The Feeding Value of "New Generation" DDGS for Swine

Dr. Jerry Shurson

Department of Animal Science

University of Minnesota

Overview

- DDGS vs other grain co-products
- Nutrient content, digestibility, and variability
- Physical characteristics
- Feeding advantages
- Feeding limitations
- Diet formulation and inclusion rates
- DDGS and gut health

Comparison of Nutrient Composition (Dry Matter Basis) of "New Generation" DDGS to Corn Gluten Feed, Corn Gluten Meal, Corn Germ Meal, and Brewer's Dried Grains

	"New" DDGS (UM)	Corn Gluten Feed (NRC)	Corn Gluten Meal (NRC)	Corn Germ Meal (Feedstuffs)	Brewer's Dried Grains (NRC)
Protein, %	30.6	23.9	66.9	22.2	28.8
Fat, %	***10.7***	3.3	3.2	1.1	7.9
NDF, %	43.6	37.0	9.7	No data	52.9
DE, kcal / kg	***4011***	3322	4694	No data	2283
ME, kcal / kg	***3827***	2894	4256	3222	2130
Lys, %	0.83	0.70	1.13	1.00	1.17
Met, %	0.55	0.39	1.59	0.67	0.49
Thr, %	1.13	0.82	2.31	1.22	1.03
Trp, %	0.24	0.08	0.34	0.22	0.28
Ca, %	0.06	0.24	0.06	0.33	0.35
Available P, %	***0.80***	0.54	0.08	0.17	0.21

DE and ME Content of "New Generation" DDGS

- Determined calculated DE and ME values based upon the following equations:
  - DE kcal/kg = [((%CP x 4) + (%NFE x 4) + (%Fat x 9)) x 4.54] x 2.205
  - ME kcal/kg = [DE x ((0.96 – ((0.2 x %CP)/100))] x 2.205
- DE kcal/kg = 3965 (CV=2.2%)
  - Range 3883 to 4020 kcal/kg
- ME kcal/kg = 3592 (CV=2.4%)
  - Range 3510 to 3654 kcal/kg

DE and ME Content of "New Generation" DDGS

- Conducted two trials at the University of Minnesota utilizing grow-finish pigs
  - Trial 1 (dry matter basis)
    - CV's range from 10 to 14%
    - DE = 4642 kcal/kg (Range 3937 to 5862 kcal/kg)
    - ME = 4449 kcal/kg (Range 3794 to 5827 kcal/kg)
  - Trial 2 (dry matter basis)
    - CV's ranged from 17 to 25%
    - DE = 3380 kcal/kg (Range 2830 to 4090 kcal/kg)
    - ME = 3205 kcal/kg (Range 2551 to 3945 kcal/kg)
  - Overall (dry matter basis)
    - **DE = 4011 kcal/kg**
    - **ME = 3827 kcal/kg**

Comparison of Energy Values for DDGS (Dry Matter Basis)

	"New" DDGS Calculated	"New" DDGS Trial avg.	"Old" DDGS Calculated	DDGS NRC (1998)
DE, kcal/kg	3965	4011	3874	3449
ME, kcal/kg	3592	3827	3521	3038

Corn: DE (kcal/kg) = 3961, ME (kcal/kg) = 3843
(NRC, 1998)

Amino Acid Content of “New Generation” DDGS

- Sampled 10 plants over a two-year sampling period (1997-99)
- Conducted a trial to determine apparent ileal digestibility of amino acids in “new generation” DDGS and “old generation” DDGS

Comparison of Amino Acid Composition of DDGS

(Dry Matter Basis)

	"New" DDGS	"Old" DDGS	DDGS (NRC, 1998)
Lysine, %	0.85 (17.3)	0.53 (26.5)	0.67
Methionine, %	0.55 (13.6)	0.50 (4.5)	0.54
Threonine, %	1.13 (6.4)	0.98 (7.3)	1.01
Tryptophan, %	0.25 (6.7)	0.19 (19.8)	0.27
Valine, %	1.50 (7.2)	1.39 (2.3)	1.40
Arginine, %	1.20 (9.1)	0.92 (18.7)	1.22
Histidine, %	0.76 (7.8)	0.61 (15.2)	0.74
Leucine, %	3.55 (6.4)	2.97 (12.4)	2.76
Isoleucine, %	1.12 (8.7)	1.00 (9.1)	1.11
Phenylalanine, %	1.47 (6.6)	1.27 (8.1)	1.44

Values in ( ) are CV's among plants

Comparison of Apparent Ileal Digestible Amino Acid Composition of DDGS (Dry Matter Basis)

	"New" DDGS	"Old" DDGS	DDGS (NRC, 1998)
Lysine, %	0.44	0.00	0.31
Methionine, %	0.32	0.24	0.39
Threonine, %	0.62	0.36	0.56
Tryptophan, %	0.15	0.15	0.14
Valine, %	0.92	0.51	0.88
Arginine, %	0.90	0.60	0.88
Histidine, %	0.51	0.30	0.45
Leucine, %	2.57	1.84	2.10
Isoleucine, %	0.72	0.42	0.73
Phenylalanine, %	0.89	0.68	1.09

Use of NIR to Determine Amino Acid and Energy Content of DDGS

- Collaborative study
  - Dr. Joe Hahn, Hubbard Milling, Mankato, MN
  - Dr. Theo van Kempen, North Carolina State University
  - Dr. Jerry Shurson, University of Minnesota
- 103 DDGS samples from 9 plants were ground using a Retsch grinder through a 0.5 mm screen
- Gross energy was determined by bomb calorimetry
- Chemical analysis of amino acids of samples previously determined at the University of Missouri
- Ground samples analyzed with an NIR Systems model 6500 spectrophotometer suing a half-sized rectangular cup
- Scans were obtained from 400 to 2500 nm
- Calibrations were developed using a partial least squares regressions with cross validation

NIR Calibrations for DDGS

Nutrient	R	Rmsep, %	R^2	CV, %
Lysine	0.89	0.064	.79	16.2
Methionine	0.81	0.044	.66	14.2
Threonine	0.73	0.046	.53	6.2
Energy	0.87	37	.76	1.9

R = correlation between actual and predicted values
Rmsep = prediction error
R^2 = proportion of the total variation explained by calibrations
CV, % = coefficient of variation among DDGS samples

Comparison of Phosphorus Level and Relative Availability of DDGS
(Dry Matter Basis)

	"New" DDGS	"Old" DDGS	DDGS NRC (1998)	Corn NRC (1998)
Total P, %	0.89 (11.7)	0.90	0.83	0.28
P Availability, %	90	No data	77	14
Available P, %	0.80	No data	0.64	0.04

Value in ( ) is coefficient of variation (%) among "new generation" plants.

