Is there after ban an Alternative to in-feed antibiotics as Growth Promoters

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What was the problematic of the 50's in the European countries ?

To increase the Productivity in Food Animals !

- because of the rapid growth of the world population
- because of an increasing demand of food and particularly of food of animal origin
- because of a limited farming area

picking crops and other farm products was no more sufficient

- because of the high quantity to be produce
- because of the necessity of profitability

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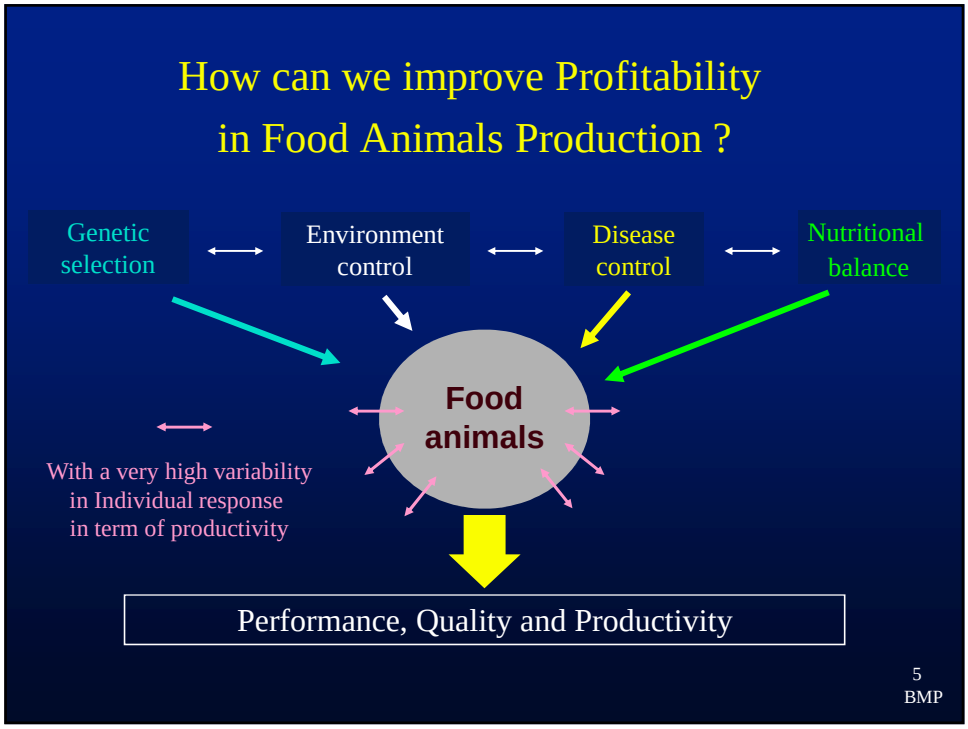
How can we improve Profitability in Food Animals Production ?
Genetic selection
Environment control
Disease control
Nutritional balance
Food animals
With a very high variability in Individual response in term of productivity
Performance, Quality and Productivity
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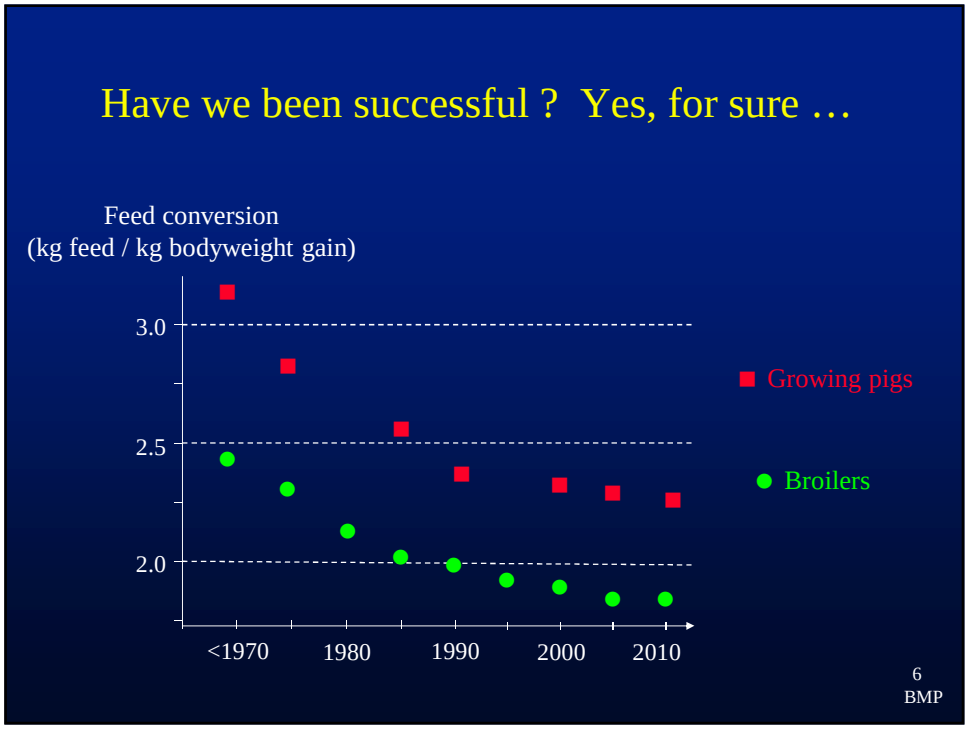
Have we been successful ? Yes, for sure …
Feed conversion
(kg feed / kg bodyweight gain)
3.0
2.5
2.0
<1970
1980
1990
2000
2010
Growing pigs
Broilers
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… but this success story has probably underestimated some parameters ...

