

Preserving health status of farm animals: what is expected from feed and nutrition

- A broad topic -



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Preserving health status of farm animals: what is expected from feed and nutrition

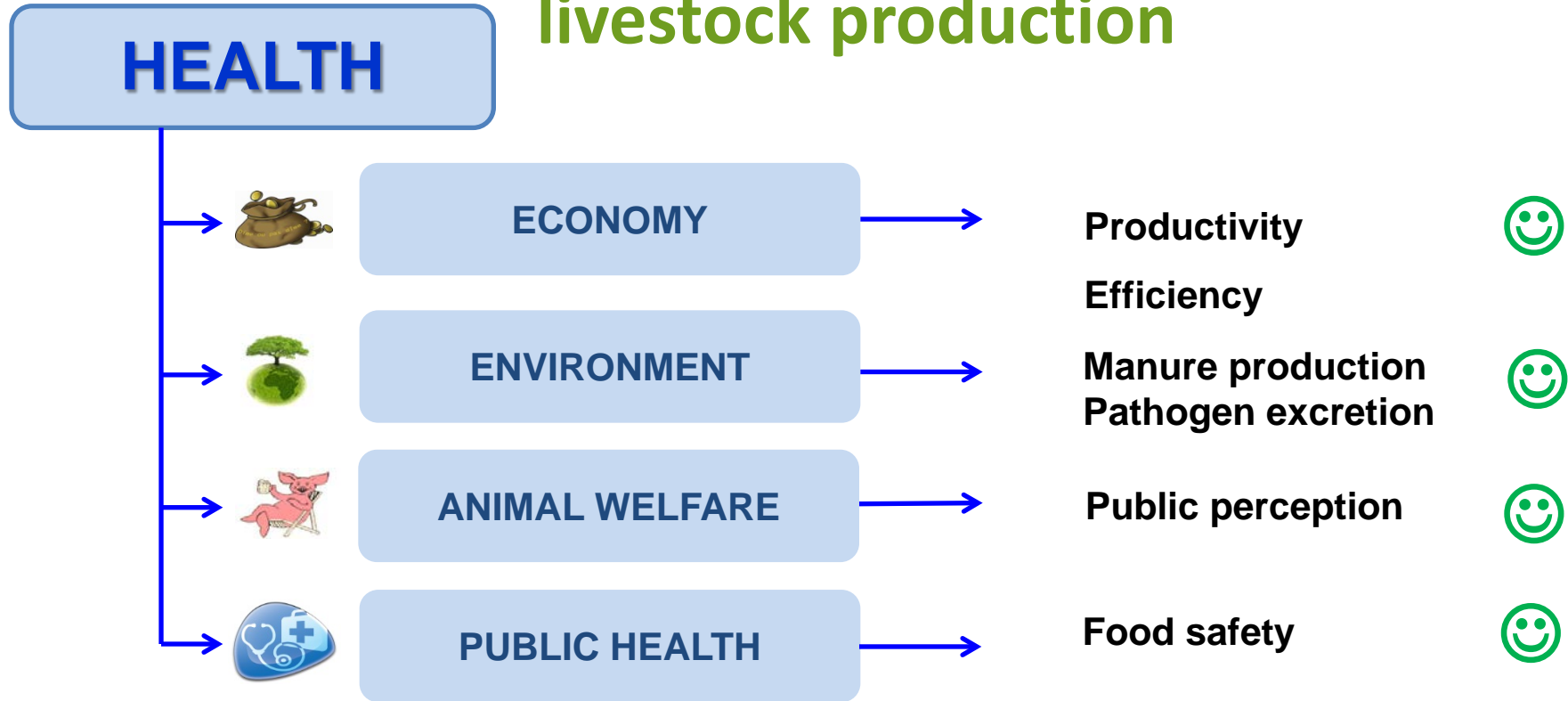
- A focus on pig nutrition -



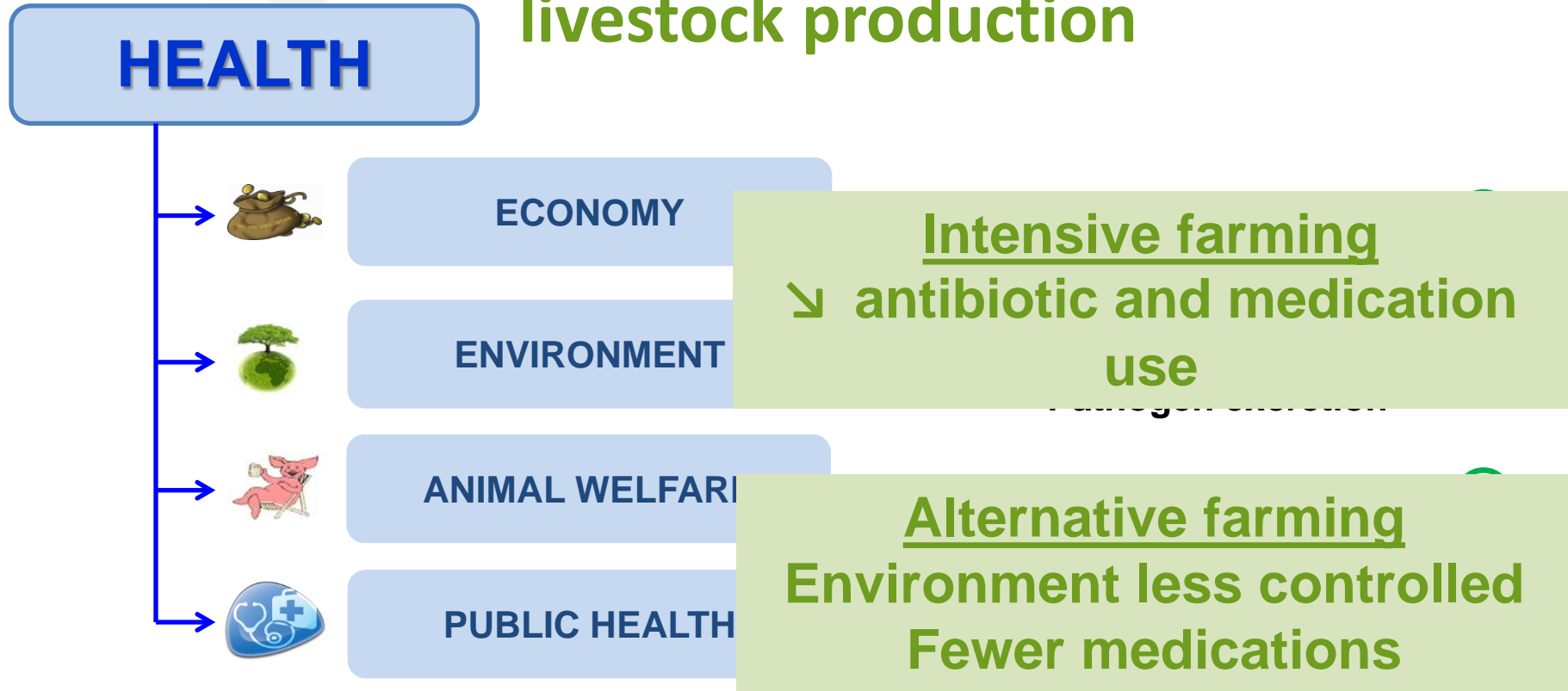
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Preserving health status : a major issue for livestock production

