DIETARY STRATEGIES FOR NURSERY PIGS TO MAINTAIN HEALTH

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Prepared for Leman Conference China, November 2022

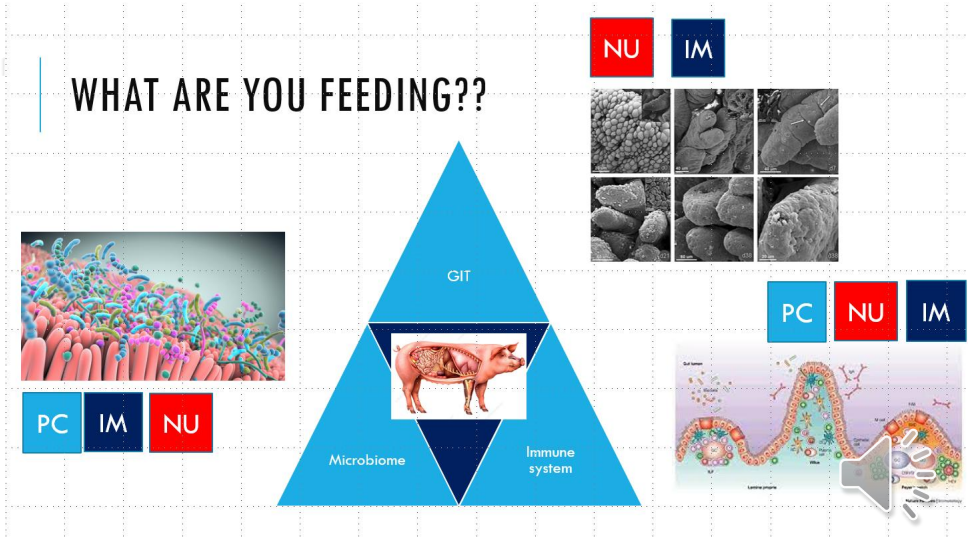
RETHINKING THE APPROACH

Traditionally nutrition has focused on meeting the nutritional requirement of the pig.

- Zinc, Copper & antibiotics have covered up many nutritional short comings.

Playing the long game (living without antibiotics) requires rethinking our approach

- What does the pig need to growth?
  - Well defined nutritional requirements for growth
- What does the gastrointestinal tract need to optimise functionality?
  - Mucus layer, cell proliferation, tight junctions regulation etc
- What does the immune system need to remain robust and protective?
  - Passive immune protection
  - Immune modulation
  - Vaccine response
- What does the microbiome need?
  - Stimulate alpha diversity, create opportunity for homeostasis



EVOLUTION OF STOMACH PH
THE LOGIC BEHIND THE CHALLENGE

Colostrum has strong buffer capacity pH 5-6

With the passive immune protection built into colostrum, the higher pH allows for controlled colonisation of the GIT.

2 days

The pH is need for the activation of chymosin to ensure the clotting of milk to slow down the transit rate of milk.

Milk, thanks to lactose content lowers pH to 4, HCl secretion is antagonized

Creep feeding stimulates stomach development and boosts acid and pepsin secretion.

3 to 4 weeks

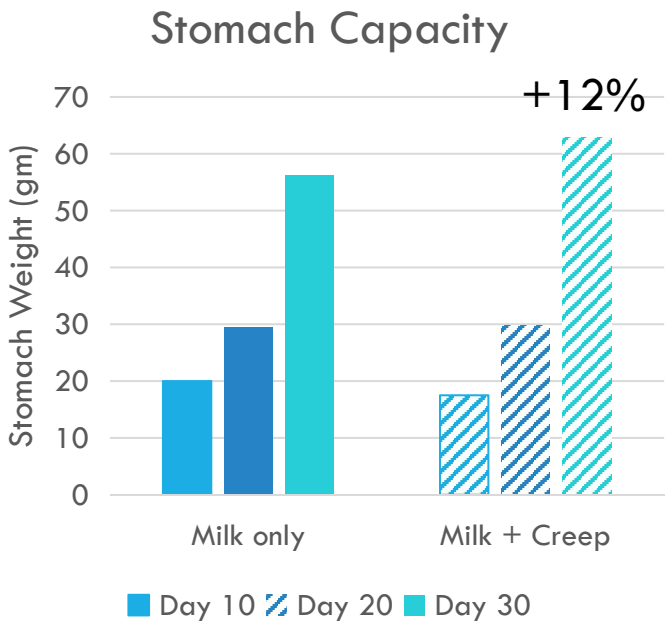
Unstable pH
High risk of suboptimal protein digestion, and proliferation of pathogens.
Effect on rate of gastric emptying.

Lactose withdrawal
Small rigid stomach
Feed ABC
Weaning age
Preweaning creep intake
Appetite
Infeed acids
Water acidifiers

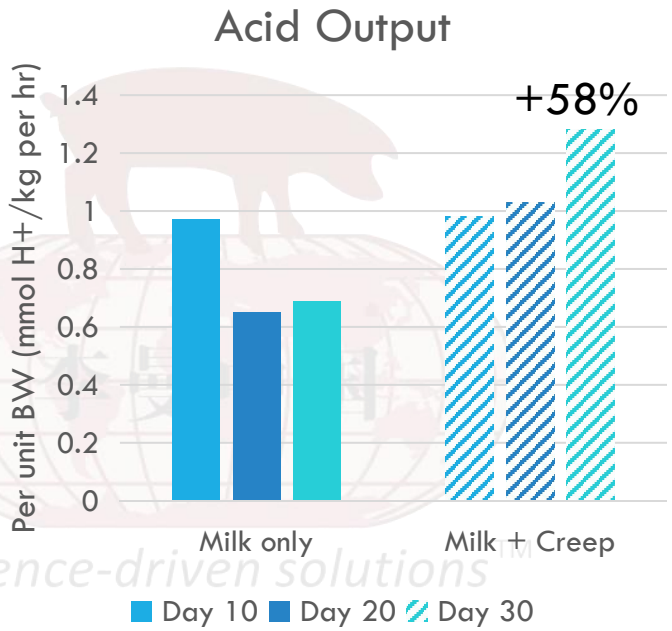
Efficacy of pepsinogen is high at pH 2 and poor at pH 4.

4 to 6 weeks

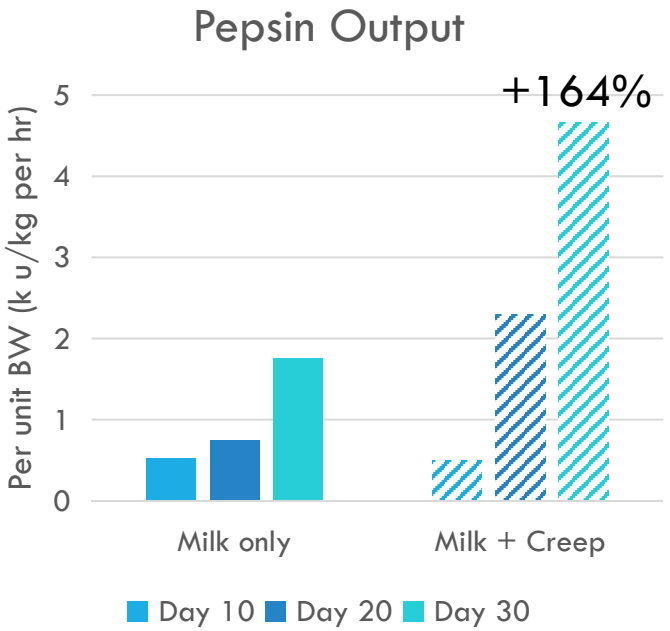
DEVELOPMENT OF STOMACH CAPACITY & FUNCTION



Larger stomach capacity increases the exposure to digestive enzymes and prolongs stomach dwell time



Acid output takes time to develop and it develops in response to substrate. Acid output is directly related to stomach pH.



