Impact of nutrition on nitrogen, phosphorus and trace elements in pig manure and emissions in the air

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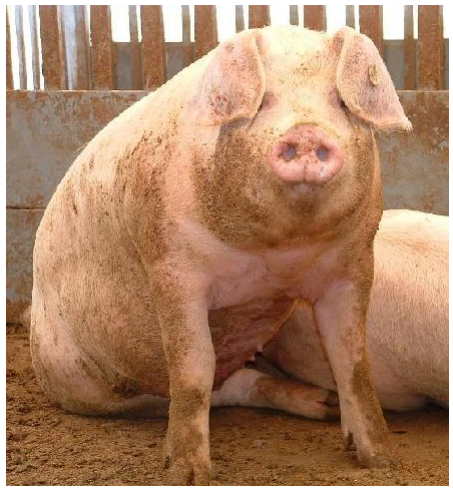
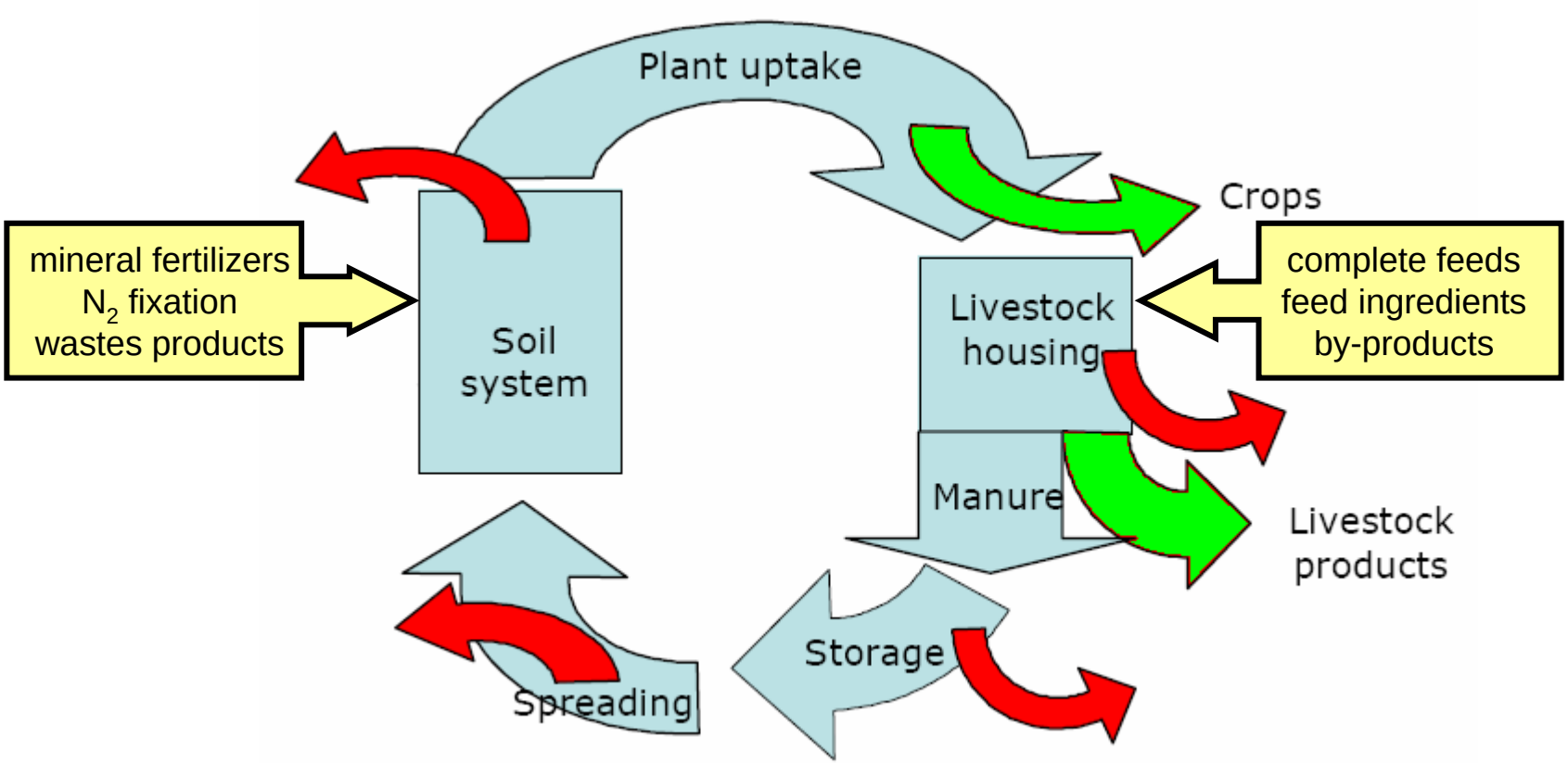
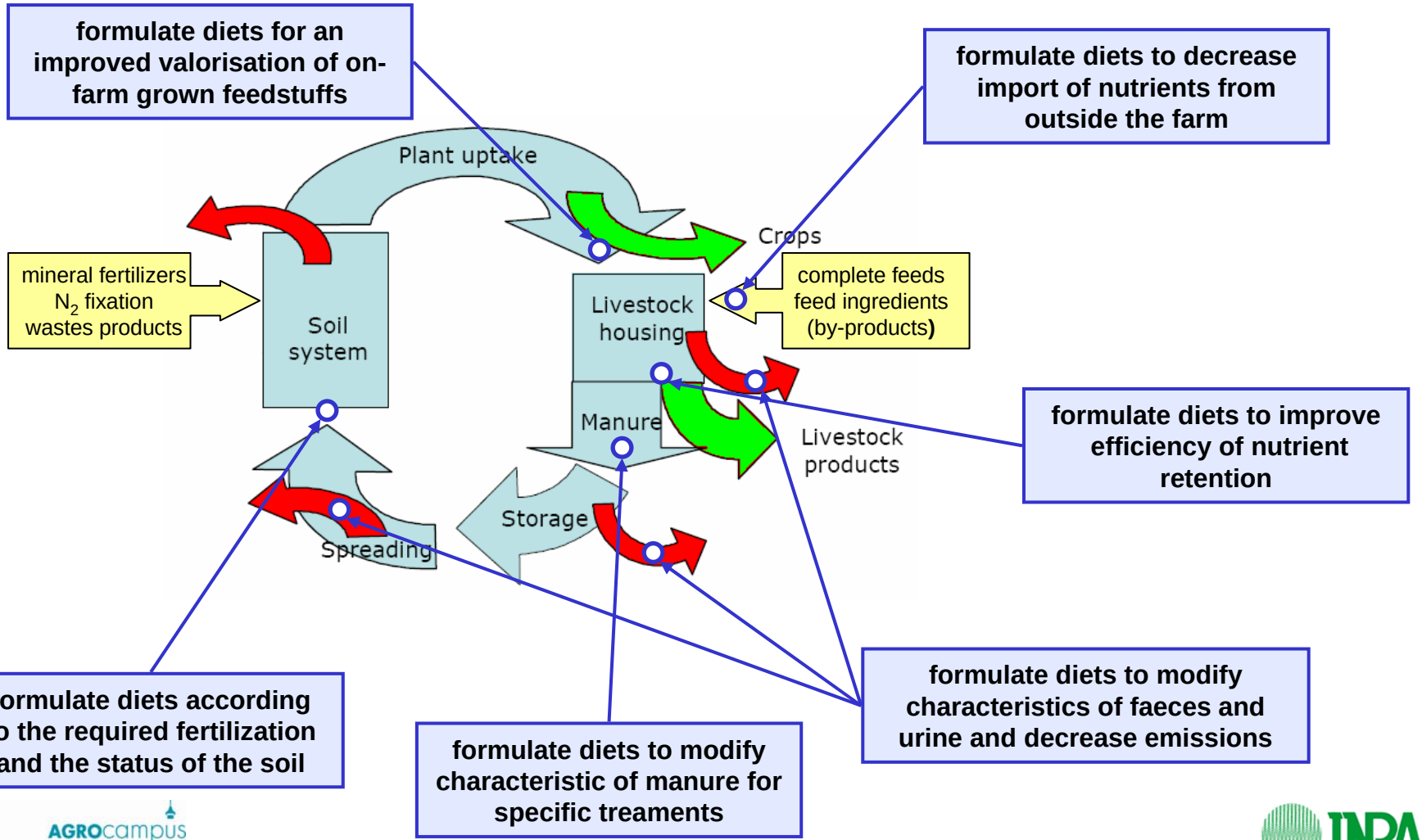


