Distiller's Dried Grains with Solubles – Redefined for Swine

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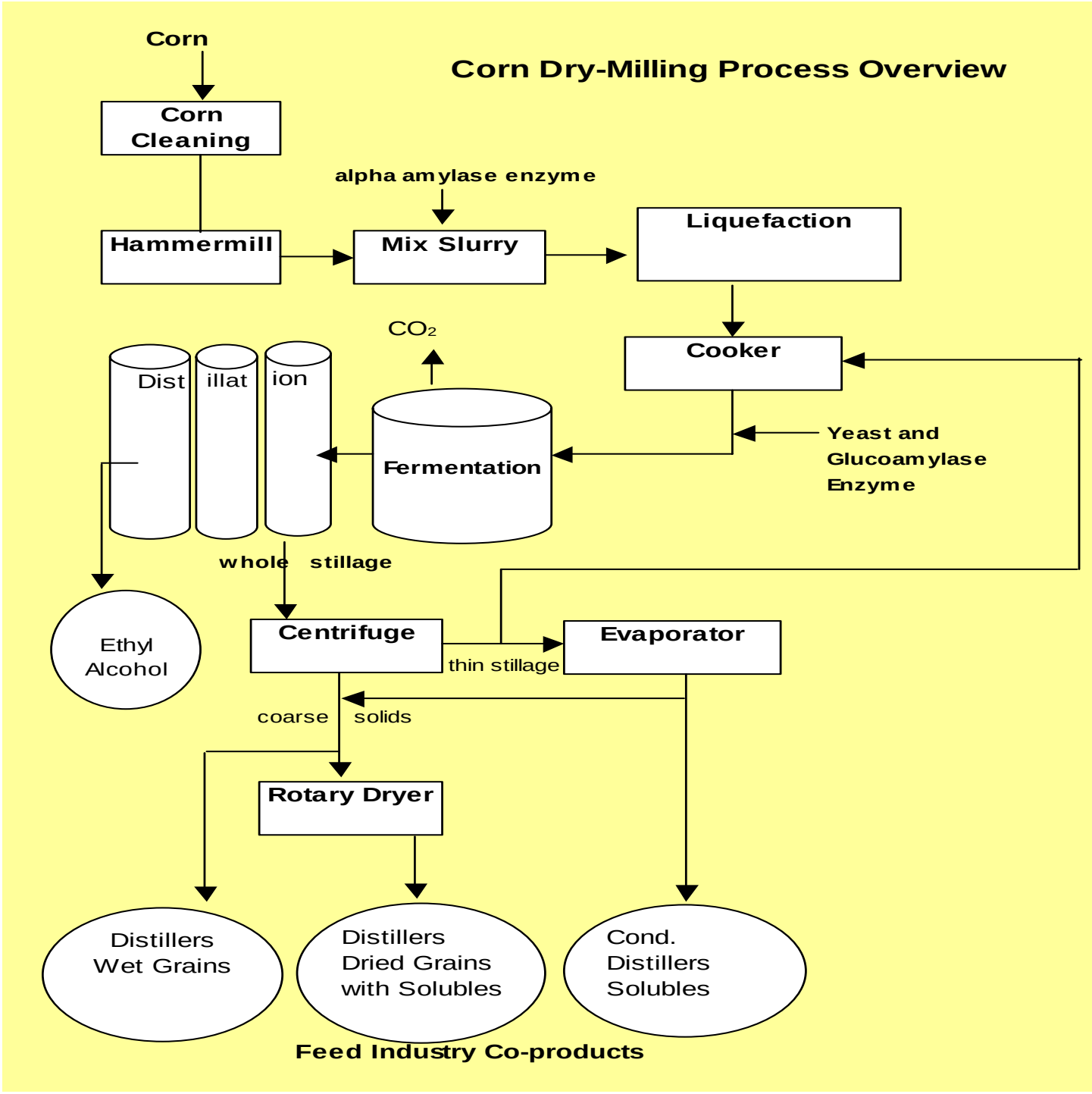
What is DDGS?

- Co-product of the dry-milling ethanol industry
  - Corn (maize) DDGS - Midwestern US
  - Wheat DDGS - Canada
  - Sorghum (milo) DDGS - Great Plains US
  - Barley DDGS
  - Rye DDGS

Production of DDGS

- Yeasts and enzymes are used to ferment the starch fraction of corn
- Ethanol and carbon dioxide are produced
- Distiller's grains and distiller's solubles are the residues remaining after fermentation
- These fractions are blended and dried to produce distiller's dried grains with solubles (DDGS)

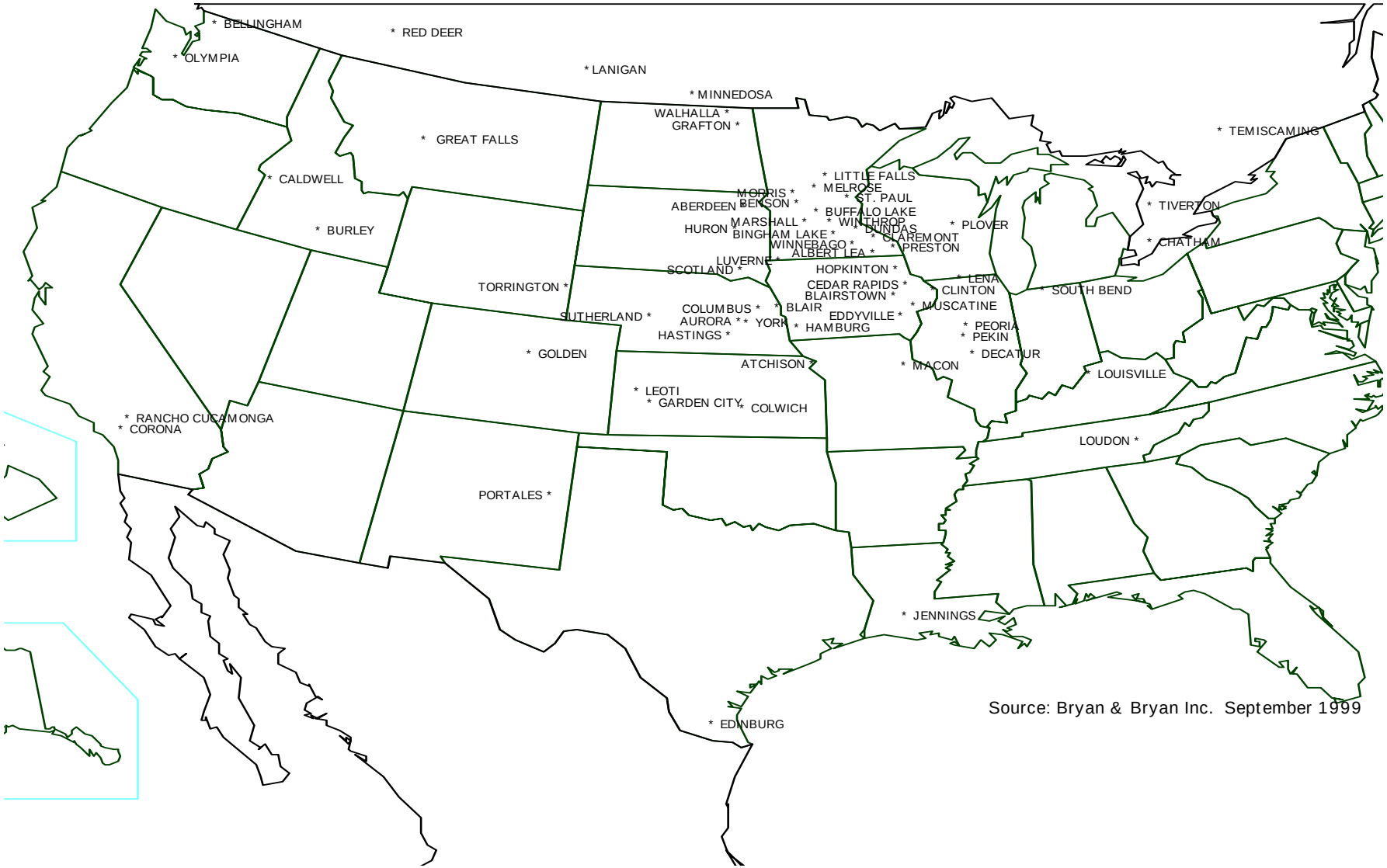

Corn
Corn Dry-Milling Process Overview
Corn Cleaning
alpha amylase enzyme
Hammermill
Mix Slurry
Liquefaction
CO_2
Cooker
Dist
illat
ion
Fermentation
Yeast and Glucoamylase Enzyme
whole stillage
Ethyl Alcohol
Centrifuge
thin stillage
Evaporator
coarse solids
Rotary Dryer
Distillers Wet Grains
Distillers Dried Grains with Solubles
Cond. Distillers Solubles
Feed Industry Co-products

Dry-Milling Average Ethanol Yield Per Bushel (25.4 kg) of Corn

- Ethanol 2.7 gallons (10.2 liters)
- DDGS 18 lbs (8.2 kg)
- CO_2 18 lbs (8.2 kg)

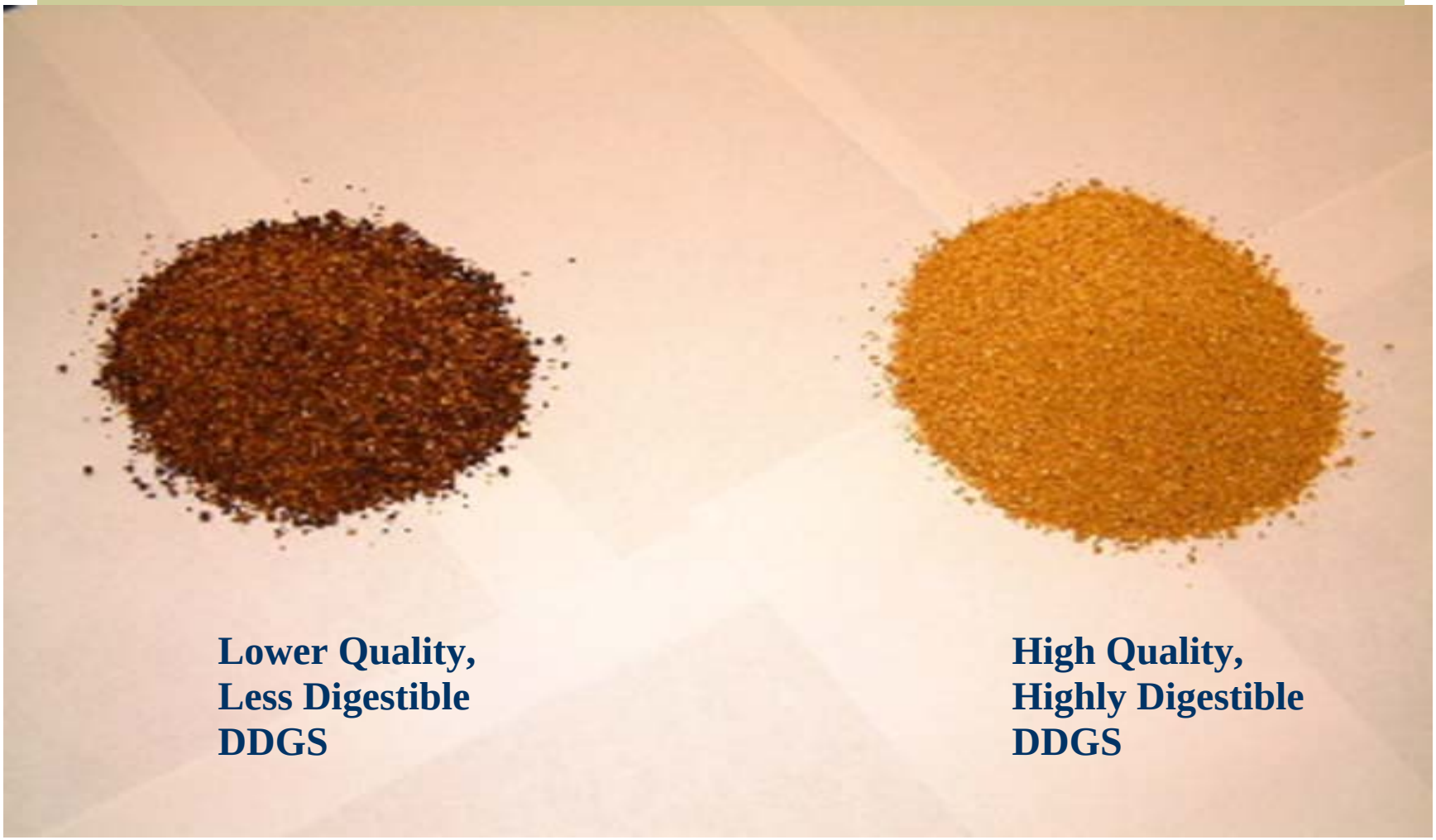
Slide courtesy of Ms. Kelly Davis, CVEC, Benson, MN

Map of U.S. Ethanol Plants



Source: Bryan & Bryan Inc. September 1999

“New Generation” vs. “Old Generation” DDGS



Lower Quality, Less Digestible DDGS

High Quality, Highly Digestible DDGS

Comparison of Energy Values for DDGS (88% Dry Matter Basis)

