Schothorst Feed Research

How feed composition can contribute to reduce antibiotic use ?

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Schothorst Feed Research

Independent research and consultancy institute in The Netherlands (located in Lelystad)

- ❑ Contract research:
  - Feed companies
  - Feed additive suppliers

- ❑ Consultancy in animal nutrition
  - Feed companies
  - Integrators

Contents

- ❑ Introduction: animal feeds without AGPs
- ❑ Consequences for feed formulation: fat – fiber - protein
- ❑ Piglet feeding during transition period
- ❑ A piglet is an immature pig!
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- ❑ Conclusions

Introduction:

Animal feeds without AGPs

History: antimicrobials in animal nutrition

- Distinguish therapeutic use and use as AGP
- Use as AGP started in the 1940's → "feed savers"

- Positive effect on production performance
- However: effect is often limited to feed efficiency

- Little or no effect in germ-free animals
- Therefore: intestinal microflora must play a role

Mode of action of AGPs

- Used in sub-therapeutic dosages

- Reduction in overall number and/or bacterial species in the gut
  - Reduction in potential pathogens
  - Reduction in harmful metabolites that depress growth
  - Reduction competition with host for nutrients
  - Reducing metabolic costs of the immune system

- Indirect effects:
  - Thinner gut wall and lower endogenous losses

Problems associated with the use of antibiotics in animal feed has led to AGP ban in the EU

- **Food safety**: antibiotic residues

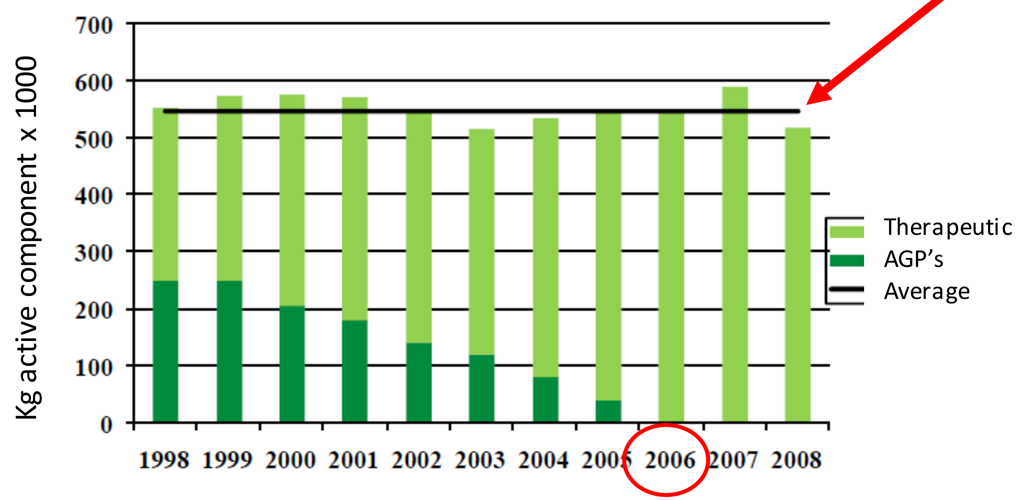
- **Public health**: development of resistant bacteria

  Resistance = ability of bacteria to survive exposure to antibiotics

- Resistance is not a "new" issue; already recognized in 1950's!

In the Netherlands

- ❑ Since 1998 gradual decline in use of AGPs, but **increased therapeutic use!**
- ❑ Total amount antibiotics (kg) used was not changed



Source: FIDIN, 2009

Use of antibiotics in NL

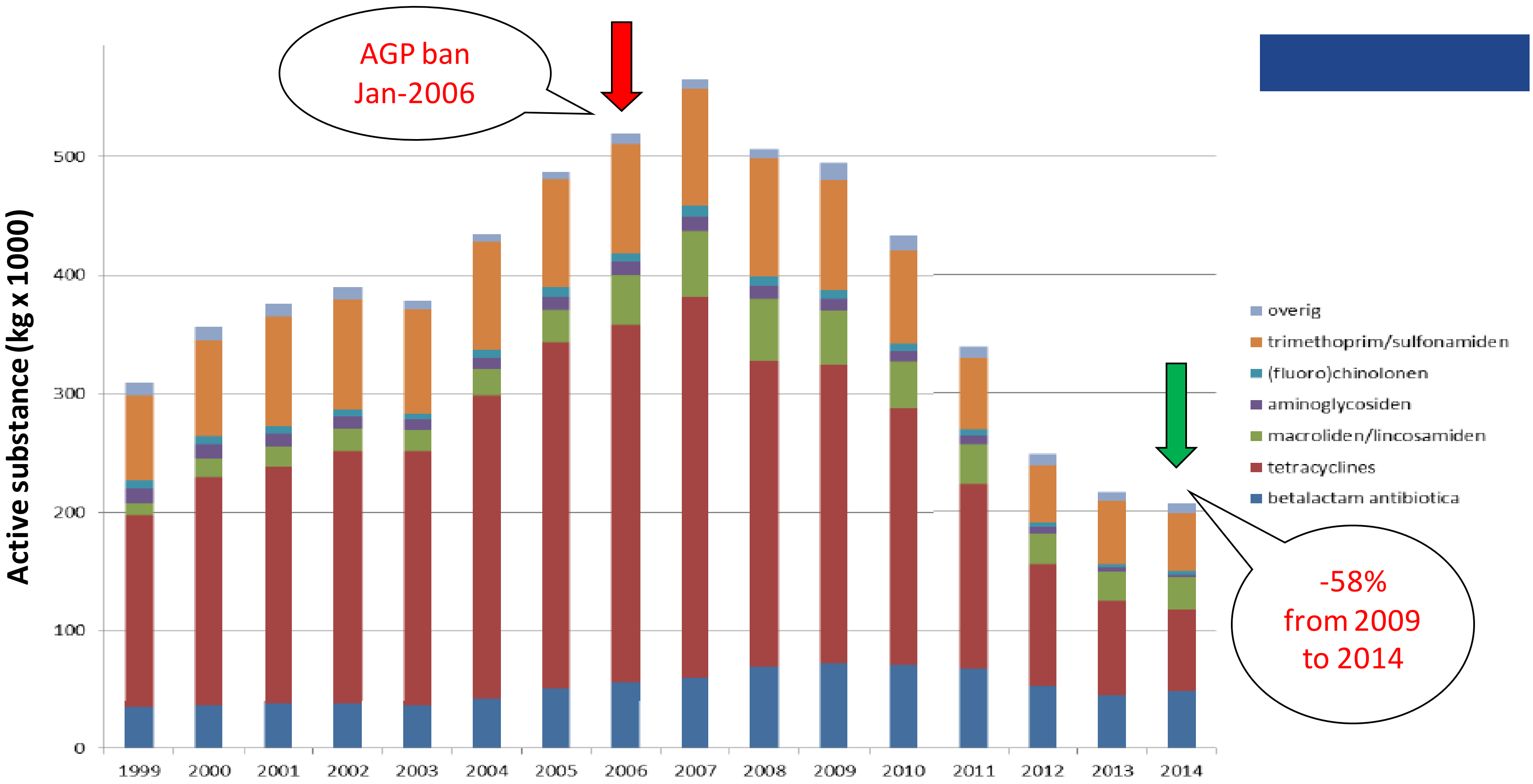
- Prior to 2008, the Netherlands was amongst the most important consumer of antibiotics in the animal sector

- Public debate on increasing antimicrobial resistance

- Covenant between government, agricultural industry, veterinarians, and farmers: reduction of total veterinary antibiotic use: **- 20% in 2011 to - 50% in 2013 and - 70% in 2015** (2009 as a reference)

- Actions include:
  - registration on farm level
  - based on kg active components, instead of total sales
  - benchmarking indicators

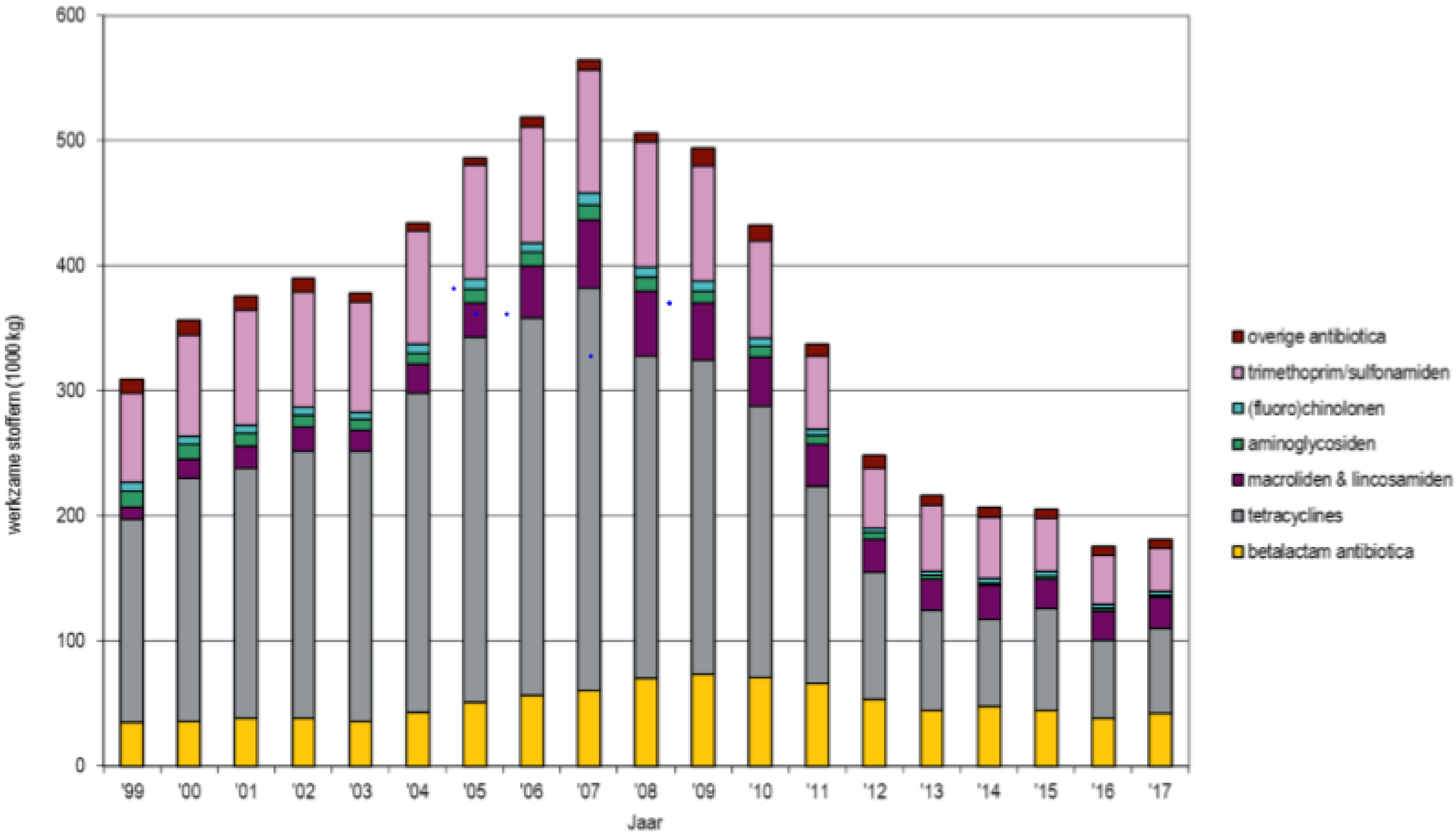
Therapeutic antibiotic usage in NL increased prior to the AGP ban and decreased since 2007