Nutrient flow on a livestock farm



Petersen et al., 2006

Impact of animal nutrition on nutrient flow at farm level



Effect of nutrition on nutient flow in pig production

- **Must be considered first at farm level**
  - solutions depends on intensity of pig production relatively to the area available for manure spreading
- **Implication of animal nutrition**
  - control the flow of nutrients entering the farm
    - better use of on-farm grown feed ingredients
    - improvement of efficiency of nutient utilisation
    - alternative formulation practices
      - use of industrial AA instead of proteins
      - use of phytase instead of phosphorus ...
  - modify the characteristics of faeces and urine excreted in oder to limit emissions in the air

Effect of nutrition on nutient flow in pig production

- **Reduction of excretion of nitrogen**
- **Reduction of gazeous losses**
- **Effect of feeding on odors**
- **Reduction of excretion of phosphorus**
- **Reduction of excretion of trace elements**

Effect of nutrition on nutient flow in pig production

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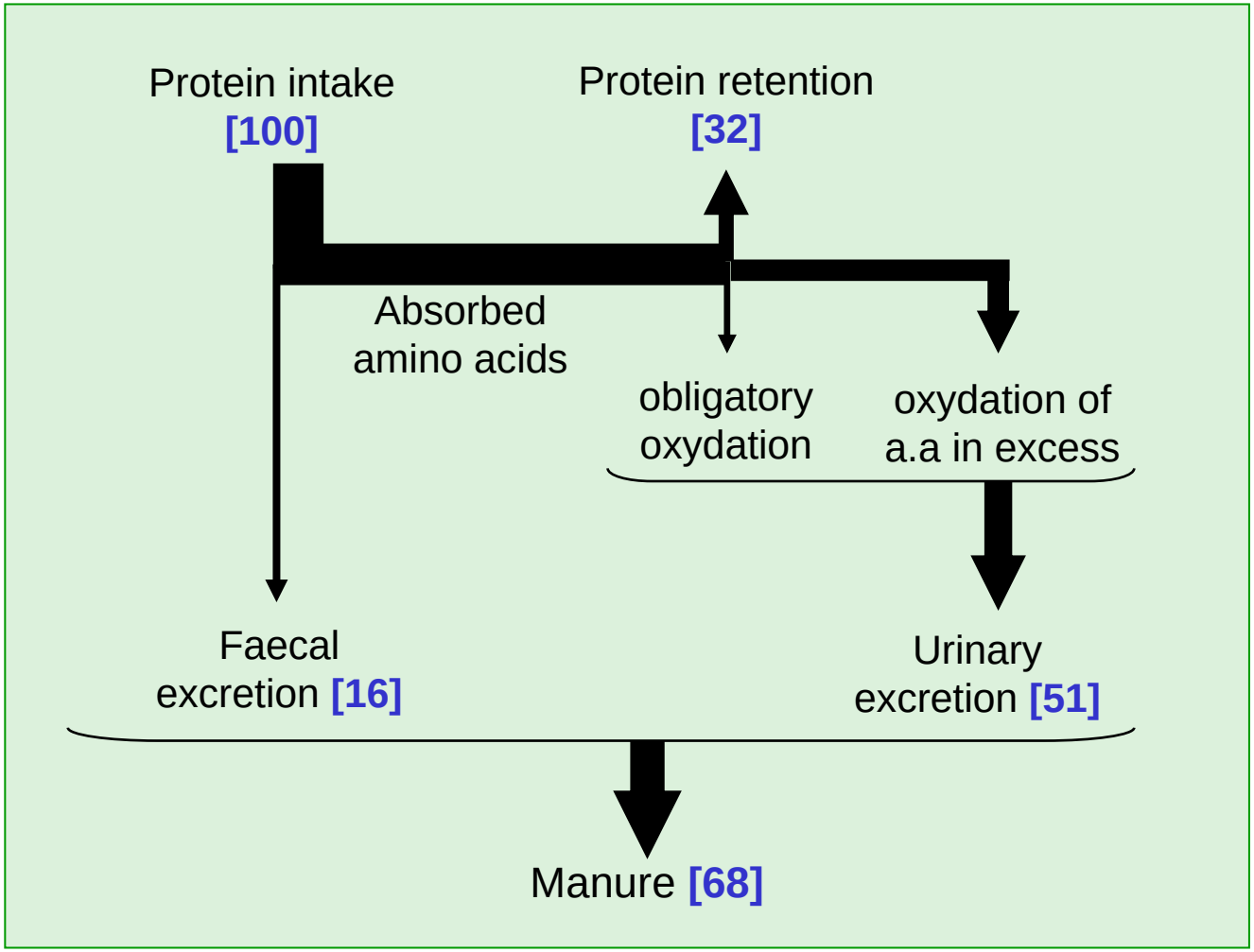
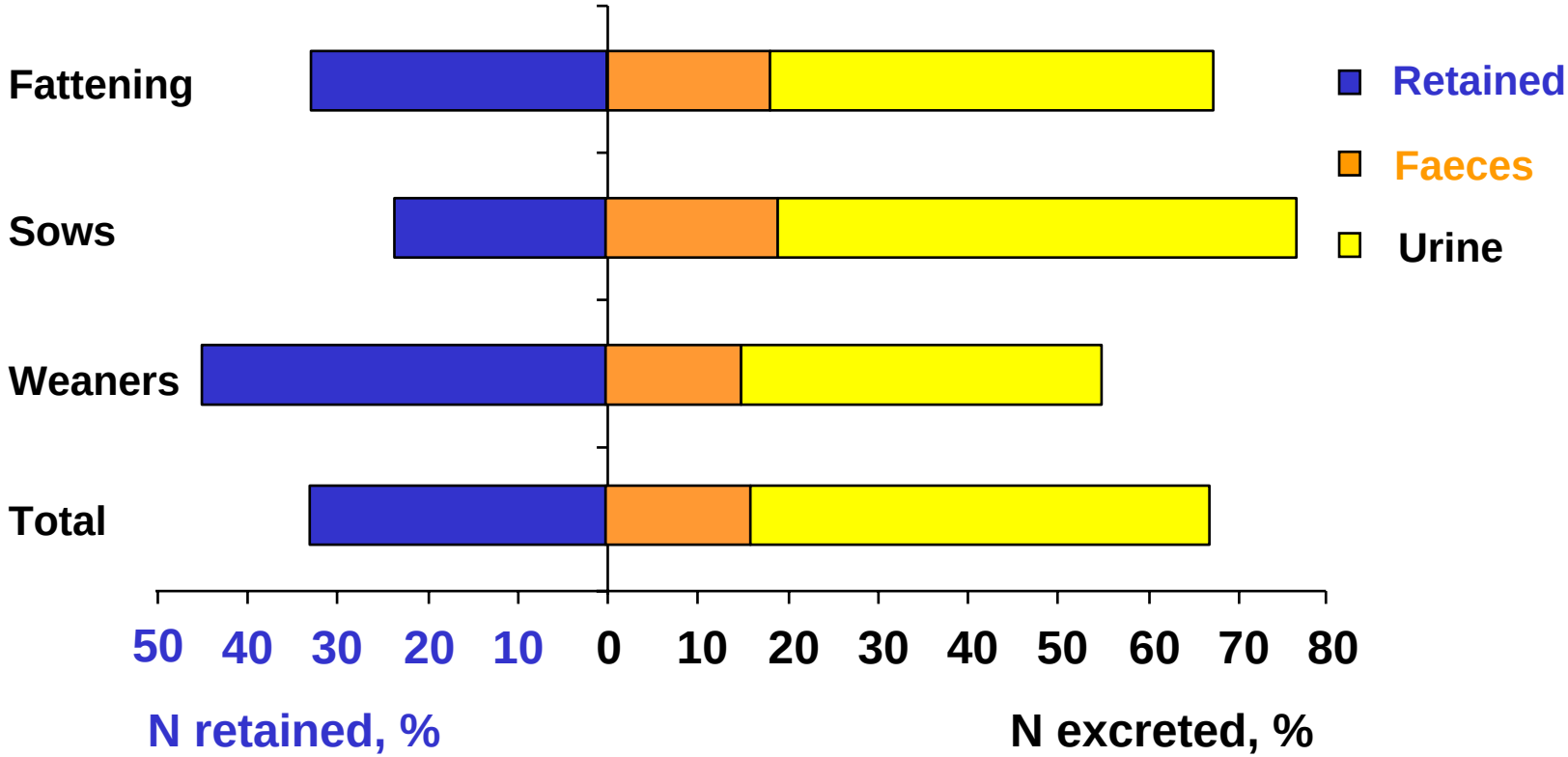
Efficiency of N utilization in growing pigs



