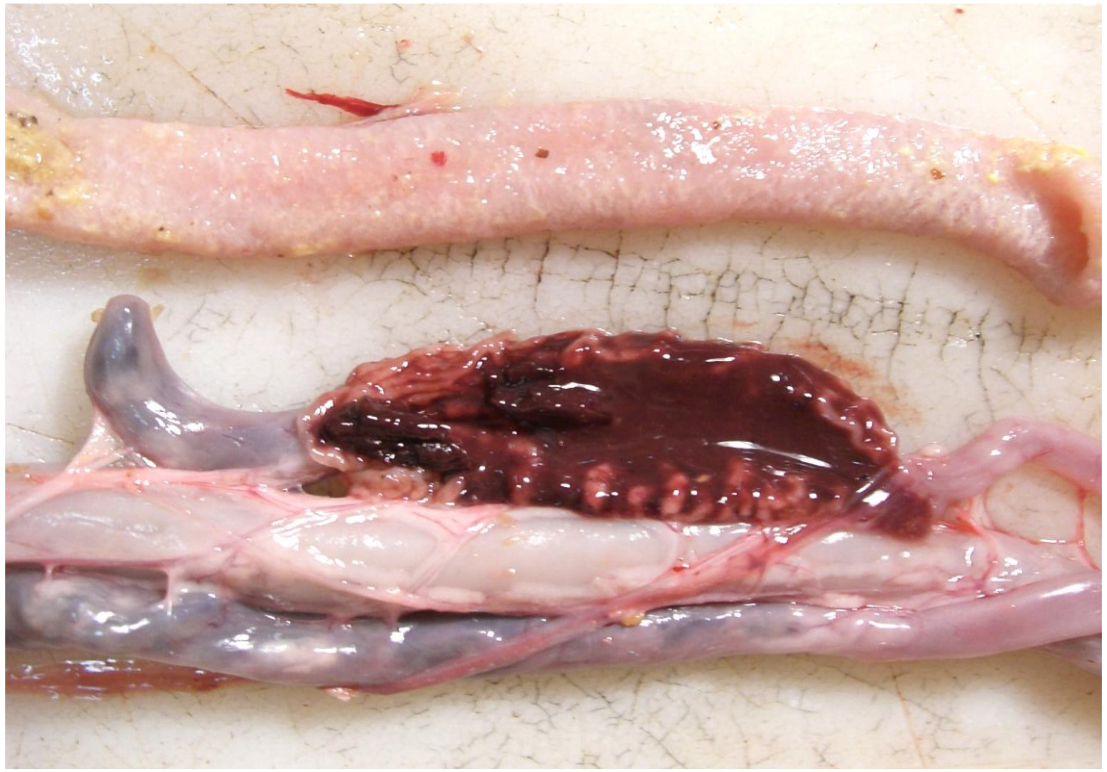
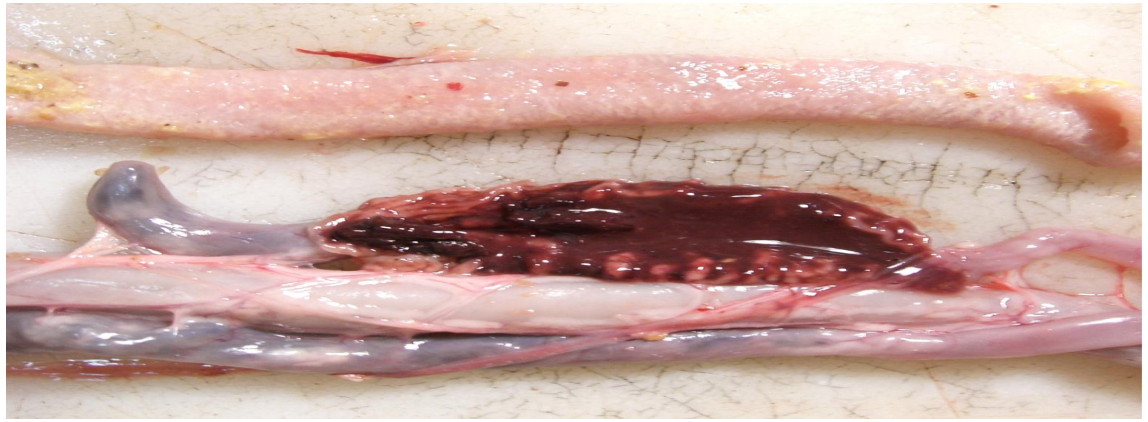
Research Update
Considerations for Nutrition and Coccidiosis



Brett Lumpkins and Greg Mathis,
Southern Poultry Feed & Research, Inc.

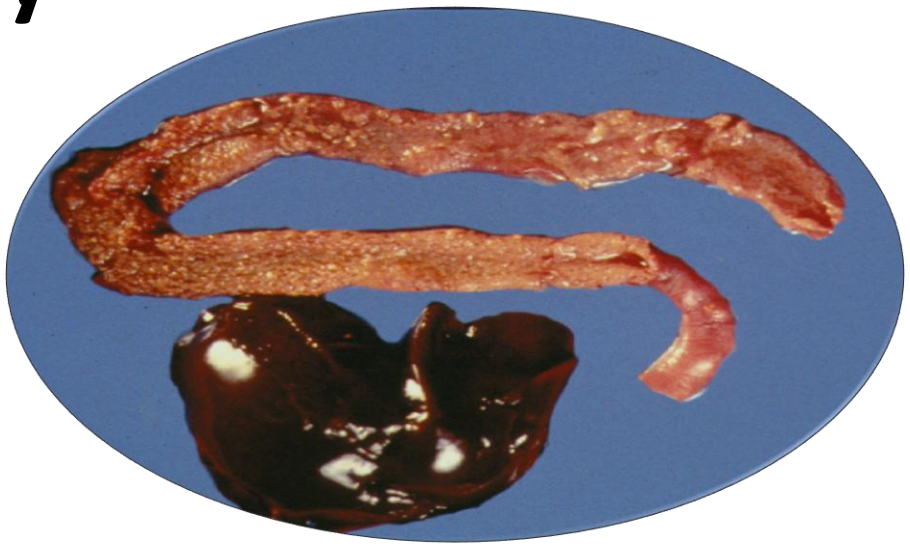
American Veterinarians In Broiler Production



#1 Coccidiosis

#2 Necrotic Enteritis

#3 Chick quality and mortality



Coccidiosis: 8-9 independent Eimeria species

Protozoa that infect intestinal tract (nutritionally E. acervulina and E. maxima most important species)

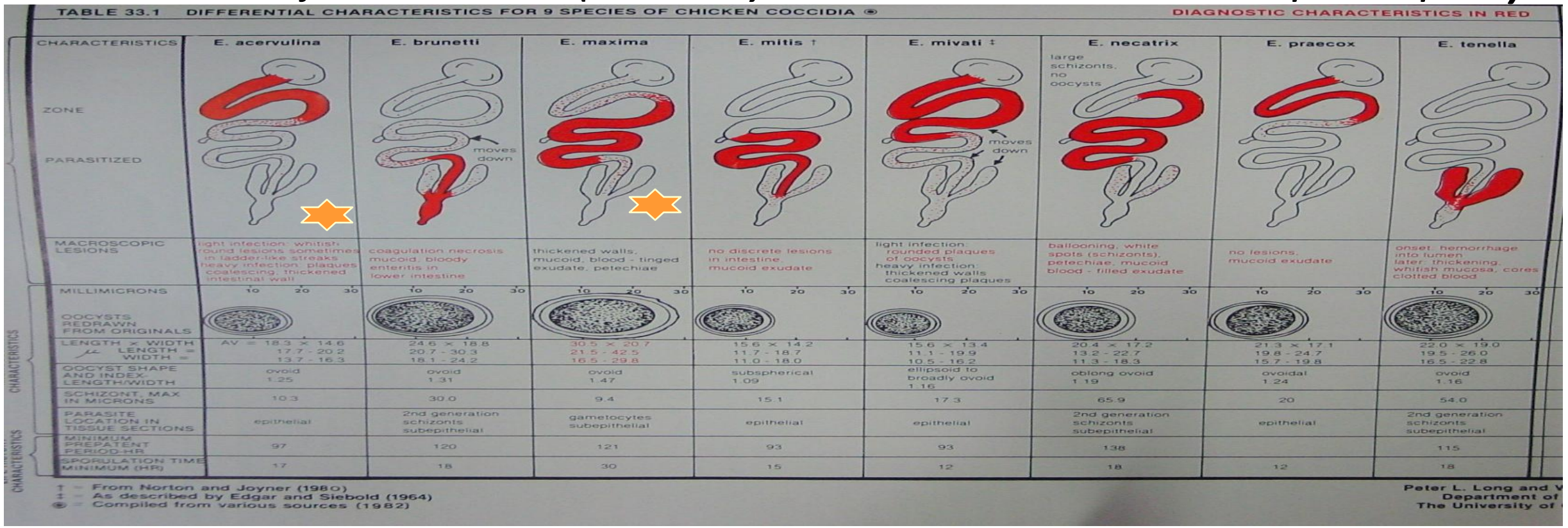


TABLE 33.1 DIFFERENTIAL CHARACTERISTICS FOR 9 SPECIES OF CHICKEN COCCIDIA ◉ — DIAGNOSTIC CHARACTERISTICS IN RED

CHARACTERISTICS	E. acervulina	E. brunetti	E. maxima	E. mitis †	E. mivati ‡	E. necatrix	E. praecox	E. tenella
ZONE PARASITIZED		moves down			moves down	large schizonts, no oocysts		
MACROSCOPIC LESIONS	light infection: whitish round lesions sometimes in ladder-like streaks; heavy infection: plaques coalescing, thickened intestinal wall	coagulation necrosis, mucoid, bloody enteritis in lower intestine	thickened walls, mucoid, blood - tinged exudate, petechiae	no discrete lesions in intestine, mucoid exudate	light infection: rounded plaques of oocysts; heavy infection: thickened walls coalescing plaques	ballooning, white spots (schizonts), petechiae, mucoid blood - filled exudate	no lesions, mucoid exudate	onset: hemorrhage into lumen, later: thickening, whitish mucosa, cores clotted blood
MILLIMICRONS 10 20 30 — OOCYSTS REDRAWN FROM ORIGINALS								
LENGTH × WIDTH; LENGTH ÷ WIDTH =	AV = 18.3 × 14.6; 17.7 - 20.2; 13.7 - 16.3	24.6 × 18.8; 20.7 - 30.3; 18.1 - 24.2	30.5 × 20.7; 21.5 - 42.5; 16.5 - 29.8	15.6 × 14.2; 11.7 - 18.7; 11.0 - 18.0	15.6 × 13.4; 11.1 - 19.9; 10.5 - 16.2	20.4 × 17.2; 13.2 - 22.7; 11.3 - 18.3	21.3 × 17.1; 19.8 - 24.7; 15.7 - 19.8	22.0 × 19.0; 19.5 - 26.0; 16.5 - 22.8
OOCYST SHAPE AND INDEX LENGTH/WIDTH	ovoid 1.25	ovoid 1.31	ovoid 1.47	subspherical 1.09	ellipsoid to broadly ovoid 1.16	oblong ovoid 1.19	ovoidal 1.24	ovoid 1.18
SCHIZONT, MAX IN MICRONS	10.3	30.0	9.4	15.1	17.3	65.9	20	54.0
PARASITE LOCATION IN TISSUE SECTIONS	epithelial	2nd generation schizonts subepithelial	gametocytes subepithelial	epithelial	epithelial	2nd generation schizonts subepithelial	epithelial	2nd generation schizonts subepithelial
MINIMUM PREPATENT PERIOD-HR	97	120	121	93	93	138		115
SPORULATION TIME MINIMUM (HR)	17	18	30	15	12	18	12	18

