Inclusion of Distillers Dried Grains with Solubles (DDGS) in Nursery Pig Diets

Distiller's Dried Grains with Solubles (DDGS)

- Feeding recommendations for nursery pigs:
  - 5% maximum inclusion (Newland and Mahan, 1990)
    - Higher fiber content
    - Lower energy density
    - Poor amino acid profile, digestibility, and variability
  - Based on:
    - A few outdated studies (+25 years old)
    - DDGS from conventional sources
      - Ethanol
      - Beverage

Recent DDGS Research

- "New generation" DDGS vs. reference values (NRC, 1998):
  - Less variability of nutrients (Spiehs et al., 2002)
  - Increased metabolizable energy (Spiehs et al., 1999)
  - Greater digestible amino acid levels (Whitney et al., 2000)
  - Improved phosphorus availability (Whitney et al., 2001)
- DDGS from "new generation" ethanol plants:
  - Is of high nutritional quality
  - Should serve as an acceptable partial substitute for corn, soybean meal, and dicalcium phosphate in nursery diets

Objectives

- Evaluate the effect of including increasing levels of DDGS from "new generation" ethanol plants in nursery diets on growth rate, feed intake, and feed efficiency
- Determine the maximum inclusion rate of "new generation" DDGS in nursery diets

Methodology

- 2 growth performance experiments
- 0, 5, 10, 15, 20, or 25% DDGS in nursery diet
- 96 pigs in each experiment
  - Blocked by gender and ancestry, then randomly allotted within each block
  - 4 pigs/pen (0.37 m^2/pig)
  - 4 pens/dietary treatment
- 3-phase feeding program
  - Phase 1: commercial, pelleted diet fed first 4 d post-weaning
  - Phase 2: fed for 14 d, meal form
  - Phase 3: fed for 21 d, meal form

Nursery Phase 2 Diets*

	DDGS inclusion level, %					
Ingredient, %	0	5	10	15	20	25
Corn	50.1	45.4	40.5	35.7	30.9	26.1
Soybean meal (47% CP)	23.4	23.2	23.1	22.9	22.7	22.5
DDGS	0.0	5.0	10.0	15.0	20.0	25.0
Whey, dried	15.0	15.0	15.0	15.0	15.0	15.0
Fish meal, select menhaden	6.0	6.0	6.0	6.0	6.0	6.0
Choice white grease	2.5	2.6	2.6	2.7	2.7	2.8
Dicalcium phosphate	1.2	1.0	0.9	0.7	0.6	0.4
Limestone	0.4	0.5	0.6	0.7	0.8	0.9
Other	1.3	1.3	1.3	1.3	1.3	1.3
Total	100.0	100.0	100.0	100.0	100.0	100.0

* Diets formulated to contain: 3340 kcal/kg ME, 1.35% AID Lys, 0.80% AID Met&Cys, 0.95% Ca, 0.80% P

Nursery Phase 3 Diets*

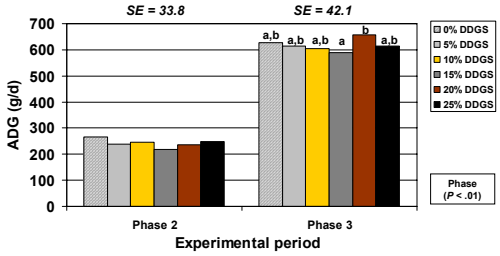
Ingredient, %	DDGS inclusion level, %					
	0	5	10	15	20	25
Corn	61.5	57.0	52.3	47.8	43.2	38.7
Soybean meal (47% CP)	32.6	32.2	31.8	31.4	30.9	30.5
DDGS	0.0	5.0	10.0	15.0	20.0	25.0
Choice white grease	2.4	2.4	2.5	2.5	2.6	2.6
Dicalcium phosphate	1.7	1.5	1.4	1.2	1.1	0.9
Limestone	0.6	0.7	0.8	0.9	1.0	1.1
Other	1.2	1.2	1.2	1.2	1.2	1.2
Total	100.0	100.0	100.0	100.0	100.0	100.0

* Diets formulated to contain: 3390 kcal/kg ME; 1.15% AID Lys; 0.65% AID Met&Cys; 0.80% Ca; 0.70% P