Total reduction mainly due to reduction in tetracyclines

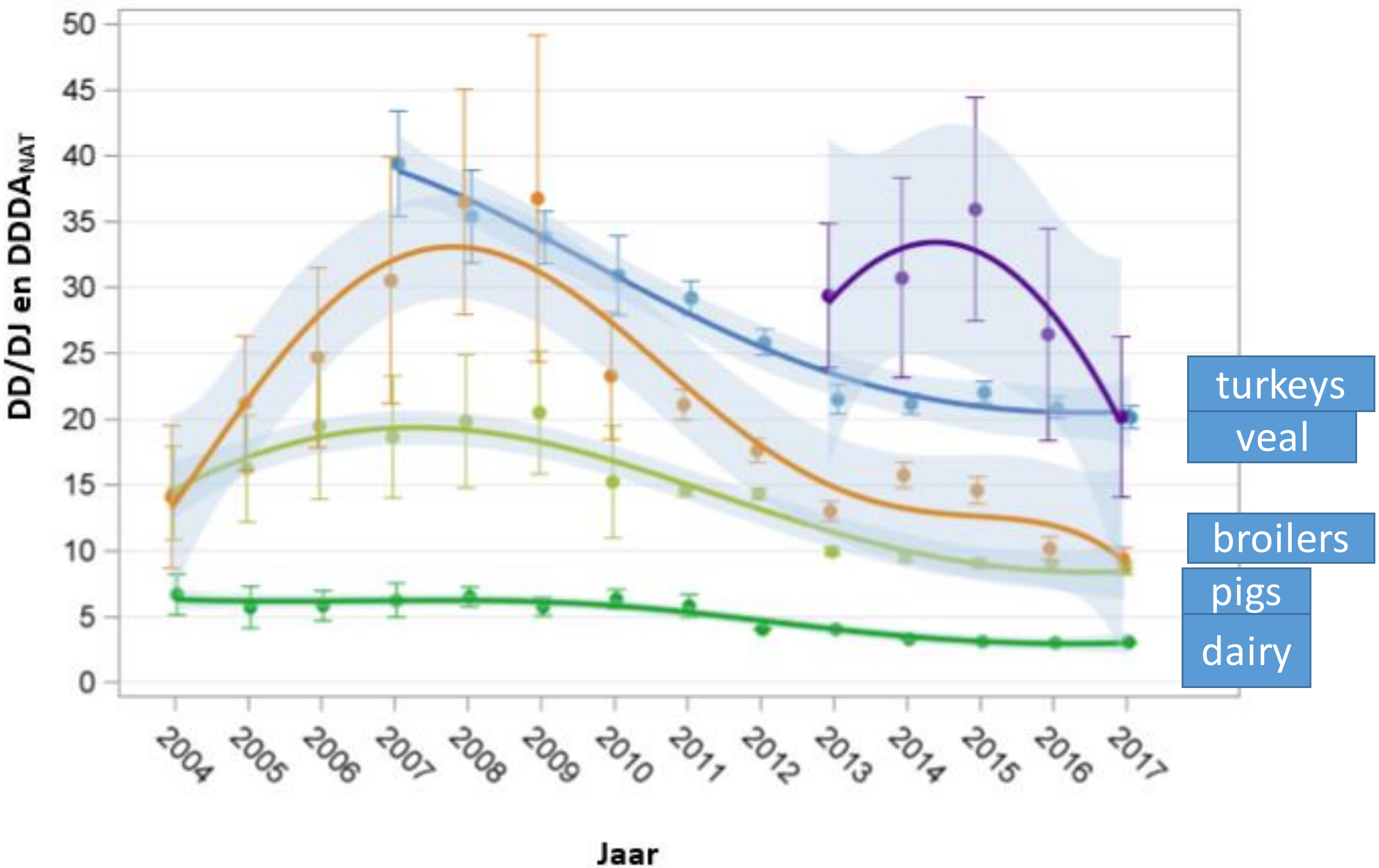
Source: FIDIN, 2015

Sales of antibiotics in the Netherlands seem to stabilize more and less



Source: FIDIN, 2018

Trends in antibiotic use in different species



Source: Sda report, 2018

Potential measures taken to minimize the effects caused by the ban of the AGPs (1)

❑ Nutrition

- Nutrient quality and level

  (protein, fat, fiber, …)
- Feed additives

  (organic acids, enzymes, MCFAs, pre- and probiotics, essential oils, anti-inflammatory compounds, antioxidants, …)
- Water quality

Potential measures taken to minimize the effects caused by the ban of the AGPs (2)

- **Management**
  - Hygiene (cleaning, disinfection)
  - Stocking density
  - Climate (temperature, relative humidity)
  - Lighting schedule
  - Feed intake pattern
  - Vaccine plan

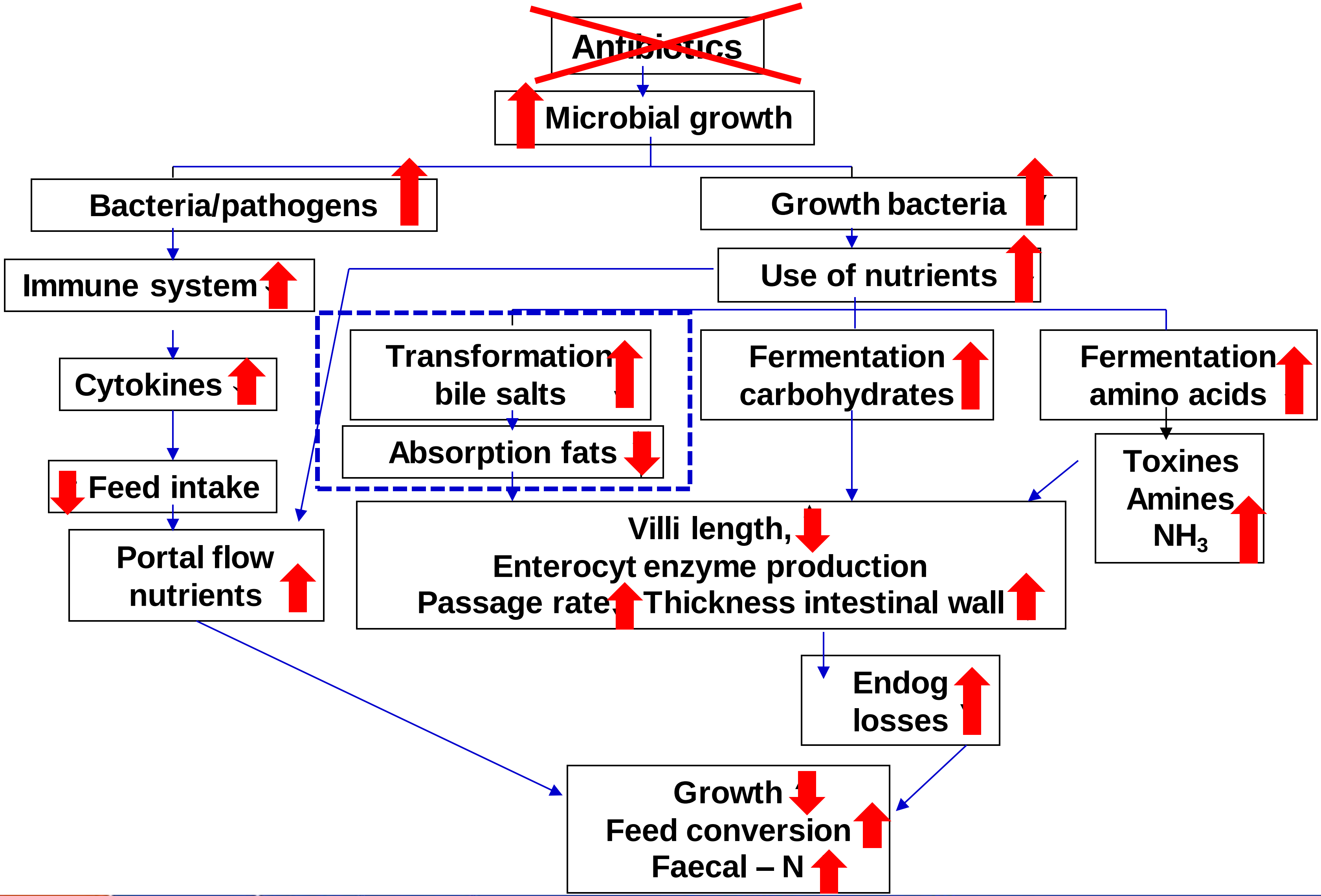
Potential measures taken to minimize the effects caused by the ban of the AGP’s (3)

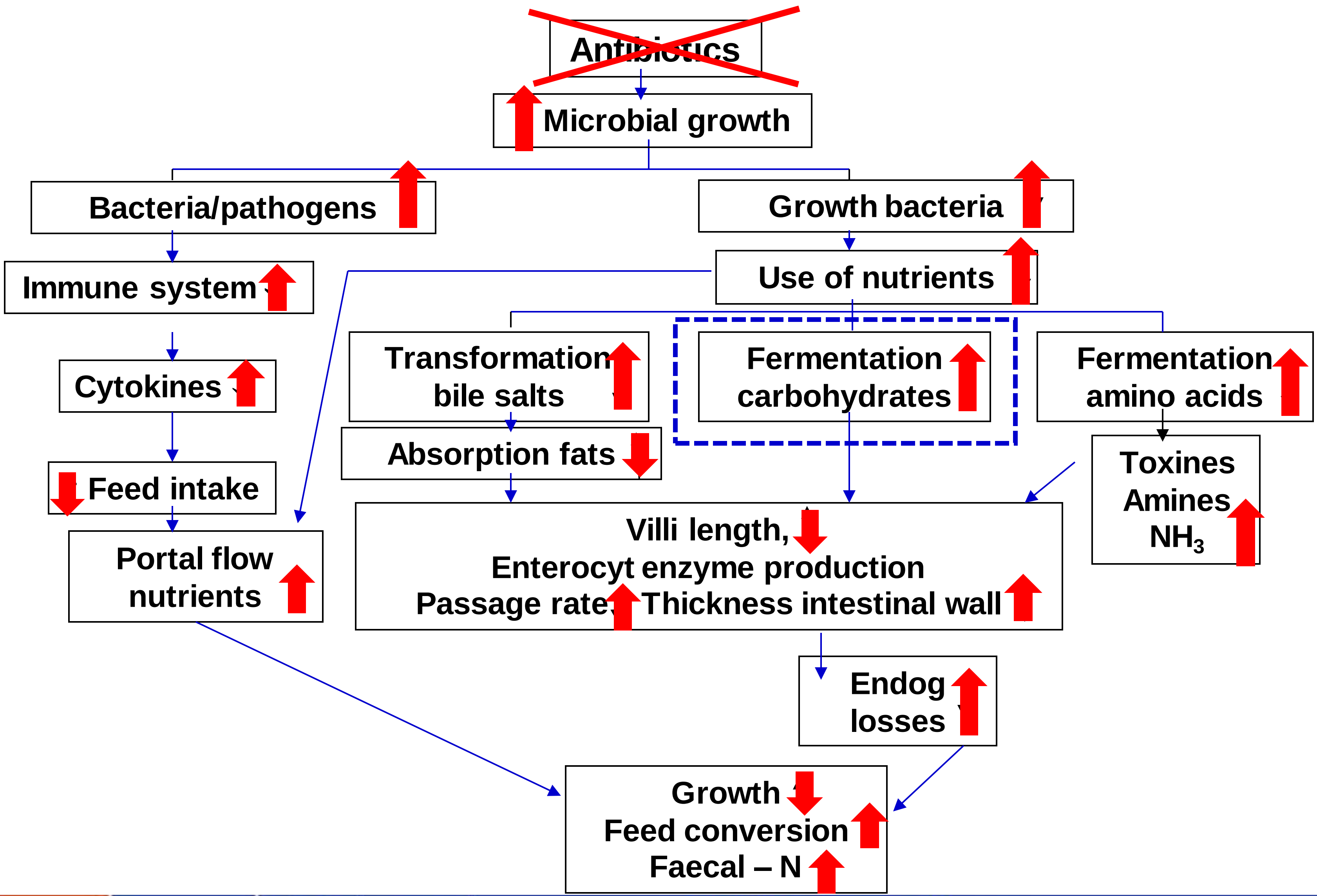
- ❑ **Bio-security**

- Limit access to visitors, feed suppliers etc.
  - Showering in and out, on farm clothing, boots etc.
  - Separate ‘clean’ and ‘dirty’ access roads
  - Prevent rodents and pets on the farm

- Prevent mingling of animals
  - All in All out, followed by cleaning and disinfecting
  - Limit cross fostering

Consequences for feed formulation:
fat – fiber - protein


Antibiotics
Microbial growth
Bacteria/pathogens
Growth bacteria
Immune system
Use of nutrients
Cytokines
Transformation bile salts
Fermentation carbohydrates
Fermentation amino acids
Absorption fats
Feed intake
Toxines
Amines
NH_3
Portal flow nutrients
Villi length,
Enterocyt enzyme production
Passage rate
Thickness intestinal wall
Endog losses
Growth
Feed conversion
Faecal – N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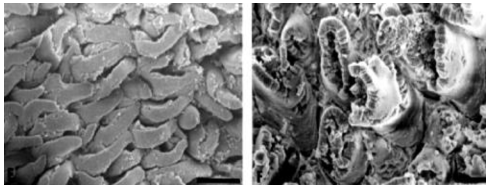
Why did fiber become an important issue?