- Sanitary problems
  residues of drugs in animal products and resistance to antimicrobial agents
- Environmental problems
  accumulation of nitrates in ground water, copper and other molecules in the soil
- Ethic problems
  animal welfare and consumers perception of modern farming

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… with some consequences

- An increasing demand for animal products from organic farming
- Consumers being more and more reluctant against manipulations of growth
- A great debate on antibiotics use in farm animal production since the late '90
  e.g. White paper on Food Safety, *(EU, 2000)*
- An emergent concept : the precautionary principle

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Antibiotics for Food Animals

Four major ways to use :

MEDICATED FEED **90/167/EEC**

1) therapy : treatment of infections in clinically affected animals, after a bacteriological diagnosis

2) metaphylactic : treatment of clinically healthy animals belonging to the same flock or pen, so before they become clinically apparent, the aim being to shorten the treatment period (e.g. the only way in broiler flocks)

3) prophylactic : treatment of healthy animals in a period of stress (e.g. early weaning) to prevent disease (may be indicative of general management problems)

USUAL FEED **70/524/EEC repealed R 1831/2003**

4) growth promotion : continuous inclusion of in-feed antibiotics to prevent subclinical infections and hence promote growth with sub-therapeutic dosage

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Antibiotics : not only for medical use !

Partition of antibiotics used in humans and animals

	Human	Animal	
	(%)	medical (%)	additive (%)
UK : Swann report, 1969	58	21	21
Canada : official stat, 1974	65	24	11
F : Rhône-Poulenc, 1978	54	30	16
Sweden : Wierup et al., 1987	62	25	13
USA : Levy, 1998	60	15	25
F : Gorce & Jannet, 1998	50	40	10
UK : Harvey & Mason, 1998	39	53	8
EU : Copenhague conf, 1998	52	33	15

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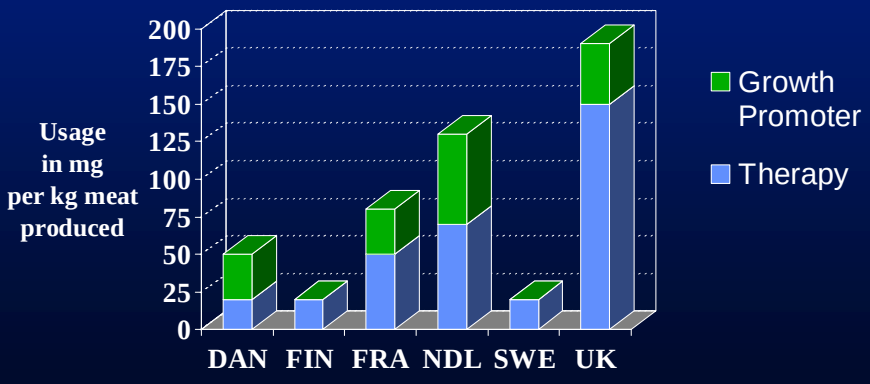
With huge variations between countries !

Milligram of antibiotics used in 1997
per kg of produced meat in different countries of EU
(from EMEA, 1999)



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What did we observe with in-feed Antibiotic Consumption by Meat Producing Animals ?

- **a better bodyweight gain** : Pigs : 2 to 20% (Weib, 1989 ; Bickel, 1983)
  Broilers : 3 to 10% (Birzer et Gropp, 1991)
- **a better feed conversion** : Pigs : 1 to 10%
  Broilers : 3 to 5%

⇨ Less feed was needed and less time to get optimal weight

- **a better homogeneity** of pen and flocks : less weak animals with delayed growth, a better presentation (better carcasses conformation, less seizure, no deterioration of carcasses composition)
- **less veterinary acts and drugs prescription**

⇨ Finally, a better profit margin (+ 15 to 20%)

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Summary of Results of Antibiotics Growth Promotion Effect in Food animals : an unanimous response !

(12 153 trials, 55 countries after Rosen, 1995)

Production type	Improvement of Body Weight Gain (%)	Decrease of Feed Conversion (%)
Piglets	+ 15,7	- 8,6
Growing pigs	+ 3,2	- 2,0
Growing turkeys	+ 6,5	- 3,1
Turkeys	+ 3,1	- 1,6
Broilers	+ 3,6	- 3,4
Pullets	+ 0,7	- 1,8
Ducks	+ 3,5	- 3,1
Geese	+ 3,6	- 4,3
Guinea fowl	+ 17,0	- 13,0
Japanese Quail	+ 3,3	- 2,1
Coefficient of variation	116 %	155 %

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Since many years, a merging question : was it the unique way to do ?

