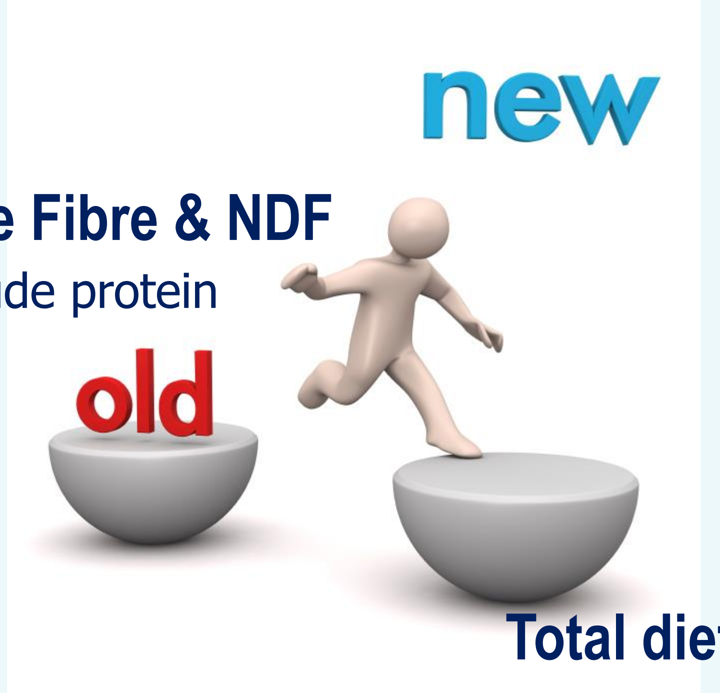
P < 0.08
SEM = 1.04

Mechanism, EXT has an indirect effect by **increasing xylo-oligomer production** that is **fermented by microbes** in the lower GI tract which **increases VFA production** especially **butyrate** which can improve microbial profile and is **energy for enterocytes**

