# Benefits and Limitations of Using DDGS in Swine Diets

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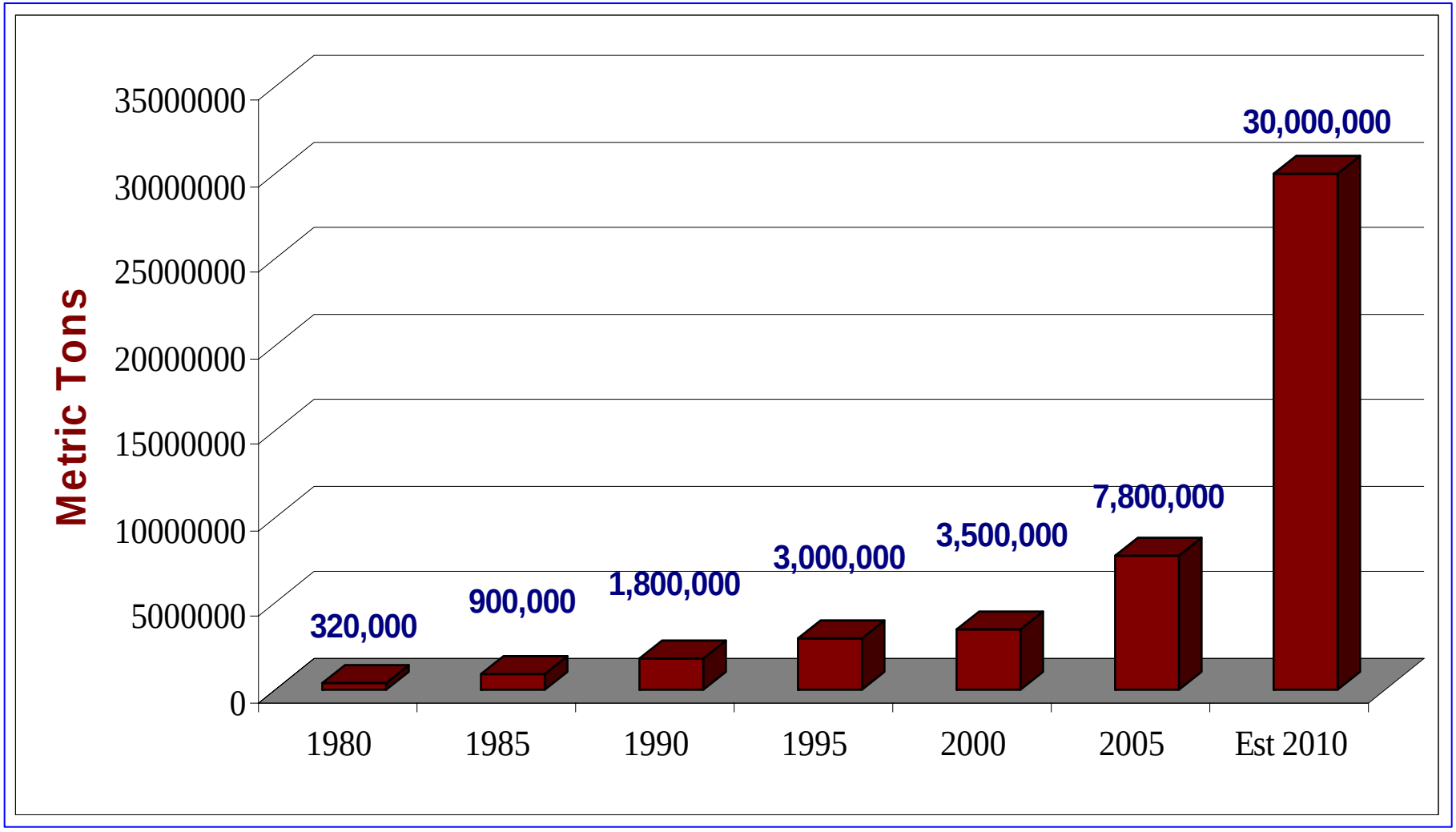
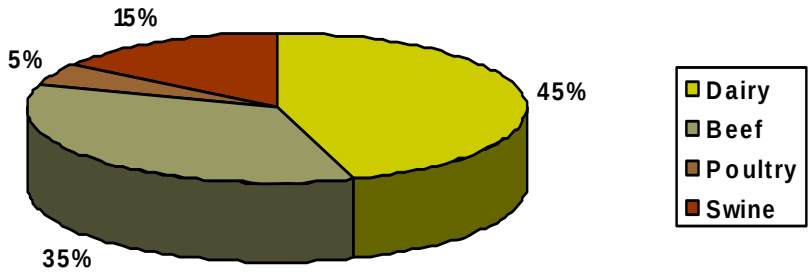
# North American DDGS Production



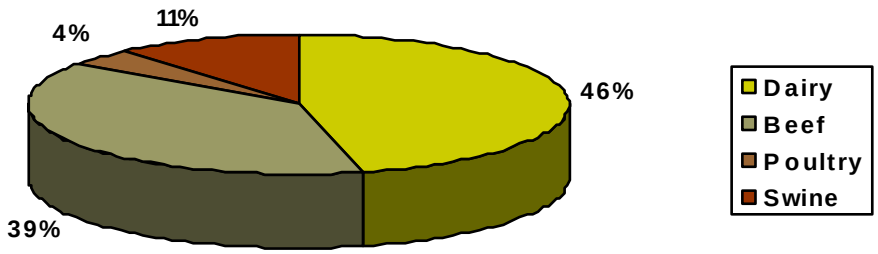

**Source: Sean Broderick, Commodity Specialists Company**

# U.S. DDGS Consumption

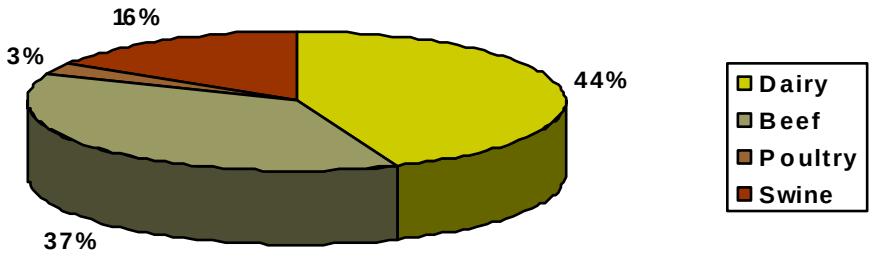
## Estimate 2002



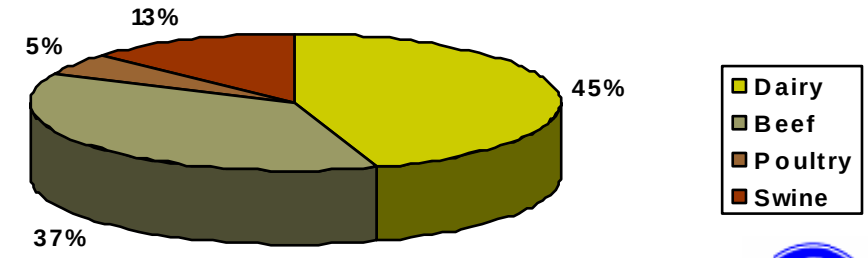

## Estimate 2003



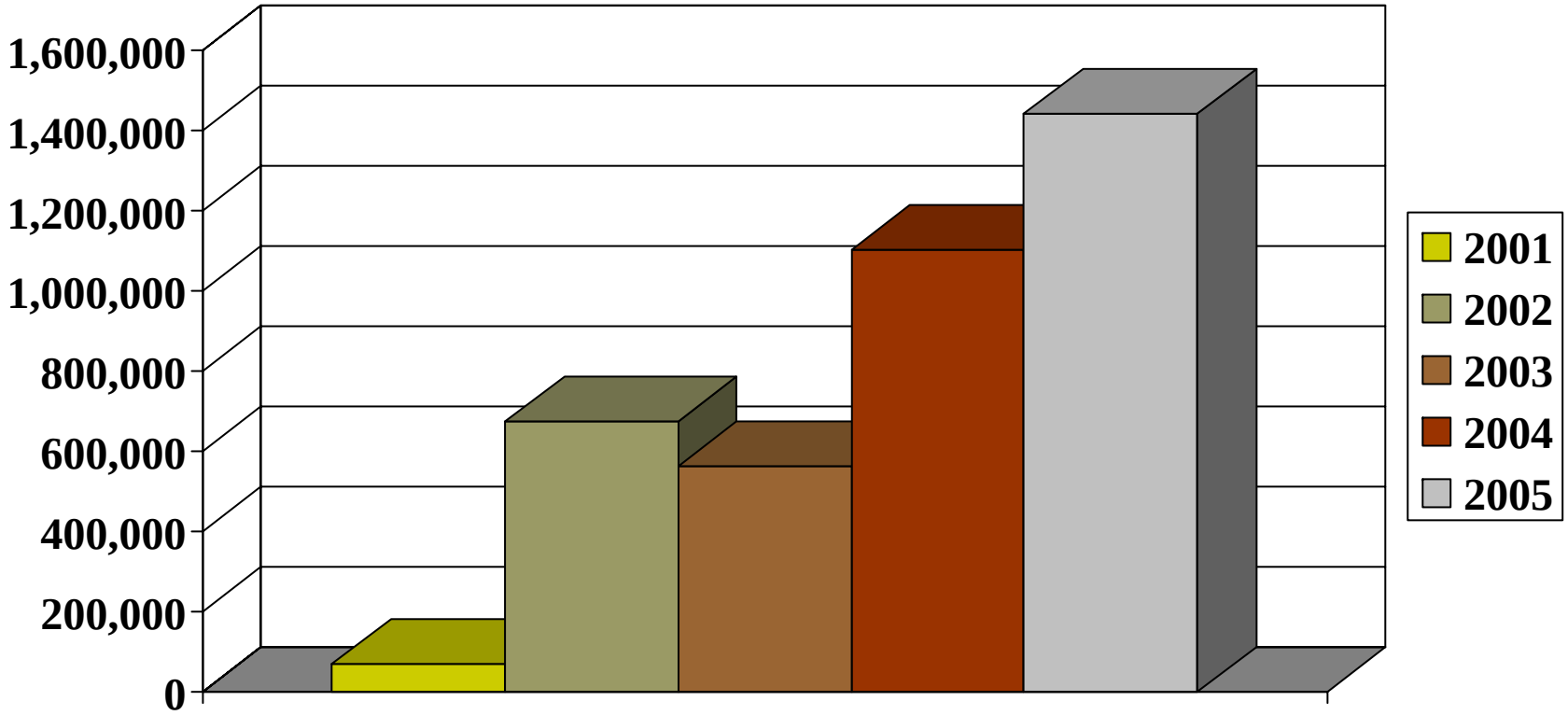

## Estimate 2004




## Estimate 2005



# Estimated DDGS Usage in U.S. Swine Feeds 2001-2005 (Metric Tonnes)



# Current Commercial Dietary DDGS Inclusion Rates and Estimated Usage

- Grower-finisher diets ~85-90%
  - 10-15% dietary inclusion rates
- Sow diets ~5-10%
  - Gestation - up to 30% dietary inclusion
  - Lactation - 5-10% of the diet
- Late nursery diets < 5%
  - Added at 5-10% of the diet