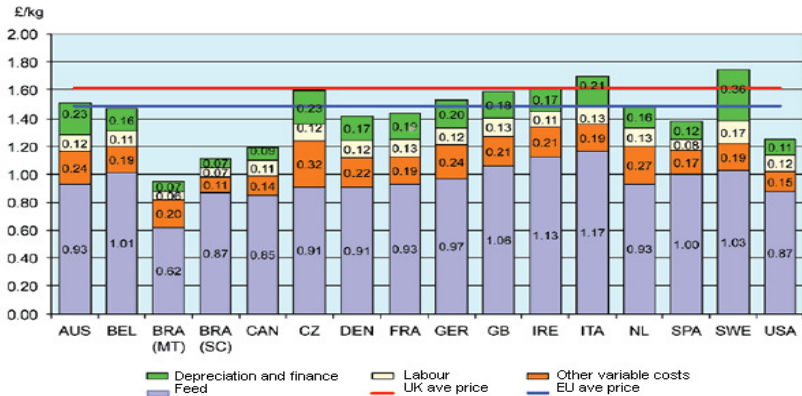


Preserving health status : a major issue for livestock production



Feed and health are interconnected

1/ a good health status contributes to maintain feed efficiency, growth rate and to limit feed cost



Ex. Chronic respiratory disease in pig :

- feed conversion ratio + 0.3
- duration of growing phase + 7-28 d

Source: <http://www.thepigsite.com/pighealth/article/33/the-costs-of-disease/>

major importance of feed costs

~60% of production cost

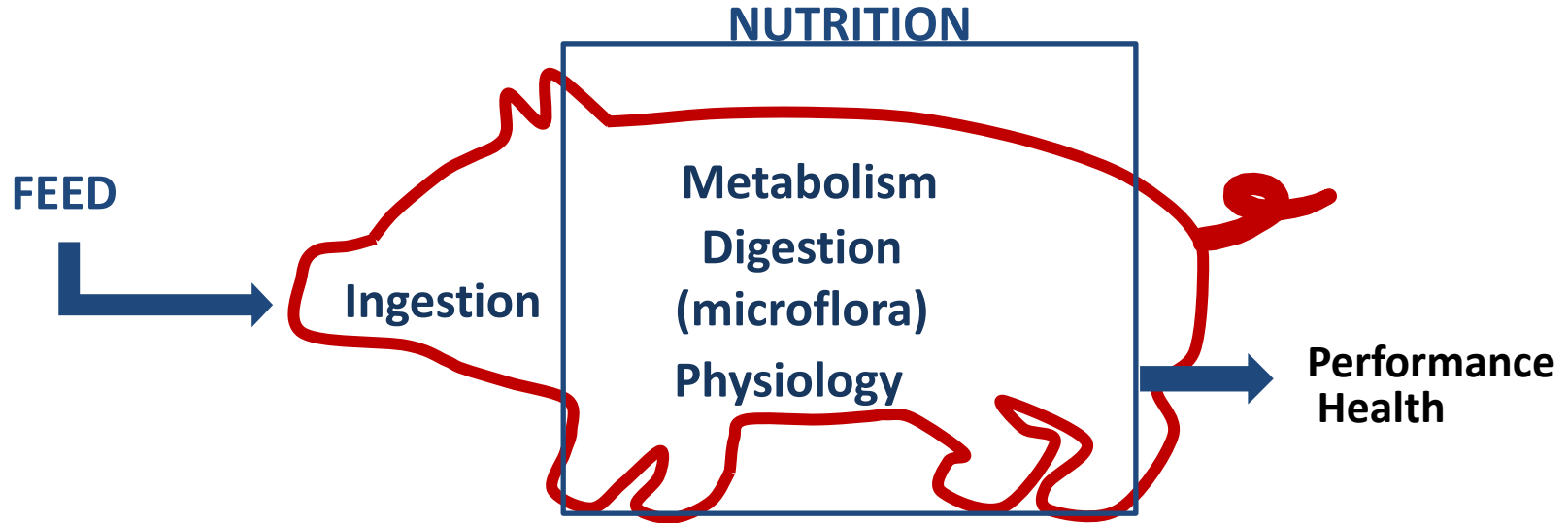


Feed and health are interconnected

1/ a good health status contributes to maintain feed efficiency, growth rate and to limit feed cost

2/ Feed and nutrition : a significant role in health maintenance

How does feed interact with animal health?



2a/ Feed can be responsible of health disturbances

Ex. Contamination by undesirable and toxic components

- bacteria, virus, fungi
 - contaminants : toxins, mycotoxins
- ➔ Feed safety issue

➔ *Not in the scope of this lecture*

Mycotoxins have multiple effects

Example in pigs

Symptoms	AFB1	OTA	DON	T-2	FB1	ZEA
Anorexia	+	+	+++	+++	+	
Growth	+++	+	+++	++	+	
Liver damage	+++	+			++	
Kidney damage		+++			+	
					+	++
						+++
						+++
					+++	
Immunomodulation	+++		++	++	+++	

Alteration of intestinal functions :
↘ nutrient absorption, ↗ pathogen translocation and inflammation ...

Mycotoxins have multiple effects

Example in pigs

Symptoms	AFB1	OTA	DON	T-2	FB1	ZEA
Anorexia	+	+	+++	+++	+	
Growth	+++	+	+++	++	+	
Liver damage	+++	+			++	
Kidney damage		+++			+	
Abortion					+	++
Infertility						+++
Vulvovaginitis						+++
Pulmonary oedema					+++	
Immunomodulation	+++		++	++	+++	

↓ Vaccine efficacy

2b/ Feed supplies ingredients that support an optimal « functioning » of the organism

- ➔ Tissue and organ development and functioning
- ➔ Animal ability to cope with various challenges and infections

- Gut physiology including microflora
- Immune capacity and body defenses
- Muscle and bone development
- ...