FIBRE AND GUT HEALTH

FIBRE : CHARACTERISTICS_CRITERIA





Crude Fibre & NDF

Crude protein

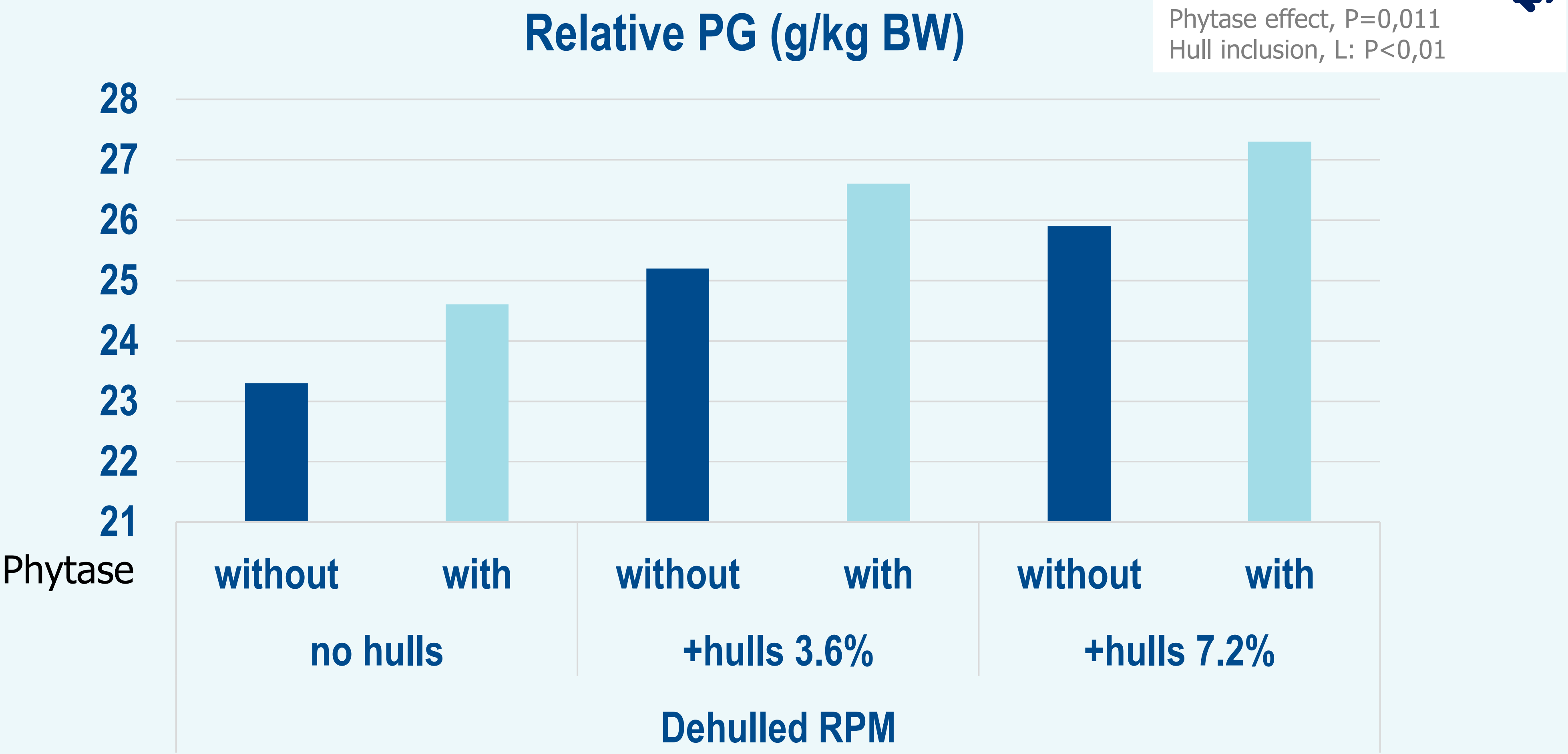
Total dietary fibre

Individual AAs

Towards a better characterisation of the functionality of fibre :
solubility and fermentability

