

## Distiller's Dried Grains with Solubles – Redefined for Swine

Dr. Jerry Shurson  
 Department of Animal Science  
 University of Minnesota

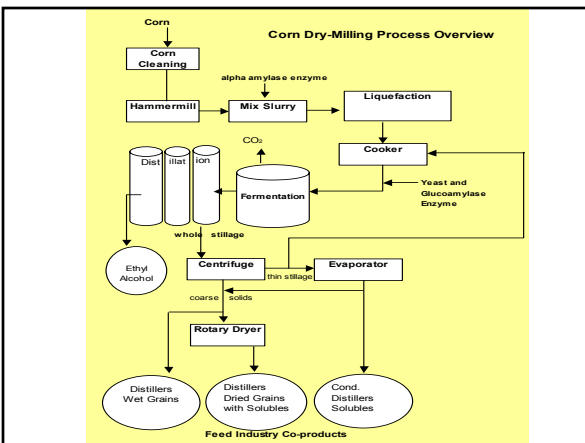
## What is DDGS?

- ◆ 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)



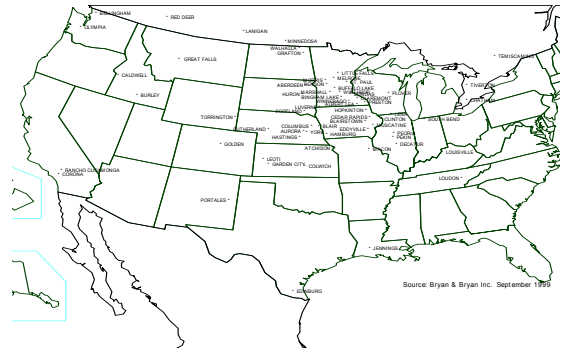
## Dry-Milling Average Ethanol Yield Per Bushel (25.4 kg) of Corn



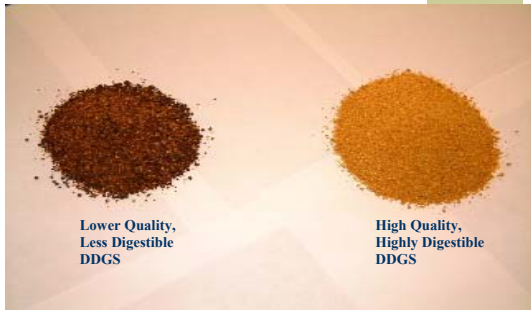
- ♦ Ethanol 2.7 gallons (10.2 liters)
- ♦ DDGS 18 lbs (8.2 kg)
- ♦ CO<sub>2</sub> 18 lbs (8.2 kg)

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

## Map of U.S. Ethanol Plants



## “New Generation” vs. “Old Generation” DDGS



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

|             | “New” DDGS<br>Calculated   | “New” DDGS<br>Trial avg.   | “Old” DDGS<br>Calculated | DDGS<br>NRC<br>(1998) |
|-------------|----------------------------|----------------------------|--------------------------|-----------------------|
| DE, kcal/lb | 1582<br>Range<br>1550-1604 | 1600<br>Range<br>1349-1853 | 1546                     | 1564                  |
| ME, kcal/lb | 1434<br>Range<br>1400-1458 | 1527<br>Range<br>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<br>(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<br>(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<br>Range<br>0.62-0.87 | 0.79       | 0.73            | 0.25            |
| P Availability, % | 90<br>Range<br>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)

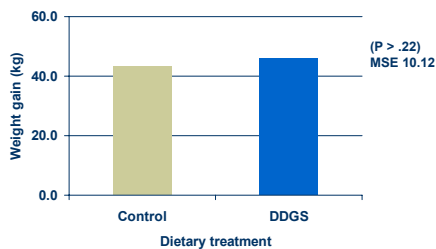
- ♦ Nursery pigs (> 7 kg)
  - Up to 25 %
- ♦ Grow-finish pigs
  - Up to 20% (higher levels may reduce pork fat quality)
- ♦ Gestating sows
  - Up to 50%
- ♦ Lactating sows
  - Up to 20%

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

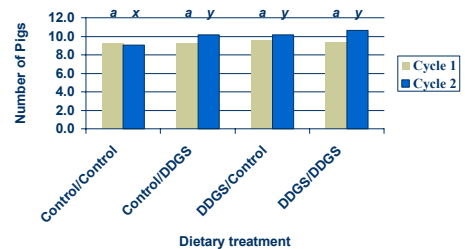
### Feeding "New Generation DDGS to Sows"



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

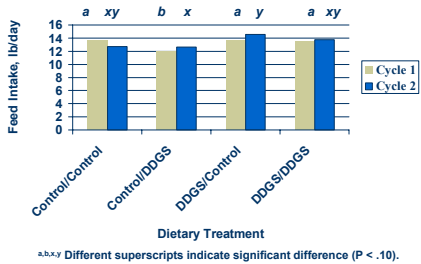


### Effect of Feeding 0 or 50% DDGS Gestation Diets and 0 or 20% DDGS Lactation Diets on Pigs Weaned/Litter



<sup>a,x,y</sup> Different superscripts indicate significant difference (P < .10).