# Maximum Inclusion Rates of Golden High Quality U.S 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 30%

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

# Benefits and Limitations of Feeding DDGS Diets to Swine

## Benefits

- Energy value = corn
- High available P
  - Reduce diet P supplementation
  - May reduce manure P excretion
- Partially replaces some corn, soybean meal, and dicalcium phosphate and reduces diet cost
- Commonly fed at 10% of diet
  - Higher levels can be used if amino acids are supplemented
- Only “golden” DDGS should be used
  - High amino acid digestibility
- Appears to reduce gut health problems due to ileitis
- May increase litter size weaned when fed at high levels to sows
- Increases pig weight gain when fed to sows during lactation

## Limitations

- Low protein (lysine) quality
  - add other supplements high in lysine and tryptophan
- Variability in nutrient content and digestibility among sources
- Manure N excretion increases
- Belly firmness and pork fat quality may be reduced when > 20% in the diet
- Fine particle size causes flowability problems in bins and feeders
- Difficult to pellet and maintain throughput of pellet mills
- Mycotoxin free grain should be used to produce ethanol and DDGS
- Short-term feed intake may be reduced when feeding high DDGS diets to sows

# DDGS Varies in Nutrient Content and Digestibility, Color, and Particle Size Among U.S. Sources

## Averages, Coefficients of Variation, and Ranges of Selected Nutrients Among 32 U.S. DDGS Sources (100% Dry Matter Basis)

| Nutrient | Average | Range |
|---|---|---|
| Dry matter, % | 89.3 | 87.3 – 92.4 |
| Crude protein, % | 30.9 (4.7) | 28.7 – 32.9 |
| Crude fat, % | 10.7 (16.4) | 8.8 – 12.4 |
| Crude fiber, % | 7.2 (18.0) | 5.4 – 10.4 |
| Ash, % | 6.0 (26.6) | 3.0 – 9.8 |
| Swine ME, kcal/kg | 3810 (3.5) | 3504 – 4048 |
| Lysine, % | 0.90 (11.4) | 0.61 – 1.06 |
| Phosphorus, % | 0.75 (19.4) | 0.42 – 0.99 |

# Standardized Ileal Lysine Digestibility Coefficients Among 10 "Golden" Corn DDGS Sources (Stein et al, 2005)

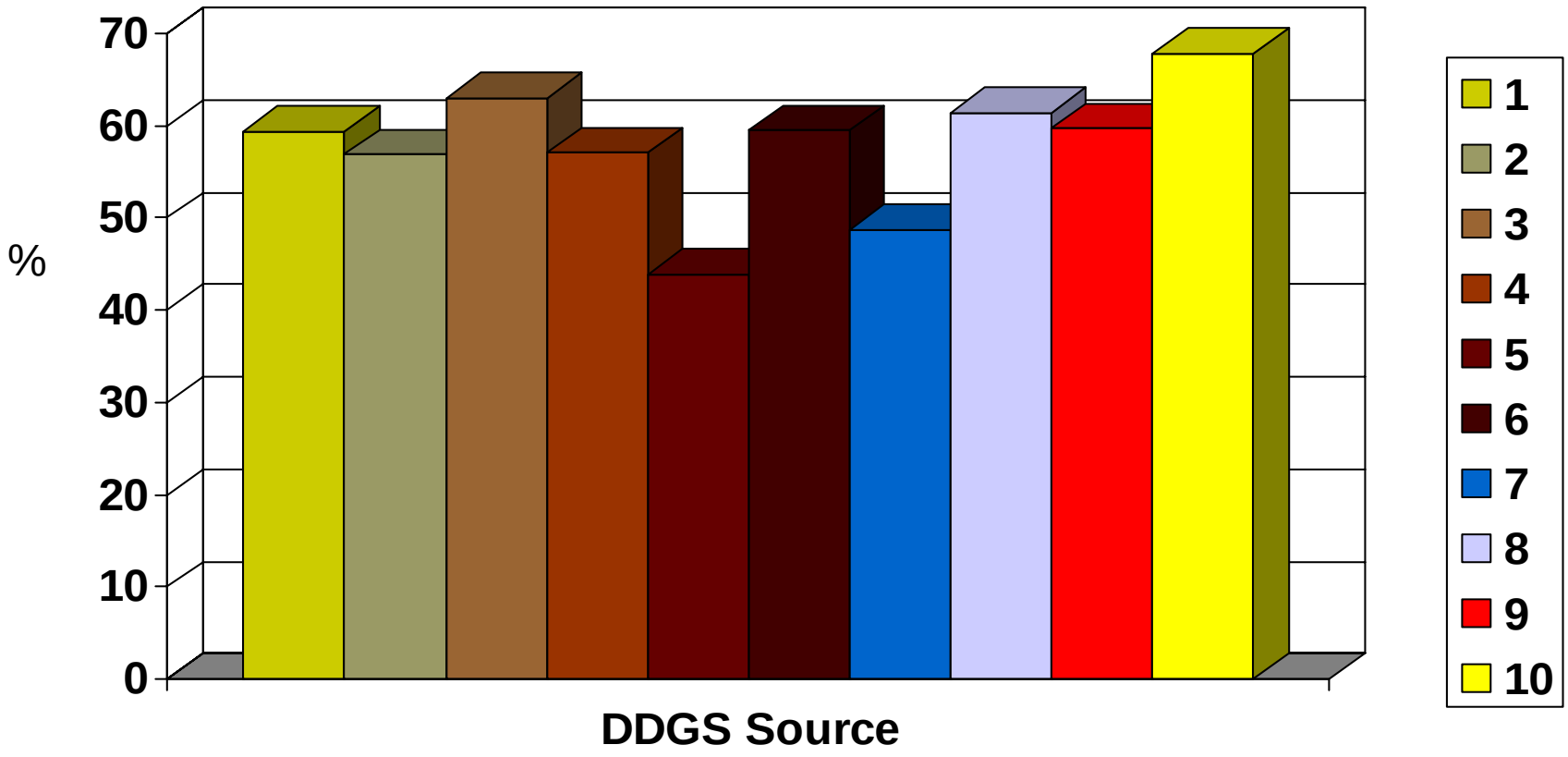
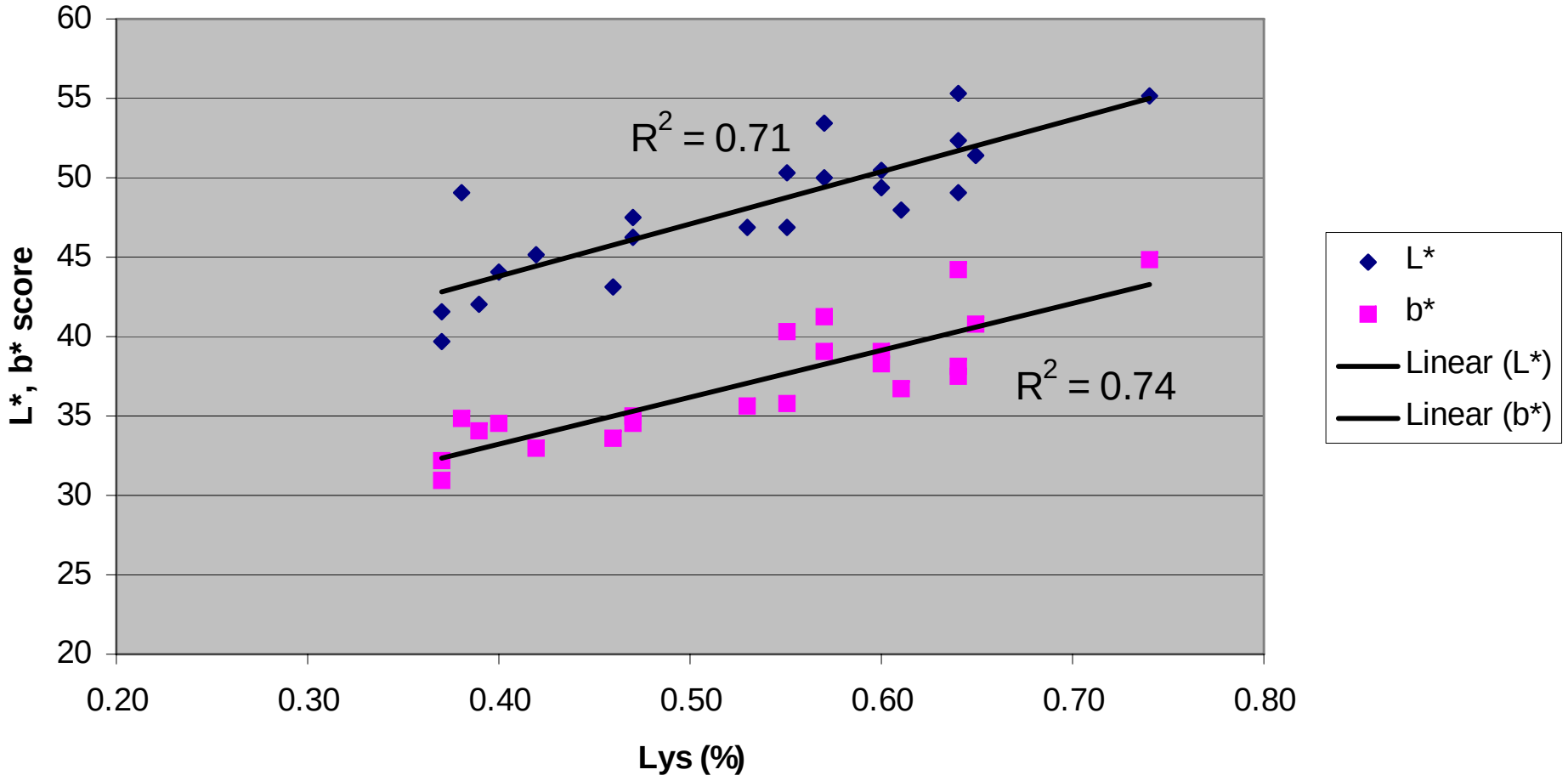
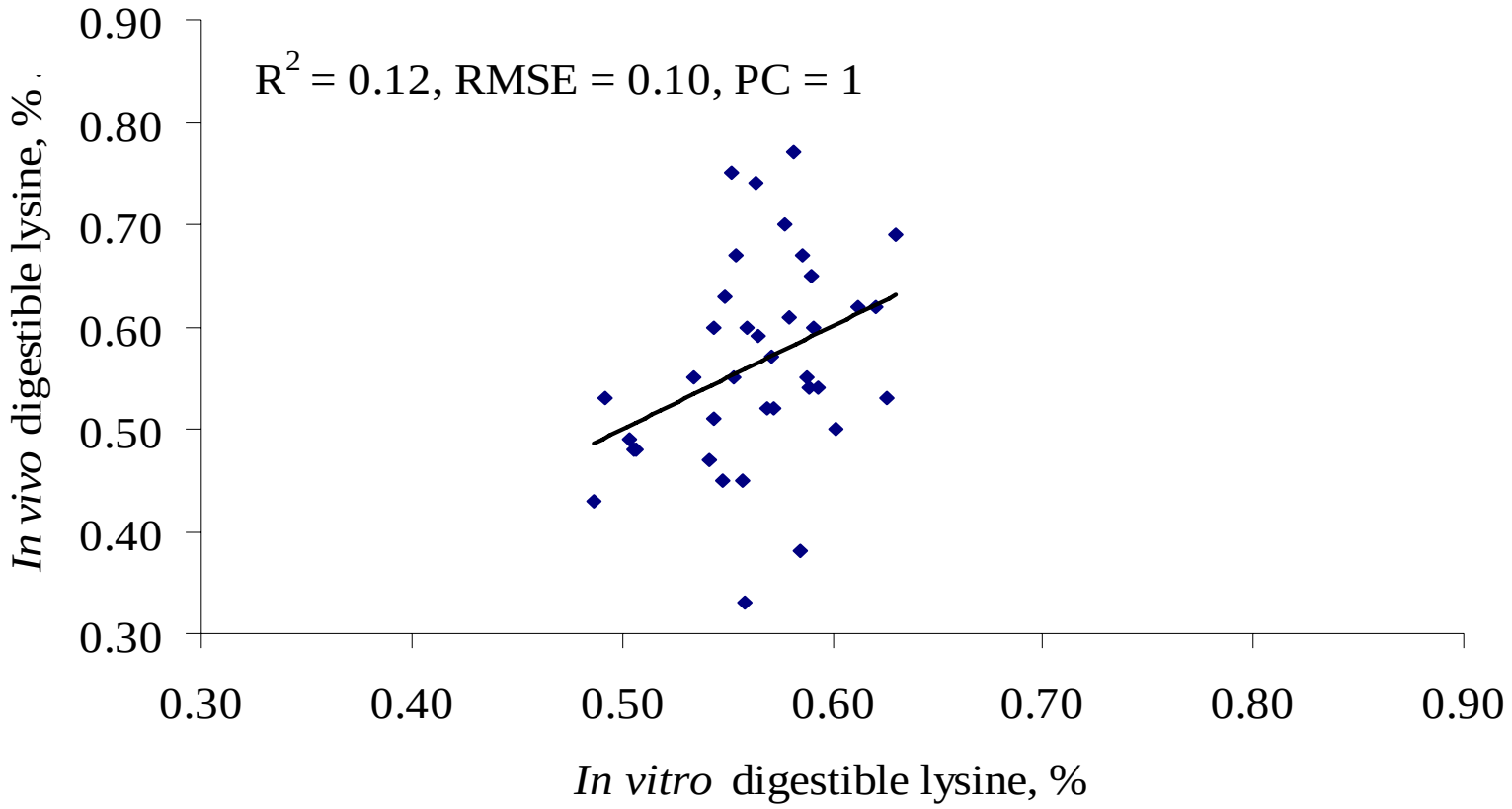


