

Antibiotic free nutrition

Dr. Yanming Han

Danisco, UK

Brief Curriculum

- Dr. Yanming Han, majored in monogastric nutrition, obtained his Ph. D. degree from the University of Illinois at Urbana-Champaign in 1989.
- He then worked at the University of Illinois for a number of years as a visiting assistant professor and research scientist.
- He published a numerous research articles in the area of amino acid nutrition.
- He then functioned as technical services manager and R&D director with Purina Nanjing (China).
- For the past 4 years with Innfeeds International, Dr. Han held responsibilities as technical service manager and business manager for various North American and Asia Pacific countries. Dr. Han is currently a technical consultant.

(Translator)

Sang-Jip, Ohh

Kang-Won National Univ.

Brief Curriculum

- 1973 ~ 1977 Kangwon National University, Korea, B.S
- 1977 ~ 1981 Seoul National University, Korea, M.S
- 1982 ~ 1986 Kansas State University, U. S. A, Ph. D
- 1987 ~ 2002 Kangwon National University(KNU)Assistant, Associate & Full Professor Director
- 1994 ~ 1996 Animal Resources Institute, KNU
- 1997 ~ 1998 Kansas State University, U.S.A.(Visiting Professor)
- 2000 ~ 2002 International Collaboration Committee, Korean
- 2001 ~ 2002 Society of Animal Sciences and Technology(KSAST)
AAAP(AsianAustralasian Animal Production Societies)
- 2001 ~ 2002 International affairs, KNU

Nutritional Strategies for Broiler/Swine Production without Antibiotic Growth Promoters

Dr. Yanming Han

Oct. 11, 2002
Seoul, Korea

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Production Problems Associated with the Removal of AGP

- **Only minor loss in FCR**
 - Note that most EU broiler feeds are wheat based & majority (>90%) contain enzymes
- **Increased incidence of Necrotic enteritis (NE)**
= No 1 CONCERN
 - Increased use of therapeutic antibiotics
- **Decreased broiler uniformity**
- **Wet litter**
- **Increased post-weaning diarrhea in pigs**

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Strategies Being Considered

- Higher quality ingredients
- Whole grain addition to complete feed
- Feed processing
- Live direct-fed microbial
- Fermentable sugars
- Feed sterilization
- Lowered feed nitrogen content
- Enzymes
- Betaine
-

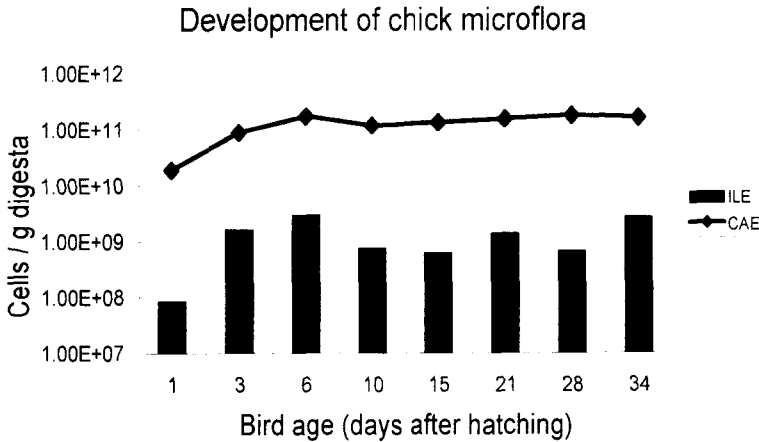
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Intestinal Microflora Reduce Host Animal Performance

- Competition with host for nutrients
- Can elicit immune response causing appetite depression and protein catabolism to fuel response
- Disease - especially NE
- Reduced digestive efficiency via degradation of digestive enzymes & reduction of absorptive surface area
- Increased GI tract size via production of stimulatory compounds e.g. polyamines - increased gut maintenance energy cost at expense of growth

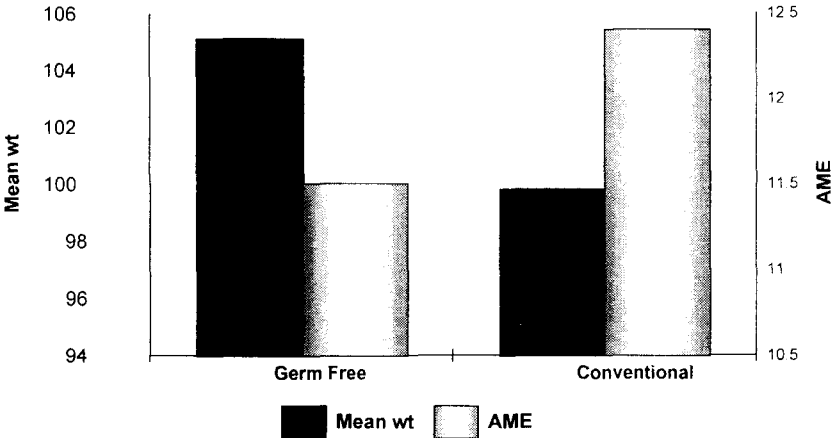
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Total Bacterial Numbers