Experiment 1

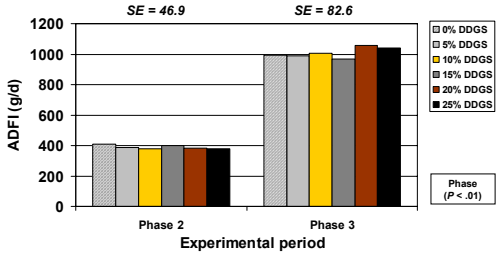
- Pigs:
  - Weaned at 19 d of age
  - Weighed 7.1 kg body weight
- Pig weight and feed consumption:
  - Measured for each phase
- Statistics
  - Utilized GLM procedure of SAS with repeated measures in time
    - Pen = experimental unit
  - Orthogonal comparisons to determine linear, quadratic, and/or cubic responses to increasing DDGS level in the diet

Effect of DDGS Level on Growth Rate, Exp. 1

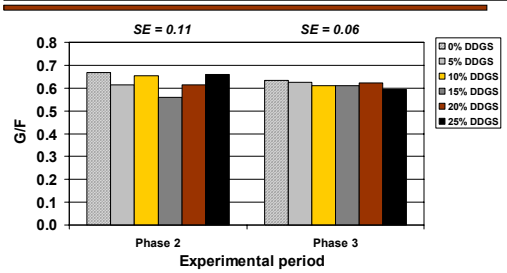


Means not sharing a common superscript letter are significantly different ($P < .05$)

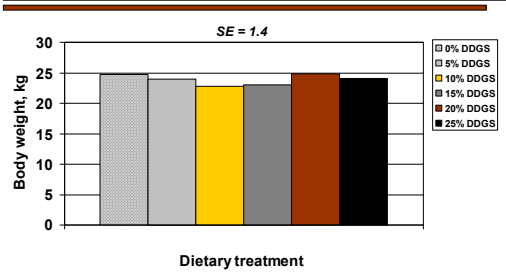
Effect of DDGS Level on Feed Intake, Exp. 1



Effect of DDGS Level on Feed Efficiency, Exp. 1



Effect of DDGS Level on Final Body Weight, Exp. 1



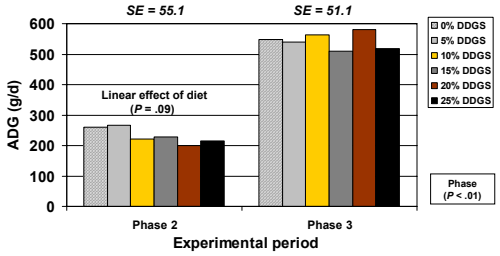
Summary of Results – Exp. 1

- No effect of increasing dietary DDGS level on:
  - Growth rate
  - Feed intake
  - Feed efficiency
  - Final nursery weight
- Pigs were able to effectively consume and convert high levels of DDGS (up to 25%) without any apparent adverse effects on growth

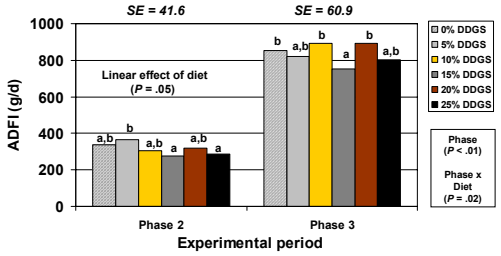
Experiment 2

- Pigs:
  - Weaned at 16.9 d of age
  - Weighed 5.3 kg body weight
- Pig weight and feed consumption:
  - Measured for each phase
- Statistics
  - Utilized GLM procedure of SAS with repeated measures in time
    - Pen = experimental unit
  - Orthogonal comparisons to determine linear, quadratic, and/or cubic responses to increasing DDGS level in the diet

Effect of DDGS Level on Growth Rate, Exp. 2



Effect of DDGS Level on Feed Intake, Exp. 2



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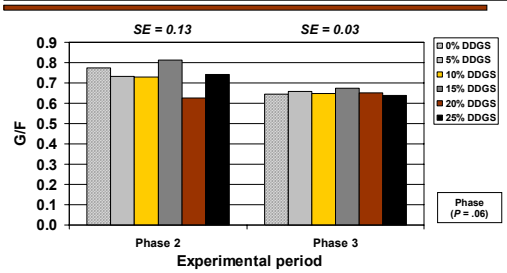
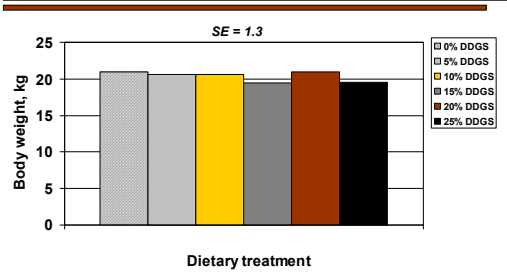
Effect of DDGS Level on Feed Efficiency, Exp. 2