	"New" DDGS Calculated	"New" DDGS Trial avg.	"Old" DDGS Calculated	DDGS NRC (1998)
DE, kcal/lb	1582 Range 1550-1604	1600 Range 1349-1853	1546	1564
ME, kcal/lb	1434 Range 1400-1458	1527 Range 1279-1776	1405	1212

Corn (NRC, 1998): DE (kcal/lb) = 1580
ME (kcal/lb) = 1534

Comparison of Amino Acid Composition of DDGS
(88% dry matter basis)

	"New" DDGS	"Old" DDGS	DDGS (NRC, 1998)
Lysine, %	0.75 (17.3)	0.47 (26.5)	0.59
Methionine, %	0.63 (13.6)	0.44 (4.5)	0.48
Threonine, %	0.99 (6.4)	0.86 (7.3)	0.89
Tryptophan, %	0.22 (6.7)	0.17 (19.8)	0.24
Valine, %	1.32 (7.2)	1.22 (2.3)	1.23
Arginine, %	1.06 (9.1)	0.81 (18.7)	1.07
Histidine, %	0.67 (7.8)	0.54 (15.2)	0.65
Leucine, %	3.12 (6.4)	2.61 (12.4)	2.43
Isoleucine, %	0.99 (8.7)	0.88 (9.1)	0.98
Phenylalanine, %	1.29 (6.6)	1.12 (8.1)	1.27

Values in ( ) are CV's among plants

Comparison of Apparent Ileal Digestible Amino Acid Composition of DDGS
(88% dry matter basis)

	"New" DDGS	"Old" DDGS	DDGS (NRC, 1998)
Lysine, %	0.39	0.00	0.27
Methionine, %	0.28	0.21	0.34
Threonine, %	0.55	0.32	0.49
Tryptophan, %	0.13	0.13	0.12
Valine, %	0.81	0.45	0.77
Arginine, %	0.79	0.53	0.77
Histidine, %	0.45	0.26	0.40
Leucine, %	2.26	1.62	1.85
Isoleucine, %	0.63	0.37	0.64
Phenylalanine, %	0.78	0.60	0.96

Comparison of Phosphorus Level and Relative Availability of DDGS
(88% dry matter basis)

	"New" DDGS	"Old" DDGS	DDGS NRC (1998)	Corn NRC (1998)
Total P, %	0.78 Range 0.62-0.87	0.79	0.73	0.25
P Availability, %	90 Range 88-92	No data	77	14
Available P, %	0.70	No data	0.56	0.03

Why is there so much interest in feeding DDGS to swine?

- "New Generation" DDGS is high in digestible nutrients
- Economical partial replacement for:
  - corn
  - soybean meal
  - dicalcium phosphate
- Increasing production and supply
- Unique properties
  - reduce P excretion in manure
  - increase litter size weaned/sow
  - gut health benefits?

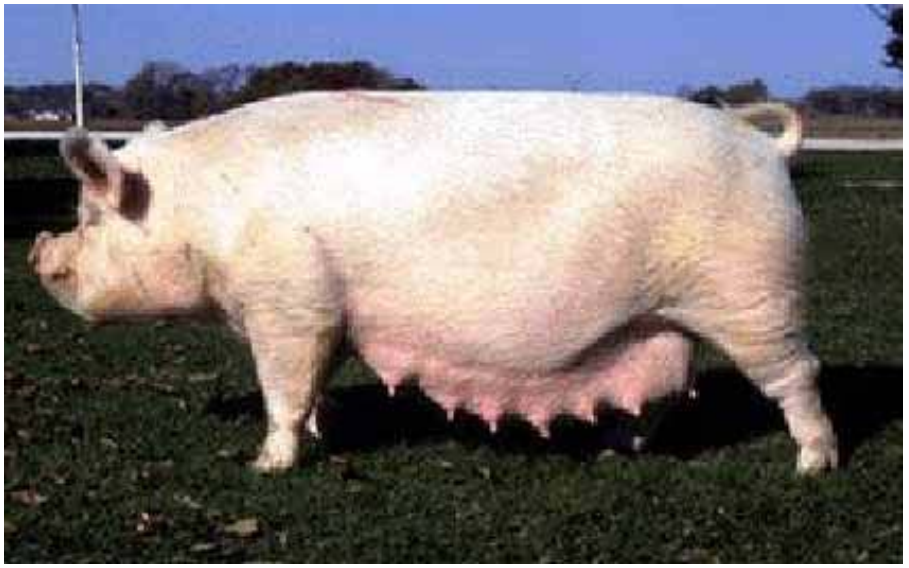
Maximum Inclusion Rates of "New Generation" DDGS in Swine Diets

(Based Upon University of Minnesota Performance Trials)

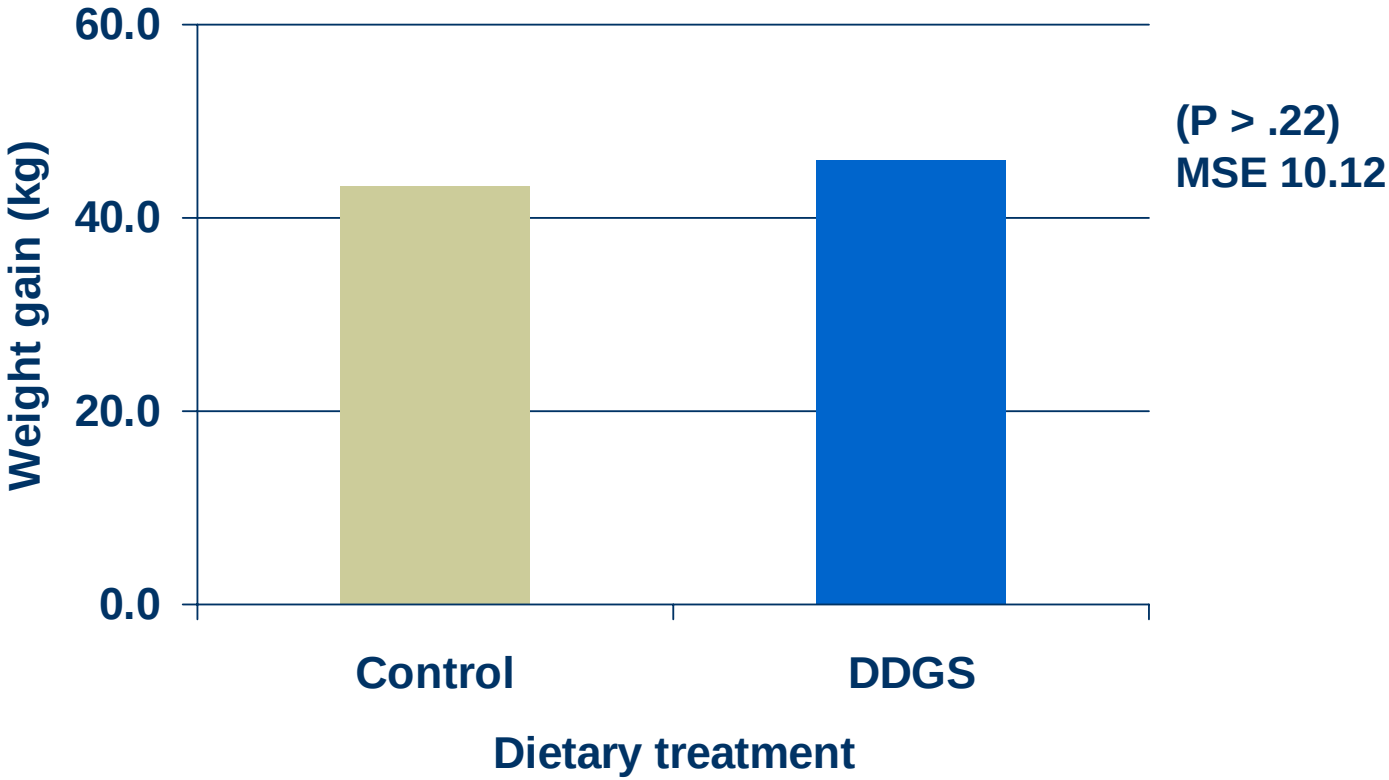
- Nursery pigs (> 7 kg)
  - Up to 25 %
- Grow-finish pigs
  - Up to 20% (higher levels may reduce pork fat quality)
- Gestating sows
  - Up to 50%
- Lactating sows
  - Up to 20%

Assumptions: no mycotoxins
formulate on a digestible amino acid and available phosphorus basis

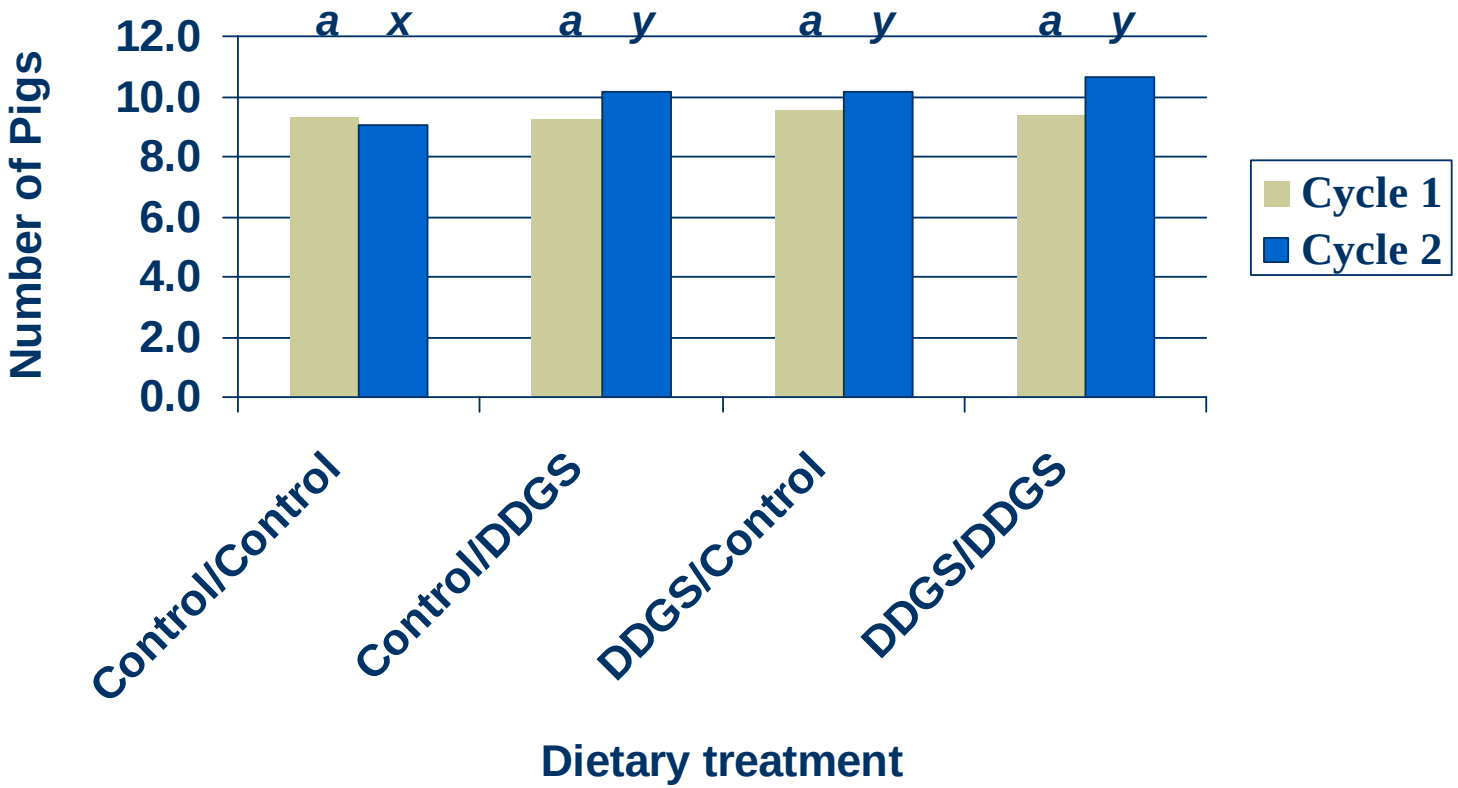
Feeding “New Generation DDGS to Sows”



Effect of Feeding a 50% DDGS Diet on Sow Weight Gain During Gestation (Reproductive Cycle 1)