Diet young animals

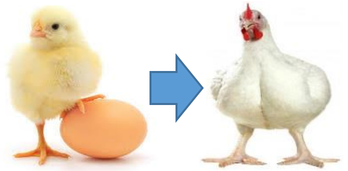
High quality ingredients
High nutrient digestibility
Low fiber
High feed intake

Reduce the incidence of enteric disorders

Might affect the **structure** of the mucosal epithelium



Compromise GIT function and nutrient utilization as the animal ages



Sources: González-Alvarado et al, 2008
Montagne et al, 2003

Fermentability of fiber sources

OAT HULLS
STRAW
WHEAT BRAN (WB)
RICE HULLS
SUNFLOWER HULLS

SOYBEAN HULLS

CITRUS PULP
OLIGOSACHARIDES
INULIN
SUGAR BEET PULP (SBP)
RESISTANT STARCH

STARCH

SUGARS

INERT FIBER ingredients

FERMENTABLE FIBER ingredients

Degree of lignification

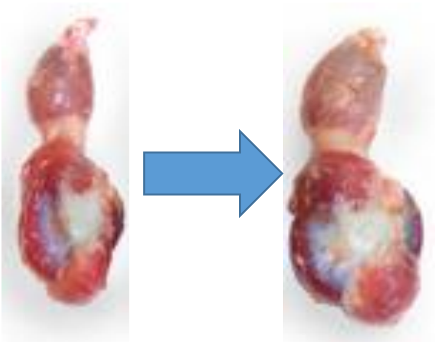
and

Solubility of NSP

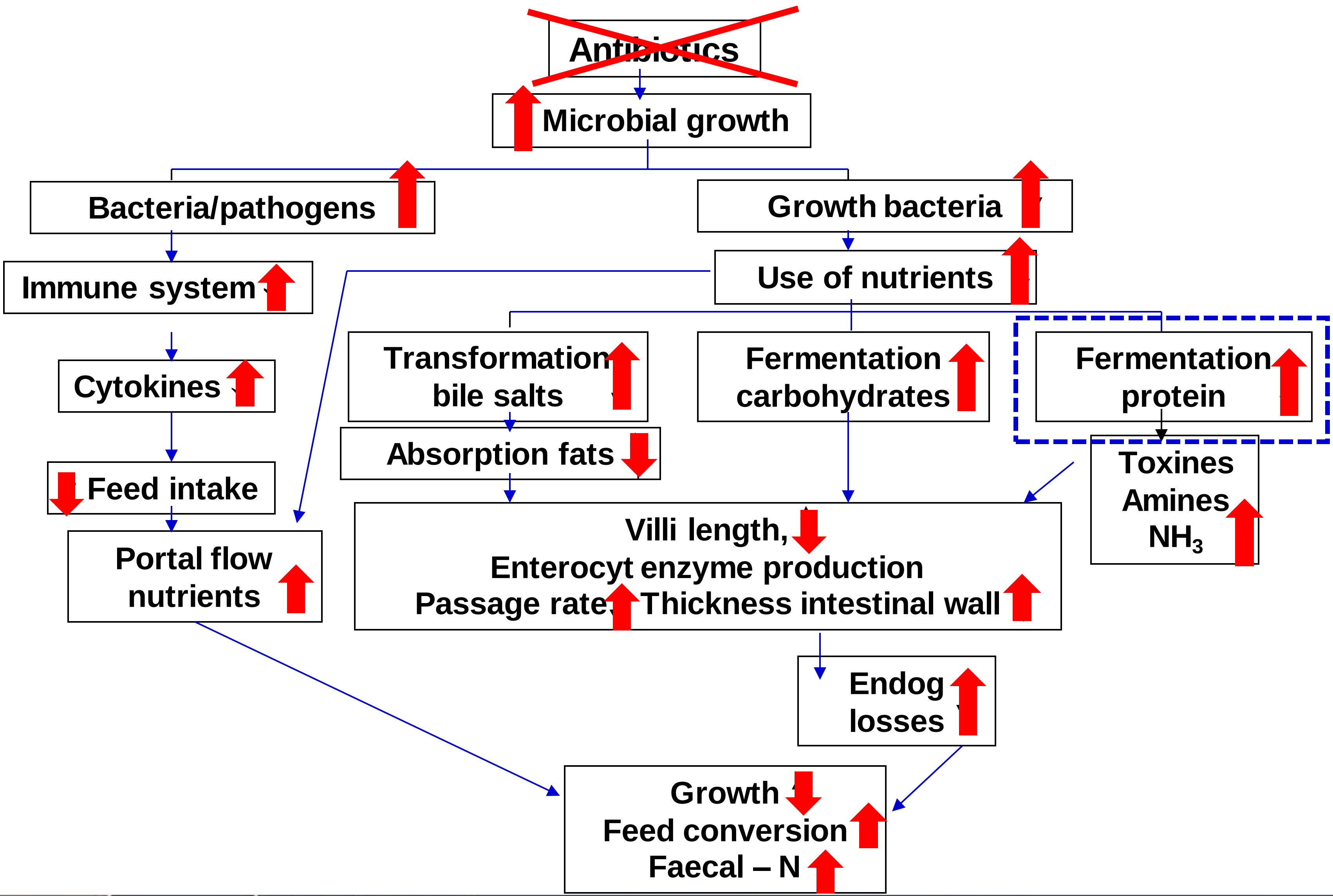
Digestible carbohydrates + Absorbable

Role of inert fiber

- Improve gastro-duodenal reflux of digesta
  - Increase grinding and mixing ➔ gizzard development
  - Reduce pH
  - Increase production pancreatic enzymes
  - Improve antibacterial effects
  - Better absorption of nutrients and water



- Shift from proteolytic to carbohydrolytic fermentation in the caeca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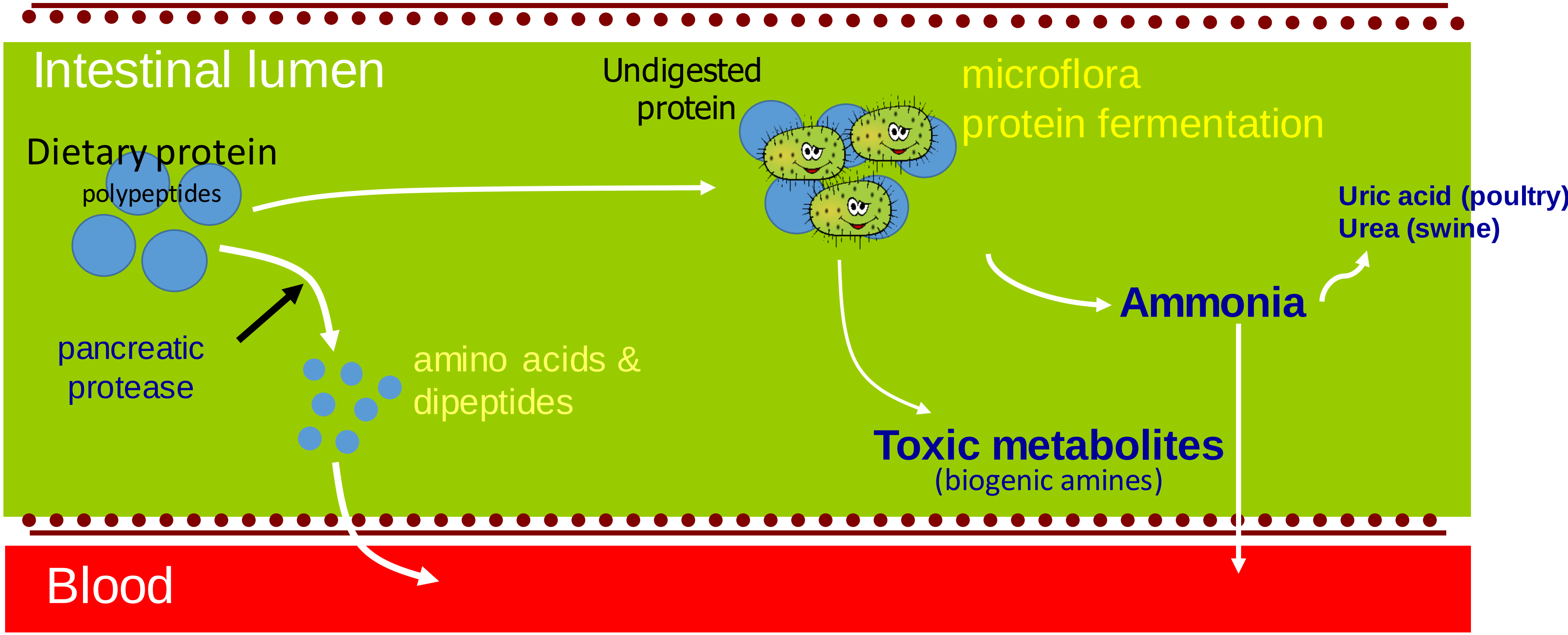
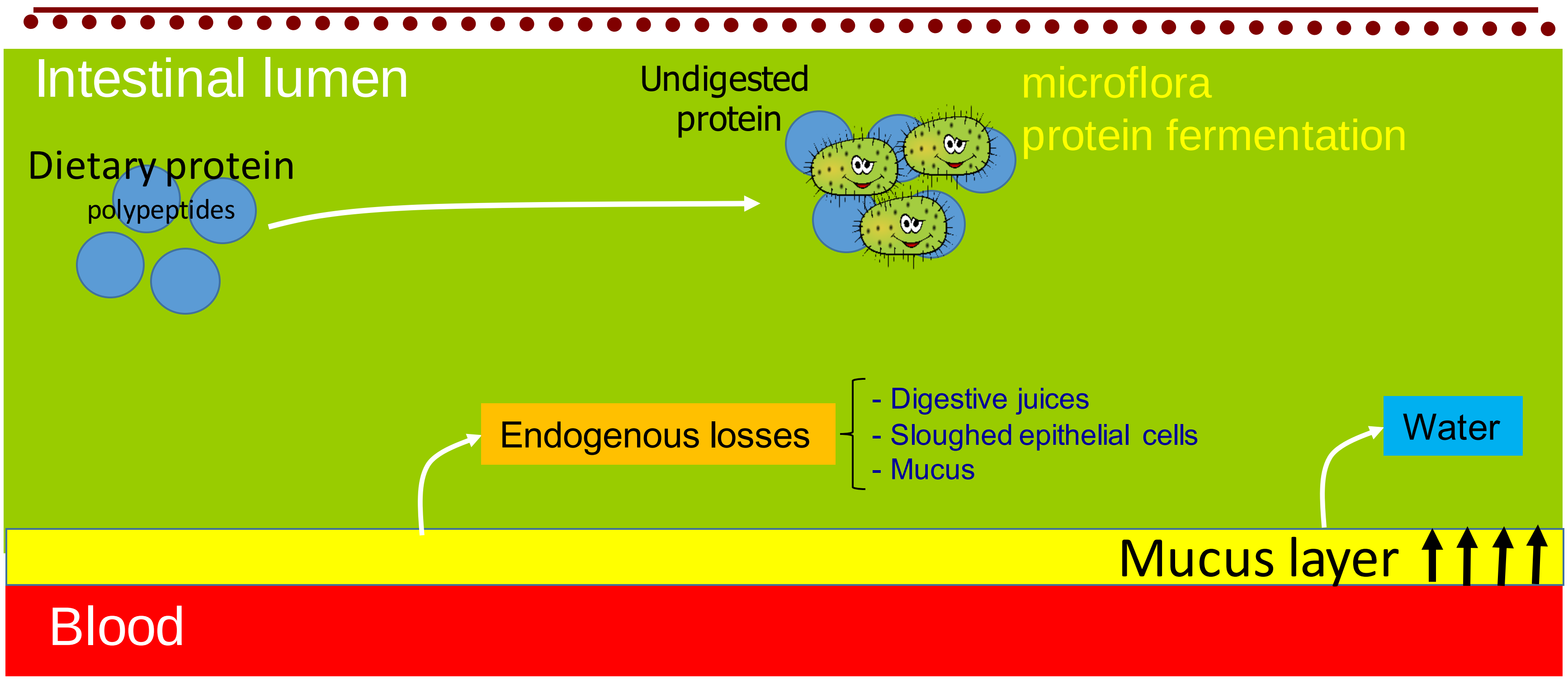
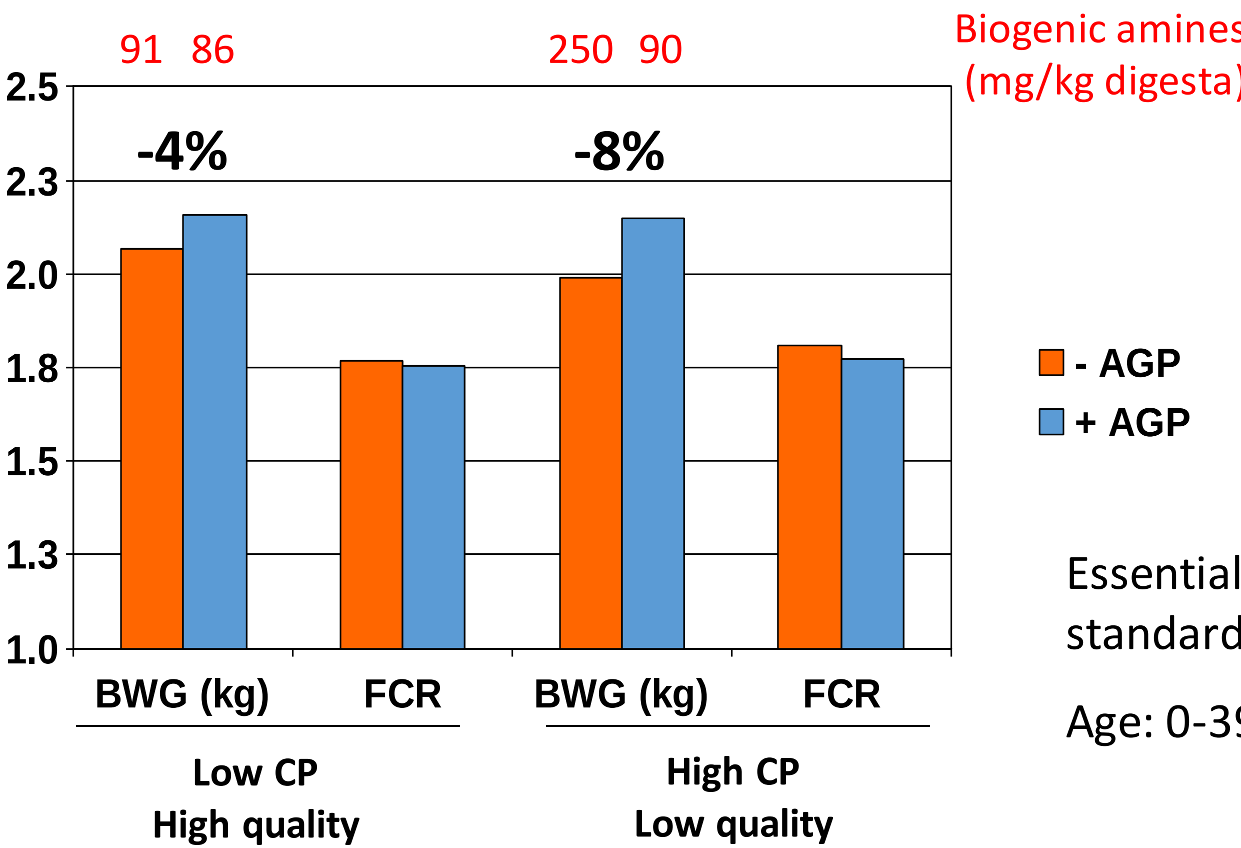
Protein digestion in small intestine