AB Vista White paper, 2020

FIBRE & PHYTASE



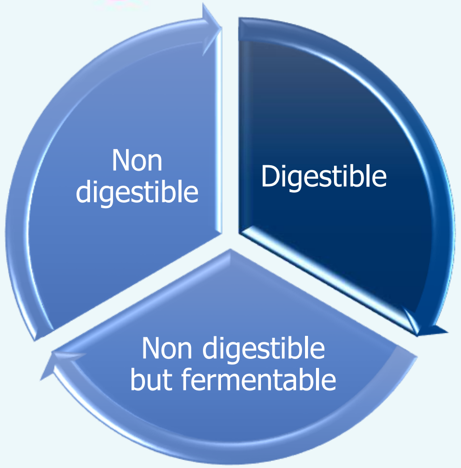
**Defatted rapeseed hulls*

Bournazel et al.,2018

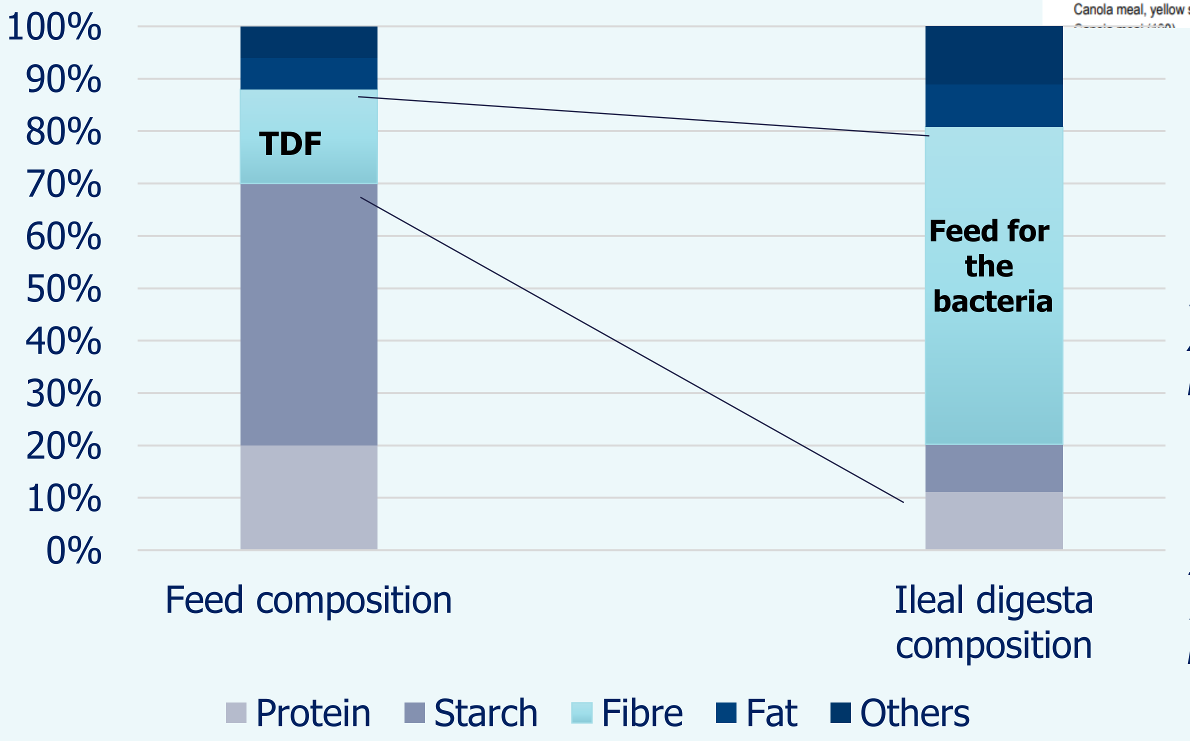
FIBRE & MICROBIOME

Table 1. Coefficient of apparent total tract digestibility (CATTD) of non-starch polysaccharides (NSP) in chickens[1].

Diet characteristics				CATTD	Bird type	Reference[6]
Main NSP sources[2]	Adaptation[3]	NSP content[4]	NSP Solubility[5]			
Barley (100)	0 to 63 d[7]	45	0.29	0.31	Male broilers (2-13 wk)	1
Barley (73), oat bran (27)	0 to 63 d[7]	91	0.43	0.35	Male broilers (2-13 wk)	1
Barley (65), oat bran (35)	0 to 63 d[7]	127	0.39	0.25	Male broilers (2-13 wk)	1
Barley (47), SBM (31), wheat (22)	41 d	127	0.31	0.39	Male broilers (6 wk)	2
Wheat bran (51), barley (49)	0 to 63 d[7]	132	0.27	0.19	Male broilers (2-13 wk)	1
Wheat bran (61), barley (39)	0 to 63 d[7]	203	0.18	0.16	Male broilers (2-13 wk)	1
Wheat (70), SBM (30)	37 d	97[8]	0.24[9]	0.05	Male broilers (7 wk)	3
Wheat (45) SBM (27), canola meal (12), wheat screenings (10), peas (6)	12 d	101[8]	0.25[9]	0.06	Male broilers (2-3 wk)	4
Wheat (37) SBM (33), barley (16), canola meal (9), wheat screenings (5)	37 d	120[8]	0.31[9]	0.15	Male broilers (7 wk)	3
Rye (58), SBM (26), wheat (16)	20 d	121	0.26	0.40	Mixed sex broilers (5-6 wk)	5
Pea fiber (54), barley (36)	0 to 63 d[7]	149	0.40	0.06	Male broilers (2-13 wk)	1
Pea fiber (64), barley (46)	0 to 63 d[7]	251	0.40	0.12	Male broilers (2-13 wk)	1
Maize (54), peas (49)	12 d	88	0.07	0.05	Male broilers (2-3 wk)	6
Maize (100)	12 d	57	0.08	0.08	Male broilers (2-3 wk)	6
Maize (100)	11 d	68	0.10[9]	0.14	Female broilers (4-5 wk)	7
Maize (52), SBM (48)	12 d	100	0.09	0.09	Male broilers (2-3 wk)	6
SBM (51), maize (35), canola meal (14)	12 d	136[9]	0.16[9]	0.12	Male broilers (2-3 wk)	8
SBM (51), maize (35), canola seed (14)	12 d	136[9]	0.16[9]	0.11	Male broilers (2-3 wk)	8
Canola meal (75), maize (25)	11 d	176	0.25[9]	0.20	Female broilers (4-5 wk)	7
Canola meal (56), maize (44)	12 d	106	0.09	0.08	Male broilers (2-3 wk)	6
Canola meal, brown seeded (100)	7 d	91	0.10	0.03	Adult laying hens	9
Canola meal, yellow seeded (100)	7 d	113	0.09	0.09	Adult laying hens	9