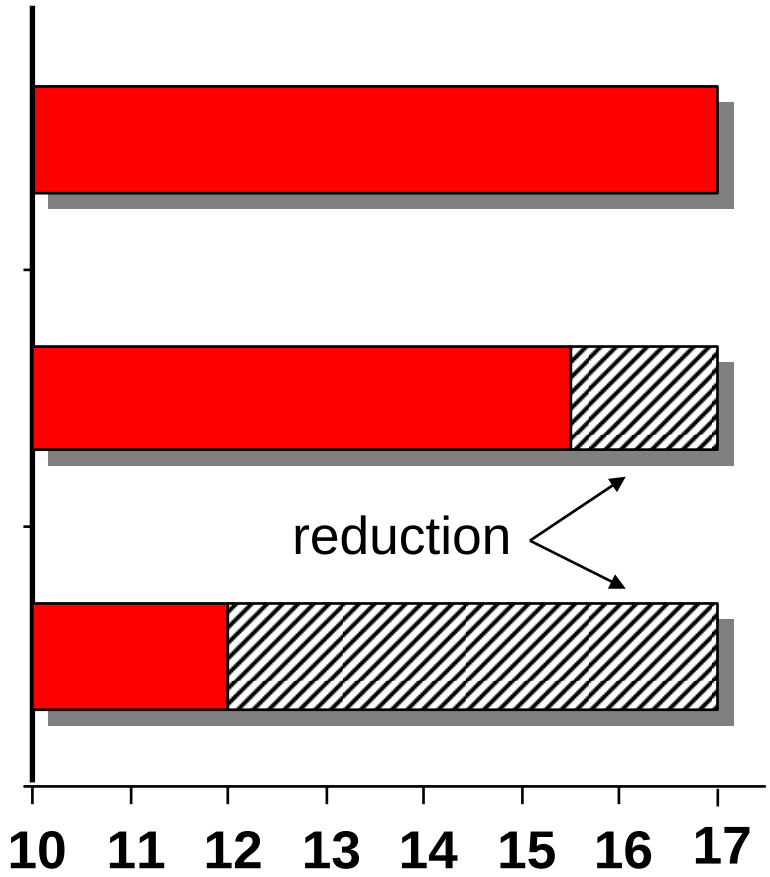
Efficiency of N utilization in different types of pigs



Improving efficiency of N utilization : a better fitting of protein supply to the requirements

- **Improvement of amino acid balance**
  - **Adequate choice of feed ingredients**
  - **Use of industrial amino acids**
  - ⇒ **Requires a precise knowledge of ideal amino acid profile of protein requirement**
- **Improvement of the feeding strategy**
  - Change the composition of the diet according to growing stage or physiological status
  - ⇒ Requires a precise knowledge of changes in amino acid requirements over time

Improvement of amino acid profile in a cereal soybean meal diet for growing pigs (30 kg BW)



17.0% CP

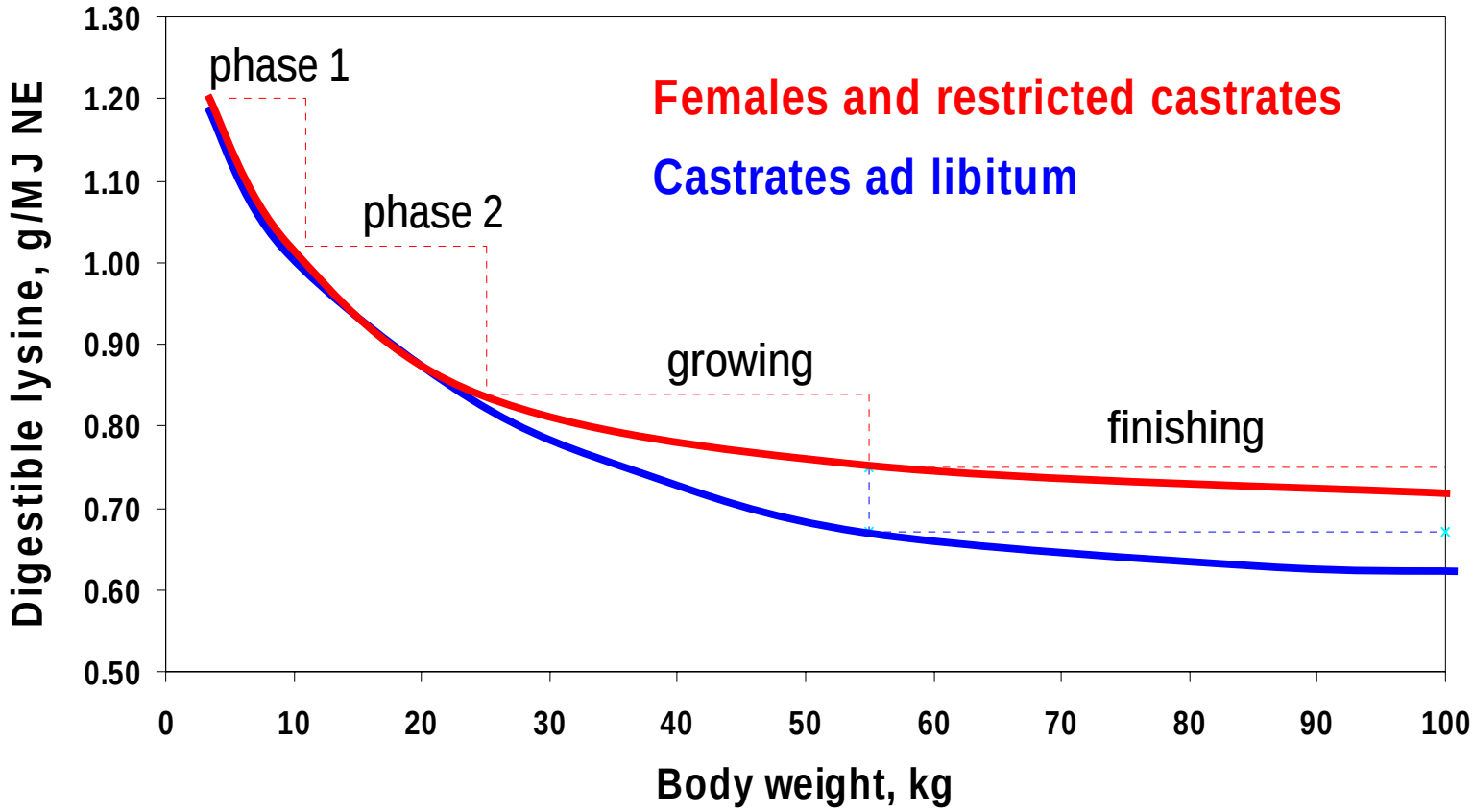
15.5% CP
lysine supplementation

12.0% CP
lys. + threo. + meth. + tryp.

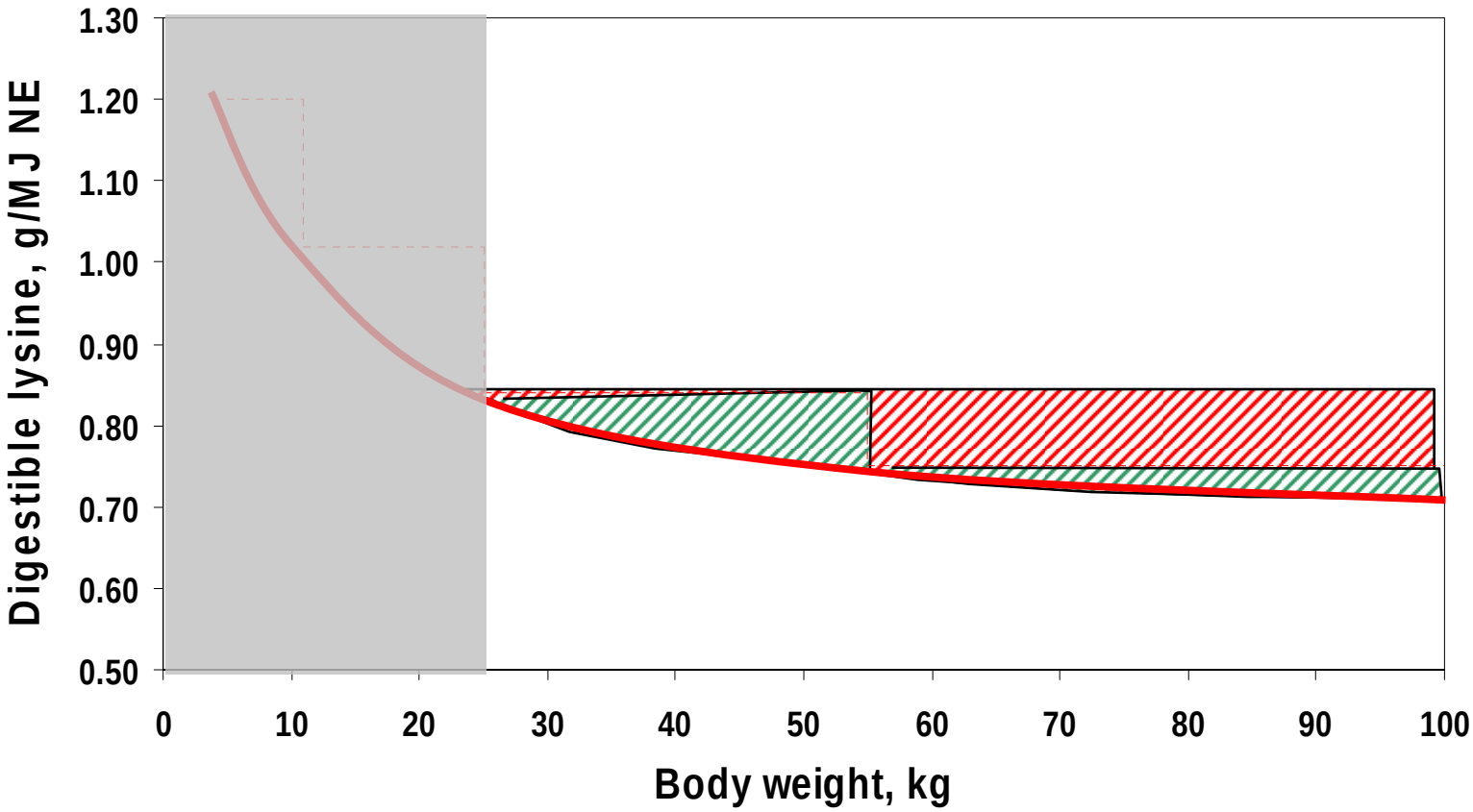
Improving efficiency of N utilization : a better adjustment of protein supply to requirements