CHARACTERISTICS — CHARACTERISTICS

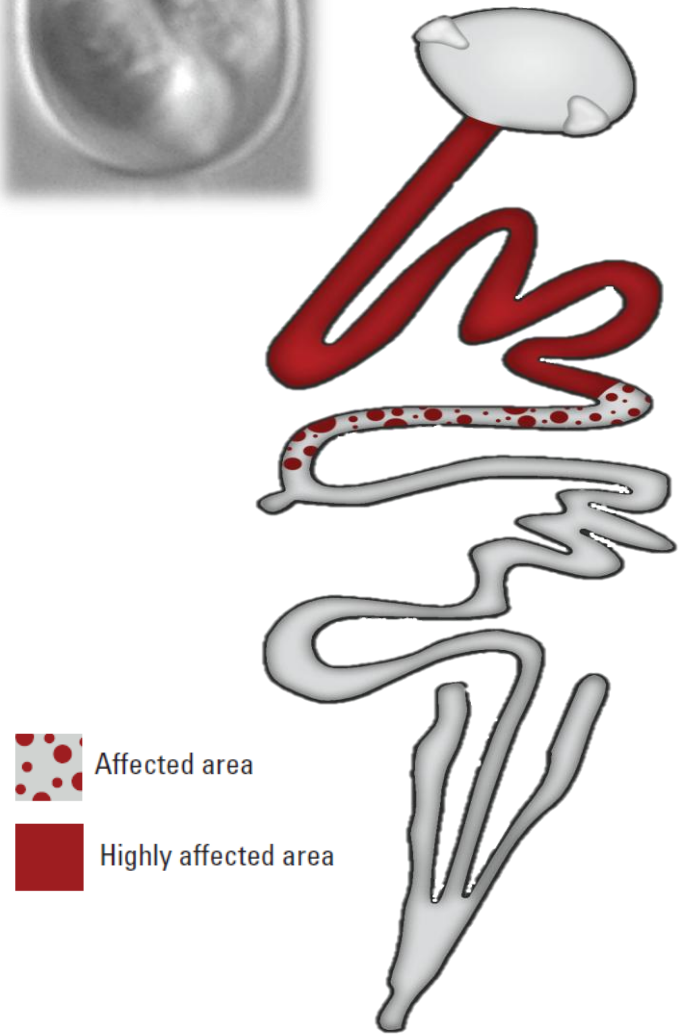
† = From Norton and Joyner (1980)
‡ = As described by Edgar and Siebold (1964)
◉ = Compiled from various sources (1982)

Peter L. Long and V
Department of
The University of

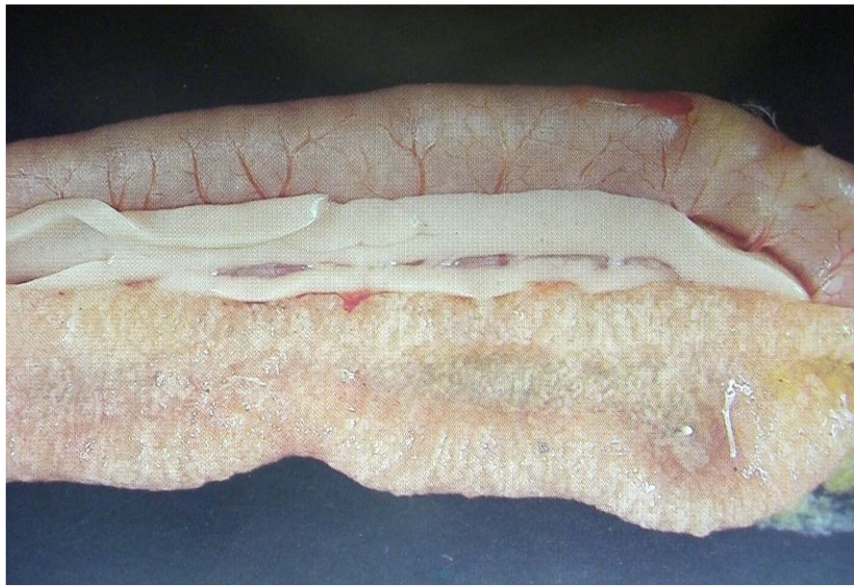
Individual species of cocci i.e. E. acervulina will have effects on fat/energy digestibility and fat-soluble vitamins and pigments. E. maxima would have more of an effect on amino acid and general digestibility in the intestine. E. tenella might have the least effect on nutrition in the ceca, but might have repercussions on fermentation.

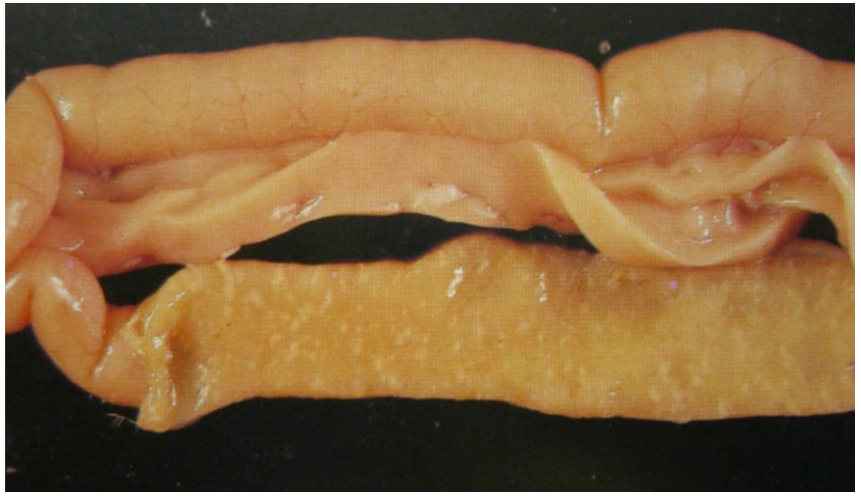
Michael E Persia, PhD, John W. Hancock Professor and Extension Specialist
Virginia Tech

E. acervulina



- *Infects duodenal loop, spreading down GIT
- *High reproductive index
- *Impairs nutrient absorption





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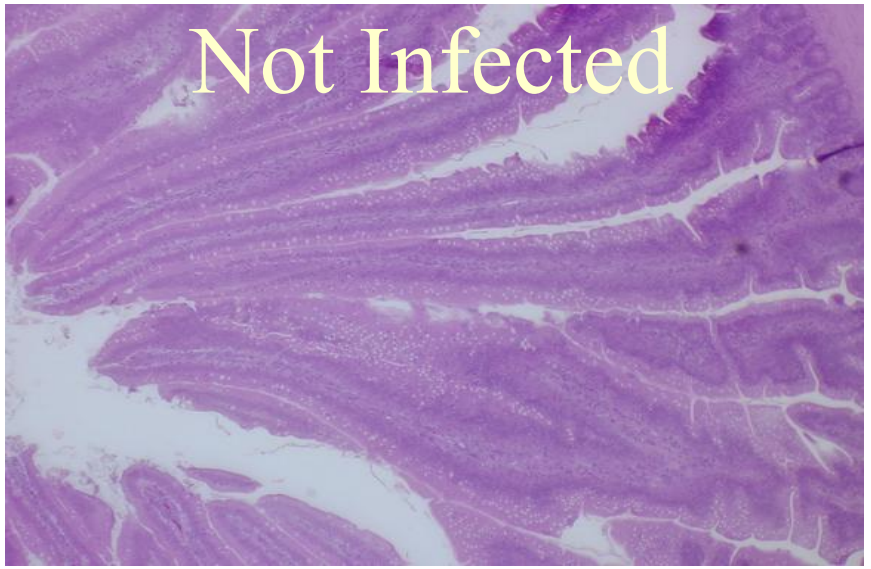
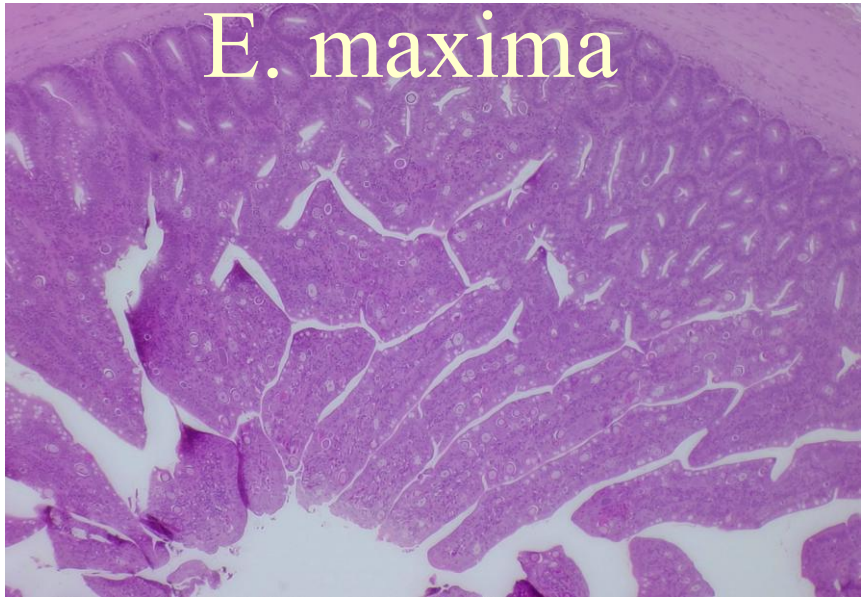
E. maxima

- *Mid-small intestine
- *Deep tissue development
- *Slow to heal
- *Impairs nutrient absorption, including xanthophyll and carotenoid pigments (Diseases of Poultry)





Coccidiosis

- Villous atrophy
- Damage to mucosa and mucus gel layer
- Intestinal malabsorption
- Reduced nutrient digestion
  - Impairment of protein digestion
  - Reduced transport of nutrients across the intestinal barrier
- Intestinal leakage of plasma proteins
- Increased intestinal passage time
- Inflammation and oxidative stress
- Alters intestinal microbial community

Basic US Commercial Corn/Soy/ Meat Meal Diet

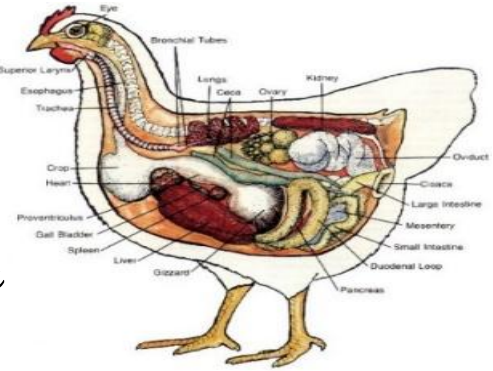
A perfectly formulated diet, fed to genetically superior bird, under ideal management conditions will produce less than ideal production if the bird is unable to use the nutrients properly.

		Costs
Ingredient	lbs/ton	US $
Corn	1121	101.34
Soybean meal	759.6	110.63
Meat and bone meal	40	9.94
Poultry Fat	33.62	11.27
Limestone	12.49	0.60
Defluorinated Phosphorus	12.13	4.73
salt	6.29	0.64
DL. Methionine	5.86	6.38
Lysine	3.57	2.15
Trace minerals	1.5	1.65
vitamins	1	0.81
Threonine	0.999	5.01
choline chloride	0.886	0.73
TBCC	0.43	2.23
phytase	0.3	1.02
nsp enzyme	0.25	1.66
		$260.76
calculated analysis		
M.E. Poultry, Kcal/kg		3086
Crude protein		23.80
Calcium, %		0.90
Available Phosphorus, %		0.45

2021 cost/t $389

“Ideal Feed Utilization”

Thermoregulation



Maintenance

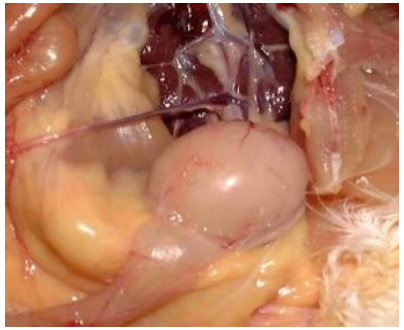
FEED

Growth

Excreta

Activity

Immunity



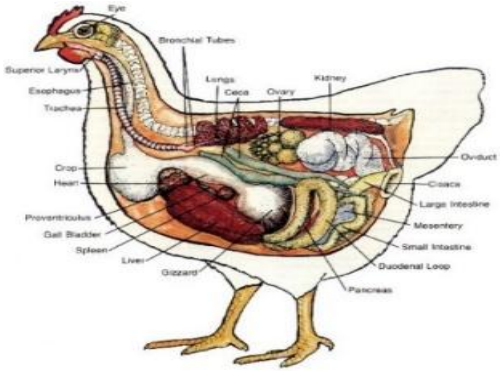
"Coccidiosis"

Gut maintenance in healthy bird is = 25% of daily protein synthesis & 20% of dietary energy. During challenge – tissue turnover rate, secretions, and tissue repair afterwards causes increased demand on GIT tissue maintenance vs productive energy.

