# Distiller's Dried Grains with Solubles in Livestock and Poultry Production Systems

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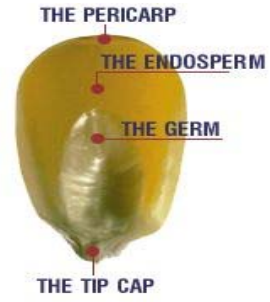
## What is DDGS?

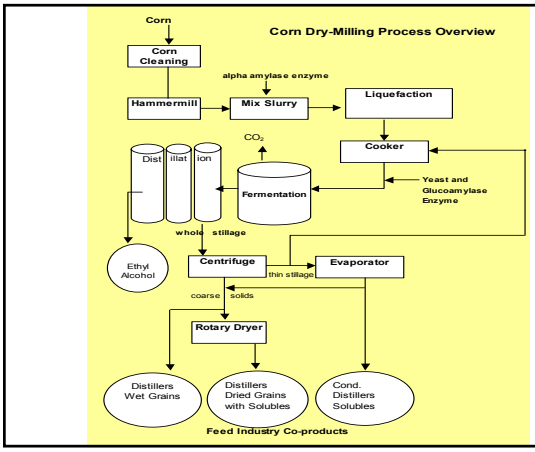
- Co-product of the dry-milling ethanol industry
  - Corn DDGS - Midwestern US
  - Wheat DDGS - Canada
  - Sorghum (milo) DDGS - Great Plains US
  - Barley DDGS
  - Rye DDGS

## Components of Yellow Dent Corn

| | |
|---|---|
| Starch | 61.0 % |
| Corn Oil | 3.8 % |
| Protein | 8.0 % |
| Fiber | 11.2 % |
| Moisture | 16.0 % |




Slide courtesy of Ms. Kelly Davis, CVEC

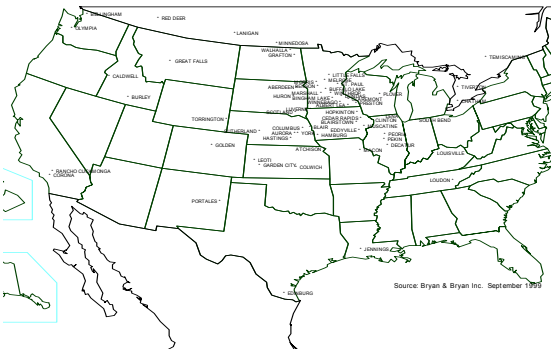



## Dry-Milling Average Yield Per Bushel

- Ethanol 2.7 gallons
- DDGS 18 lbs
- $CO_2$ 18 lbs

Slide courtesy of Ms. Kelly Davis, CVEC

## Map of U.S. Ethanol Plants



## DDGS Quality is Variable

- Color ranges from very light to very dark
- Odor ranges from sweet to smoky or burnt
- Range in concentration in selected nutrients:
  - Dry matter – 87 to 93%
  - Crude protein – 23 to 29%
  - Crude fat – 3 to 12%
  - Ash – 3 to 6%
  - Lysine – 0.59 to 0.89%

Source: Cromwell et al. (1993)

## "New Generation" vs. "Old Generation" DDGS


## DDGS Quality is Variable

- Nutritionists want PREDICTABILITY AND CONSISTENCY in feed ingredients.
- The keys for getting maximum value from DDGS are:

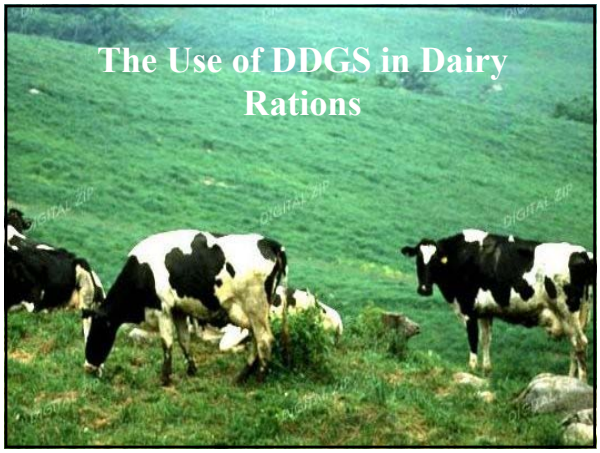
"Know what you have (or want)"

and

"Know how to use it"