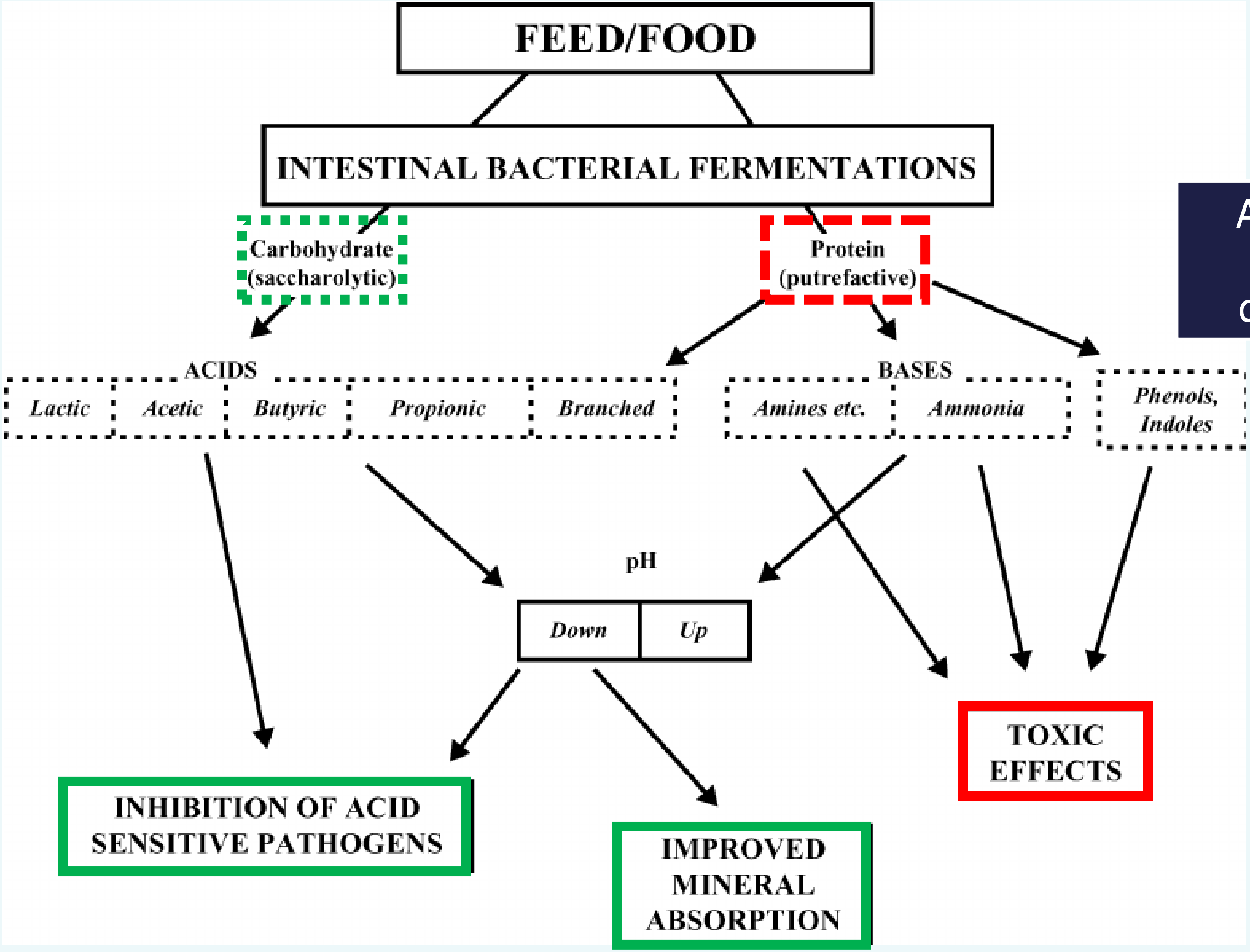
FIBRE



NSP in raw materials chickens 2% to 43%
ATTD
De Vries 2015

In swine NSP ileal digestibility is 12%
fecal digestibility around 68%
Bach Knudsen et al.,2014 Midwest p35