## Effect of Dietary Treatment Combination on Sow Lactation ADFI



Abbrev Different superscripts indicate significant difference ( $P < .10$ ).

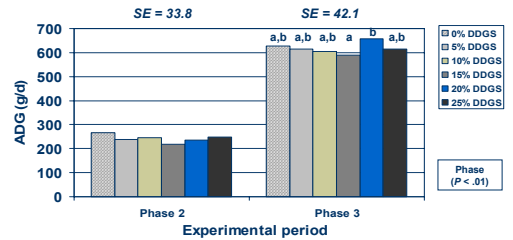
## Feeding "New Generation" DDGS to Weaned Pigs



## Materials and Methods – Nursery Experiments

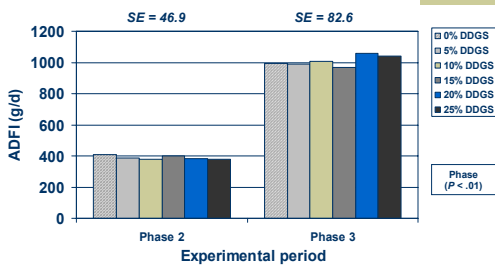
- Experiment 1
  - Pigs weaned at  $19.0 \pm 0.3$  d of age
  - Weighed  $7.10 \pm 0.07$  kg
- Experiment 2
  - Pigs weaned at  $16.9 \pm 0.4$  d of age
  - Weighed  $5.26 \pm 0.07$  kg
- Pigs were fed a commercial pelleted diet (d 0 to 3 postweaning)
- Phase II (d 4-17) and Phase III (d 18 – 35) diets 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)

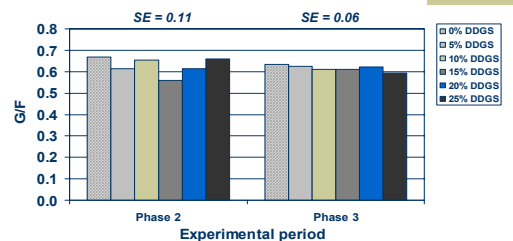


Means not sharing a common superscript letter are significantly different ( $P < .05$ )

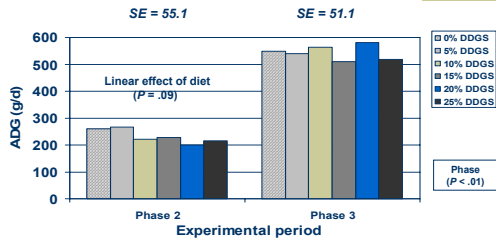
## Effect of DDGS Level on ADFI (Experiment 1)



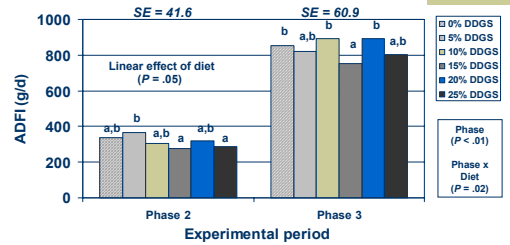
## Effect of DDGS Level on Gain/Feed (Experiment 1)



## Effect of DDGS Level on Growth Rate (Experiment 2)

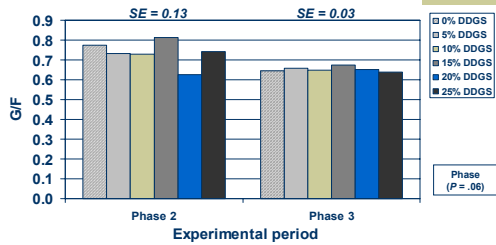


## Effect of DDGS Level on Feed Intake (Experiment 2)

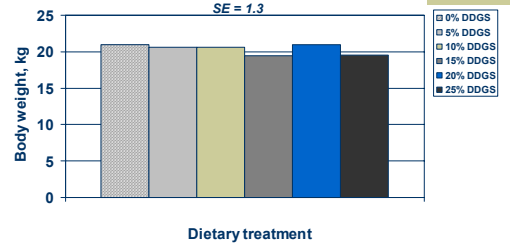


Means not sharing a common superscript letter are significantly different ( $P < .05$ )