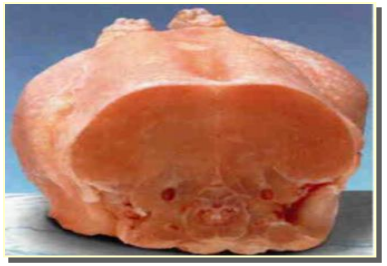
Todd Applegate, Ph.D. Poultry Science Dept. UGA

FEED

Maintenance



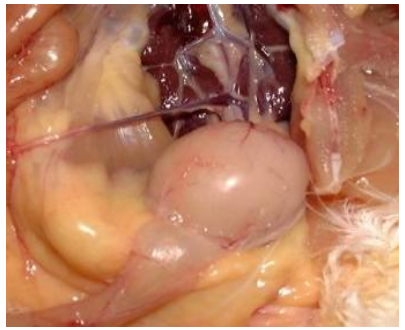
Growth



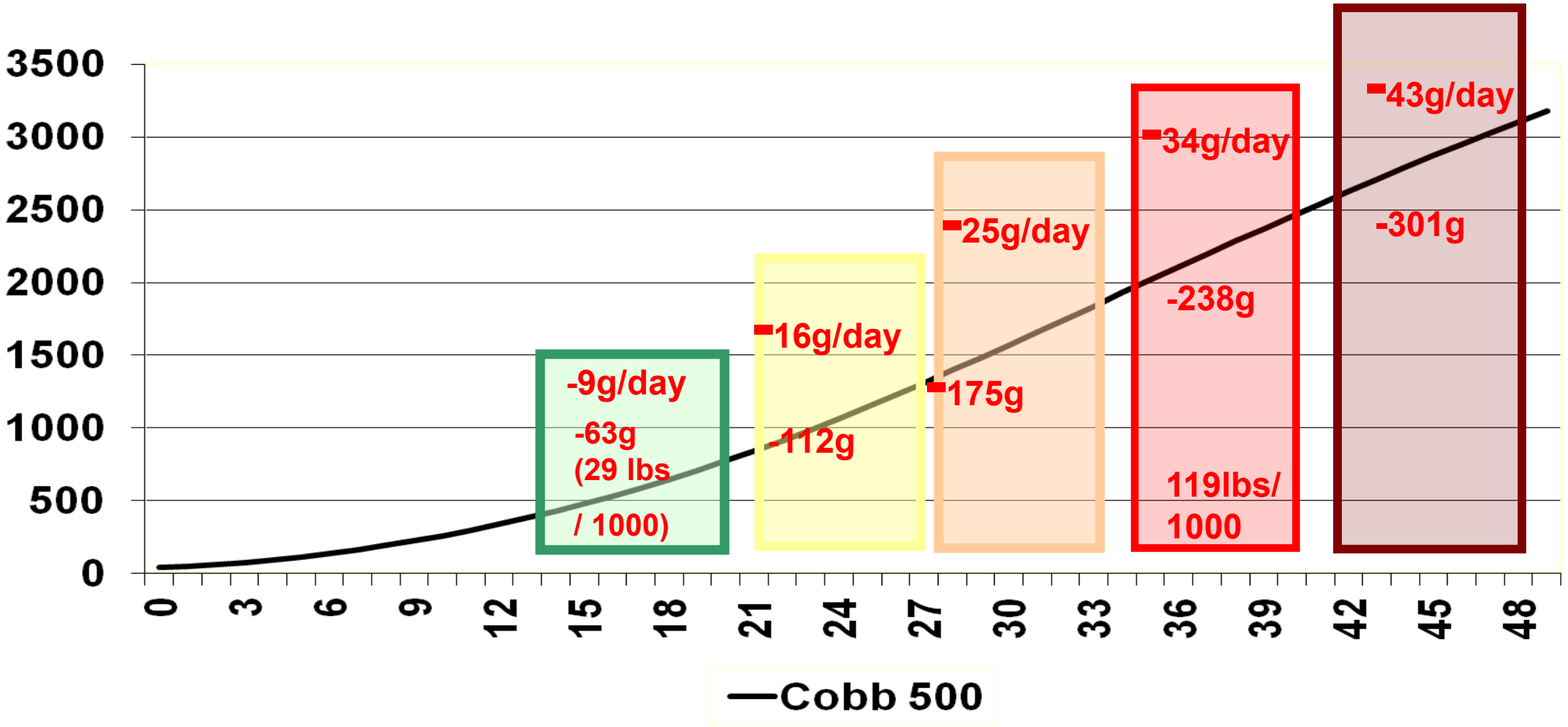
Excreta

Activity

Immunity



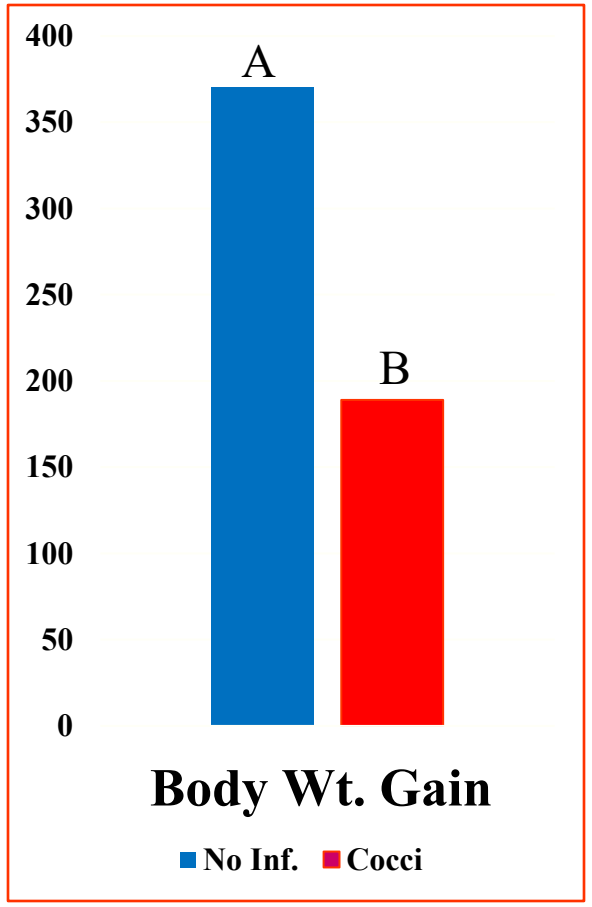
Late infection more detrimental to performance

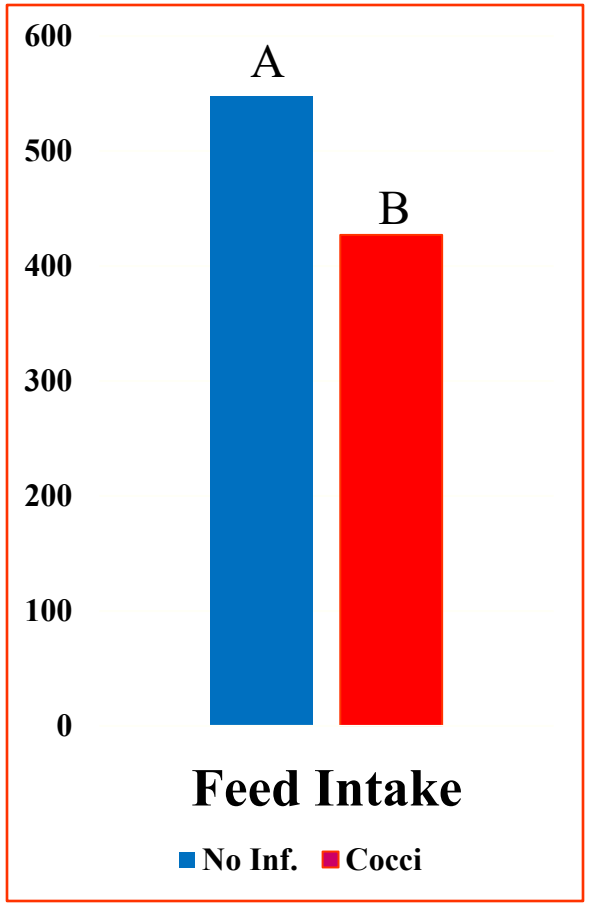


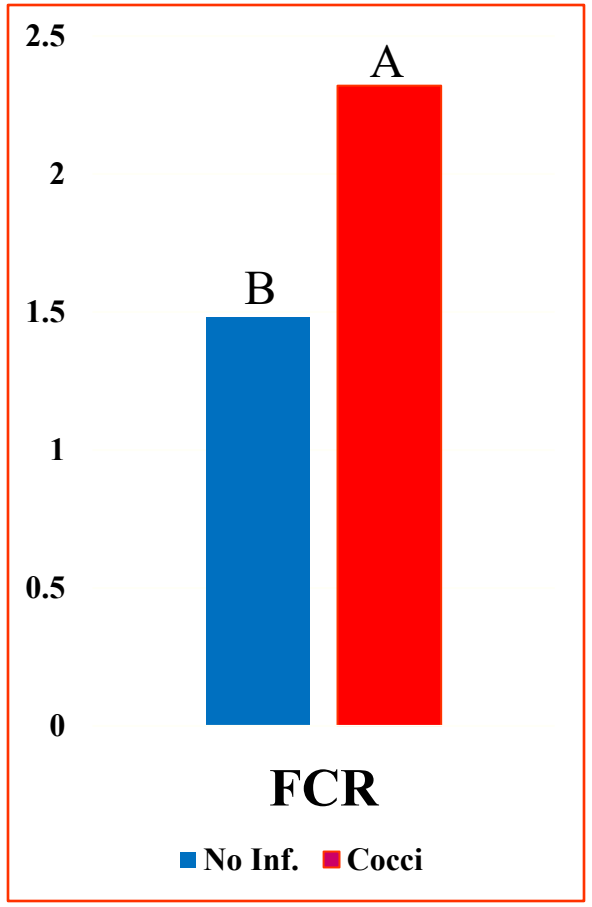
Each Increase in Microscopic Lesion Score, Decreases ADG by 1.5% of Body Weight Throughout the Period (Teeter,OSU)

Coccidiosis (Mixed Infection) and Performance

(Teng, et. al., 2020)





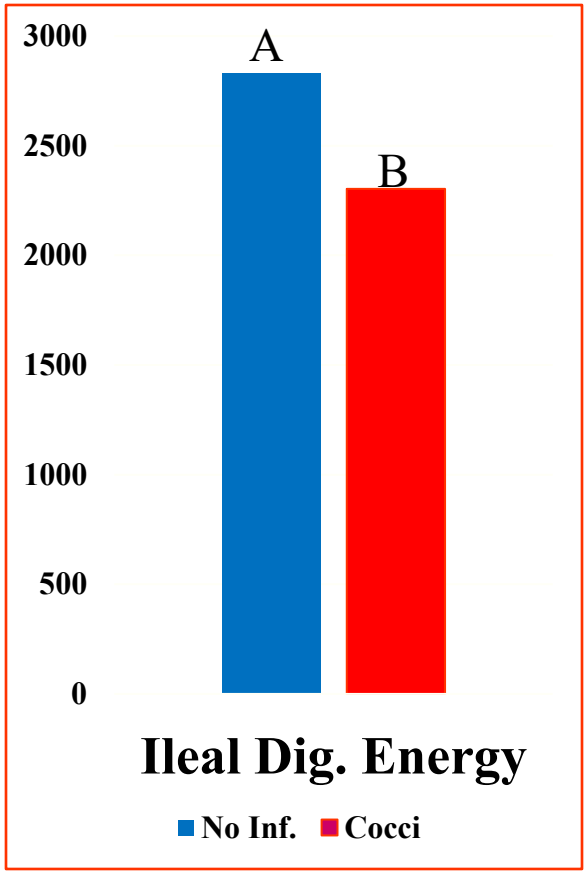


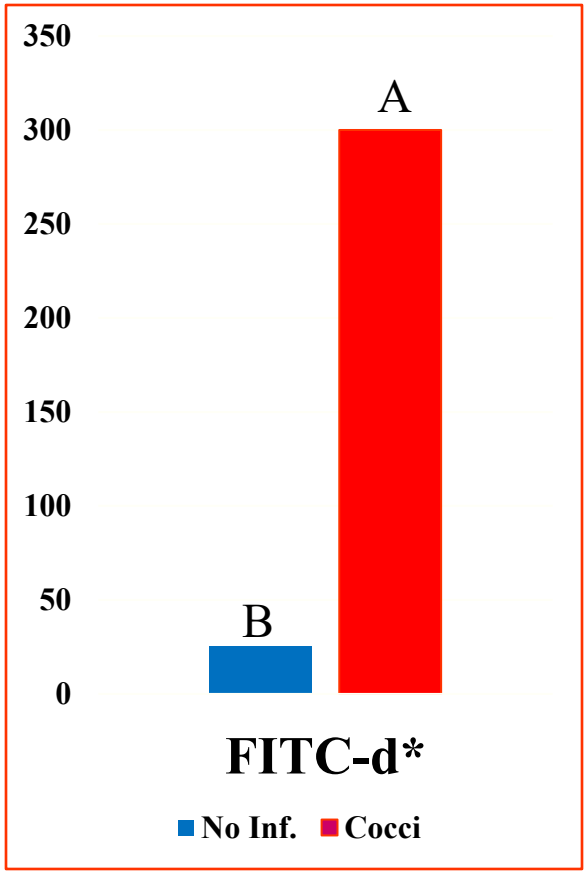
First reported by Tyzzer, 1929

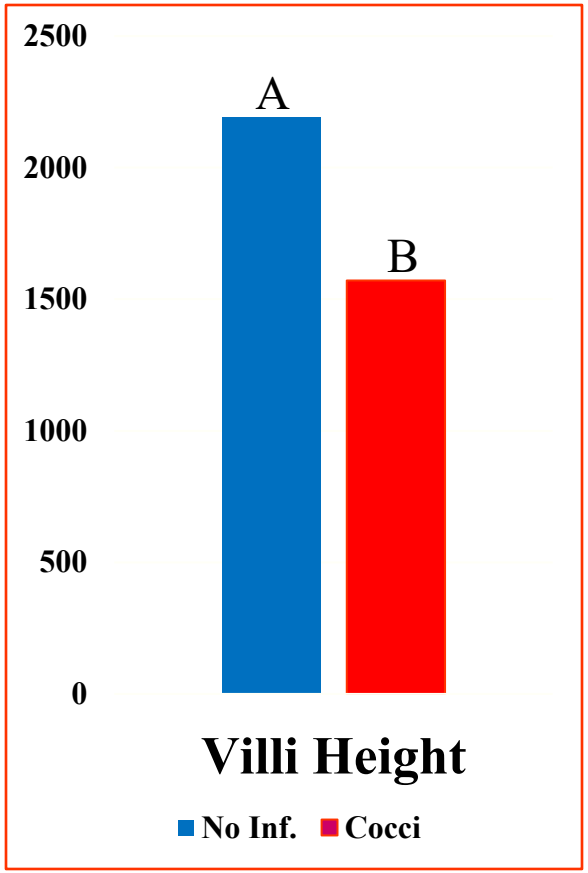
Ruff, 1974: Performance loss is not solely feed intake