- Improvement of amino acid balance
  - Choice of feed ingredients
  - Use of industrial amino acids
  - ⇒ Requires a precise knowledge of ideal amino acid profile in the protein requirement
- **Improvement of feeding strategy**
  - **Change the composition of the diet according to growing stage or physiological status**
  - **⇒ Requires a precise knowledge of changes in amino acid requirement over time**

Changes in lysine requirement of growing pigs according to their body weight



Changes in lysine requirement of growing-finishing pigs according to their body weight

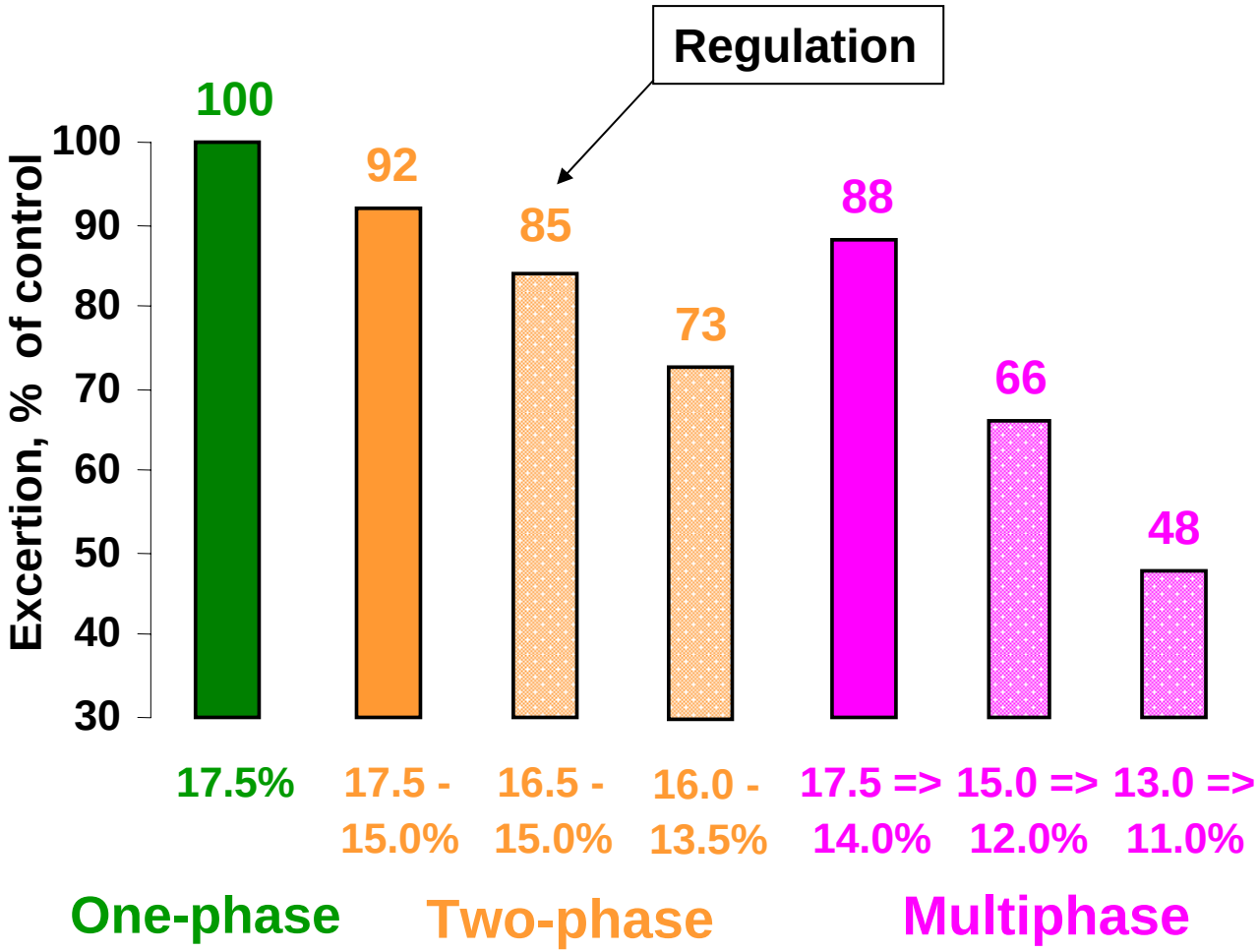


Effect of phase feeding of growing-finishing pigs on N excretion in the slurry

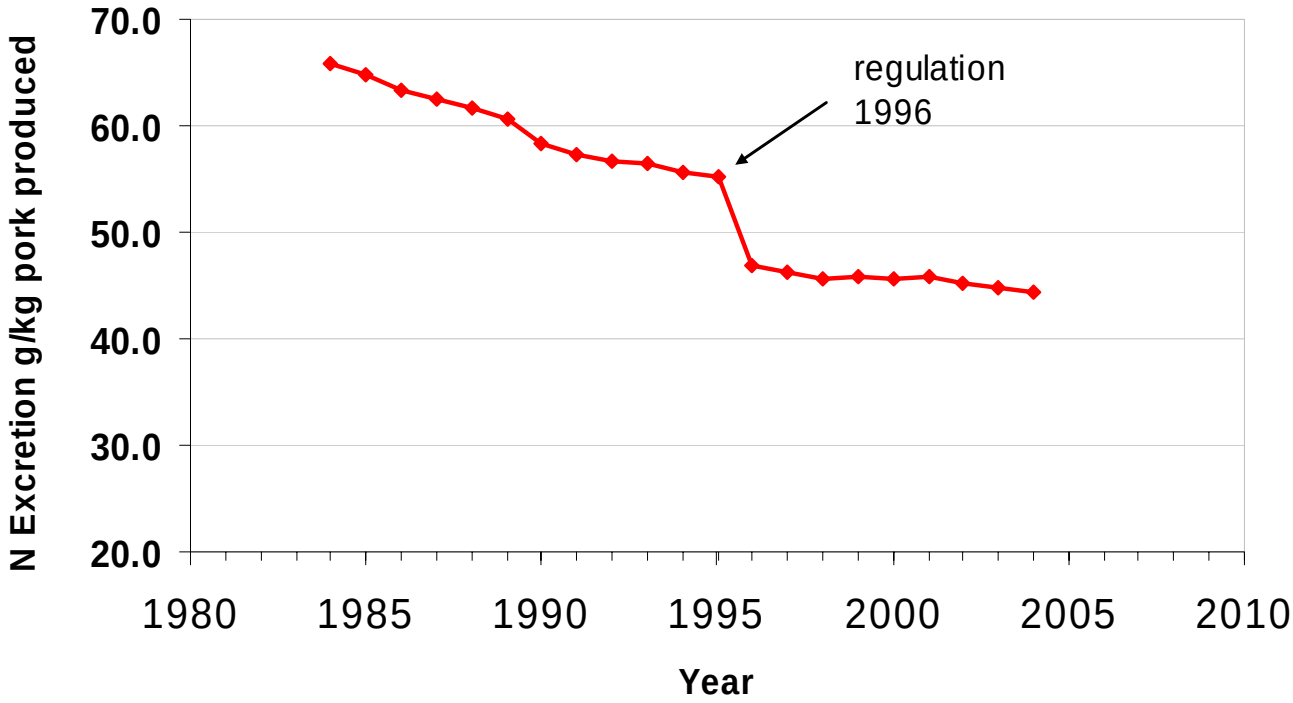
	One phase	Two phases
Protein quality	*normal*	*normal*
CP, % Growing	17.8	17.8
Finishing	17.8	15.4
ADG, g/d	781	795
FCR, kg/kg	2.93	2.89
N slurry, %	0.84	0.78
N slurry, kg/pig	2.85	2.64
	(100)	(92)