Protein digestion in small intestine



Effects of crude protein on performance with and without AGP in broiler diets



Essential d. AA standardized

Age: 0-39 days

- ❑ Same d.lys level in all diets
- ❑ Different protein sources (quality) → poor digestibility → higher CP level
- ❑ Diets with and without antibiotics

Source: SFR Internal report

Piglet feeding during transition period

In absence of in-feed AGP, higher risk of PWS?

INTENSIVE PRODUCTION

LACTATION

Day 21-28

PRODUCTIVE EFFICIENCY

WEANING

- New environment
- New diet
- Mixing with animals from different sows

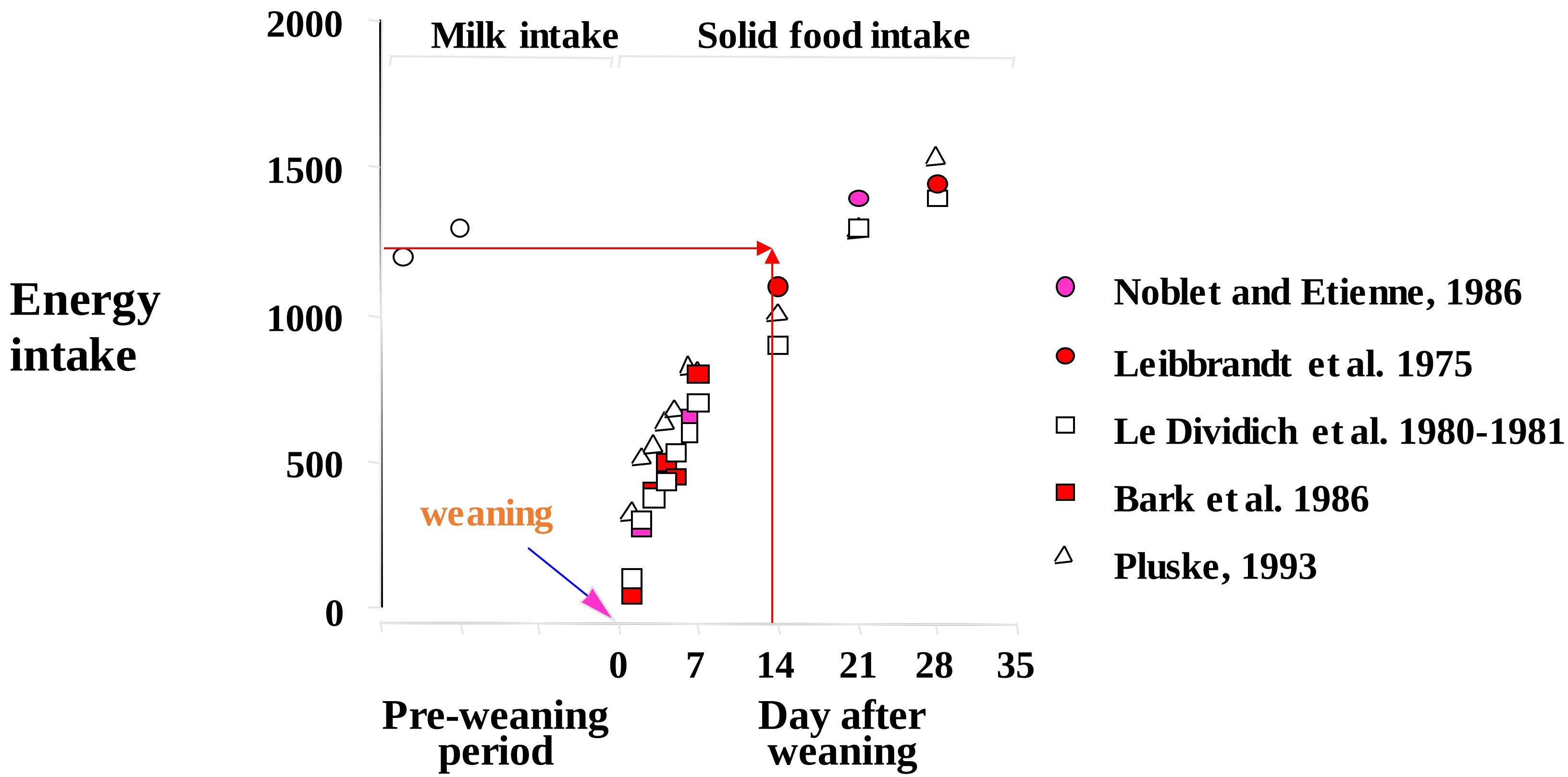
+

- Immature immune and intestinal system

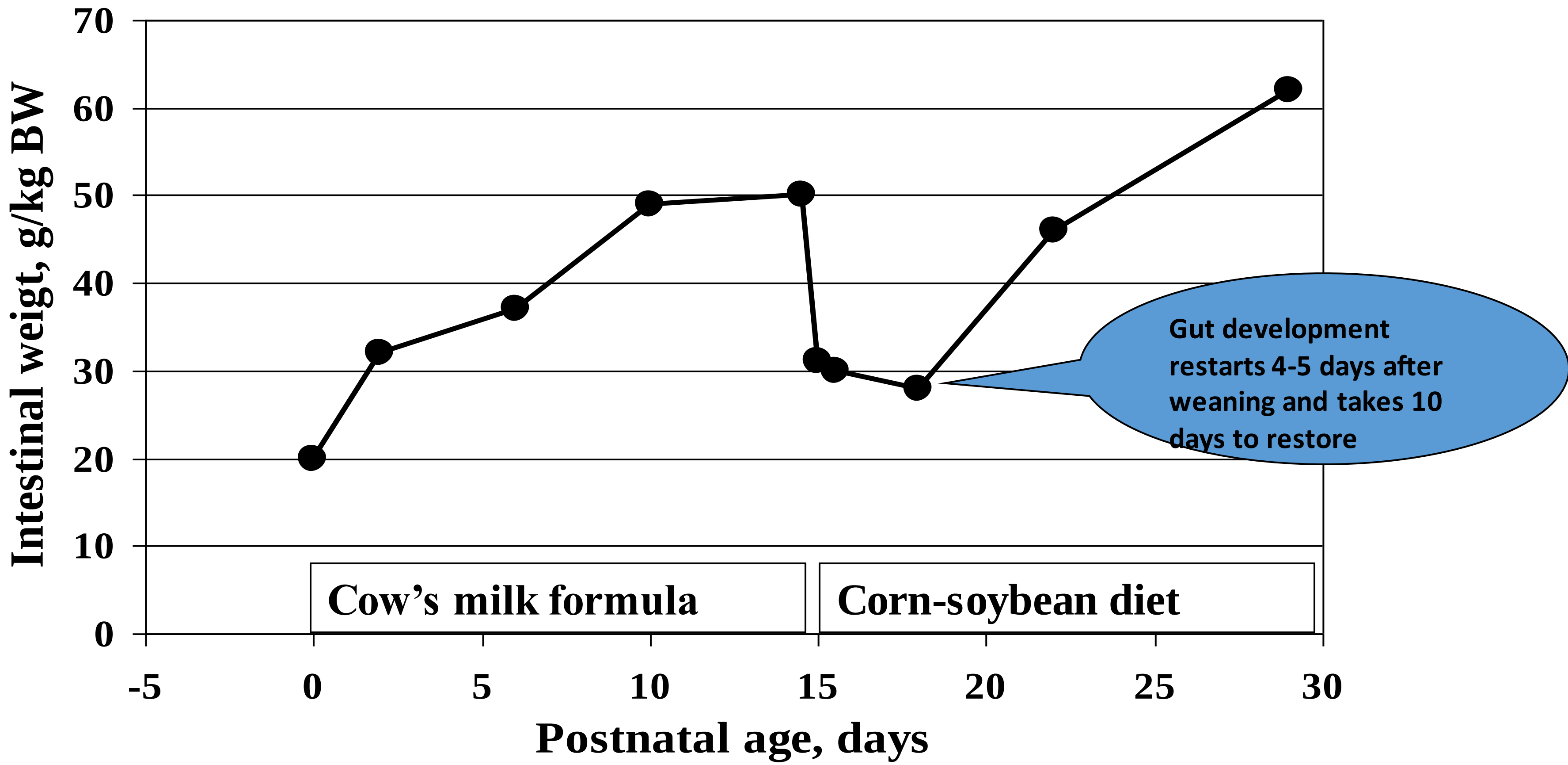
Antibiotic growth Promoters (AGP)

RISK OF POST WEANING (PW) DISEASES ?

Feed and Energy intake is reduced first 2 weeks after weaning



Gut development is related to feed (energy) intake and compromised after weaning



Burrin et al., 2003

Interaction between fermentable carbohydrates (F-CHO) and health status of the animals

Fermentable (x3)

Inert (x1)

Table 1. Formulation and chemical composition of the experimental diets[1]