- Probably not as we observed in Northern Europe in '90
  - Sweden (1986) : ban of all antibiotics as growth promoters (ABGP) ⇒ Antibiotic consumption fall from 50 T/year to 20 T/year in 1996 and 17.3 T in 2001
  - Finland (1997) : ban of macrolides (tylosin & spiramycin)
  - Denmark : ban of Avoparcin (1995), Virginiamycin (1998) and finally of all ABGP since the end of 1999 !
- Other European countries ban Avoparcin (april 1997), Bacitracin, Spiramycin, Virginiamycin and Tylosin since the end of 1998, and Olaquindox and Carbadox in 1999
- All the remaining in feed-AB were also banned in EU starting on January 2006

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Do the ban has had any consequences on animal performances ? Yes at least at the beginning

• A survey in Switzerland (ABGP banned in 1999) (After Pfirter, 1998)

	Reduction of weight gain	Increase of feed per gain
Veal calve production	7,5 %	4,5 %
Beef production	4 %	2 %
Weaned piglets	8 %	5 %
Growing piglets	5 %	3 %
Fattening pigs	2 %	1 %
Pig production	5 %	2 %
Growing chicken	3 %	2 %

• Which confirm data from Sweden (ABGP banned in 1986)

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Do the ban have any consequences on animal sanitary status ?

- Reduction of competitive exclusion with pathogen :
  - Prevalence of necrotic enteritis in broilers and others *Clostr*. dependant diseases : significant increase with wheat & barley formulas since bacitracin ban in UK, DK & France
  - Incidence of condemnation at the processing plant due to cholangiohepatitis : an increase as a result of *Clostr*. invasion of the bile duct and liver of broilers in UK
  - Prevalence of post-weaning diarrhea (due to *E. coli* and *Lawsonia intracellularis*) in piglets : also an increase in Denmark & Spain
  - But very low incidence on sanitary status for pigs at the finishing stage

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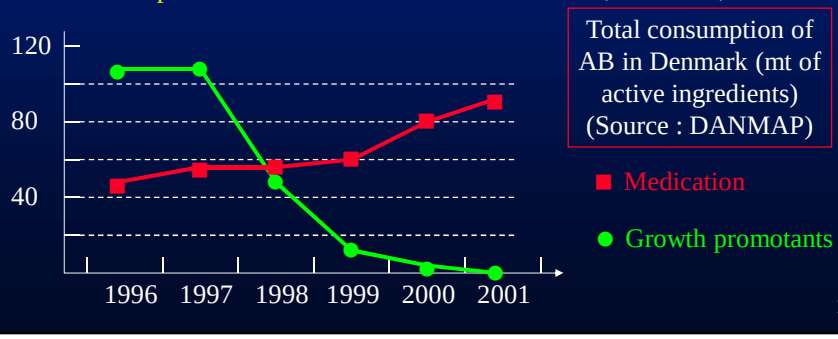
Do the ban have any consequences on animal antibiotic global use ?

- Anti-infectious drugs consumption for therapeutic use : seems to improve in some countries as prophylactic use declines : in EU therapeutic AB use has increased from 383,000 mt in 1999 to 437,000 mt in 2000 (+ 14%)
- For Denmark as an example :
  - Global AB use has declined 54% from 1996 (205,686) to 2001 (94,200)
  - But therapeutic AB use has increased 96% from 48,300 to 94,200



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Is there an alternative to Antibiotics as Growth Promoters ? Of course yes !

I - The European approach

- Procedures in matters of food safety
- The main classes of additives
- EC Guidelines for the assessment of additives in animal nutrition

II – Which identified solutions as an alternative ?

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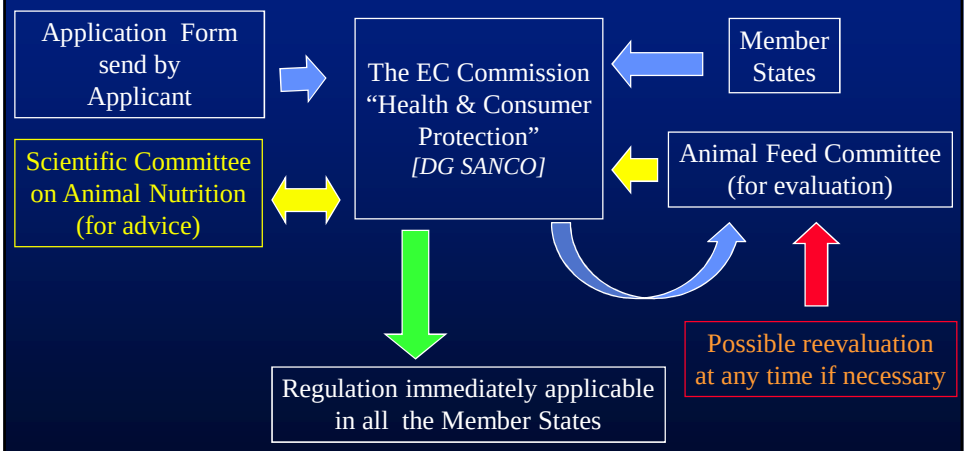
EC Procedures in matters of Feed Safety

European Food Safety Agency (EFSA) (EC regulation 178/2002)



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Is there an alternative to Antibiotics as a Growth Promoter ? Probably yes !