**Fig. 1. Regression of digestible lys (%) and color (L*, b*)**



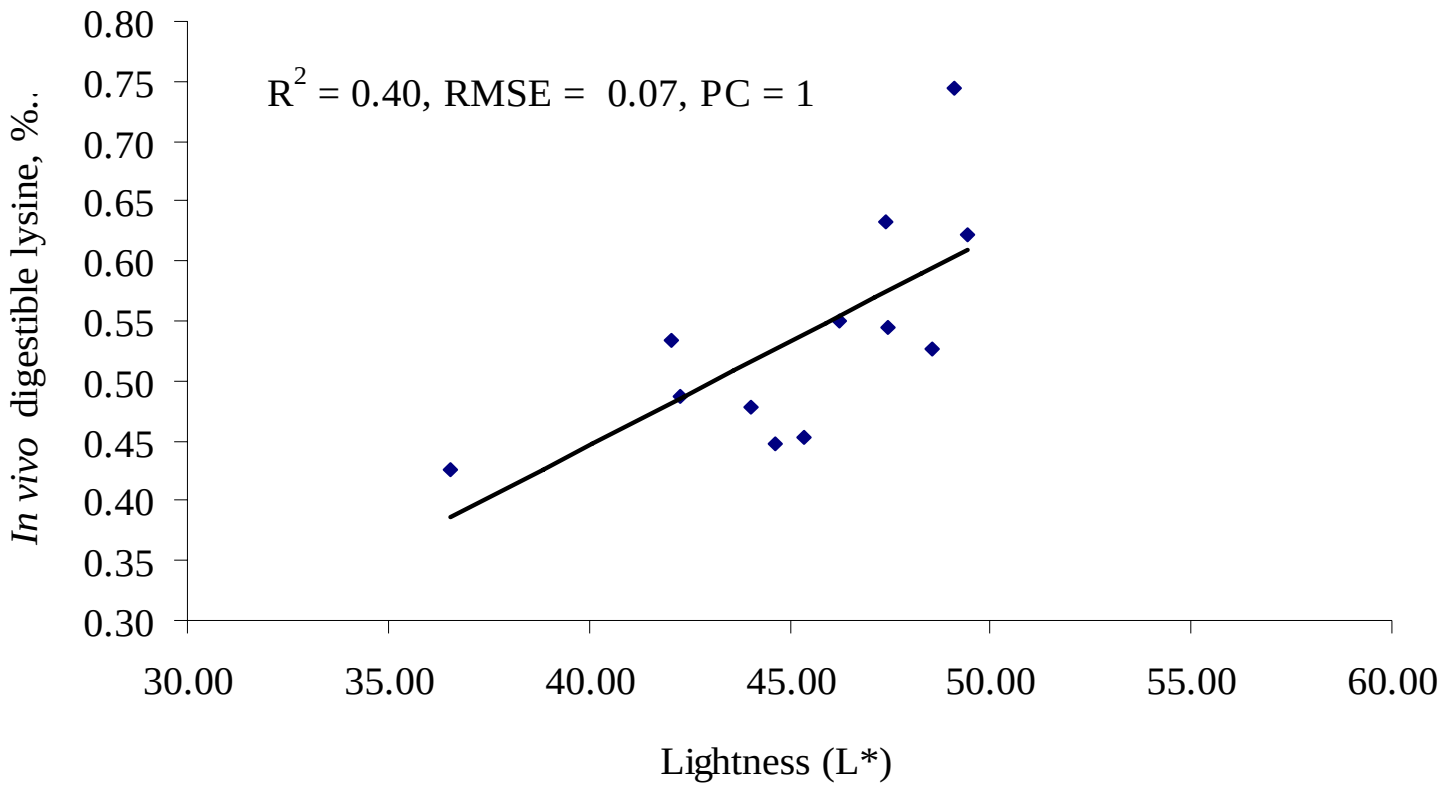

Source: Dr. Sally Noll (2003)