## 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 <sup>a</sup> | 3.00 <sup>a,b</sup> | 2.84 <sup>a,b</sup> | 2.71 <sup>b</sup> |
| Belly firmness score, degrees          | 27.3 <sup>a</sup> | 24.4 <sup>a,b</sup> | 25.1 <sup>a,b</sup> | 21.3 <sup>b</sup> |
| Adjusted belly firmness score, degrees | 25.9 <sup>a</sup> | 23.8 <sup>a,b</sup> | 25.4 <sup>a,b</sup> | 22.4 <sup>b</sup> |
| Iodine number                          | 66.8 <sup>a</sup> | 68.6 <sup>b</sup>   | 70.6 <sup>c</sup>   | 72.0 <sup>c</sup> |

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 of 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

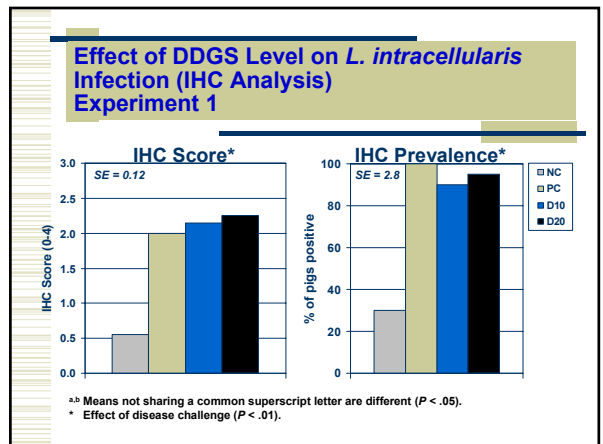
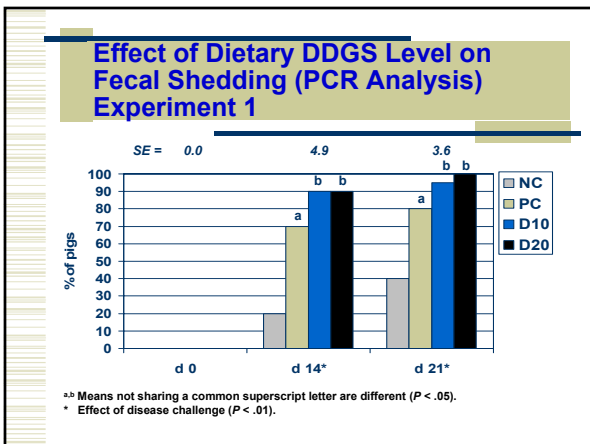
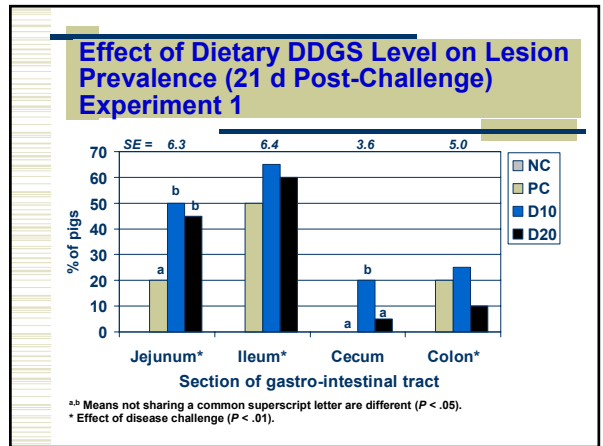
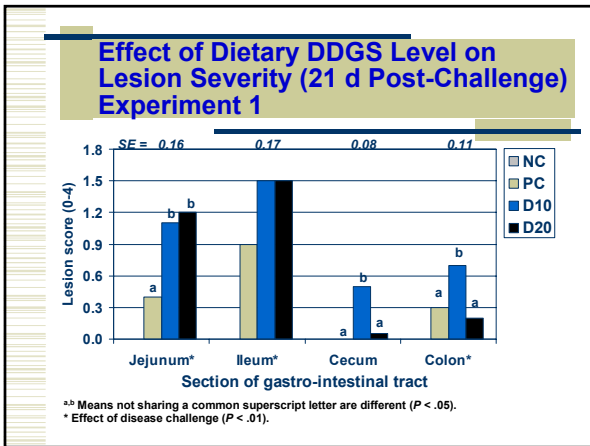
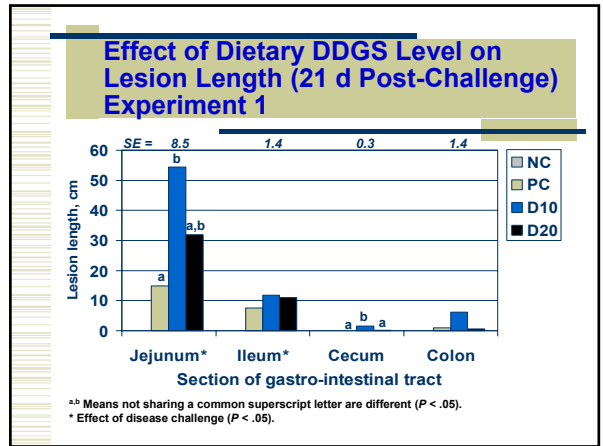
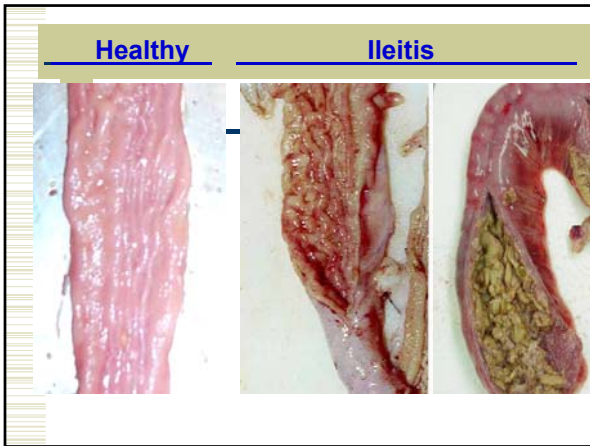
## What is Ileitis?