Summary of Nutrient Content and Digestibility of "New Generation" DDGS

- Energy value
  - appears to be equal to corn
  - higher than "old generation" DDGS
  - higher than values in NRC (1998)
- Amino acid content and digestibility
  - higher than "old generation" DDGS
    - especially lysine
  - higher than NRC (1998)
- Available phosphorus
  - higher than NRC (1998)
  - significantly greater than corn (20x)

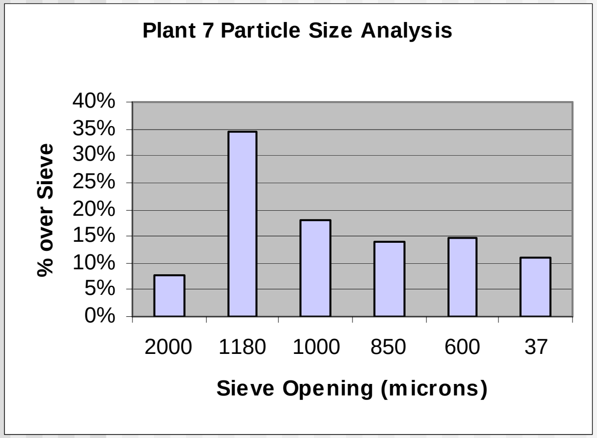
Physical Characteristics of "New Generation" DDGS

- Particle size
- Bulk density
- Color
- Smell

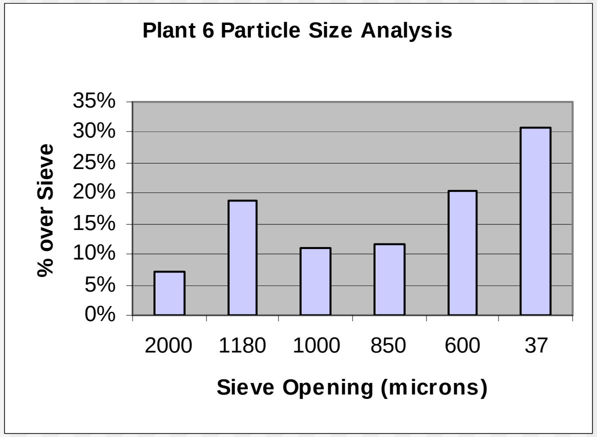
DDGS Particle Size

- DDGS samples obtained from 16 “new generation” plants
  - Average particle size = 1282 microns
  - Standard deviation = 305 microns
  - Coefficient of variation among plants = 24%
  - Range in average particle size among plants - 612 to 2125 microns

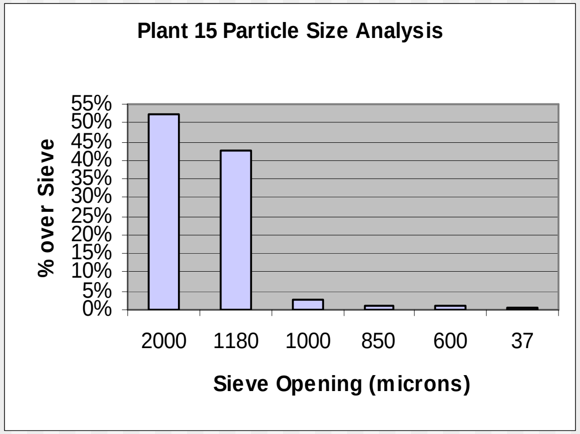
Examples of Particle Size Distribution of "New Generation" DDGS



Typical



Lowest Avg. Particle Size



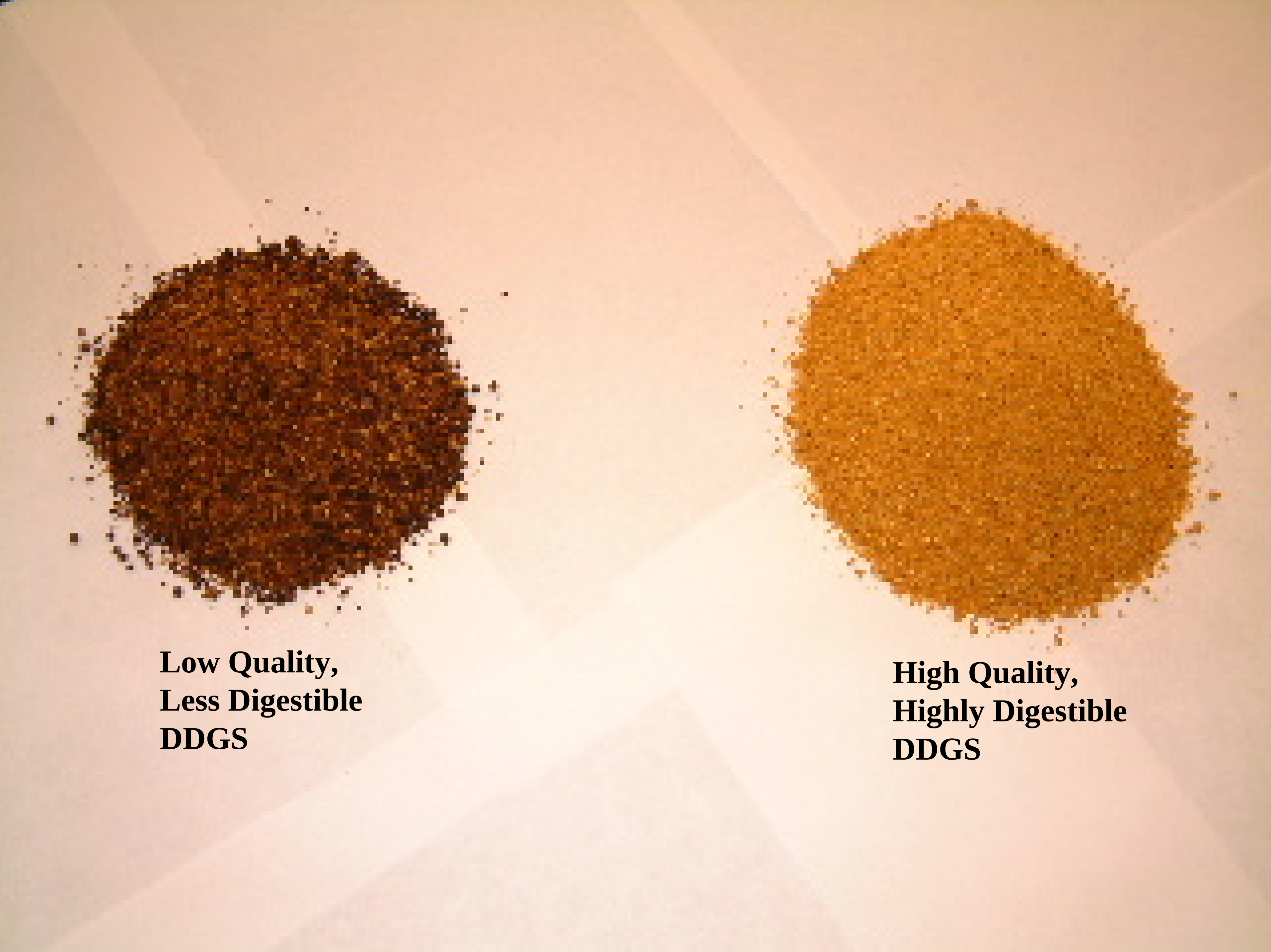
Highest Avg. Particle Size

Bulk Density of "New Generation" DDGS

- DDGS samples from 16 "New Generation" plants
  - Avg. bulk density = 35.7 lbs/cubic ft.
  - Std. deviation among plants = 2.79 lbs/cubic ft.
  - Coefficient of variation among plants = 7.8%
  - Range in bulk density among plants:
    - 30.8 to 39.3 lbs/cubic ft.