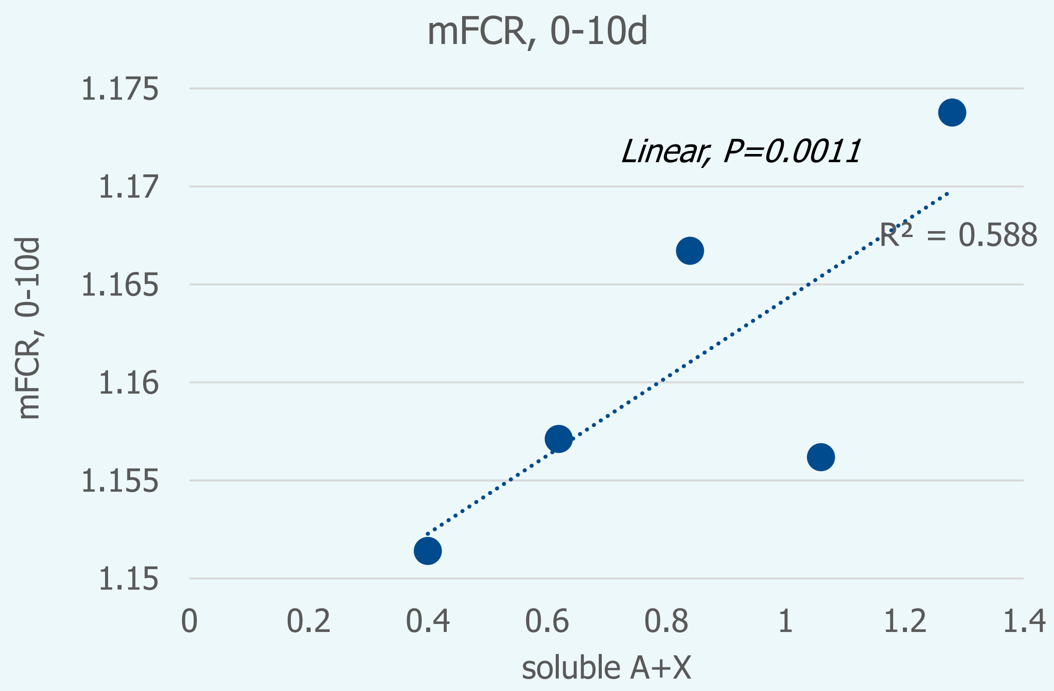
FIBRE & MICROBIOME

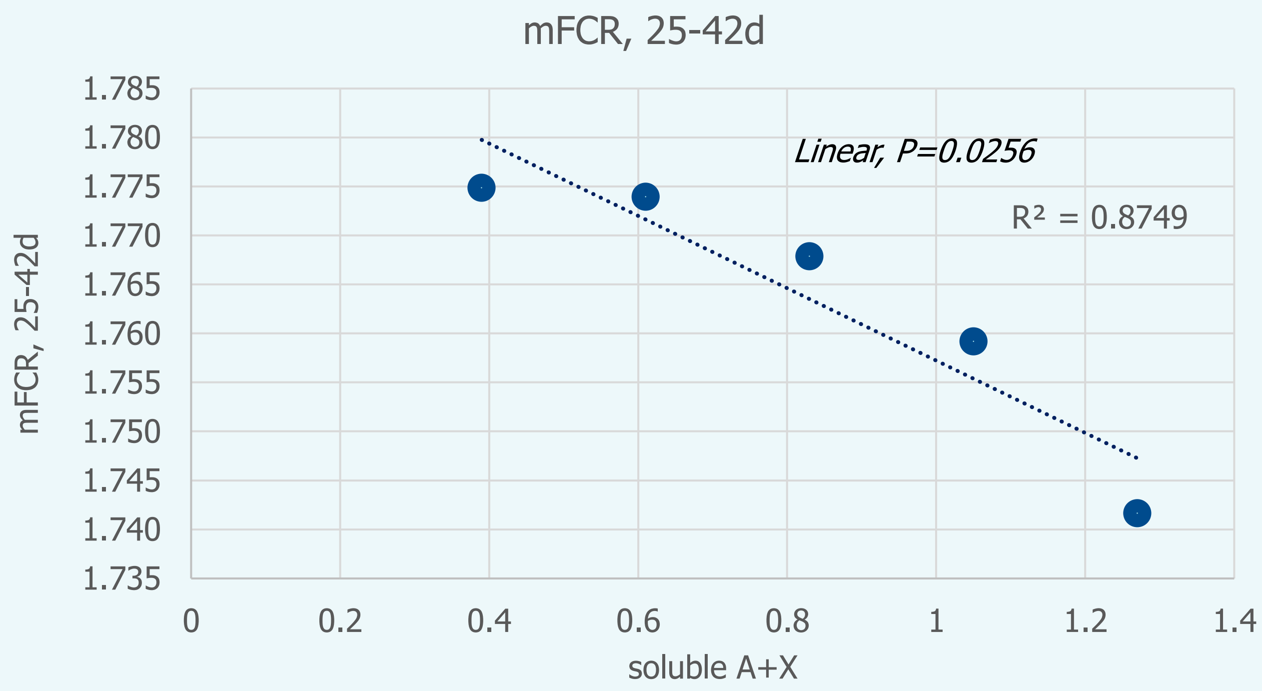


Also where enzymes improving protein digestibility will help

Apajalahti, 2005

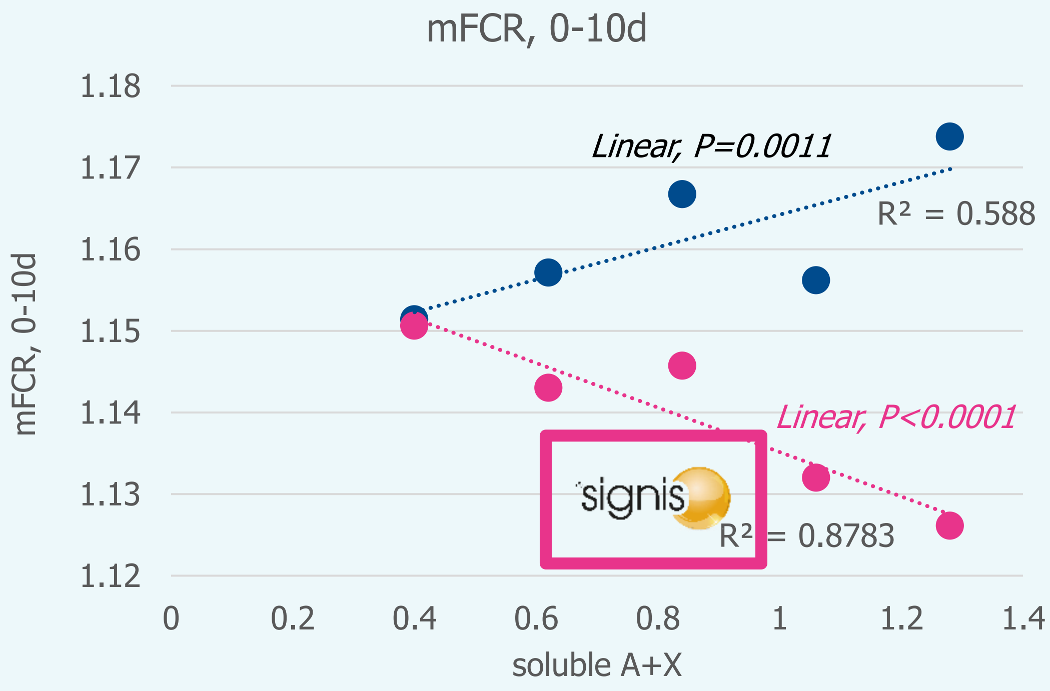
FIBRE _ SOLUBLE A+X

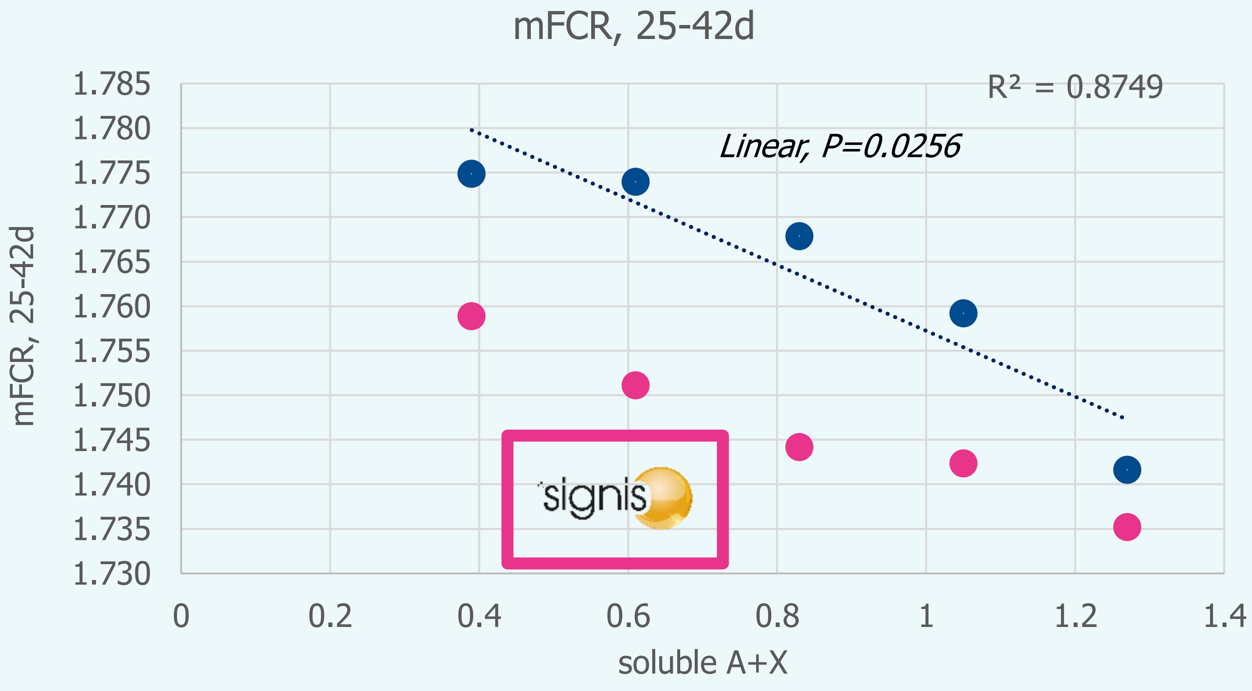