Effect of DDGS Level on Final Body Weight, Exp. 2



Summary of Results – Exp. 2

- Increasing level of DDGS during Phase 2:
  - Decreased feed intake
  - Tended to decrease growth rate
  - No effect of feed efficiency
- No effect of DDGS on ADG, ADFI, or G/F during Phase 3
- No effect of DDGS on ending nursery body weight

Implications

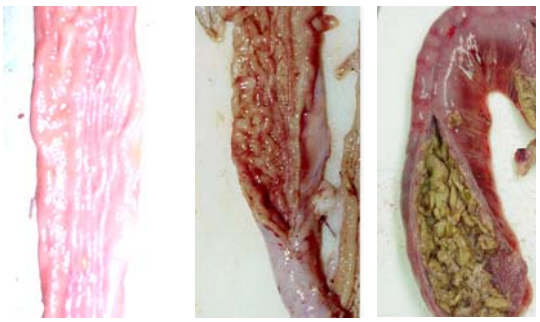
- DDGS from "new generation" ethanol plants is an acceptable partial substitute for corn, soybean meal, and dicalcium phosphate in nursery diets
  - Formulate diets on ME and digestible amino acid basis
  - Can include up to 25% DDGS in Phase 3 with no detrimental effects on growth performance
  - In younger, lighter pigs, including greater than 5% DDGS in Phase 2 may decrease feed intake and subsequent growth rate
    - No detrimental effect in older, heavier pigs
    - No difference in body weight at end of the nursery period

Effect of Dietary Corn Distiller's Dried Grains with Solubles (DDGS) on the Ability of Growing Pigs to Resist Ileitis

Ileitis

- Porcine Proliferative Enteropathy
- Caused by *Lawsonia intracellularis*
  - gram negative microaerophil bacteria
  - infects immature epithelial cells located in the crypts of the lower small intestine
  - inhibits maturation of cells, resulting in cells multiplying without being sloughed off
  - affects other species of animals
    - rabbits, deer, horses, ostrich, hamsters (Cooper et al., 1997)

Healthy **Ileitis**



Ileitis

- Animals are infected by oral contact with feces from animals shedding the bacteria
- 7-10 days after infection:
  - lesions of the intestinal wall begin to form
  - height of lesions around 21 days post-infection
- Pigs affected: (Glock et al., 1994)
  - 40-100 lb growing pigs*
  - bred gilts
  - sows and boars
  - finishing pigs

DDGS and Ileitis

- Field reports from a number of pork production operations have indicated:
  - Including 5 to 10% DDGS to grow-finish diets in ileitis swine herds
    - Improved performance
    - Reduced mortality (> 50%)
    - Ability to remove part or all of sub-therapeutic antibiotics without ileitis outbreak
  - Similar results have been reported with using soybean hulls

DDGS and Gut Health

- DDGS contains low levels of soluble (0.7 %) and high levels of insoluble (42.2 %) fiber (Shurson et al., 2000)
  - Low soluble fiber diets may reduce the proliferation of pathogenic organisms in the GI tract (Hampson, 1999)
    - Reduced pathogen substrate availability?
    - Fiber may influence the secretory function of the epithelium, which are implicated with bacterial adhesion (Smith and Halls, 1968)
    - May have a "cleansing" effect in gut through changes by reducing the viscosity of digesta (Lawrence, 1972)
- DDGS contains yeast cells
  - May have nutraceutical properties

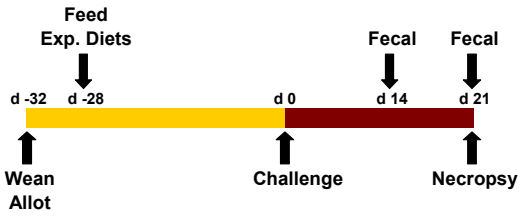
DDGS Ileitis Experiments

- Exp 1:
  - Determine if dietary DDGS inclusion (10 or 20%) reduces the incidence or severity of ileitis in pigs
- Exp 2:
  - Evaluate dietary DDGS inclusion (10%) on ileitis severity
  - Compare DDGS inclusion to an antimicrobial regimen for ileitis
- Exp 3:
  - Evaluate dietary DDGS inclusion (10%) on ileitis severity
  - Compare DDGS inclusion to dietary soybean hull inclusion or feeding a polyclonal antibody product