DDGS Color and Smell

- Color varies among sources
  - ranges from dark to golden (Cromwell et al., 1993)
  - “new generation” DDGS is more golden and color is less variable
  - golden color is correlated with higher amino acid digestibility in swine and poultry
- Smell varies among sources
  - ranges from burnt or smoky to sweet and fermented (Cromwell et al., 1993)
  - “new generation” DDGS has a sweet, fermented smell
  - smell may affect palatability


Low Quality,
Less Digestible
DDGS
High Quality,
Highly Digestible
DDGS

The Use of DDGS in Swine Diets

Positive Attributes of Using "New Generation" DDGS in Swine Diets

- Cost effective partial replacement for corn, soybean meal, and dicalcium phosphorus
  - High energy
    - similar to energy value of corn
  - High available phosphorus
    - reduce need for dicalcium phosphorus supplementation
    - reduce P excretion in manure
  - Higher amino acid digestibility than other DDGS sources
    - golden color "New Generation" DDGS has improved amino acid digestibility
- May improve gut health (i.e. ileitis, gut edema)
  - May decrease mortality and improve growth performance

Negative Attributes of Using “New Generation” DDGS in Swine Diets

- Poor amino acid profile relative to pig’s amino acid requirements
  - same problem with corn grain
- High crude protein content
  - increases N excretion in manure
- High fiber content
  - should not be used in diets for young pigs (< 15 lbs)
  - high DDGS inclusion rates (50% in gestation and 20% lactation) and abrupt change from corn-soybean meal diets will temporarily (5 to 7 days) reduce sow feed intake

Negative Attributes of Using “New Generation” DDGS in Swine Diets

- High oil content
  - limits use to < 20% in grow-finish diets due to reduced pork fat quality
    - belly firmness
    - softer fat - increased unsaturated fatty acids
- Mycotoxin contaminated corn
  - DDGS mycotoxin concentrations 2 to 3x more concentrated
  - risk may limit maximum inclusion rates in gestation and lactation diets
  - minimal risk for corn produced in northern “Corn Belt”

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

(Based Upon University of Minnesota Performance Trials)

- Nursery pigs (>15 lbs)
  - Up to 25 %
- Grow-finish pigs
  - Up to 20% (higher levels reduce pork fat quality)
- Gestating sows
  - Up to 50%
- Lactating sows
  - Up to 20%

Assumptions:

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

Example Swine Grower Diet Containing 20% "New Generation" DDGS

Ingredient	%	Nutrient Composition	
Corn	60.05	Crude protein, %	19.07
DDGS	20.00	App. Dig. Lysine, %	0.74
Soybean meal, 46%	17.70	App. Dig. M + C, %	0.51
Dicalcium phosphate	0.60	App. Dig. Thr., %	0.48
Limestone	1.05	App. Dig. Trp, %	0.15
Salt	0.30	ME, kcal/kg	3309
Vitamin-TM premix	0.15	Ca, %	0.60
L-lysine HCl	0.15	P, %	0.53
Total	100.00	Avail. P, %	0.30

Example Swine Grower Diet Containing 20% “New Generation” DDGS and 100 FTU/kg Phytase

Ingredient	**%**
Corn	60.70
DDGS	20.00
Soybean meal, 46%	17.65
Dicalcium phosphate	0.05
Limestone	0.95
Salt	0.30
Vitamin-TM premix	0.15
L-lysine HCl	0.15
Phytase - 1000	0.05
Total	100.00

Nutrient Composition	
Crude protein, %	19.10
App. Dig. Lysine, %	0.74
App. Dig. M + C, %	0.51
App. Dig. Thr., %	0.48
App. Dig. Trp, %	0.15
ME, kcal/kg	3330
Ca, %	0.44
P, %	0.43
Avail. P, %	0.20

Calculating the Value of "New Generation" 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

Calculating the Value of “New Generation” DDGS in Swine Diets Using Soybean Meal 46%

Additions/1000 kg diet

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

Subtractions/1000 kg diet

- 89 kg corn	x	cost/kg	= $
- 9.5 kg **SBM (46%)**	x	cost/kg	= $
- 3 kg dicalcium phosphate	x	cost/kg	= $
TOTAL SUBTRACTIONS (S)			**= $**

S - A = Opportunity cost for DDGS/100 kg

Other Benefits of Feeding DDGS?

- Manure management
  - decreases P excretion in manure
  - increases N excretion in manure
    - minimized by using synthetic amino acids
  - no effect on reducing NH_3, H_2S, or odor emissions
- Improved gut health (e.g. ileitis)

What is 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 animal species
    - rabbits, deer, horses, ostrich, hamsters (Cooper et al., 1997)

What is Ileitis?

- *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
  - Can survive in the environment for at least 1 to 2 weeks at temperatures between 5 and 15 °C (Collins et al., 2000)
    - Most susceptible to a quarternary ammonium disinfectant

What is Ileitis?

- Pigs affected (Glock et al., 1994)
  - 40-100 lb growing pigs (most common)
  - Bred gilts
  - Sows and boars
  - Finishing pigs
- Generally affects 1 - 10% of herd
  - Infection may be as high as 50% in young pigs

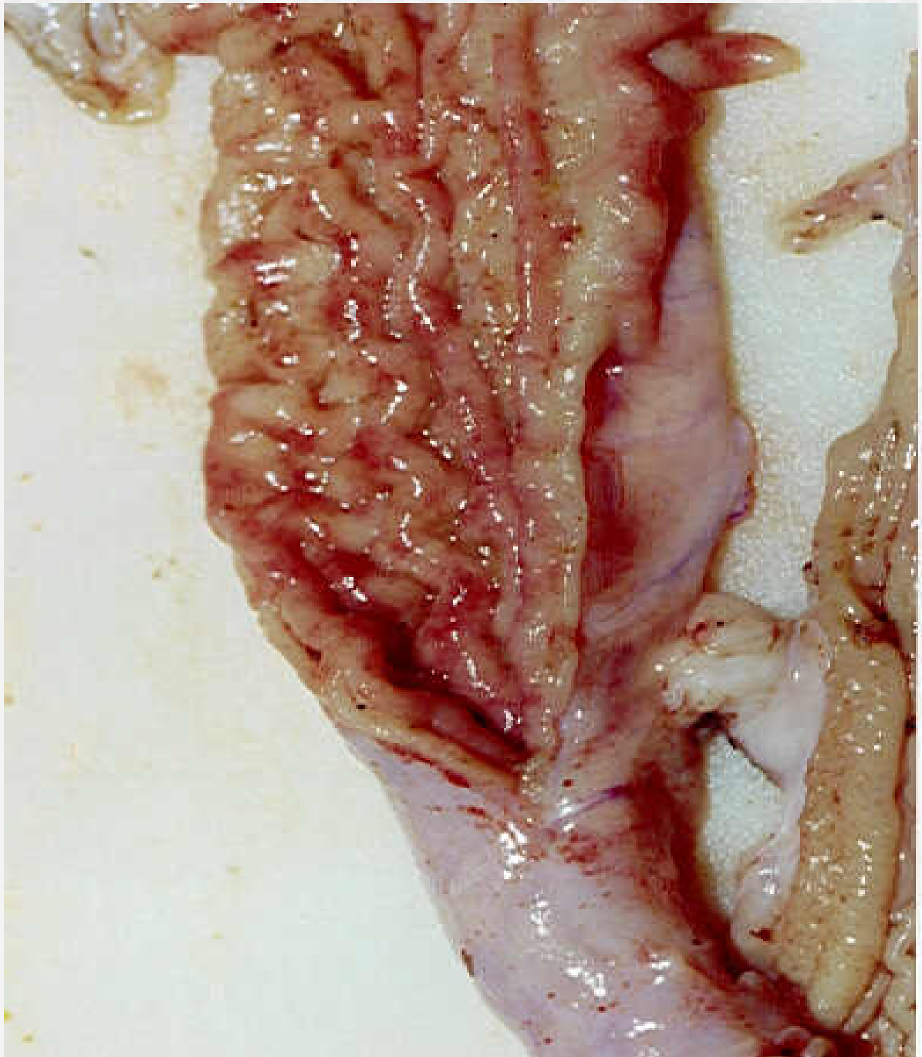
What is Ileitis?