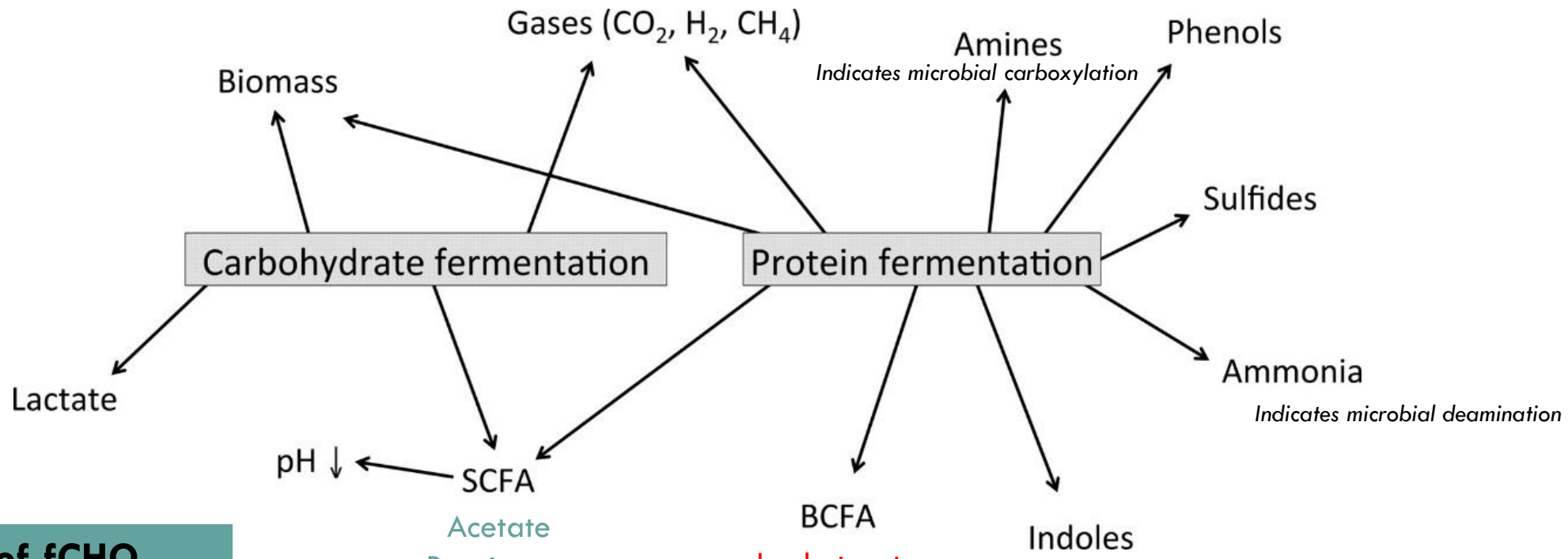
Pepsin output is closely linked to acid output. Creep feed provides a substrate for hard to digest proteins. Pepsin output influences protein digestibility and the risk of diarrhea.

Cranwell 1985

HIND GUT FERMENTATION: AN OVERVIEW

(Pieper et al 2012, Jha & Berrocoso 2016)

Histamine
Spermidine
Spermine
Cadaverine
Putrescine



The benefits of fCHO

Provides energy for intestinal epithelium and peripheral tissue.
Inhibits pathogens
Facilitates tight junctions
Inhibits inflammation

The consequences of fP

Cytotoxic (toxic to intestinal tissue/cells)
Proinflammatory (irritation)
Carcinogenic
Disruptive to cellular metabolism

OPTIMAL PROTEIN DIETS

UNDERSTANDING THE LIMITATIONS

Lowering crude protein needs to be down carefully

- Protein is essential for growth and immunity
  - Mucin production
  - Immunoglobulin production
- Protein level and quality influences palatability/appetite
- It is not protein that is an issue per se but undigested protein
  - Sows milk contains 26% crude protein on a DM basis
- Protein quality x piglet digestive ability needs to be considered

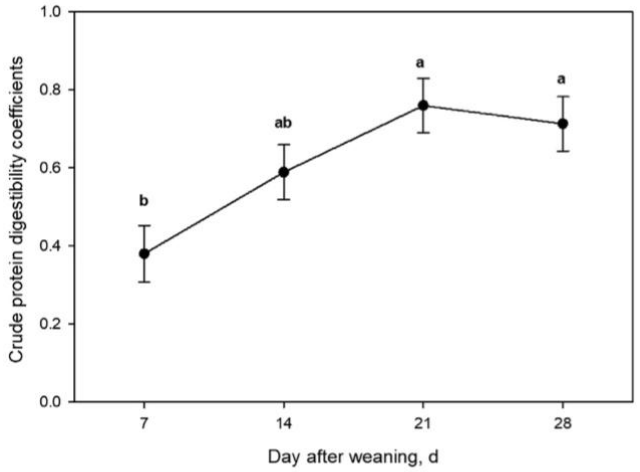
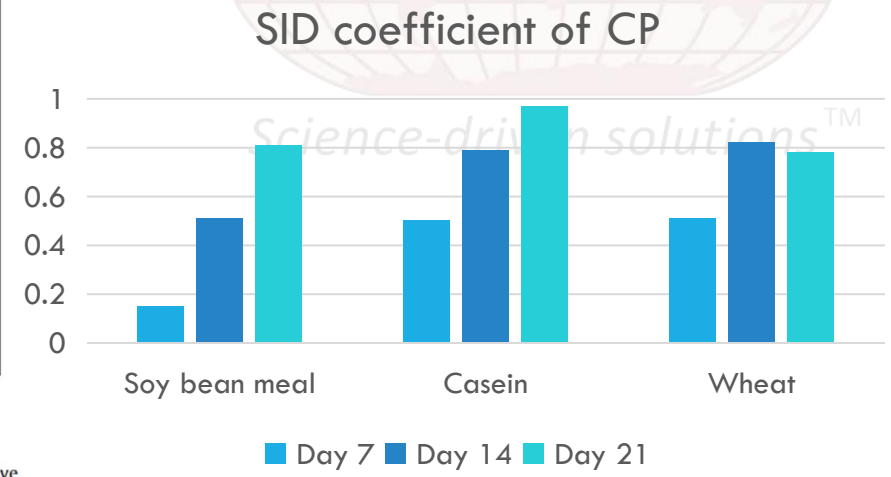


Fig. 1. The average standardised ileal digestibility coefficients of CP across the five dietary protein sources fed to pigs over the weaning period. Statistically significant ($P < 0.05$) levels between days are indicated with different letters (a, b).



Engelsmann et al., 2022

FORMULATION CONSIDERATIONS

Promote feed intake before & after weaning

- Best way to maintain gut structure

Formulate to undigestible protein

- Less than 2.2% creep
- Less than 2.3% prestarter
- Less than 2.4% starter

Formulate to acid binding capcity

- Less than 550MEQ/kg pH3 creep
- Less than 600 MEQ/kg pH 3 prestarter
- Less than 650 MEQ/kg pH 3 starter

Balance EAA:NEAA

- Best response when 50:50

Limit the use of synthetic amino acids

- Maximum synthetic lysine = 35% of SID lysine

Stimulate stomach development

- Inert fibre
- Substrate exposure

Use eubitoics to modulate microbiome

OPTIMAL RATIO OF EAA:NEAA IS ESTIMATED TO BE CLOSE TO 50 FOR PIGS FROM 15-30KG

(Toledo et al 2014)