## Nutrient Profile of Corn Distiller's Dried Grains with Solubles

| Nutrient | MW DDGS | Low Quality DDGS | NRC (1998) |
|---|---|---|---|
| Dry matter, % | 88.9 | 88.3 | 93.0 |
| Crude protein, % | 30.2 | 28.1 | 29.8 |
| Fat, % | 10.9 | 8.2 | 9.0 |
| Fiber, % | 8.8 | 7.1 | 4.8 |
| Calcium, % | 0.06 | 0.44 | 0.22 |
| Phosphorus, % | 0.89 | 0.90 | 0.83 |
| P availability, % | 90.0 | ? | 79.0 |
| DE, kcal/kg | 3965 | 3874 | 3449 |
| ME, kcal/kg | 3592 | 3521 | 3038 |
| Lys, % | 0.83 | 0.53 | 0.67 |
| App. Dig. Lys, % | 0.44 | 0.00 | |
| Met, % | 0.55 | 0.50 | 0.54 |
| App. Dig. Met, % | 0.32 | 0.24 | |
| Thr, % | 1.13 | 0.98 | 1.01 |
| App. Dig. Met, % | 0.62 | 0.36 | |
| Trp, % | 0.24 | 0.19 | 0.27 |
| App. Dig Trp, % | 0.15 | 0.15 | |

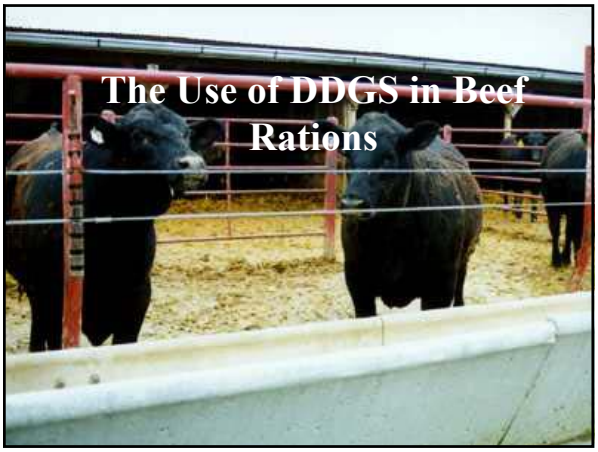



## Nutritional Value of DDGS for Dairy Cows

- Excellent protein source (28% crude protein)
- High in by-pass protein
- High in NDF (44%)
- Very palatable – increases dry matter intake
- Effective partial replacement for corn and soybean meal

## Recommended Feeding Levels of DDGS for Dairy Cows and Replacements

- Lactating dairy cows
  - Up to 30% DMI under normal feeding conditions
  - > 30% DMI if BST is used
- Calves
  - Up to 20 % DMI
- Replacement heifers
  - Up to 25% DMI




## Nutritional Value of DDGS for Beef Cattle

- Excellent protein source (28% crude protein)
- High by-pass protein
- Excellent source of essential minerals (P and K)
- Improves rumen health
- Very palatable
- 1.8 times more value compared to soybean meal

## Recommended Feeding Levels of DDGS for Beef Cattle

- Creep feeding
  - Up to 20%
- Feedlot cattle
  - Up to 40 % DMI
- Receiving/starting cattle
  - Up to 20%
- Brood cows
  - Up to 35% of supplement

