EAAP 2008: 59th Annual Meeting, Vilnius, Lithuania - Session 6

Utilizing Functional Feed Ingredients for Pre-Harvest Food Safety Strategies

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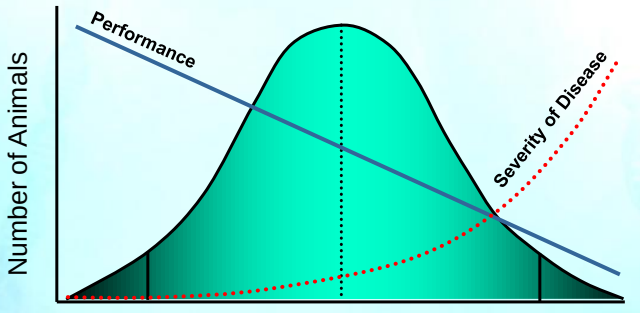
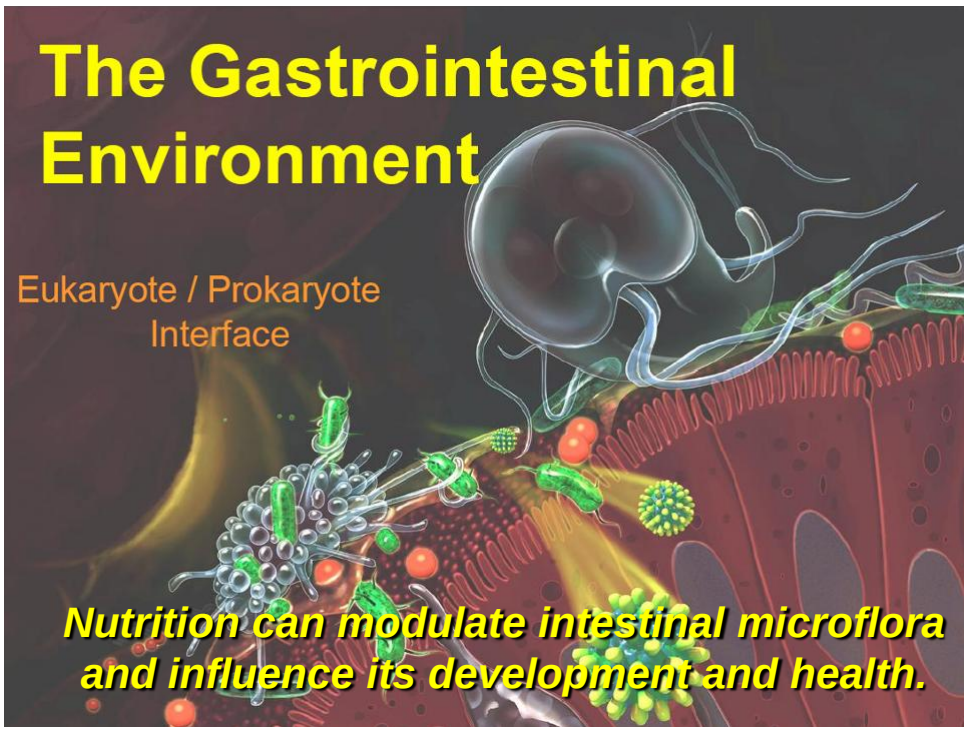
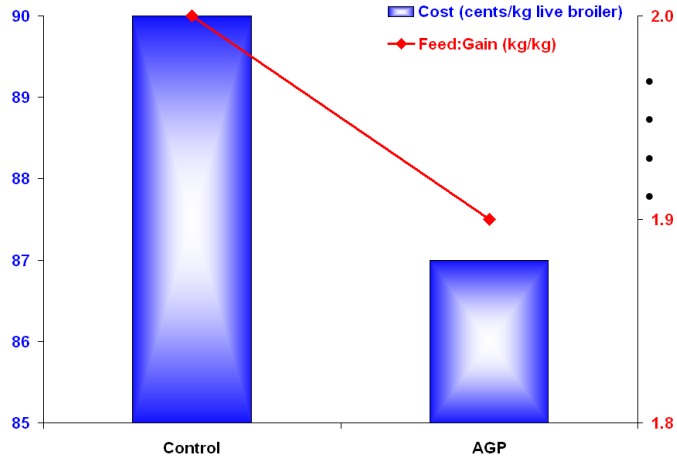
Health and Animal Performance




Intestinal Health
DIET
Macro/micronutrients
Antinutritional factors
Additives
MUCOSA
Epithelium
Intestinal immunity
Mucus layer
Equilibrium
MICROFLORA
Commensal bacteria
Transient bacteria*
(*including pathogens)


The Gastrointestinal Environment
Eukaryote / Prokaryote Interface
Nutrition can modulate intestinal microflora and influence its development and health.