# Prediction of Digestible Lysine from Color (L*, a*, and b*) Among DDGS Sources for Swine



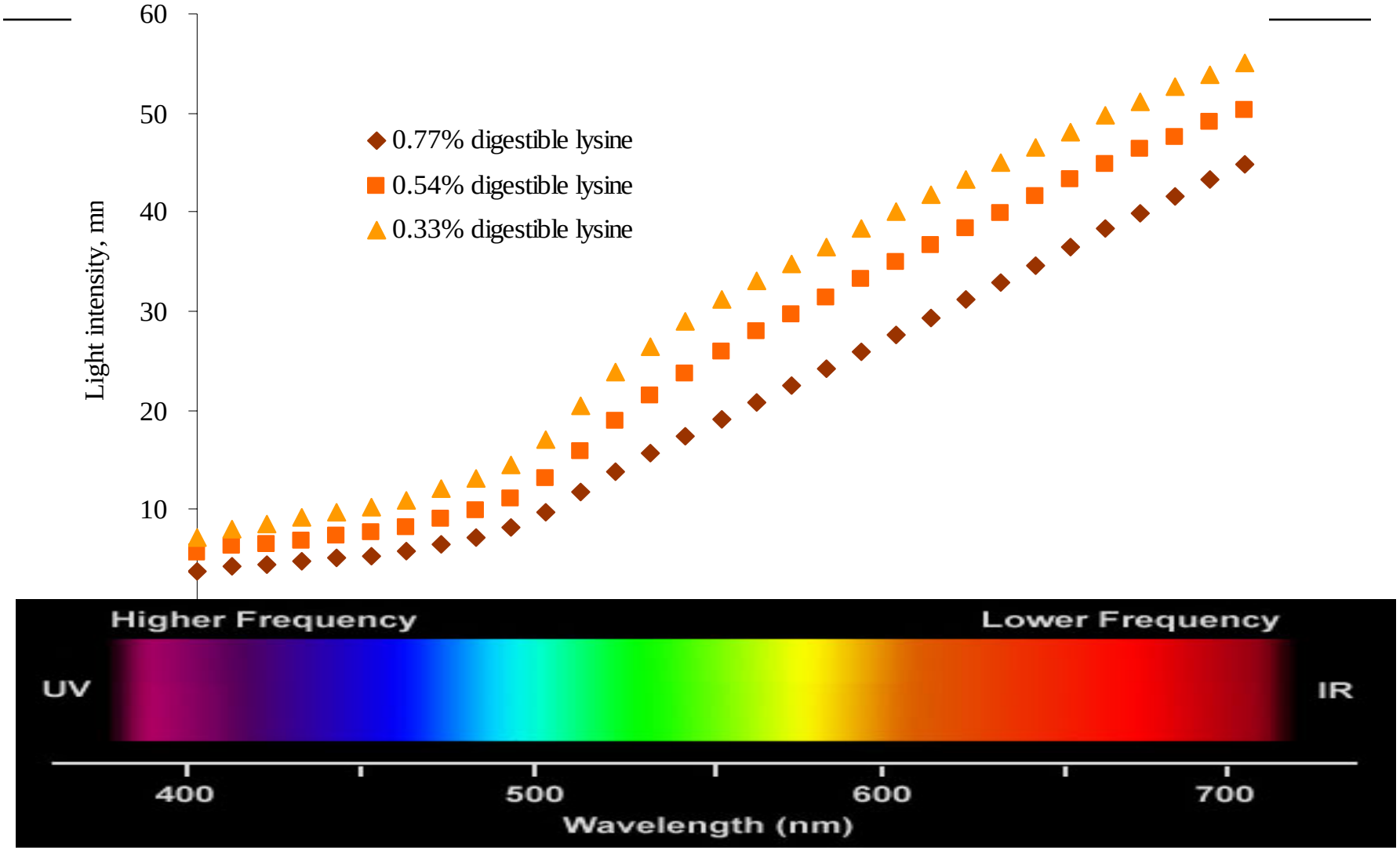

**Urriola et al. (2006)**

# Prediction of Digestible Lysine from Color L*, a*, and b* (L* < 50 in Corn DDGS)

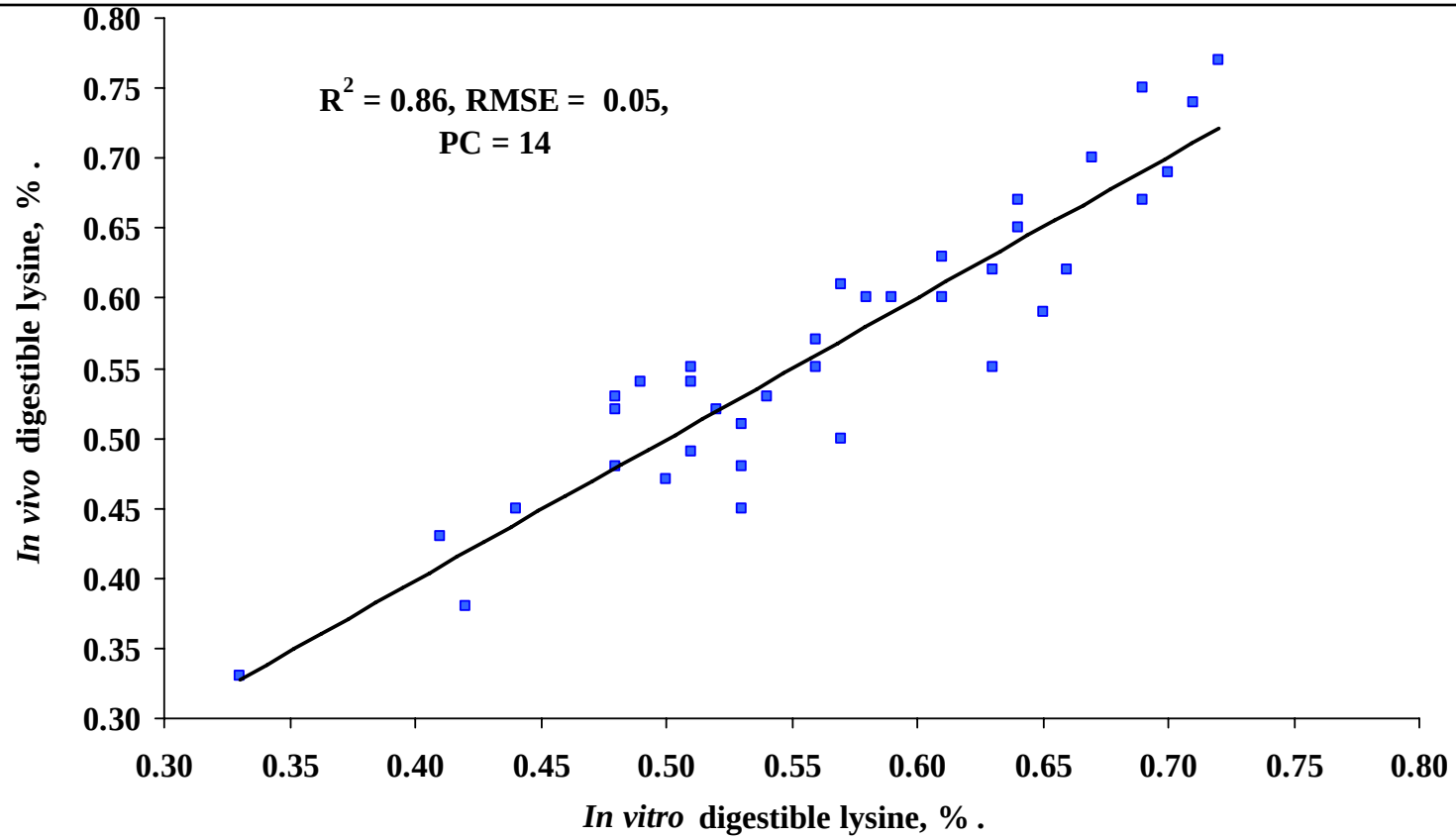



**Urriola et al. (2006)**

# Prediction of Digestible