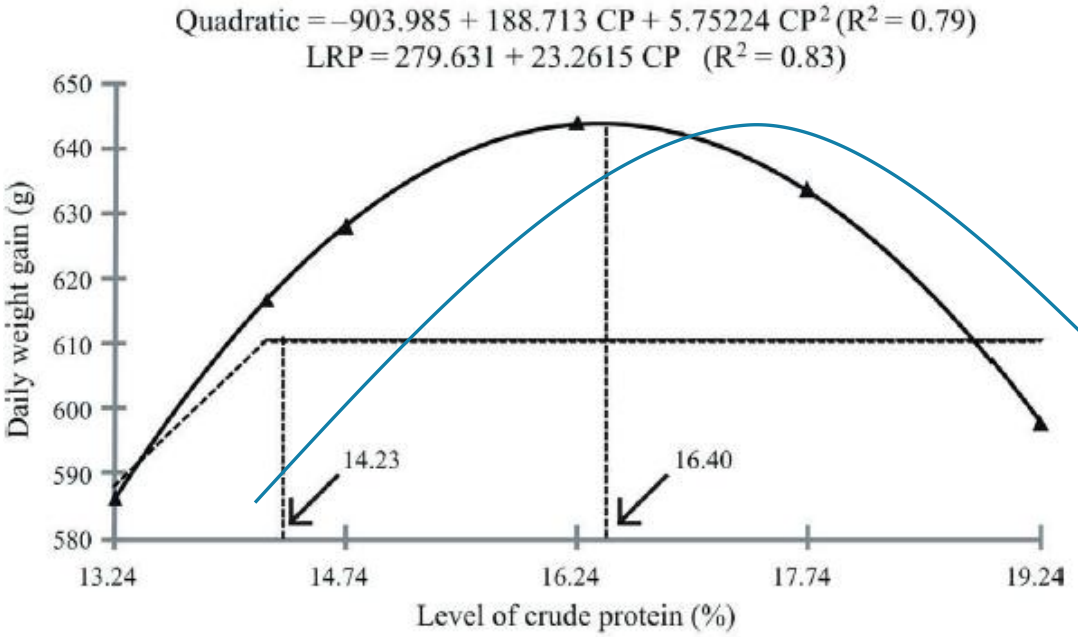
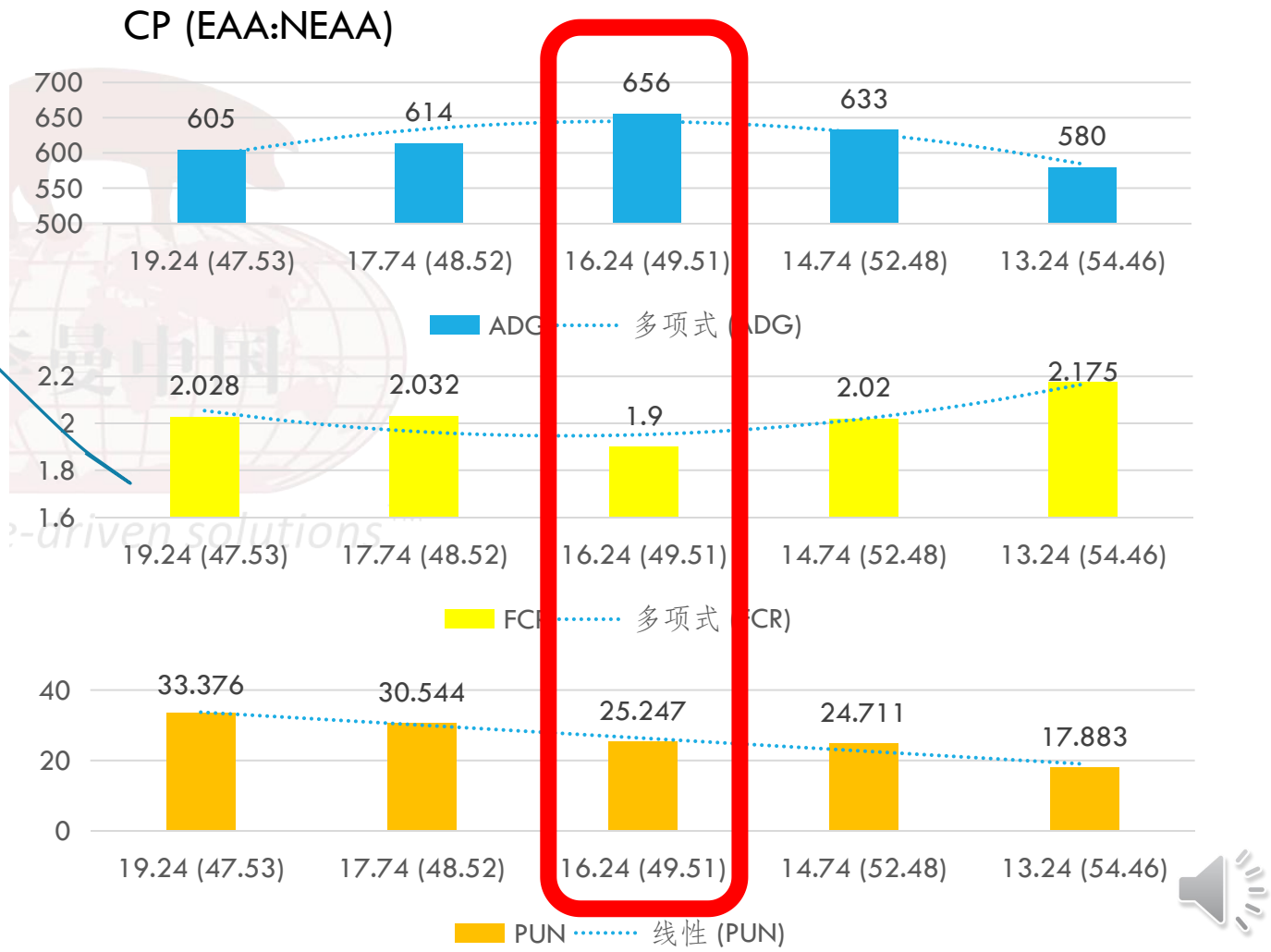


Figure 1- Daily gain of piglets of 15 to 30 kg fed low-protein diets supplemented with essential synthetic amino acids.



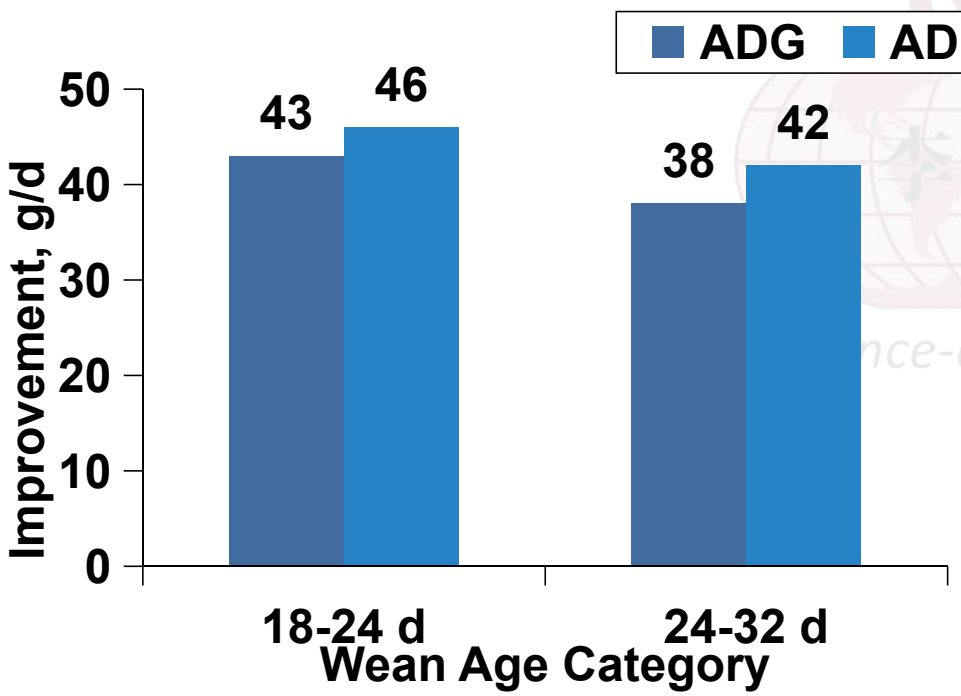
Diets formulated to all 10 essential amino acids.

Trial diets contained antibiotics.

Pigs were individually housed in research setting.

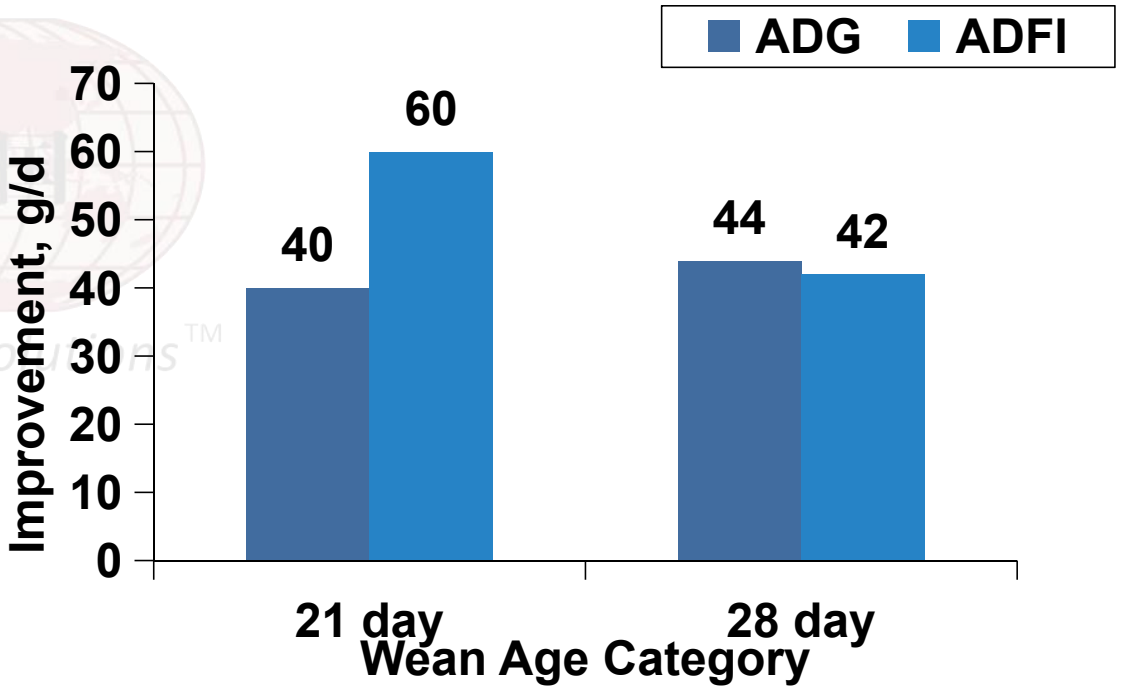
PLASMA PROTEIN ENHANCES NURSERY PERFORMANCE

Meta-analysis of growth performance improvements in nursery pigs in the first 14 days post weaning



(Torrallardona, 2010)

Meta-analysis of growth performance improvements in nursery pigs in the first 14 days post weaning