I - The European approach

- Procedures in matters of food safety
- The main classes of additives
- EC Guidelines for the assessment of additives in animal nutrition

II – Which identified solutions as an alternative ?

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Five main classes of additives

[All claim have to be justified !]

1 - Technological additives

- Antioxidants
- Preservatives (including chemical, microbiologic and enzymatic silage preservatives)
- Binders & anti-caking agents, pH modifiers
- Emulsifiers, stabilizers, coagulants, binders, gelling agents,
- Substances for reduction of mycotoxin contamination
- Denaturing agents

2 - Sensory additives

- Aromas, flavoring and appetizing compounds,
- Colourants, including pigments for feeds and for animal products

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3 - Nutritional additives

- Amino-acids, their salts & analogues
- Vitamins & pro-vitamins
- Compounds of trace elements
- Urea & derivatives

4 - Zootechnical additives

- Digestibility enhancers (enzymes)
- Gut flora stabilisers (probiotics & prebiotics)
- Substances which favourably affect the environment
- Other zootechnical additives

5 – Coccidiostats & histomonostats

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Is there an alternative to Antibiotics as a Growth Promoter ? Probably yes !

I - The European approach

- Procedures in matters of food safety
- The main classes of additives
- EC Guidelines for the assessment of additives in animal nutrition (R (CE) 429/2008 of April 25th 2008)

II – Which identified solutions as an alternative ?

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EC Guidelines for the Assessment of Additives in Animal Nutrition

Three key words : Identity, Efficacy & Safety

I – Identity of the additive

- Description of the additive : name, type & function, composition, ...
- Characterization of the active substance(s) : structure, purity, ...
- Characterization of the additive : physico-chemical and technological properties : stability, incompatibilities & interactions, ...
- Conditions of use of the additive : mode of use, level of inclusion
- Control methods : description of the methods for traceability

II – Efficacy of the additive

III – Safety of the additive

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I – Identity of the additive

II – Efficacy of the additive [All claims have to be justified !]

- Studies on the effects on feedingstuffs (depending of the mode(s) of action of the technological additives)
- Studies on the effects on animals (coccidiostats & zootechnical additives) : test performed on target animal/species categories in comparison with negative & positive control groups with statistical evaluation
- Studies on the quality of animal produce (organoleptic, nutritional, hygienic & technological qualities of animal products)
- Studies on the effects on the characteristics of animal wastes (if any modification of nitrogen, phosphorus, odor, volume)

III – Safety of the additive

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III – Safety of the additive (1)

1 - Studies on target species :

- to determine a safety margin (ratio min level with unfavorable effects / proposed dose-level has to be at least 10)
- to assess microbiological safety : ability to induce cross-resistance or to select resistant bacterial strains
- to assess metabolic pathways and identify residues and excreted subst

2 - Studies on laboratory animals (toxicity studies)

- acute toxicity
- genotoxicity including mutagenicity
- subchronic (90 days) oral toxicity
- chronic oral toxicity including carcinogenicity
- reproduction toxicity including teratogenicity
- determination of a no observed effect level (NOEL)

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III – Safety of the additive (2)

3 - Safety evaluation for the human consumer :

- residues of the additives or its metabolites
- determination of the acceptable daily intake (ADI) using a safety factor of at least 100
- proposal of a maxi residue limits (MRLs) of the additive
- proposal of the withdrawal period for the additive

4 - Worker safety assessment :

- effect on respiratory system
- effect on eyes and skin

5 - Environmental risk assessment :

- determination of predicted environmental concentration (PEC)
- if any, determination of bio-accumulation potential and the predicted no effect concentration(s) (PNEC) value(s)

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Is there an alternative to Antibiotics as a Growth Promoter ? Probably yes !

I - The European approach

II – Which identified solutions as an alternative ?

– Transitory solutions : trace minerals at pharmacological level

– Other Solutions with a future (may be !)

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Trace Mineral at pharmacological level

- Known since 30 years following the observations of Barber and Braude with copper sulfate as a growth promoter for growing pigs
- Widely used through the world, but under serious debate
- A second approach in Sweden since 1986 after ABGP ban : a massive use of zinc oxide seems to give some interesting results as an anti-diarrheic substance for post-weaning piglets

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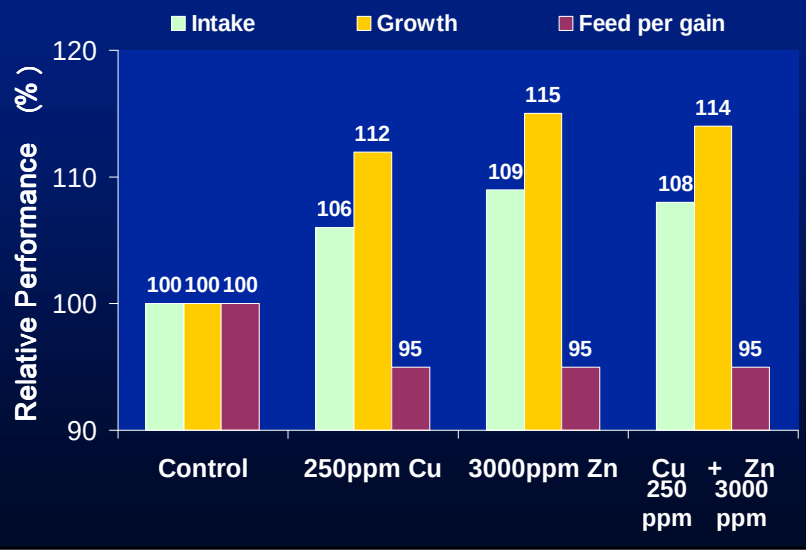
Efficiency of high levels of Cu and/or Zn for piglets (3 to 7 weeks) (Hill, 1996)