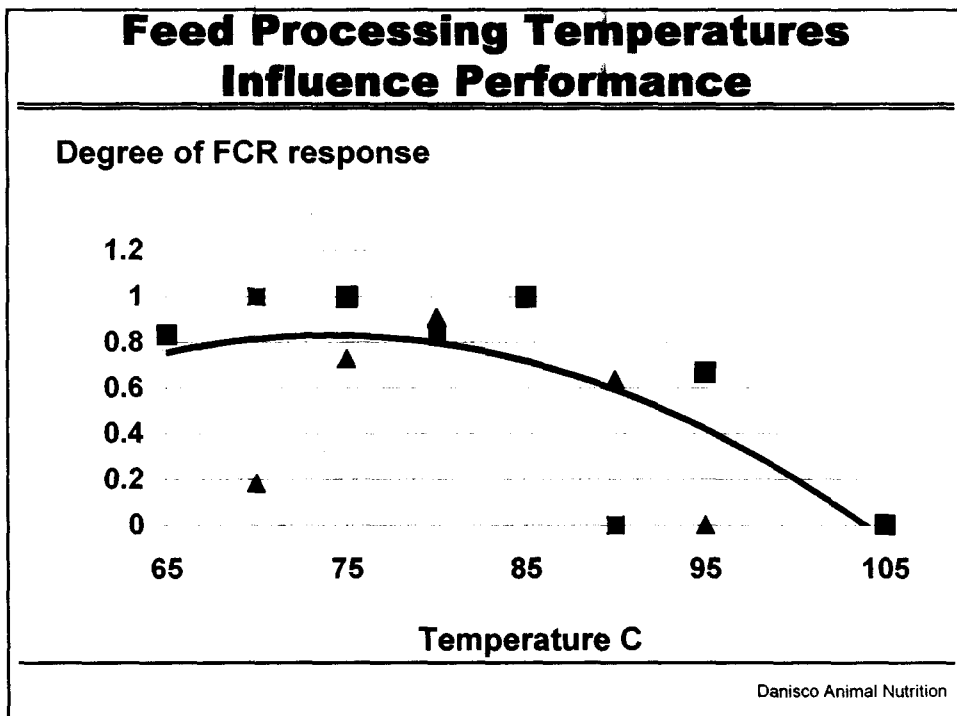
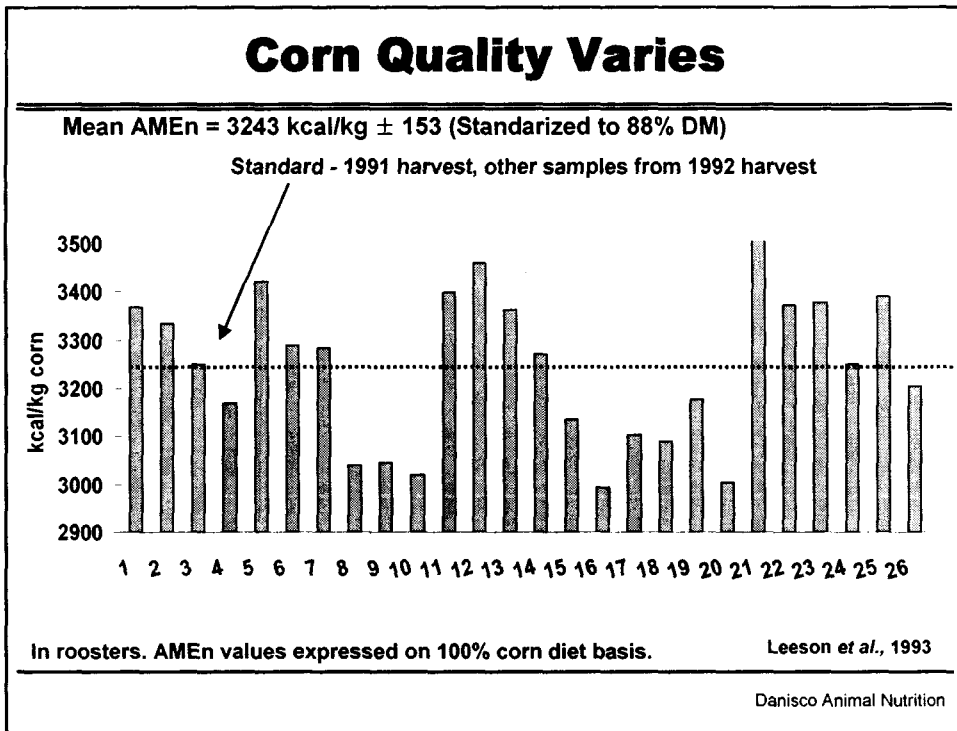
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The Presence of Microflora Influences Broiler Growth Rate and Energy Dynamics



(Murumatsu et al, 1994)

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ENZYMES

It's role in broiler diets without antibiotic growth promoters

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Comparison - AGPs & Enzymes

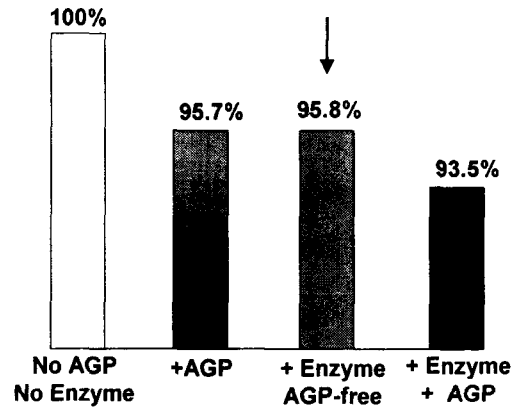
<u>Antibiotic Growth Promoters</u>	<u>Xylanase Complex Enzymes</u>
➤ Improves FCR approx. 4% (- enzymes)*	➤ Improves FCR approx. 4% (- AGP)**
➤ Directly kill microflora in small intestine & caeca	➤ Changes intestinal environment - no anti-microbial effect ➤ NSP breakdown & improved nutrient digestibility reduces microflora in small intestine & stimulates microflora in caecum
➤ Response dependent upon microbial challenge	➤ Response dependent upon microbial challenge

Reference: *Rosen 1995. **Finnfeeds Internal Data

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Effect of AGPs & Enzymes on Broiler FCR

FCR Response (relative to Control)

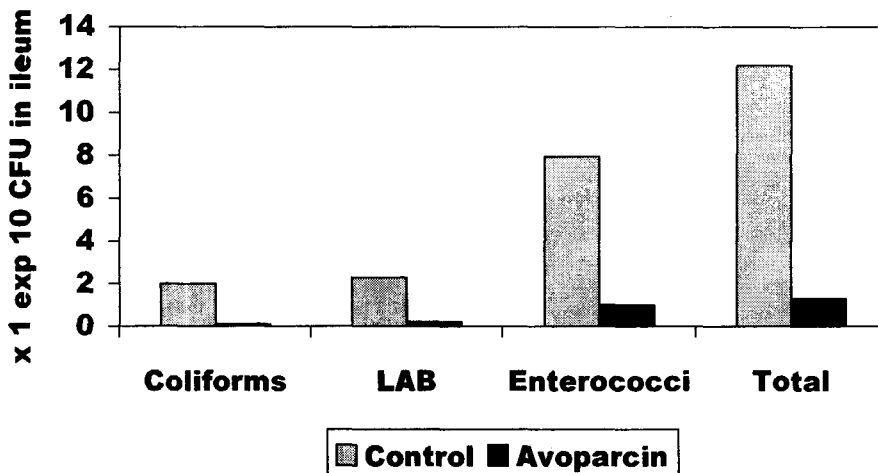


n=78 experimental tests, broilers av 31 days of age

Reference: Rosen, European Symposium on Feed Enzymes, 2000

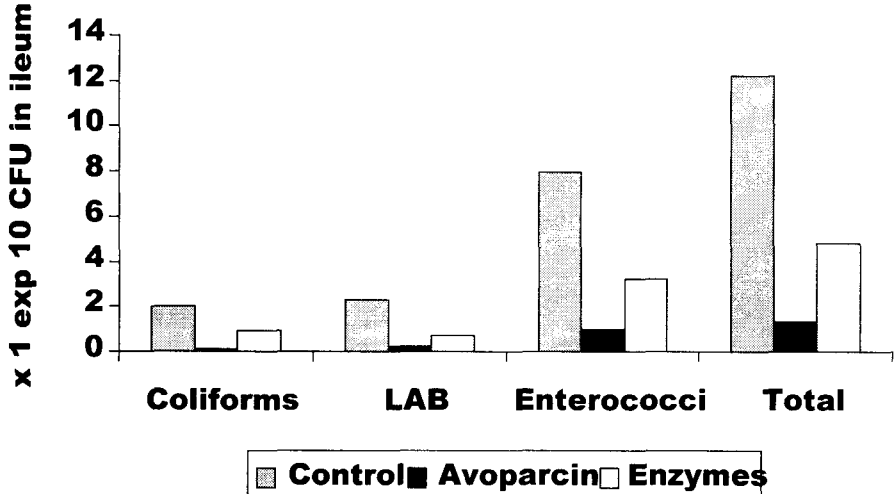
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Antibiotic Growth Promoters Directly Reduce Ileal Microflora