AGP Improves Production & Profitability

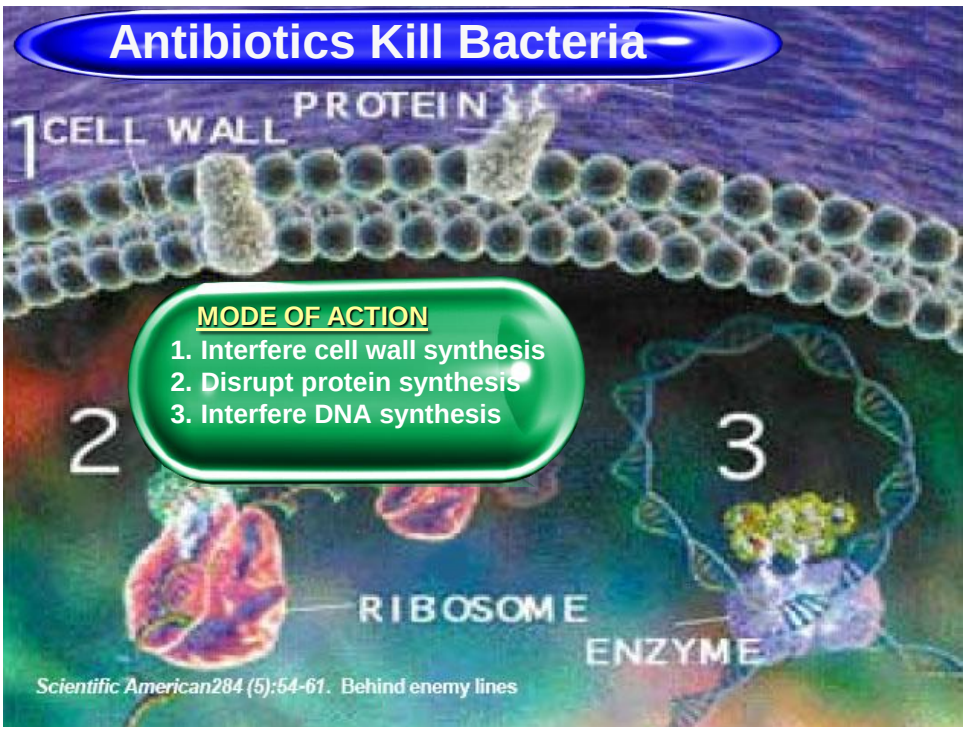


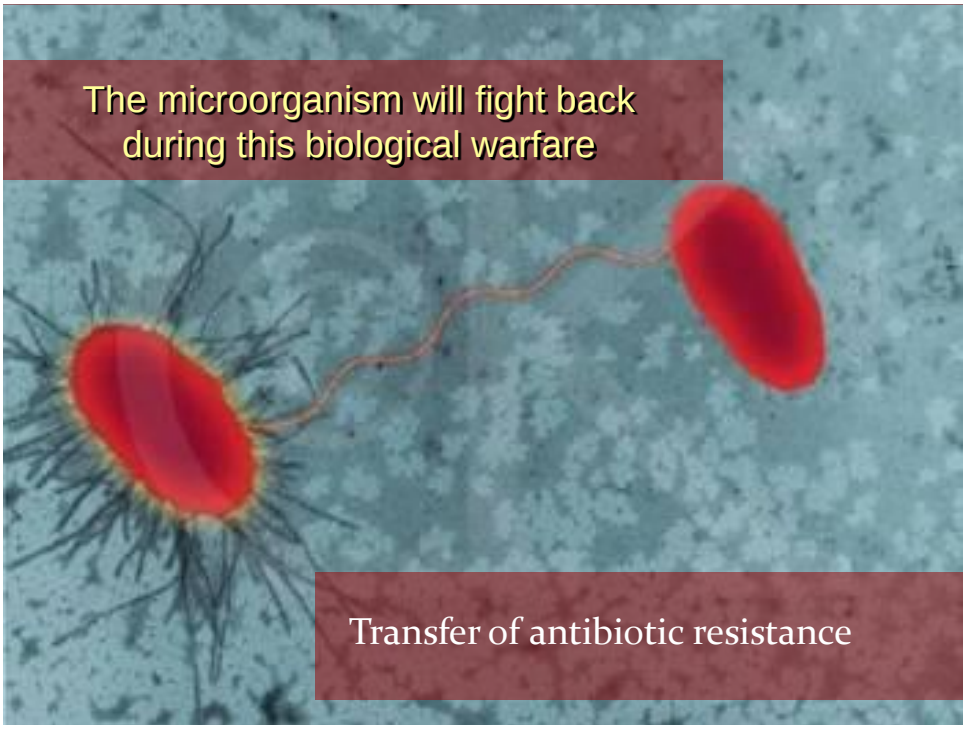
Advantage

- ↓ microbial load
- ↑ productivity
- ↓ FCR 2.3%
- ↑ Weight Gain 1.5%

Rosen, 2003

Antibiotics Kill Bacteria



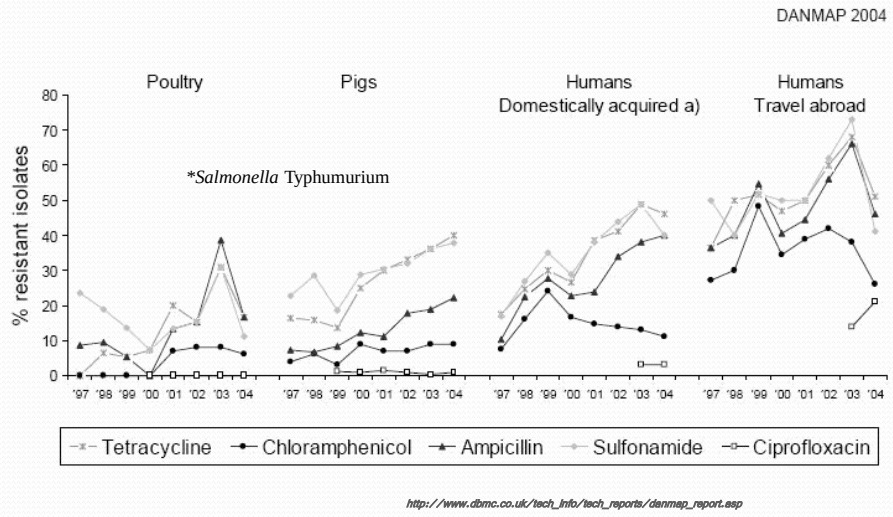


The World followed

Major poultry companies respond to consumer demands on ban of AGP in feed.