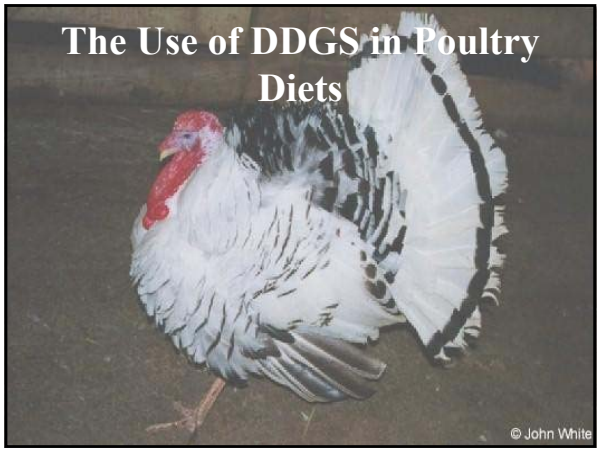
## Considerations for Selecting DDGS Sources for Swine and Poultry

- Must be golden color
  - Golden DDGS has higher amino acid digestibility
- Produced by new Midwestern plants
  - Higher nutrient content and digestibility than DDGS from older plants

## Quality Considerations for Selecting DDGS Sources for Swine and Poultry

- Nutrient Specifications
  - Moisture – maximum 12%
  - Protein – minimum 27%
  - Fat – minimum 10%
  - Fiber – maximum 7.5%

# The Use of DDGS in Poultry Diets




## Nutritional Value of DDGS for Poultry

- Must use high quality DDGS
  - Light color = high amino acid digestibility
- Excellent energy and available phosphorus source
- Nutritional value higher than previously thought
- Unidentified growth factors?
  - 5% DDGS resulted in 17-32% improvement in gain
  - 3% DDGS in turkey breeder hen diets increased egg numbers and hatch
- Effective partial replacement for corn and soybean meal

## Nutrient Content of Corn DDGS for Poultry (5 Sources)

| Nutrient | Range | Average | NRC, 1994 |
|---|---|---|---|
| Protein, % | 25.5 - 30.7 | 27.5 | 27.4 |
| Fat, % | 8.9 - 11.4 | 10.0 | 9.0 |
| Fiber, % | 5.4 - 6.5 | 5.7 | 9.1 |
| Ca, % | 0.02 - 0.05 | 0.05 | 0.17 |
| P, % | 0.62 – 0.78 | 0.73 | 0.72 |
| Na, % | 0.05 – 0.17 | 0.11 | 0.48 |
| Cl, % | 0.13 – 0.19 | 0.17 | 0.17 |
| K, % | 0.79 – 1.05 | 0.95 | 0.65 |
| TME (kcal/kg) | 2650 – 3082 | 2850 | 3097 |
| AME (kcal/kg) | 2090 – 2418 | 2260 | 2480 |

Source: Noll and Parsons. 2003. Unpublished data.

## Amino Acid Content of Corn DDGS (5 Sources)

| Amino acid | Range | Average | NRC, 1994 |
|---|---|---|---|
| Methionine, % | 0.44 – 0.56 | 0.49 | 0.60 |
| Cystine, % | 0.45 – 0.60 | 0.52 | 0.40 |
| Lysine, % | 0.64 – 0.83 | 0.74 | 0.75 |
| Arginine, % | 1.02 – 1.23 | 1.08 | 0.98 |
| Tryptophan, % | 0.19 – 0.23 | 0.22 | 0.19 |
| Threonine, % | 0.94 – 1.05 | 0.98 | 0.92 |

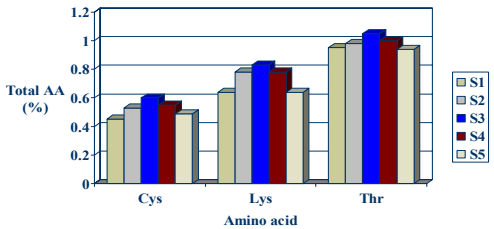
Source: Noll and Parsons. 2003. Unpublished data.