- 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
  - 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 140 – 240 lb finishers
  - Massive intestinal hemorrhaging, bloody diarrhea, increase in mortality

PIA



Does Feeding DDGS Reduce the Incidence and Severity of Ileitis?

- Field reports from several MN pork production operations have indicated:
  - Adding 5 to 10% DDGS to grow-finish diets in herds with recurring problems with ileitis
    - Improved performance
    - Reduced mortality (by as much as 50%)

Possible Relationships Between DDGS and Gut Health

- DDGS is high in fiber (Shurson et al., 2000)
  - High insoluble fiber (42.2 %)
  - Low soluble fiber (0.7 %)
- Feeding diets low in soluble non-starch polysaccharides reduce proliferation of pathogenic organisms in the GIT (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)
- Presence of yeast cells in DDGS from fermentation
  - May have mannan oligosaccharide properties

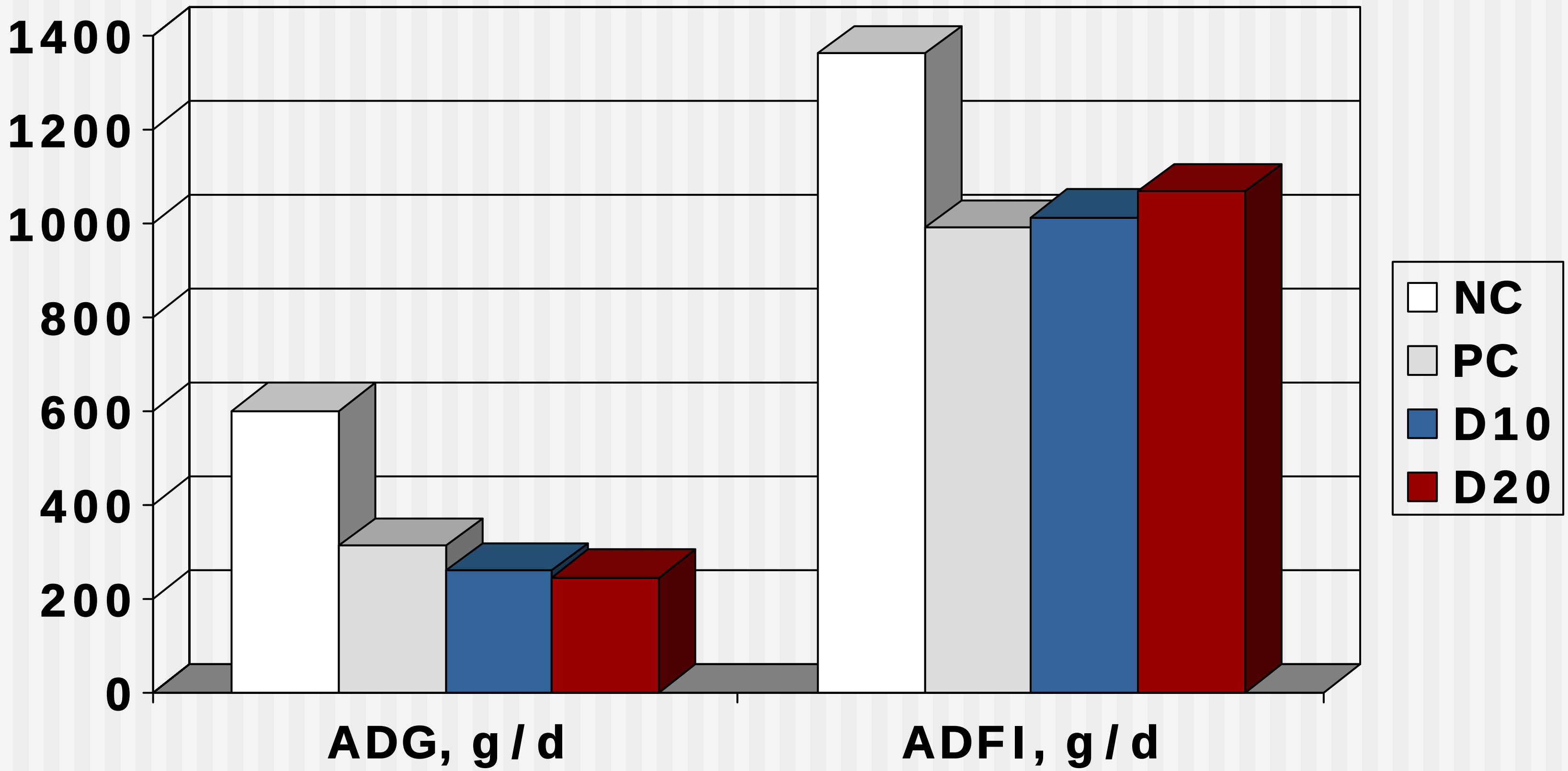
Ileitis Challenge Experiment 1 - Methodology

- 80 pigs, initial age = 17 d (10 pigs/room, 2 rooms/trt)
- Randomly allotted to 1 of 4 dietary treatments:
  - (NC) Negative control corn-soybean meal diet
  - (PC) Positive control corn-soybean meal diet*
  - (D10) 10% DDGS diet*
  - (D20) 20% DDGS diet*
- 4 wk acclimation period to diets and isolation pens
- 1 day challenge period
  - Mucosal homogenate from infected porcine intestines
- Pigs maintained and observed for additional 3 wks
- All animals euthanized and samples were collected