Beware! It's not always simple!

Don't just replace AGP's with therapeutic antibiotics



Alternatives to AGP

- **Probiotics (Direct-Fed Microbials)**
- **Herbs, Spices, and Essential Oils**
- **Acidifiers and Organic Acids**
- **Prebiotics**
- **Enzymes**
- **Nucleotides**

Probiotics

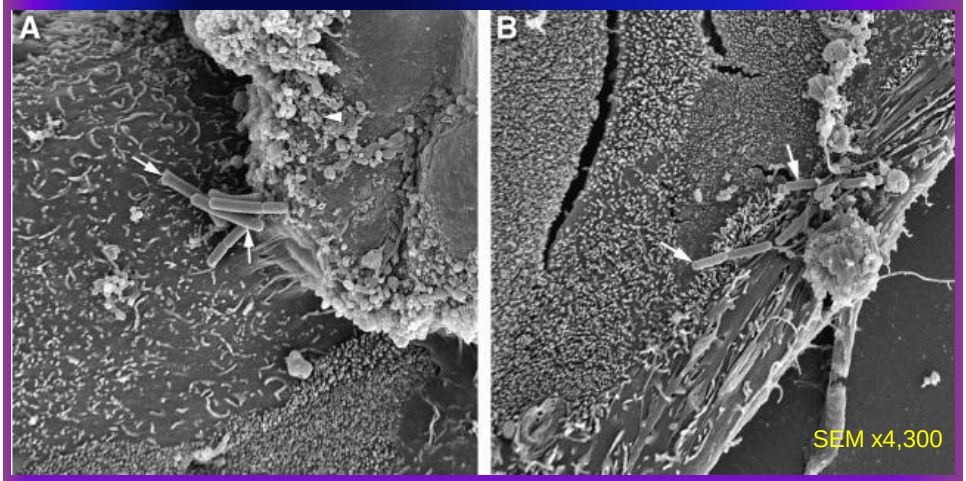
Probiotics Benefit Host-Microflora Symbiosis

"Inhibit the growth of pathogenic bacteria by CE"

(Nurmi & Rantala, 1973)

- –Produces lactate and **SCFA = ↓ pH GIT**
- –Competes for attachment to the gut lining
- –Competes for nutrients available in the GIT
- –Stimulates the intestinal associated immune system
- –Stimulates mucus secretion

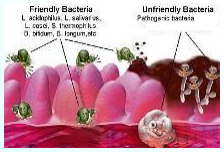
Lactobacilli adhere to the surfaces of epithelial cells and inhibit adhesion of *E. coli*



Sherman et al., 2005

Probiotics Cultures

- **Bacteria**: *Lactobacillus*, *Bifidobacterium*, *Bacillus*, and *Enterococcus*.
- **Yeast**: *Sacharomyces*.

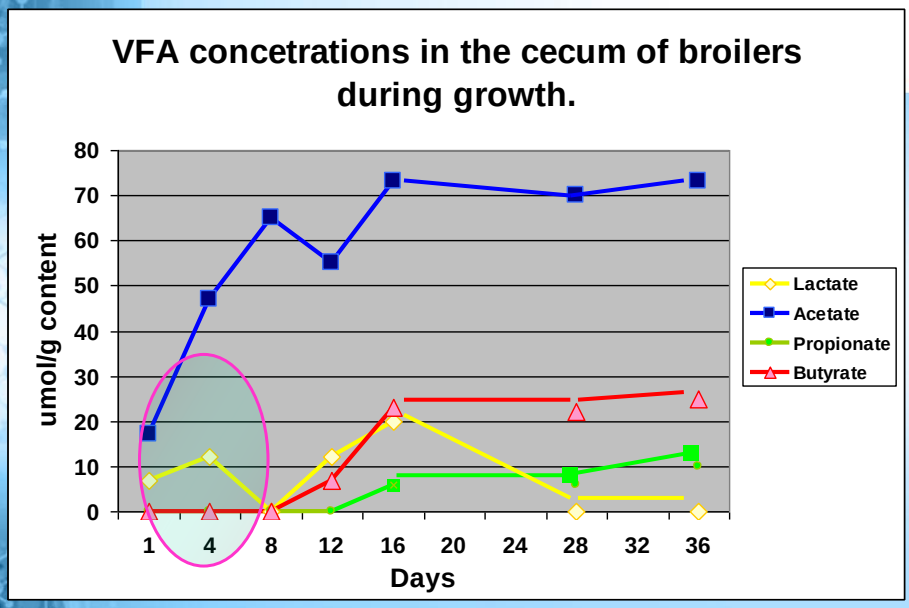


  - Few species of microorganisms can be considered for use in probiotics products due:
    - Limited ability to culture
    - Application constraints (i.e. water chlorination).
    - Stability during storage