Latimier and Dourmad, 1993

Effect of phase feeding and protein quality on N excretion by fattening pigs



Evolution of average N excretion per kg pork produced in france



Effect of nutrition on nutient flow in pig production

- Reduction of excretion of nitrogen
- ✓ Reduction of gazeous losses
- Effect of feeding on odors
- Reduction of excretion of Phosphorus
- Reduction of excretion of trace elements

Reduction of volatilisation of N compounds

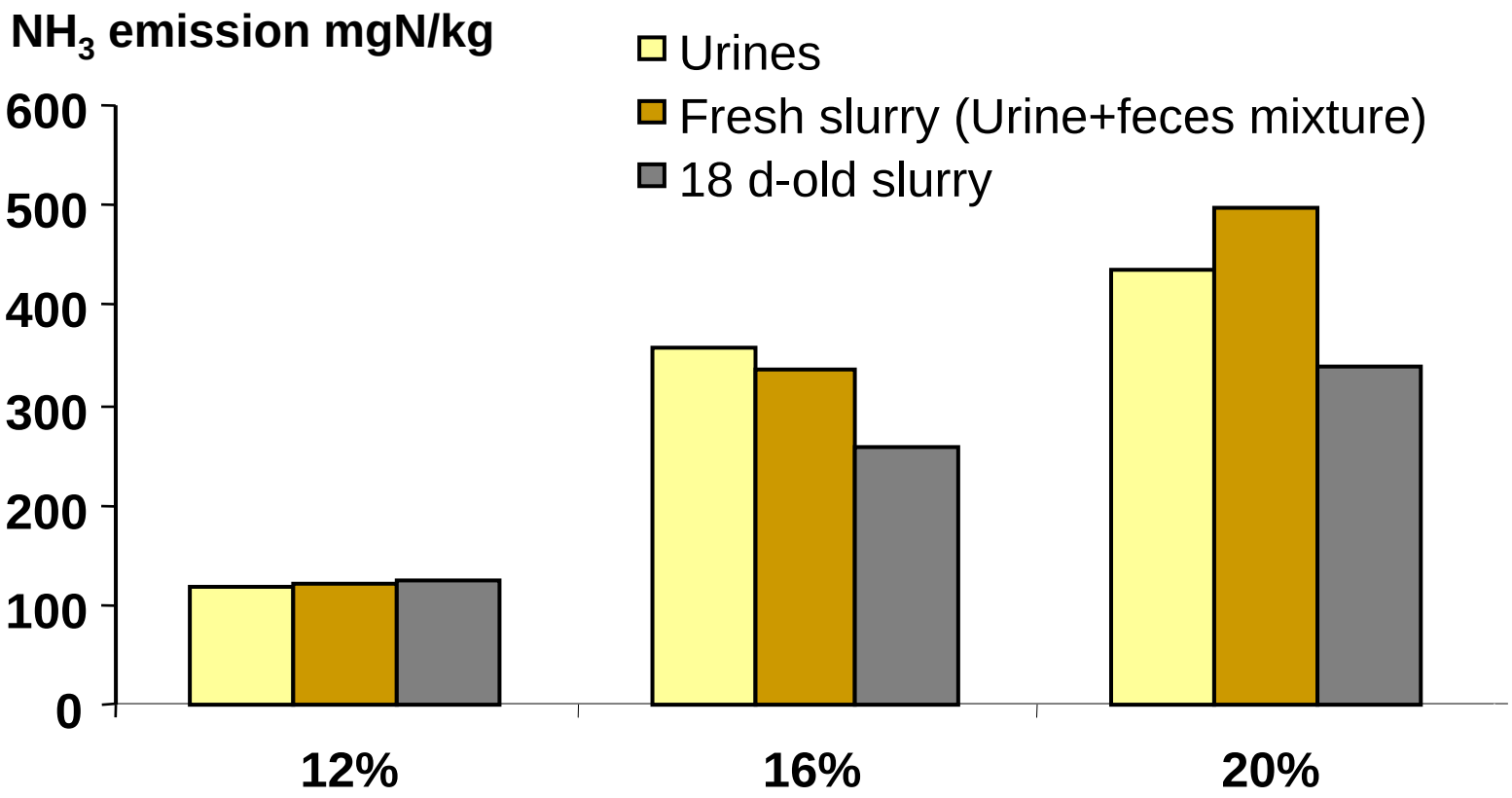
- **Factors affecting emissions (liquid slurry)**
  - **[NH_3] , pH, air renewal, type of floor…**
  - **⇒ Can be manipulated through feeding**
    - **CP content => [NH_3] and pH**
    - **Electrolyte balance ($Na^+ + K^+ - Cl^- - S^-$) => affect urinary pH**
    - **Supplementation with acids or salts => affect urinary pH**
    - **Addition of NSP => production of VFA => affect pH**

Effect of CP on slurry characteristics and ammonia volatilisation in fattening pigs

	Dietary crude protein content		
	20%	16%	12%
Slurry composition			
Amount, kg/d	5.7	5.1	3.6
DM, %	4.4	4.6	5.9
Total Kjeldahl N (g $N.kg^{-1}$)	5.48	4.30	3.05
Ammoniacal N (g $N.kg^{-1}$)	4.32	3.13	1.92
pH	8.92	8.61	7.57
N balance (g.pig^{-1}.d^{-1})			
Retention	23.2	23.5	21.9
Excretion	40.7	27.6	15.0
Ammonia volatilization	17.4	13.8	6.4
Soil (available for plants)	23.3	13.8	8.6

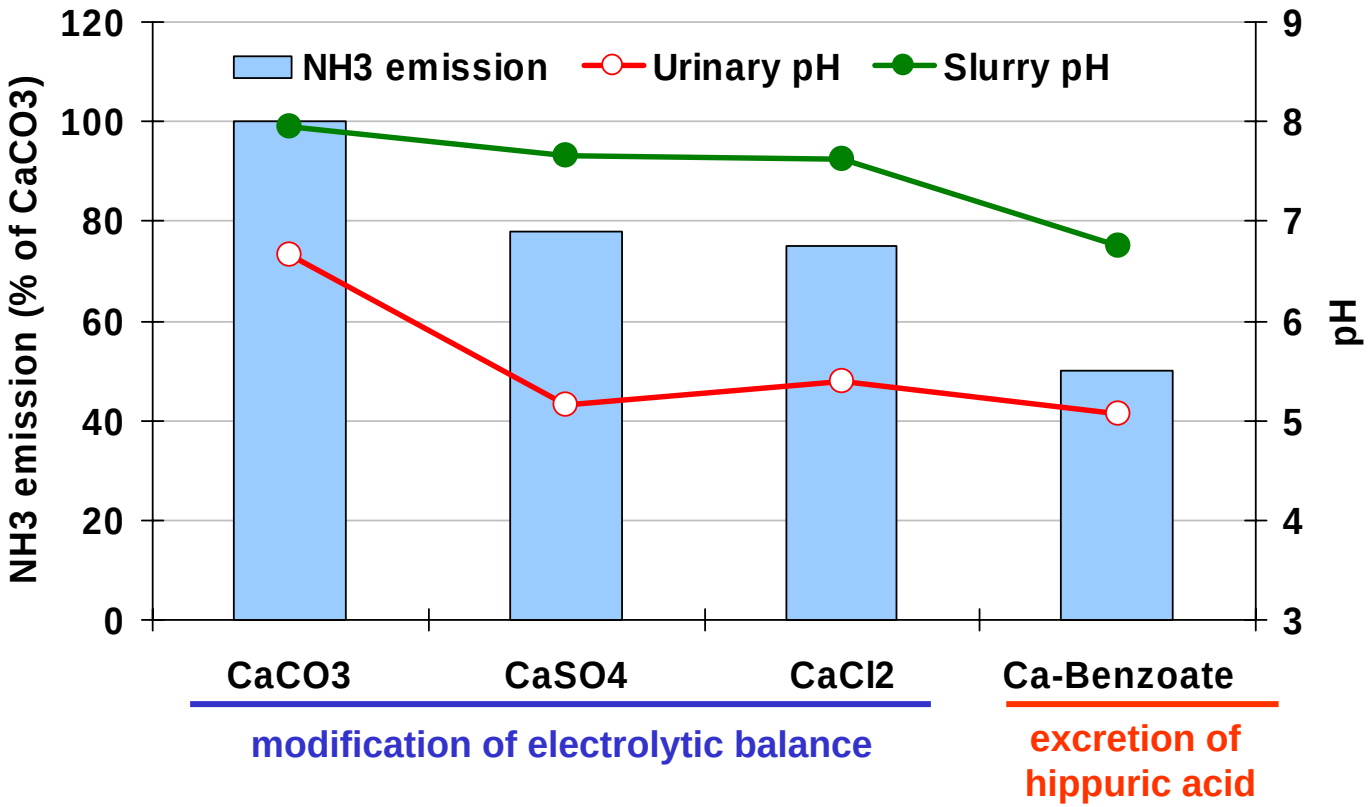
Portejoie et al., 2005

Effect of dietary CP on NH_3 volatilization measured in a laboratory pilot system