Experiment 1 - Methodology

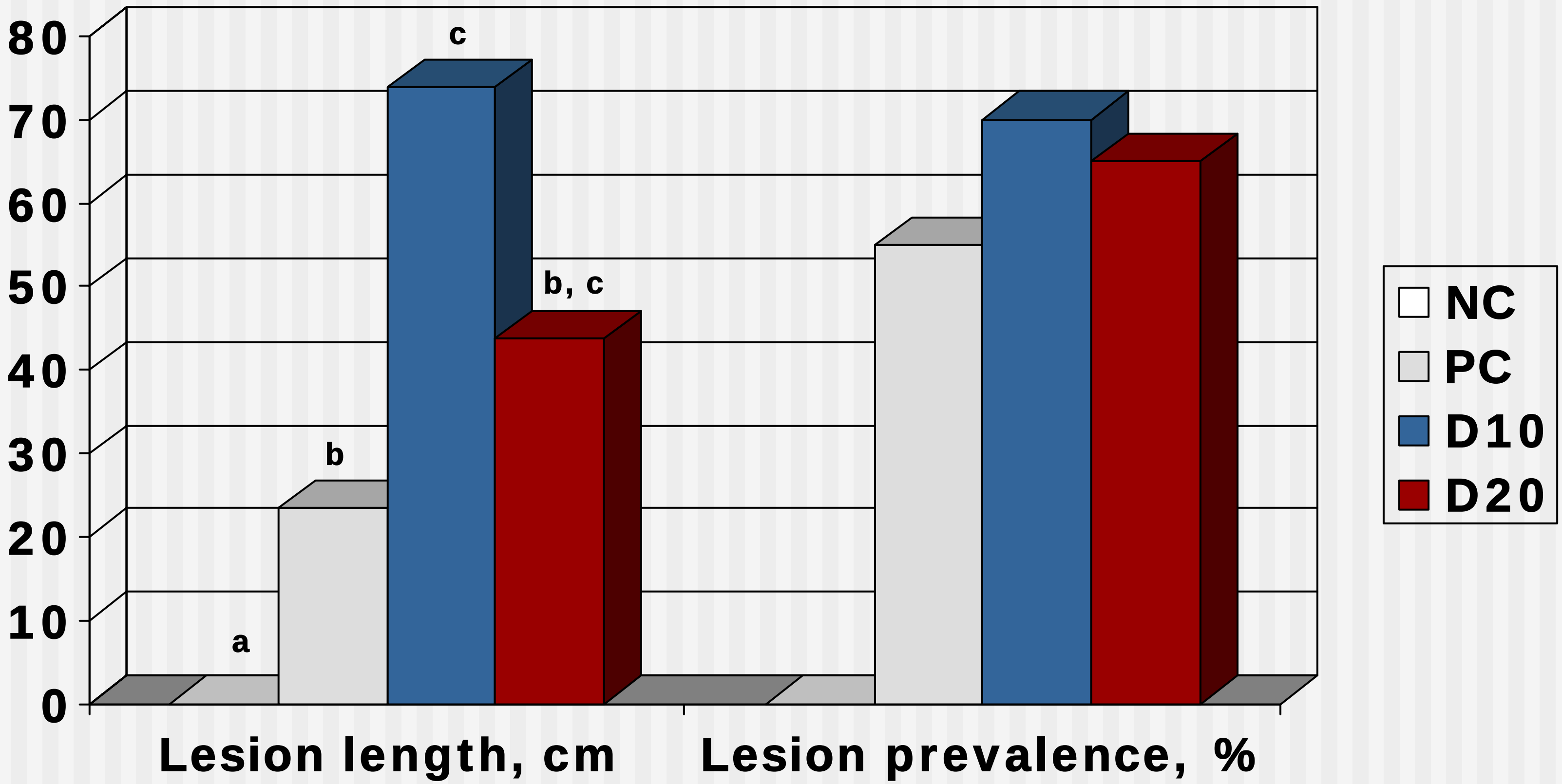
- Growth performance and feed intake data were collected
- Fecal samples collected on d 14 and d 21 post-challenge
  - PCR to determine rate of fecal shedding of the organism
    - Most accurate measure in live animal
- Necropsy
  - Pathologist: length and location of gross lesions
  - Severity of gross lesions (Score of 0 - 4)
  - Collected 4 inch tissue section of distal ileum
    - Immunohistochemistry to establish presence and prevalence of *L. intracellularis*-infected cells from the mucosa
    - IHC is most sensitive and accurate evaluation measure available

Effect of DDGS on Growth and Feed Intake of Pigs Post-Challenge – Experiment 1



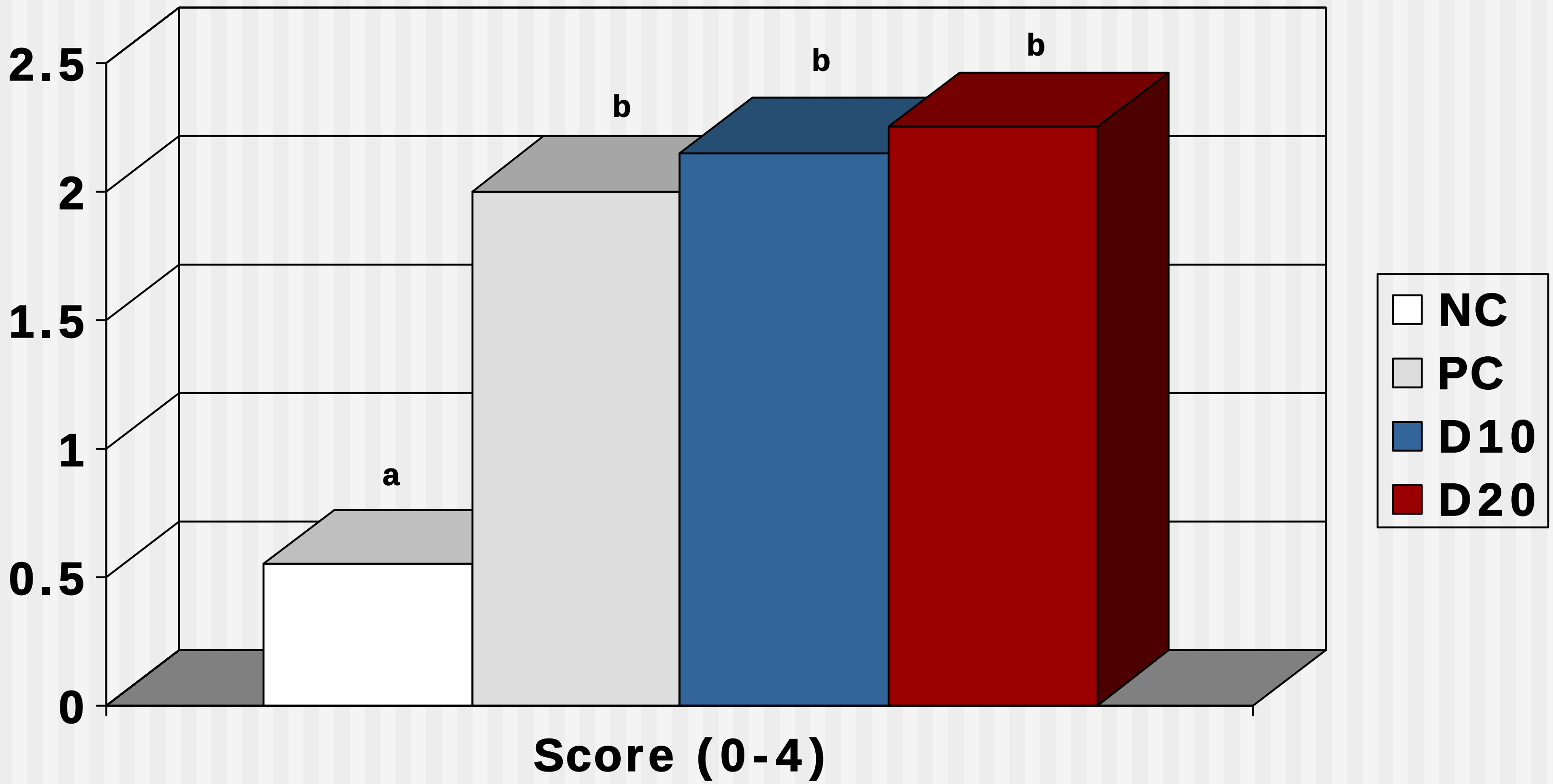
Pen was experimental unit, 2 pens/treatment

Effect of DDGS on Overall Lesion Length and Lesion Prevalence of Pigs Post-Challenge – Experiment 1