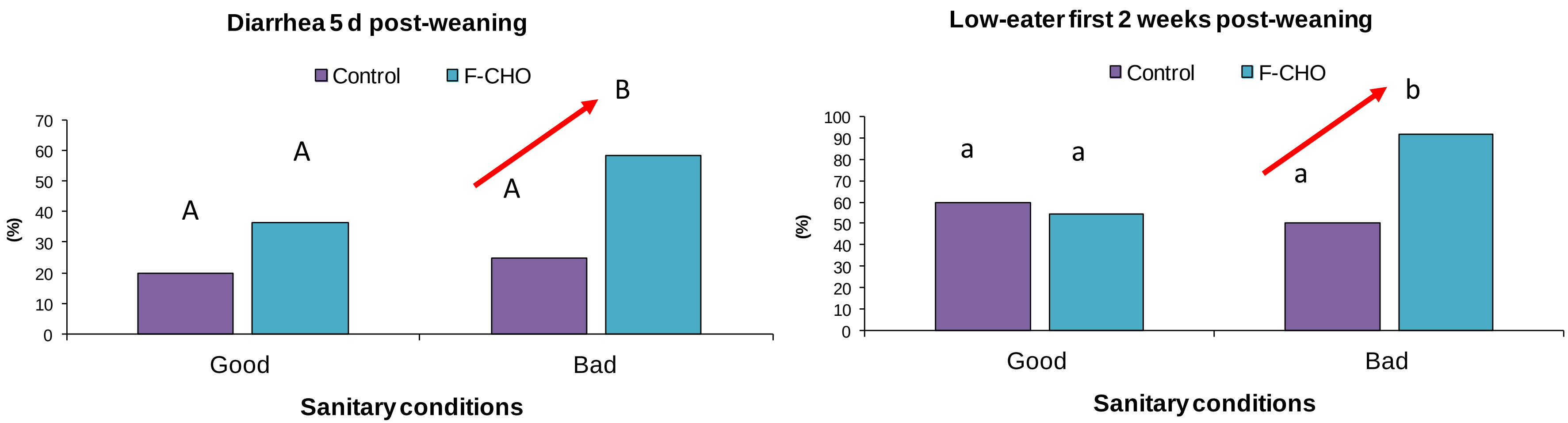
Item	Phase I: Control I	Phase I: Fiber I	Phase II: Control II	Phase II: Fiber II
Ingredient, g/kg (as-fed basis)				
Wheat	225	198	350	303
Corn	200	175	200	172
Barley	120	105	150	129
Soybean meal (48% CP)	240	230	250	230
Dried whey	150	150	-	-
Dehydrated sugar beet pulp	-	60	-	90
Soybean hulls	-	20	-	30
Vegetable oil	25	25	10	10
Dicalcium phosphate	10	9.8	11.2	11.5
Calcium carbonate	11.3	9	11.2	7.3
L-Lys·HCl	5.6	5.2	4.6	4.2
DL-Met	2.7	2.7	1.6	1.6
L-Thr	2.5	2.4	1.9	1.9
L-Trp	0.8	0.8	0.4	0.4
Salt	2	2	4	4
Premix[1]	5	5	5	5
3-phytase[2]	0.1	0.1	0.1	0.1
Calculated composition, g/kg DM				
NE, MJ/kg	10.4	10.0	9.8	9.3
Digestible Lys	13.0	12.5	11.6	10.9
Digestible P	3.8	3.7	3.2	3.1
Chemical composition, g/kg DM				
Ash	64.5	64.9	58.8	60.1
CP (N × 6.25)	219.1	212.3	220.2	213.0
Ether extract	47.2	46.0	31.6	32.2
Starch	381.5	341.5	488.8	425.9
GE, MJ/kg	18.77	18.65	18.55	18.41
Crude fiber	32.5	48.9	35.8	63.9
NDF	109.6	112.5	122.3	153.2
ADF	34.6	50.1	39.3	69.0
ADL	2.1	8.6	3.9	9.9
Total dietary fiber	120.9	169.1	145.8	216.8
Water insoluble fiber	102.6	140.7	122.7	186.1

Montagne et al., 2012

2x2 Experimental design:

- **Level of F-CHO**: high and low
- **Sanitary conditions**: good and bad

Interaction between fermentable carbohydrates (F-CHO) and health status of the animals



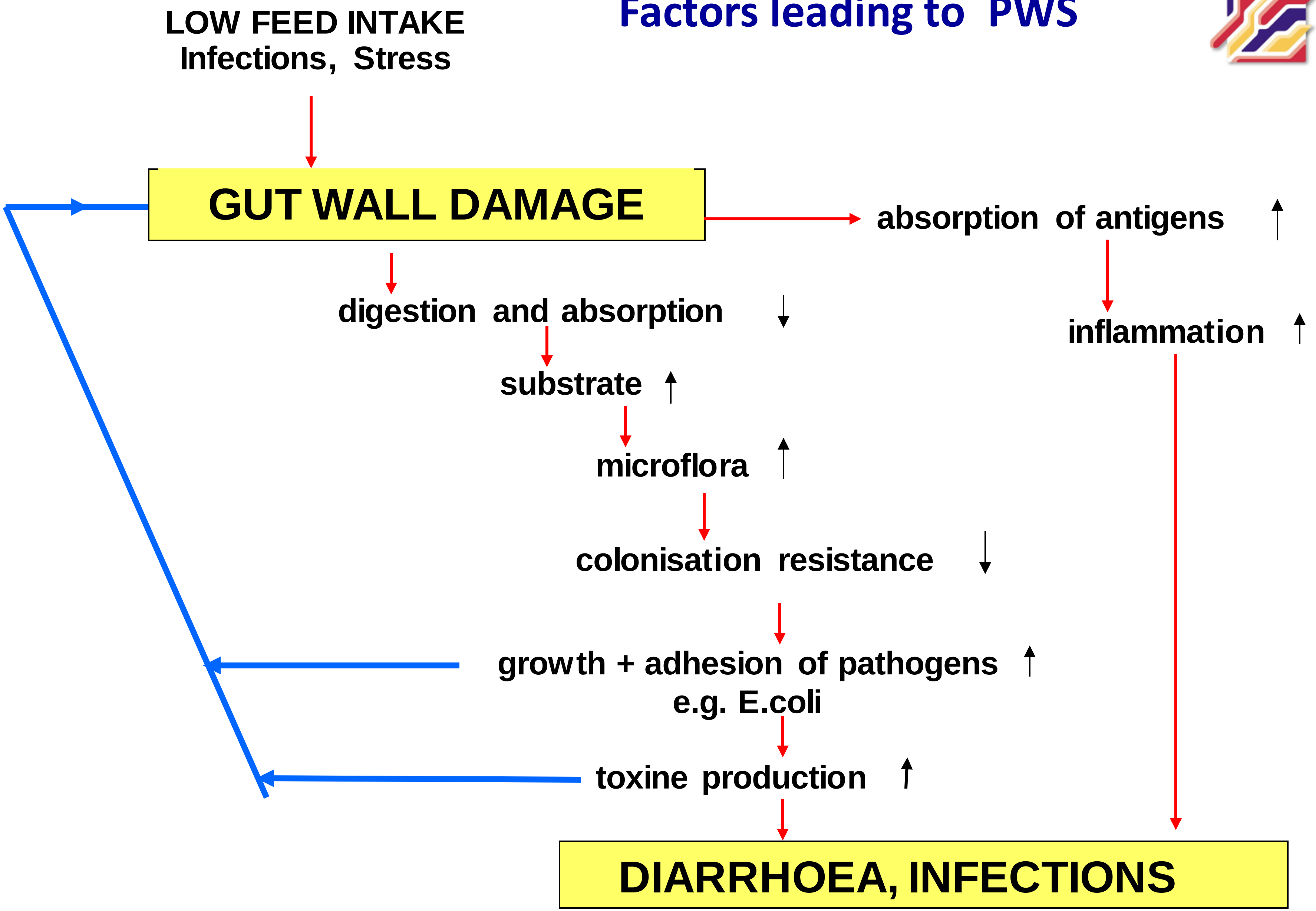
P diet x sanitary conditions = 0.07

P diet x sanitary conditions = 0.01

Montagne et al., 2012

In situations with bad sanitary conditions, the utilization of F-CHO sources in the first week post-weaning is an additional risk factor

Factors leading to PWS



Diarrhoea prevention

- Low feed intake initiates gut wall damage

  => stimulate early feed intake and use highly digestible energy sources

- Reduced gut health decreases protein and fat digestibility

  => use highly digestible protein and fat sources

- Microbial growth is stimulated by undigested protein and carbohydrates entering large intestine

  => reduce crude protein and fermentable or soluble carbohydrate content

- Overconsumption of feed causes the same problem

  => feed restriction and increase retention time in stomach

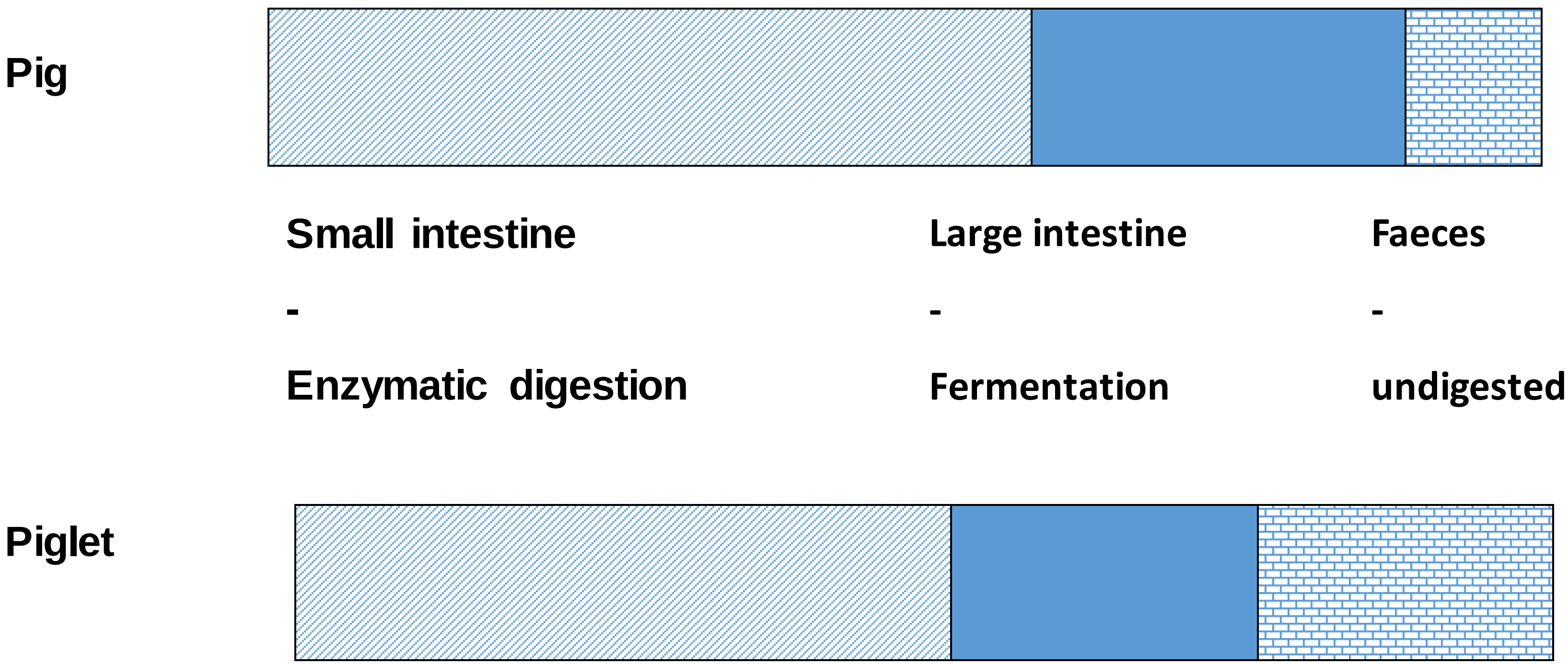
A piglet is an immature pig!

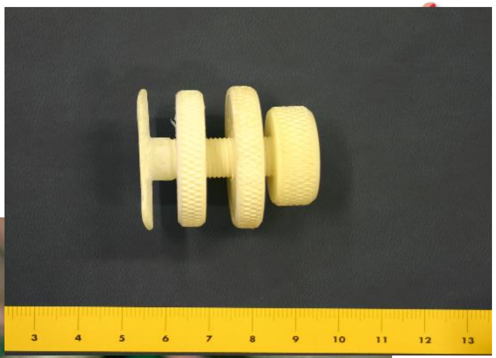
Effect of animal category on nutrient digestibility

	Pig (G/F)	Gestating sow	Lactating sow	P value
DC dry matter (%)	77.4 [a]	79.7 [b]	80.0 [b]	<0.001
DC organic matter (%)	82.9 [a]	85.4 [b]	84.9 [b]	<0.001
DC cr. protein (%)	77.0 [a]	82.3 [b]	81.9 [b]	<0.001
DC cr. fat (%)	69.4 [a]	72.0 [b]	73.3 [c]	<0.001
DC cr. fibre (%)	50.2 [a]	58.3 [c]	55.9 [b]	<0.001
DC NSP (%)	67.1 [a]	70.7 [c]	69.4 [b]	<0.001
NE-value (MJ/kg)	8.54 [a]	8.77 [b]	8.76 [b]	<0.001
Relative	97.4	100	99.9	