Methodology – Experiment 1

- Pigs:
  - Weaned at 17 d of age
  - Blocked by gender and weight
  - Fed experimental diets for 7 weeks
- Dietary treatments:
  - NC: Negative control, corn-soybean meal diet
  - PC: Positive control, corn-soybean meal diet*
  - D10: 10% DDGS diet*
  - D20: 20% DDGS diet*
    - Diets formulated to contain: 3390 kcal/kg ME, 1.15% AID lysine, 0.65% AID methionine & cystine, 0.80% Ca, and 0.70% P

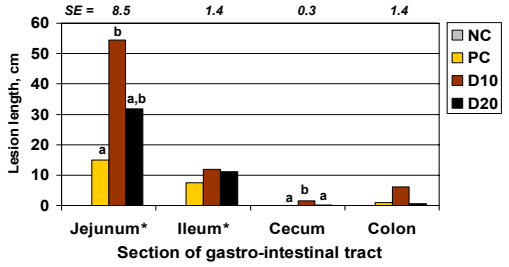
Methodology – Experiment 1



Methodology – Experiment 1

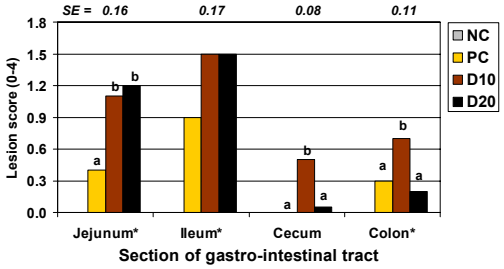
- Statistical analysis:
  - Utilized the GLM procedure of SAS (ANOVA and LSMeans)
    - Compared NC and PC treatments (effect of challenge)
    - Analyzed within challenged groups (effect of diet)
    - Individual pig = experimental unit

Effect of Dietary DDGS Level on Lesion Length, d 21 Post-Challenge, Exp. 1



[a,b] Means not sharing a common superscript letter are different ($P < .05$).
* Effect of disease challenge ($P < .05$).

Effect of Dietary DDGS Level on Lesion Severity, d 21 Post-Challenge, Exp. 1



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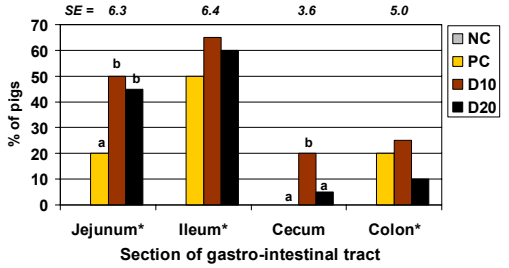
Effect of Dietary DDGS Level on Lesion Prevalence, d 21 Post-Challenge, Exp. 1



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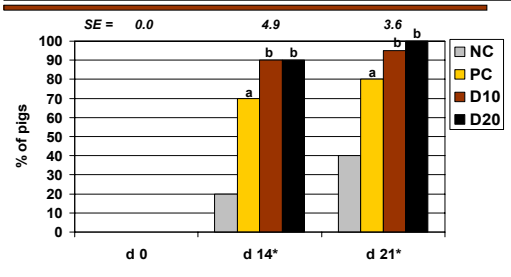
Effect of Dietary DDGS Level on Fecal Shedding (PCR Analysis), Exp. 1



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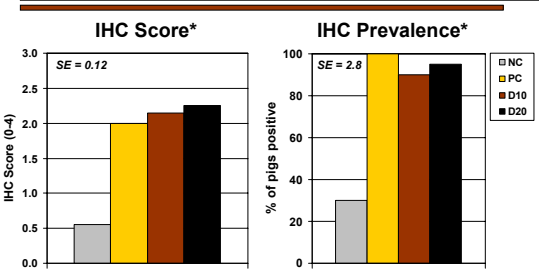
Effect of DDGS Level on *L. intracellularis* Infection (IHC Analysis), Exp. 1



[a,b] Means not sharing a common superscript letter are different ($P < .05$).
* Effect of disease challenge ($P < .01$).