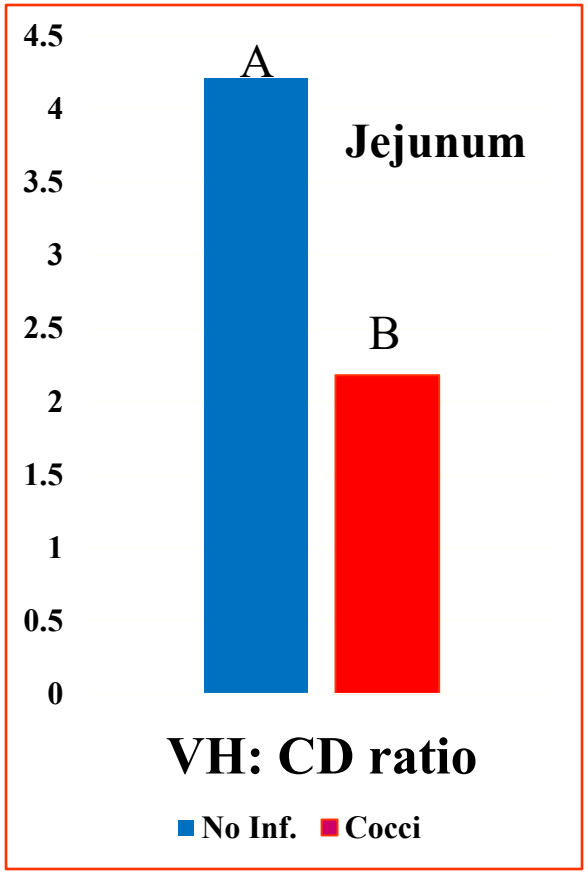
Coccidiosis (Mixed Infection) Gastrointestinal Changes

(Teng, et. al., 2020)





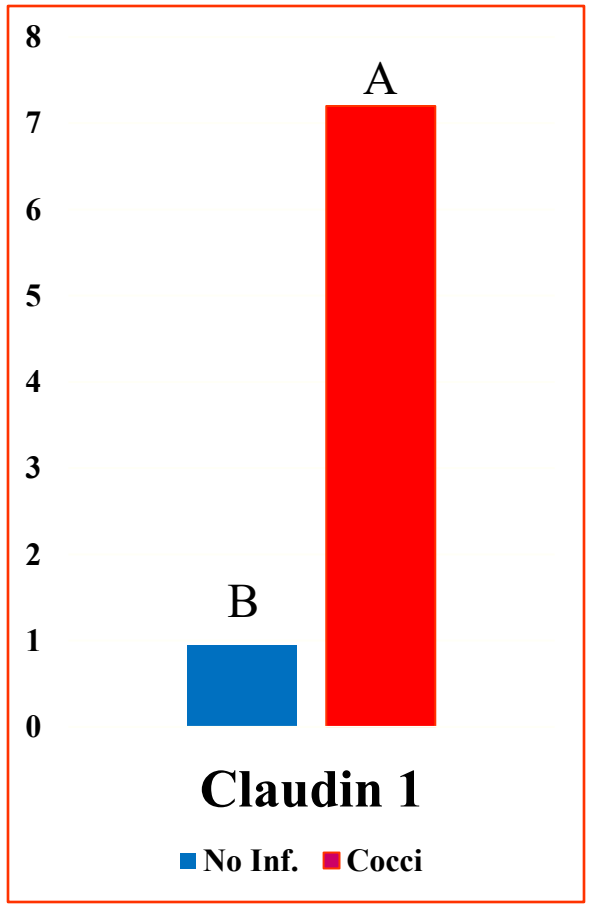


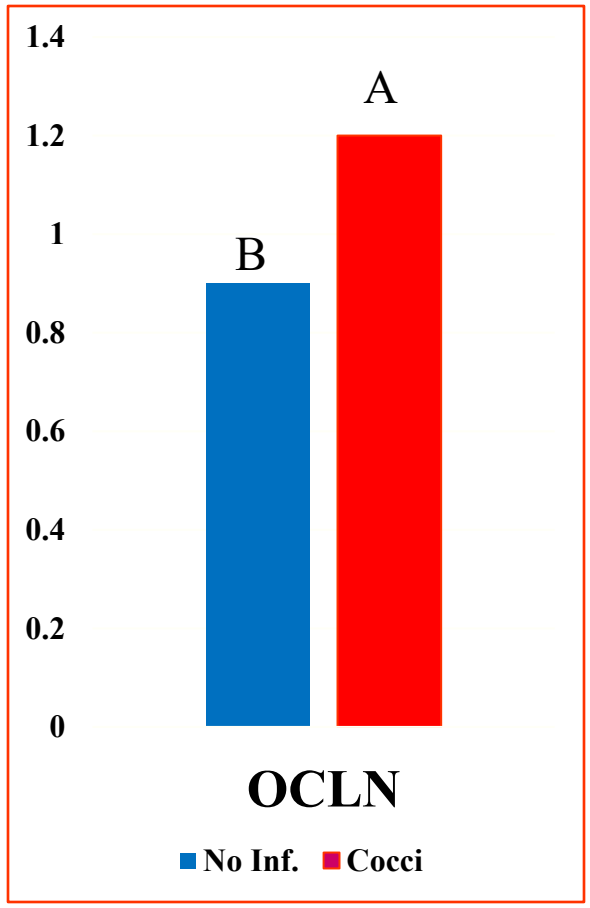


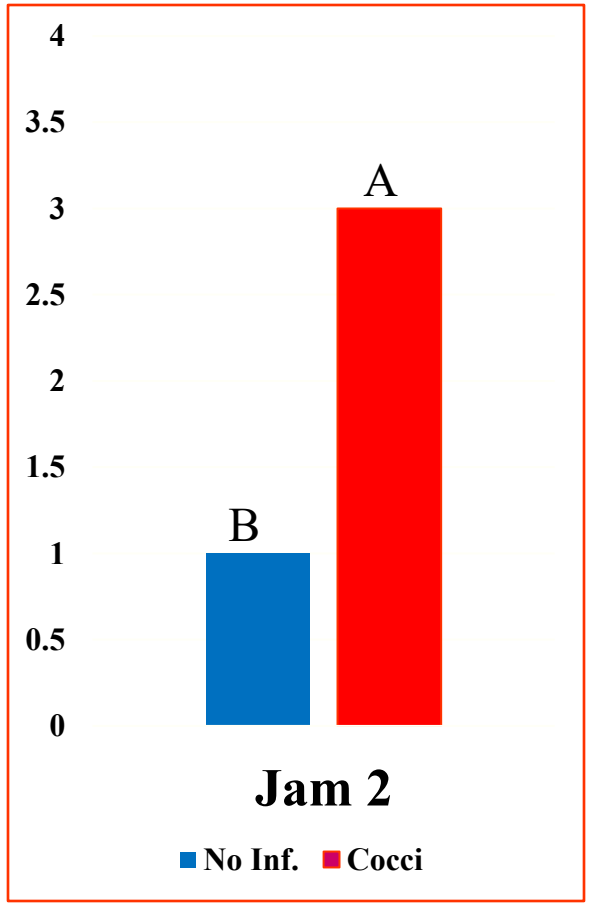
*Higher serum levels of FITC-d = increased gastrointestinal permeability

Coccidiosis: Intestinal Epithelial Junctions and Adhesion

(Teng, et. al., 2020)

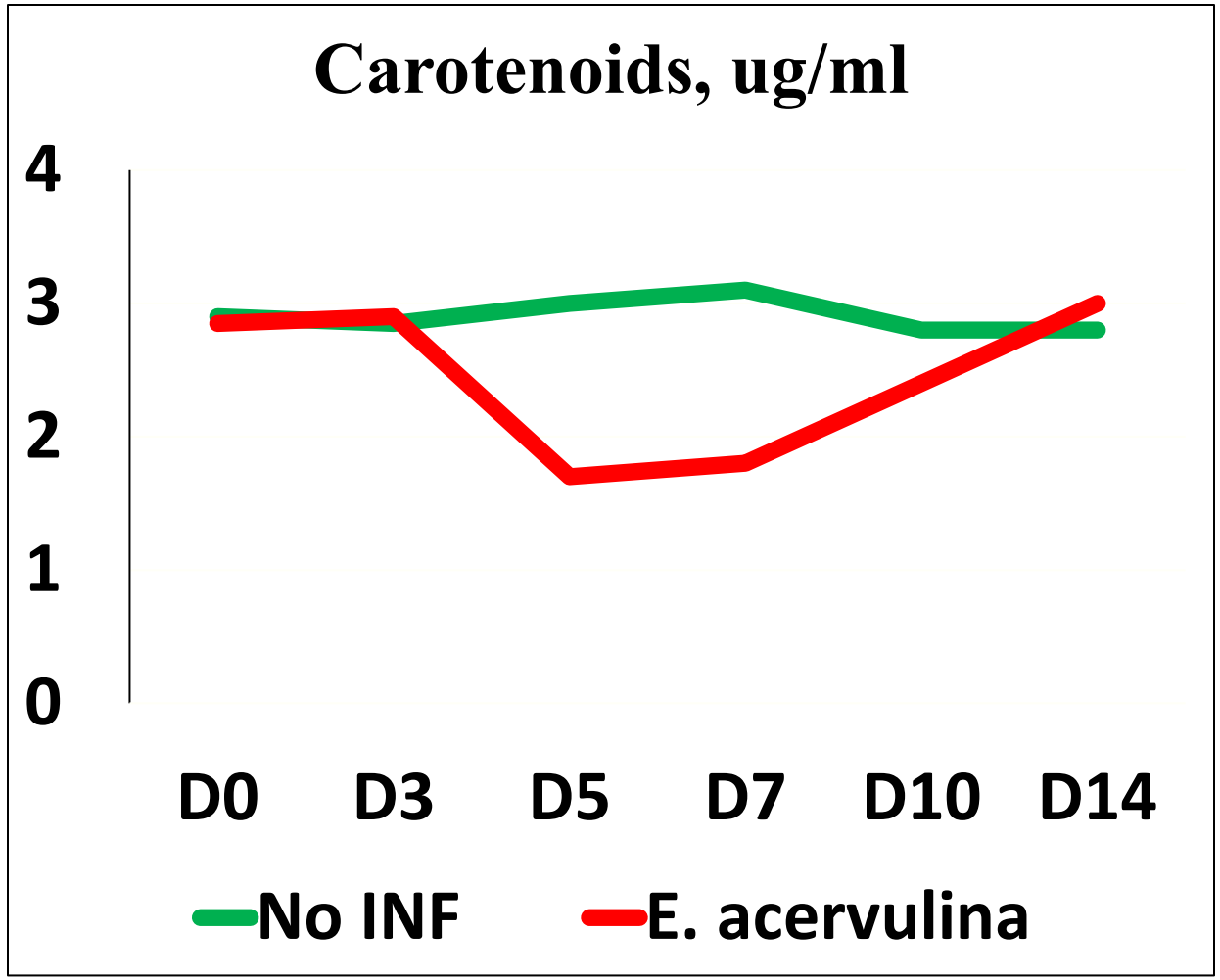






Claudin 1 and Occludin (OCLN) are tight junction proteins, JAM 2 is a junctional adhesion molecule. Higher levels indicate less adhesion and more leakage.