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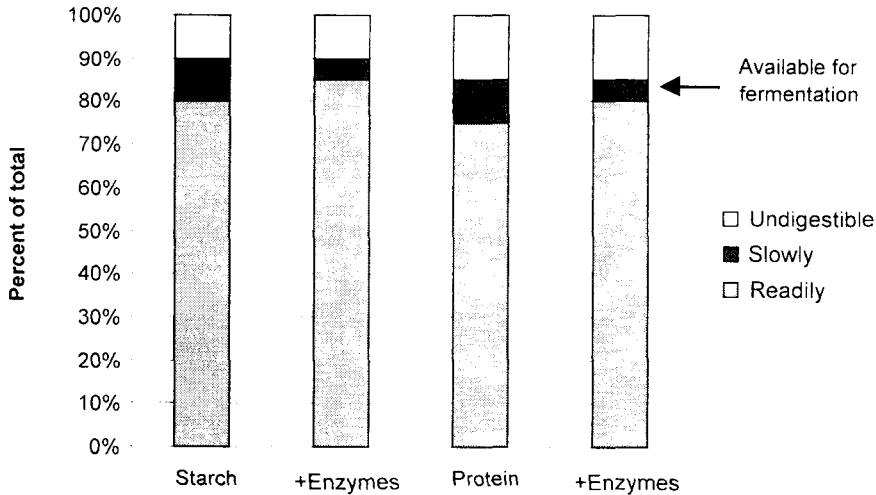
Enzyme Complex Reduce Substrate Available for Ileal Microflora



Reference: CTC, Finland, 1996

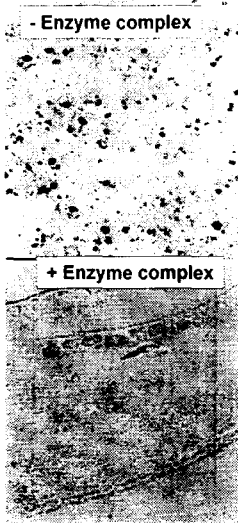
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Rate of Digestion Influences Substrate Available for Microflora



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Enzymes Reduce Undigested Starch Available As Bacterial Substrate



➤ Digesta contents in the small intestine of a bird fed a corn soy-based diet without enzyme supplementation

➤ Black staining shows undigested starch

➤ Some starch remains undigested in the small intestine providing substrate for bacteria

➤ Enzyme complex (xylase, amylase, protease) significantly improves starch digestion in the small intestine & reduces substrate for bacteria

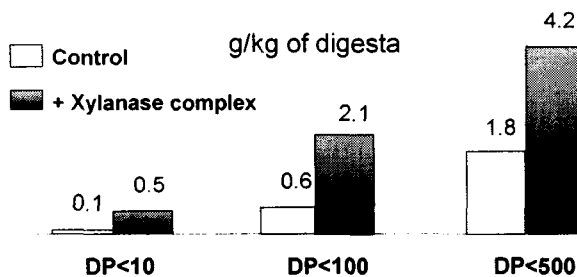
Terminal ileum - staining for starch

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Enzymes Alter the Carbohydrate Profile Reaching the Lower Intestine

Carbohydrate profile influences intestinal microfloral populations
Bird performance varies according to intestinal microfloral populations

Enzyme increases the amount of short chain carbohydrates reaching the lower intestine



Xylanase complex increases the amount of short chain carbohydrates leaving small intestine (DP <500)

DP = degree of polymerisation;; small intestine-broilers

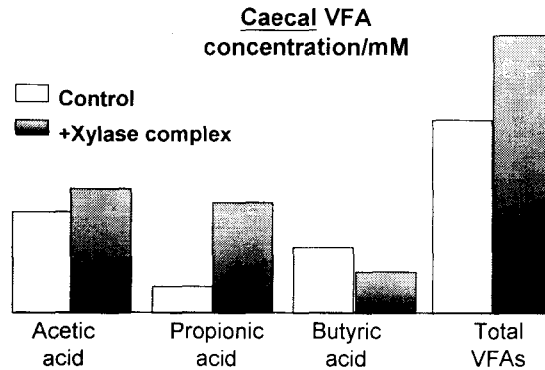
Reference: Apajalahti & Bedford, 1998

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Alteration of Substrate Availability Influences VFA Concentrations

Carbohydrate profile influences intestinal microfloral populations
Bird performance varies according to intestinal microfloral populations

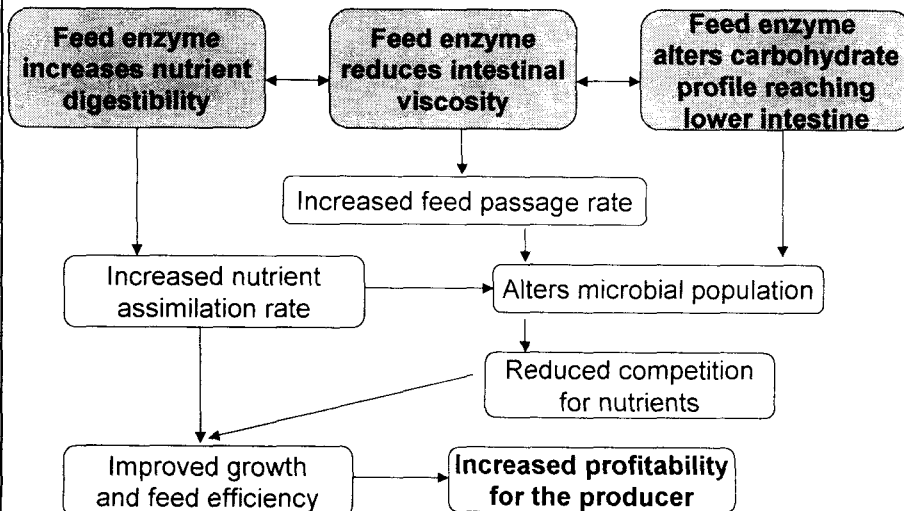
Enzyme increases short chain carbohydrates reaching the caeca ⇒ short chain sugar fermentation increases & propionic and acetic acid levels increase in the caeca



Reference: Apajalahti & Bedford, 1998

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The Role of Enzymes in Antibiotic Growth Promoter Free Broiler Diets

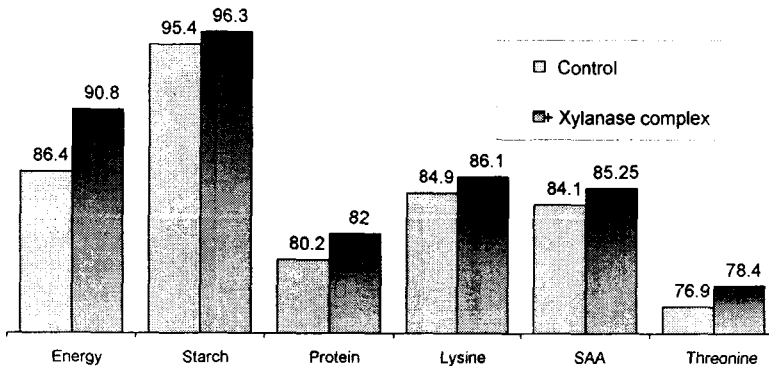


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Enzymes Increase Nutrient Uptake From Small Intestine