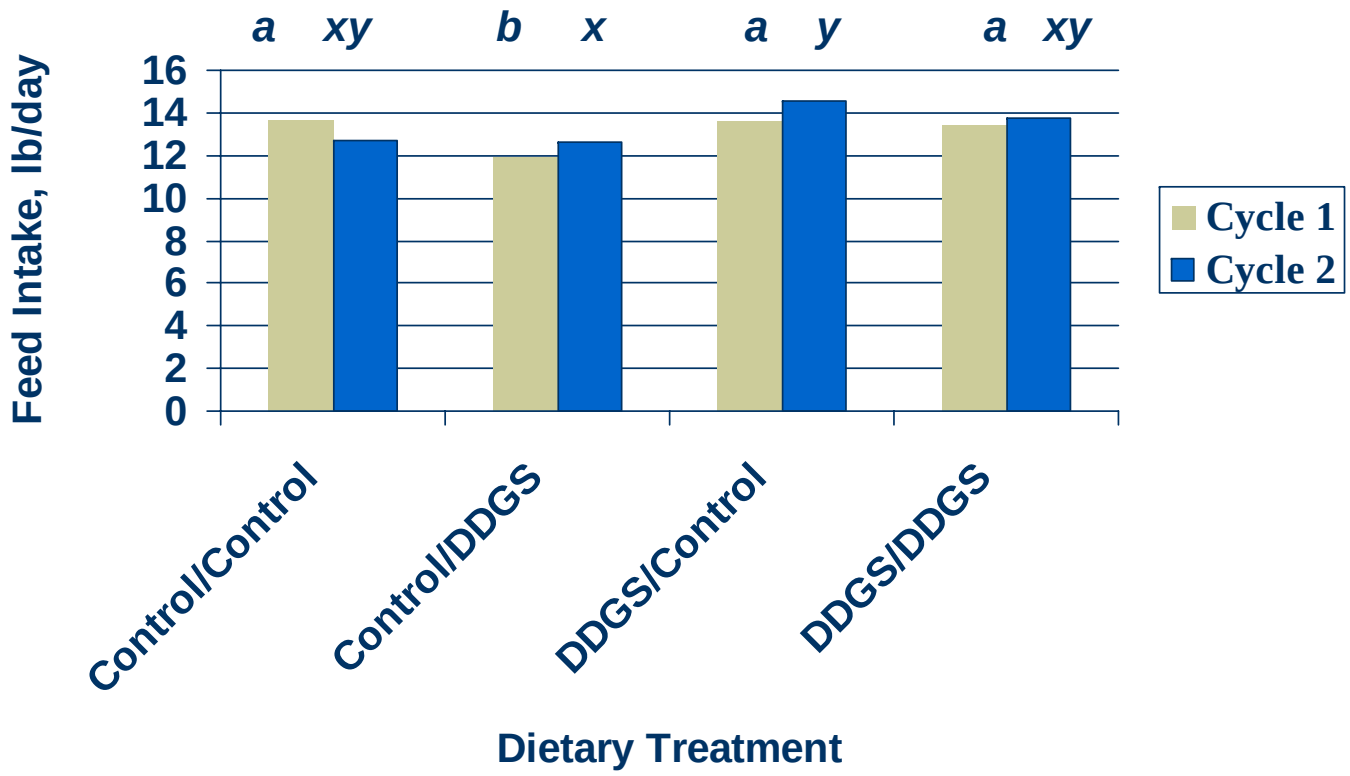


Effect of Feeding 0 or 50% DDGS Gestation Diets and 0 or 20% DDGS Lactation Diets on Pigs Weaned/Litter



[a,b,x,y] Different superscripts indicate significant difference (P < .10).

Effect of Dietary Treatment Combination on Sow Lactation ADFI



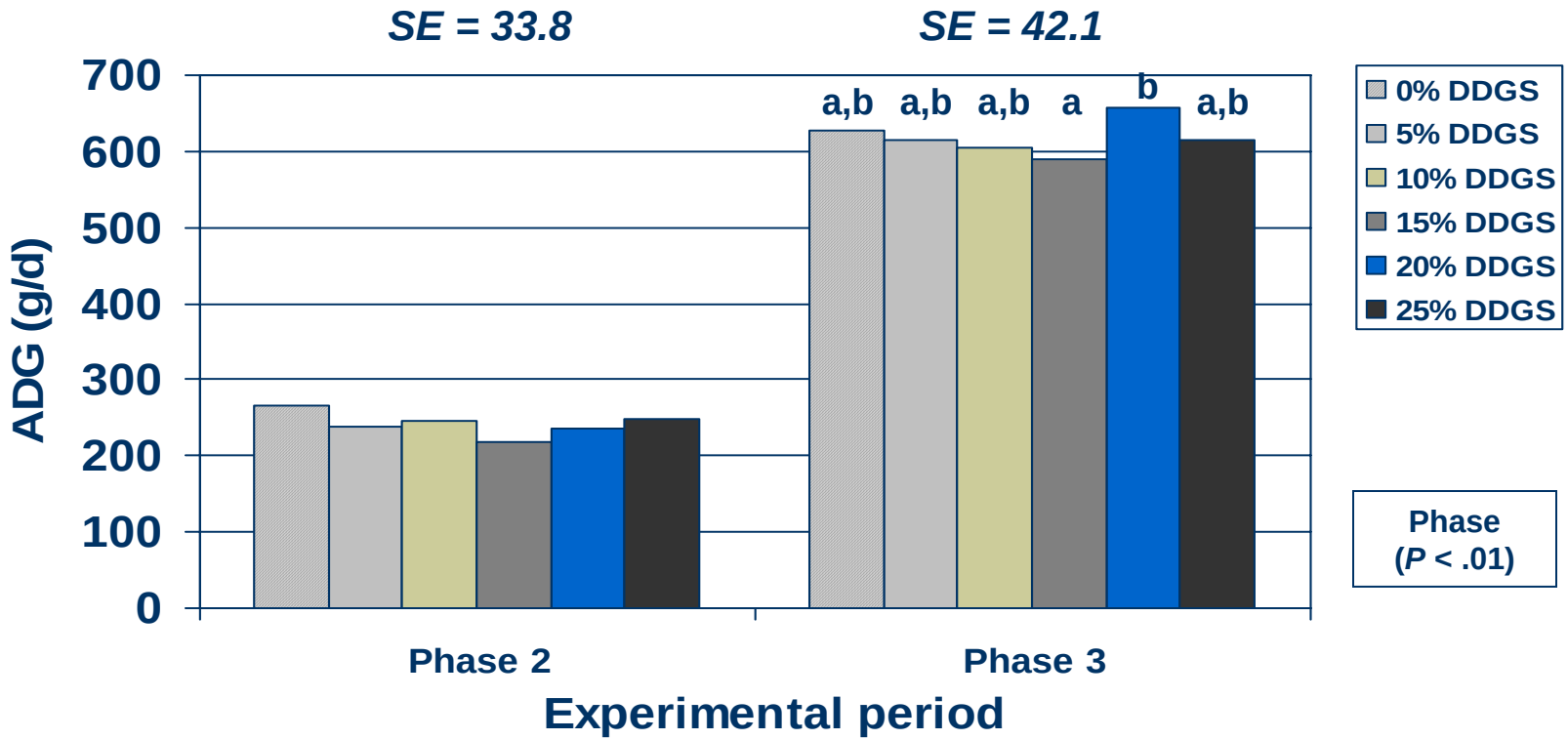
[a,b,x,y] Different superscripts indicate significant difference (P < .10).

Feeding “New Generation” DDGS to Weaned Pigs

Materials and Methods – Nursery Experiments

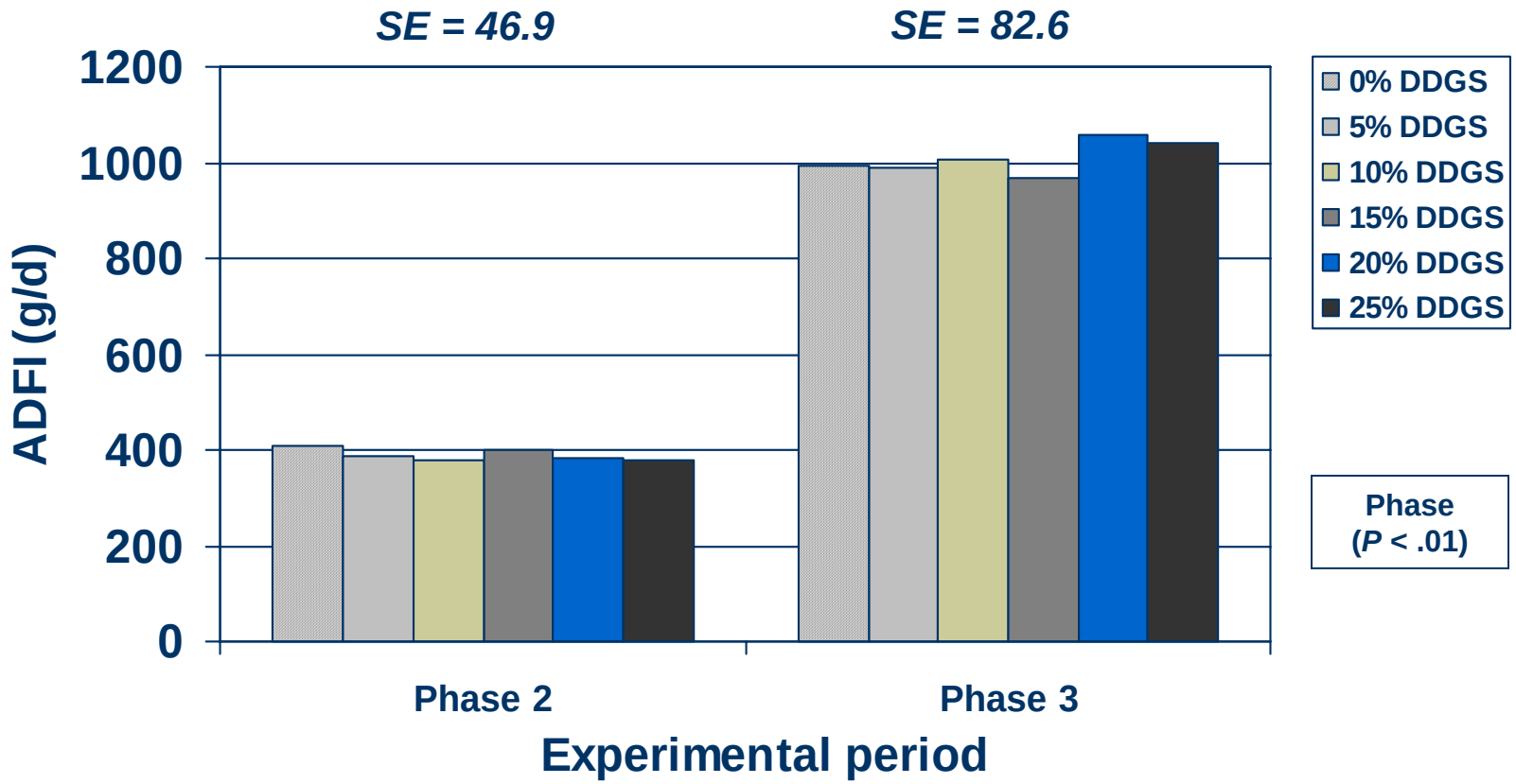
- Experiment 1
  - Pigs weaned at 19.0 ± 0.3 d of age
  - Weighed 7.10 ± 0.07 kg
- Experiment 2
  - Pigs weaned at 16.9 ± 0.4 d of age
  - Weighed 5.26 ± 0.07 kg
- Pigs were fed a commercial pelleted diet (d 0 to 3 postweaning)
- Phase II (d 4-17) and Phase III (d 18 – 35) diets were formulated on a digestible amino acid basis.
  - Diets contained 0, 5, 10, 15, 20, or 25% DDGS

Effect of DDGS Level on Growth Rate (Experiment 1)

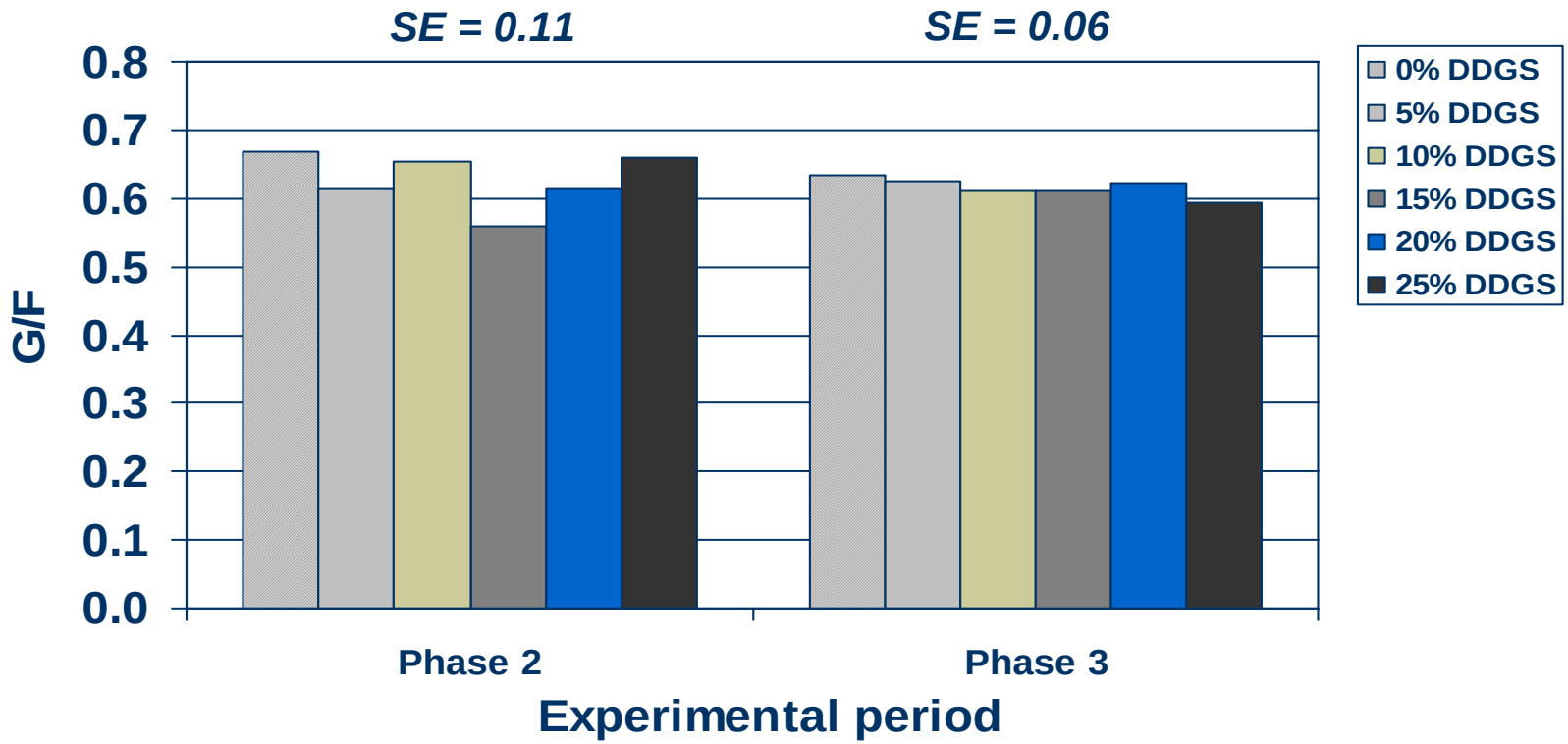


Means not sharing a common superscript letter are significantly different ($P < .05$)