SFR-report 897, 2008

Digestive capacity piglets versus pigs and sows

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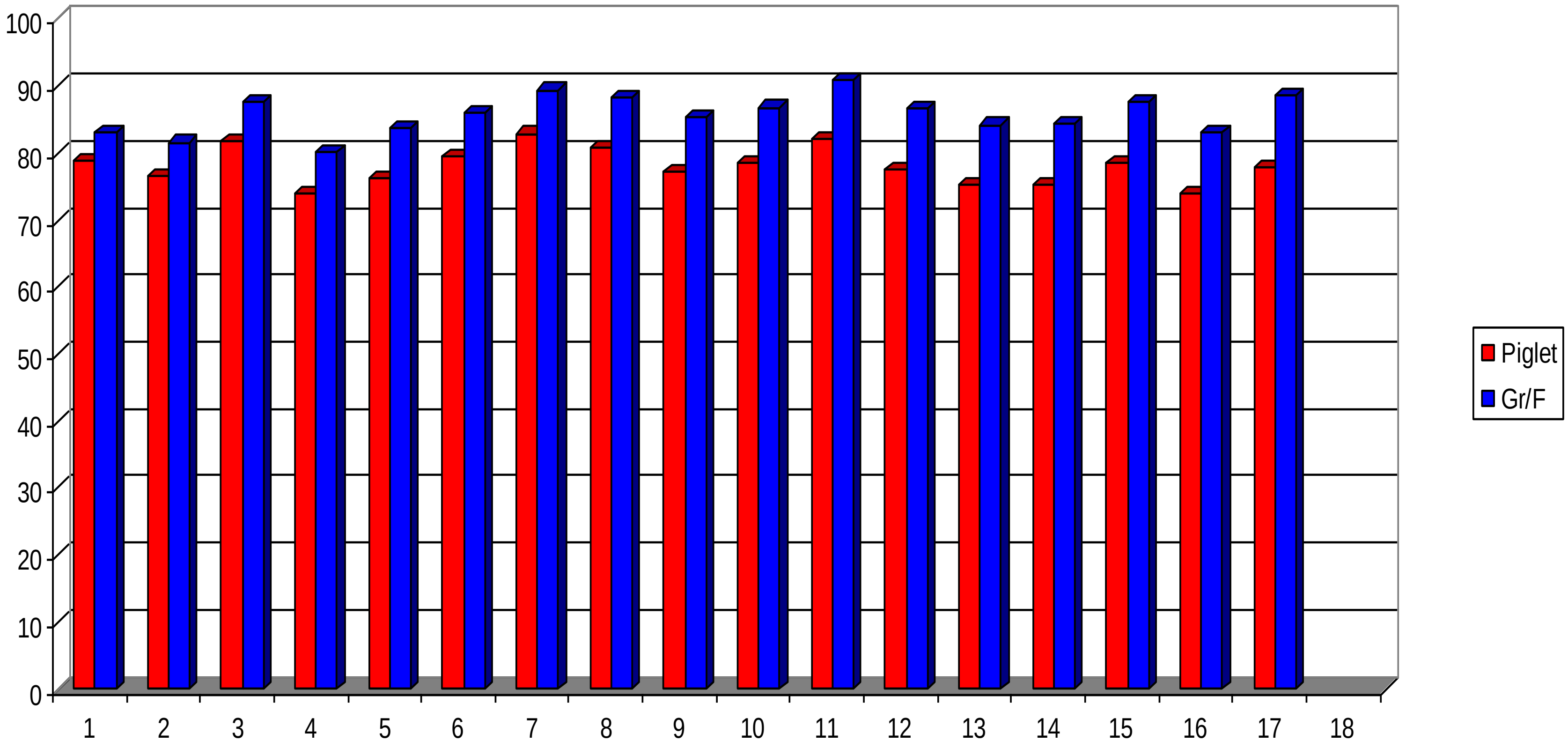
Digestibility crude protein of 17 different feedstuffs: piglet versus growing/finishing pigs



SFR research report 743

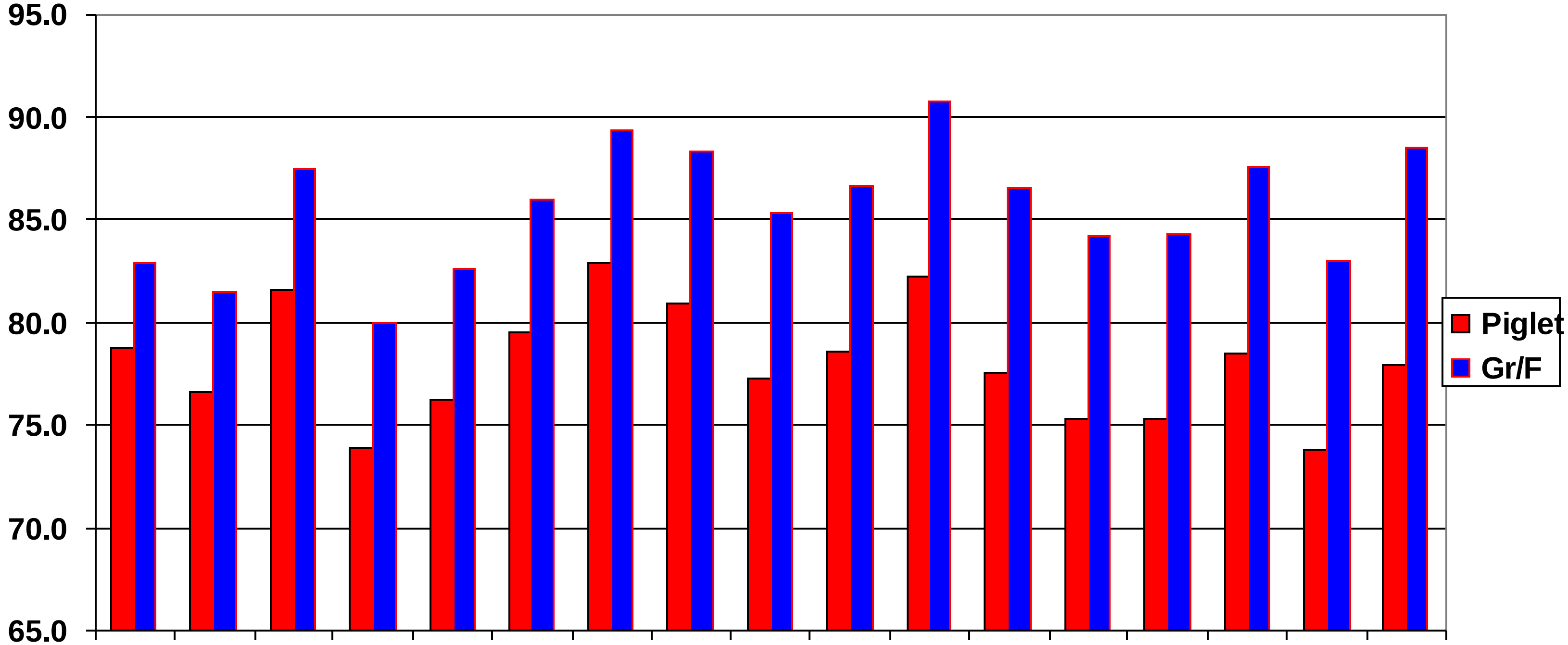
Piglet ileal protein digestibility feedstuffs
(ileal fistulated pigs, 2-3 weeks after weaning (27 days))

	SBM	Whey	SPC	RSM	wheat	WG
DC-OM	77.3	79.5	82.9	66.7	78.3	86.9
DC-CProt	70.1	78.9	74.6	65.7	68.3	86.5
CVB	85	88	n.d.	70	80	98

SBM Soy Bean Meal; SPC Soy Protein Concentrate; RSM Rape Seed Meal; WG Wheat Gluten

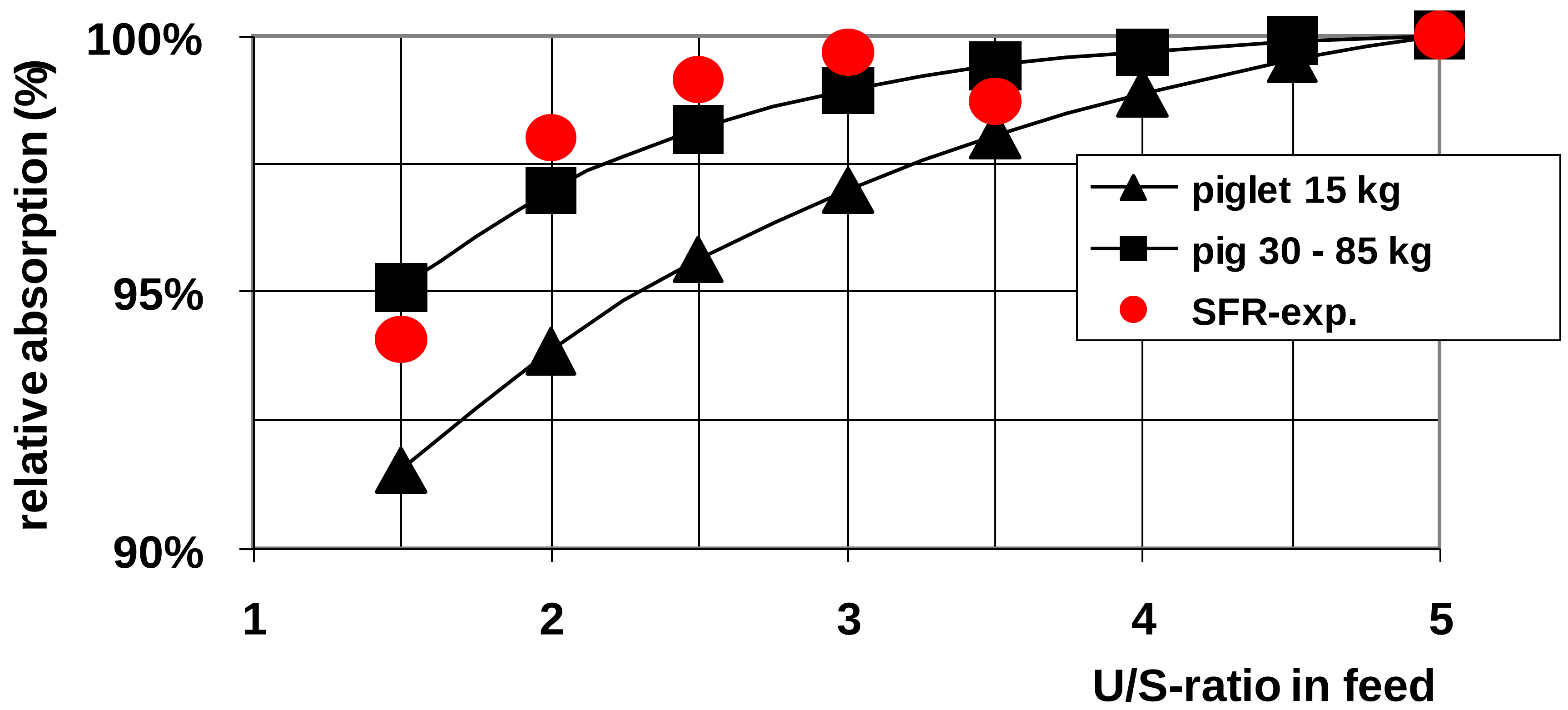
SFR experiment LVD-46

Digestibility crude fat of 17 different feedstuffs: piglet versus growing/finishing pigs

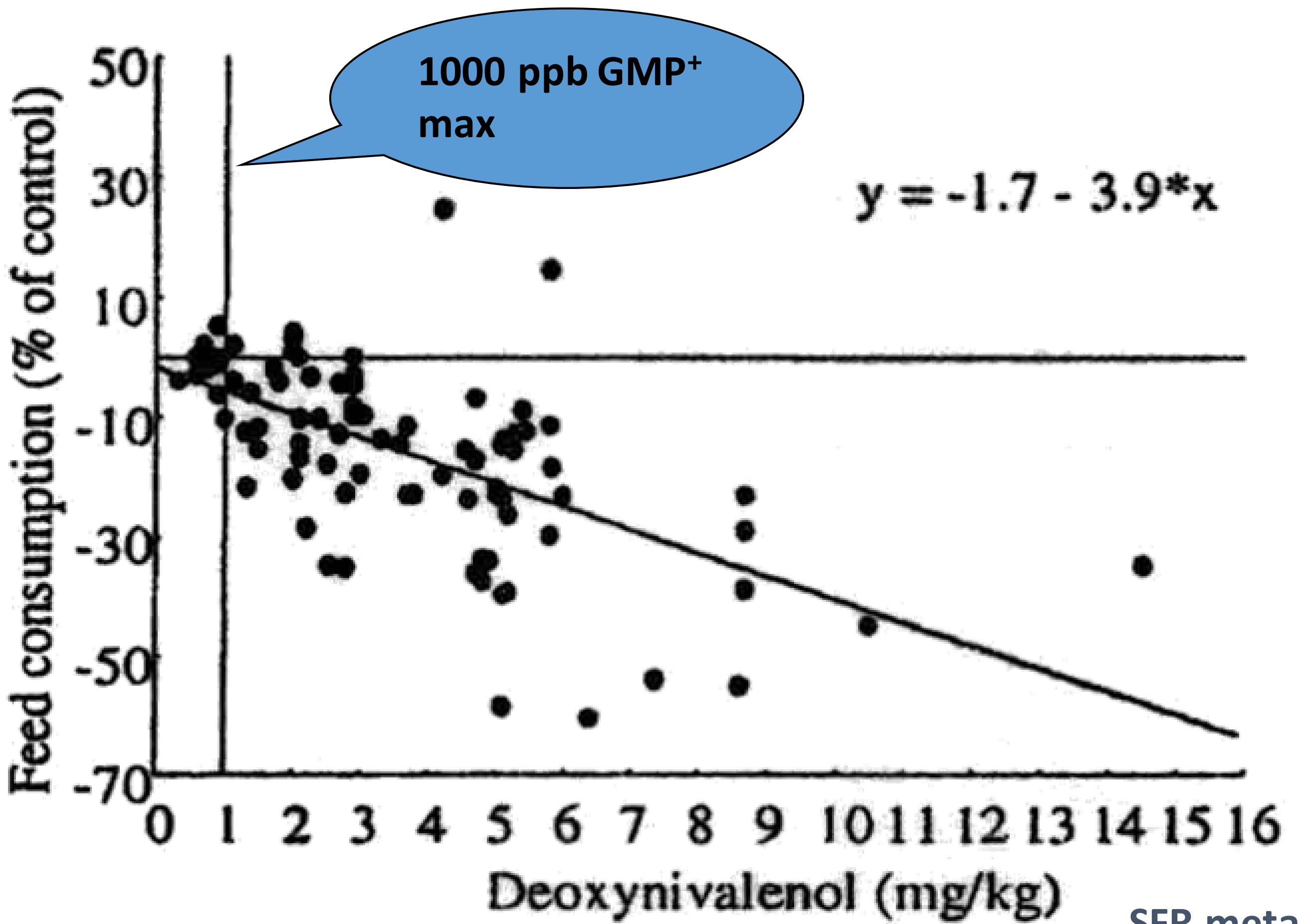


SFR research report 743

Effect of U:S-ratio on fat digestibility (according to Wiseman et. al. and Schothorst experiment)