Undigested nutrients reach the lower gut ⇒ these nutrients represent a loss to the bird & may be utilised by the microbes for growth

Enzyme increases nutrient digestibility ⇒ more nutrients for bird growth ⇒ less nutrients reach the lower gut ⇒ less nutrient availability for microbial growth



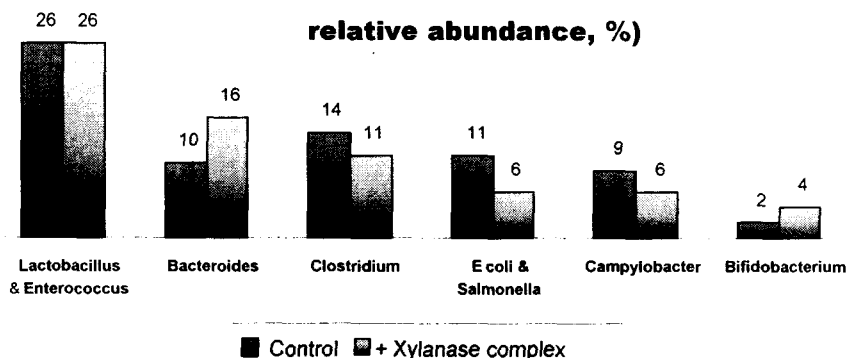
Reference: 1300.UK.94.03
SAC, Auchincruive, UK

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Alteration of Substrate Availability Influences Bacterial Populations

Carbohydrate profile influences intestinal microfloral populations
Bird performance varies according to intestinal microfloral populations

Enzyme increased short chain carbohydrates resulting in more ⇒ short chain sugar fermentation increases & propionic & acetic acid levels increase in the caeca ⇒ microbial population changes



Reference: Apajalahti & Bedford, 1998

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Enzymes Reduced *Campylobacter jejuni* in Broilers

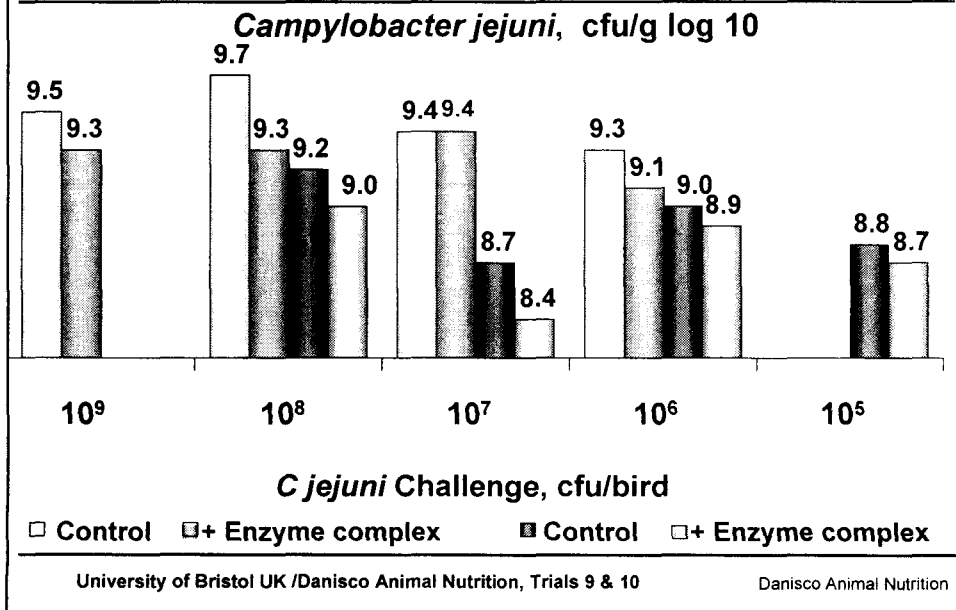
Design:

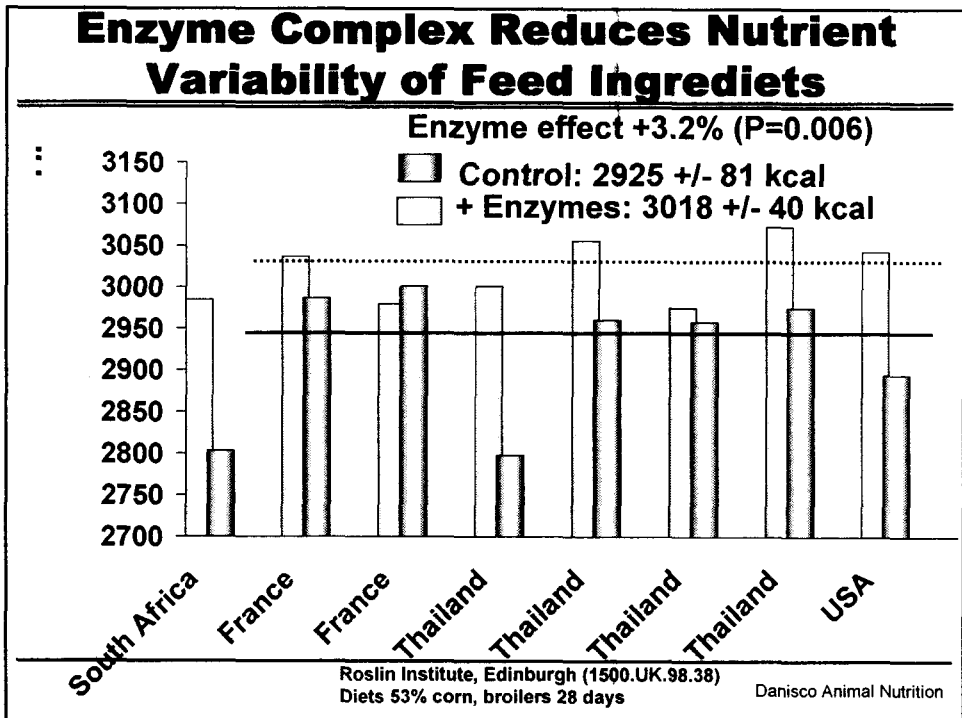
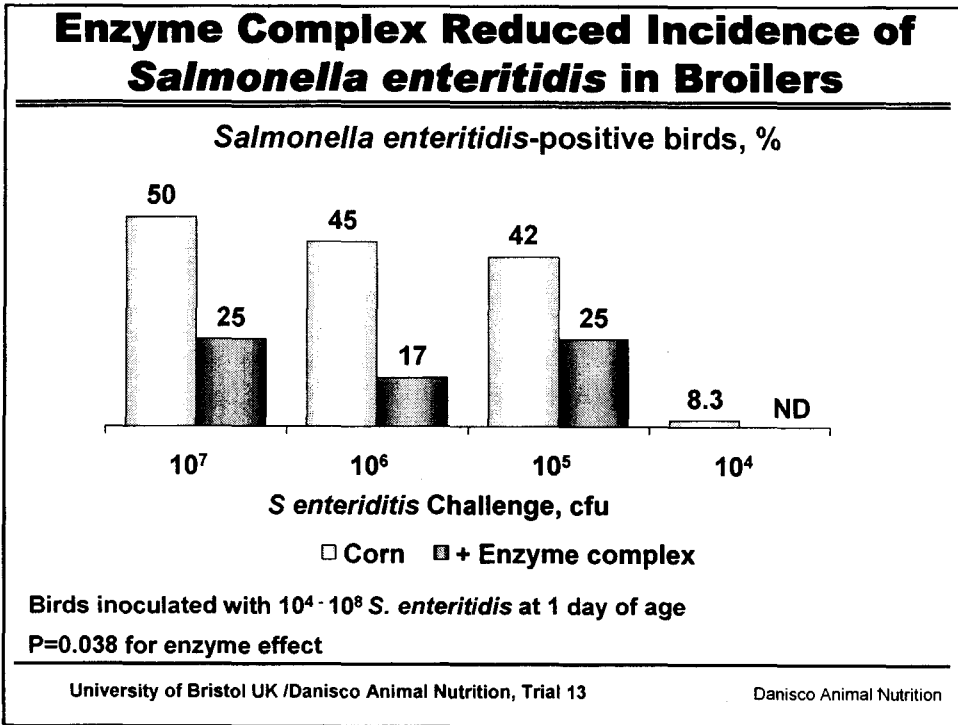
- Birds were assigned to 5 treatments in two similarly designed trials (1 and 2)
- All birds were inoculated with *Campylobacter jejuni* at 4 days of age: $10^9 \rightarrow 10^6$ cfu (trial 1) & $10^8 \rightarrow 10^5$ cfu (trial 2)
- Presence of *C. jejuni* (cfu/g) in caecal digesta was determined at 17 days of age
- Dietary treatments:
 - Corn-based diet
 - Corn-based diet + Xylanase/amylase/protease complex (1kg/tonne)