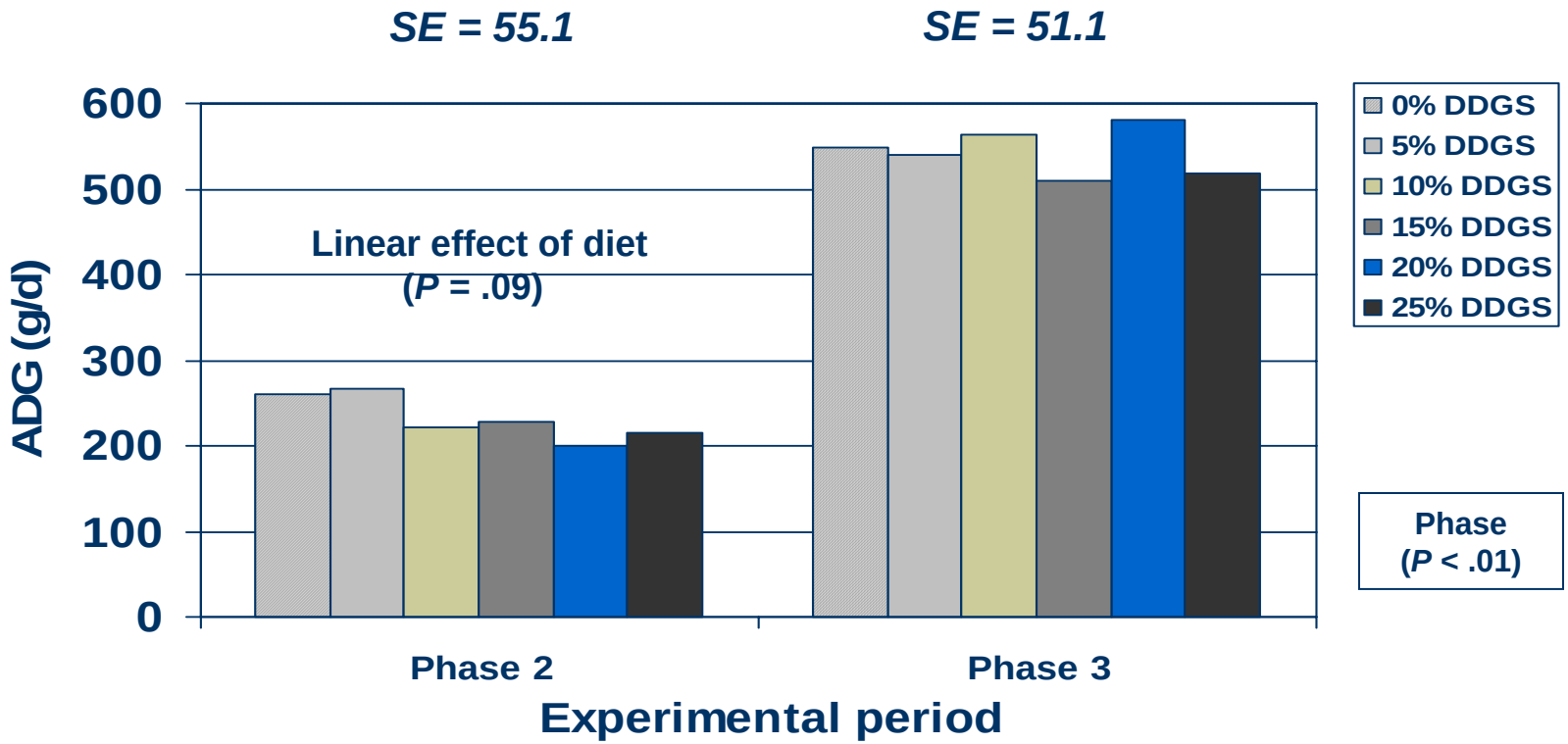
Effect of DDGS Level on ADFI (Experiment 1)



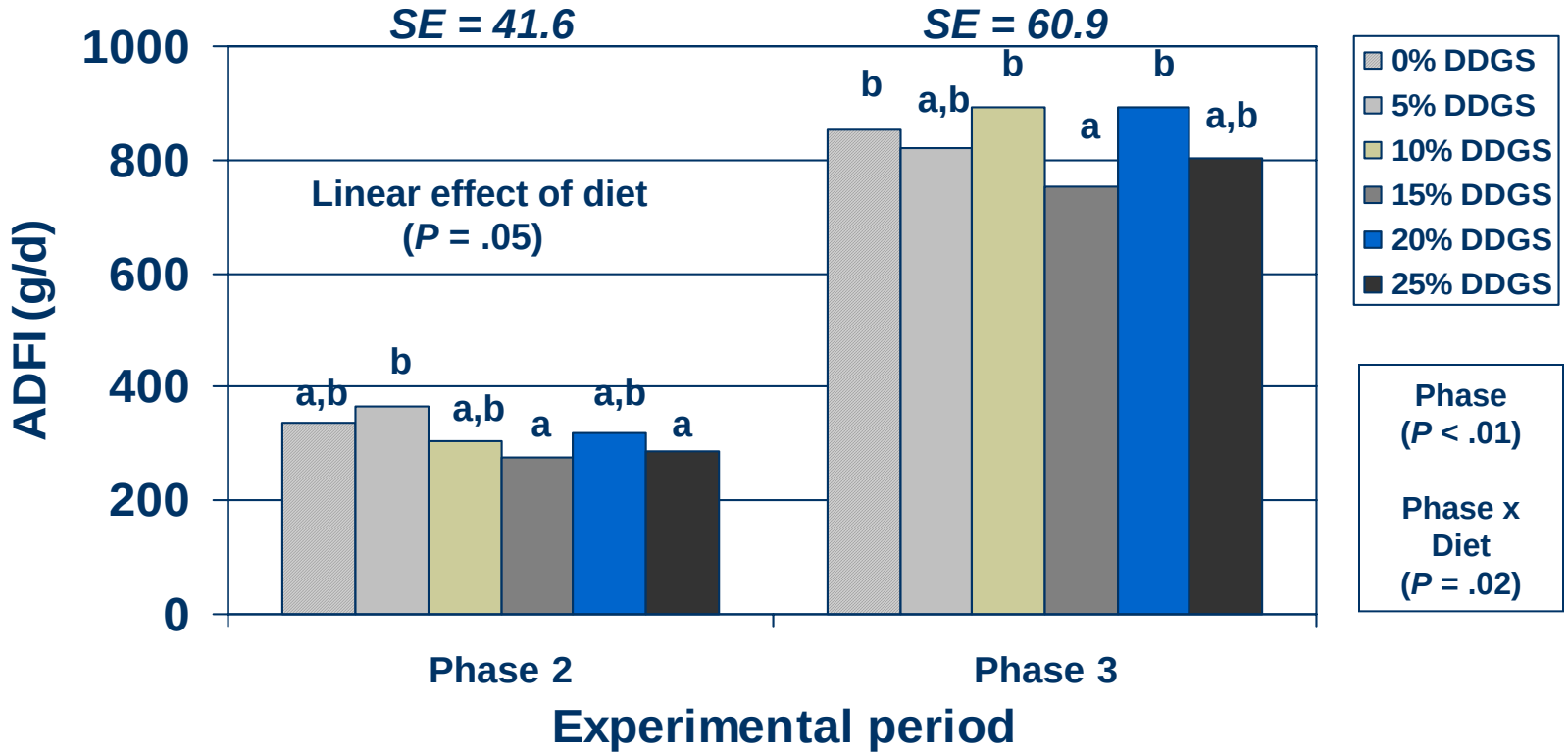
Effect of DDGS Level on Gain/Feed (Experiment 1)



Effect of DDGS Level on Growth Rate (Experiment 2)



Effect of DDGS Level on Feed Intake (Experiment 2)



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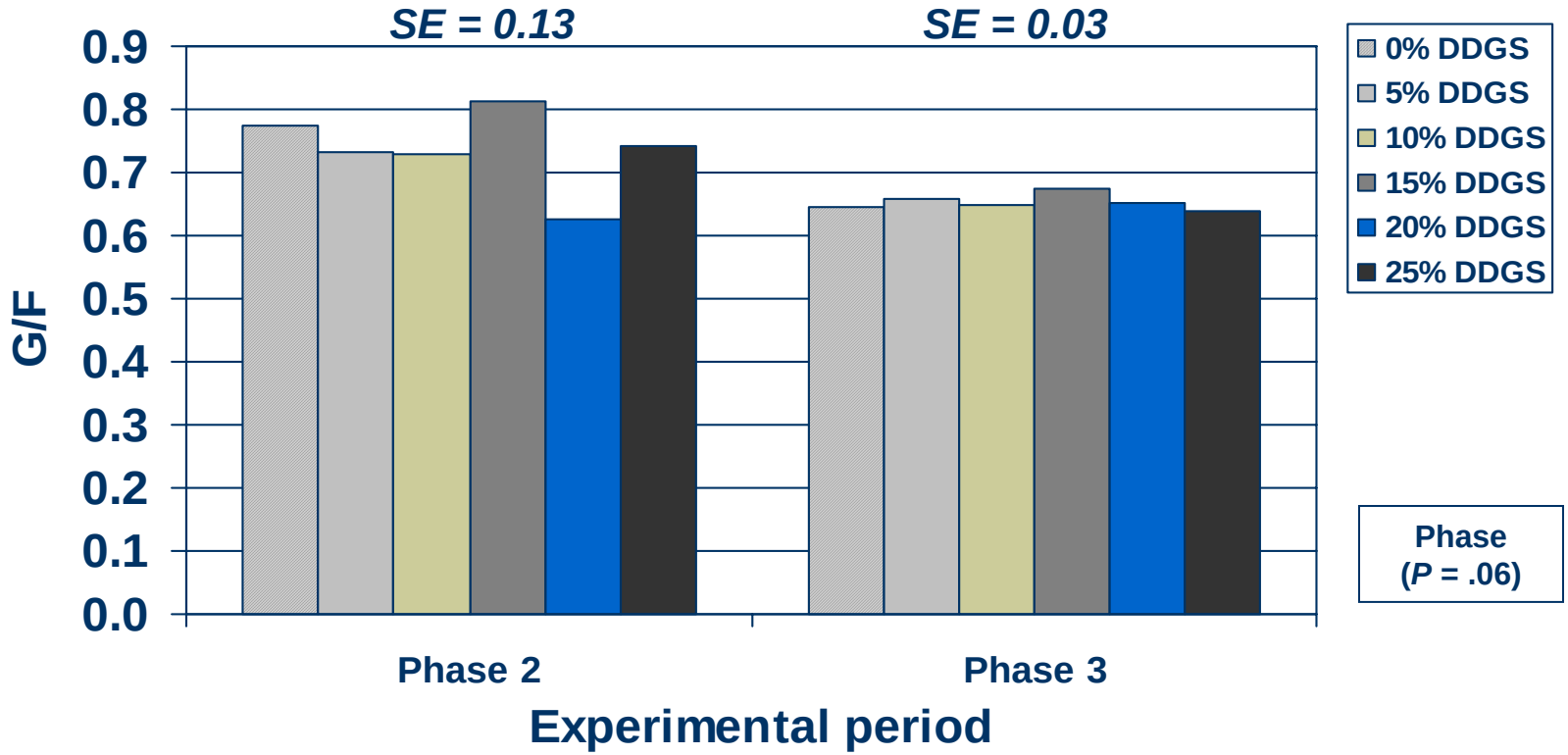
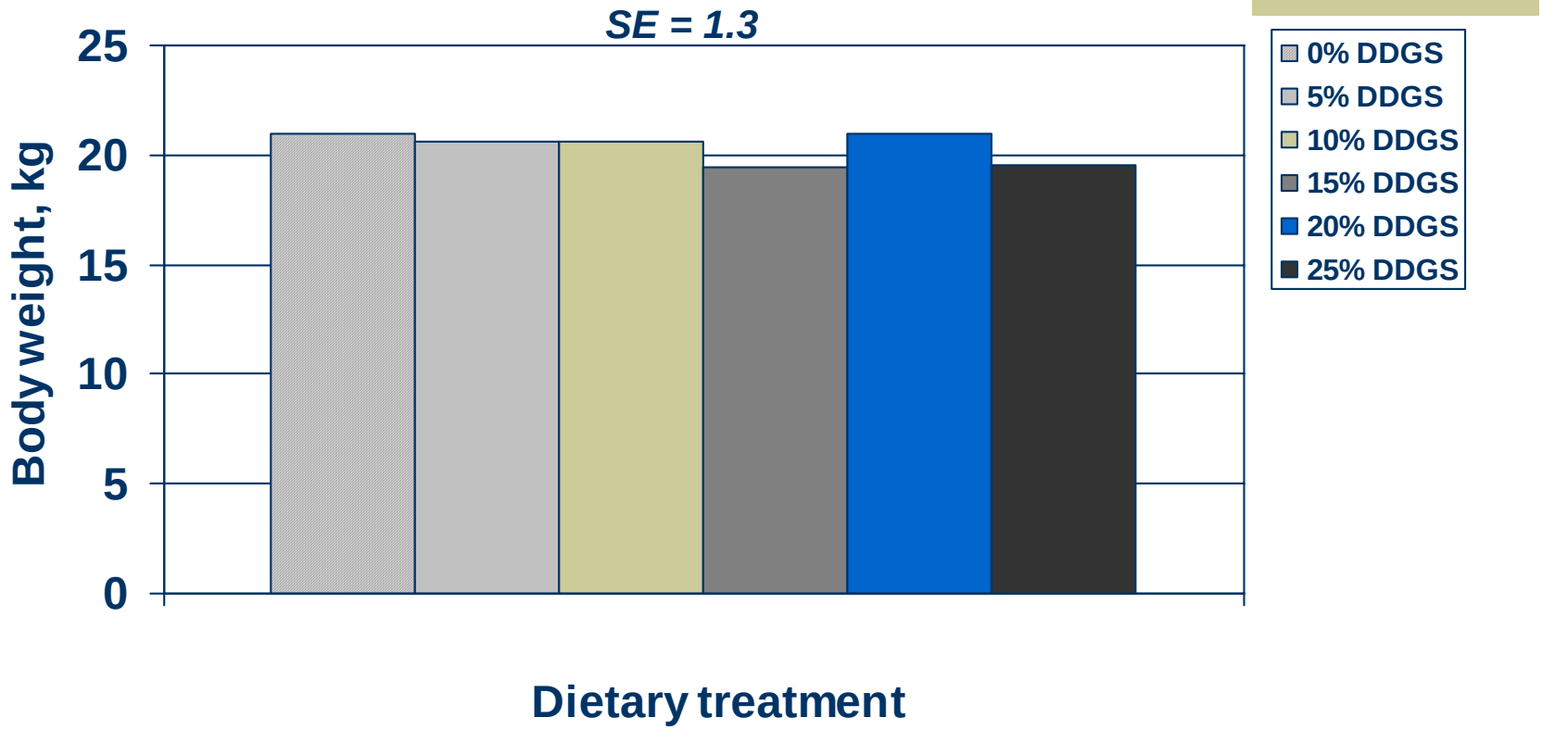
Effect of DDGS Level on Gain/Feed (Experiment 2)