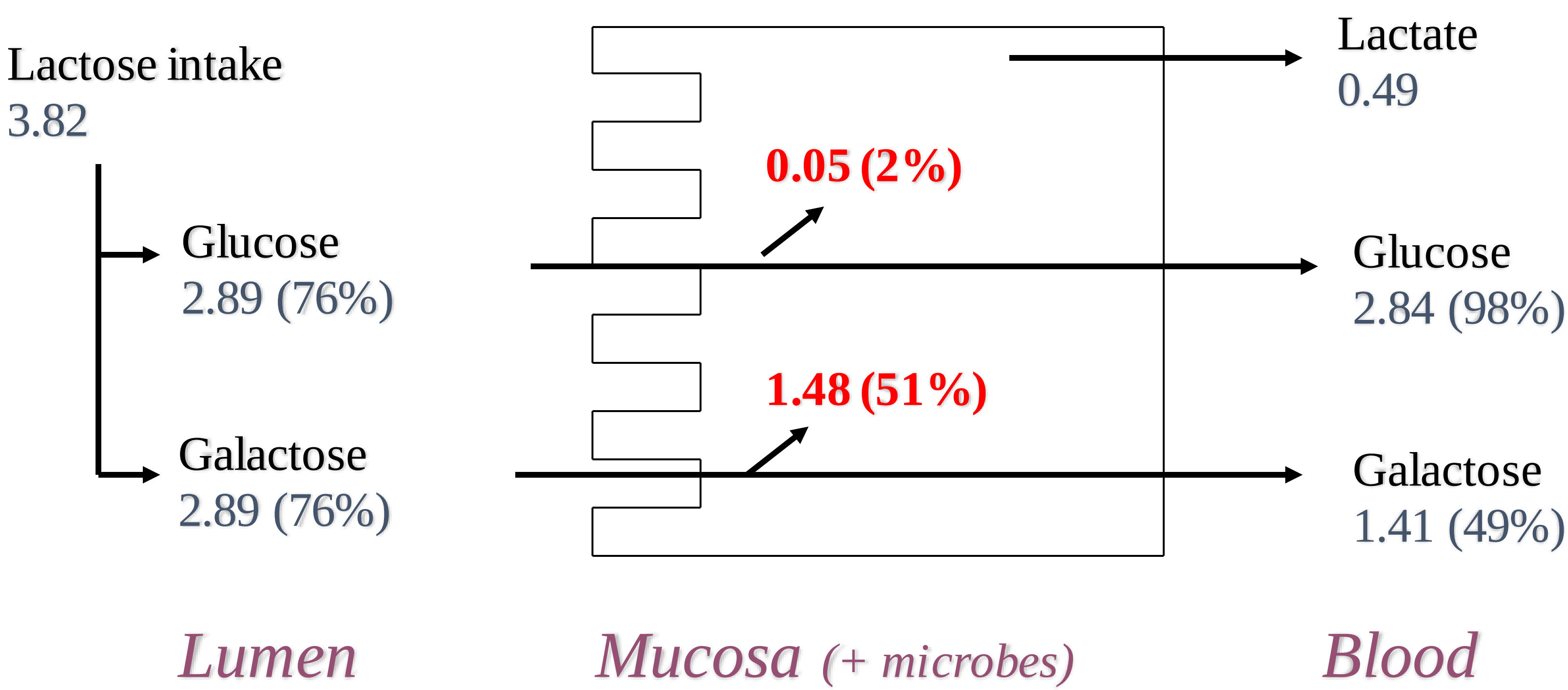
Mycotoxins (DON) decrease feed intake



SFR meta analyses

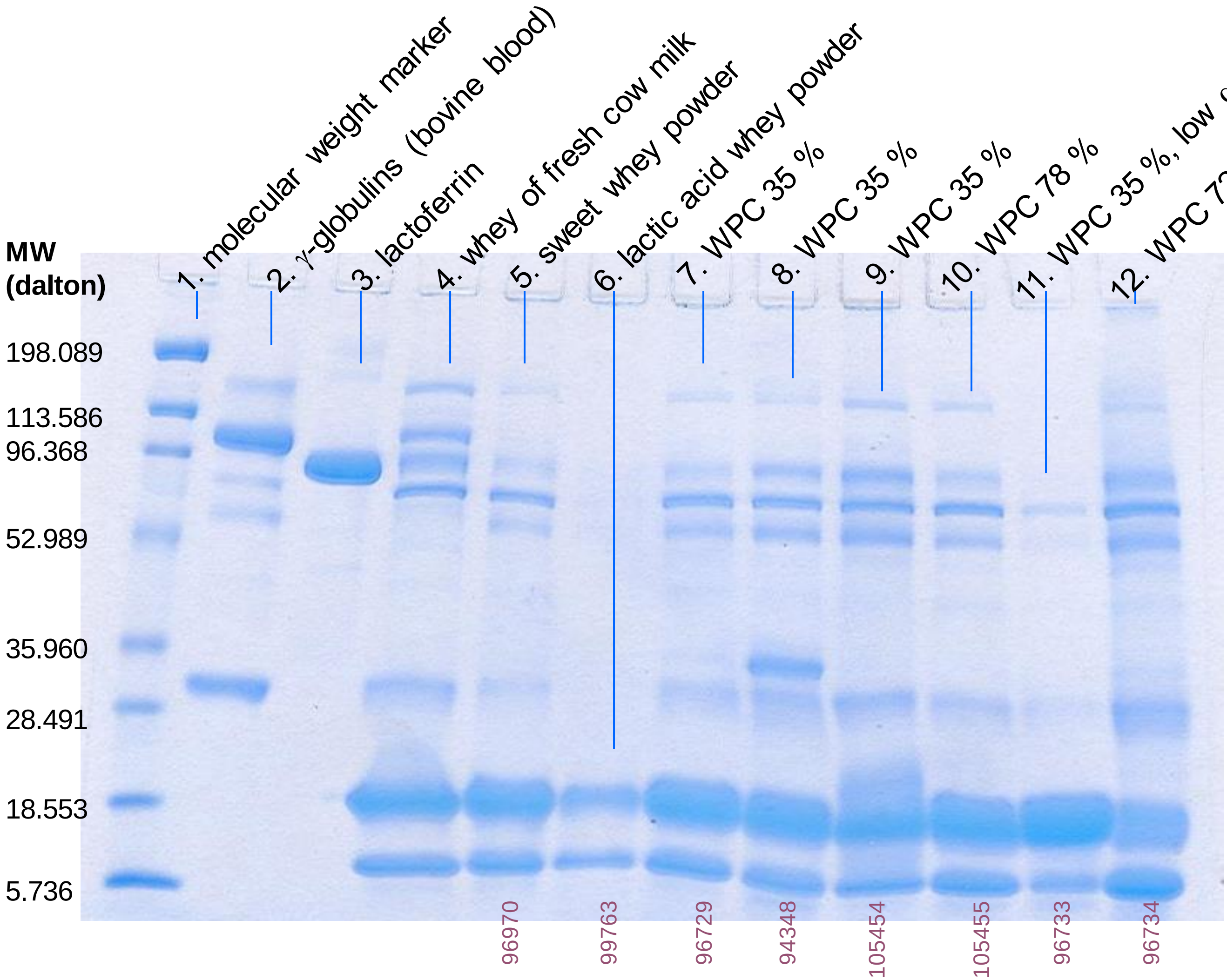
Galactose from lactose is an energy source for endocytes

piglets 24 days old, milk replacer (52.7% lactose), absorption (mmol/kg BW/h)



Burrin et al., 2003

Whey differs in IgG content and profile



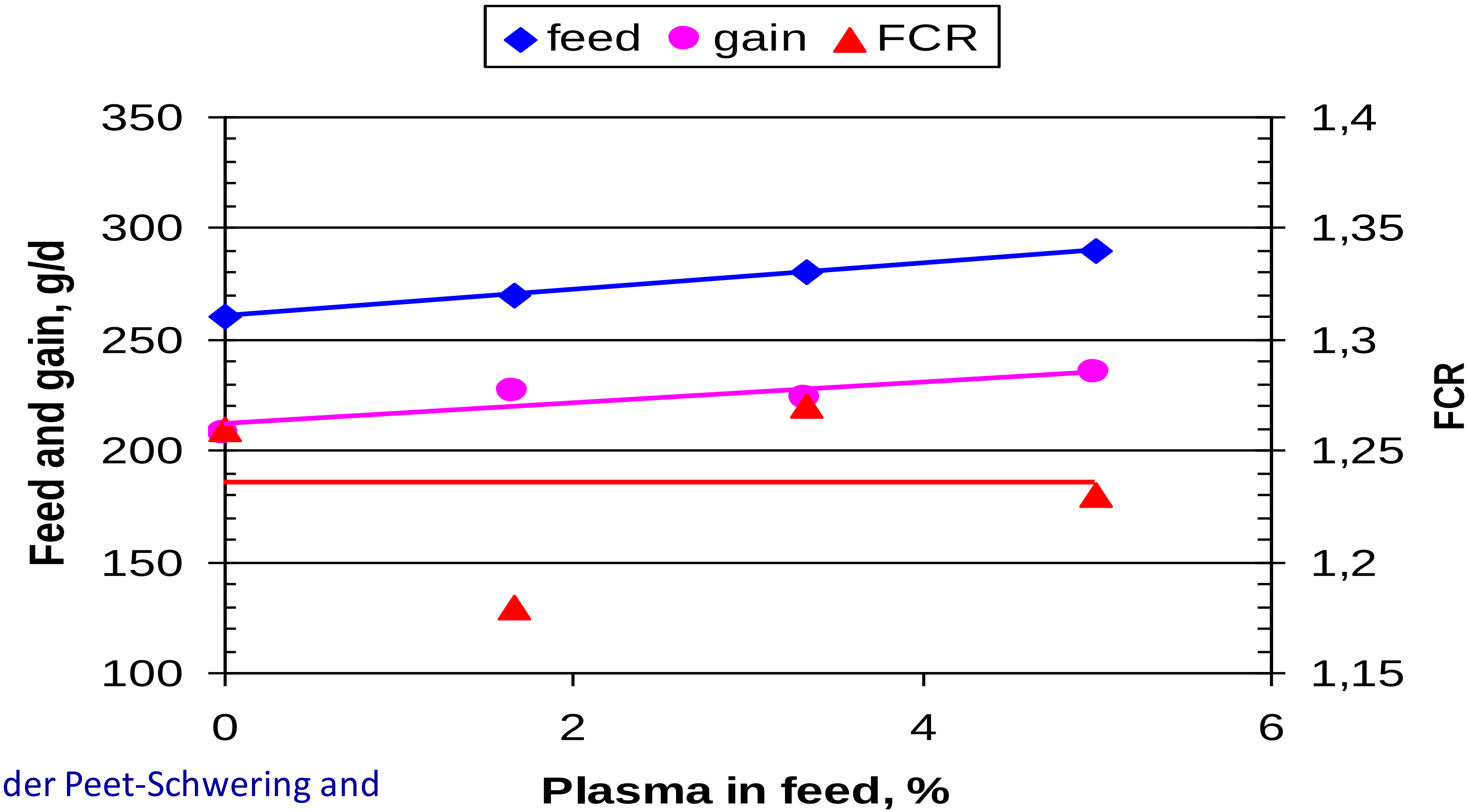
(Van de Braak, 2004)