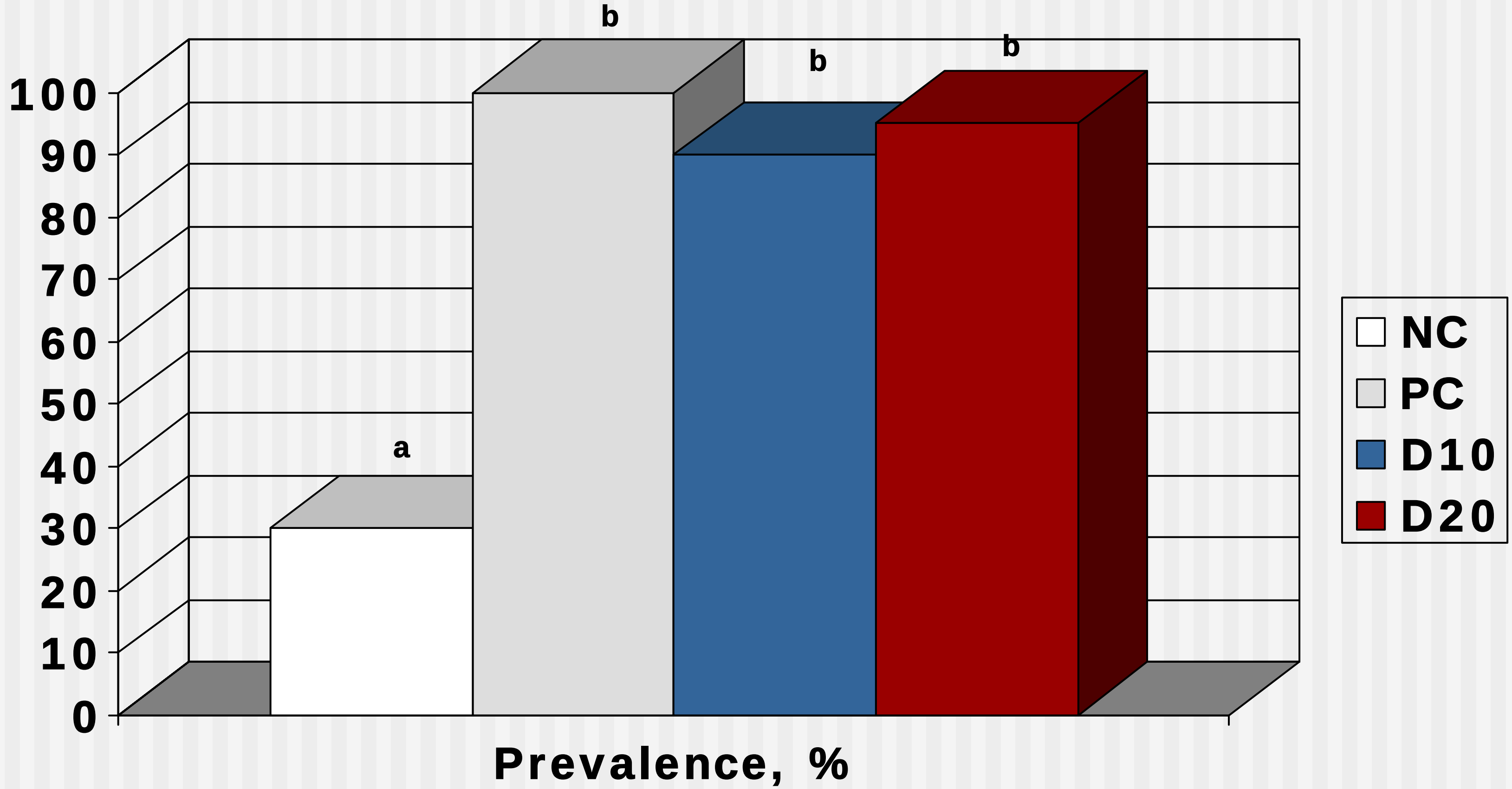
[a, b, c] Bars with different superscripts are significantly different ($P < .01$)

Effect of DDGS on Immunohistochemistry Score (0-4) of Pigs Post-Challenge – Experiment 1



[a, b] Bars with different superscripts are significantly different ($P < .01$)

Effect of DDGS on Immunohistochemistry Prevalence (%) of Pigs Post-Challenge – Experiment 1



[a, b] Bars with different superscripts are significantly different (P < .01)

Experiment 1 - Conclusion

- DDGS inclusion did not positively affect the pig's ability to resist an ileitis challenge
  - Feeding 10% DDGS resulted in greater prevalence, length, and/or severity of lesions in many portions of the G.I. Tract
- Dosage (inoculation) rate was higher than desired
  - Goal: 1×10^8 dose of *L. intracellularis*
  - Actual: 1.56×10^9 dose of *L. intracellularis*
  - Because of high dosage level, ability to detect dietary effects may have been masked
    - Concentration would overwhelm any dietary effects

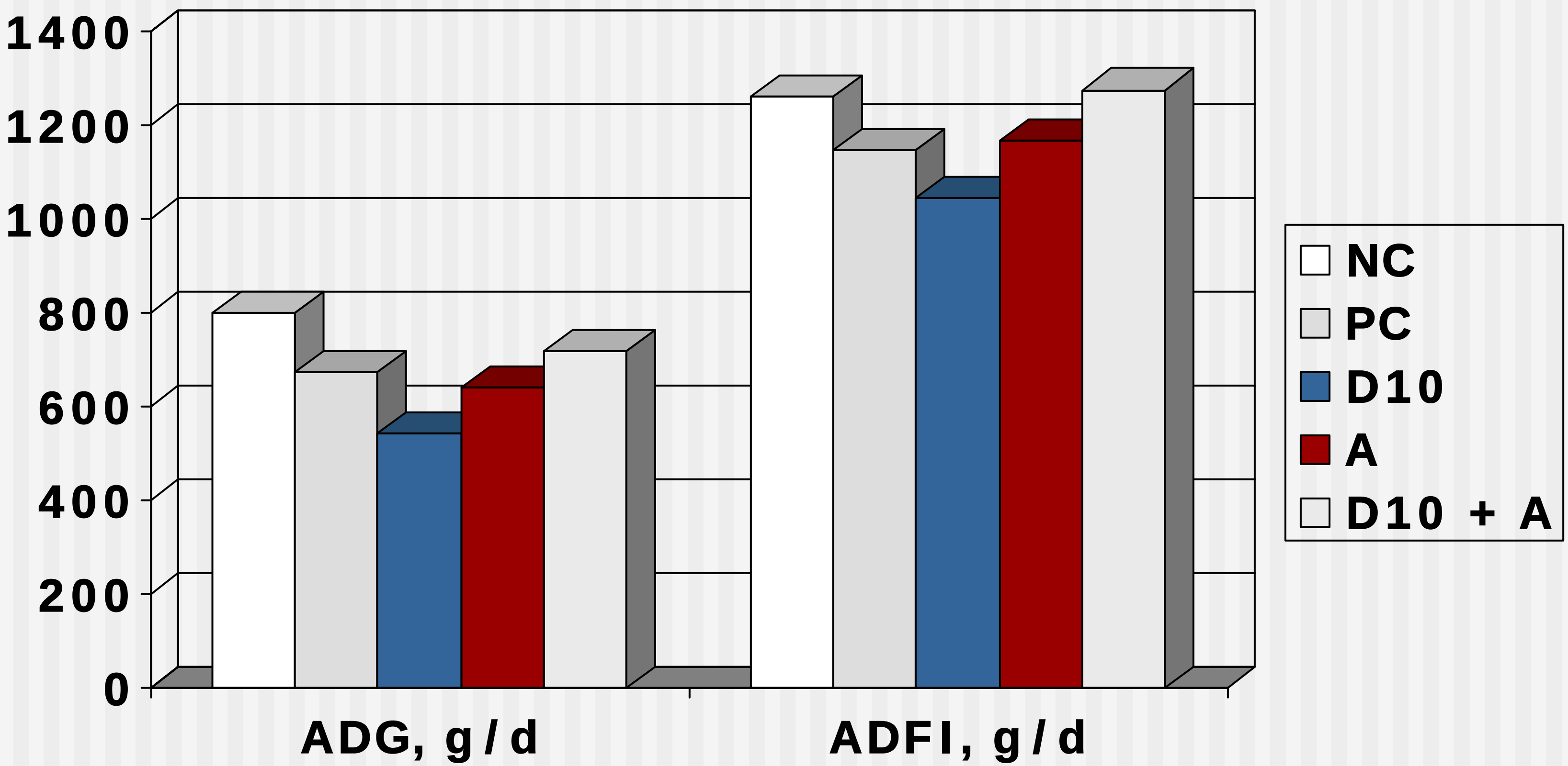
Ileitis Challenge Experiment 2 - Objectives