Effect of DDGS Level on Final BW (Experiment 2)



Feeding “New Generation” DDGS to Grow-Finish Pigs

Fat Quality Characteristics of Market Pigs Fed Corn-Soy Diets Containing 0 to 30% DDGS

	0 %	10%	20%	30%
Belly thickness, cm	3.15^{a}	3.00^{a,b}	2.84^{a,b}	2.71^{b}
Belly firmness score, degrees	27.3^{a}	24.4^{a,b}	25.1^{a,b}	21.3^{b}
Adjusted belly firmness score, degrees	25.9^{a}	23.8^{a,b}	25.4^{a,b}	22.4^{b}
Iodine number	66.8^{a}	68.6^{b}	70.6^{c}	72.0^{c}

Means within a row lacking common superscripts differ ($P < .05$).

Formulation Methods for Diets Containing DDGS

- Total vs digestible amino acid basis
  - Maximum DDGS inclusion rate = 10%
    - if formulating on a total amino acid basis
  - Much higher DDGS inclusion rates (>10%)
    - if diets are formulated using digestible amino acids
- Total vs available phosphorus basis
  - Formulating diet on an available P basis increases economic benefit and reduces P content of manure

Cost Savings Depends on Diet Formulation Method Used

Comparison of Formulating DDGS Diets on a Total Lysine and P Basis vs. Digestible Lysine and Available P Basis

Ingredient	Typical Corn-SBM-Lysine Diet	10% DDGS Total Lysine Total P	10% DDGS Digestible Lysine Available P
Corn, kg	731.5	650.5	643
Soybean meal 44%, kg	241	223	231.5
DDGS, kg	0	100	100
Dicalcium phosphate, kg	12	9.5	8.5
Limestone, kg	7	8.5	8.5
Salt, kg	3	3	3
L-lysine HCl, kg	1.5	1.5	1.5
VTM premix, kg	4	4	4
TOTAL, kg	1000	1000	1000
Total Cost, $	109.80	108.40	109.18
Difference, $	-	-1.40	-0.62

corn = $2.00/bu, DDGS = $85/ton, soybean meal 44% = $190/ton, dicalcium phosphate = $15.00/cwt, limestone = $1.75/cwt, salt = $6.90/cwt, L-lysine HCl = $1.00/lb, VTM premix = $1.17/lb

Why is Feed Cost Savings Higher When Formulating Diets on a Total Amino Acid and Phosphorus Basis?

- Formulating on a total lysine and P basis replaces:
  - 7.5 kg less corn ($0.079/kg)
  - 8.5 kg more soybean meal 44% ($0.209/kg)
  - 1 kg less dicalcium phosphate ($0.33/kg)
- compared to formulating on a digestible amino acid and available phosphorus basis

Quick Calculation of Feed Cost Savings

Thumb rule:

Additions/2000 lbs diet

+ 200 lbs DDGS x _____ $/lb = $_____
+ 3 lbs limestone x _____ $/lb = $_____
TOTAL ADDITIONS (A) $_____

Subtractions/2000 lbs diet

- 177 lbs corn x _____ $/lb = $_____
- 20 lbs SBM (44%) x _____ $/lb = $_____
- 6 lbs dical. phos. x _____ $/lb = $_____
TOTAL SUBTRACTIONS (S) $_____

(S – A) = Feed cost savings/ton by adding 10% DDGS to the diet

DDGS and Phytase are a Key Part of Manure Phosphorus Management

- Adding 20% DDGS to a corn-soy diet and formulating on an available P basis
  - can reduce manure P by > 12%
- Adding phytase to a corn-soy diet
  - increases P bioavailability from 15% to > 45%
- Lowering dietary P, adding 20% DDGS & phytase
  - can reduce manure P excretion by 40 to 50%

Diet Compositions and Cost Comparison from Adding 18.8% DDGS and Phytase

Ingredient	Corn-SBM-1.5 kg Lysine	18.8% DDGS + Phytase
Corn, kg	798.3	636.3
Soybean meal 44%, kg	176.9	159.4
DDGS, kg	0.0	188
Dicalcium phosphate, kg	11.6	0.0
Limestone, kg	7.2	9.8
Salt, kg	3.0	3.0
L-lysine HCl, kg	1.5	1.5
VTM premix, kg	1.5	1.5
Phytase, 500 FTU/kg	0.0	0.5
TOTAL, kg	1000.0	1000.0
Total Cost, $	96.25	96.36
Difference, $	-	+ 0.11

Does Feeding DDGS Improve Gut Health?

DDGS and Gut Health

- Field reports:
  - Beneficial effect of adding 5 to 10% DDGS in grow-finish diets
- 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).
- DDGS contains components of yeast cells
  - May have nutraceutical properties

What is Ileitis?

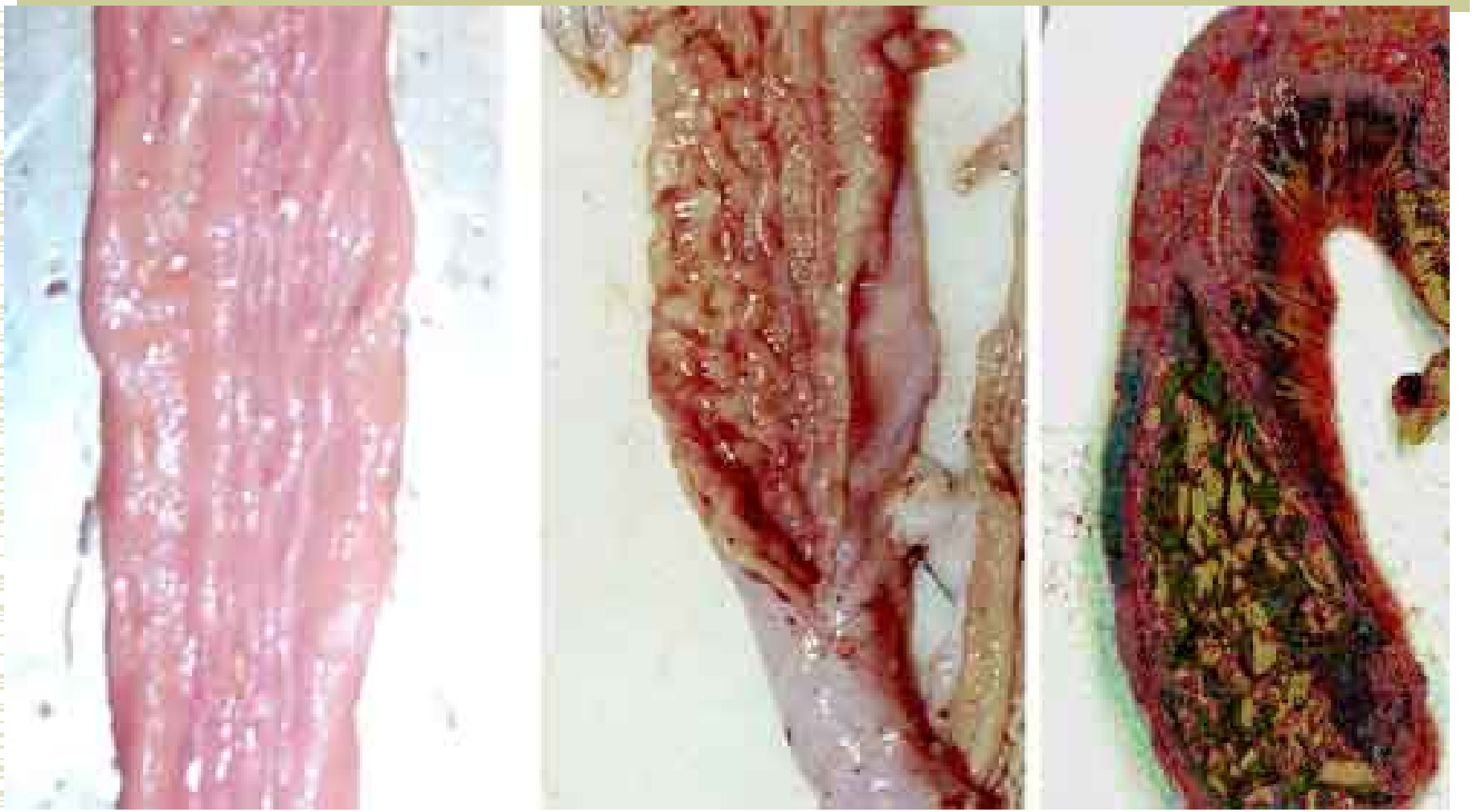
- Porcine Proliferative Enteropathy
- Caused by *Lawsonia intracellularis*
  - Present in 96% of U.S. swine herds (Bane et al., 1997)
    - 28% of pigs affected (NAHMS, 2000)
  - Can be shed in infected pigs for up to 10 weeks
- Animals are infected by oral contact with feces from animals shedding the bacteria
- 7-10 days after infection:
  - Lesions of the intestinal wall begin to form
  - Lesions maximized around 21 days post-infection