## True Digestible Amino Acid Levels of Corn DDGS for Poultry (5 Sources)

| Amino acid | True Dig. Amino Acid, % | Average | Digestibility Coefficient, % | Average |
|---|---|---|---|---|
| Methionine | 0.35 – 0.53 | 0.43 | 86 - 90 | 88 |
| Cystine | 0.28 – 0.57 | 0.40 | 66 - 85 | 76 |
| Lysine | 0.37 – 0.74 | 0.53 | 59 - 83 | 71 |
| Arginine | 0.73 – 1.18 | 0.93 | 80 - 90 | 86 |
| Tryptophan | 0.14 – 0.21 | 0.18 | 76 - 87 | 82 |
| Threonine | 0.61 – 0.92 | 0.74 | 67 - 81 | 75 |

Source: Noll and Parsons. 2003. Unpublished data.

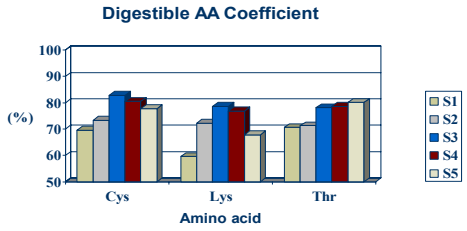
## Total Amino Acid Content as Affected by Production Source



## Correlation Between DDGS Color and Amino Acid Digestibility ($r^2$)

| | | | |
|---|---|---|---|
| Amino acid | L* | a* | b* |
| Lys | .67 | NS | .77 |
| Cys | .67 | NS | .74 |
| Thr | .51 | NS | .58 |

## Effect of DDGS Source on True Amino Acid Digestibility for Poultry




## Recommended Inclusion Rates of DDGS for Poultry

- Broilers and Turkeys
  - 5-10% inclusion rates (Starter/Finisher)
    - Without energy adjustments
  - > 10%
    - With adjustments for lys, met, thr, trp, and energy
- Chicken Egg Layers
  - 10% inclusion rate

## Summary of Corn DDGS Source Characteristics for Poultry

- Nutrient profile is consistent within source
- Na, P, K, S are most variable among minerals
- Higher protein and fat content than NRC, 1994
- High amino acid digestibility
- DDGS with high lysine content tended to have high amino acid digestibility
- DDGS color is a fairly reliable predictor of amino acid digestibility

## The Use of DDGS in Swine Diets

## 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?

## Comparison of Energy Values of DDGS for Swine (88% DM Basis)

| | "New" DDGS Calculated | "New" DDGS Trial avg. | "Old" DDGS Calculated | DDGS NRC (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 (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 for Swine (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 for Swine (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 |

## 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

## Calculating the Value of DDGS in Swine Diets Using Soybean Meal 44%

**Additions/1000 kg diet**

| | | | |
|---|---|---|---|
| + 100 kg DDGS | x | cost/kg | = $ |
| + 1.5 kg limestone | x | cost/kg | = $ |
| **TOTAL ADDITIONS (A)** | | | **= $** |

**Subtractions/1000 kg diet**

| | | | |
|---|---|---|---|
| - 88.5 kg corn | x | cost/kg | = $ |
| - 10 kg SBM (44%) | x | cost/kg | = $ |
| - 3 kg dicalcium phosphate | x | cost/kg | = $ |
| **TOTAL SUBTRACTIONS (S)** | | | **= $** |

**S - A = Opportunity cost for DDGS/100 kg**

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

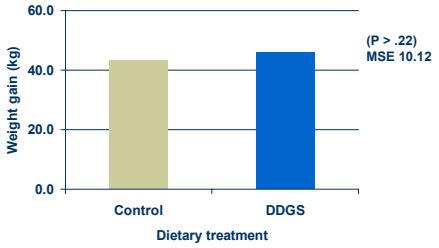
(Based Upon University of Minnesota Performance Trials)