Outlines

- Feeding level : impact of *restricted feeding* on health
- Feed ingredients : *role of fibers* on digestive functioning and « gut health »
- The roles of *nutrients* on animal health : the exemple of amino acids



Outlines

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Feeding strategies for post-weaning pigs (when removing antibiotics growth promoters)

Kil and Stein (2010)

liquid feeding

- adapted to the immature digestive system
- improved ADG and feed efficiency compared to dry feed
- positive effect on intestinal villi

Restricted feeding

- less substrates for microbial fermentation
- reduced incidence of diarrhea
- growth retardation but possible compensatory growth (> feed efficiency)

Low protein diets

- ↓ microbial fermentation and production of toxic compounds (NH₃)
- growth retardation but compensatory growth (crystalline amino acids)

The effects of restricted feeding on health has been studied for many species



weaning

50% AL

- ↘ Diarrheas *Rantzer et al 1996*
- ↘ fecal excretion of *E.coli*
- ↘ Growth rate *Pastorelli et al 2012*
- No positive impact on health



weaning and growing period

60-80% AL*

- ↘ Mortality *Gidenne et al 2012*
- ↘ Morbidity



LPS injection

50-75% AL

- ↘ hyperthermia *Matsuzaki et al 2001*
- ↘ inflammatory response

* *Ad libitum*

Effects of restricted feeding in growing pigs housed in poor sanitary conditions

Le Floc'h et al 2014

- Health was challenged for 5 weeks at the beginning of the growing phase : model of poor hygiene (*adapted from Le Floc'h et al 2010*)

Poor hygiene : no cleaning

➔ inflammation

Good hygiene : cleaning and disinfection

- 2 feeding levels : Ad Libitum feeding (AL) vs Feed restricted (FR = 60% AL)
- 4 experimental treatments : 2 hygiene x 2 feeding levels (n=80)

Effects of restricted feeding in growing pigs housed in poor sanitary conditions

Le Floc'h et al 2014

- Poor hygiene reduced growth rate and nutrient digestibility, and induced an inflammatory response that was not modified by feed restriction

➔ *No positive effect of feed restriction*

Effects of restricted feeding in growing pigs housed in poor sanitary conditions

Le Floc'h et al 2014

- Poor hygiene reduced growth rate and nutrient digestibility, and induced an inflammatory response : these responses were not modified by feed restriction

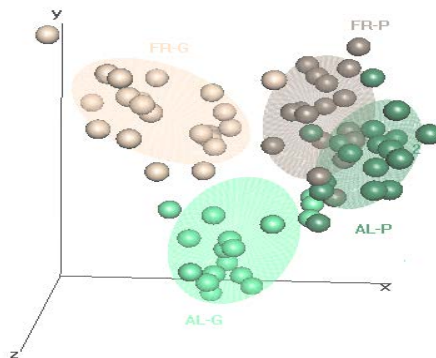
➔ *No positive effect of feed restriction*

- Feed efficiency was improved in previously feed restricted pigs irrespective of hygiene conditions
- Both feed restriction and hygiene modified the profile of the faecal microbiota

Effects of restricted feeding in growing pigs housed in poor sanitary conditions

Le Floc'h et al 2014

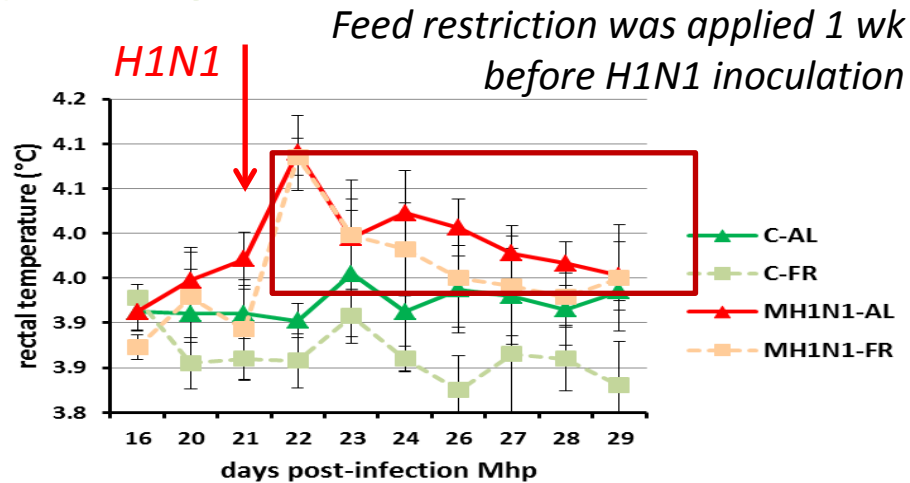
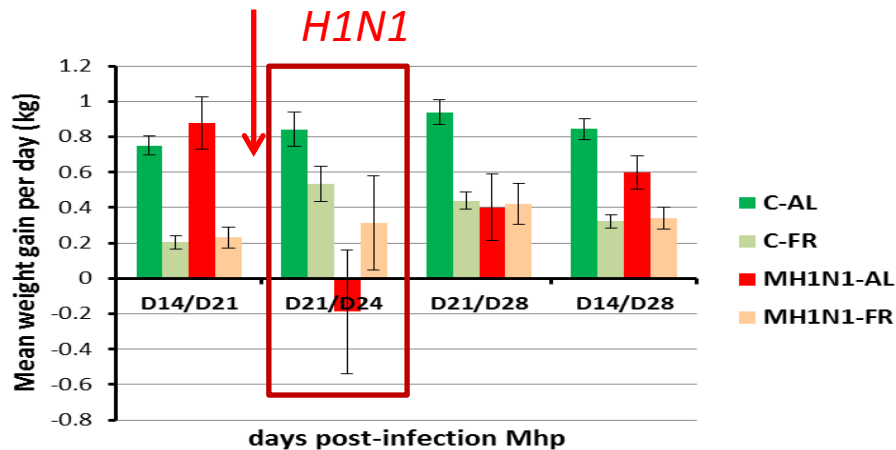
- ✓ Separation of the 4 experimental groups on the total 16S microbial communities



- ✓ Among the 18 most discriminating phylotypes : feed restriction favours bacteria that may reduce the local and systemic inflammation (*Clostridium butyricum*, *Lactobacillus animalis*, *Bifidobacterium choerinum* ...)

Effect of restricted feeding on pig co infected with respiratory pathogens

Le Floc'h et al 2014



- Feed-restricted pigs : *shorter hyperthermia* and a *positive mean weight* gain over the 3 first days following H1N1 infection as compared to AL pigs (↘ weight)

The effects of restricted feeding on health has been studied for many species

... with contrasted effects

- Could be a relevant strategy to limit gut disorders in young animals : adaptation of digestive capacity (limits overfeeding)
- Reduced growth rate could be compensated by gain in feed efficiency
- Feed restriction should be transitory and not too drastic



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Diversity of fibers for diverse effects

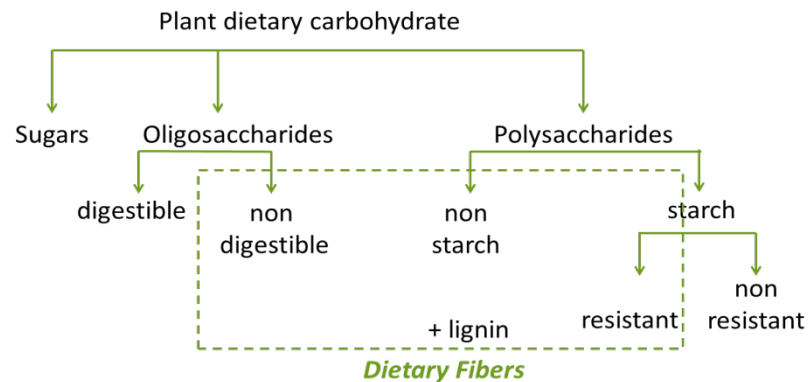
Fibers

- plant structural and non structural dietary carbohydrate
- resistant to hydrolysis by digestive enzymes
- *hydrolyzed and fermented by the microorganisms*

Physicochemical properties

- depend on polysaccharides
- viscosity, adsorption capacity, hydration ...