- Modify disease challenge model from first experiment to ensure a less severe dose and challenge
- Determine if dietary inclusion of DDGS can reduce the incidence or severity of ileitis
- Compare dietary DDGS inclusion to a common antibiotic/antimicrobial treatment currently being used

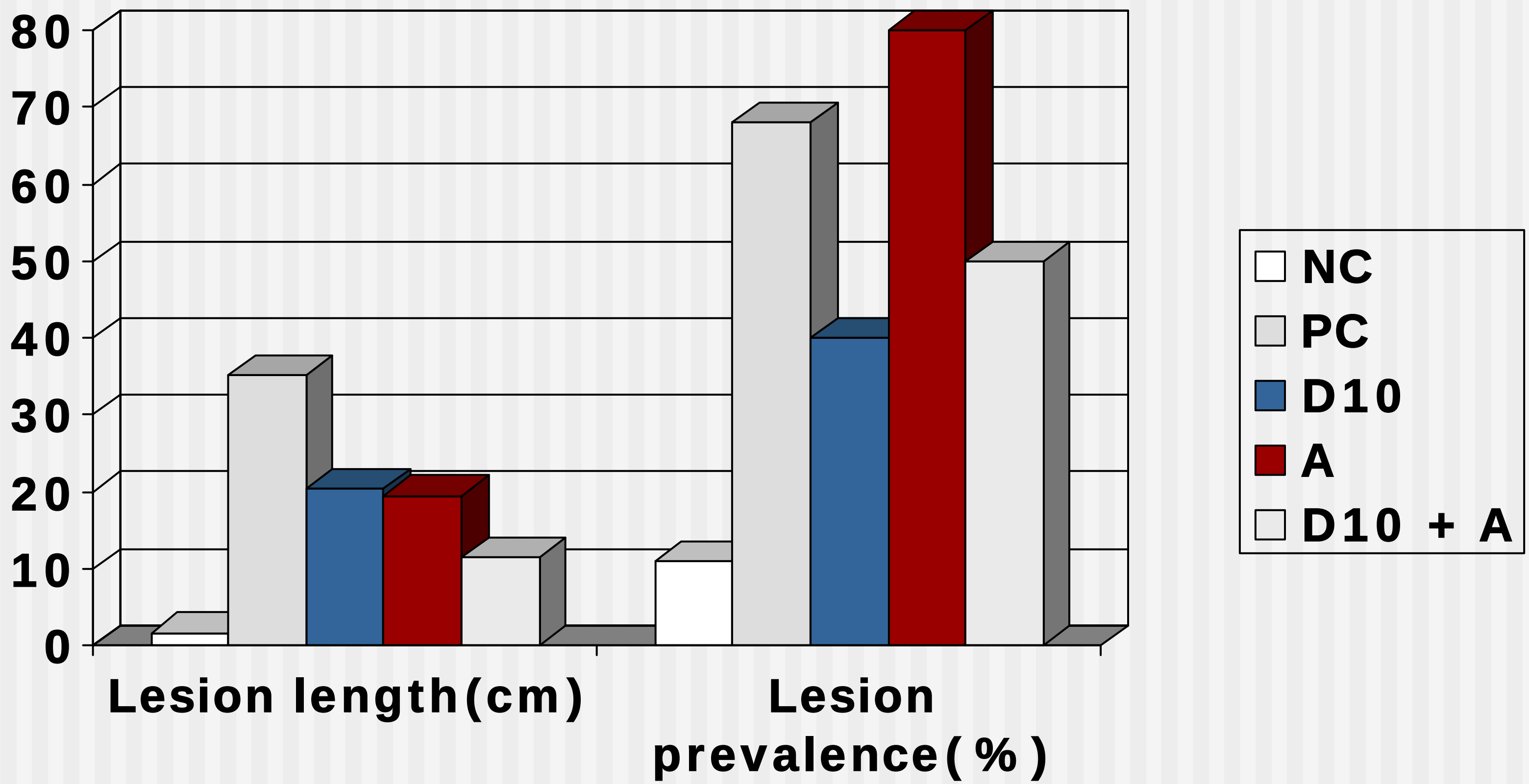
Experiment 2 - Methodology

- 100 pigs, initial age = 17 days
- Randomly allotted to 1 of 5 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
  - (A) Control diet with BMD/CTC
  - (D10+A) DDGS diet with BMD/CTC
- Conducted similar to Experiment 1.
- BMD/CTC treatments (A)
  - BMD continuous (30 g/t)
  - CTC (Aureomycin) (500 g/t) provided from 3 days pre- to 11 days post-challenge