- 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%

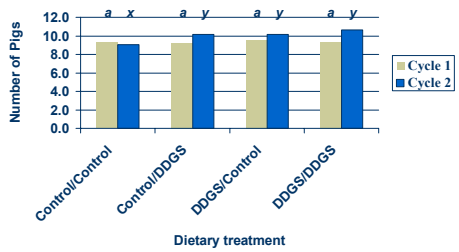
Assumptions: no mycotoxins
formulate on a digestible amino acid and available phosphorus basis

## Feeding "New Generation DDGS to Sows"

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

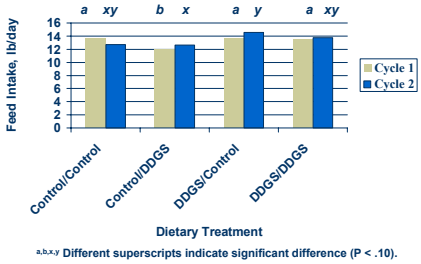


## Effect of Feeding 0 or 50% DDGS Gestation Diets and 0 or 20% DDGS Lactation Diets on Pigs Weaned/Litter




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

## Effect of Dietary Treatment Combination on Sow Lactation ADFI



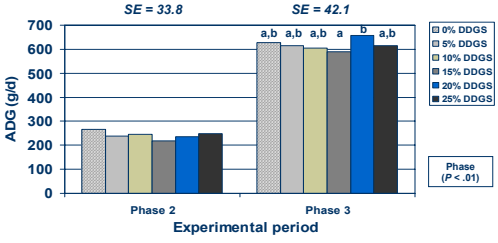

a,b,x,y Different superscripts indicate significant difference (P < .10).

## Feeding "New Generation" DDGS to Weaned Pigs

## Materials and Methods – Nursery Experiments

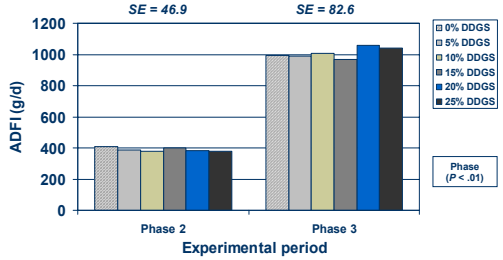
- Experiment 1
  - Pigs weaned at 19.0 ± 0.3 d of age
  - Weighed 7.10 ± 0.07 kg
- Experiment 2
  - Pigs weaned at 16.9 ± 0.4 d of age
  - Weighed 5.26 ± 0.07 kg
- Pigs were fed a commercial pelleted diet (d 0 to 3 postweaning)
- Phase II (d 4-17) and Phase III (d 18 – 35) diets were formulated on a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

## Effect of DDGS Level on Growth Rate (Experiment 1)

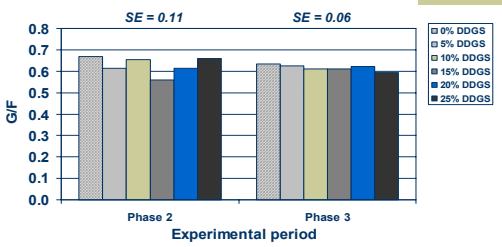



Means not sharing a common superscript letter are significantly different (P < .05)

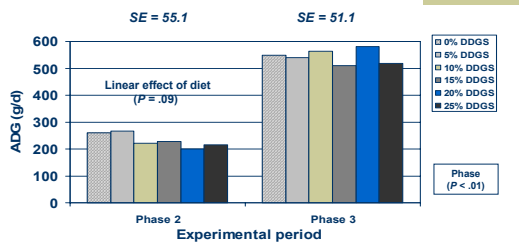
## Effect of DDGS Level on ADFI (Experiment 1)



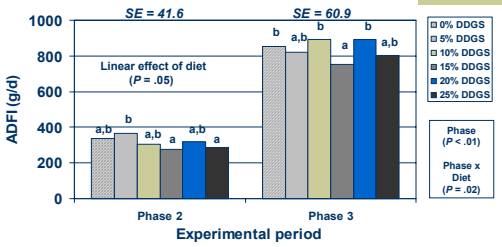
## Effect of DDGS Level on Gain/Feed (Experiment 1)