Acidifiers and Organic Acids

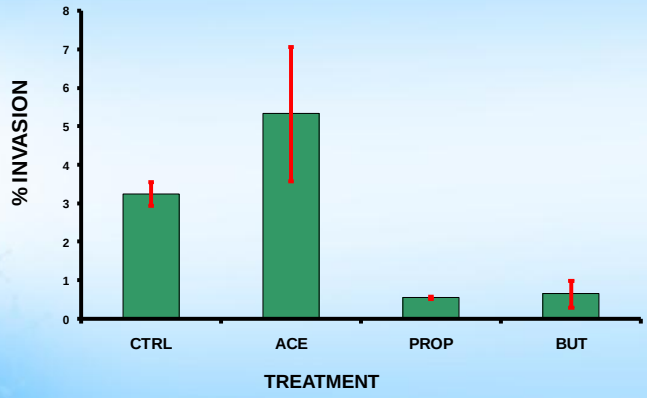
- **Used for decades for feed preservation**
  - prevents microbial deterioration
- **Recent use of Organic Acids**
  - ***Antimicrobial control agent*** in feed and water
- **Common OA in poultry nutrition**

Butyric Acid	Sorbic Acid
Acetic Acid	Tartaric Acid
Citric Acid	Lactic Acid
Fumaric Acid	Formic Acid
Propionic Acid	Benzoic Acid



Adapt. from van der Wielen (2002)

Invasion of *Salmonella* Enteritidis in epithelial cells *in vitro* is influenced by short-chain fatty acids



(van Immerseel, 2005)

Increase of Villus Height of Piglet (42-98d)

	Control (n=5)	**Na-Butyrate** 0.17% (n=5)
Length of Ileum Villi, µm	234	304*

↑ **+30%**

Source: Galfi et al., 1991
*P<0.05

Acidifiers and Organic Acids

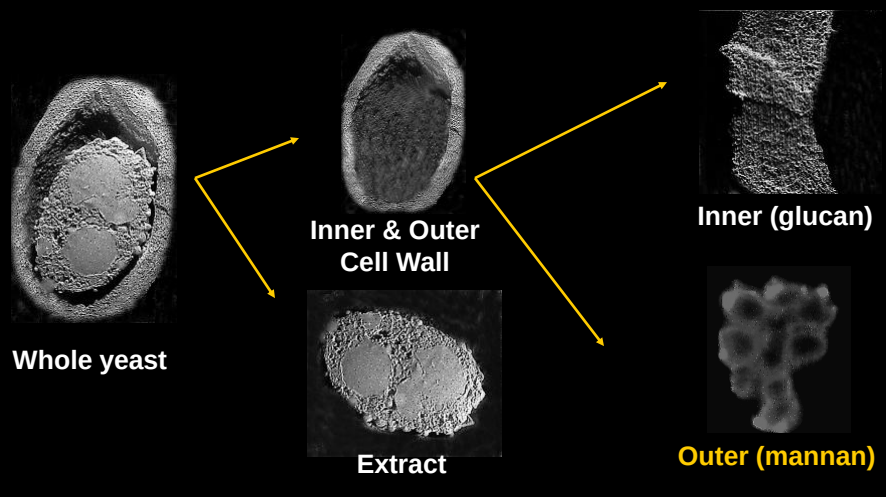
- **Benefits:**
  - ↑ gastric proteolysis: AA dig.
  - ↑ mineral digestibility: Ca, P, Mg & Zn.
  - Antimicrobial activity, specially *Salmonella* and *E. coli* (Gram- bacteria).
  - Supply of energy to the intestinal mucosa.
  - Intestinal development.

Prebiotics

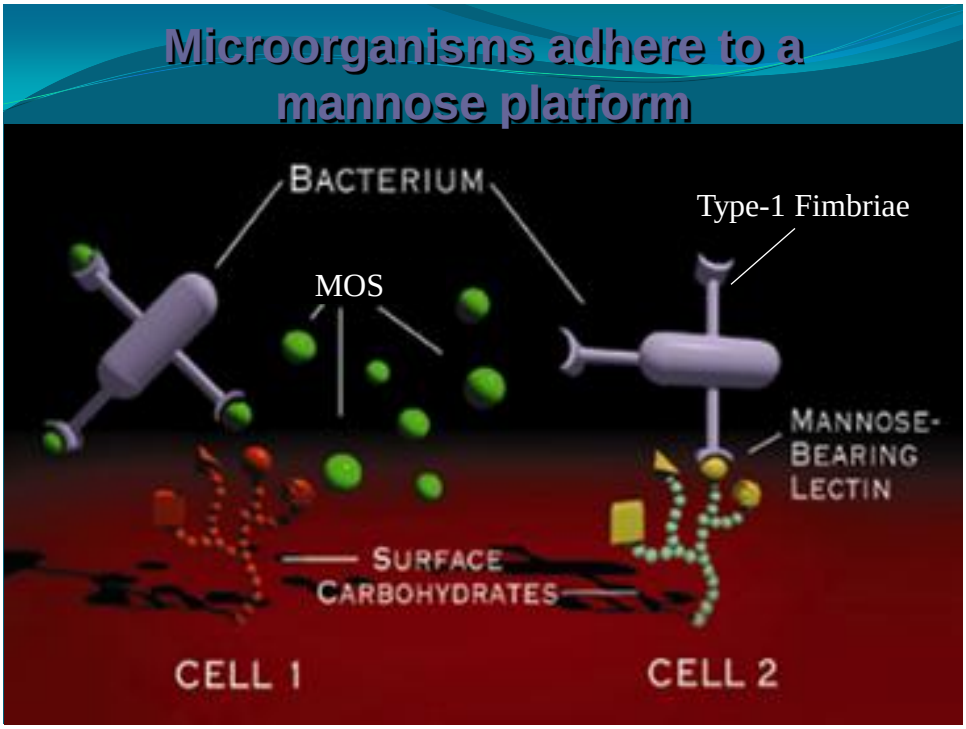
Indigestible dietary components that promote intestinal health of the host