Effect of DDGS on Growth and Feed Intake of Pigs Post-Challenge – Experiment 2

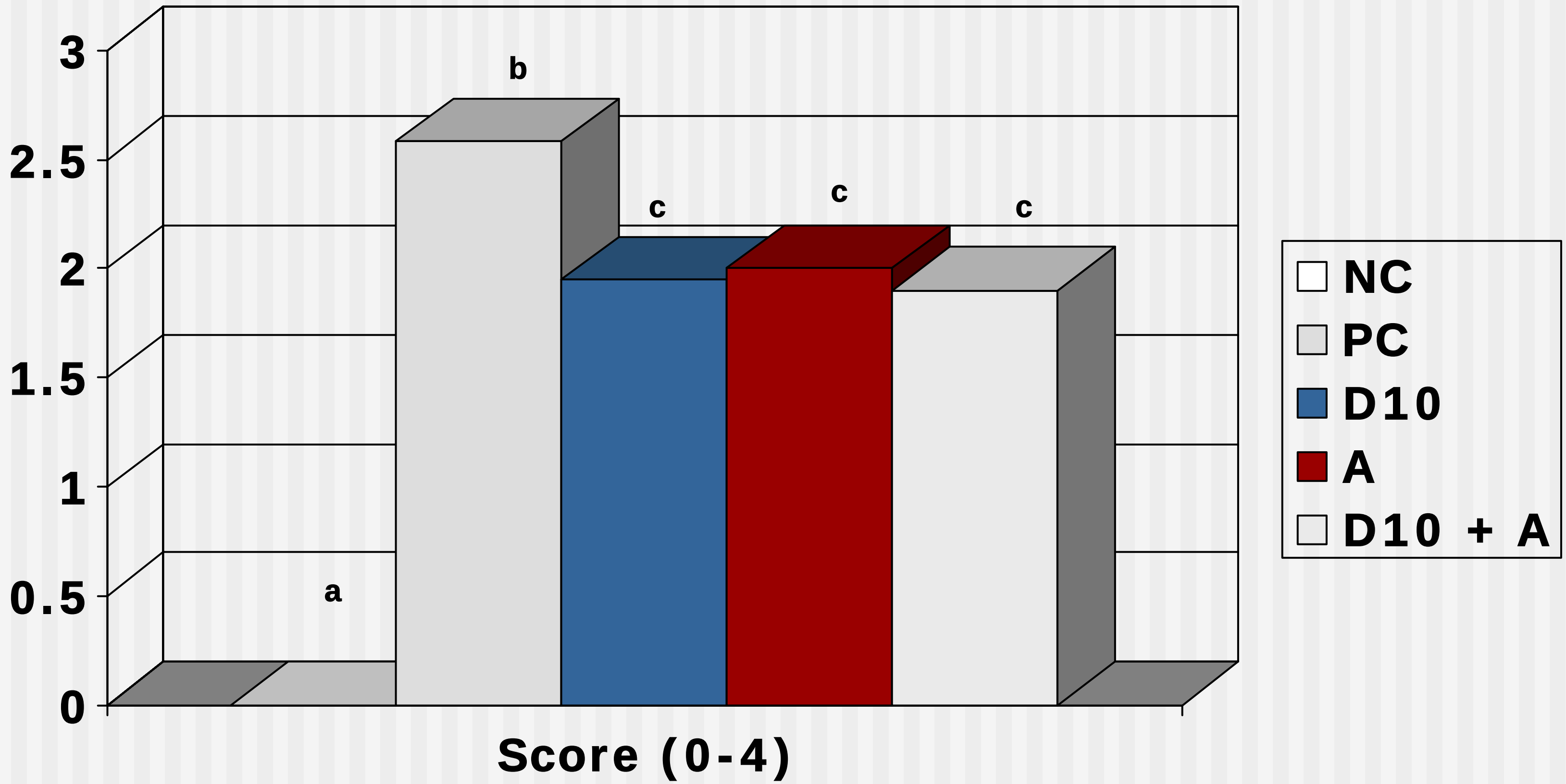


Effect of DDGS on Overall Lesion Length and Lesion Prevalence of Pigs Post-Challenge – Experiment 2



Lesion length: DDGS effect (P < .14), BMD + CTC effect (P < .11)
Lesion prevalence: DDGS effect (P < .01)

Effect of DDGS on Immunohistochemistry Score (0-4) of Pigs Post-Challenge – Experiment 2



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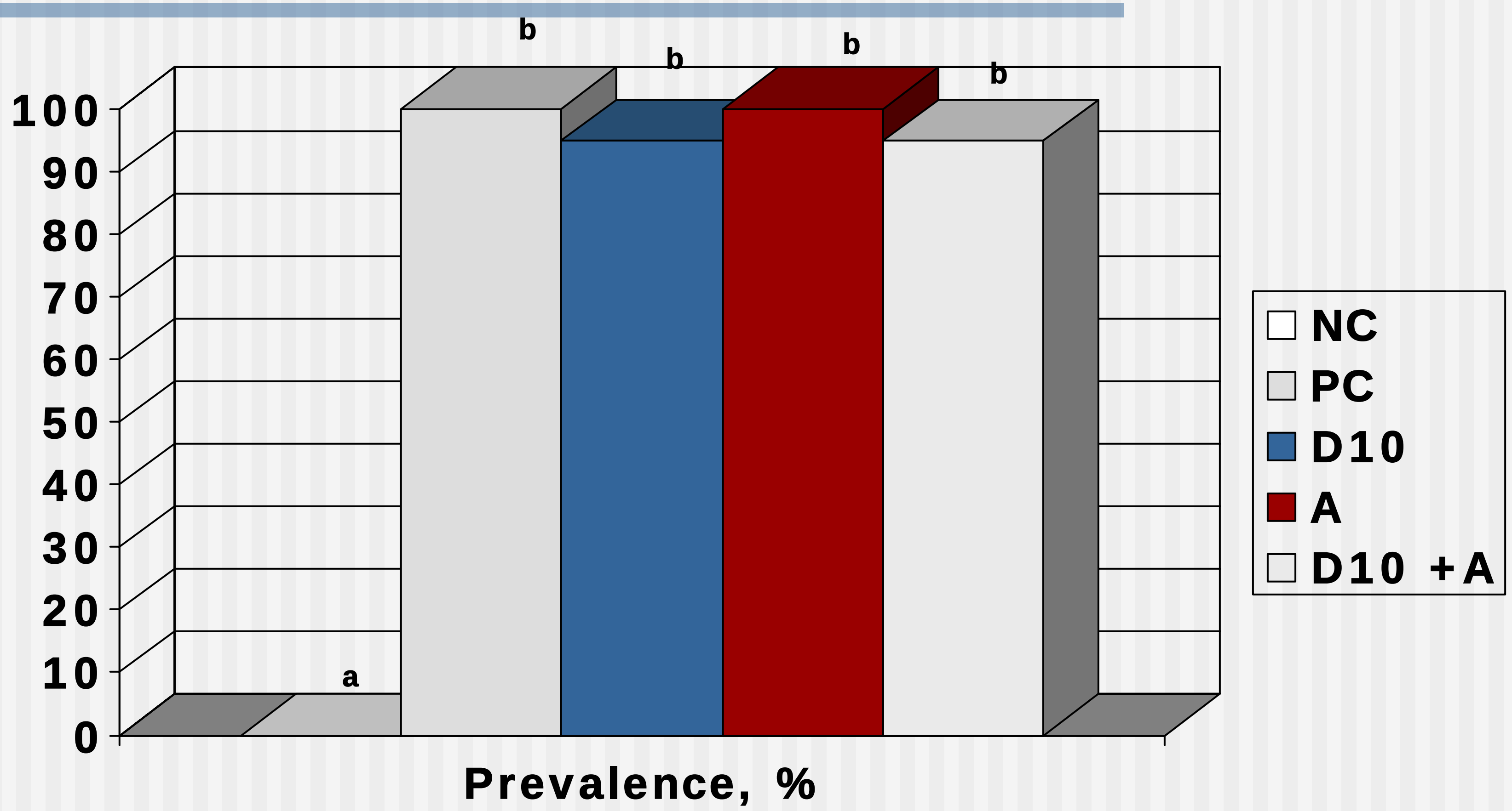
Effect of DDGS on Immunohistochemistry Prevalence (%) of Pigs Post-Challenge – Experiment 2



[a, b] Bars with different superscripts are significantly different (P < .01)

Experiment 2 - Conclusion

- Dosage (inoculation) rate appeared to more acceptable
  - Still had a 63% prevalence in challenged pigs
  - Less severe lesions
- DDGS inclusion (10%) had a positive effect on the pig's ability to resist an ileitis challenge
  - Decreased lesion length, score and prevalence in the ileum, colon, and overall
- BMD/CTC also appeared to improve:
  - Jejunum lesion score and prevalence
  - Total lesion length
- DDGS x BMD interaction appeared to be minimal

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

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