Gomes et al.,2021 under publication

FIBRE _ SOLUBLE A+X & MICROBIOME





Gomes et al.,2021 under publication

FIBRE & MICROBIOME

TRT	day 14 TNF-α, pg/ml	day 35 TNF-α, pg/ml
GS-CON	9.6[b]	42.5[c]
GS-Stimbiotic	9.3[b]	39.3[c]
PS-CON	18.8[a]	73.9[a]
PS-Stimbiotic	14.1[ab]	55.9[bc]
PS-FOS	15.0[ab]	69.3[ab]
PS-MOS	15.7[a]	68.7[ab]
SEM	0.8	2.6
P-Value	**0.012**	**<0.0001**

Stimbiotic use decreased by 24% TNF alpha at 35d where MOS & FOS had no effect

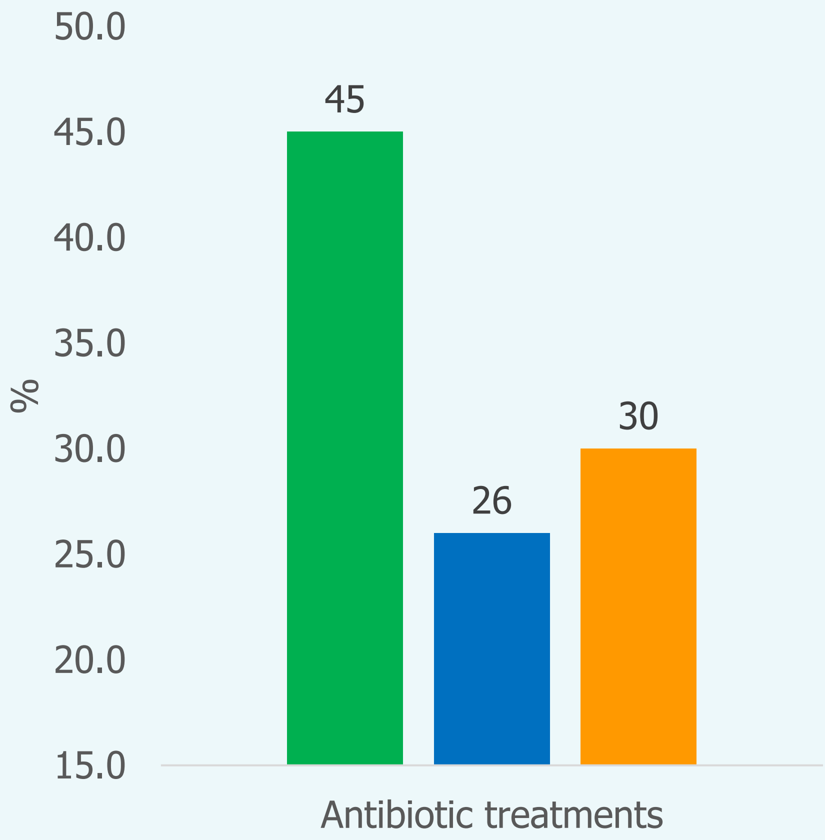
Dirty conditions increased TNF alpha (95% & 76% at 14 et 35d respectively) vs clean conditions = inflammatory reaction