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

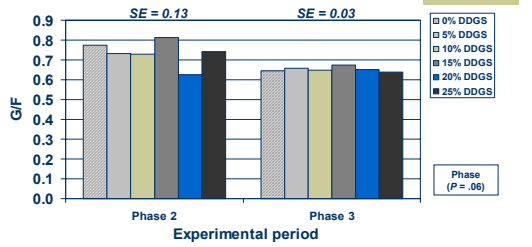



## Effect of DDGS Level on Feed Intake (Experiment 2)

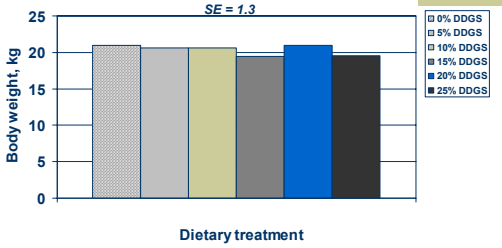



Means not sharing a common superscript letter are significantly different ($P < .05$)

## 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[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).

## 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

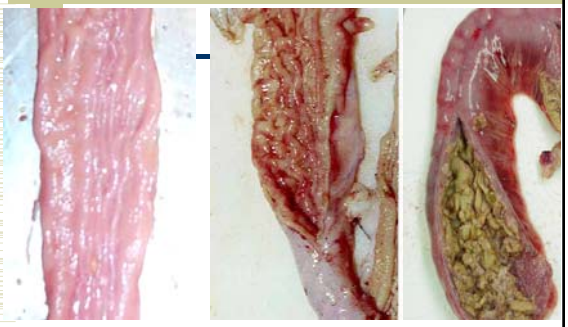
## What is Ileitis?

- 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

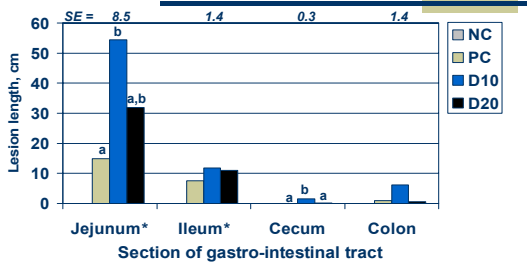
# Clinical Forms of Ileitis

- 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

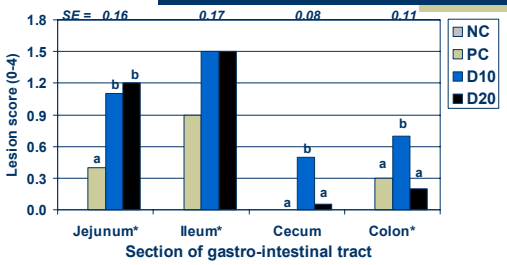


## Effect of Dietary DDGS Level on Lesion Length (21 d Post-Challenge) Experiment 1



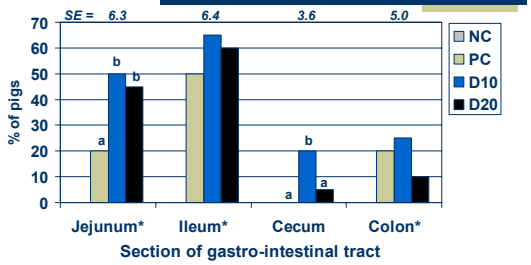

[a,b] Means not sharing a common superscript letter are different ($P < .05$).
* Effect of disease challenge ($P < .05$).

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



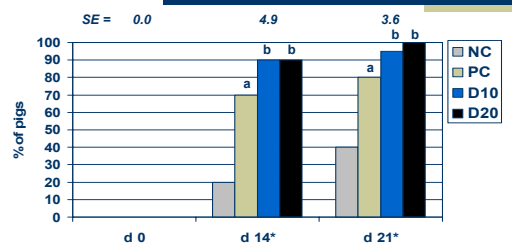

[a,b] Means not sharing a common superscript letter are different ($P < .05$).
* Effect of disease challenge ($P < .01$).