Coccidiosis Decreases Carotenoid Levels

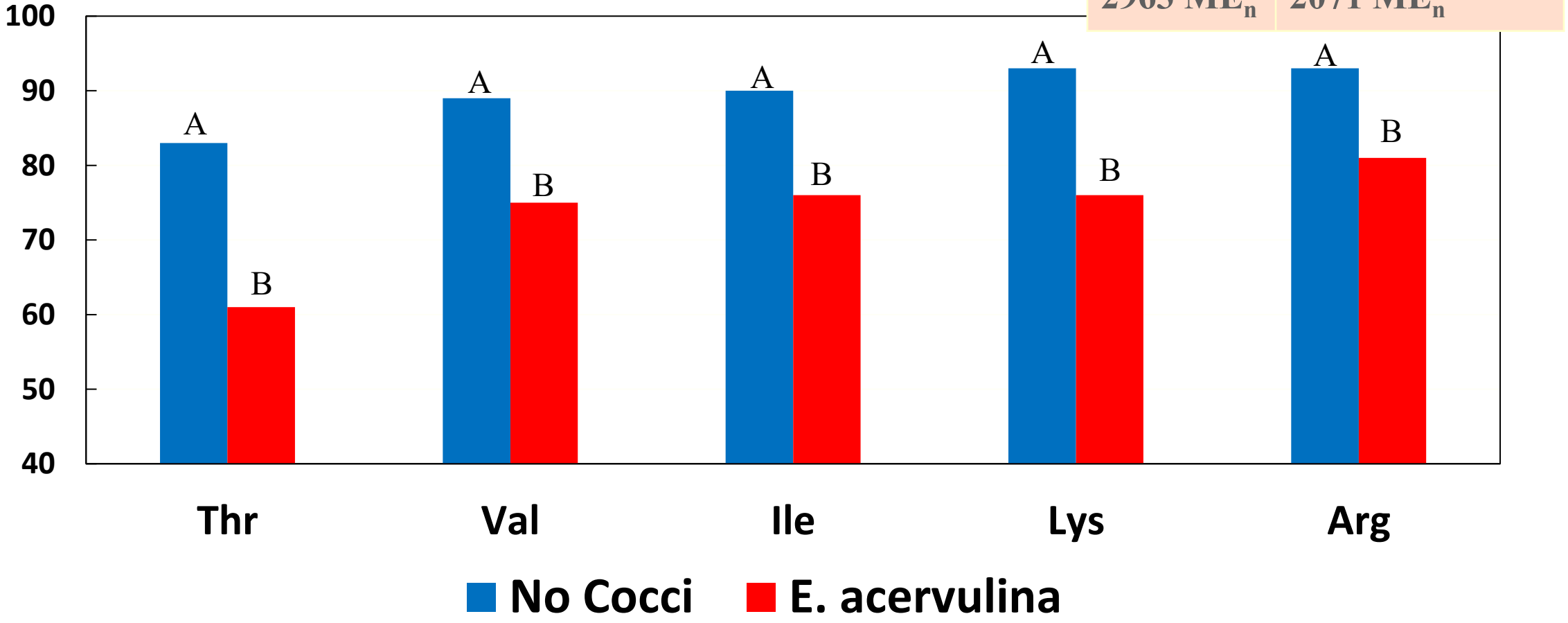


E. acervulina decreased carotenoids

Vaccine: early cocci=immunity= no late cocci= no effect on late pigmentation

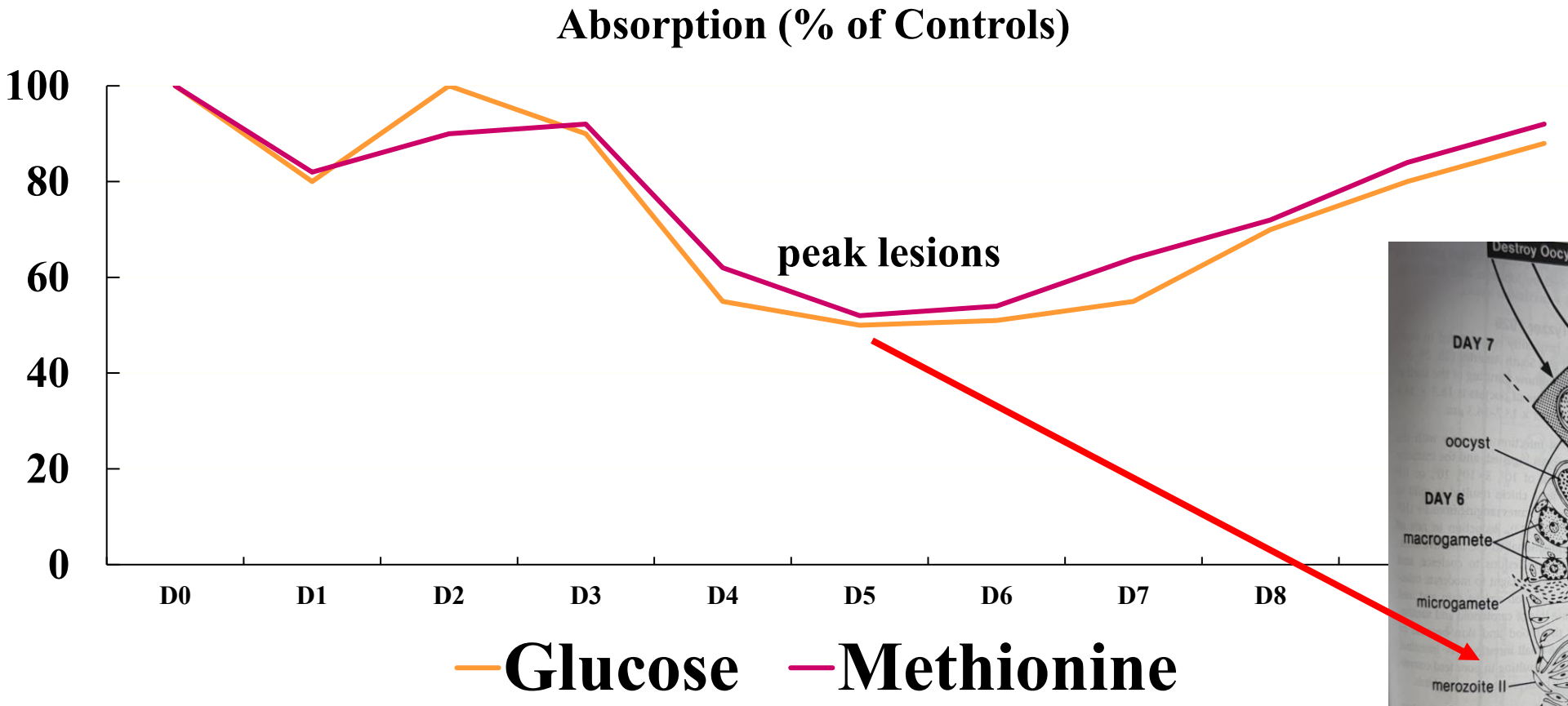
Influence of Coccidia on % AA Digestibility and Metabolizable Energy

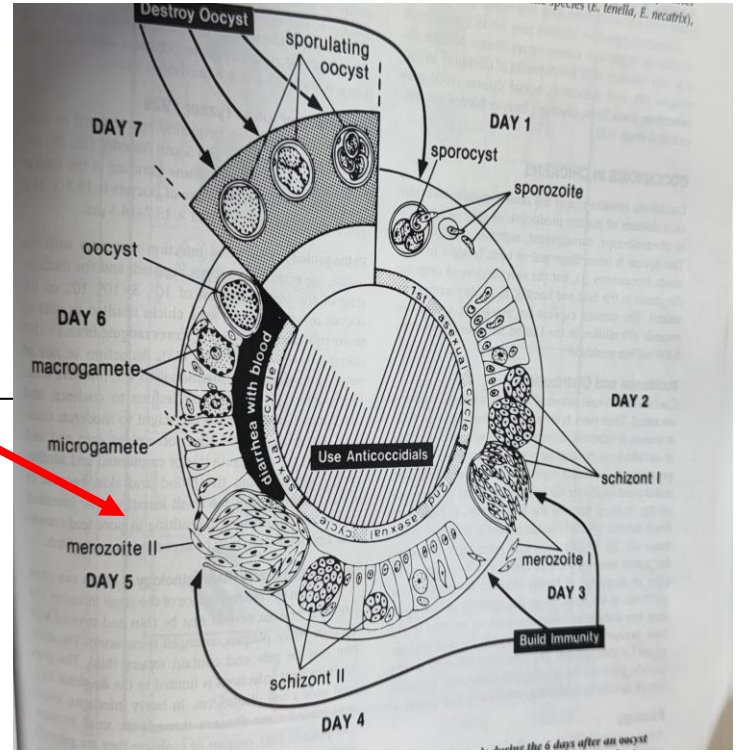
No Cocci	E. acervulina
2963 ME_n	2071 ME_n



Persia, M. E., et. al. 2006. Effects of dietary ingredients and E. acervulina on chick performance, apparent metabolizable energy, and amino acid digestibility, Poult. Sci. 85:48-55

Absorption of Glucose and Methionine of chickens infected with E. acervulina. M. D. Ruff, 1985





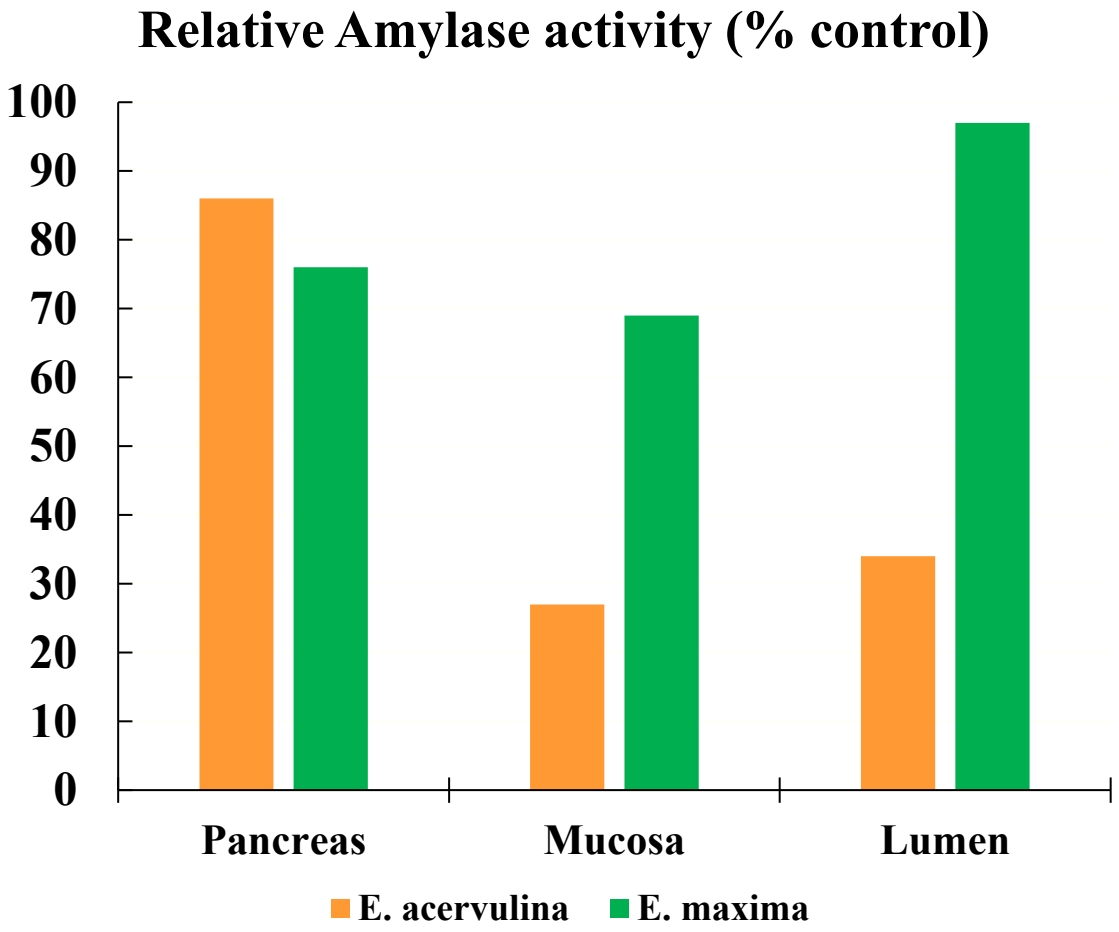
Effects of Amino Acid Supplementation on the Growth Performance of Broiler Chicks Challenged With Coccidiosis: A Meta-Analysis