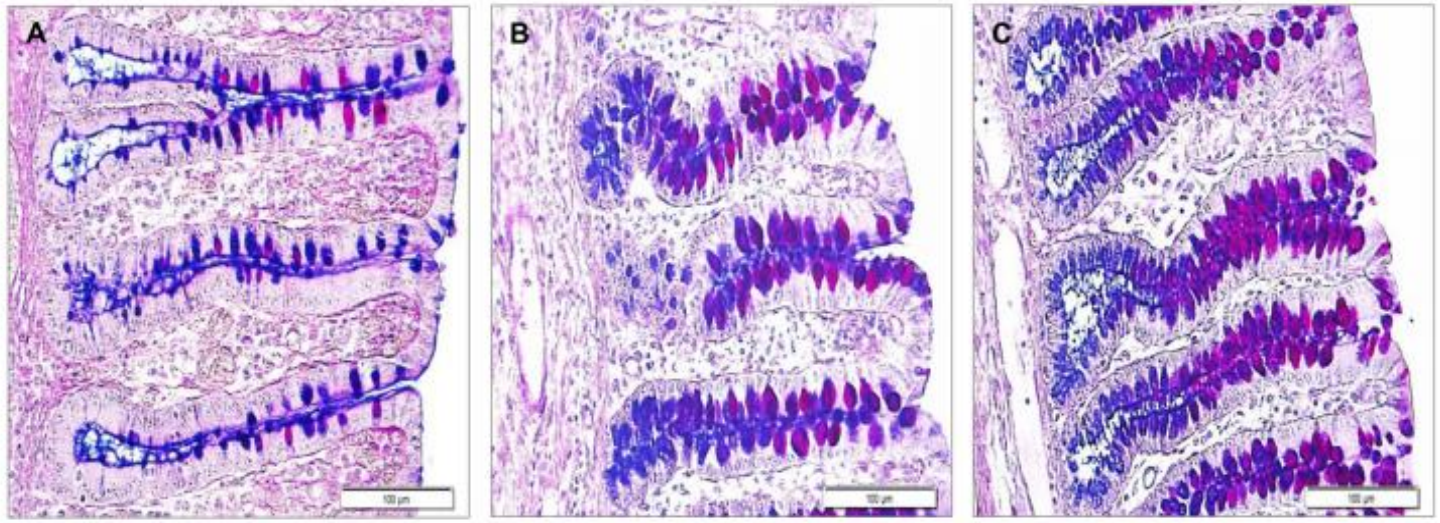
(Balan, 2020)

INFLUENCE OF ZINC ON MUCIN DISTRIBUTION IN COLON OF NEWLY WEANED PIGS

Zinc from raw materials only 57ppm

Zinc from raw materials & premix 164ppm

3kg of added ZnO



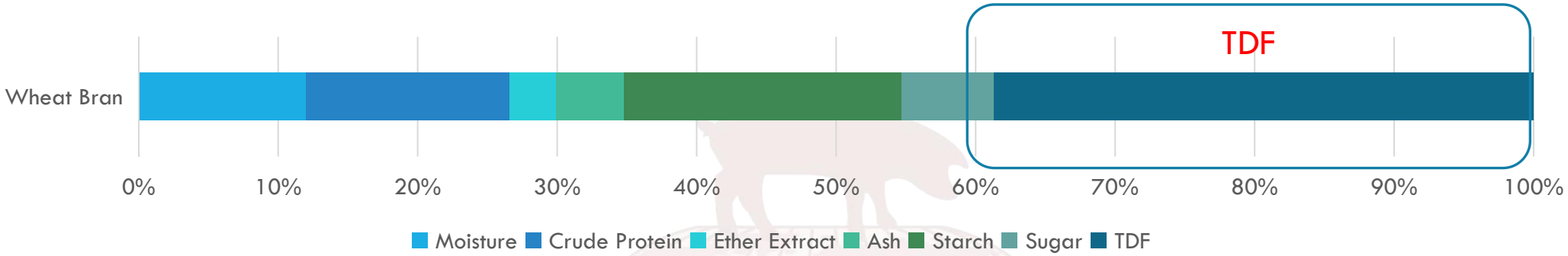
Nutrition strategies in the nursery must aim to protect and maintain the mucous layer.

Stimulating feed intake is the best way to maintain gut integrity.

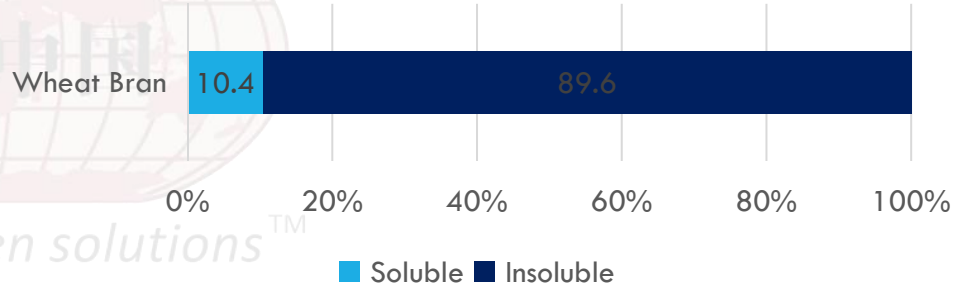
Use of plasma protein in Nursery diets has similar positive effect of the gut integrity and mucin layer.

Figure 1. Alcian blue (pH 2.5)-periodic acid Schiff stained section in the ascending colon of weaned piglets. Mucin distribution and characteristics with three concentrations of dietary zinc treatments on 33 days of age in piglets. **A.** Low dietary zinc treatment (57 mg/kg zinc); **B.** Medium dietary zinc treatment (164 mg/kg zinc); **C.** High dietary zinc treatment (2425 mg/kg zinc), magnification X160. Neutral mucins (magenta) were found to be spread over the epithelial surface and the upper crypt, while acidic mucins (blue) dominated in the lower crypt area of the colon. The mixture of neutral-acidic mucins (magenta-purple or blue-purple colors) were mainly found along the crypt.
doi:10.1371/journal.pone.0091091.g001

AN EXAMPLE
WHEAT BRAN – NUTRIENT & FIBRE PROFILE

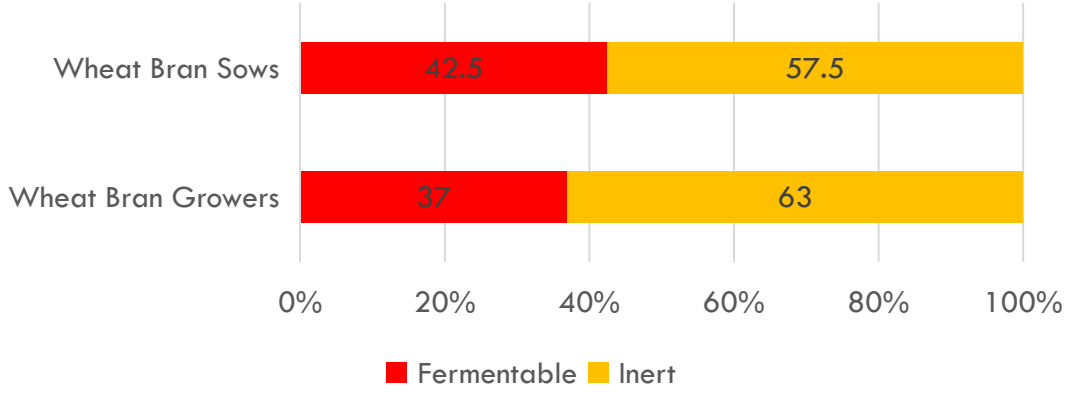


We need to have formulation strategies that allow us to understand the functional value of fibre within our ingredients.



Soluble fibre highlights fibre which is rapidly fermented.

Fermentable fibre shows us a clearly picture of the functional value of the fibre.



Inert fibre is important to understand for transit rate of digests and constipation prevention etc.

INFLUENCE OF NDF IN PIGLET DIETS (NEPOMUCENO ET AL., 2016)

Table 2: Average daily feed intake (ADFI), average daily gain (ADG), feed conversion ratio (FCR) and average occurrence of diarrhoea transf
neutral detergent fibre.