University of Bristol UK /Danisco Animal Nutrition, Trials 9 & 10

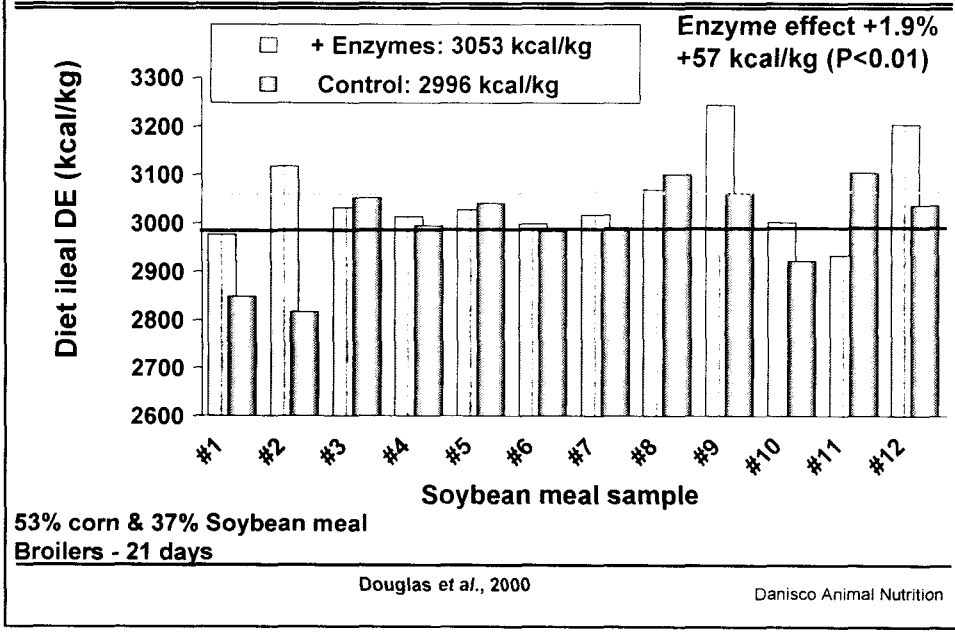
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Enzyme Complex Reduced *Campylobacter jejuni* in Broilers





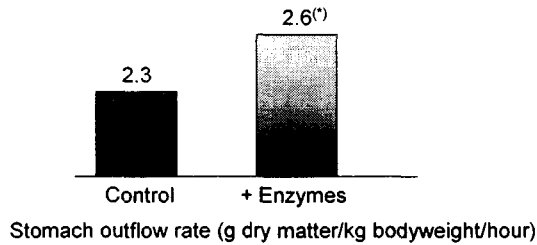
..... And Soybean Meal



Feed Enzymes and its indirect effects on the microflora Swine Diets

Effect of Enzyme Addition on Stomach Outflow Rate

↑ **Digesta Flow**
means less likelihood of microbial migration from the large to the small intestine

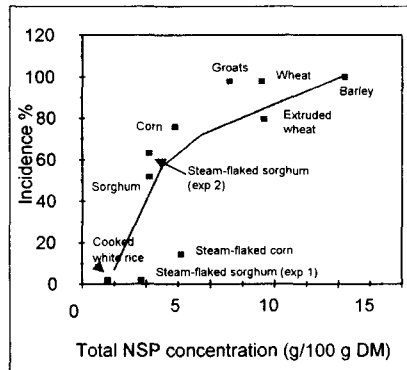
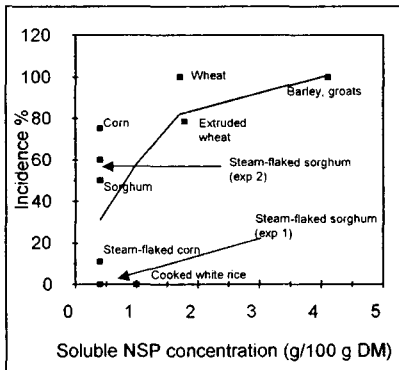


(*) p<0.10 Wheat-based diets; Enzyme complex

Ref: Sudendey and Kamphues 1995

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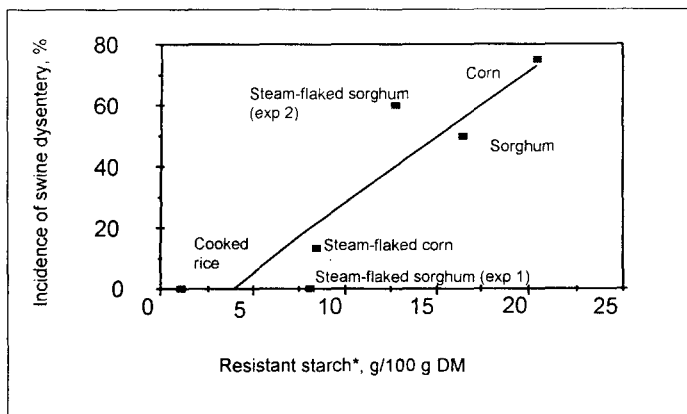
Incidence of Swine Dysentery and Non Starch Polysaccharide Concentration