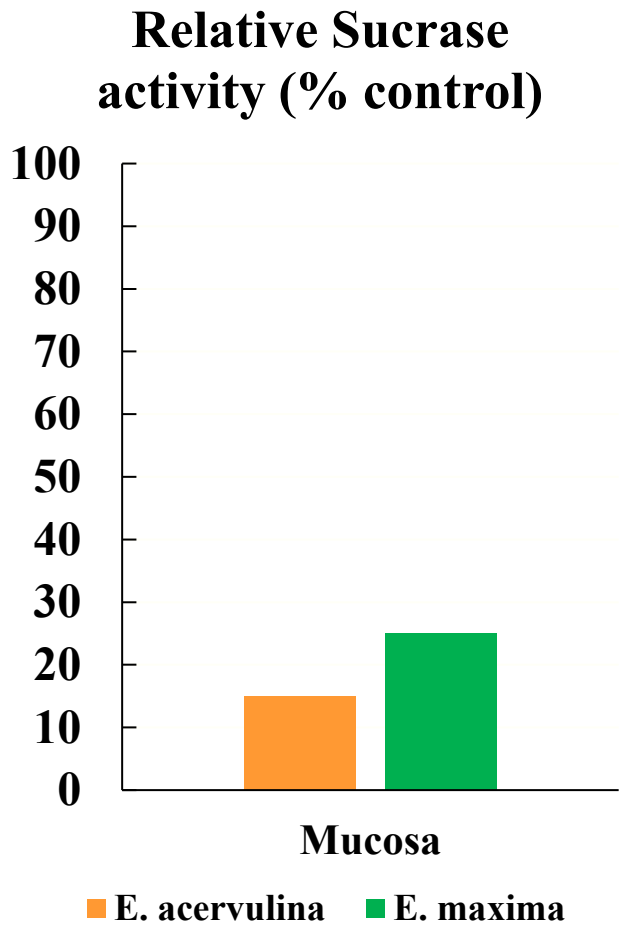
Fatemeh Izadi Yazdanabadi, et. al., 2024. Vet Med Sci: 21;11

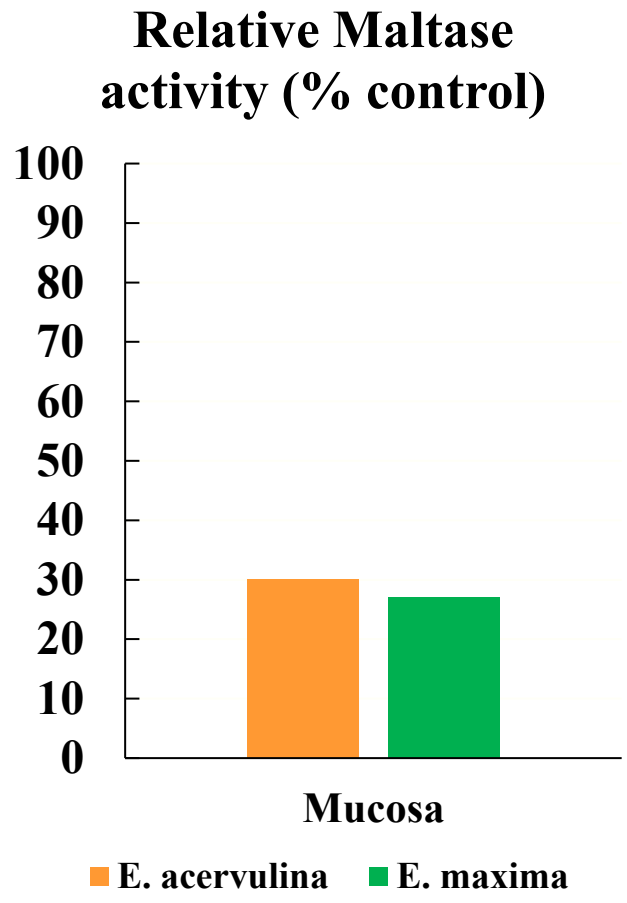
Supplementation of amino acids is one of the most important nutritional strategies for improving growth performance in broilers challenged by coccidiosis

- **Methionine is a limiting amino acid that participates in protein synthesis,**
- **Lysine is a precursor for the synthesis of cytokines, which are essential for antibody production and protein synthesis**
- **Glutamine and arginine promote gut development and enhance gastrointestinal efficiency arginine is recognized as an anti-inflammatory amino acid that enhances immune responses under challenging conditions.**
- **Threonine is involved in the production of mucus, which is crucial for maintaining gut integrity.**

Coccidiosis Impairs Digestive Enzymes

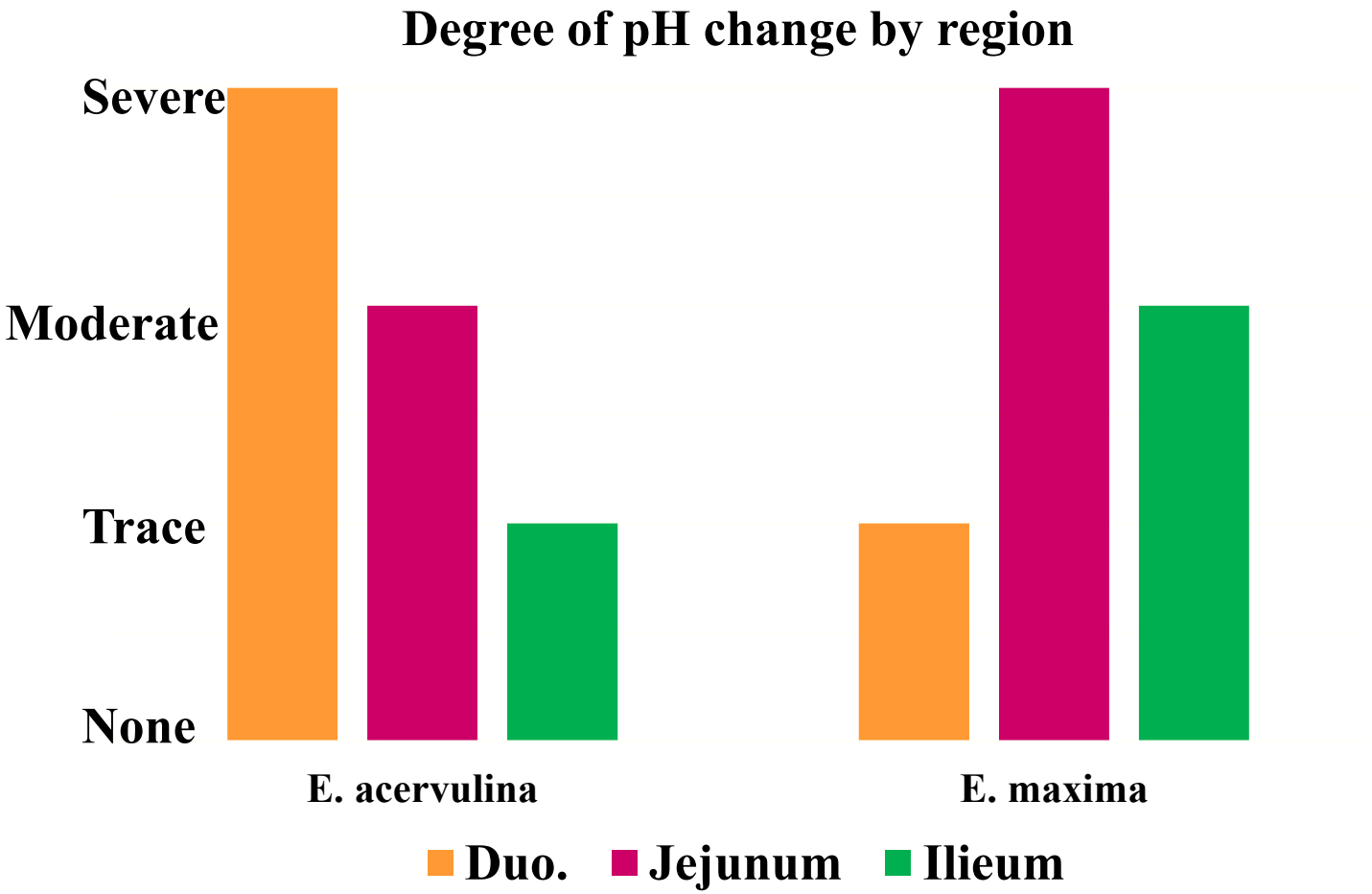






Major and Ruff, 1978. Eimeria spp: Influence of coccidia on digestion

Coccidiosis Changes Intestinal pH



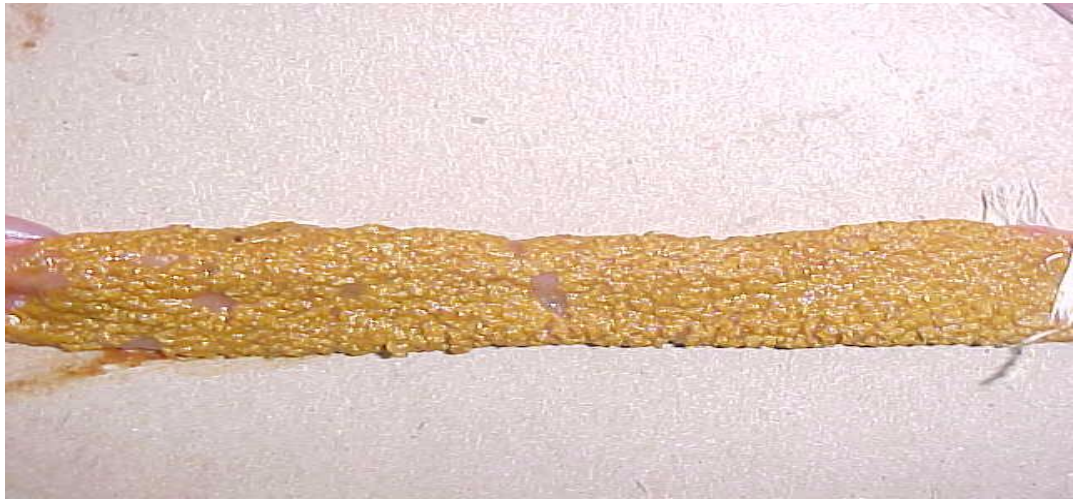
E. acervulina lowers pH duodenum below 5

E. maxima lowers pH jejunum from 6.7 to 5.3

Low pH may play a role in decreased enzymatic activity

Major and Ruff, 1978. Eimeria spp: Influence of coccidia on digestion

Necrotic Enteritis



Necrotic enteritis is caused by a proliferation of *Clostridium perfringens* and toxin production often associated with coccidiosis damage.

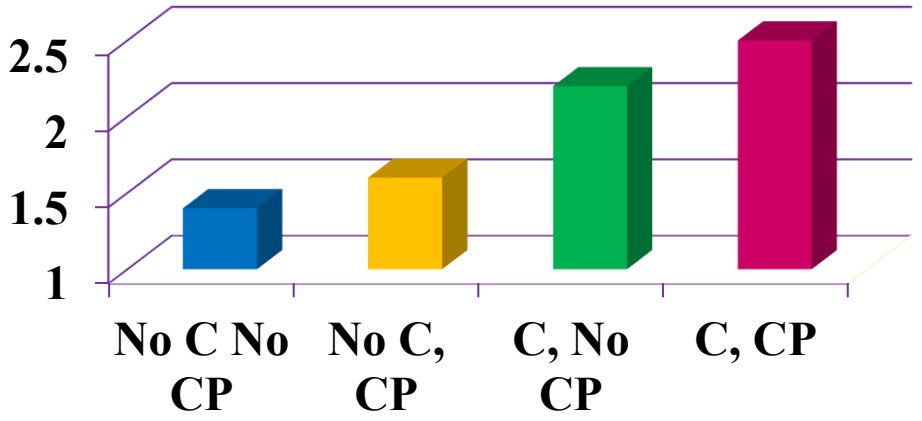
E. maxima

+2 cocci lesion score

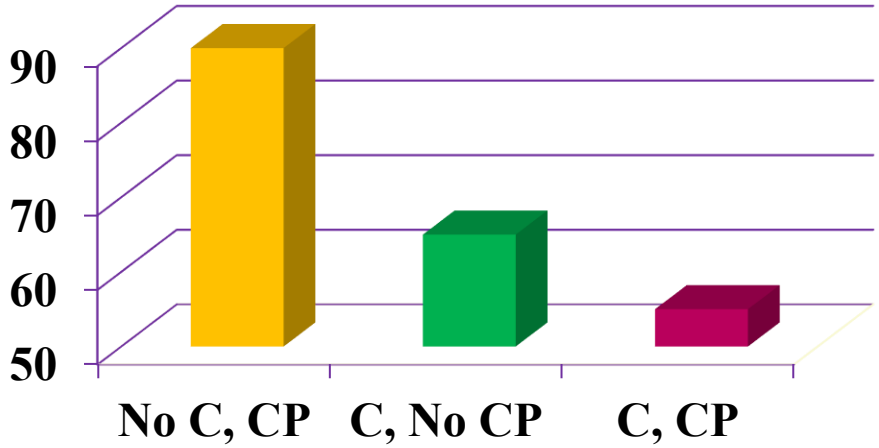
Necrotic Enteritis

The mucosal surface is roughened, intestinal contents filled with pinpoint blood clots and mucus
Clostridium feeds on mucin