Soy protein quality affects gut health

	Milk Protein	SBM	SPC
Soy antigens in products	0	6.0	2.4
Villus Height µm	364	234	309
Crypt Depth µm	198	222	214
Xylose Absorption mg/100 ml	0.82	0.42	0.61
Coliforms %/bacteria)	2	37	24
ADG g/d	326	182	208

Li et al., 1991

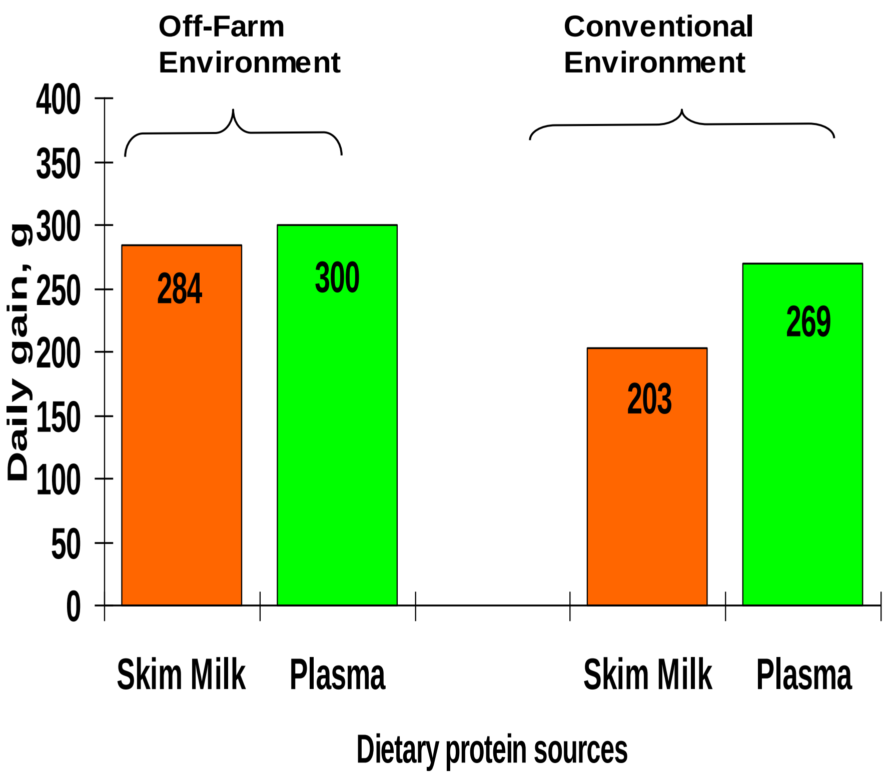
SDPP replacing fishmeal, 2 weeks post-weaning



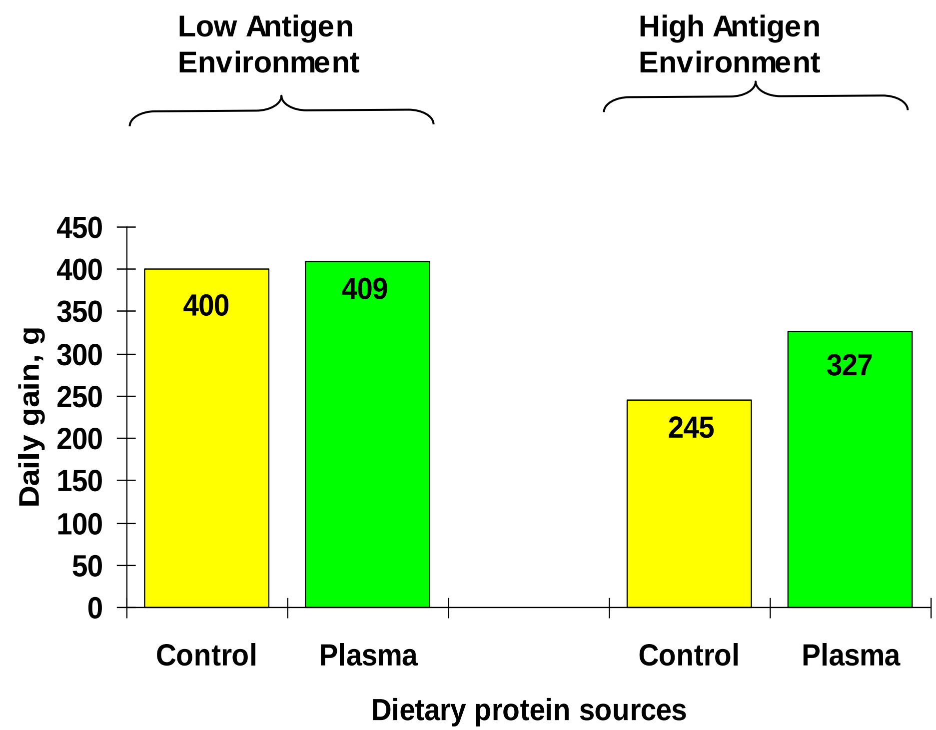
Van der Peet-Schwering and Binnendijk, 1997.

Effect of SDPP depending on environment

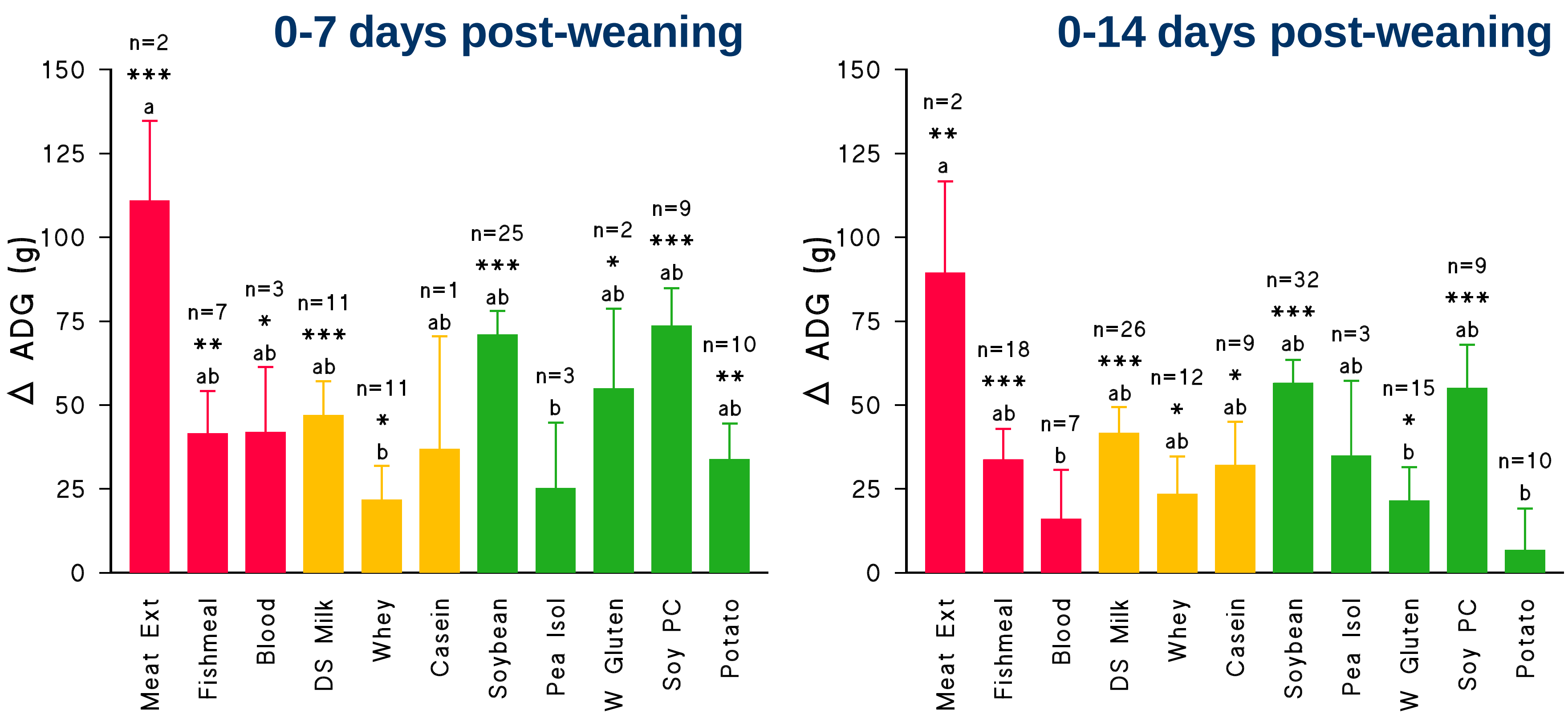
Coffey and Cromwell., 1995



Stahly et al., 1994



ADG improvement of SDPP is dependent on protein source replaced and age of piglets



Torrallardona, 2007

Formulating piglet feed to improve (gut) health and reduce the use of antibiotics

- Reduction of crude protein and indigestible protein content (i.e. use of synthetic amino acids)
- Use of highly digestible protein sources (i.e. animal proteins, hydrolyzed proteins, processed plant proteins)
- Use of highly digestible fat sources (high U:S ratio, rich in MCFA)
- Reduction of fermentable or soluble carbohydrate content (high starch feeds)
- Absence of undesired substances that decrease feed intake (GSL, DON) and usage of feedstuffs that improve feed intake (fish meal, plasma protein, sugars)
- Decrease buffering capacity of feed in conjunction with use of organic acids (i.e. reduced incorporation of limestone)
- Functional proteins (IgG sources) and carbohydrates (lactose)

Piglet milk replacers

Feed intake before weaning

- Milk production of the sow is not sufficient to provide all the piglets the necessary amount to reach the desired weaning weight.
- Before weaning, piglet milk replacer (in liquid or paste form) and/or creep feed (in dry form) can be distributed (as a complementary feed) in different feeding systems put in the farrowing pens
- Advantages of supplementary feed intake before weaning:
  - Increase of nutrient intake
  - Improvement of weaning weight
  - Adaptation to solid feed intake
    - Ease the process of weaning (shift from milk to dry feed)
    - Stimulate further development of gastrointestinal tract
    - Prevent drop in feed intake after weaning

Early weaning and feed intake in nursery systems

- Milk production of the sow is not sufficient to provide all the piglets the necessary amount to reach the desired weaning weight.
- Supernumerary piglets (the strongest piglets of each litter) can be weaned very early and fed separately in a nursery room.
- A complete piglet milk replacer (in liquid or paste form) and/or creep feed (in dry form) can be distributed in different feeding systems put in the nursery room, i.e. cup system, automatic drinking machine, …
- Since this complete piglet milk replacer has to replace sow's milk, the composition has to take into account:
  - Functional proteins (immunoglobulins, bio-active peptides, …), i.e. spray-dried plasma protein (SDPP), whey protein concentrate (WPC), …
  - Functional carbohydrates (lactose, fermented sugars, maltodextrins, …)
  - SCFA and MCFA (C4:0 – C6:0 – C8:0 – C10:0 – C12:0), i.e. coconut oil, …

Example of recommendations for the formulation of milk replacer, creep feed and weaner feed for piglets

	Milk replacer	Creep feed	Weaner feed
Kcal/kg NE	-	2650	2350
MJ/kg NE	-	11.09	9.83
Crude protein (%)	17-22	17-19	17-18
Crude fat (%)	19-24	10-15	5-8
Lactose (%)	25-30	~ 10	~ 5
Total sugars (%)	35-40	~ 20	~ 10
Starch (%)	5-10	~ 20	~ 30
SID-lysine (%)	1.5-1.9	1.2	1.15
SID-M+C/THR/TRP(%LYS)	60/65/21	60/65/21	60/65/21
Ca/P*/Na	0.8/0.6/0.45	0.8/0.4*/0.3	0.7/0.35*/0.3

* Digestible P in creep and weaner feed, taking into account phytase activity

Conclusions

1. The higher sow prolificacy and the reduced birth weight of piglets had led to the implementation of early weaning and nursery systems with increased use of piglet milk replacers (rich in SCFA/MCFA, functional proteins and functional carbohydrates)
2. The severity of PWS (post weaning syndrome) in piglets can be reduced via feed formulation (reduction of crude protein and soluble fibres, increase of U:S ratio) and feed additives (organic acids, SCFA/MCFA)
3. Feedstuff choice can increase feed intake and improve gut health (fish meal, plasma protein, highly digestible plant proteins & fats, synthetic amino acids)
4. Inert fibre sources (oat hulls, rice hulls, sunflower hulls, straw, wheat bran) can be used in prestarter feeds to reduce the energy content, increase feed intake and increase gut development

Thanks for your attention!

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connecting knowhow with farm practice