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Copper sulfate as a Growth Promoter :
Efficacy is known since many years

- Braude (1967) :

  250 ppm SO_4Cu in 83 published trials on growing pigs :

  daily bodyweight gain : + 8,1%
  feed efficiency : + 5,4%

- Wallace (1967) :

	daily bodyweight gain	feed efficiency
piglets	+ 22,1%	+ 8%
growing pigs	+ 6,5 %	+ 2,3%
finishing pigs	+ 3,6%	+ 1,1%

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- Cromwell (1991, 1997) :

  250 ppm SO_4Cu in 22 published trials on piglets :

  daily bodyweight gain : + 12%
  daily feed ingestion : + 8%
  feed efficiency : + 5%

➢ So a well accepted efficacy of Copper Sulfate, but mostly with low performing pens !

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Copper sulfate use : EC Regulation

- Up to 2004 (R (CE) 2316/98)
  - Pigs for fattening
    (in member states where the mean density of porcine population is lower than 175 pigs per 100 ha of utilizable agricultural land)
    - up to 16 weeks : 175 ppm (in total)
    - from 17th week to 6 months : 100 ppm (in total)
    - over 6 months up to slaughter : 35 ppm (in total)

    other States : 35 ppm from 17th week up to slaughter
  - Breeding pigs : 35 ppm (in total)
- Last update (R (CE) 1334/2003) valuable since 2004 January : a significant reduction
  - Pigs for fattening :
    - up to 12 weeks : 170 ppm (in total)
  - Others pigs : 25 ppm (in total)

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Copper sulfate as a Growth Promoter : is there any Hazard ?

– Is there a toxic hazard for pigs ?

LOW related to

- good tolerance of pigs up to 500 ppm
- a limited liver accumulation because of a quick turn over (biliary elimination)
- some protective effect of Zn and Fe supplementation
  [130 ppm of Zn & 150 ppm of Fe may help to counterbalance the effects of high level of Cu]

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– Is there a toxic hazard for environment ?

HIGH related to spreading of manure

- accumulation of Cu in forages

→ high toxic risk for ruminants (sheep >> bovine) even if the bioavailability is low (interaction with Mo)

- accumulation of Cu in soils if long term use (+ 1 mg per kg soil each 10 years with previous dosage)
- highly phytotoxic (less than 100 years for soil sterilization with 50 to 100 m^3/ha/year)
- highly toxic for soil micro-flora and worms

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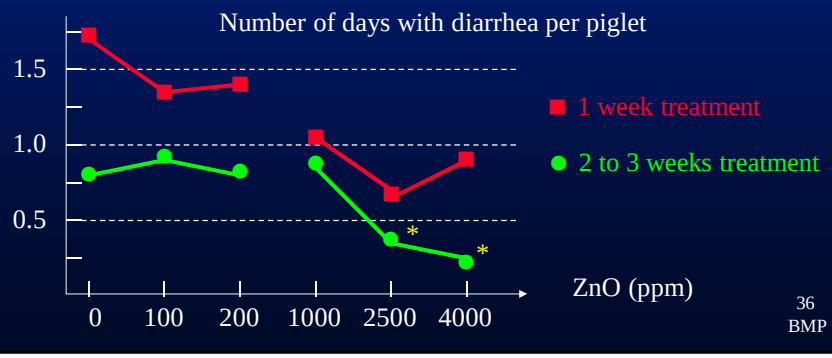
Zinc oxide as an Anti-Diarrheic Supplement

- extra-nutritional (pharmacological) role as anti-diarrheic for post-weaning piglets [2 to 3000 ppm during 2 to 3 weeks]
- a high benefit generally observed on prevalence and severity of post-weaning *E. coli* diarrhea (Holm et Poulsen, 1996)



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Zinc Oxide Supplementation : Practical approach
(Holm et Poulsen, 1996)

1) White ZnO (100% pharmaceutical quality) should be used, to minimize the supply of cadmium and lead
2) No other zinc source can be used for this purpose
3) The zinc oxide should be mixed into the creep feed. Top dressing is avoided.
4) Creep feed supplemented with high levels of zinc oxide should only be used for two to three weeks after weaning.
5) Addition of ZnO (2500/3000 ppm) allows *ad libitum* feeding of pigs after weaning
6) Attempt to prolong the period of ZnO supplementation to 4 weeks after weaning can lead to problems
7) Don't mix ZnO supplement with $CuSO_4$ supplement (Smith et coll., 1995; Carlson et coll., 1995)

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Zinc oxide as an Anti-Diarrheic Supplement : is there any Hazard ?

– Is there a toxic hazard for pigs ?