Lysine Content of DDGS Using Optical Density

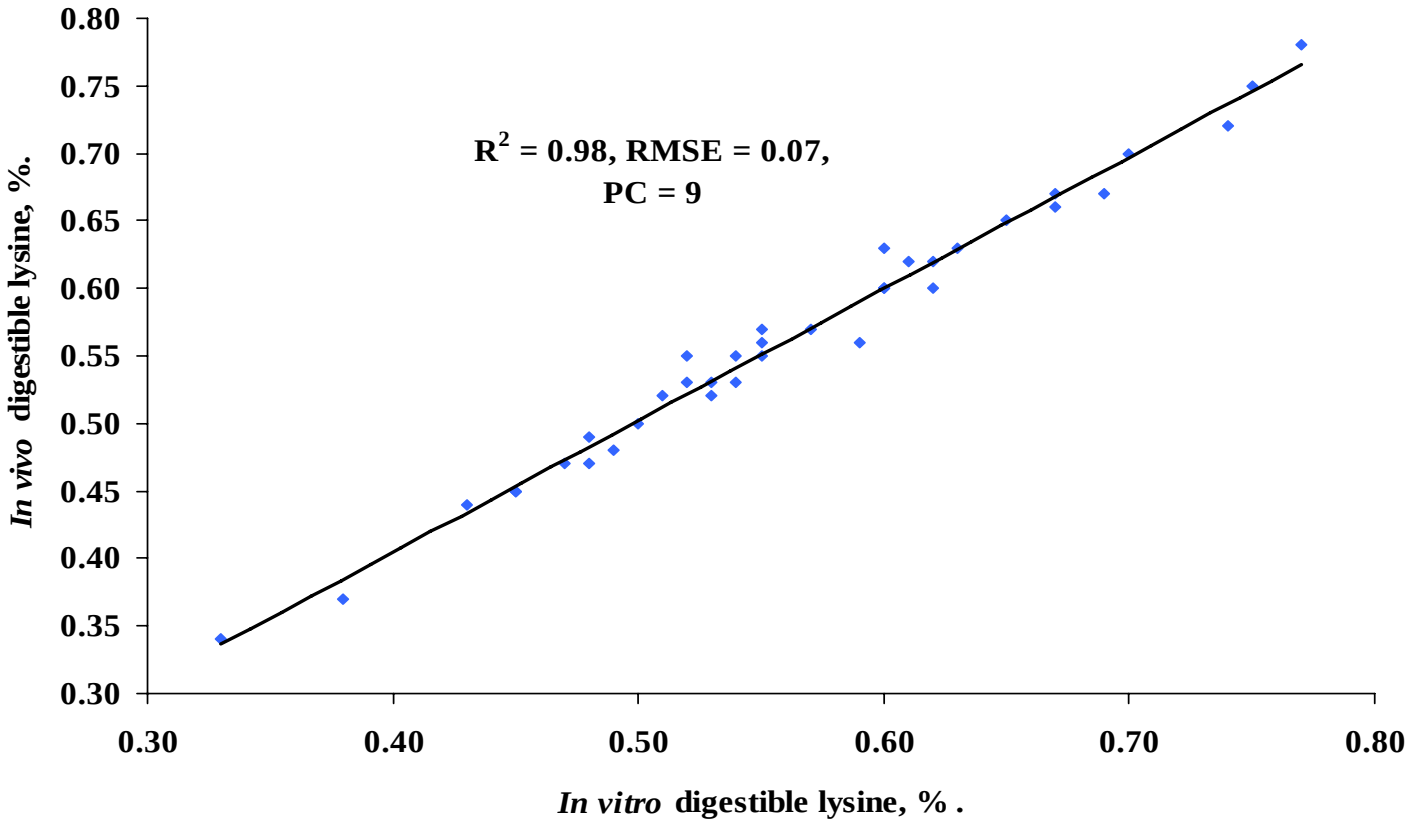


# Prediction of Digestible Lysine from Optical Density (400 to 700 nm)

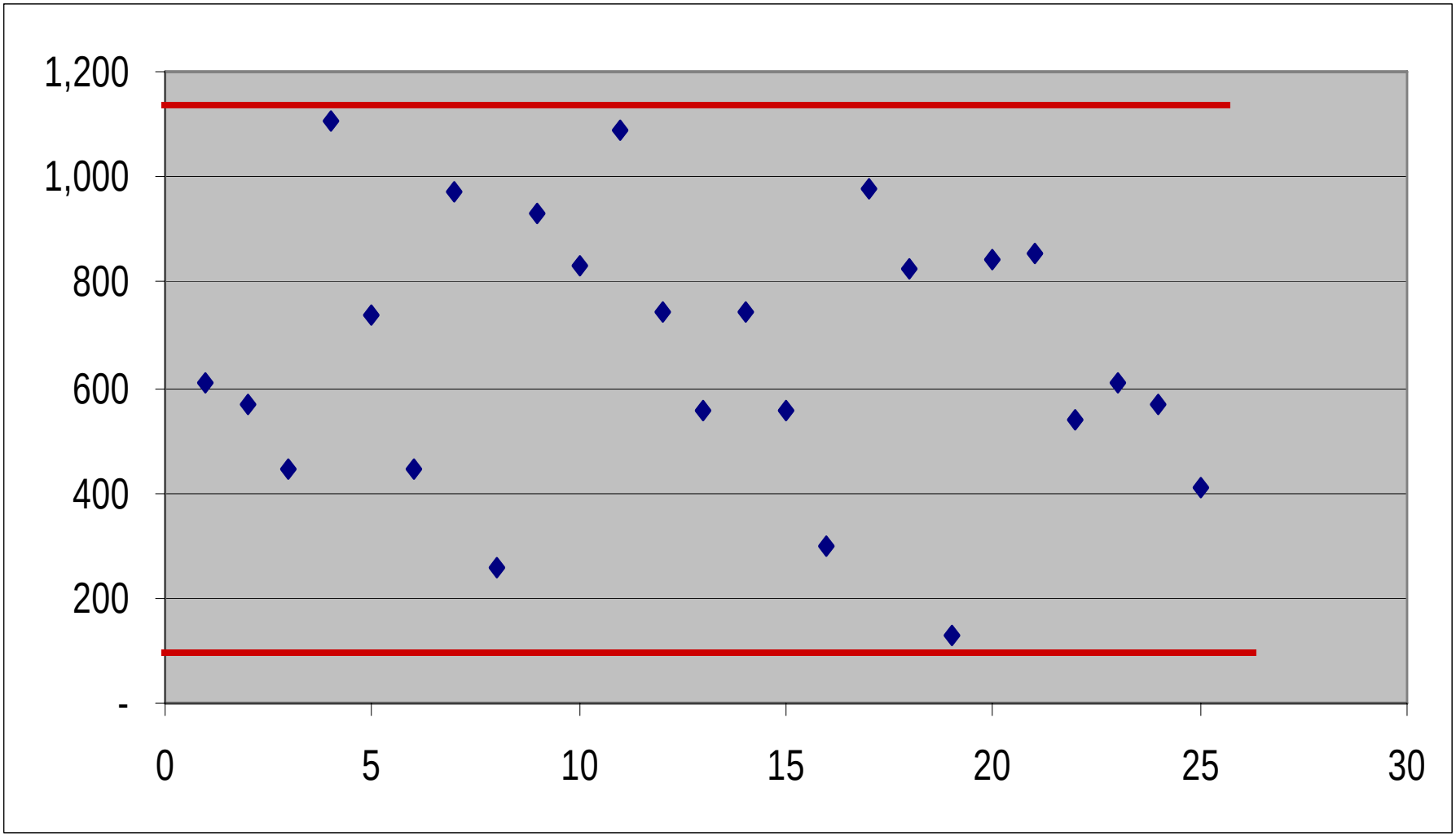



**Urriola et al. (2006)**

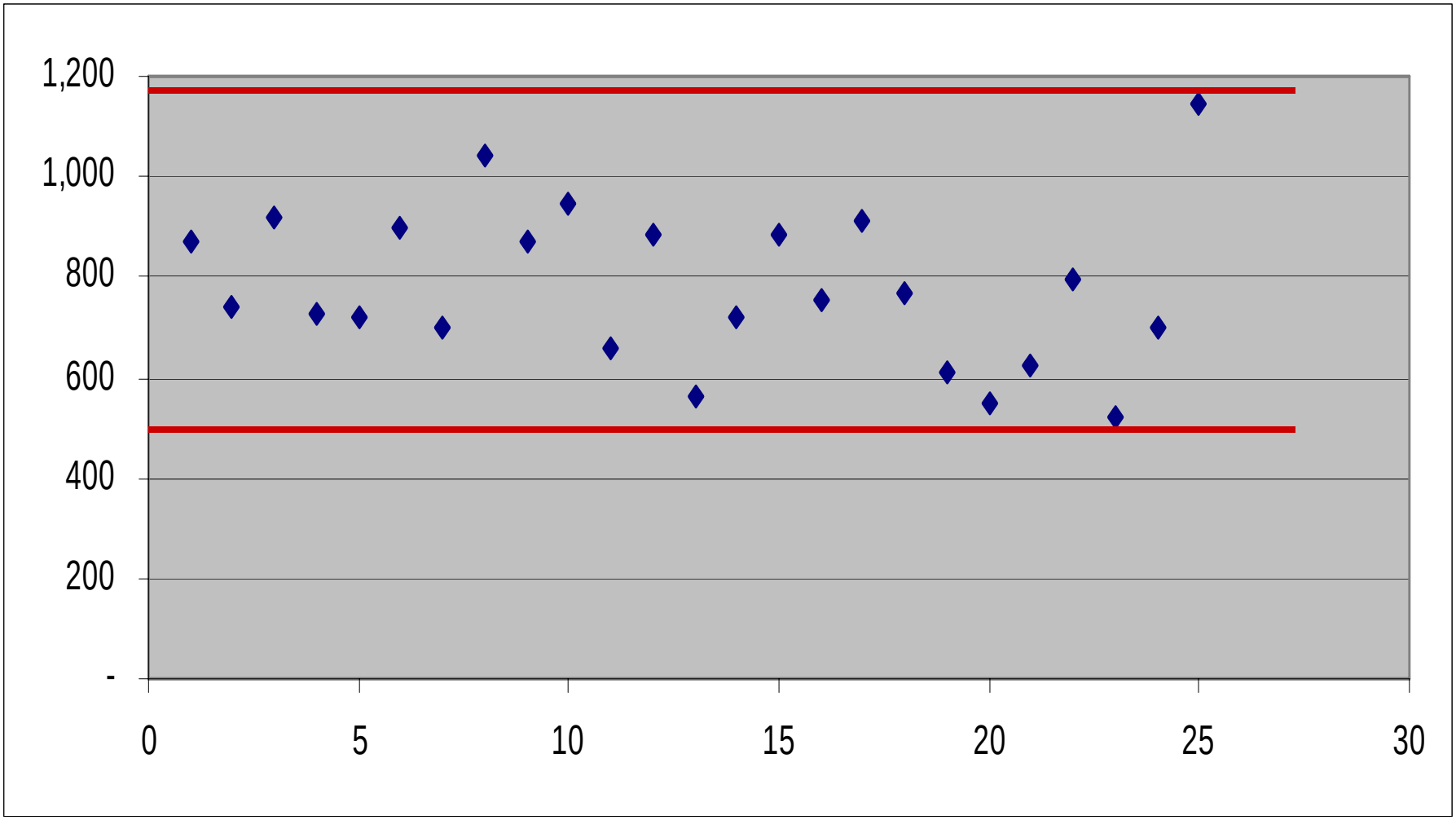
# Prediction of Digestible Lysine in DDGS Using Front Face Fluorescence