Adapted from Le Gall & Montagne 2012,
Lindberg 2014



Fibers exert positive effects on digestive tract

On gut mucosa

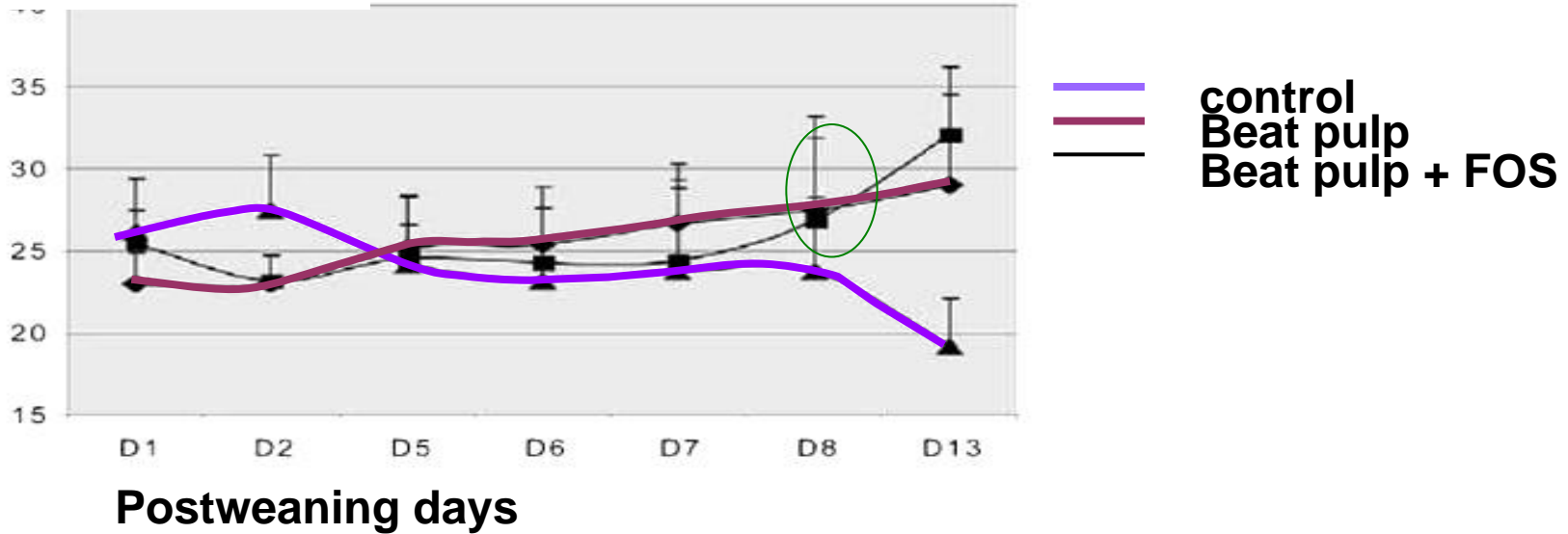
- Anti inflammatory molecules
- Cell proliferation (trophic effect)
- ...

On gut microbiota

- Fermentation : VFA production, acidification of gut content, anti inflammatory molecules
- Proliferation : microflora diversity, exclusion of pathogenic bacteria
- ...

Fibers favour diversity of microflora

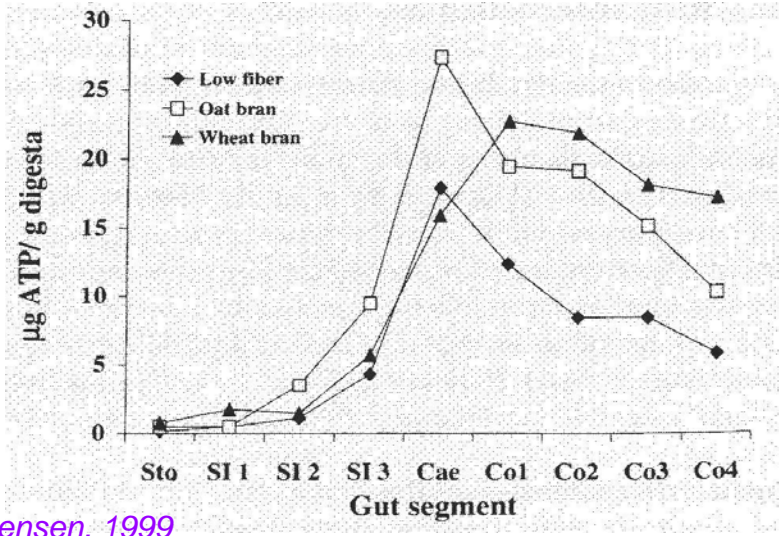
Diversity



Konstantinov et al. 2003; 2004, 2006; Lallès et al, 2004

Dietary fibers increase bacterial proliferation and fermentation

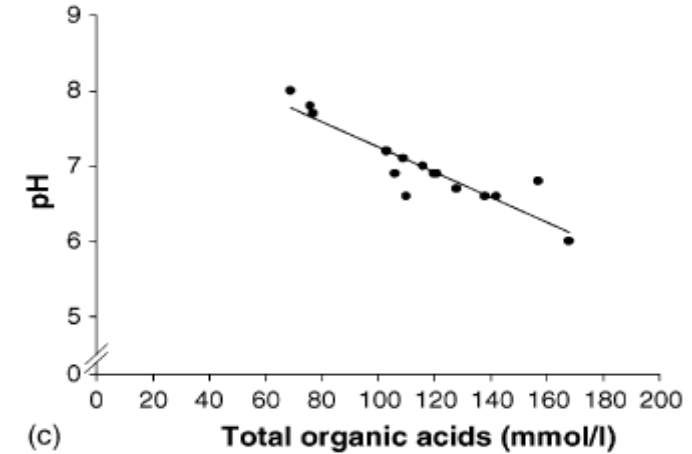
Proliferation



Jensen, 1999

Fermentation

Relationship between pH and [VFA] in the colon digesta of piglets



Högberg & Lindberg 2006

Dietary fibers reduced fermentation of proteins

Weaning at 28 d of age

Awati *et al.*, 2003

Fiber source: beat pulp/inuline/lactulose (50/7.5/20 g/kg)

Feces characteristics (10 d postweaning)

Feces content	Diet		<i>P</i>
	Control	+ fiber	
DM (g/kg)	331	300	<0.05
NH ₄ (mmol/L)	78	↓ 64	<0.05
VFA (mmol/L)	118	120	ns
% acetate	65	66	ns
% propionate	18	18	ns
% butyrate	8.1	8.2	ns
Branched VFA	6.0	↓ 5.1	<0.05