Ref: Pluske et al (1996) J.Nutr. 126:2920-2933

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Incidence of Swine Dysentery and Resistant Starch Concentration



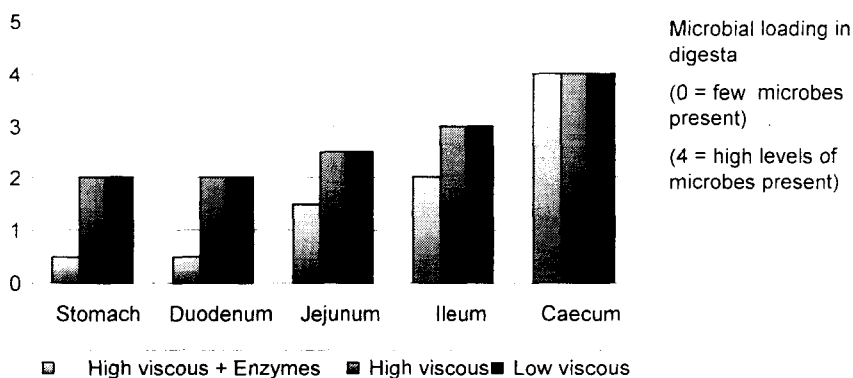
**In vitro* estimation, after simulated digestion

Ref: Pluske et al (1996) J Nutr. 126:2920-2933

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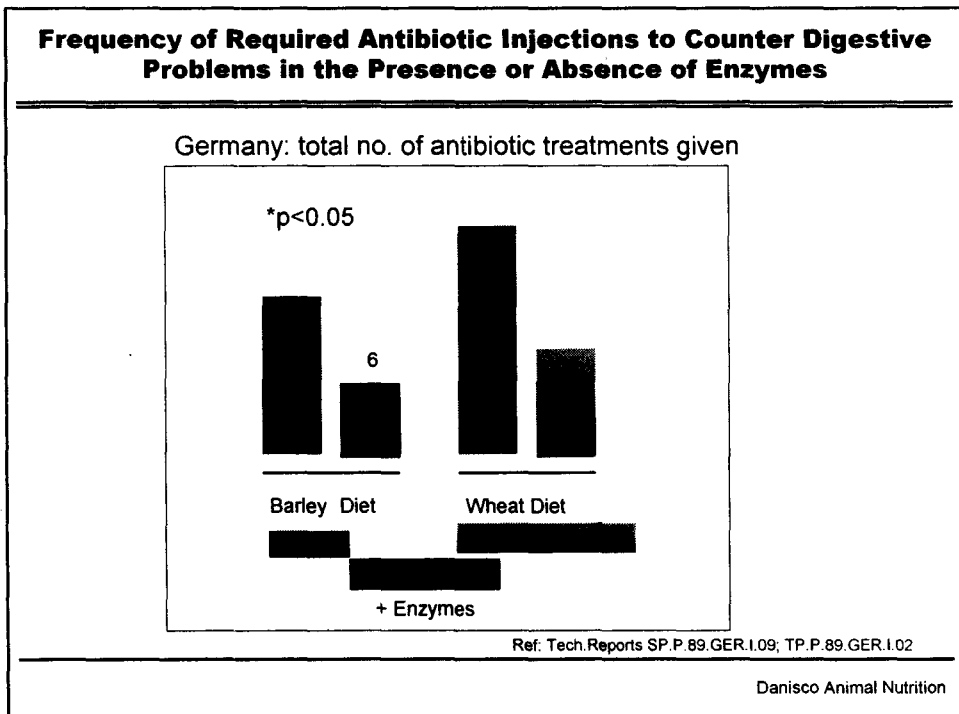
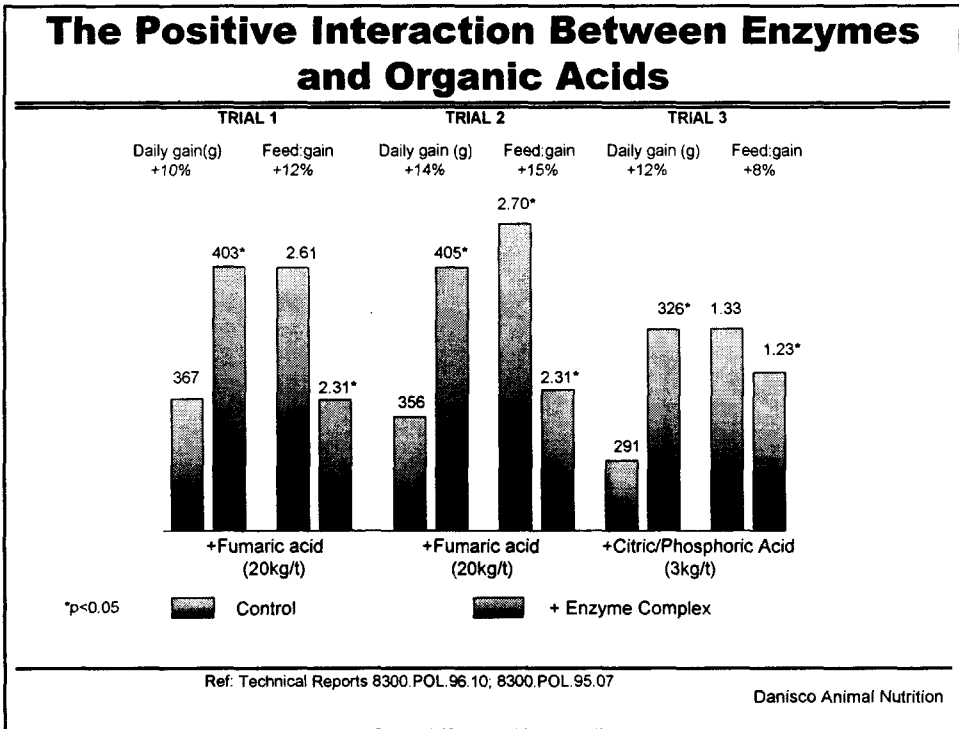
Effect on Microbial Populations in Digesta When Piglets Are Fed Diets Based on High Viscous Wheat Containing Xylanase & Protease

Microscopical analysis of digesta (VTT Biotechnology and Food Research, Finland)



Ref: 8300.GER.98.15

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Enzymes - Implications of AGP Withdrawal

- Enzymes deliver larger performance response in **poorly digested diets** - since these diets provide most substrate for intestinal microflora
- Enzymes deliver larger performance response in an **environment of higher microbial challenge** - a clean research facility will underestimate responses in commercial practice
- In the absence of AGPs **relative response to enzymes will increase** and so importance & value of enzymes for performance/uniformity improvements will increase

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BETAINE

**It's role in broiler diets
without antibiotic growth
promoters**

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Betaine as Osmolyte

- **Maintain ion/water balance, prevent cell dehydration, Especially important for animals during weaning, transportation, heat stress, or disease challenge**
- **Will not interfere enzyme activities in cell. Protect normal functions of enzymes and cell wall during osmotic stress**
- **Maintain intestine cell integrity, increase resistance to pathogen invasion and improve nutrient utilization**