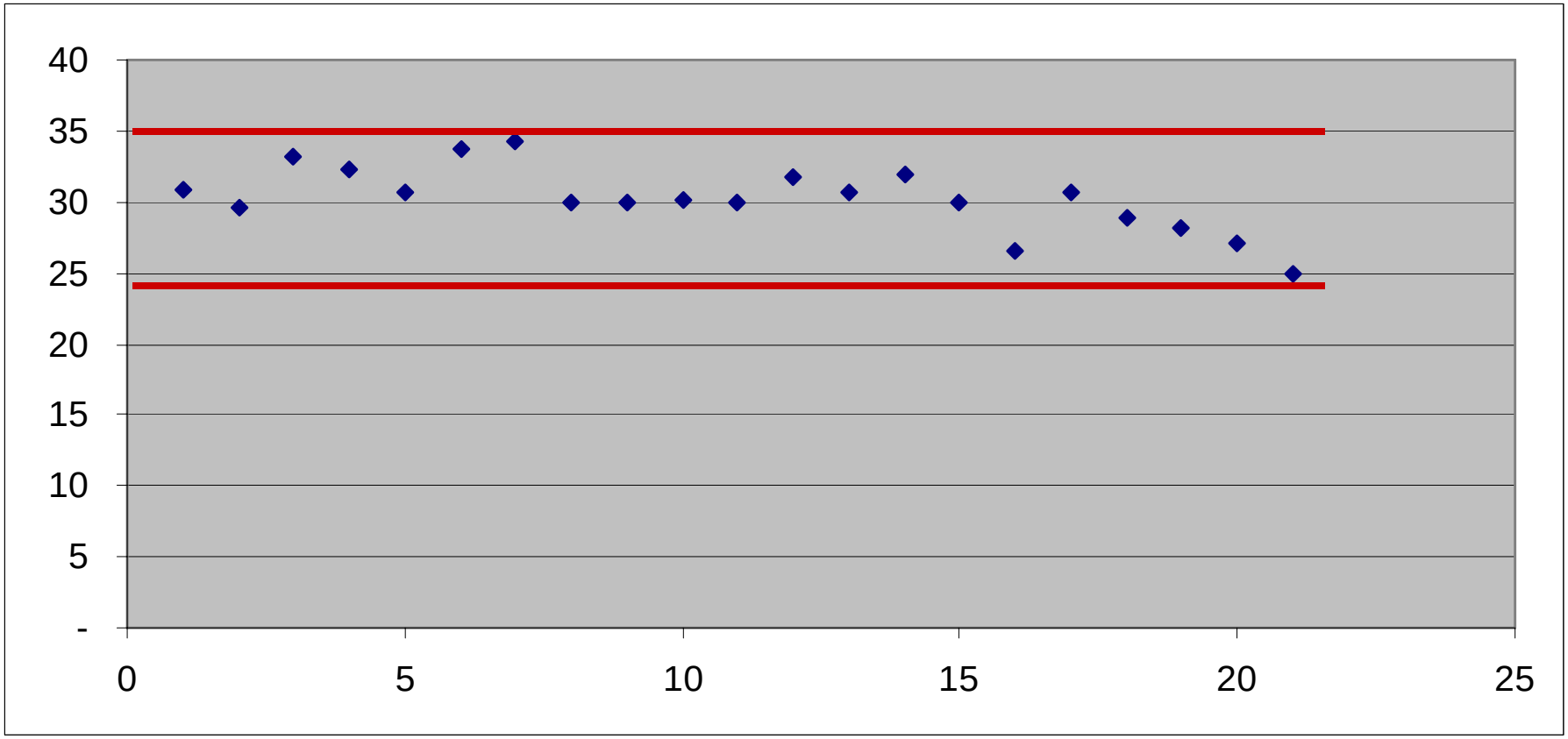

**Urriola et al. (2006)**



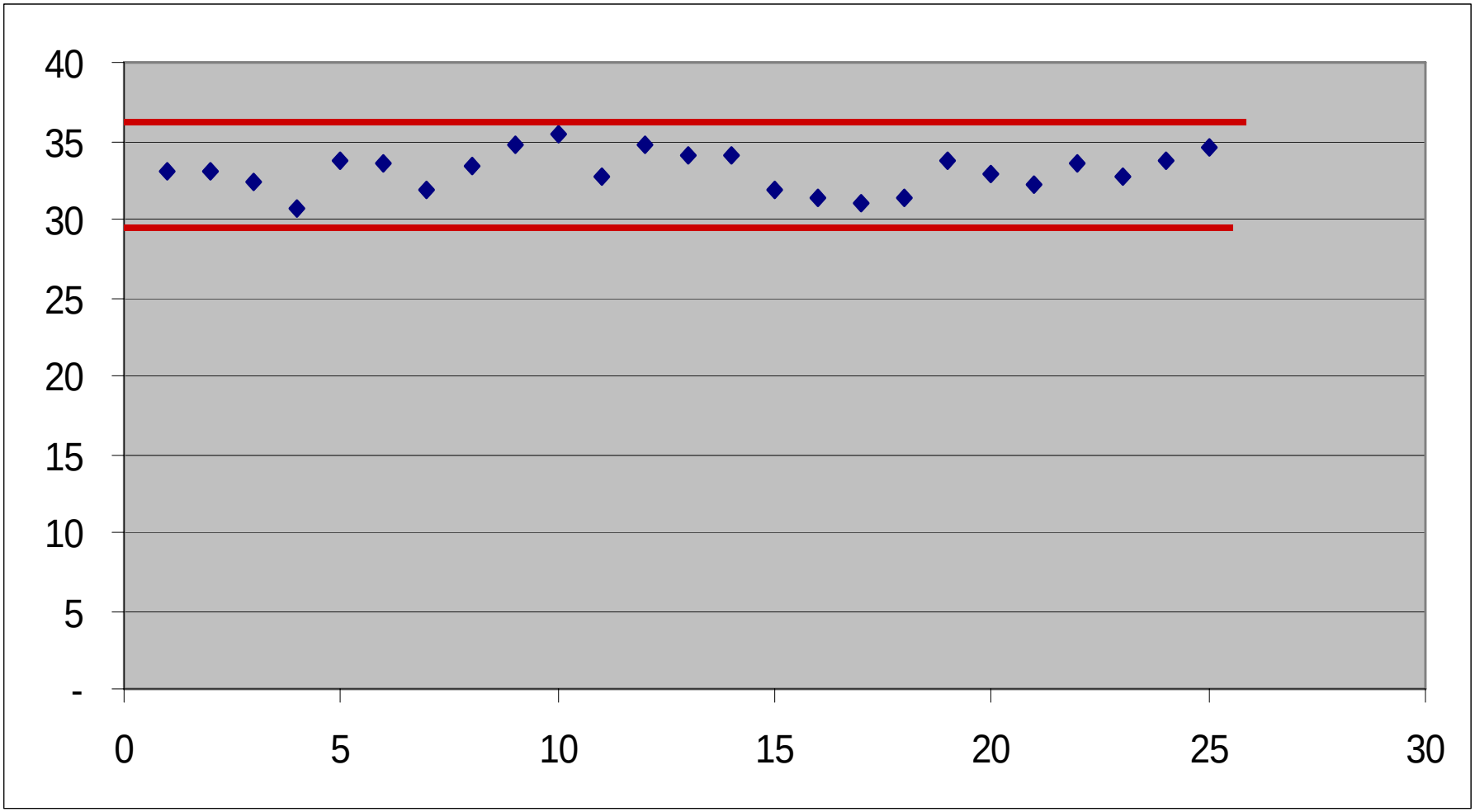

**Variation in Particle Size Among DDGS Samples Representing 25 U.S. Ethanol Plants 2005**




**Variation in Particle Size Among Soybean Meal Samples Representing 6 U.S. Plants 2005**




**Variation in Bulk Density (Lbs/Cubic Ft.) Among DDGS Samples Representing 25 U.S. Ethanol Plants**
**1/05**



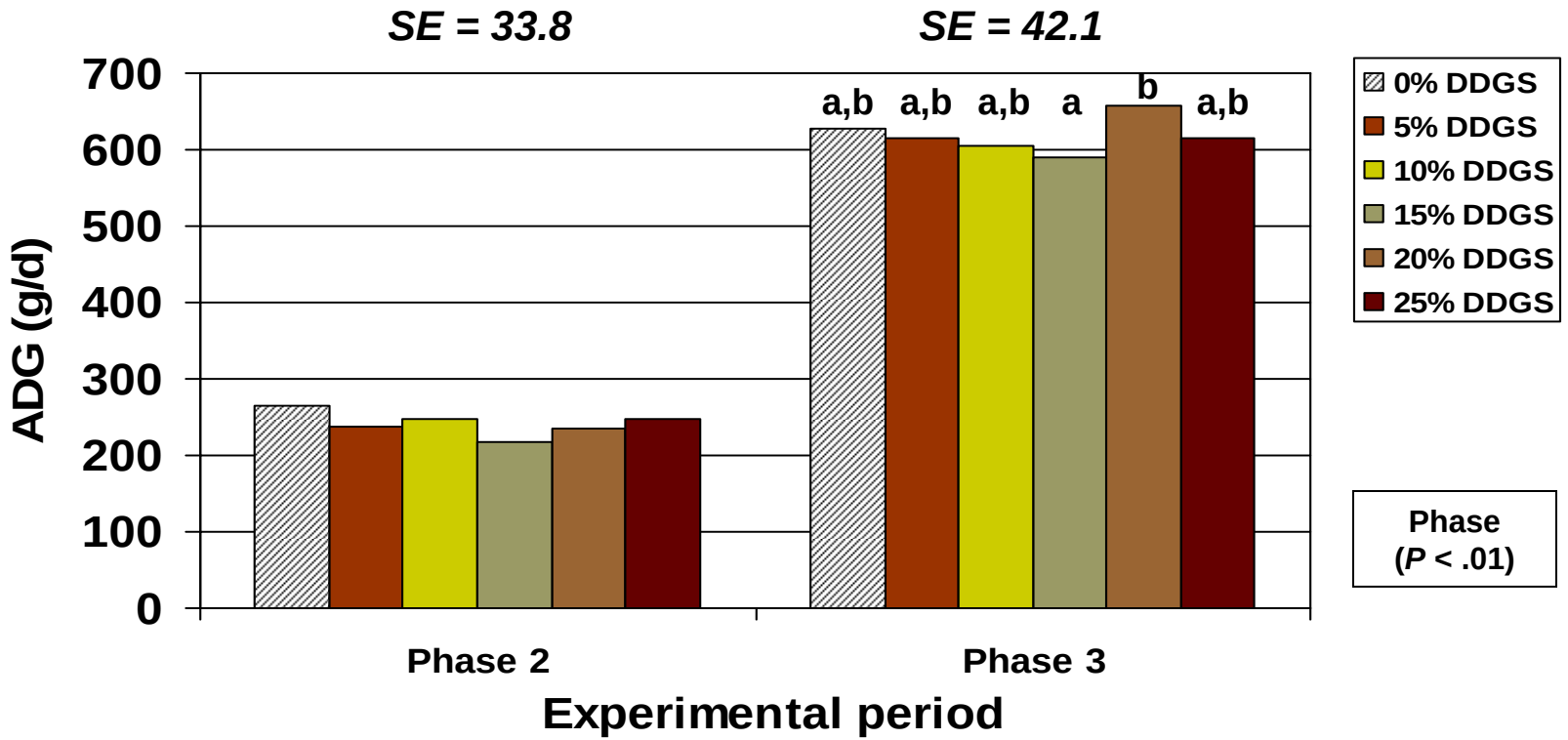

**Variation in Bulk Density (Lbs/Cubic Ft.) Among Soybean Meal Samples Representing 6 U.S. Plants 2003**

# Feeding High Quality DDGS to Weaned Pigs

# Materials and Methods – Nursery Experiments

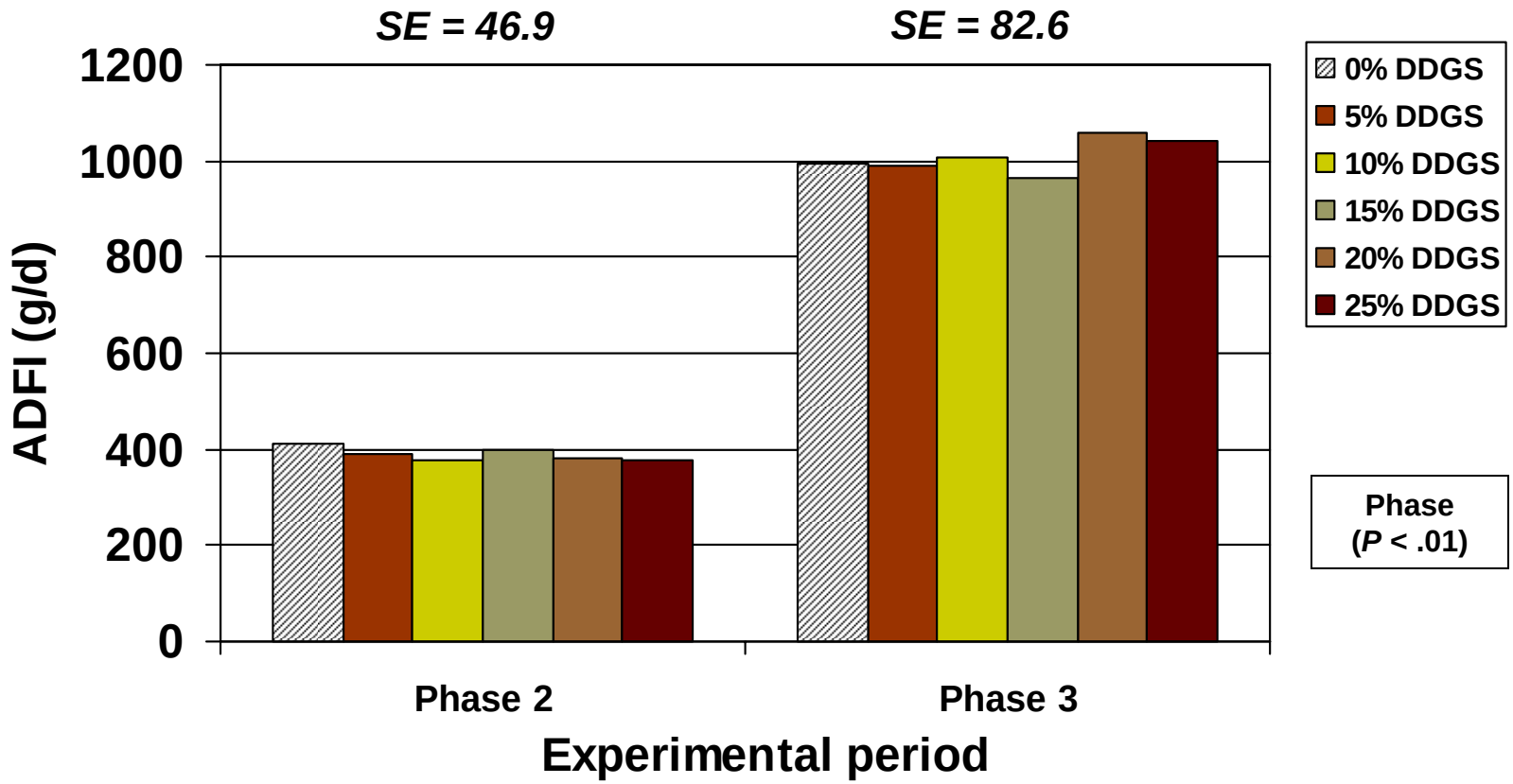
- Experiment 1
  - Pigs weaned at 19.0 ± 0.3 d of age
  - Weighed 7.10 ± 0.07 kg
- Experiment 2
  - Pigs weaned at 16.9 ± 0.4 d of age
  - Weighed 5.26 ± 0.07 kg
- Pigs were fed a commercial pelleted diet (d 0 to 3 postweaning)
- Phase II (d 4-17) and Phase III (d 18 – 35) diets were **formulated on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