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



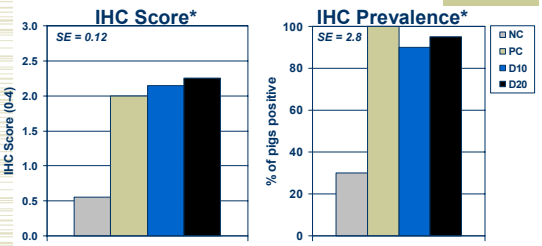

[a,b] Means not sharing a common superscript letter are different ($P < .05$).
* Effect of disease challenge ($P < .01$).

## Effect of Dietary DDGS Level on 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

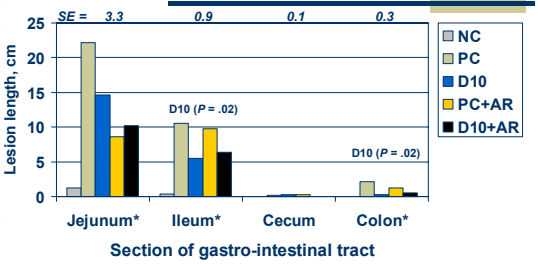



[a,b] Means not sharing a common superscript letter are different ($P < .05$).
* Effect of disease challenge ($P < .01$).

## Summary of Results – Experiment 1

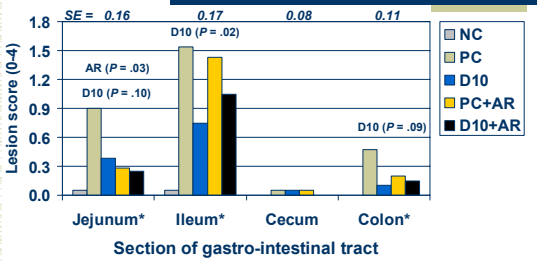
- DDGS inclusion did not improve the pig's ability to resist an ileitis challenge
- Dosage (inoculation) rate was higher than desired
  - Actual: 1.56 x $10^9$ dose of *L. intracellularis*
  - Goal: 1 x $10^8$ dose of *L. intracellularis*

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



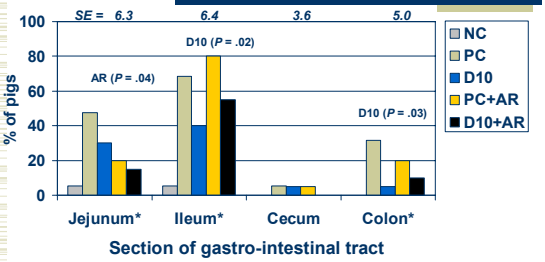

* Effect of disease challenge ($P < .01$).

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



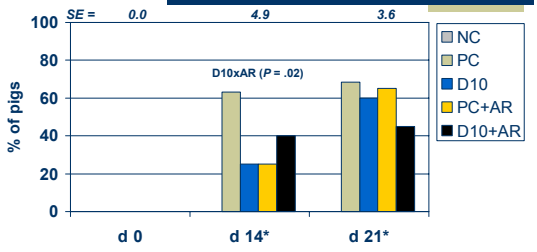

* Effect of disease challenge ($P < .01$).

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



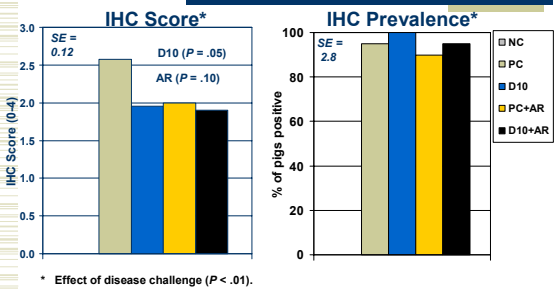

* Effect of disease challenge ($P < .01$).

## 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

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