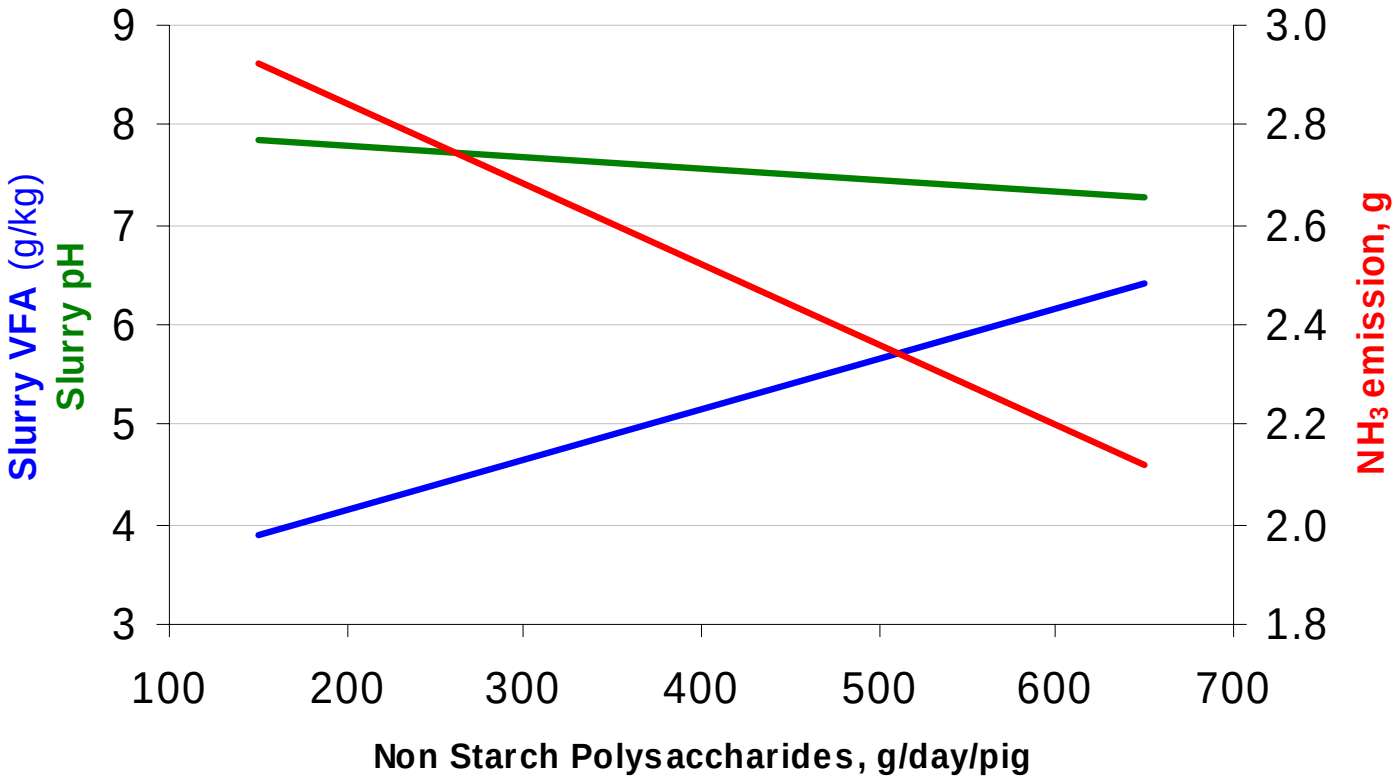
Portejoie et al., 2005

Effect of calcium salts on urinary pH, slurry pH, and ammonia volatilization



Canh et al., 1998

Effect of dietary carbohydrates (NSP) on slurry pH and ammonia volatilization



Canh et al., 2000

Effect of nutrition on nutient flow in pig production

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- ✓ **Effect of feeding on odors**
- **Reduction of excretion of Phosphorus**
- **Reduction of excretion of trace elements**

Effect of feeding on odours

- **Few studies on the effect of diet manipulation on odours**
  - **difficulty to objectively assess odours**
- **Some promising results**
  - **low protein diet reduce both ammonia and odours (Hobbs et al., 1996; Hayres et al., 2004)**
  - **In the study of Moeser et al. (2003)**
    - **worst odours associated with diets high in sulphur**
    - **most pleasent odors associated with semi-purified diets (starch & casein)**
- **More research in needed on the mechanisms involved in odours production**