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Coccidiosis & Necrotic Enteritis

- **In the absence of AGPs, intestinal pathogens have greater opportunity to proliferate & depress bird performance**
- **Removal of AGPs increases the incidence of Necrotic enteritis (NE) due to their direct effect on the causative organism - Clostridium perferingens (Cp)**
- **NE is known to follow coccidiosis outbreaks (Elwinger, 1998) & species most commonly associated are E acervulina, maxima and necatrix but not E tenella**

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Coccidiosis & Necrotic Enteritis

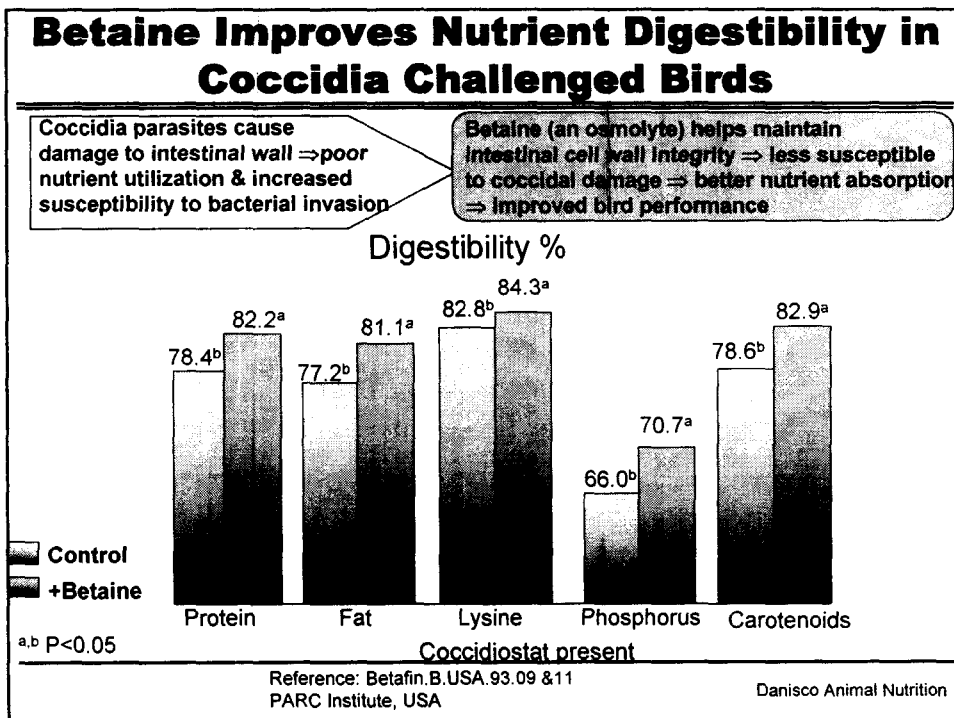
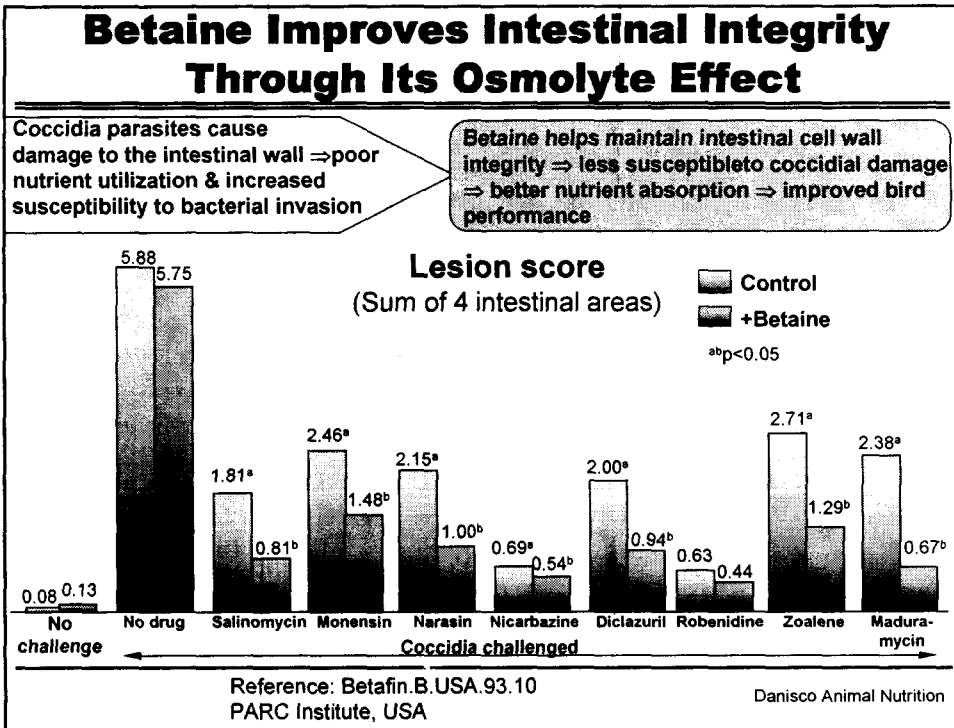
- It is believed that proliferation of Cp & development of NE is facilitated by appearance of large amounts of nitrogen in the caeca - experimental models for inducing NE often involve feeding high levels of protein
- When viscous/ poorly digested diets are fed or when coccidiosis causes intestinal damage, excessive nitrogen enters caeca & NE incidence increases

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Coccidiosis & Necrotic Enteritis

- Sloughed cells from damaged villi also provide nitrogen to the caeca
- Reducing the damage that coccidiosis causes to the small intestine is essential to minimize NE incidence (& to maximize nutrient digestibility)
- Betaine, through its osmolyte function, improves the osmotic condition of the intestinal enterocyte. Improved intestinal integrity reduces the opportunity for coccidiosis & secondary infection e.g. NE

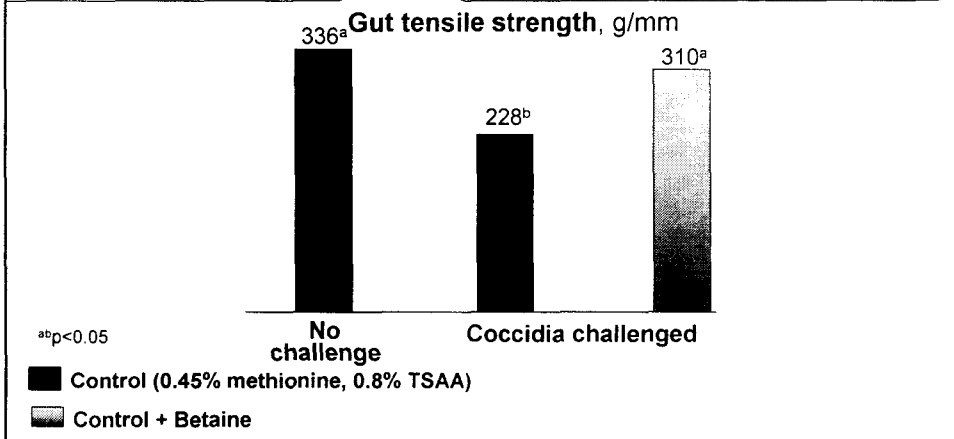
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Betaine Improves Intestinal Integrity Through Its Osmolyte Effect