Effect of dietary fibers on growth and health of weanling piglets housed in low hygiene conditions



Montagne et al 2012

➤ Experimental design :

- 48 piglets weaned at 28 d of age
- Piglets housed in poor hygiene conditions (n=24) or good hygiene conditions (n=24)
- Period 1 : Phase I (2 wks) control Phase I diet (highly digestible : 12% TDF) vs high fiber diet (beet pulp + soybean hulls : 17% TDF)
- Period 2 : Phase 2 (3 wks) Control Phase 2 diet vs high fiber diet (14 vs 31% TDF)

Effects of dietary fibers on growth and health of weanling piglets housed in low hygiene conditions

Montagne et al 2012

- **Short term effects** of fibers after weaning
 - ↘ pig growth : ↘ digestibility and feed intake (satiety) and energy dilution
 - ↗ diarrheas in poor hygiene environment
- **Long term effects** of fibers after weaning
 - No detrimental impact on growth
 - ↗ Straight chain VFA and ↘ Branched chain VFA : « positive » effect
 - ↗ Microbial diversity (feces) : « positive » effect

Impact of fibers on digestive functioning and health of weaning piglet

5-6 % CF : effects on « gut health »



Palmer et Hulland, 1965
Armstrong et Cline, 1976
Bertschinger *et al*, 1978
Larsen, 1981
Skoeries *et al*, 1982
Bolduan *et al*, 1988
Göransson *et al* 1995
Aumaitre 1995
Kim *et al* 2005
Mateos *et al* 2006
Bach-Knudsen *et al* 2008
Wellock *et al* 2008



Rivera *et al*, 1978
Piel *et al*, 2005



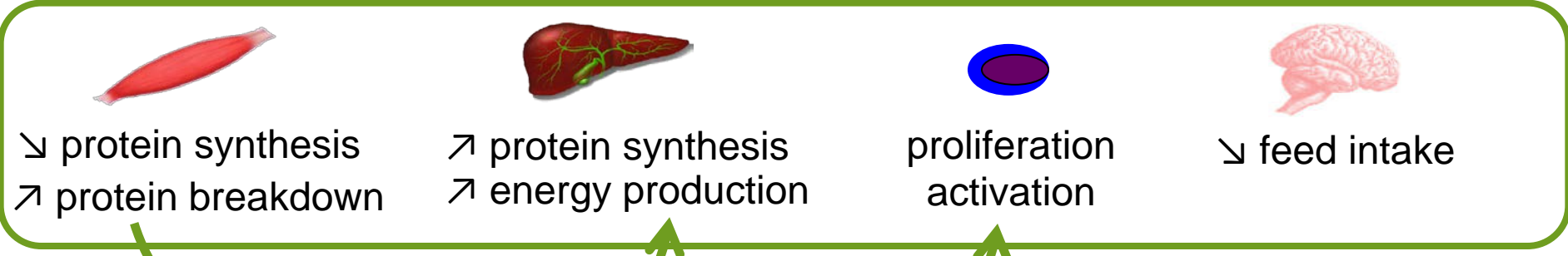
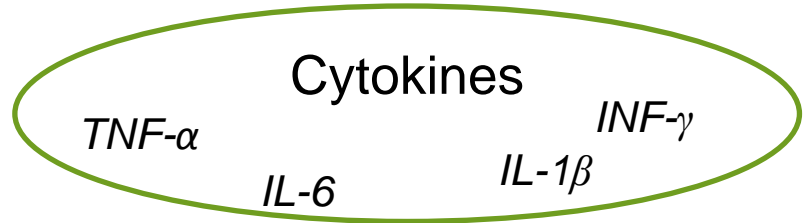
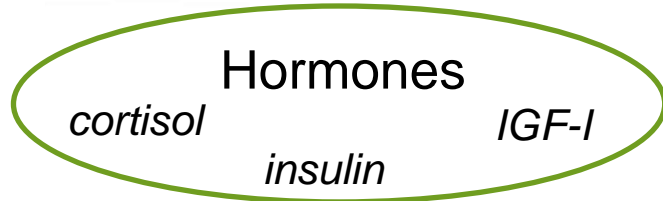
English, 1981
Ball et Aherne, 1982
Etheridge *et al*, 1984
Mc Donald *et al*, 1999, 2000, 2001
Hopwood *et al*, 2002
Montagne *et al* 2004
Montagne *et al* 2012



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Metabolic disturbances caused by immune system activation



AA

Changes in AA partitioning !!!



AA and health

- Incorporation into specific proteins

Mucins, immunoglobulins, APP ...

Thr, Trp

- AA are nutrients for the liver and immune cells

- neoglucogenesis
- cell proliferation

Trp, Gln

- AA are precursors for the synthesis of active molecules

- cytotoxic compounds
- antioxidant compounds

Cys, Arg

AA and health: nutritional consequences

- AA are essential for body defenses
 - ➔ AA dietary supply may contribute to support body defenses and immune capacity
- AA are less available for performance (growth ...)
 - ➔ AA dietary supply may contribute to support performance when health status is not optimum

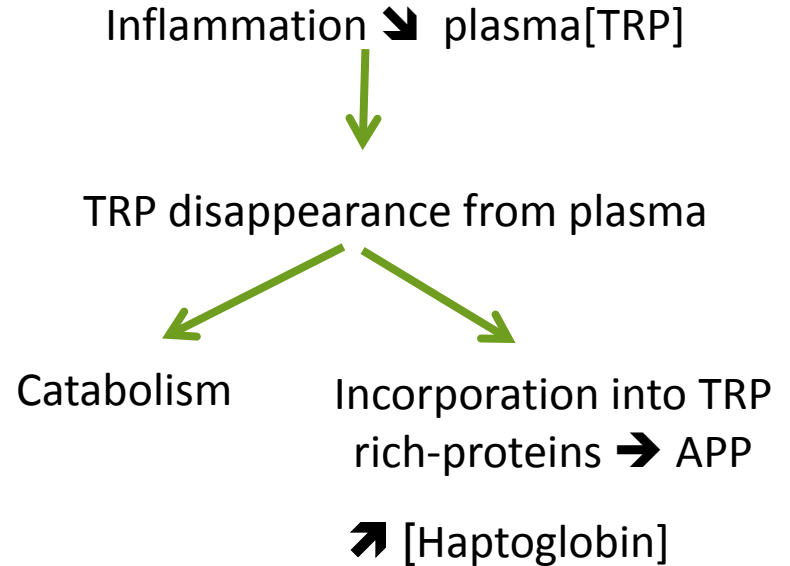
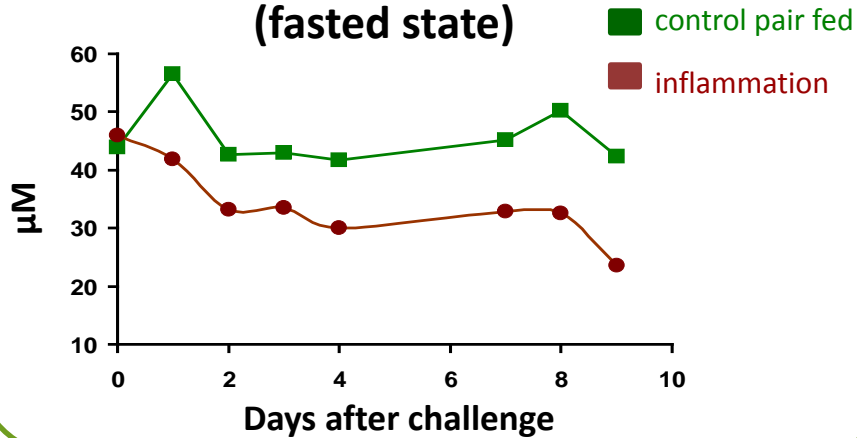
Effect of a chronic lung inflammation on TRP metabolism