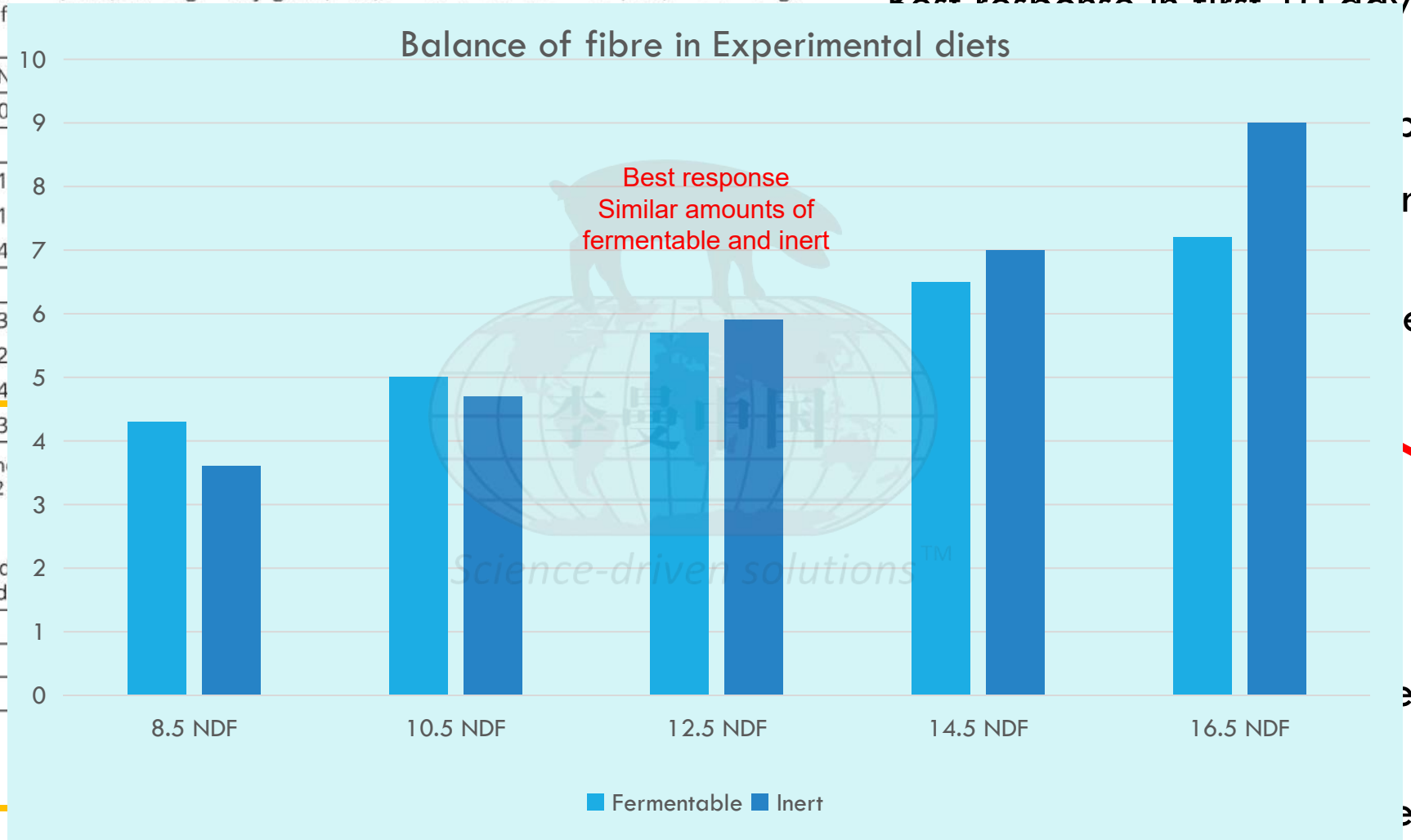
Variables	N 8.5	10
ADFI (kg)	0.174	0.1
ADG (kg)	0.125	0.1
FCR (kg/kg)	1.470	1.4
ADFI (kg)	0.309	0.3
ADG (kg)	0.208	0.2
FCR (kg/kg)	1.487	1.4
AODT	2.508	2.3

CV – Coefficient of variation; NS – n
and R^2 0.96; $^3y = -0.0979x + 3.3402$

Table 7: Average weight of the c
days of age fed with diets with d

Digestive organs	8.5							
Liver	3.35							
Pancreas	0.25							
Stomach	0.75							
Small intestine	5.00							
Caecum and colon	1.64	1.61	1.70	1.79	1.94	16.23	Linear2	0.0283
Rectum	0.447	0.463	0.421	0.455	0.397	21.37	NS	0.6115

CV – Coefficient of variation; NS – not significant; $^1y = 0.0091x + 0.7225$ and R^2 0.86; $^2y = 0.0144x + 1.5135$ and R^2 0.84.



Best response in first 10 days after

performance

ntrol

e

e stomach

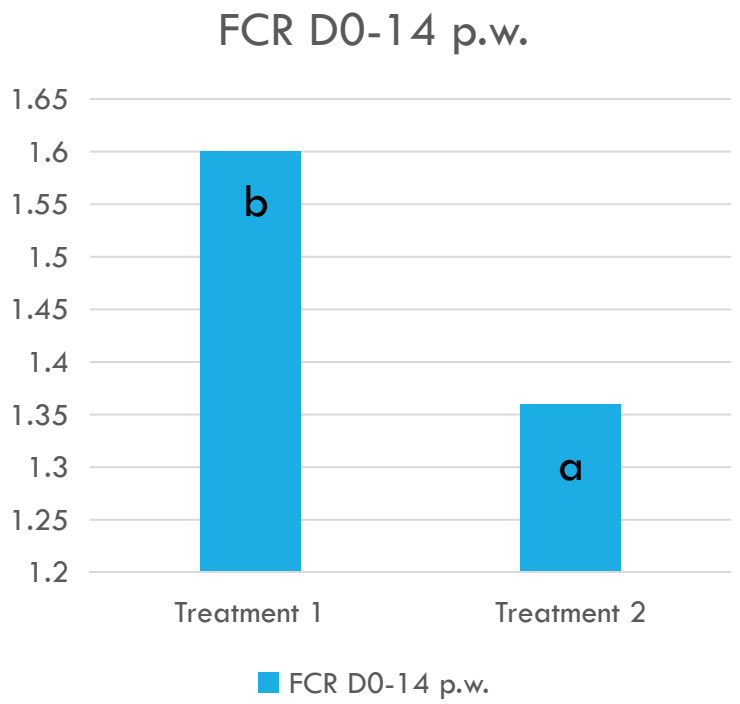
e the caecum and colon capacity (fermentation potential)

INERT FIBRE TO BOOST STOMACH FUNCTIONALITY

Kratz et al., 2022
Danish study conducted in commercial farm.
Hyperprolific sows >40 piglet/sow/year.
Corn, barley, soy protein concentrate based diets.
Treatment applied in farrowing house only from D5 to D21
Estimated feed intake of 366gm/pig prior to weaning

Treatment 1 used soy hulls as fibre source
Treatment 2 used combination of Eubiotic lignoncellulose & soy hulls

	Treatment 1	Treatment 2
Total dietary fibre %	9.5	10.2
Inert fibre %	2.5	5.0
Fermentable fibre %	7.0	5.2

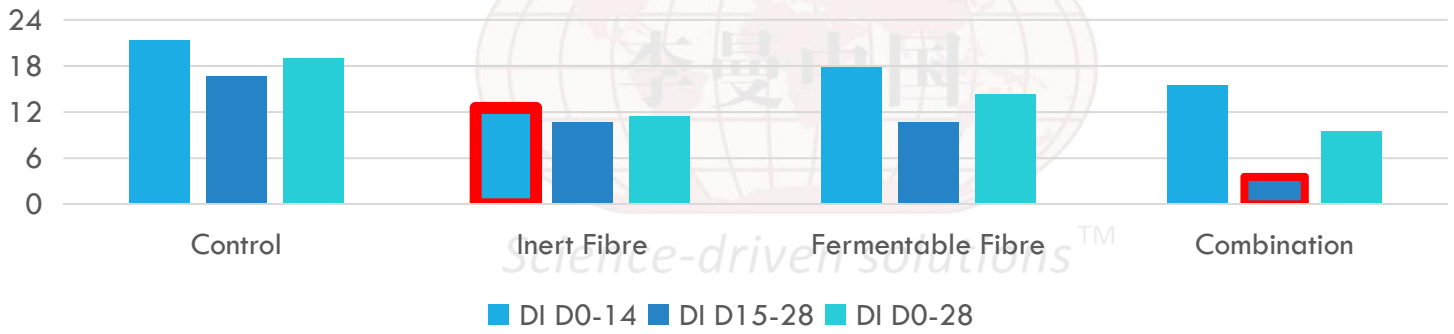


COMPARING FIBRE STRATEGIES IN THE NURSERY

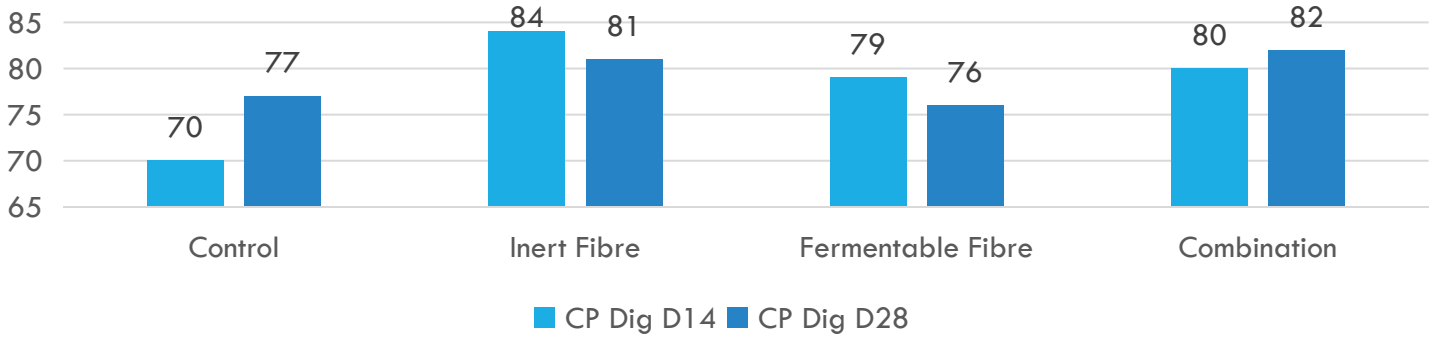
Fibre profiles of experimental diets

	Control	Inert fibre	Fermentable fibre	Combination
Total dietary fibre	10.8	11.7	11.7	11.75
Inert fibre	4.6	5.5	4.6	5.05
Fermentable fibre	6.2	6.2	7.1	6.7