- Promotes symbiotic fermentation: ↑ CE.
  - **Fructooligosaccharides** (FOS, oligofructose and inulin).
  - Trans-galactooligosaccharides, glucooligosaccharides, raffinose glycooligosaccharides, lactulose, xylo-oligosaccharides, stachyose.
- Stimulate the immune system: enhancing intestinal humoral immunity.
  - **ß-glucans, Arabinoxilans.**

Mannan Oligosaccharide



Serve as binding sites for pathogenic bacteria: preventing attachment and colonization of the GIT.

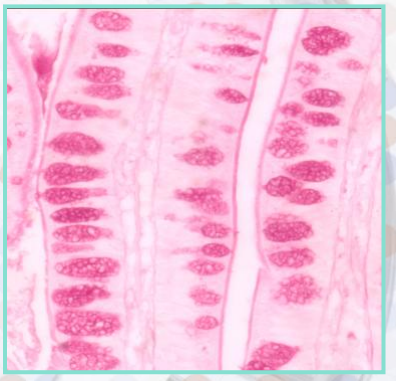


Meta-analysis *broilers*

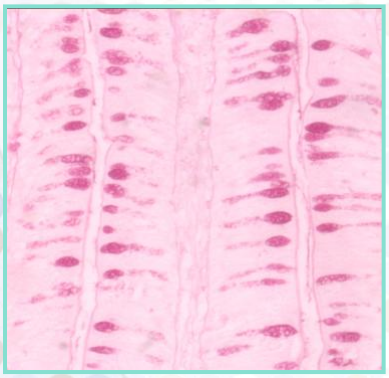
	Trials	Ave. Age (Days)	Negative Control	Bio-Mos	% Difference
Body wt, g	34	42.2	2,147[b]	2,190[a]	+1.95
FCR, g/g	34	42.2	1.879[a]	1.837[b]	- 2.25
Mortality, %	19	42.6	5.582[a]	4.366[b]	- 21.78

Hooge (2004)

MOS enhances mucus protection of gut mucosa



Bio-Mos



Control

(Smirnov et al., 2005)

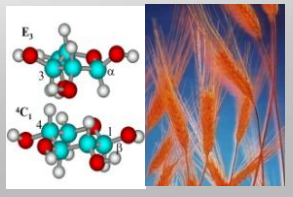
Synergistic effect of MOS on the GIT

- Inflammatory response reduced
- Protective barrier enhanced
- Microbial ecology stabilized
- Nutrient absorption function improved

= **better performance & health**

Advantages of Prebiotics

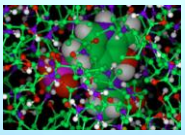
- Easier handling and application
  - **stable** to heat and pressure incurred during feed processing.
- Can stimulate the growth of culturable and **unculturable** bacteria.
- **Economic** advantage.



(Rastall et al., 2005; Playne et al., 1996)

Dietary Enzyme Supplementation

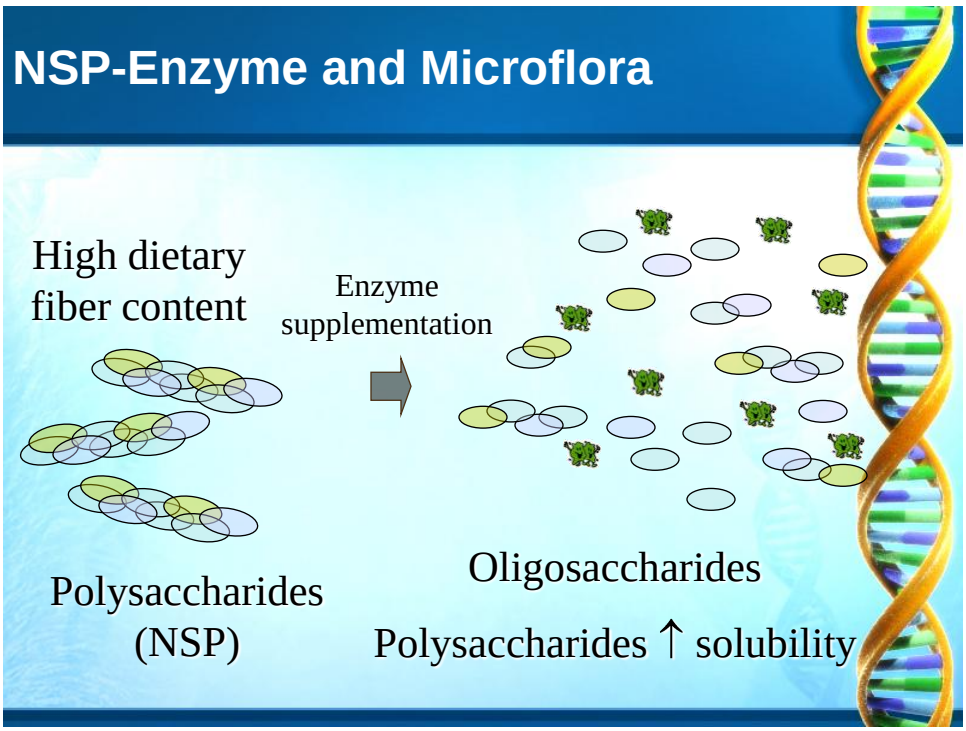
- Increases the animal own supply.
- Alleviates the adverse effects of ANF (e.g. arabinoxylans).
- Increases nutrient digestibility
- **Modulate intestinal microflora.**