lung inflammation induced by IV CFA* injection

Melchior et al 2004

plasma TRP concentrations
(fasted state)



* CFA : complete Freund's adjuvant

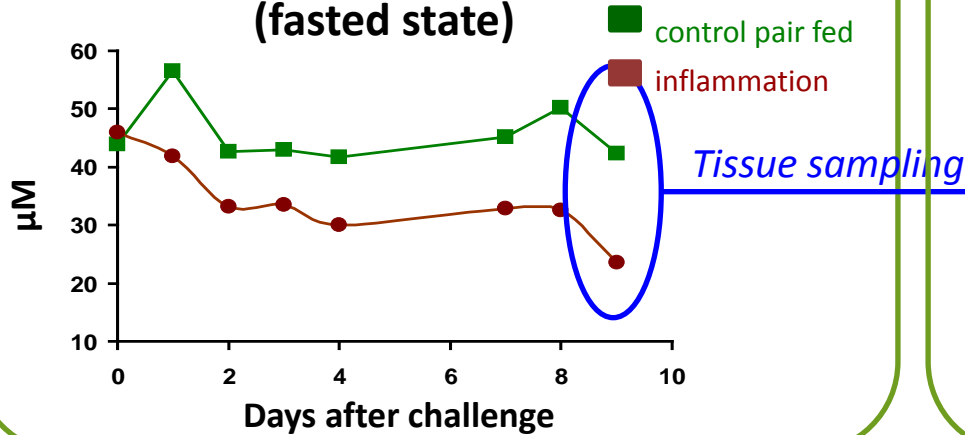
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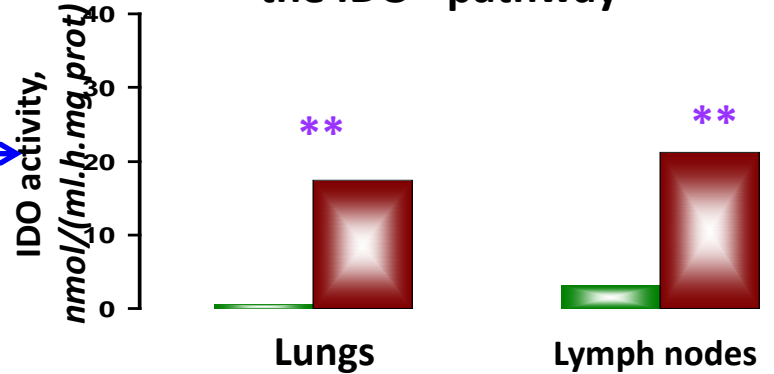
lung inflammation induced by IV CFA injection

Melchior et al 2005

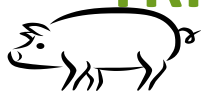
plasma TRP concentrations
(fasted state)



↑ TRP catabolism through
the IDO* pathway



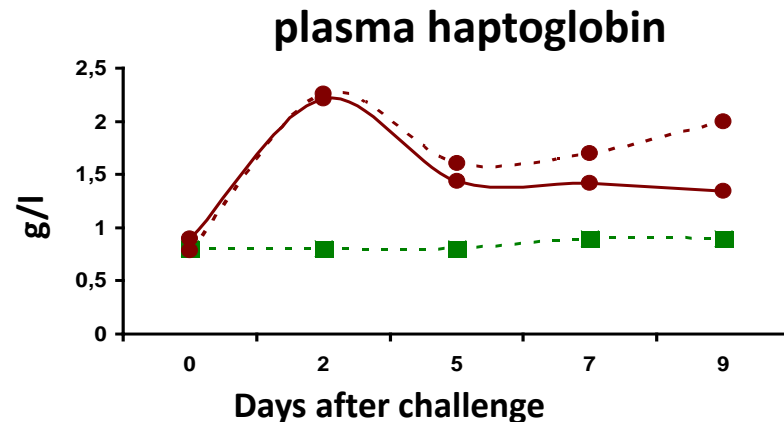
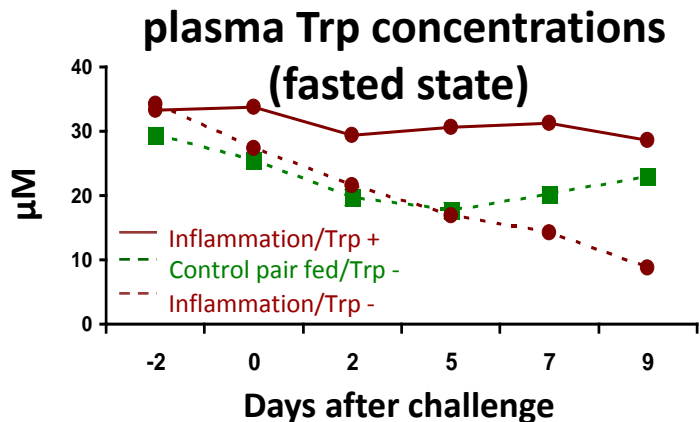
* IDO indoleamine 2,3 dioxygenase