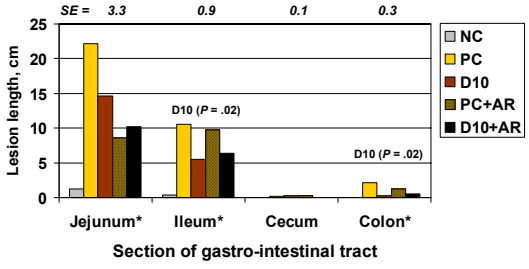
Summary of Results – Exp. 1

- DDGS inclusion did not improve the pig's ability to resist an ileitis challenge
- Dosage (inoculation) rate was higher than desired
  - Actual: 1.56 x 10^9 dose of *L. intracellularis*
  - Goal: 1 x 10^8 dose of *L. intracellularis*

Methodology - Experiment 2

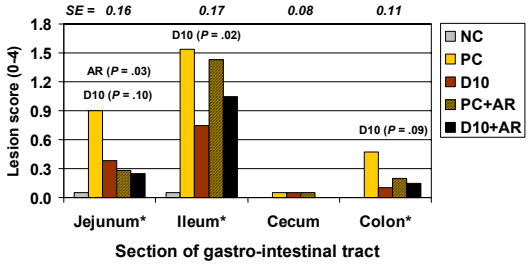
- Dietary treatments:
  - NC: Negative control corn-soybean meal diet, no antimicrobial
  - PC: Positive control corn-soybean meal diet, no antimicrobial*
  - D10: 10% DDGS diet, no antimicrobial*
  - PC+AR: Control diet with antimicrobial regimen*
  - D10+AR: DDGS diet with antimicrobial regimen*
- Antimicrobial regimen (AR):
  - Bacitracin Methylene Disalicylate (BMD®)
  - Chlortetracycline (Aureomycin®)
- Statistical analysis:
  - Compared NC and PC treatments (effect of challenge)
  - Factorial (2x2) arrangement of challenged treatments

Effect of Dietary Treatment on Lesion Length, d 21 Post-Challenge, Exp. 2



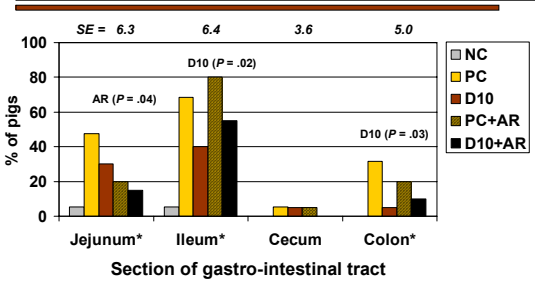
* Effect of disease challenge ($P < .01$).

Effect of Dietary Treatment on Lesion Severity, d 21 Post-Challenge, Exp. 2



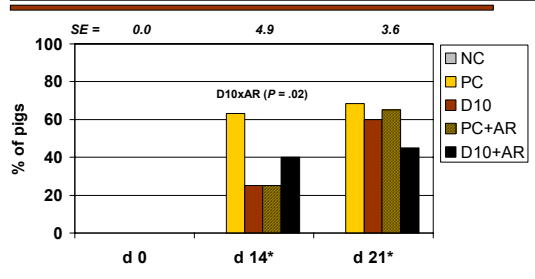
* Effect of disease challenge ($P < .01$).

Effect of Dietary Treatment on Lesion Prevalence, d 21 Post-Challenge, Exp. 2



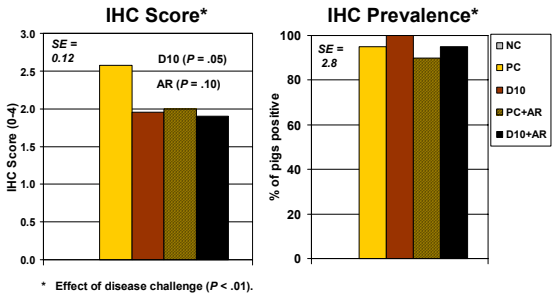
* Effect of disease challenge ($P < .01$).

Effect of Dietary Treatment on Fecal Shedding (PCR Analysis), Exp. 2



* Effect of disease challenge ($P < .01$).

Effect of Treatment on *L. intracellularis* Infection (IHC Analysis), Exp. 2



* Effect of disease challenge ($P < .01$).