Effect of nutrition on nutient flow in pig production

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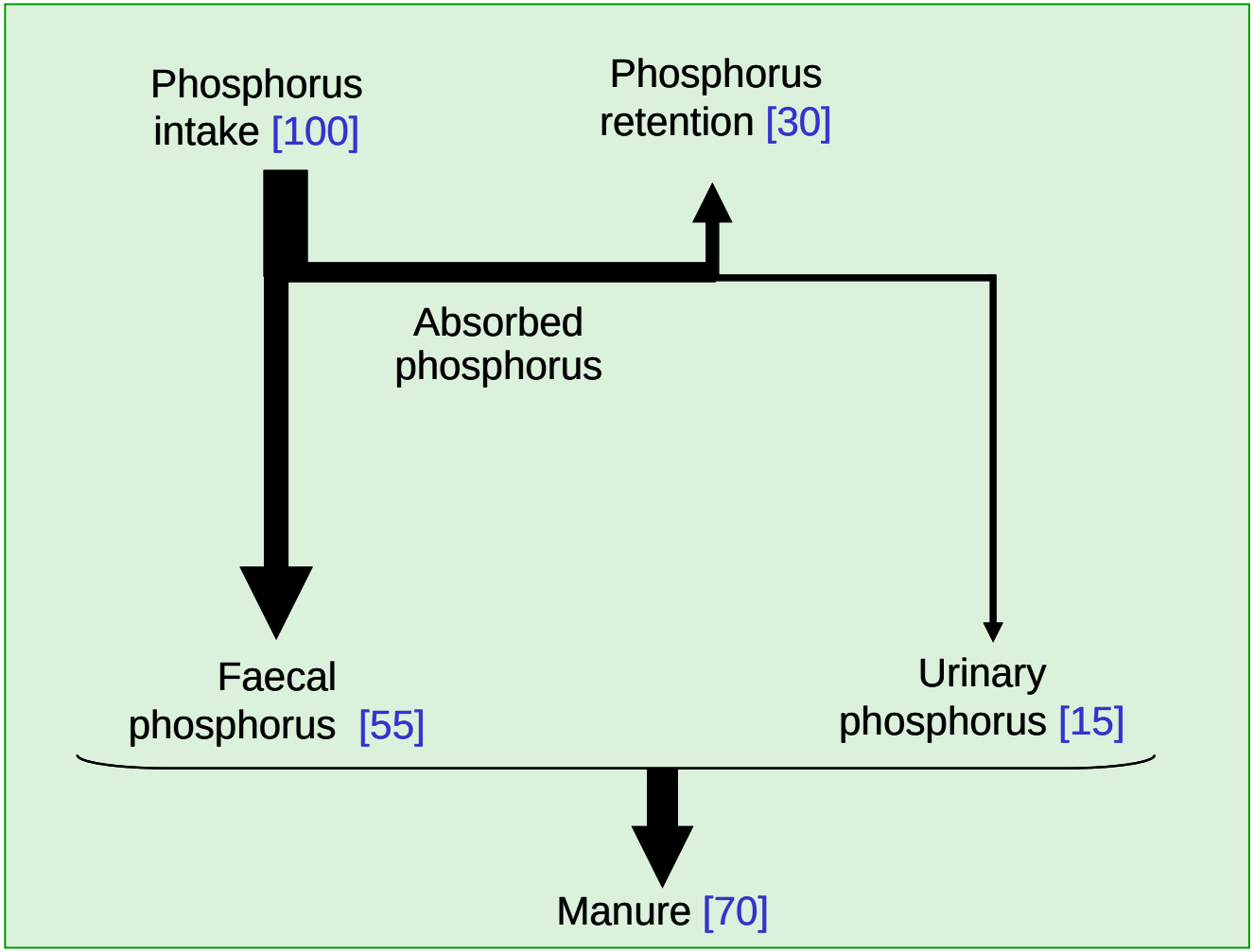
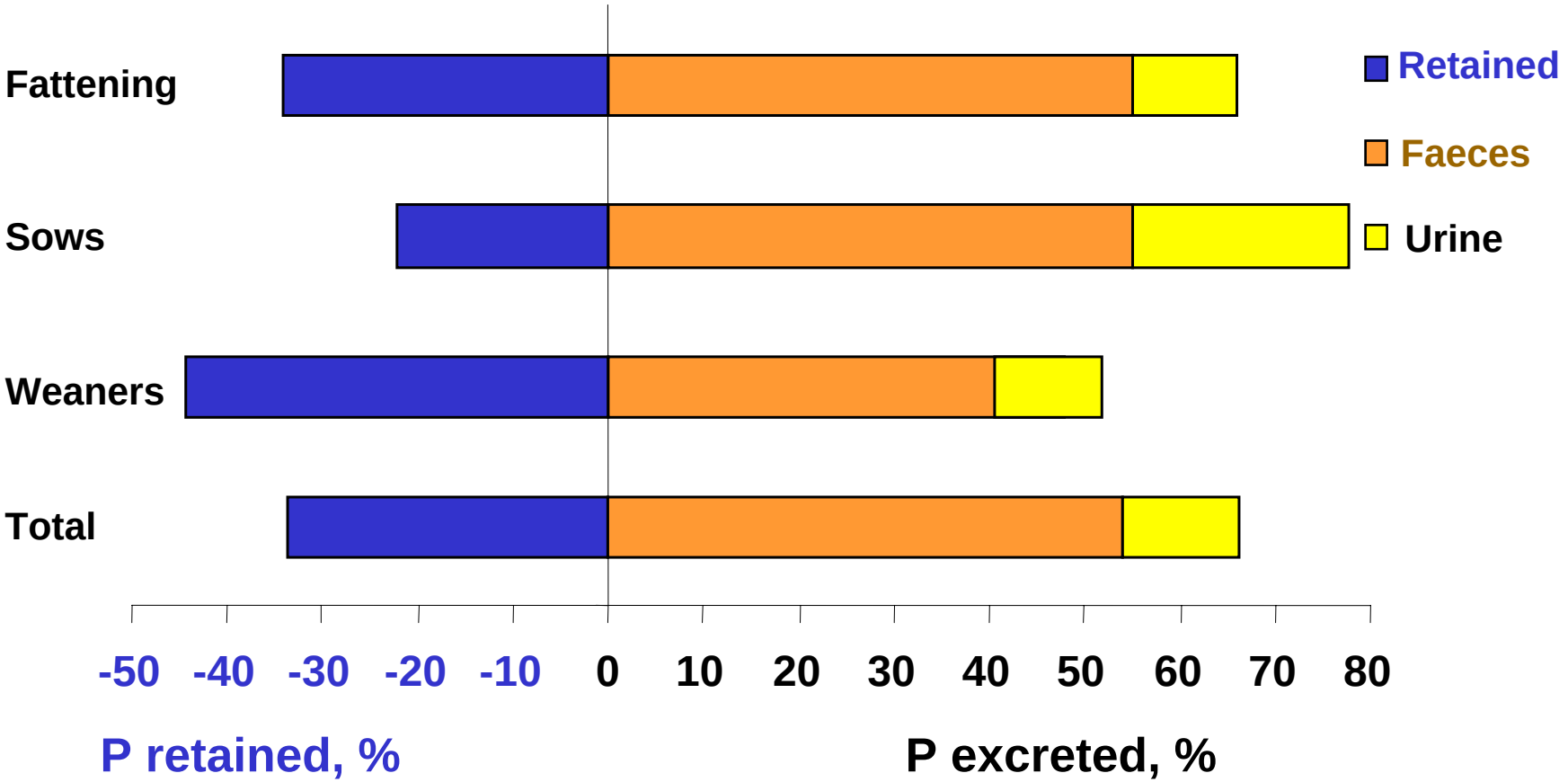
Efficiency of P utilization in growing pigs



Efficiency of N utilization in different types of pigs



Strategies and knowledge required to reduce P excretion in manure

- **Strategies**
  - Better adjustment of P supply to P requirement
  - Improved P digestibility in diets fed to pigs
- **Scientific knowledge**
  - Evaluation of P value of feedstuffs and diets
  - Ways to improve dietary P digestibility
  - Precise estimation of P requirements

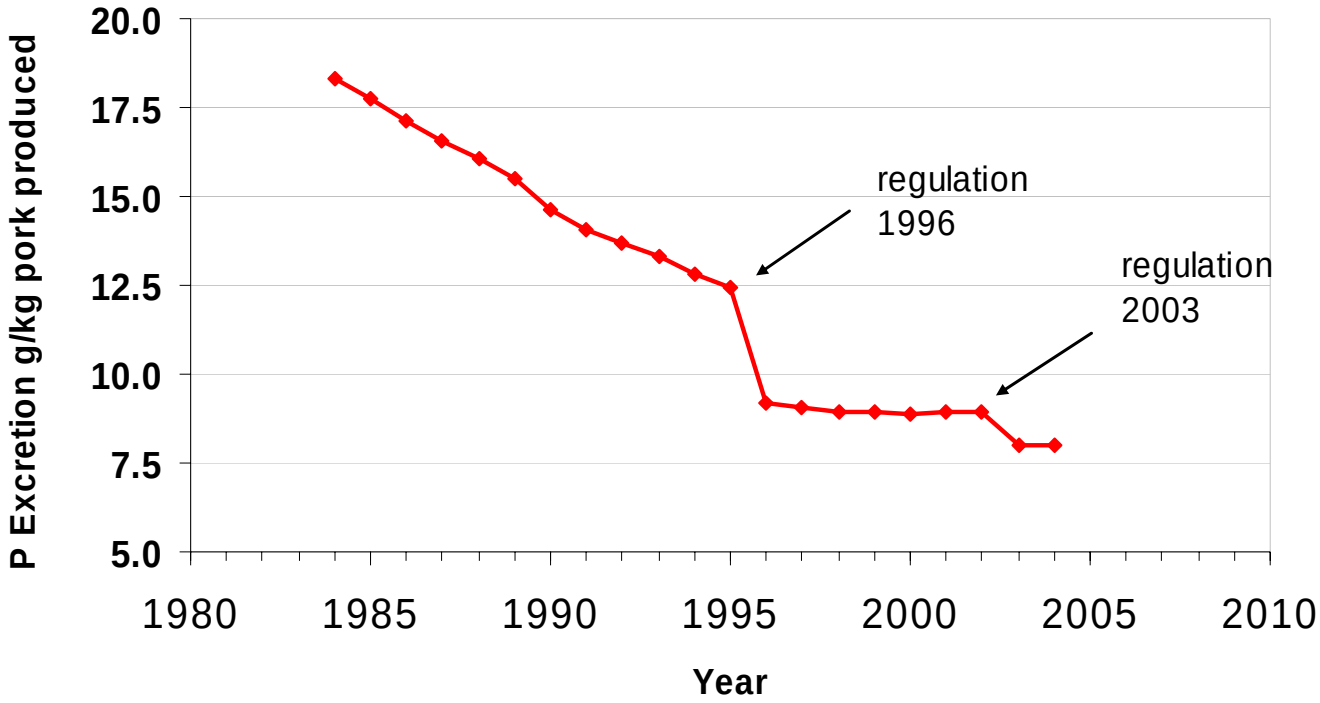
Evaluation of P value in feedstuffs and diets

- **In the past**
  - **total P content**
  - **high security margin for requirements**
- **New systems**
  - **"apparent digestibility" (CVB, 2000; INRA-AFZ, 2004)**
    => measured values
  - **"relative bio-availability" or "relative biological value" (NRC, 1998)**
    => expressed as a percentage of a reference (mono-calcium P or monosodium P)

Improving P digestibility of pig diets

- **Use of highly digestible phosphates**
- **Improve phytate P digestibility**
  - ***GMO pigs expressing salivary phytase***
  - **Low phytate cultivars (maize, barley)**
  - **Phytase**
    - **Endogenous phytases**
    - **Microbial phytase**