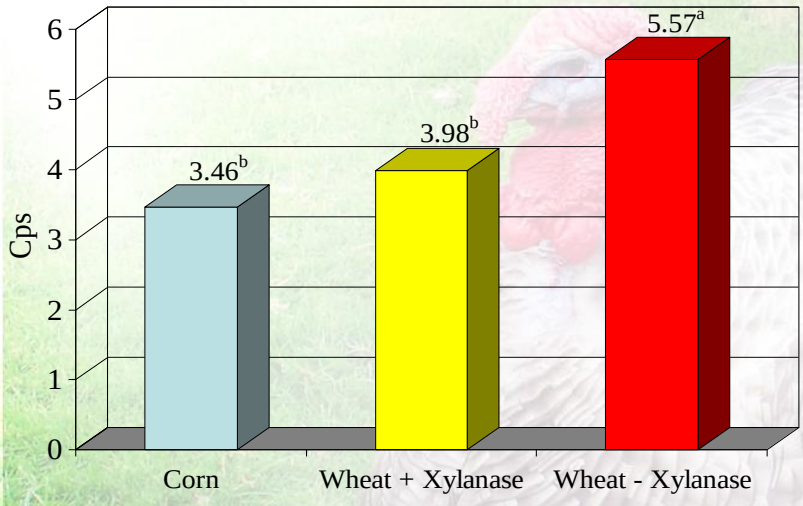
Commercial Exogenous Enzyme

SUBSTRATE	ENZYME	EFFECTS
Protein	Protease, Peptidase	Supplementation of endogenous enzymes
Starch	Amylase	
Lipids	Lipase	
Phytate (phytin complex w/ P, etc.)	Phytase	Enhance plant phosphate use
Hemicellulose (grains)	Hemicellulase	Reduction of intestinal viscosity – enhance nutrient digestibility.
Pentosans (xylose, arabinose)	Pentosanase	
β-glucans	β-glucanase	
Pectins (plant protein sources)	Pectinase	
Oligosaccharides (mannans, galactans, etc.)	α-galactosidase	
Cellulose (plant cell wall)	Cellulase, Cellobiase	Cellulose digestion - release nutrient

NSP-Enzyme and Microflora

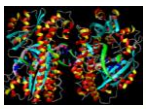


Jejunum digesta viscosity (Cps) of tom poults



Santos et al., 2003

Xylanase in wheat-based diets fed to turkeys 1-17d



7.300 EXU/kg
1.800 BGU/kg

50%

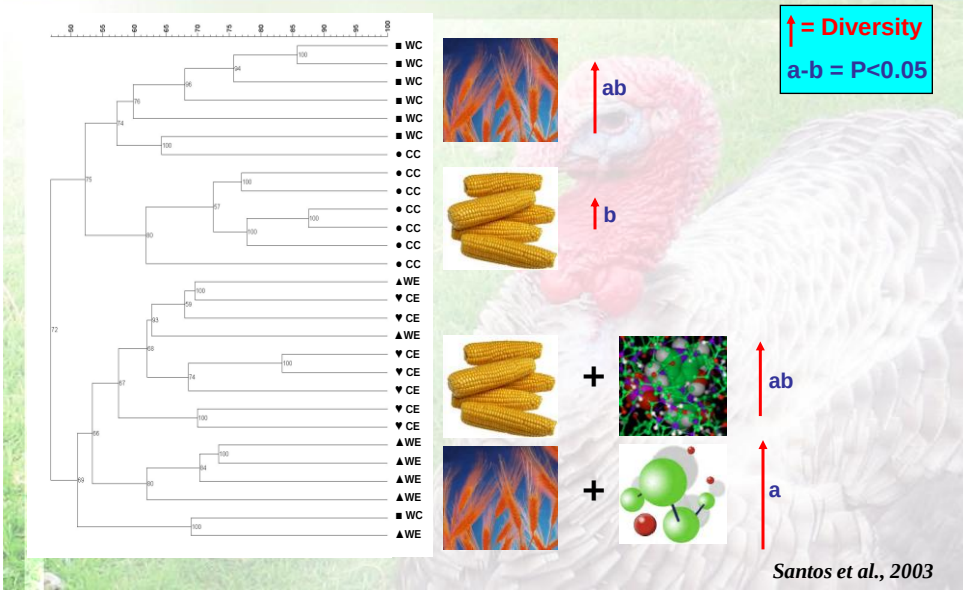
39%

	Enzyme + Wheat (50%)		Diference %
	-	+	
Body Weight, g	350.7[b]	380.5[a]	+ 8.5
FCR, g/g	1.555[a]	1.493[b]	- 4.2
AMEn, Kcal/kg	2,204[b]	2,455[a]	+ 11.4
N Retention, %	35.0[b]	41.4[a]	+ 18.3