Clinical Forms of Ileitis

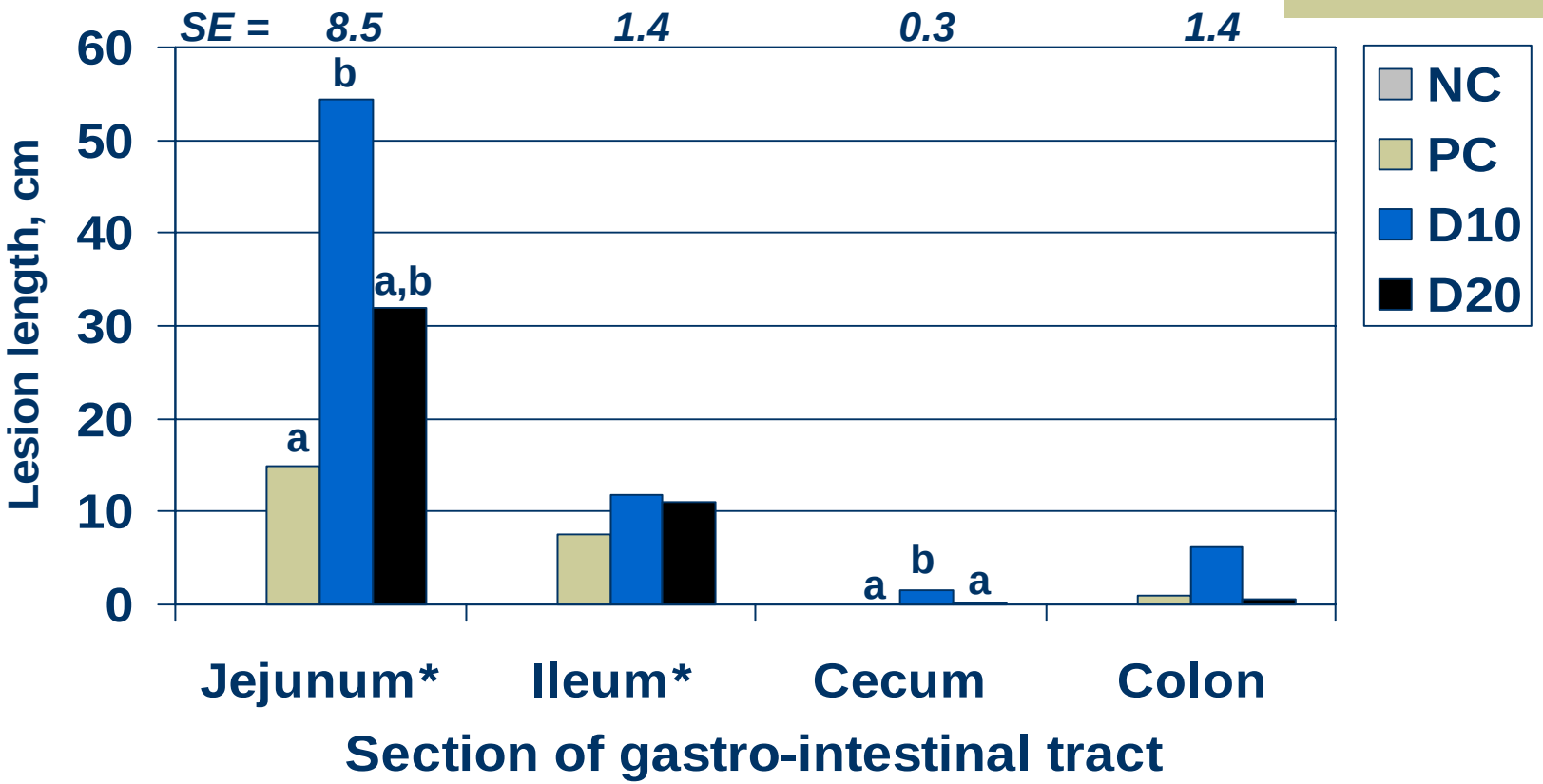
- Porcine Intestinal Adenomatosis (PIA)
  - Chronic form
  - Seen in growing pigs (6 - 20 weeks of age)
  - Decreased feed intake, lethargic
- Porcine Hemorrhagic Enteropathy (PHE)
  - Acute form, affects heavier pigs
    - Greatest frequency appears to be from 65 – 110 kg pigs
  - Massive intestinal hemorrhaging, bloody diarrhea, increase in mortality

Healthy

Ileitis



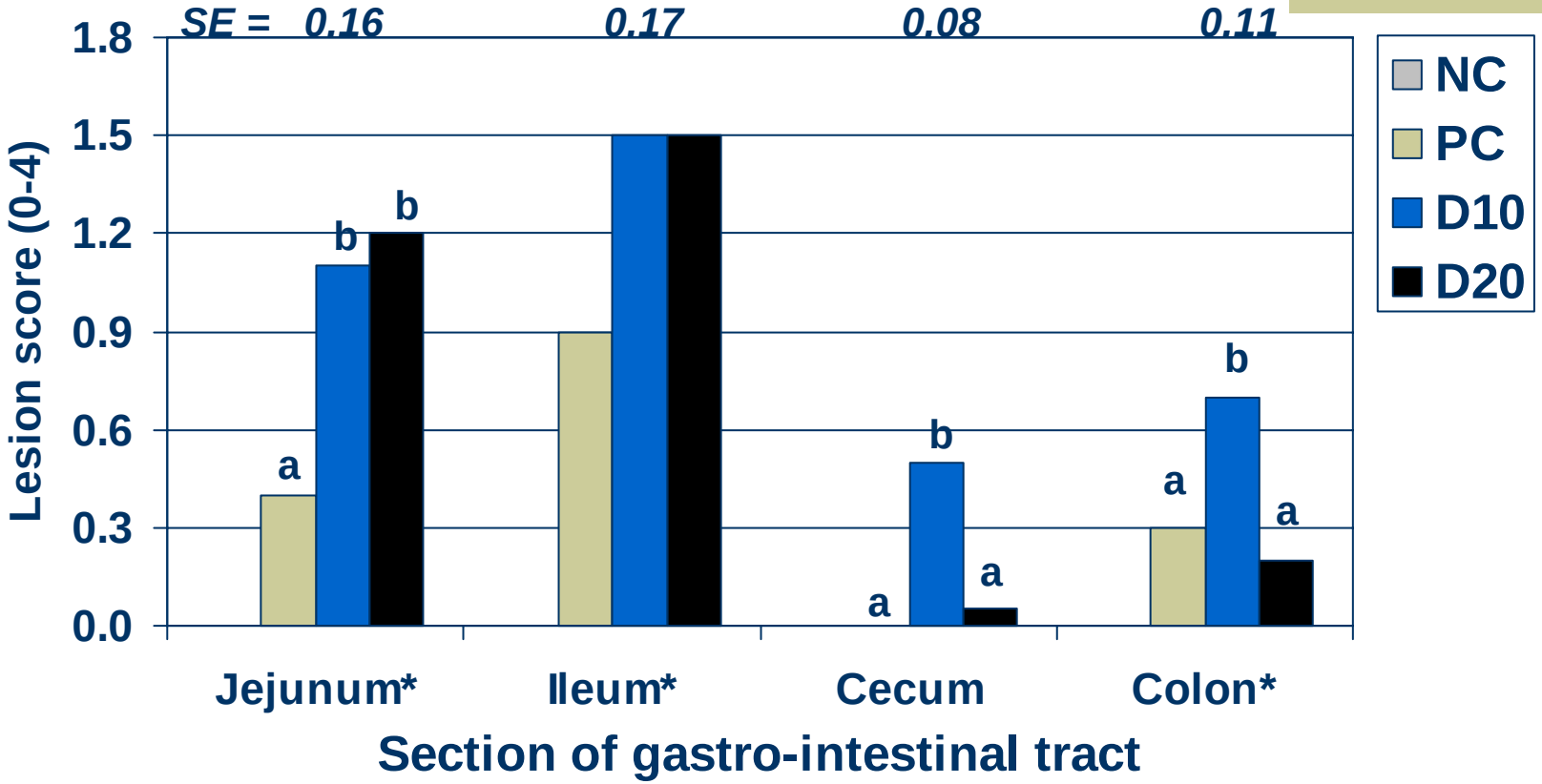
Effect of Dietary DDGS Level on Lesion Length (21 d Post-Challenge) Experiment 1



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

* Effect of disease challenge ($P < .05$).

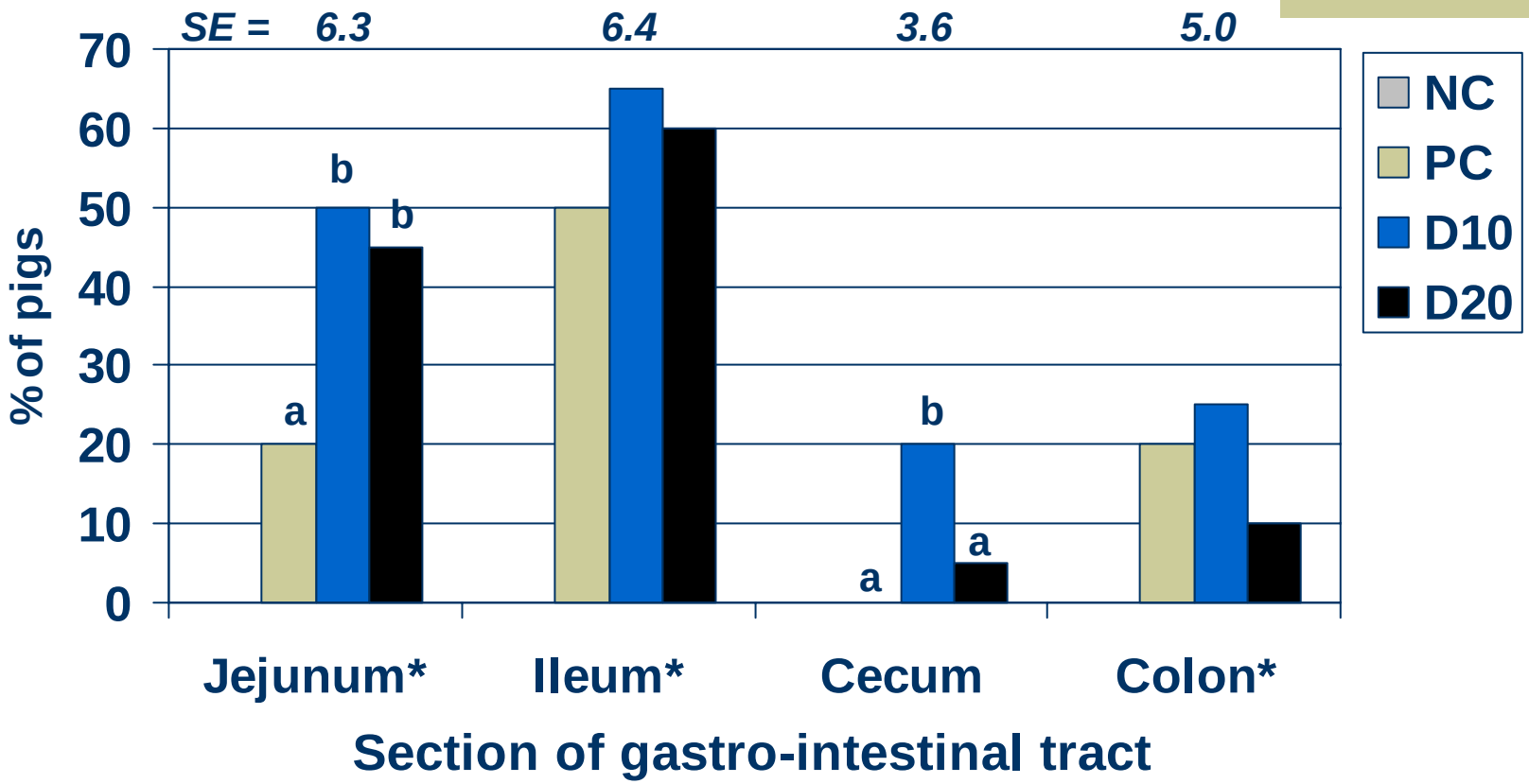
Effect of Dietary DDGS Level on Lesion Severity (21 d Post-Challenge) Experiment 1



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

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

Effect of Dietary DDGS Level on Lesion Prevalence (21 d Post-Challenge) Experiment 1