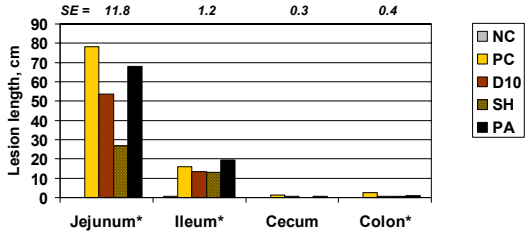
Summary of Results, Exp. 2

- Inoculation level was closer to goal
  - 8.0 x 10^8 *L. intracellularis* / pig
- DDGS inclusion (10%) or antimicrobial regimen had a positive effect on the pig's ability to resist an ileitis challenge
- No beneficial additive effects of combining DDGS and BMD®/Aureomycin® regimen

Methodology - Experiment 3

- Dietary treatments:
  - NC: Negative control corn-soybean meal diet, no antimicrobial
  - PC: Positive control corn-soybean meal diet, no antimicrobial*
  - D10: 10% DDGS diet
  - SH: 5% soybean hulls diet
  - PA: Polyclonal antibody spray-dried on soybean hulls (5%)
- Statistical analysis:
  - Utilized the GLM procedure of SAS (ANOVA and LSMeans)
    - Compared NC and PC treatments (effect of challenge)
    - Analyzed within challenged groups (effect of diet)
    - Individual pig = experimental unit

Effect of Dietary Treatment on Lesion Length, d 21 Post-Challenge, Exp. 3



[a,b] Means not sharing a common superscript letter are different ($P < .05$).
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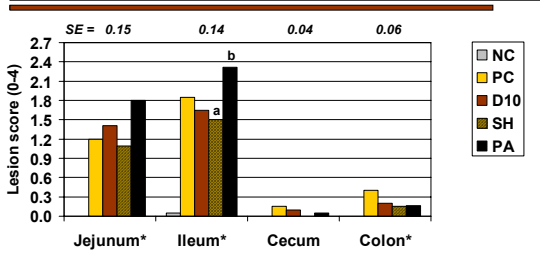
Effect of Dietary Treatment on Lesion Severity, d 21 Post-Challenge, Exp. 3



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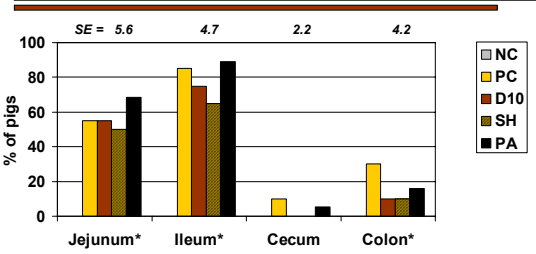
Effect of Dietary Treatment on Lesion Prevalence, d 21 Post-Challenge, Exp. 3



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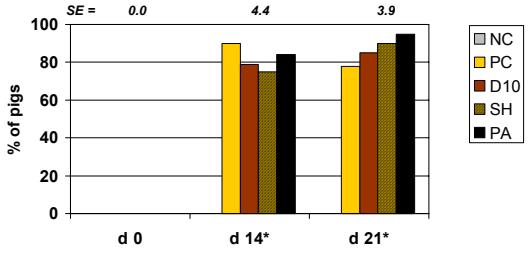
Effect of Dietary Treatment on Fecal Shedding (PCR Analysis), Exp. 3



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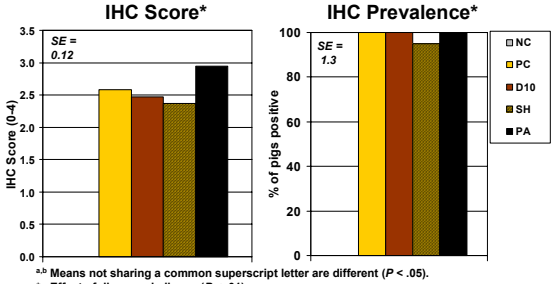
Effect of Treatment on *L. intracellularis* Infection (IHC Analysis), Exp. 3



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* Effect of disease challenge ($P < .01$).

Summary of Results, Exp. 3

- Inoculation level was similar to Experiment 2 (8.0×10^8)
  - Much more severe ileitis challenge, however:

	Experiment 2	Experiment 3
Total lesion length	35 cm	98 cm
Lesion severity (ileum)	1.54	1.85
Total lesion prevalence	70%	85%
Fecal shedding (PCR)	68% (d21)	90% (d14)

- No beneficial effects of 10% DDGS or 5% soybean hulls inclusion, or feeding polyclonal antibody product

Implications

- Dietary inclusion of DDGS
  - May provide some benefit during moderate ileitis challenge
  - May not provide a detectable benefit during a severe ileitis challenge
- Disease challenge model
  - Mucosal homogenate provides variable response
    - Use of pure culture may provide more predictable responses
  - Inoculation level must be reduced (1×10^8 or less)