Diarrhoea incidence %



ATTD CP %



Chen et al., 2020

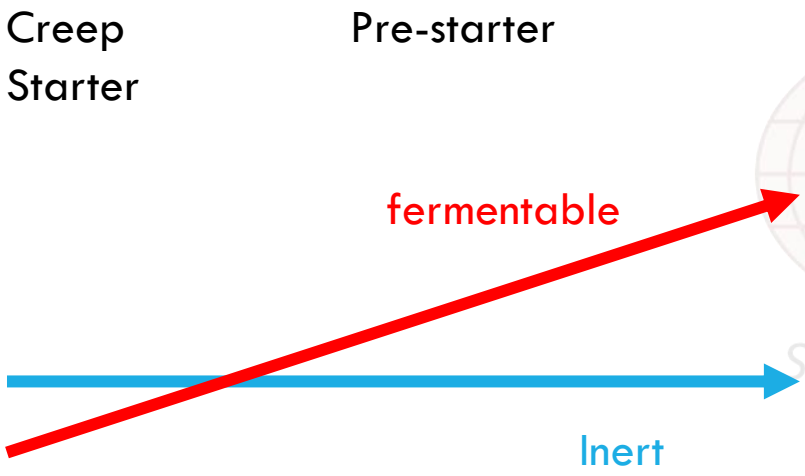
Adequate inert fibre in phase 1 reduced diarrhoea.

Adequate and balanced inert and fermentable fibre in phase 2 reduce diarrhoea.

Increasing TDF and inert fibre improves protein digestibility.

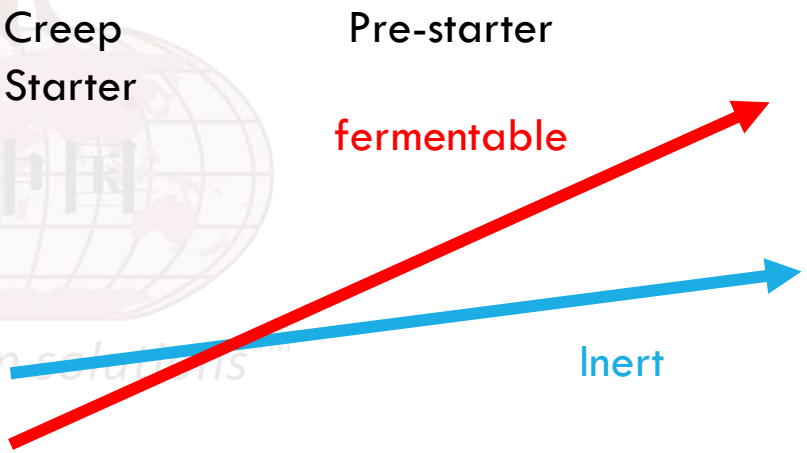
FIBRE PATTERNS IN THE NURSERY

Low fibre market strategy



Fermentable fibre must be gradually introduced to allow the microbiome to adapt this this substrate. Avoiding high amounts of rapidly soluble/fermentable fibre in young piglet diets is advised.

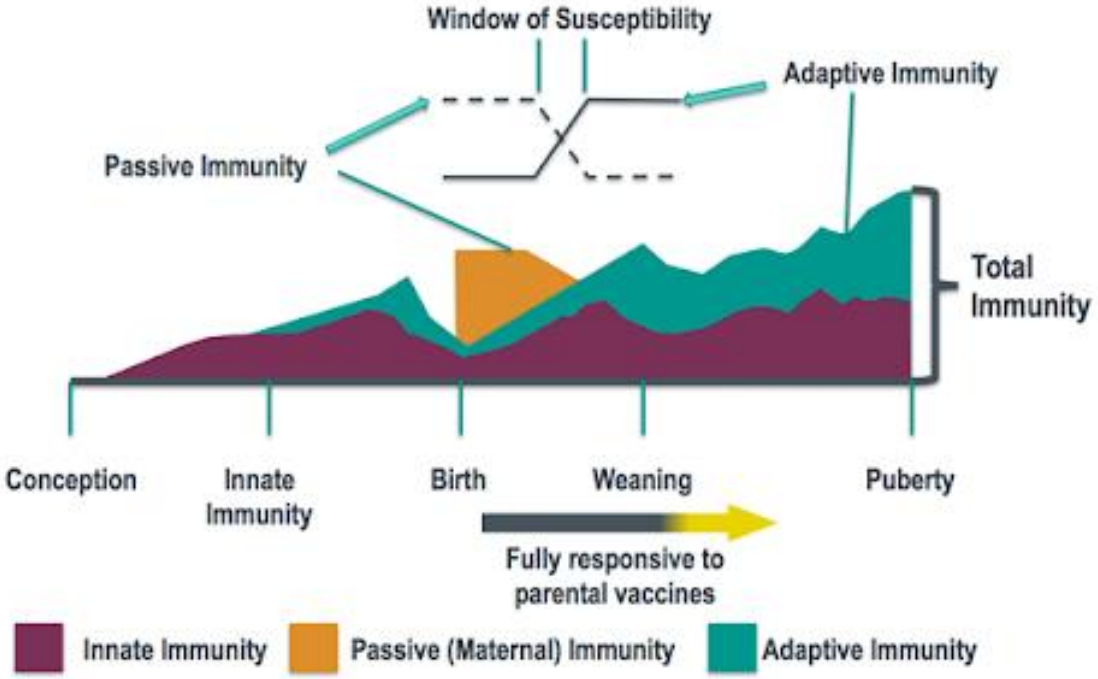
High fibre market strategy



Inert fibre should be used as a functional tool to aid in stabilising the digesta transit rate (avoid constipation and diarrohea) as well as stimulate the development and capacity of the gastrointestinal tract for later stages.

PROVIDING PASSIVE IMMUNE PROTECTION

- Plasma proteins, colostrum, egg antibodies, anti-microbial peptides
  - Glyco-proteins, immunoglobulins
  - Antibodies
  - Cytokine regulation
  - Hormones??
- Medium chain fatty acids
  - Anti-bacterial (gram –ve, gram +ve)
  - Neutrophil viability
  - Accumulate in the Peyers Patches (similar to antibiotics)
  - Boost innate immune response to bacterial infection and/or inflammation (van Meenen 2011)
- Short chain organic acids, phytogenics, mannans
  - Antibacterial effect
- Beta-glucans
  - Prime immune system
  - Improve humoral immunity
  - Modulate cellular immunity
  - Regulate inflammatory cytokines
- Live Yeast, Probiotics
  - Improved immunological parameters observed in weaner pigs fed live yeast (high dose) during an E.coli challenge (Xu et al., 2016).