- ◆ 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



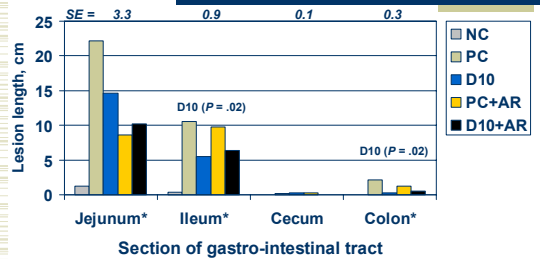




## Summary of Results – Experiment 1

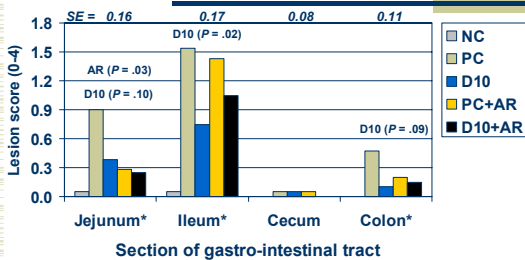
- DDGS inclusion did not improve the pig's ability to resist an ileitis challenge
- Dosage (inoculation) rate was higher than desired
  - Actual:  $1.56 \times 10^9$  dose of *L. intracellularis*
  - Goal:  $1 \times 10^8$  dose of *L. intracellularis*

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



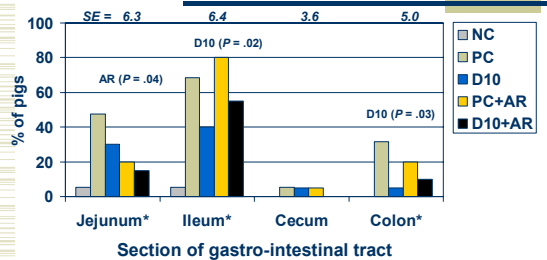
\* Effect of disease challenge ( $P < .01$ ).

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



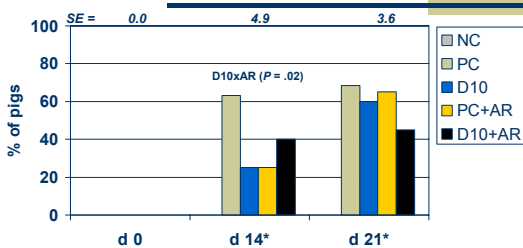
\* Effect of disease challenge ( $P < .01$ ).

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



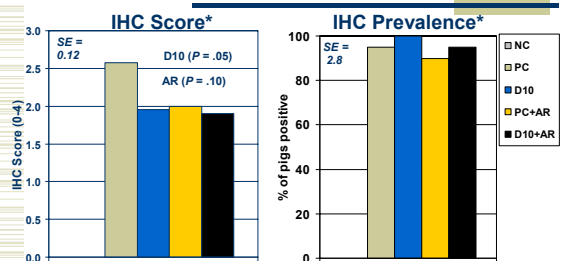
\* Effect of disease challenge ( $P < .01$ ).

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



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

## 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](http://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