NOT TO HIGH related to

- good tolerance of pigs (up to 4000 ppm for 2/4 w)
- a limited liver accumulation because of a quick turn over (biliary elimination)
- liver content increase 6 fold and kidney 3 fold but return quickly back to normal after removal
- toxicological problems with level higher than 4000 ppm : reduced feed intake and growth retardation
- more often observed with other Zn sources (sulfate, lysinate or methionate)

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– Is there a toxic hazard for environment ?

NOT TO HIGH even with spreading of manure

- little accumulation of Zn in forages
- some accumulation in soil (but less toxic than Cu)
- because of shortness of treatment (2/4 weeks)
- only tolerated in northern European states (S, DK)

– Up to date EC regulation :

- current maximum : 150 ppm for most species

– Proposed maximum for the future : a reduction

- pigs : 100 ppm
- dairy cows : 120 ppm
- fish : 200 ppm

fur animals : 150 ppm
other bovines : 100 ppm
other species : 120 ppm

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Is there an alternative to Antibiotics as a Growth Promoter ? Probably yes !

I - The European approach

II – Which identified solutions as an alternative ?

– Transitory solutions : trace mineral salts overload

– Solutions for the future to fully compensate for the loss of AGP : may be through a mix of them !

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Solutions for the future

- Better sanitary and hygiene control in animal husbandry through good farming and breeding practice
  - better fitting of pens & buildings
  - optimal ambiance control : temperature, fresh air, no draft, adapted space and appropriate floor, low humidity and minimal dust, etc.
  - good rotation system : systematic disinfections & sanitary vacuum
  - selection of animals from better origin and more homogeneous
  - better feed sanitary quality : a lesser level of mycotoxins (through adsorbents) & less microbes and molds (through sterilization treatment)

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Feed sanitary quality : sterilizing agents, antibacterial compounds

- Aim : to limit and even eradicate feedborne zoonotic organisms such as *Salmonella* spp. & *Campylobacter* spp.
- Means :
  - Prolonged conditioning times and elevated temperatures
  - Use of antibacterial agents : organic acids (formic, acetic, lactic, propionic & fumaric)

  (Probably more efficient on feed bacterial population and with combinations of acids)
  - Essential oil products : some antimicrobial properties directed toward gram positive bacteria but very dependant of the source and the method of its purification/standardization

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- Better valorization of feed by animals through :

1) supplementary exogenous enzymes
   - to improve feed efficiency : better digestibility of dietary fiber
   - to increase absorption & decrease phosphate output in manure
2) adding cell wall extract to enhance intestinal immune system (GALT) and enterocytes integrity
3) improving gastric pH control and promoting a stable and normal micro-flora with organic acidifiers
4) supplementary probiotic micro-organisms to maintain or improve a beneficial digestive micro-flora
5) supplementary prebiotics (fermentescible substrates like FOS) allowing multiplication of healthy micro-organisms (*Lactobacillus*, *Bifidobacterium*, …)
6) adding herbs or plant extracts naturally occurring in aromatic plants & spices obtained by extraction or synthesis

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1 - Exogenous Enzymes : two main goals

- to improve feed efficiency of lesser quality feeds
  - better digestibility of water soluble polysaccharides components of the dietary fiber with
    - 1-4 β xylanases for better digestibility of β xylans from wheat
    - 1-4 β glucanases for β glucans from barley
  - better digestibility of vegetable protein (soybeans and other legumes) with proteases
  - better availability of phytate phosphorus from cereals with phytases
  - and more generally better digestibility of organic matter and energy
- & to reduce environmental load of N and P

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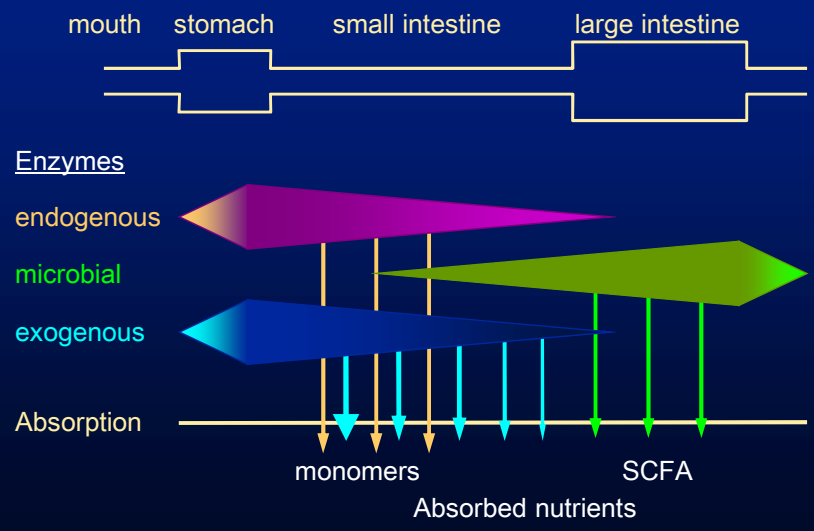
Exogenous Enzymes need to be well adapted to endogenous and microbial enzymes of the Digestive Tract (Wenk, 2002)