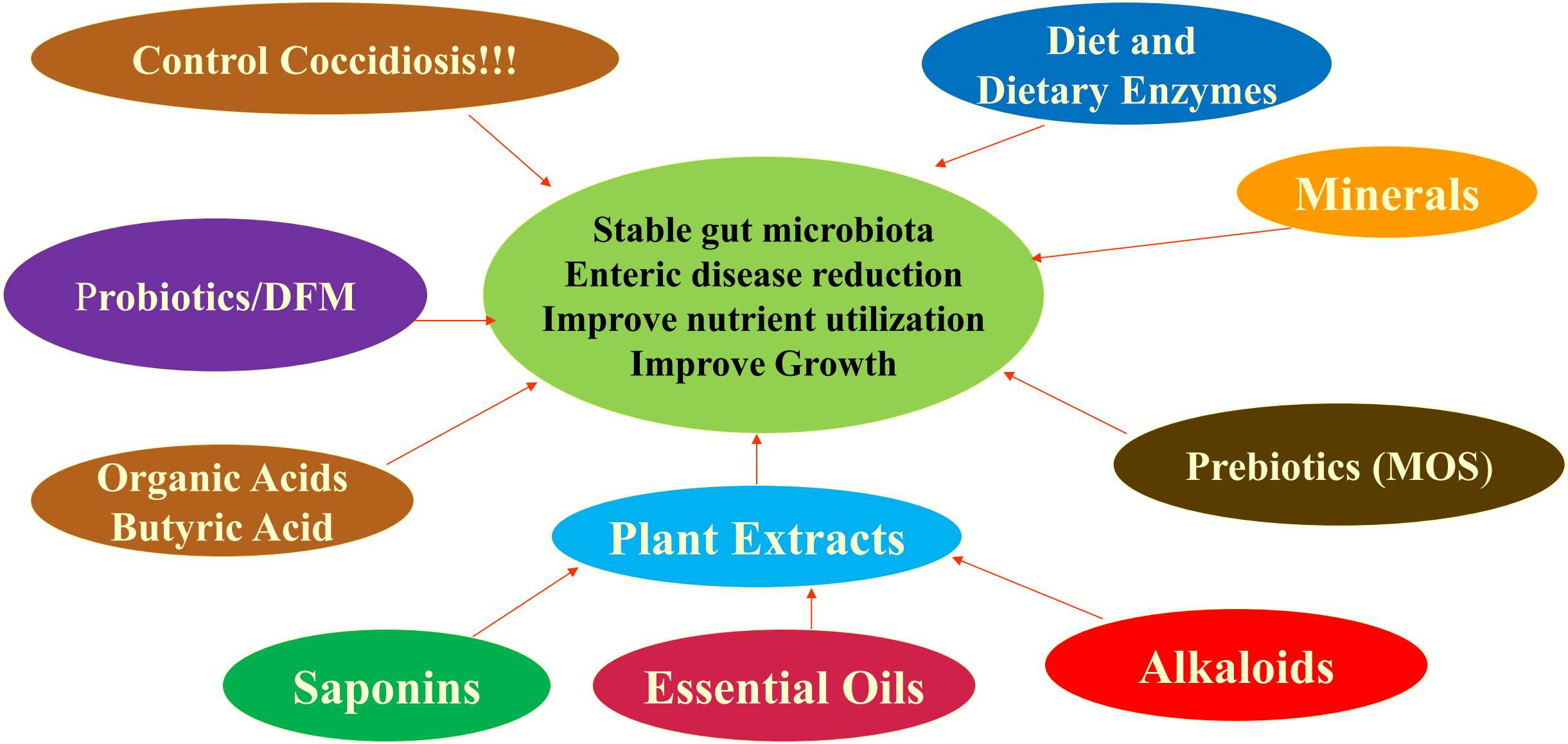
Feed Conversion



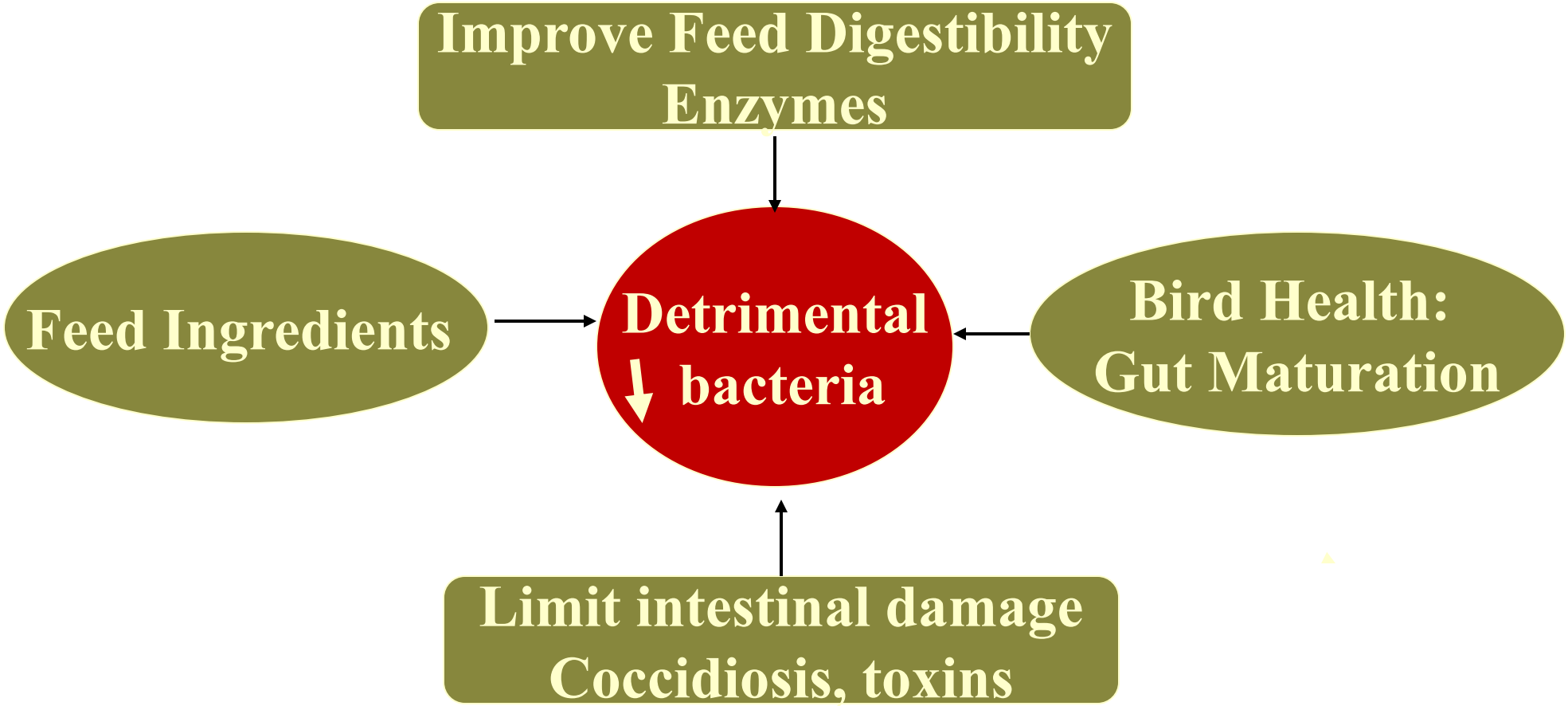
% Weight Gain



Reduce *Clostridium perfringens* proliferation: Necrotic Enteritis



Dietary composition (carbohydrates, enzymes, and fat source) can directly influence intestinal bacterial profile (Dibner, *2002)*



Enzymes

↓ viscosity

↑ rate of digesta passage

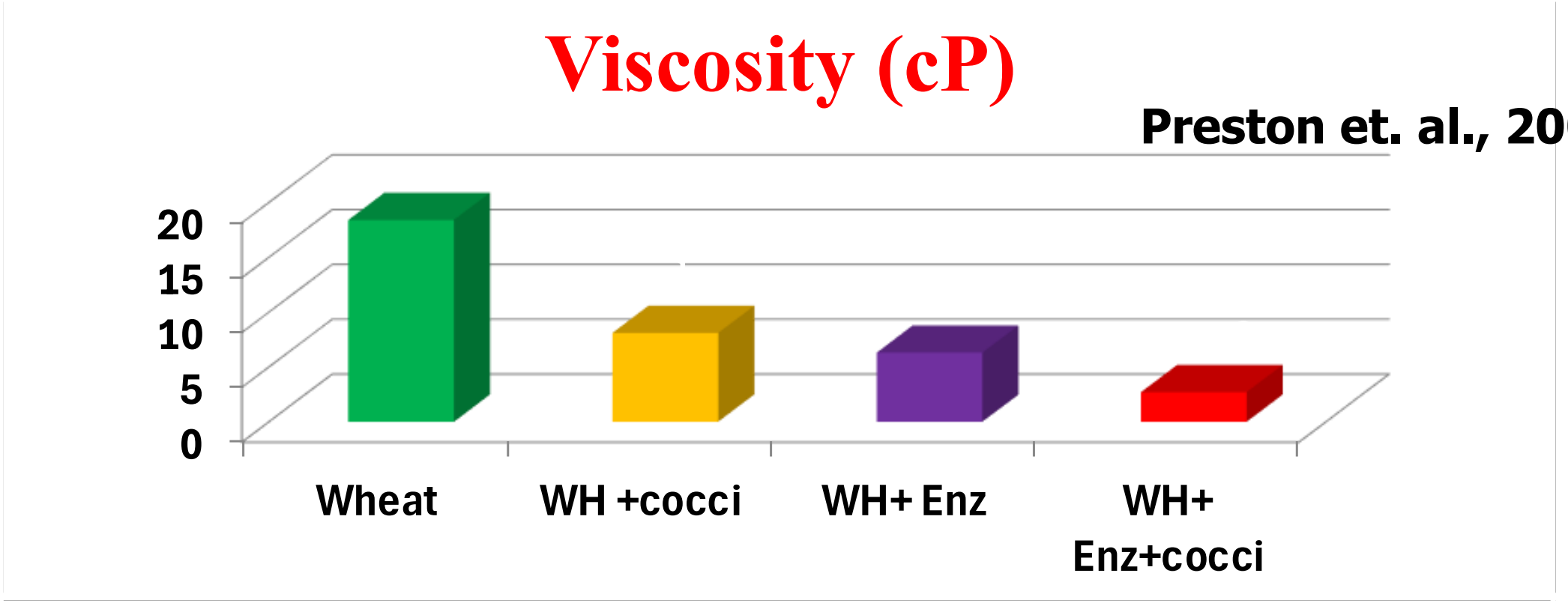
↓ free nutrients

↓ microbial fermentation

*change bacteria level and species profile

Enzymes cleave NSPs into small polymers
viscosity is related to exchange rate of nutrients
which impacts GIT bacterial profile, Moran 2006

Effect of Diet and Enzyme on Intestinal Viscosity and Coccidiosis



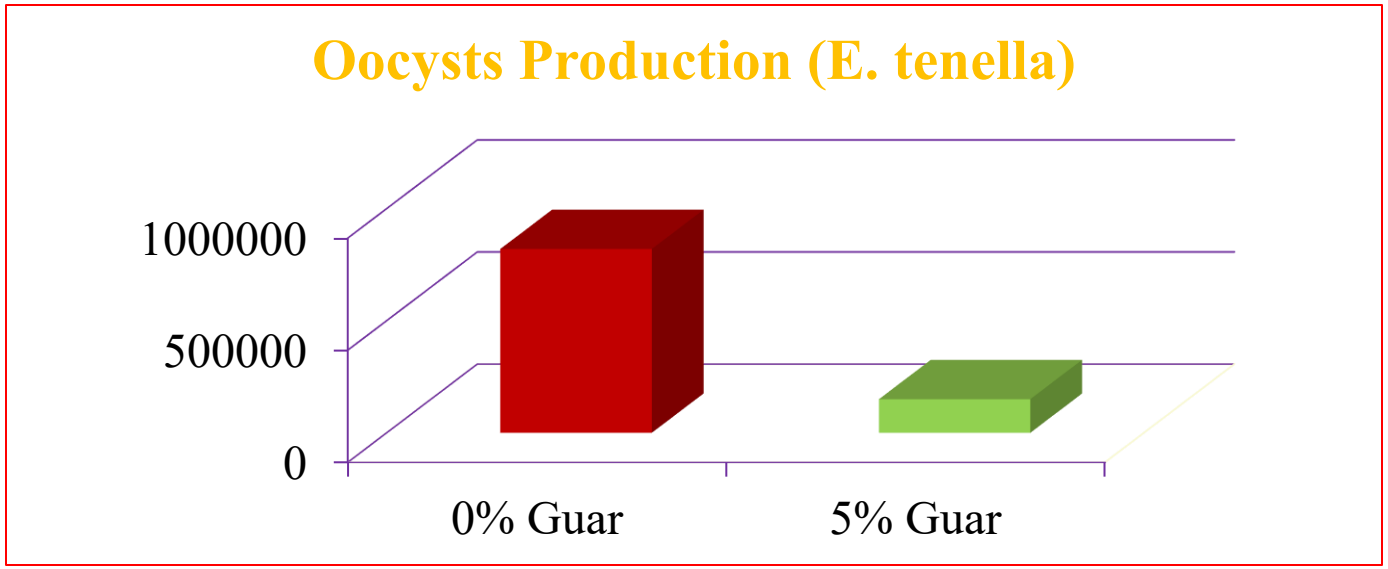
Ruff ,1984 diets that change passage time can influence how long invasive stages of coccidia are available for penetration

Morgan and Bedford, 1995, 22% improvement in weight gain of coccidia challenged birds fed wheat based diets with enzymes.