TRP supply alleviates the effect of lung inflammation

Le Floc'h et al 2008,

lung inflammation induced by IV CFA injection

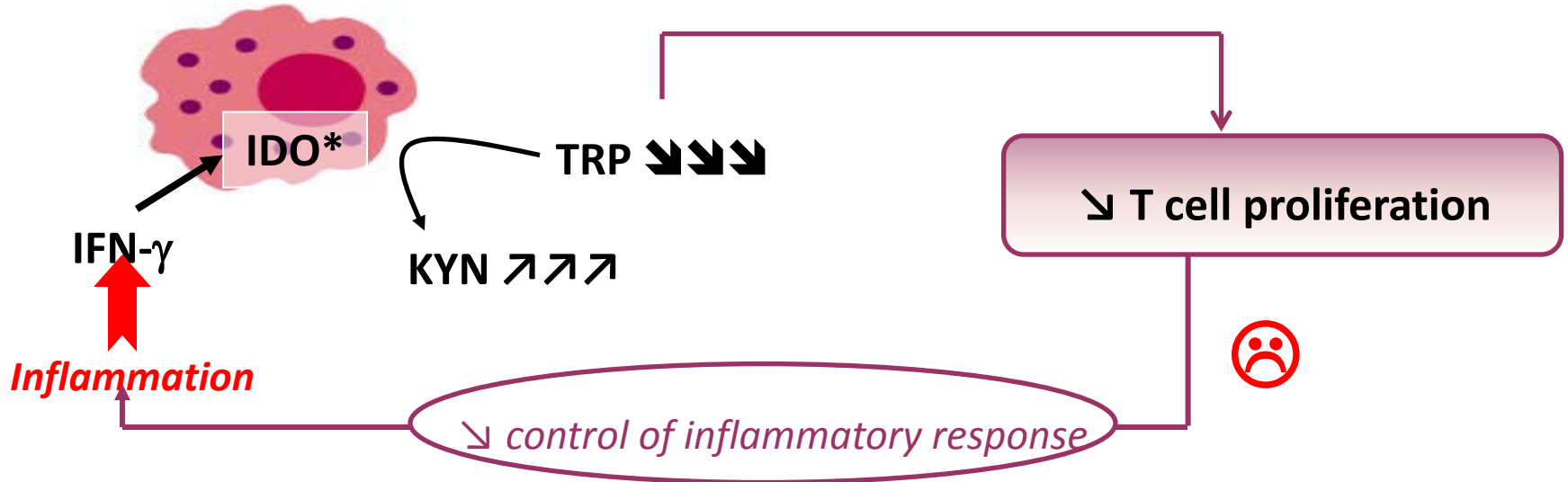


TRP supply above recommendations maintains TRP plasma concentrations and limits the inflammation

How TRP could be involved in the control of inflammation

Mellor & Munn, 2003

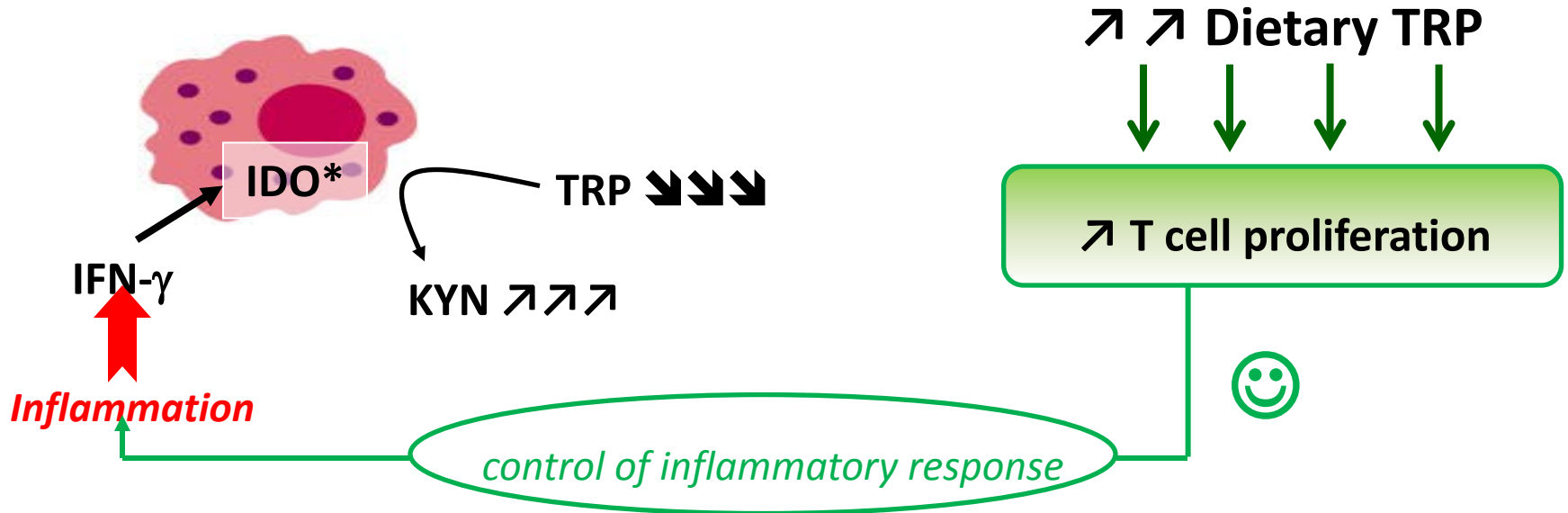
Catabolism of TRP by immune cells



How TRP could be involved in the control of inflammation

Mellor & Munn, 2003

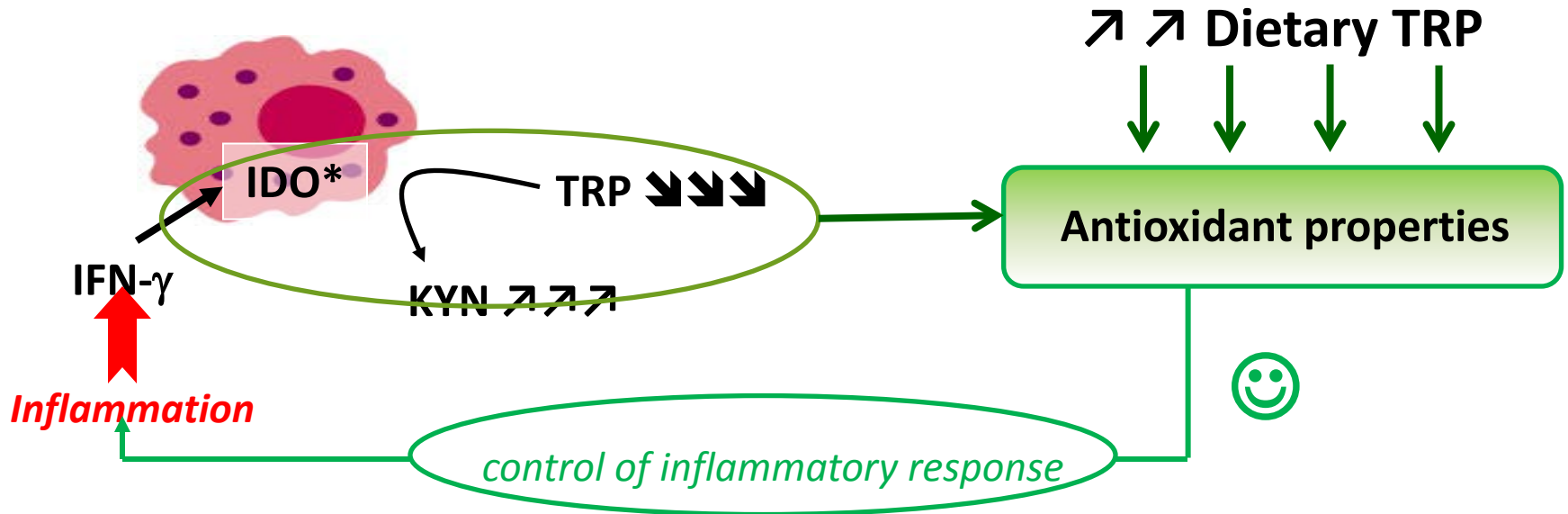
Catabolism of TRP by immune cells



How TRP could be involved in the control of inflammation

Mellor & Munn, 2003

Catabolism of TRP by immune cells



Impact of TRP dietary supply on parameters related to health

- TRP above recommendations (0.30 vs 0.18%) ↘ oxidative stress induced by diquat* injection in piglets :