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Exogenous carbohydrases

Effect of beta-glucanase supplementation on feed utilization by pigs (55 kg BW)

	control	beta-glucanase +	
dry matter digestibility (%)	80.5	82.7	
protein digestibility (%)	75.1	77.7	
energy digestibility (%)	78.0	80.8	(+ 3.6%)

(Thacker & al., 1988)

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Exogenous phytases

Reduction in P-excretion on slaughter pigs fed with phytase additive (Dunn, 1994)

	Control	Feed with phytase	
P intake per pig			
Growing ration (g)	409	351	
Finishing ration (g)	626	485	
Total intake (g)	1035	836	(- 19%)
P excretion per head (g)	652	428	(- 34%)

Beneficial effect of phytase on broiler performance (Harter-Dennis & al., 2001)

Dietary non phytate-P (%)		Phytase (U/kg diet)	Wheight gain (g)	Feed conversion	Toe ash (%)
days 0-21	days 22-42				
0.3	0.2	-	2 452	1.911	9.68
0.3	0.2	500	2 640	1.775	10.70
0.3	0.2	2 000	2 781	1.740	10.96

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2 – Cell wall extract of *Saccharomyces cerevisiae*

- Acting through modifications of intestinal immune system and micro-flora resulting in
  - increased number of goblet cells in the mucosa
  - increase in the depth of the intestinal crypts
  - better feed conversion efficiency and improved growth rate

Effect of cell wall extract on broiler performance (Sefton & Collet, 2002)

Treatment	49 days liveweight (kg)	Feed conversion	Mortality (%)
Negative control	2.392	2.014	7.08
Treated	2.507	1.830	4.58
Positive control (antibiotic)	2.581	1.815	5.42

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3 – Acidifiers : acids & acid salts

- Acting through modifications of upper digestive tract environment (mainly crop/stomach)
  - decrease gastric pH and improve secretion of digestive juices and activity of digestive enzymes
  - promote the natural micro-flora and decrease *E. coli* and *Salmonella* along all (?) or upper part of the digestive tract
- Many applicants
  - fumaric, citric, propionic & formic acids and salts give encouraging but inconstant results
  - potassium di-formate : with a good evidence of efficacy & recognized as growth promoter in EU

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Comparative efficacy of Anti-microbial & Acidifiers as Growth Promoters

	control	Avilamycin (40 ppm)	K di-formate (6000 ppm)
Feed utilization			
Feed Conversion Ratio	1.75	1.64	1.65
improvement	0	6.26%	5.64%
feed use/pig (kg)	49	45.9	46.2
Growth			
BW Gain (g/d)	476	526	528
improvement	0	10.5%	11%
days 7-35 kg	58.8	53.2	53

(Blanchard, 2002)

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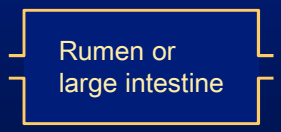
4 - Probiotics : active modulators of the Gut Flora

"A live microbial feed supplement which beneficially affects the host animal by improving its intestinal microbial balance" (Fuller, 1989).

Goal of using probiotics = Stimulation of beneficial bacteria in the GI tract
Reduction of pathogens through Competitive Exclusion



Cellulose degraders ↗
Lactic acid utilizers ↗
Lactic acid producers ↘

Yeast cultures
in ruminant and horses

Lactic acid producers ↗
E. coli ↘
Salmonella ↘

Lactobacilli
in pigs and poultry

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They act through :

- anti-microbial barrier effect subject to fixation *in situ* (to allow nutritional competition, limiting toxins production)
- competitive exclusion from attachment sites
- anti-toxin barrier effect (e.g. *Saccharomyces boulardii* reduce pathogenic effect of *Cl. difficile*)
- stimulation local immunity system (GALT)
- reduction of translocation risk of G- (enterobacteria) by G+, activation of macrophages et alteration of T lymphocytes
- nutritional effect : production of VFA (C3), B vitamines, ...
- production of antimicrobial compounds (acids, reuterin)

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With respect of some important conditions ...

- well known identity, purity & genetic stability
- absence of pathogenic properties (NO production of enterotoxin) for Human and Animals
- NO acquired & NO transmissible antibio-resistance
- proved zootechnical efficiency
- easy identification
- possibility of in-feed use (even if pelleting or extrusion)
- high safety margin (x 10) for target animals and the environment

... and clear direction for use

- living organisms, incorporated at 10^6 fcu/g feed
- and continuous use during at least 3 weeks

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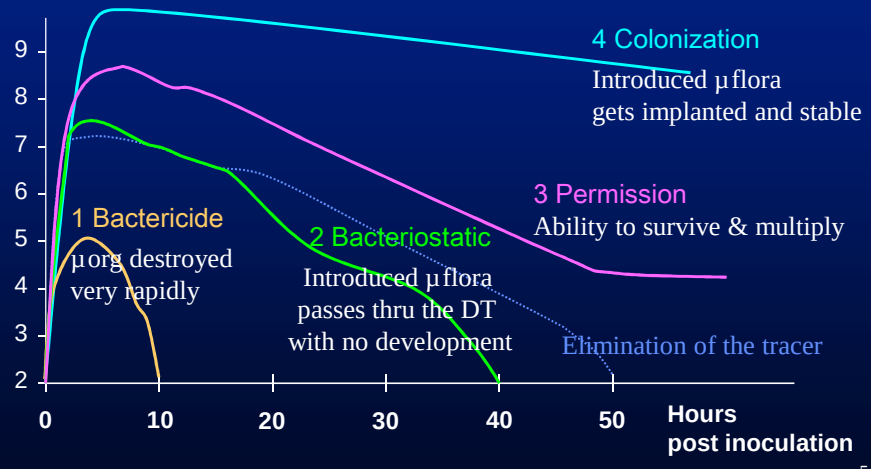
Duration of stay of the bacteria in the digestive tract (from Raibaud et al., 1992)