Enzymes and Gaur Meal

- Gaur Meal contains high levels of saponins
- Saponins have anti-protozoal (coccidia) activity
- Additon of β-mannanase to diets containing Gaur Meal improves performance
- Will this allow Guar Meal to be used and will it have some anticoccidial activity

Cocci vaccine 5% Guar

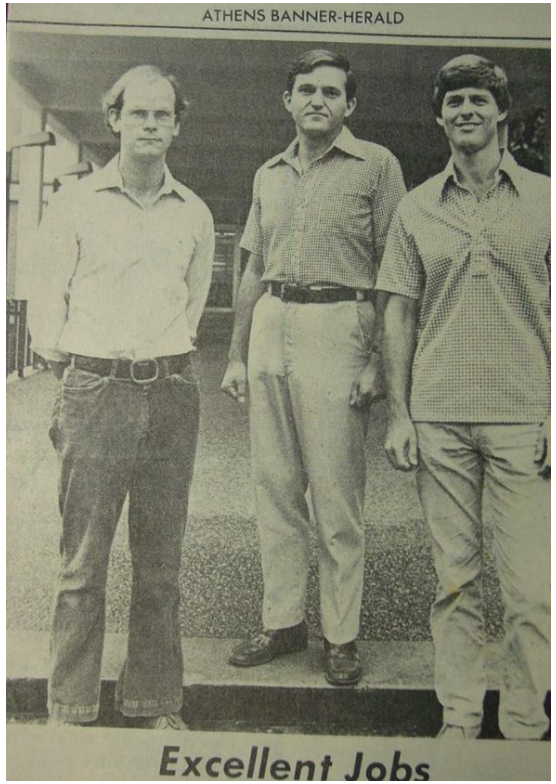


Hassan, 2008

Cocci vaccine 5% Guar + Enzyme

Enzymes decrease anti-nutritive components

- Soybean contains trypsin inhibitors
- Trypsin essential for coccidia to develop
- Protease breaks down trypsin inhibitors



% Raw SBM of total SBM	Wt. Gain (g) D12-21	Coccidia Lesion Score
0	205	3.6
100	75	0.9

Effect of dietary raw soybeans on coccidiosis in chickens, Mathis and Dale, 1995

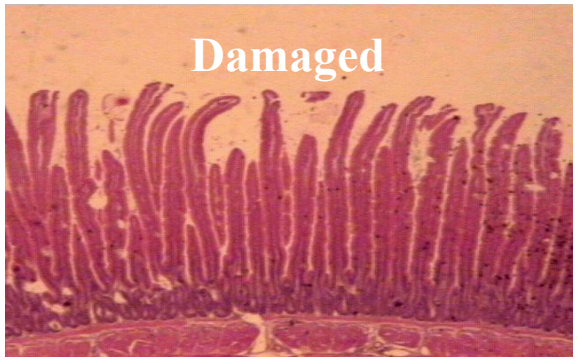
Phytase

Phytase	Non Infected	Coccidiosis
Growth/BWG	Improves	Inconsistent
Bone/Ash strength	Improves	Partially restored
Lesions/ oocysts	No effect	No effect

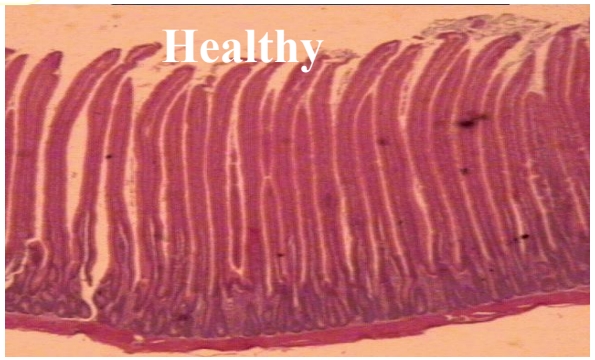
- Coccidiosis/vaccination reduces P and Ca absorption and bone strength; phytase can partially restore growth and bone ash
- Coccidiosis lowers duodenal pH into phytase's optimal range, which may enhance enzyme activity, yet mucosal damage and reduced absorptive area limit the realized benefit

Mike Beford, Ph.D.

Minerals



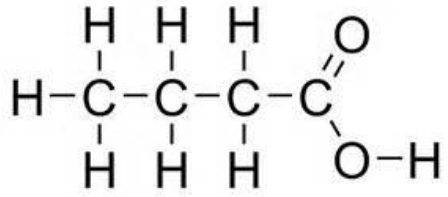
Zn



Immune function
Skin integrity
Improved GIT cellular development
Foot pad improvement
Antibacterial Activity (reduced NE)

Trials with stressed broiler (Cocci vaccination and environmental) birds fed highly available Zn improved FCR and Weight Gain

Butyric Acid



- **Butyrate: short-chain fatty acid with 4 carbons**
- **Benefits**
  - **direct antimicrobial properties**
  - **optimization of the profile of intestinal microbiota and intestinal pH**
  - **support of tissue development and repair**
  - **improved integrity of the cells of the gut lining**
  - **boosting of the gut's defense systems**

Saponins

- Source is important (Yucca 400 species (steroidal) or Quillaja (triterpenoid)
- Reduction in ammonia
- Improve villus height and width

- Emulsification of nutrients and improved utilization
- Destabilize parasite cell membrane leading to increased cell permeability and disruption

SAP (ppm)	Salmonella % incidence D42	Coccidia Lesions (Avg)	*C. Perfringens* enumeration D42	Protein digestibility %
0	70.0	1.71	4.06	52
250	44.7	1.12	3.57	61
500	37.7	0.47	3.42	65

Essential Oils

Treatment	E. acervulina	E. maxima	E. tenella
NMU	0.0a	0.0a	0.0a
NMI	1.8b	1.5b	1.3b
Oregano (0.5kg/t)	1.2b	0.9ab	0.5a

- Stimulate appetite
- Increase enzyme secretion
- Immune modulation
- Anticoccidial activity: BWG, lesions, opgs

Nutritional strategies (pre- and pro-biotics, postbiotics, herbal extracts, and functional amino acids) are important to minimize detrimental effects of coccidiosis and stimulate recovery from it:

1) **reducing intestinal damage and maintain intestinal integrity,**
2) **reducing inflammation and oxidative stress;**
3) **restoring gut balanced microbial community; and**
4) **stimulating compensatory growth.**

Woo Kyun Kim, Ph.D. Department of Poultry Science, University of Georgia

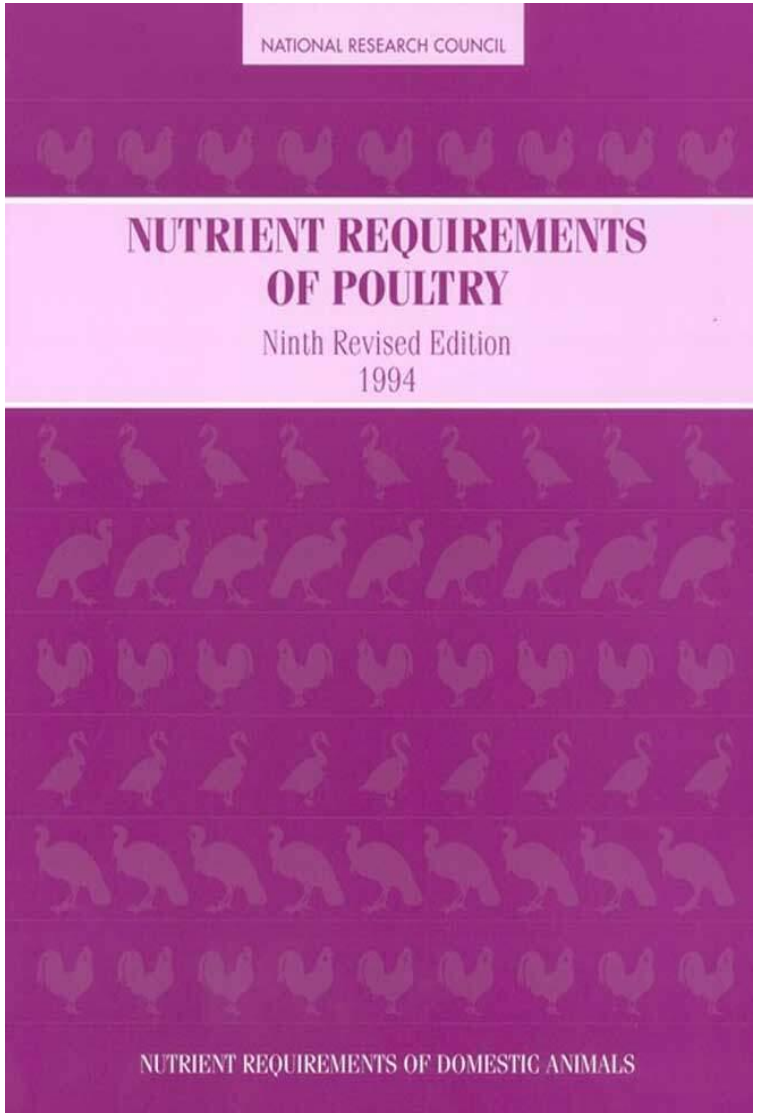
“Coccidiosis control is not just about killing the parasite-
It’s about feeding the bird in a way that limits intestinal damage, reduces nutrient leakage, and prevents secondary enteric disease.
We want to feed the bird and not the disease.”
Dr. Amy Batal-ABB Nutrition LLC

1. Want to increase nutrient density as we know that coccidial challenge will lead to decreased nutrient digestibility, but this is something that can be done during a challenge.

2. Cocci infections will impact fat digestion first and we often do not think about this - especially in the low fat diets we are feeding today with only 0.5% fat, thus our fat source needs to be considered.

3. Protein in the hindgut can lead to more issues such as NE,
-so if possible, tighten our AA balance to avoid excess protein and consider more digestible protein sources.

Progress through Nutrition Includes Coccidiosis Considerations



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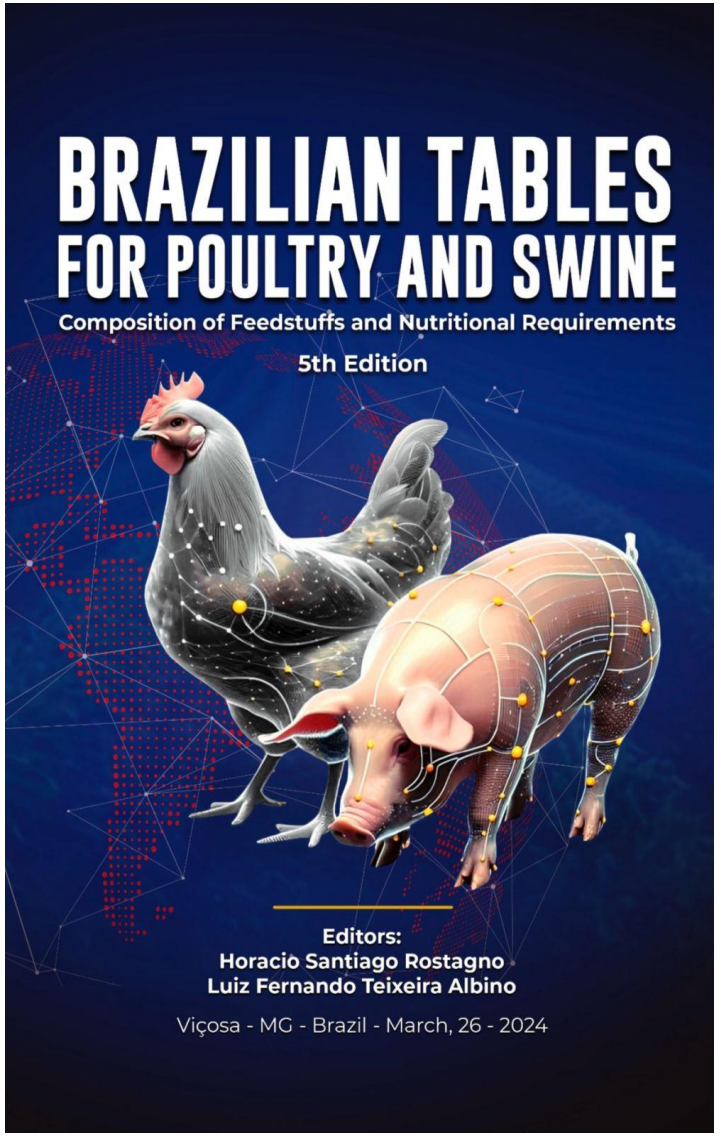

"You miss 100% of the shots you don't take!"

Wayne Gretzky