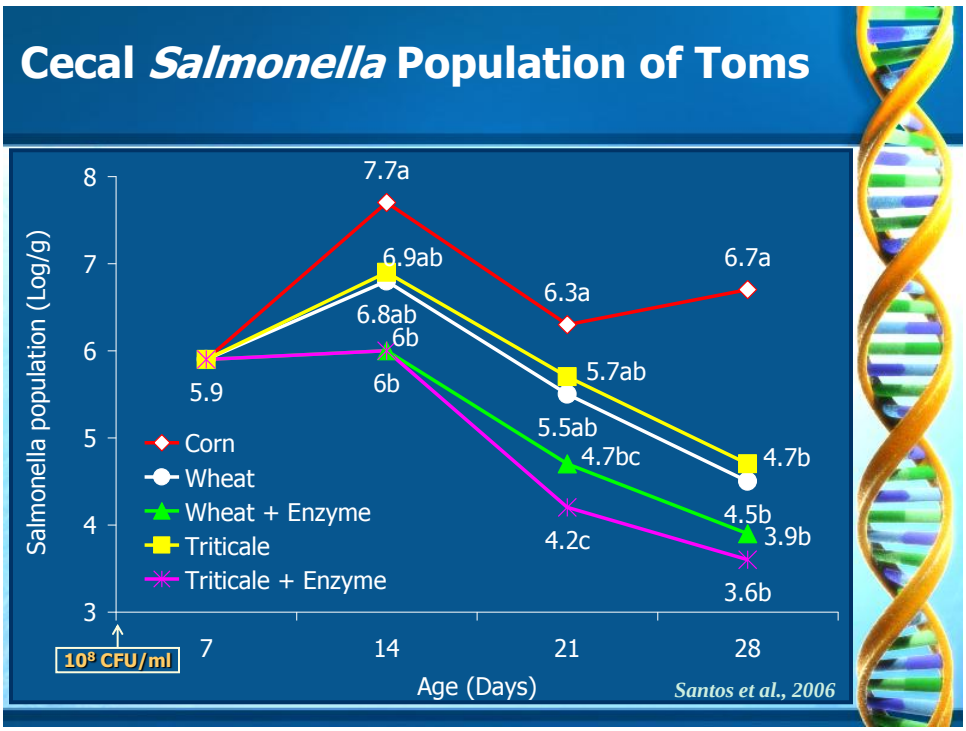
P<0.05

Santos et al., 2003

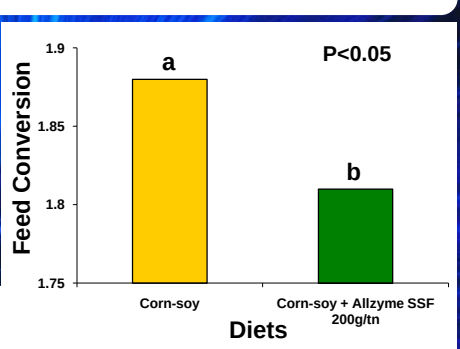
Dendrogram of PCR-DGGE Bands from Ileum Content of Toms (16wk)

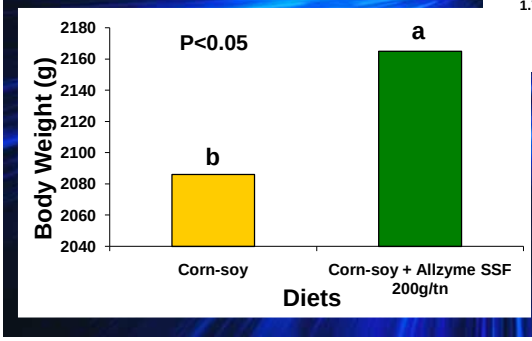


Cecal *Salmonella* Population of Toms



Enzyme Blend and Performance of Broilers (42d)