- ↗ antioxidant SOD* and GPx* in the liver and ↘ plasma MDA*

Mao et al 2014

- ↘ plasma urea

- did not attenuate the effect of oxidative stress on growth performance

** Diquat : an herbicide known for inducing oxidative stress; SOD and GPx are antioxidative enzymes and MDA is a biomarker of oxidative stress*

- TRP above recommendations (0.24 vs 0.74%) ↘ the impact of weaning stress :

- ↘ salivary cortisol response

- maintains gut morphology

Koopmans et al 2006

- TRP supplied intragastrically reduced colitis lesions caused by DSS* in neonatal piglets

- ↘ local inflammatory response

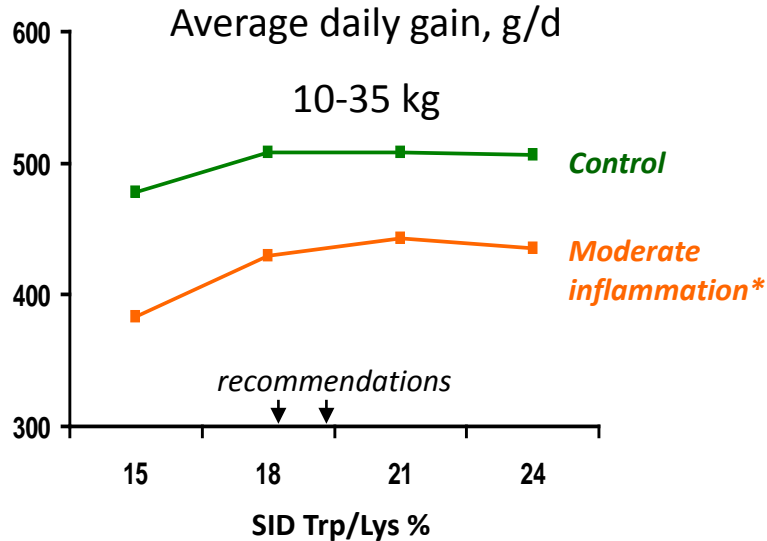
- healthier pigs (less severe diarrheas)

Kim et al J 2010

** Dextran sodium sulfate*

Growth rate of pigs in good and poor hygiene conditions : effect of Trp level

Le Floc'h et al 2010



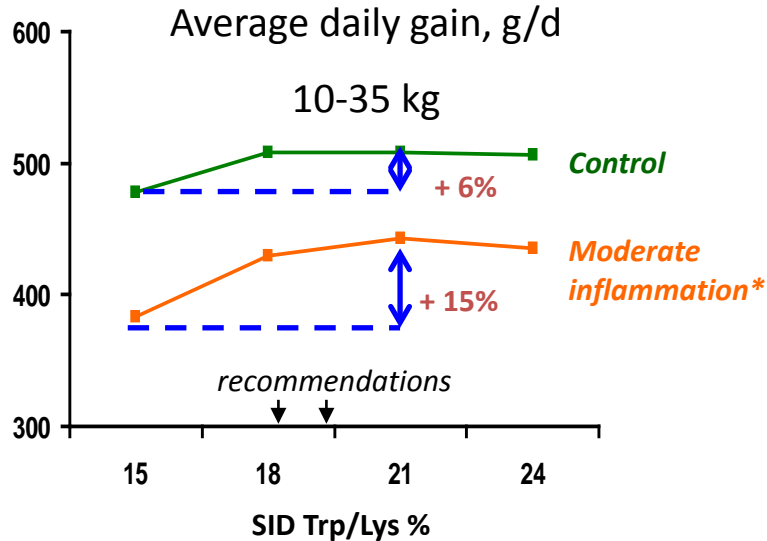
In pigs suffering from inflammation :

- ↗ Trp : no growth restoration

* Inflammation caused by low hygiene of housing

Growth rate of pigs in good and poor hygiene conditions : effect of Trp level

Le Floc'h et al 2010



In pigs suffering from inflammation :

- ↗ Trp : no growth restoration
- greater impact of low TRP supply on growth rate
→ greater response of growth to additional TRP

* Inflammation caused by low hygiene of housing



Conclusions (1)

Preserving health of farm animals : What is expected from feed and nutrition?

- *strategies for health preservation with less medication*
- *strategies for limiting the consequences of poor health status on performance*



Conclusions (2)

From a research perspective

- ✓ The interactions between feed and health are numerous, diverse and complex

- ✓ New knowledge are still necessary
 - Role of digestive microbiota
 - Knowledge on nutrient functions beyond performance
 - ...



Conclusions (2)

From a research perspective

- ✓ The next step :
 - physiologic response
 - changes in the microflora profile
 - gene expression ...

} → *Animal health :
an integrated
response*



Conclusions (3)

From on-farm use perspective

- ✓ Some limitations are still to overcome
- ✓ **When** feed formulation and feeding practices could be adapted to preserve both health and performance
 - in a preventive way → identification of sub limiting nutrients
 - in a curative way → problem of low feed intake
 - to support compensatory performance



Conclusions (3)

From on-farm use perspective

- ✓ **How** feed formulation and feeding practices could be adapted to preserve both health and performance
 - group of individuals (critical phase) vs individual in a group



Conclusions (3)

From on-farm use perspective

- ✓ What could be expected from **Precision Livestock Farming** :
 - the challenge of (early) detection of health disturbances : *cough and lameness detection (Berkmans 2014), changes in feeding behavior (Maselyne et al 2015), drinking behavior (Cornoue et al 2013)*
 - Feed the group or the individual through precision feeding (*Andretta et al 2014*)



Conclusions (3)

From on-farm use perspective

- ✓ Feed should be associated to other management strategies

What is ongoing? An example



An European project dedicated to production diseases* in intensive pig and poultry production systems



Leader : University of Newcastle (I Kyriazakis)
22 partners - 2014-2018

Production diseases* : multifactorial diseases in which genetics, environment (housing, nutrition, management) and pathogenic challenge show complex interactions

- To develop our understanding of the underlying physiological and metabolic mechanisms in interaction with the genotype (bone health, inflammatory response, digestive disorders) and housing conditions (sows)
- To test nutritional strategies to overcome the impact of these diseases

Many thanks to my colleagues:

Ludovic Brossard

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Florence Garcia-Launay

Lucile Montagne

Isabelle Oswald

Any questions?

http://www6.rennes.inra.fr/pegase_eng/

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