# Effect of DDGS Level on Growth Rate

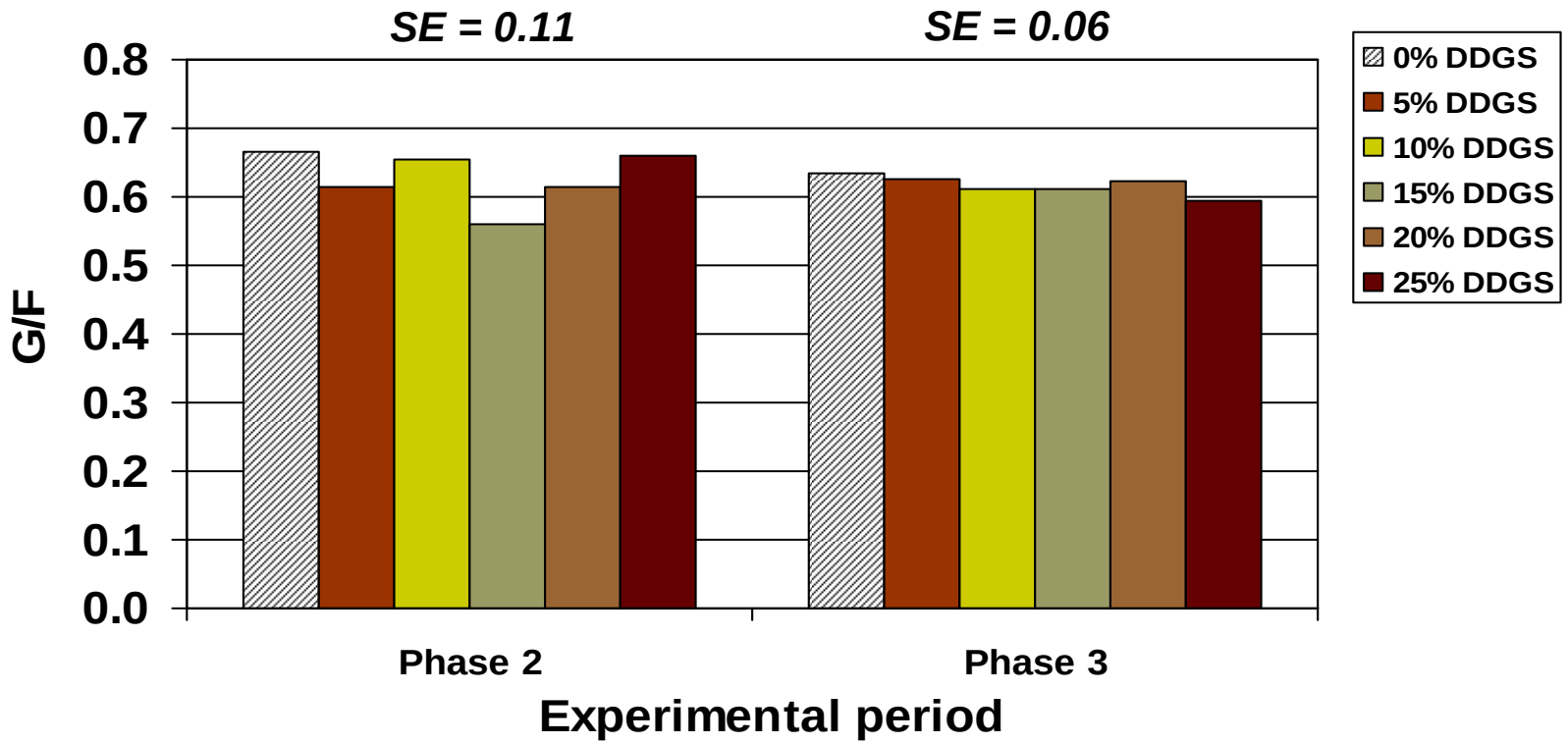



**Means not sharing a common superscript letter are significantly different ($P < .05$)**

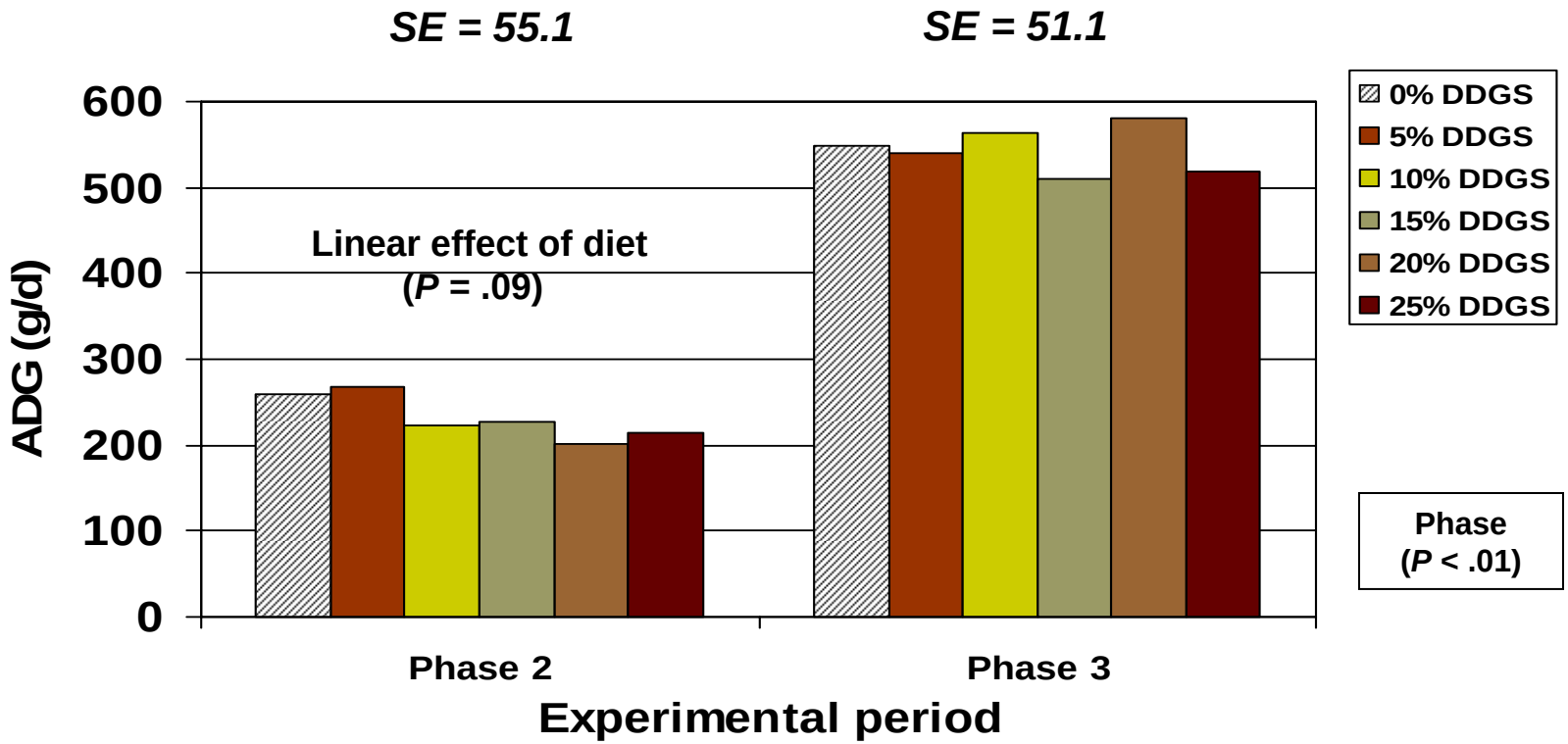
# Effect of DDGS Level on ADFI



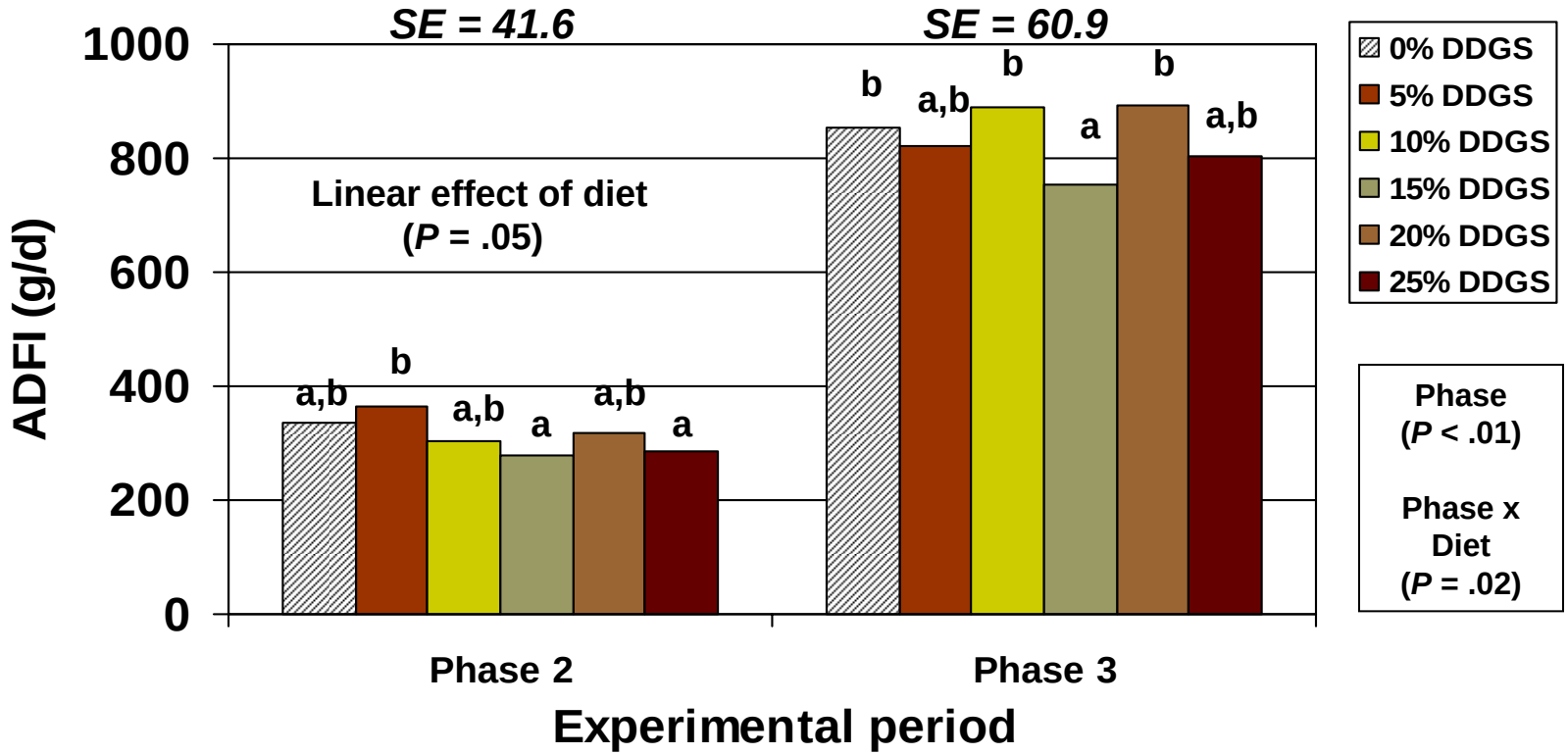
# Effect of DDGS Level on Gain/Feed



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

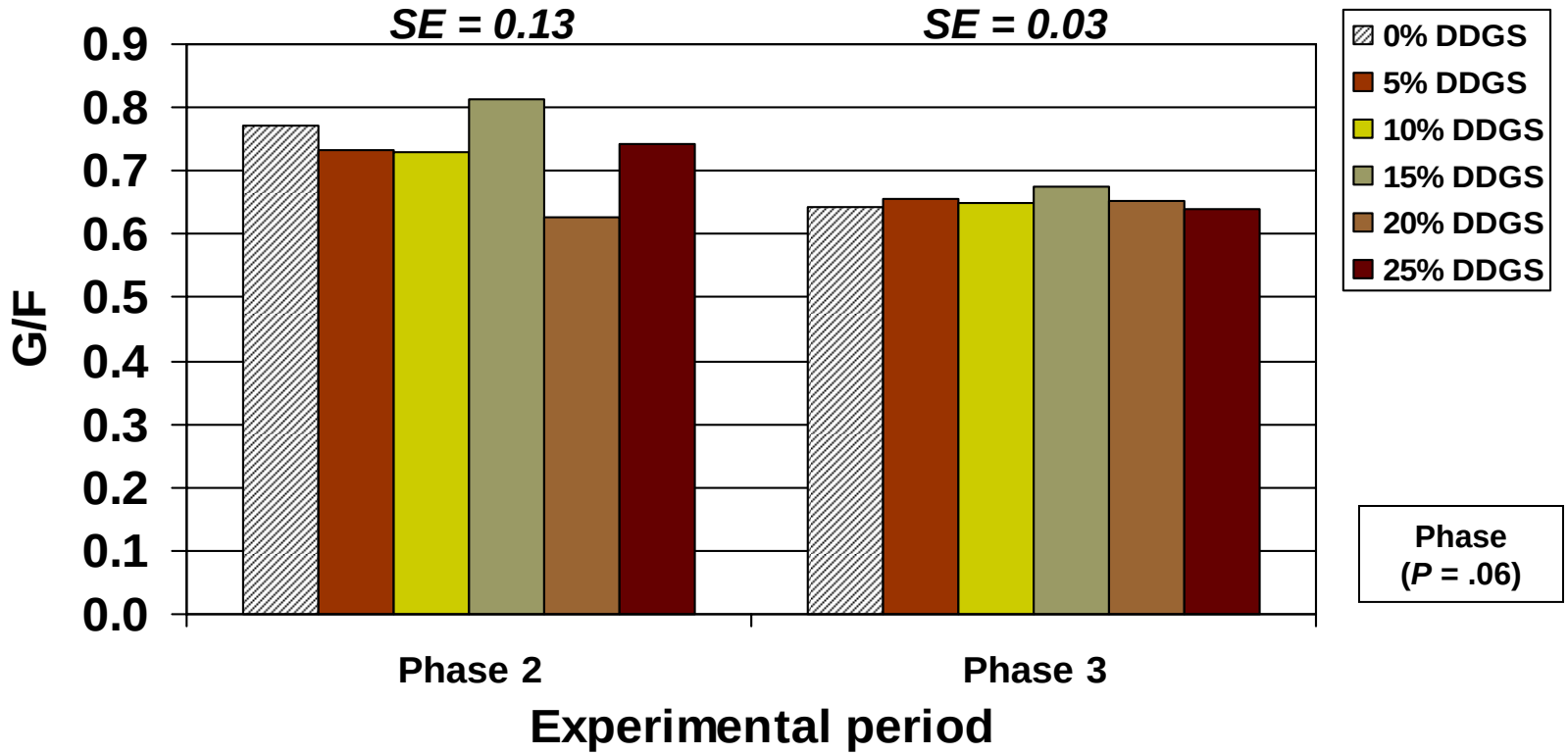