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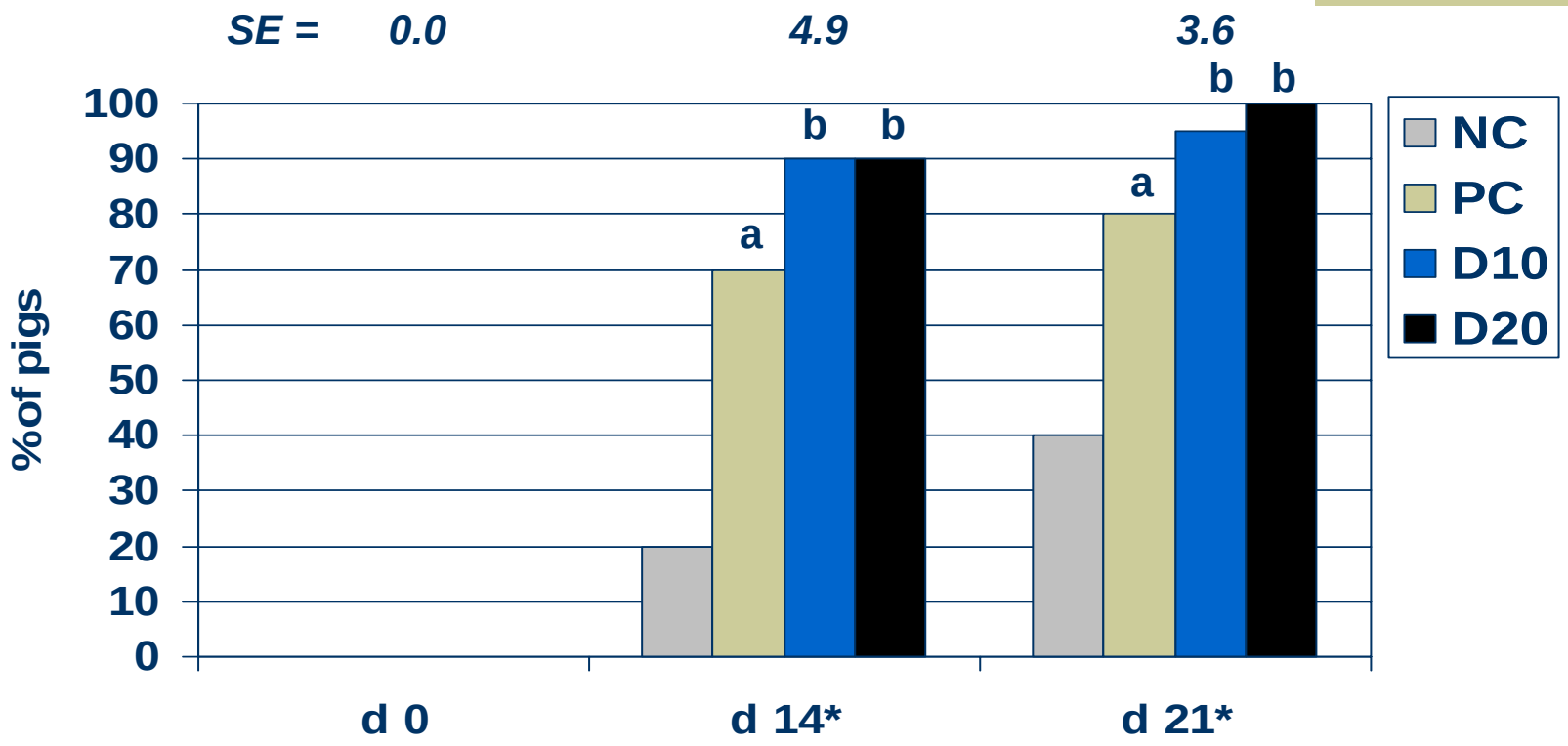
* Effect of disease challenge ($P < .01$).

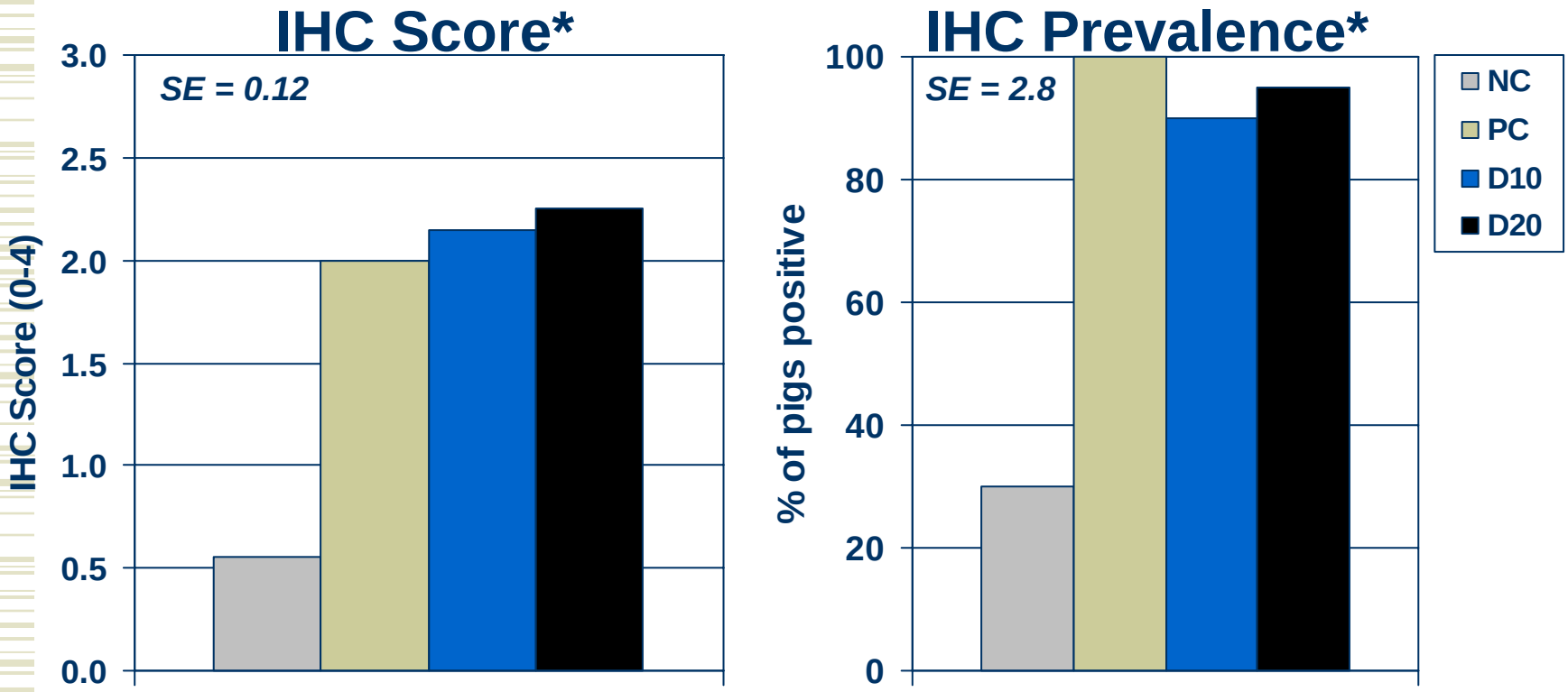
Effect of Dietary DDGS Level on Fecal Shedding (PCR Analysis) Experiment 1



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

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

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



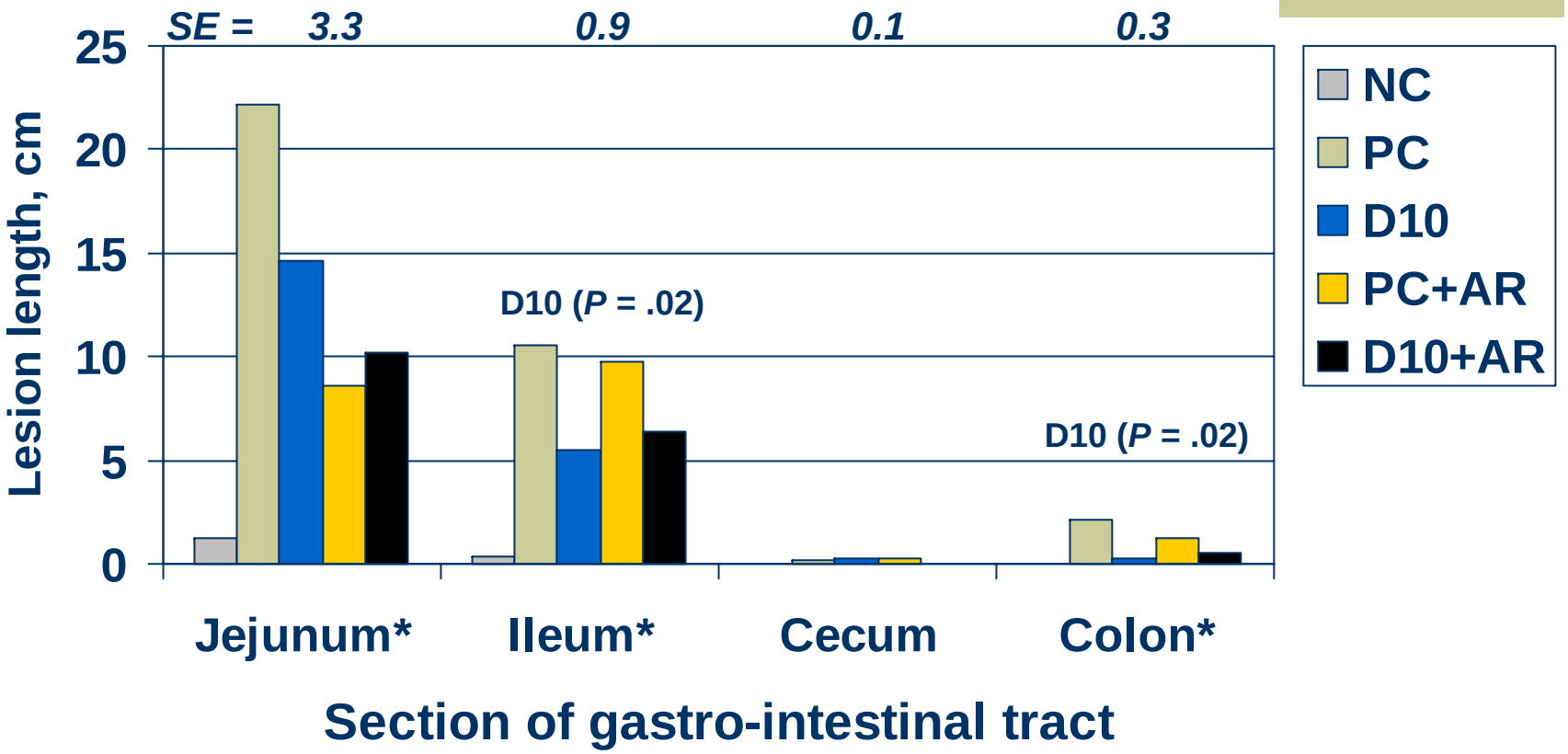
[a,b] Means not sharing a common superscript letter are different ($P < .05$).

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

Summary of Results – Experiment 1

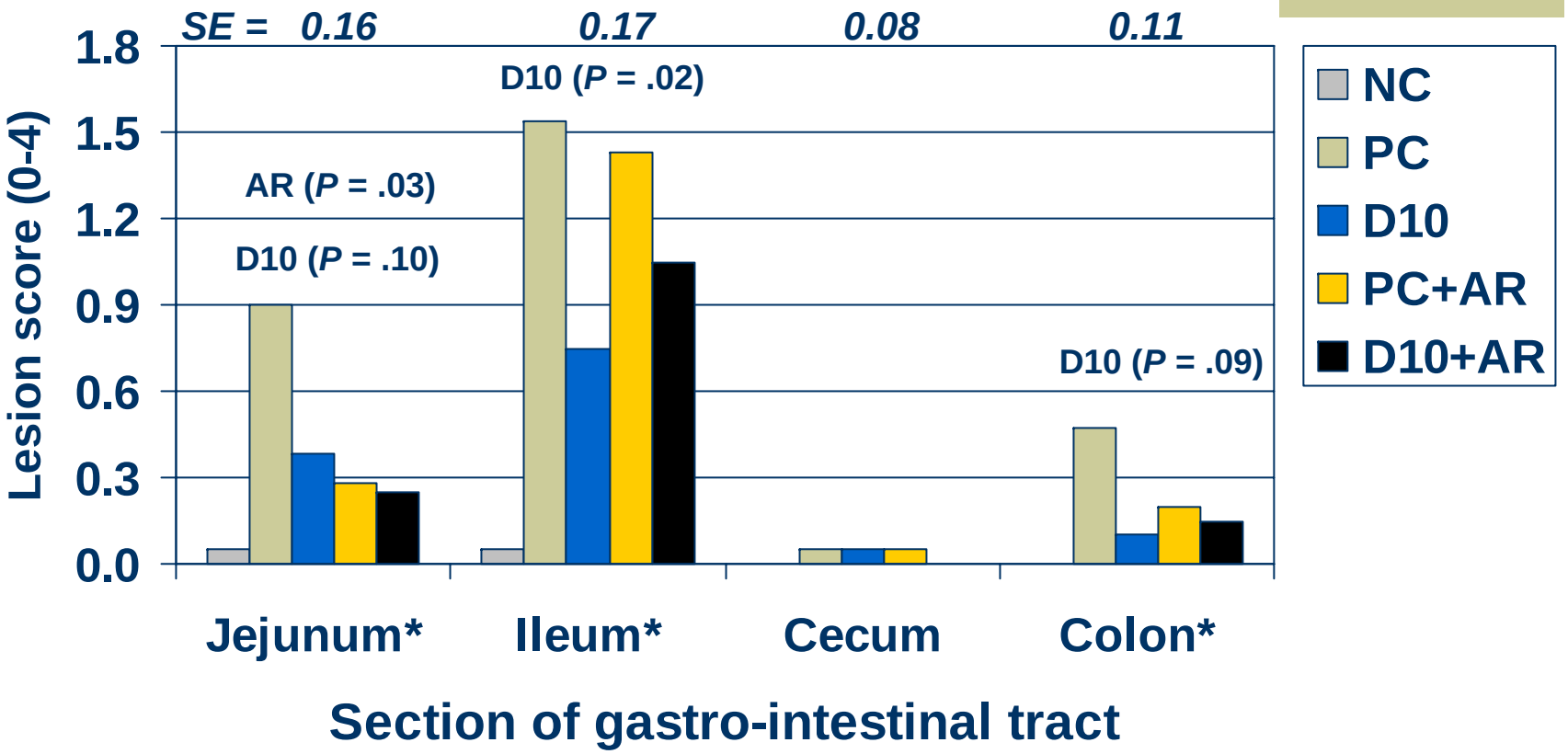
- DDGS inclusion did not improve the pig's ability to resist an ileitis challenge
- Dosage (inoculation) rate was higher than desired
  - Actual: 1.56×10^9 dose of *L. intracellularis*
  - Goal: 1×10^8 dose of *L. intracellularis*