Coccidia parasites cause damage to intestinal wall \Rightarrow poor nutrient utilization & increased susceptibility to bacterial invasion

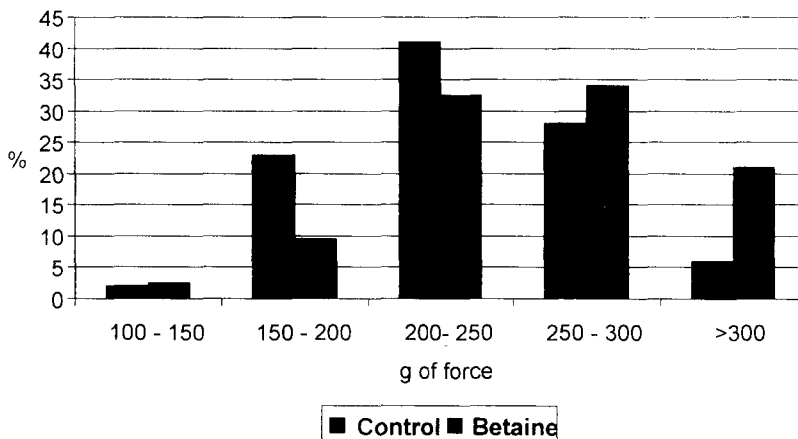
Betaine helps maintain intestinal cell wall integrity \Rightarrow cells less susceptible to coccidial damage \Rightarrow better nutrient absorption \Rightarrow improved bird performance



Reference: Betafin.B.USA.98.26
 Colorado Quality Research, USA

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Betaine Increases Gut Tensile Strength in Broilers



Significant Betaine effect at P < 0.05

Reference: Betafin.B.USA.98.27
 Broiler Integrator, USA

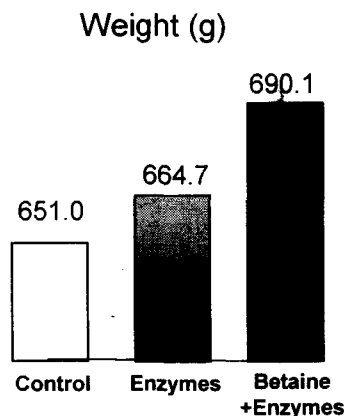
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Betaine - Implications for AGP Withdrawal

- In the absence of AGPs risk of NE is substantially increased
- Betaine, through its function as an osmolyte, can enhance the ability of a coccidiostat to minimise intestinal damage caused by small intestinal *Eimeria* species
- Digestive integrity of the intestinal tract is better maintained & so nutrient uptake is improved and less nitrogen can enter the caeca

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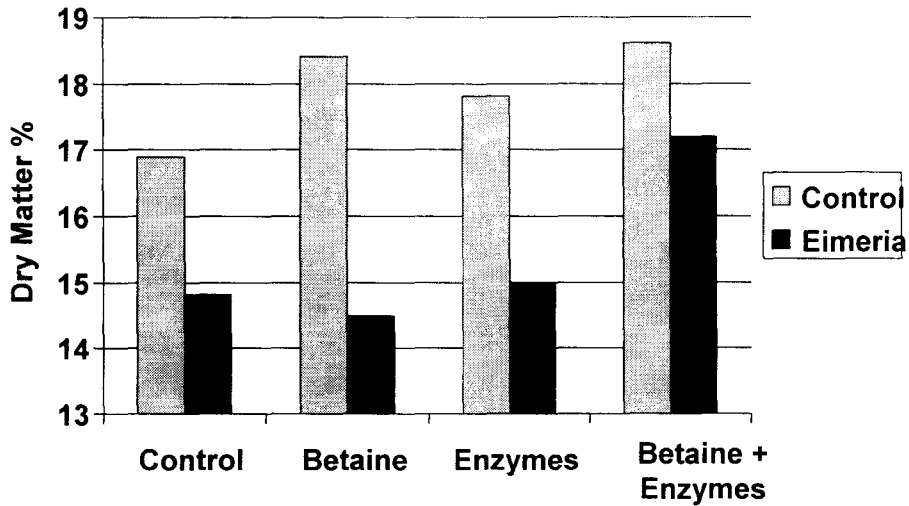
Effect of Enzymes/Betaine on Bird Performance - Exp 1



Performance at 21 days, challenged with E Maxima at 14 days

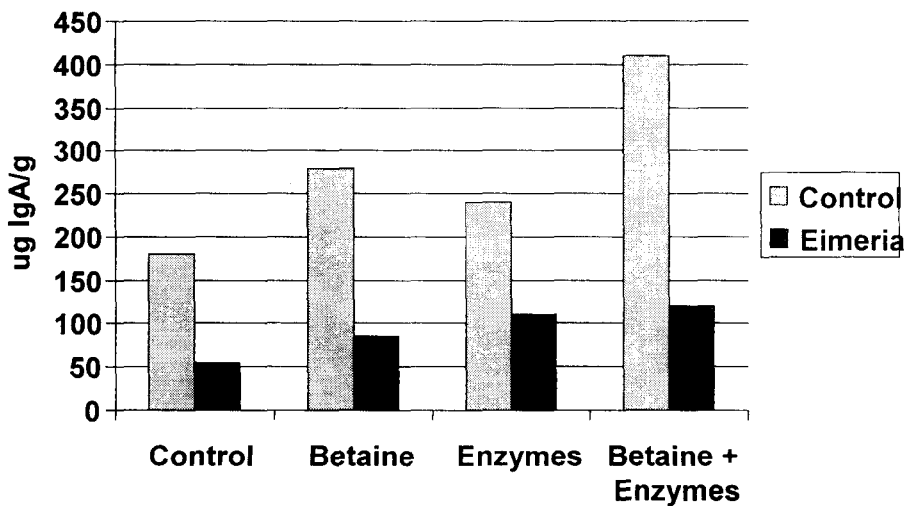
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Effect of Enzymes/Betaine on Ileal Digesta Dry Matter - Exp 2



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Effect of Betaine/Enzyme on IgA Concentration in Ileal Digesta



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Enzyme Complex + Betaine - Implications for AGP Withdrawal

- Enzyme + betaine, in combination, have been shown to be synergistic in broilers, improving bird performance & creating an intestinal environment that does not favor growth of C. perfringens - the pathogen commonly associated with Necrotic Enteritis
- NE and intestinal disorders are caused by multitude of factors which are not yet fully understood. Enzyme & betaine fed in combination can reduce the impact of some of these factors and thus the limit risk in AGP-free production systems

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Conclusion

With the removal of AGPs:

- Nutritionists should be as concerned with the impact of the diet on the intestinal microflora as they are with the meeting the nutrient requirements of the bird
- Enzymes to reduce variation in diet digestibility
- Betaine to improve the intestinal environment
- Enzyme/betaine combination to limit NE risks

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