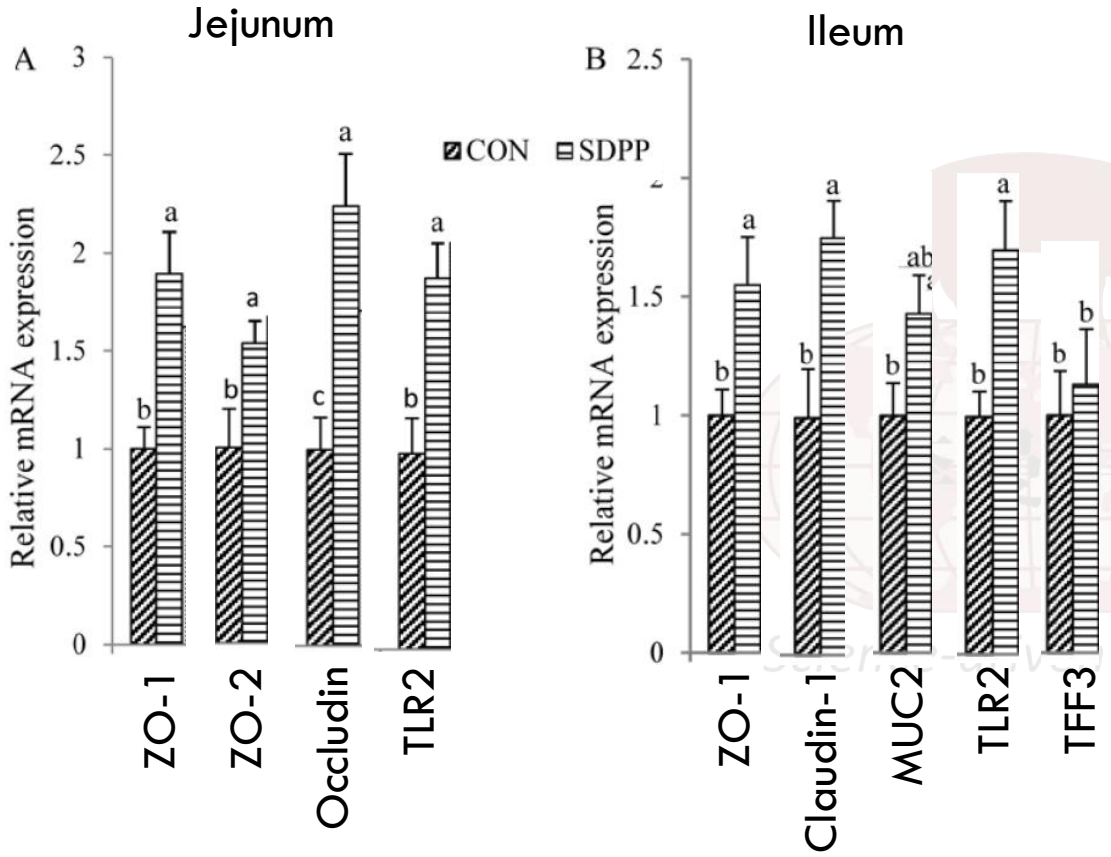


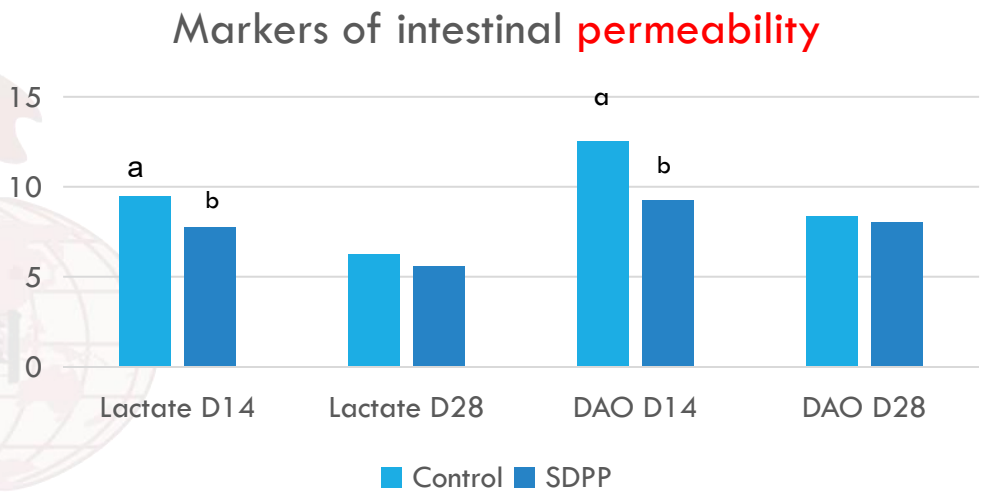
http://www.circumvent-g2.com/immunology.aspx

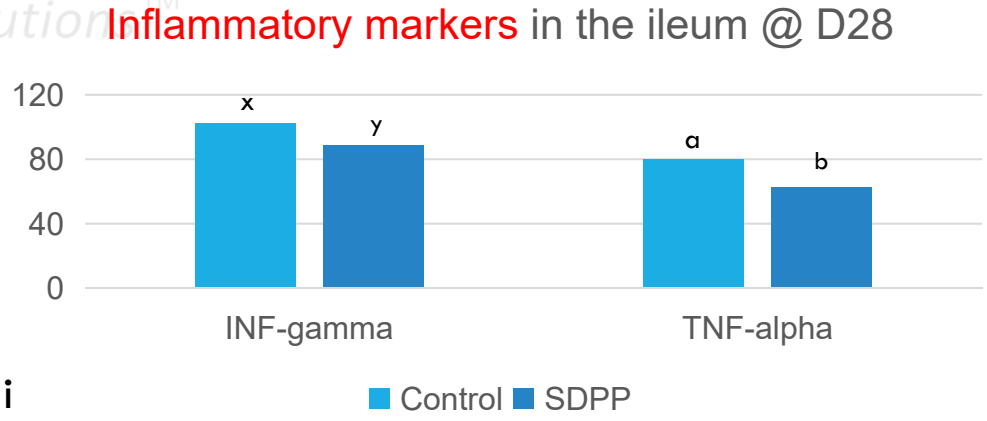
PLASMA ENHANCES BARRIER INTEGRITY AND REDUCES INFLAMMATION

(Zhang et al., 2016)

5% SDPP for 28 days

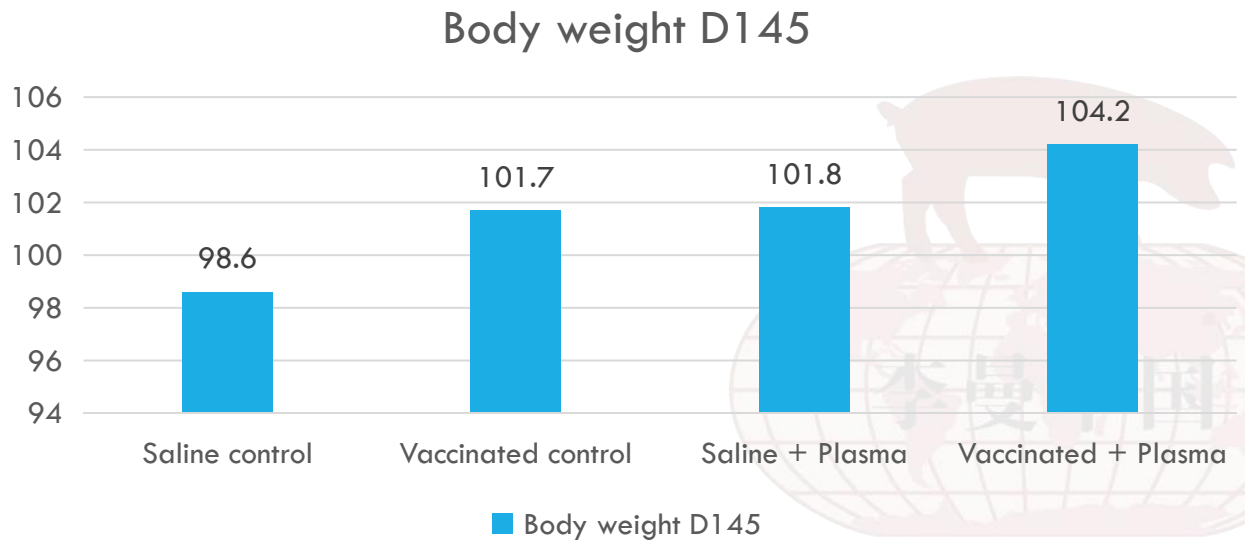






ZO-1, ZO-2, Occludin = Tight junction proteins
MUC2 = Indicator of globlet cell secretion and gut protection
TLR2 = Receptor for recognition of bacteria, virus, parasites & fungi
TFF3 = Secretory protein involved in protection, stabilisation, healing

PLASMA AS A TOOL TO ENHANCE HEALTH



Published studies show feeding plasma can provide both direct health benefits and indirect health benefits (e.g. improve microbiome, boost vaccine efficacy etc.)

- E.coli
- PEDV
- PCV2
- ASF

	Saline control	Vaccinated control	Saline + Plasma	Vaccinated + plasma
Pigs in study (n)	91	91	91	90
Mortality %	9.95b	11.06b	4.44a	4.37a
Kg of slaughter weight	8085.2	8237.7	8856.6	8961.2
Extra kilograms		152.5	771.4	876.0
Cost of vaccination	$0.00	$91.00	$0.00	$90.00
Cost of plasma	$0.00	$0.00	$59.00	$67.50

Plasma had a pronounced effect on mortality rate in growing pigs. Main cause of mortality was bacterial infections.