Stimbiotic increased 42d BW in good conditions (21.9 vs 23kg) and even more in « dirty conditions » (20.14 vs 22.11kg).

Cho et al., 2020

FIBRE & MICROBIOME

Inclusion of Signis reduced FCR by 17 points compared to SBP (1.49 vs. 1.66, *P*=0.011) at 42 days post-weaning.



Diets

Diet (%)	Nursery 1	
	CTRL/ SIGNIS*	SBP
Corn	43.2	37.9
Soybean Meal	19.0	19.0
Corn DDGS	4.0	
Steamed Rolled Oat	5.0	21.8
Cereal Fines	14.3	
Sugar beet pulp		5.0
Fat	1.60	2.91
MonoCal 21%	1.75	2.00
Calcium carbonate	0.75	0.64
Zinc Oxice	0.35	0.35
Salt	0.42	0.63
Concentrate Pack[1]	7.60	7.87
Others[2]	1.91	1.85
		C
ME (kcal/kg)	3284	3284
Crude Protein (%)	18.8	18.97
Crude fat (%)	4.46	5.99
NDF (%)	8.97	12.56
Insoluble Fibre	7.47	7.57
Soluble Fibre	1.67	2.88
Ins/Sol Fibre ratio	4.47	2.63
SID Lysine (%)	1.20	1.20
Calcium	0.72	0.72
Phosphorus	0.76	0.76
Av. Phosphorus	0.53	0.53

CONCLUSIONS

Gut health is dependant on many factors => **nutritional tools** are available to get animals able to ensure optimal gut integrity and capacity to cope with any gut challenges

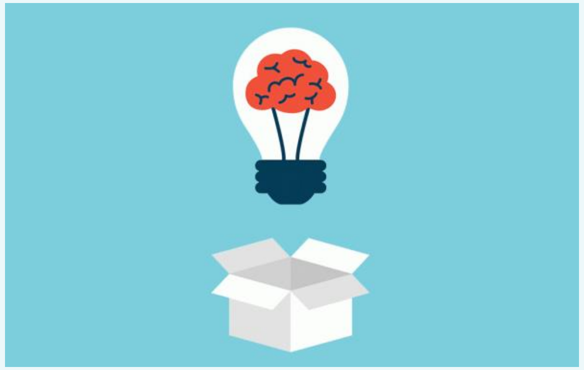
1. Enzymes are relevant tools by their effect in increasing nutrient digestibility of protein, amino acids, minerals, fibre but there is probably much more to extract than we thought.
Targeting maximum **inositol release** can help to control diarrhoea in piglets and breast myopathies incidence : high dosage of phytase application

2. Controlling the AXOS arriving in the hindgut to get beneficial fermentation : NSPase

3. Having a **better monitoring of fibre characteristics** and understanding the **requirement of the animals** to adapt the fibre fraction would be a key as to help for a proper and **quick adequate microbiome establishment**

All the 3 above are relevant tools , are interlinked and the strategy needs to be adjusted following the target

TAKE HOME MESSAGE



Think also enzymes application beyond nutritional matrix

&

Look at fibre as the feed for gut microbiome

ABVista

The most important additive is intelligence