Effect of Dietary Treatment on Lesion Length (21 d Post-Challenge) Experiment 2



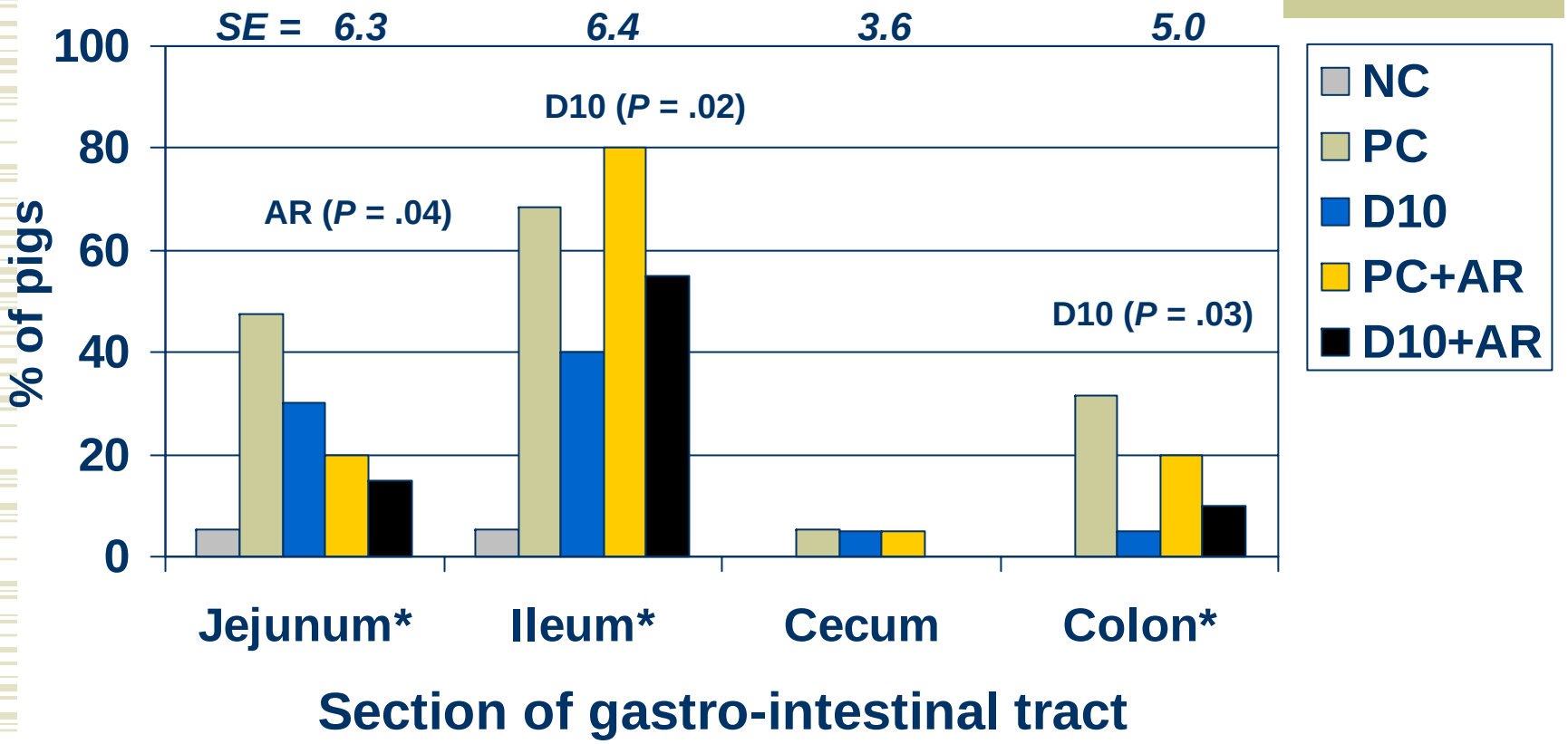
* Effect of disease challenge ($P < .01$).

Effect of Dietary Treatment on Lesion Severity (21 d Post-Challenge) Experiment 2



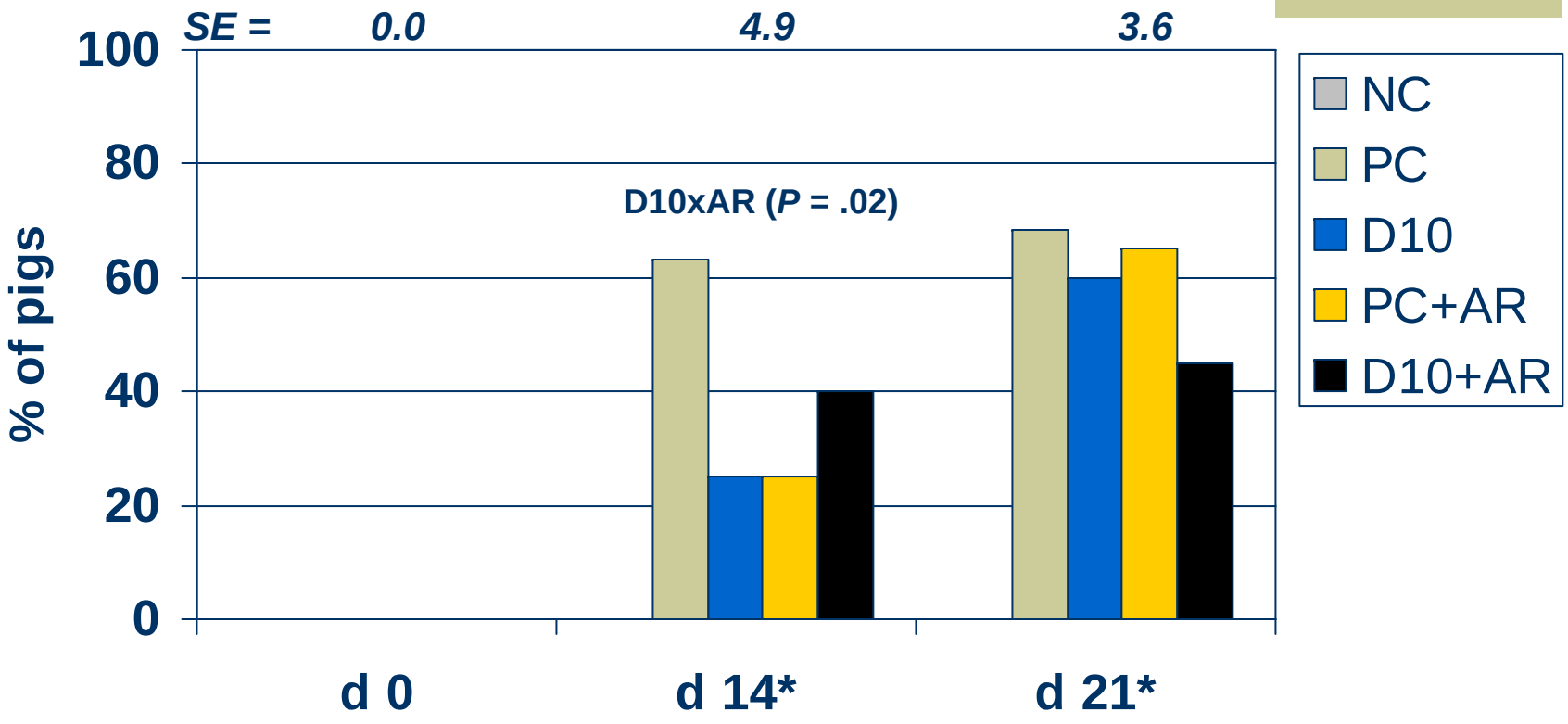
* Effect of disease challenge ($P < .01$).

Effect of Dietary Treatment on Lesion Prevalence (21 d Post-Challenge) Experiment 2



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

Effect of Dietary Treatment on Fecal Shedding (PCR Analysis) Experiment 2



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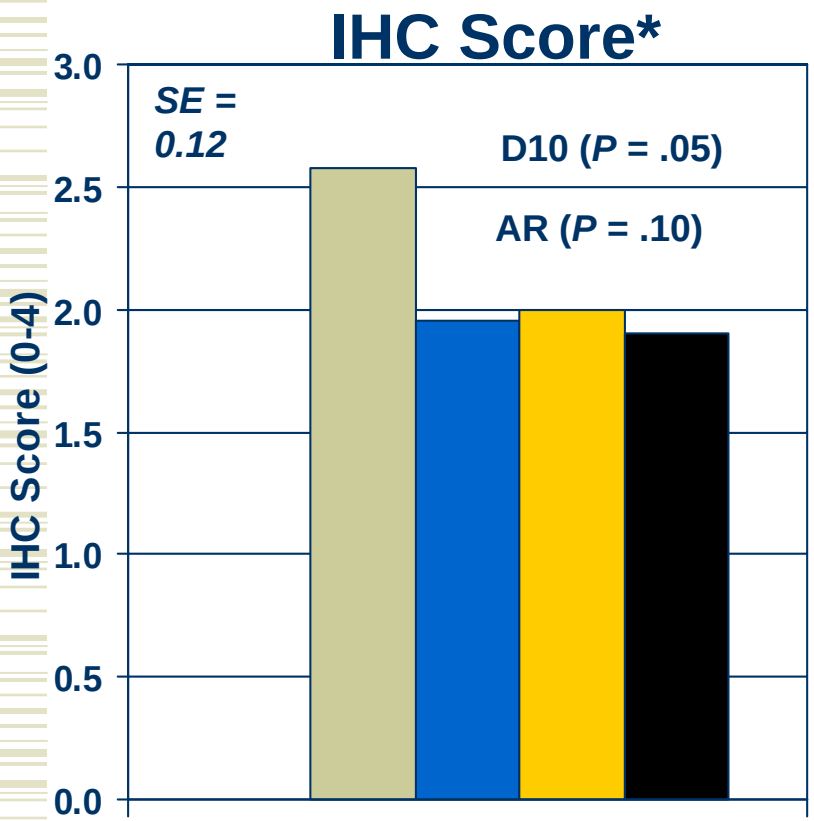
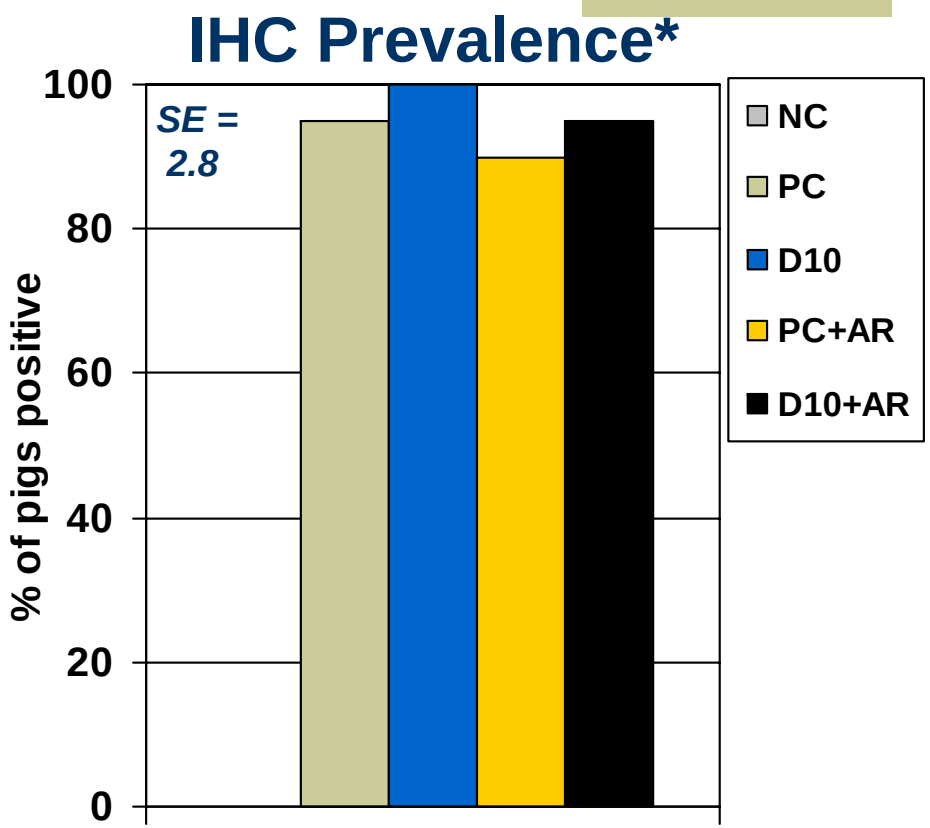
Effect of Treatment on *L. intracellularis* Infection (IHC Analysis) Experiment 2





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

Summary of Results, Experiment 2

- Inoculation level was closer to goal
- 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

U of M DDGS Web Site
www.ddgs.umn.edu

We have developed a DDGS web site featuring:

* research summaries
    - swine, poultry, dairy, & beef
    - DDGS quality
* presentations given
* links to other DDGS related web sites
* international audiences