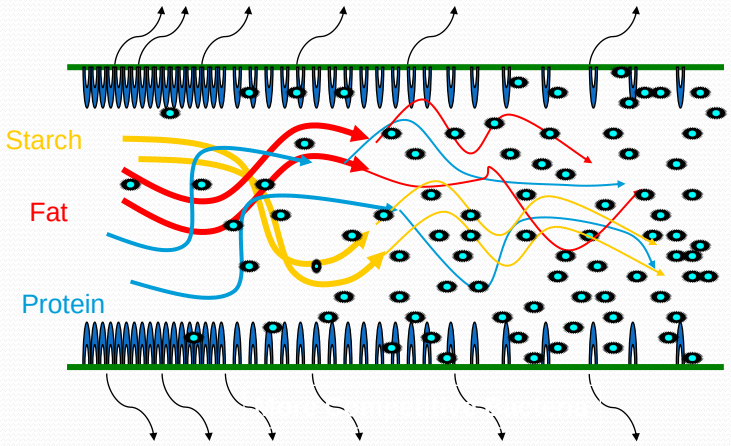




Enzyme complex working synergically

Ramesh et al., 2004

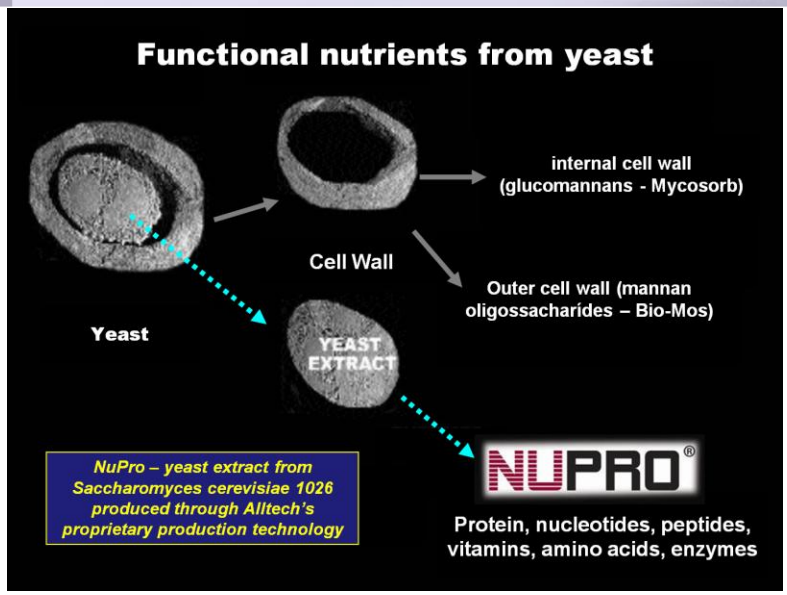
Poor digestion by the bird leads to more substrate for bacteria



Pathogens in hind gut cause inflammation that suppresses digestion in the foregut.

Bedford (2002)

Yeast Extract



Yeast Extract Composition

- **50% Crude protein**
  - *highly digestible and consistent protein source*
- **Rich source of vitamins & minerals**
- **Rich source of glutamate, free amino acids**
  - *improves palatability*
- **5-7% Nucleotides**
  - *improves immunity & gut health*
- **Rich source of inositol**
  - *improves cell growth & repair*

Benefits of Yeast Extract

Improved FCR
(W. Kramer, Field trials, 2004-2005)

Improved growth and weight gain
(Kramer, Field trials, 2004-2005; Gatica, 2005)

Reduced mortality to disease challenge *(Mendoza et al., 2001; Gatica, 2005)*

Increased resistance to bacteria, viruses, parasites
(Burrells et al., 2001a)

Improved response to vaccination
(Burrells et al., 2001b)

Improved immunity, intestinal health & growth
(Burrells et al., 2001; Estevez, 2003; Sritunyalucksana et al., 2005)

Attractant/palatability properties
(Carr et al., 1984; Mackie, 1973; Mackie & Adron, 1978; Ikeda, 1988)

Improved reproductive performance
Gonzalez-Vecino, 2004)

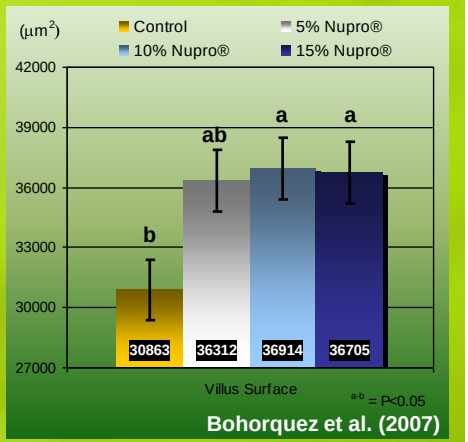
Nutritional Value of Yeast Extract

Precision-Fed Roosters

- 87% True Amino Acid Digestibility
- 3,611 Kcal TME/kg

Broiler Chicks (19-21 d)

- 3082 Kcal AME/kg
- 72.5% Apparent Nitrogen Retention
- No adverse effects on growth performance up to 15% dietary inclusion level
  - 2% dietary inclusion is optimum



Bohorquez et al. (2007)

Nutritional Strategies

- Antibiotics
- Herbs, spices and essential oils
- Acidifiers and organic acids
- Probiotics
- Synbiotics
- Prebiotics
- Enzymes
- Nucleic Acids

Decrease microbial load

↕

Shift microflora
↓
Competitive exclusion
↓
Promote intestinal health

Practical Application

	Factors for Application				Solution				
	Stress	↓ Immunity	Control of animal and human health	Transfer of passive immunity	Anti-bacterial activity	Imuno-stimulator	Block colonization	↑ symbiotic microflora	Tissue Repair
Broilers (starter)	+	+	+	-	PROB	-	MOS	-	NUCL OA
Broilers (grower)	-	+	+	-	-	β-GL	-	PREB ENZ	NUCL
Broilers (Finisher)	+	-	+	-	-	-	OA	ENZ	OA
Breeders	-	-	+	+	-	β-GL	MOS	-	-

Conclusion

- Diet can affect enteric microflora and modulate the intestinal tract to a healthy state.
- Several nutritional strategies to modulate the microflora are available in the market, which many has great potential to promote intestinal health.
- Research has shown that combination of feed additives strategies can be used to achieve good intestinal health, growth performance and control of enteric pathogens and benefit food safety