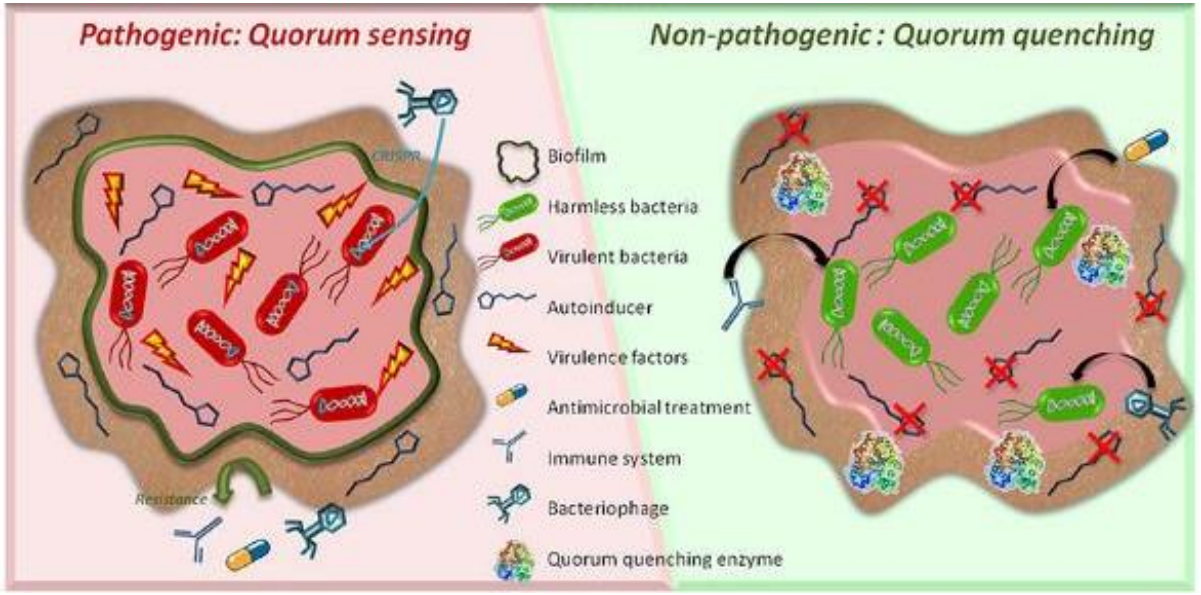
Pujols et al 2016, Duffy et al 2018, Moreto et al 2020, Monferdini et al 2017, APC 2022

MICROBIOME MODULATION

A lot of tools available to us

- Probiotics
  - Live yeast
  - Sporulating bacterial probiotics
- Post-biotics
  - Yeast & bacterial origins
- Prebiotics
  - Resistant starch
  - Inulin
  - FOS, MOS, GOS etc
  - Ingredient derived sources
- Short chain and medium chain fatty acids
- Functional proteins
  - Colostrum, egg antibodies, plasma protein etc
- Antimicrobial peptides *(Wang et al., 2016)*
  - *Lactoferrin, AMP A3 & AMP P5 etc*
- Phytogenic
  - Quorum sensing disruption

Quorum Quenching

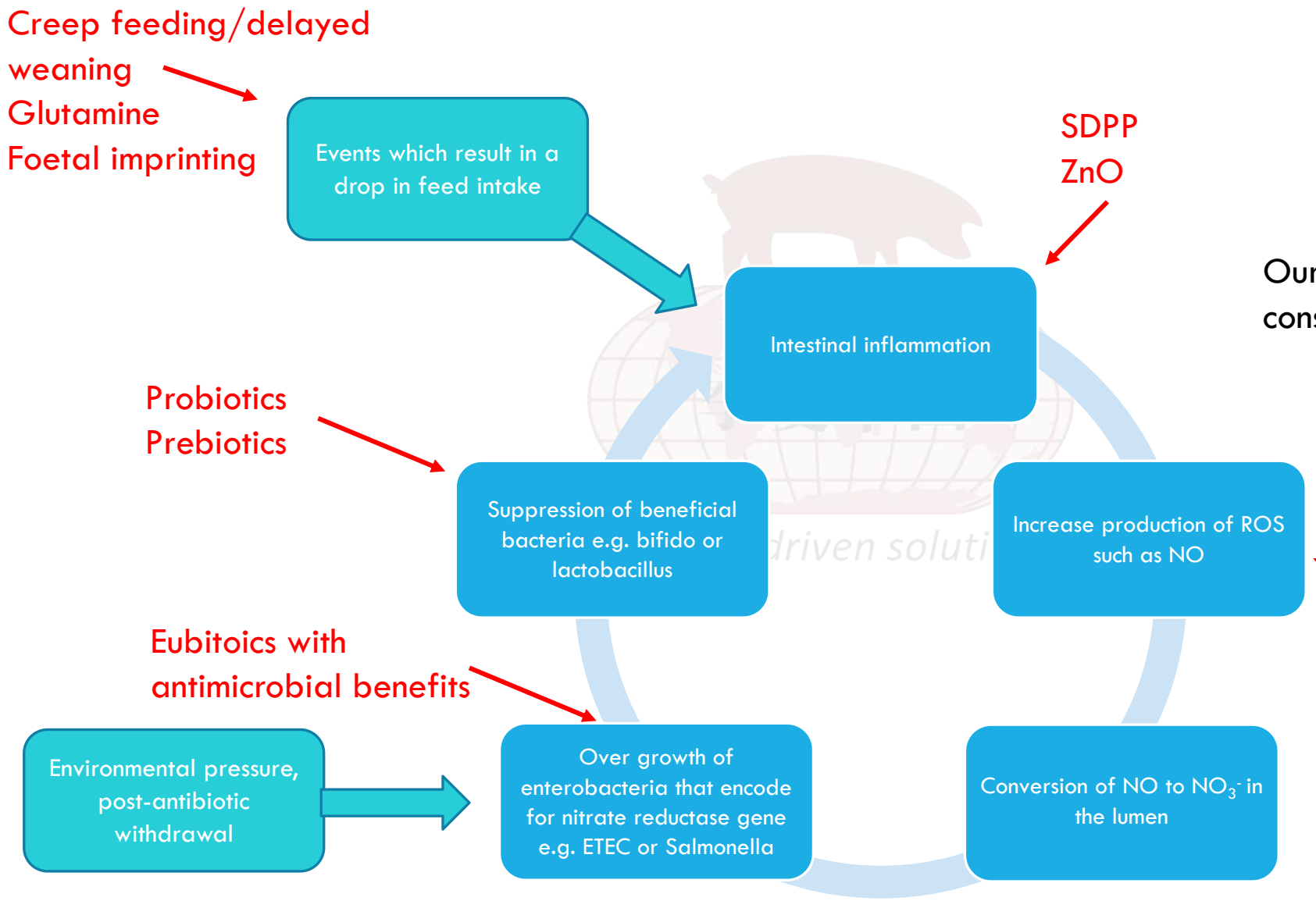


MOA (Rossi et al., 2020)

Inhibit bacterial bio-film formation

Inhibit bacterial virulence factors

INTESTINAL INFLAMMATION & MICROBIOTA SHIFTS



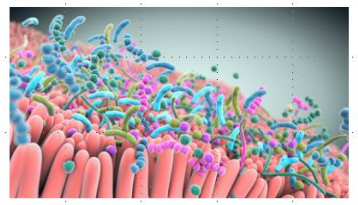
Our nutritional approach must consider options to break this cycle.

(Guevarra et al 2019)

NUTRITION MUST DELIVERS LONG TERM BENEFIT

- Boosts feed intake
  - Helping to maintain the gut structure and function
- Passive immunity
  - Avoids excessive wastage of nutrients through over reaction of the immune system
  - Allows for less interruption during immune development
- Hindgut stabilisation
  - Colon function is a key driver of health
  - Avoid gut dysbiosis events whilst beneficial microflora establish to drive
    - Balance undigested protein and fibre fermentation
      - Maintain favourable pH
      - Maintain tight junctions
      - Maintain microbial diversity

WHAT ARE YOU FEEDING??



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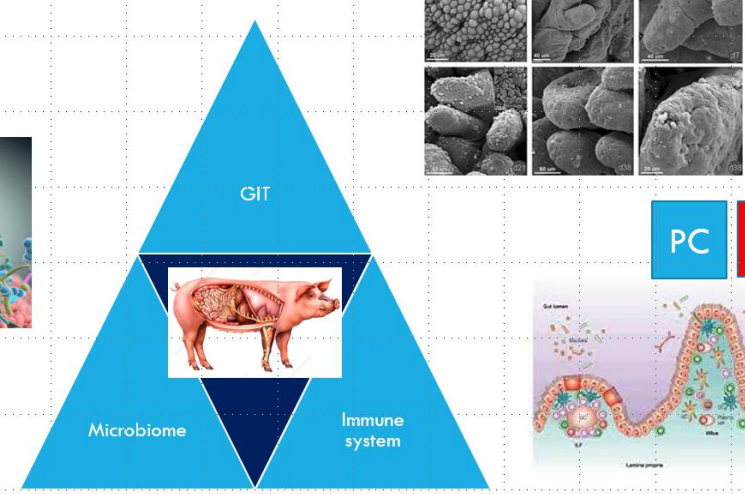

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THANK YOU FOR LISTENING

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