Evolution of average P excretion per kg pork produced in france



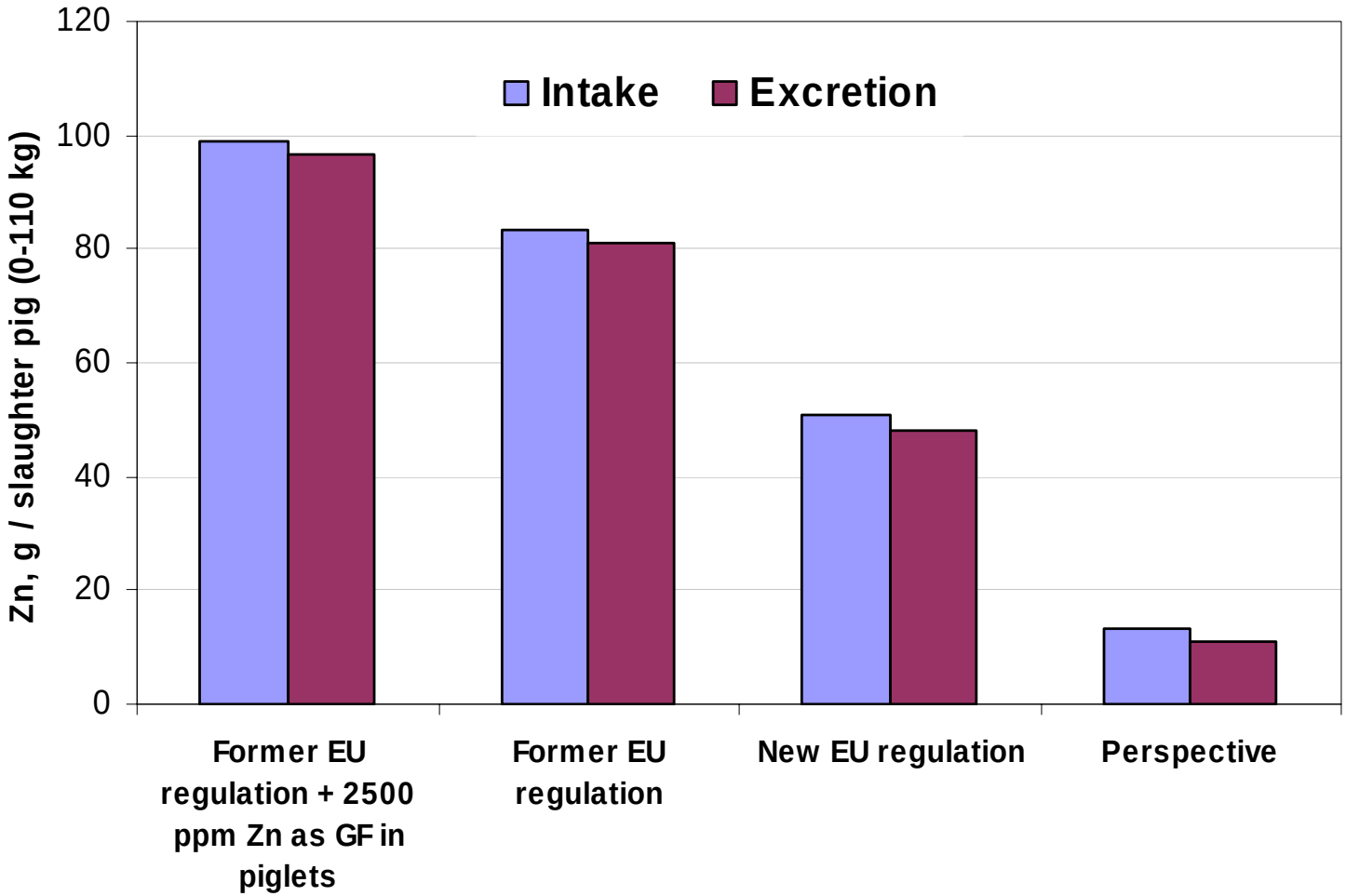
Effect of nutrition on nutient flow in pig production

- Reduction of N excretion
- Reduction of gazeous losses
- Effect of feeding on odours
- Reduction of excretion of Phosphorus
- ✓ **Reduction of excretion of trace elements**

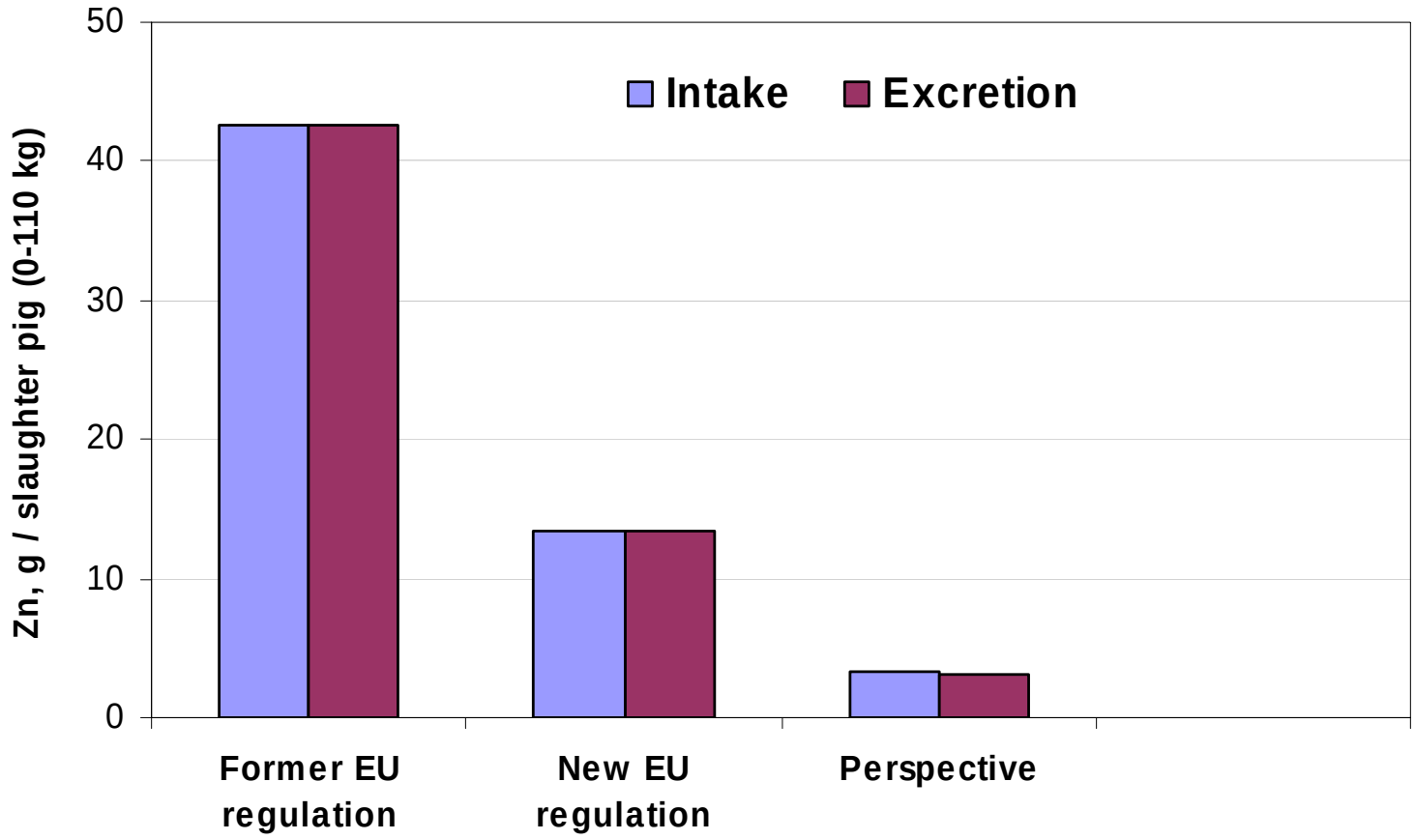
Excretion of trace elements (Zn, Cu)

- **Oversupply of trace elements in pig feeding**
  - because they are (were) used as growth promoters
  - because large safety margin are applied
- **Environmental problems**
  - medium or long term toxicity to plant and micro-organisms
  - increased risk with some slurry treament
    => concentrate in the solid fraction
- **Reduction of trace elements in manure**
  - limit their in corporation in the diet
    - avoid their use as growth promoters
    - better adequacy between supply and requirement
    - improvement of their bio-availability
  - Drastic improvements due to the recent changes in the EU regulation

Evolution of Zn excretion by pigs and perspectives



Evolution of Cu excretion by pigs and perspectives



Conclusion

- **Important improvements already achieved**
  - **reduction of excretion of N, P, Cu and Zn**
  - **reduction of gazeous emissions**
- **Nutrition is an efficient way to modify characteristics of manure**
  - **pH**
  - **N compounds**

for the future

- **Reduction of excretion**
  - Perspectives are more limited but still exists (trace elements > phosphorus > nitrogen)
- **Manipulation of characteristics of excreta**
  - reduce emissions and odors
  - better adapt manure composition to treatment or crop requirements
- **a more global approach is required**
  - optimization of (plant <=> animal <=> manure) system
  - consider the environmental impact associated to the production of the feed ingredients

  ⇒**Modelling - Life Cycle Assessment**