µorg = micro-organism

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- Now in use (EU) :
  - aerobic sporulated micro-organisms genus *Bacillus* :
    - *B. licheniformis, B. subtilis,*
    - *B. cereus :* one strain has been recently suspended in EC (2002) relatively to the risk of enterotoxin production
  - many Lactic Acid Producing micro-organisms :
    - *Bifidobacterium,*
    - *Lactobacillus farciminis, L. rhamnosus, L. casei, L. plantarum*
    - *Steptococcus infantarius*
    - *Enterococcus faecium* (many strains)
    - *Pediococcus acidilactici*
  - one Yeast :
    - *Saccharomyces cereviciae* (many strains)

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5 – Prebiotics : passive modulators of the Gut Flora

"A non-digestible food ingredient (mainly FOS and inulin) that beneficially affects the host by selectively stimulating the growth and/or activity of one or a limited number of bacteria in the colon"
(Gibson & Roberfroid, 1995)

- Deep modifications of the bowel content and functions ….
  - decrease bowel content pH
  - increase FVA production
  - increase colocytes metabolism
  - induce a new balance of the micro-flora in favor of *Lactobacillus* and *Bifidobacterium,* to the detriment of *E. coli* & *Clostridium spp.*
- … to the host benefit :
  - better growth performances,
  - digestive hygiene and feces quality

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6 – Plant Extracts

- Plant extracts naturally occurring in aromatic plants & spices are obtained by extraction or synthesis
- Usually used as appetizers ...
- ... with a promising efficacy as growth promoter :
  - by stimulating enzymes secretion and activity
  - by improvement of digestibility and absorption
  - by improvement of microbial flora (positive effects on *Lactobacillus* and negative on *E. coli*, *Clostridium spp.* & *Salmonella*)
  - by modification of FVA production
    - ➢ So, a similarly action as other gut micro-flora modifiers with an advantage : a natural origin !

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Essential oil as Growth Promoters

Growth performances of post-weaning piglets from d_{21} to d_{70} on diet supplemented with Plant Extract (XT) with or without Formic acid (FA)

Parameters	Negative control	Group 1 XT	Group 2 XT + FA
Number of piglets	28	28	28
Initial body weight(kg)	6,90	6,92	6,90
Final body weight (kg)	21,21	22,36	22,32
BWG (g/j)	292	315	335
Feed intake (g)	491	503	530
Feed efficiency (kg/kg)	1,68	1,58	1,52
Diarrhea score	39	33,8	28,5

(from Kamel, 2001)

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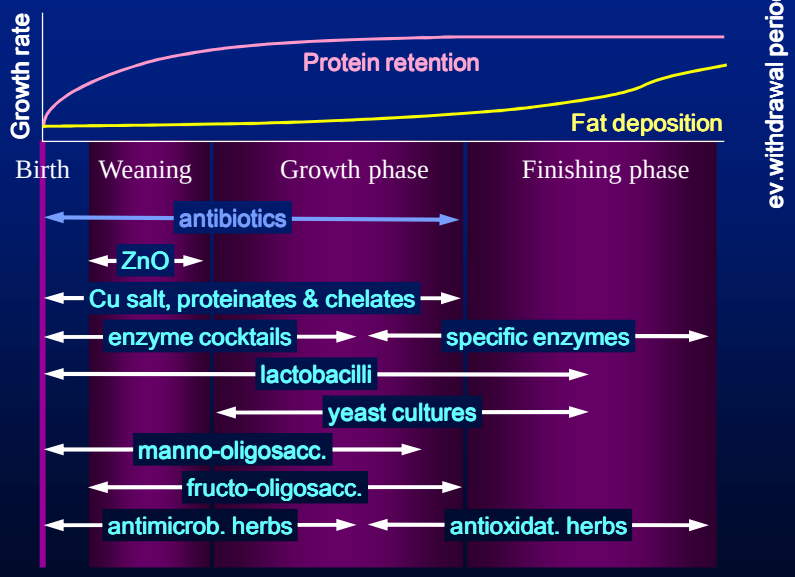
Some alternatives to antibiotics as feed additives in growing animals (Wenk, 2002)



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Take Home Message

- Many opportunities and solutions to replace in-feed antibiotics which are banned as growth promoters
- During this phase-out period all the alternative products offered have to be scientifically validate
- Many products have been rushed to the market with very limited or no scientific data upon which to base products claims
- All over the world, the same criteria have to be required:

Traceability + Efficacy + Safety

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