# Effect of DDGS Level on Feed Intake (Experiment 2)

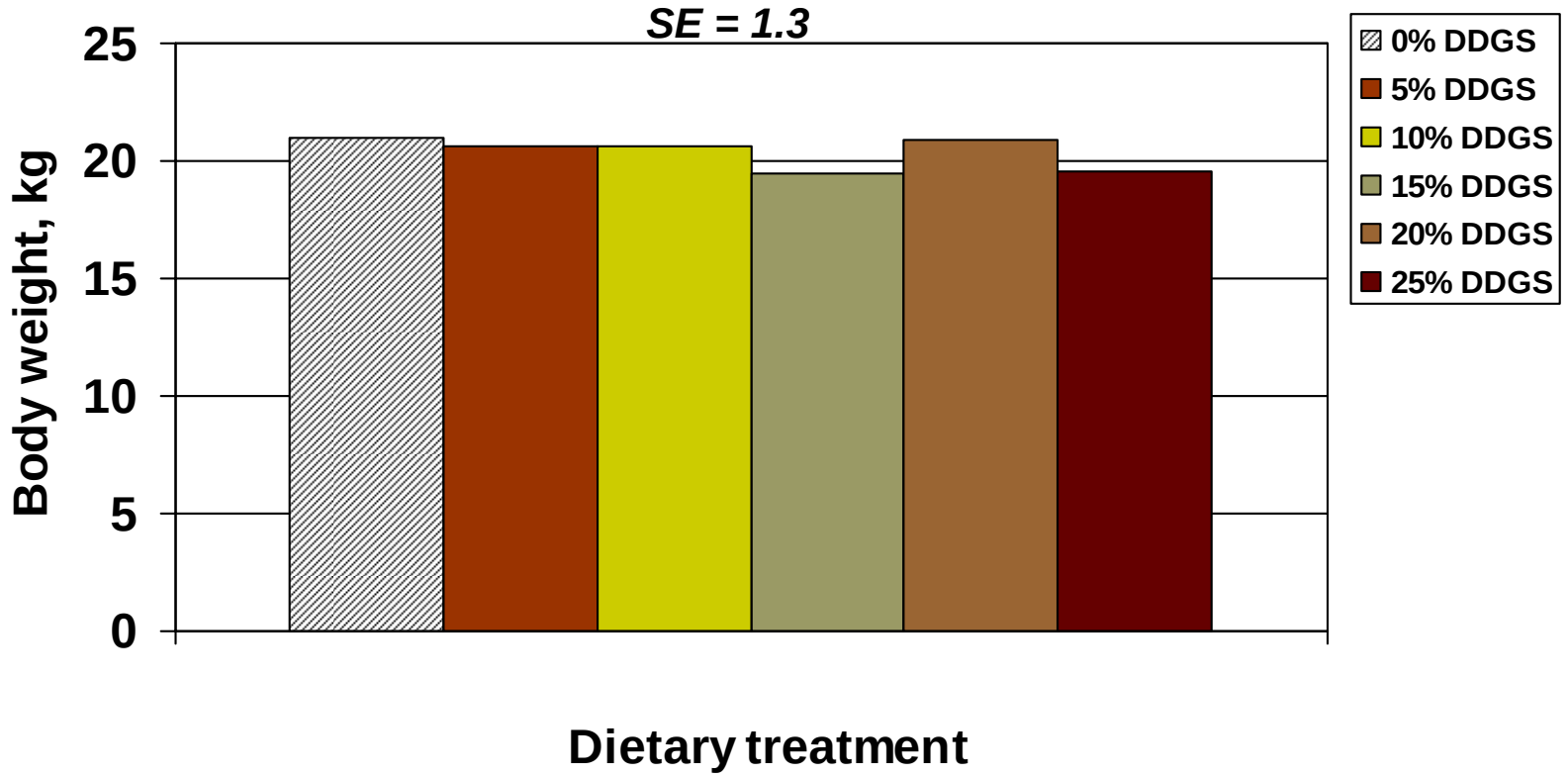



Means not sharing a common superscript letter are significantly different ($P < .05$)

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



# Effect of DDGS Level on Final BW (Experiment 2)

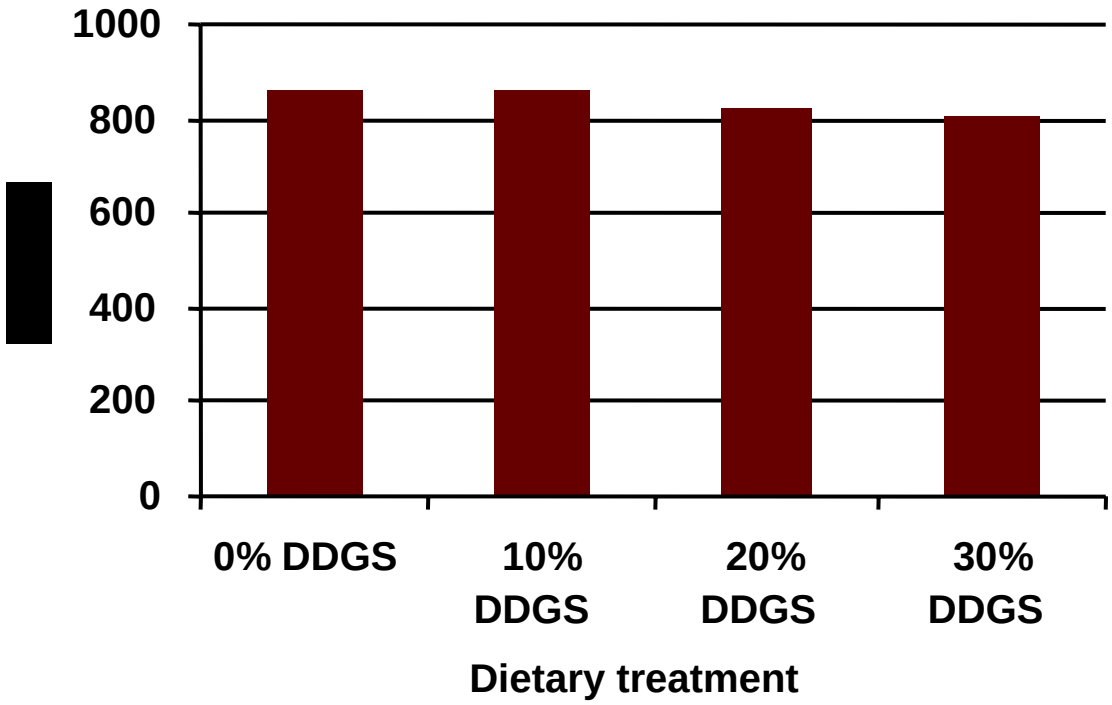


# Effects of Feeding DDGS to Grow-Finish Pigs on Growth Performance, Carcass, and Pork Quality

# Materials and Methods

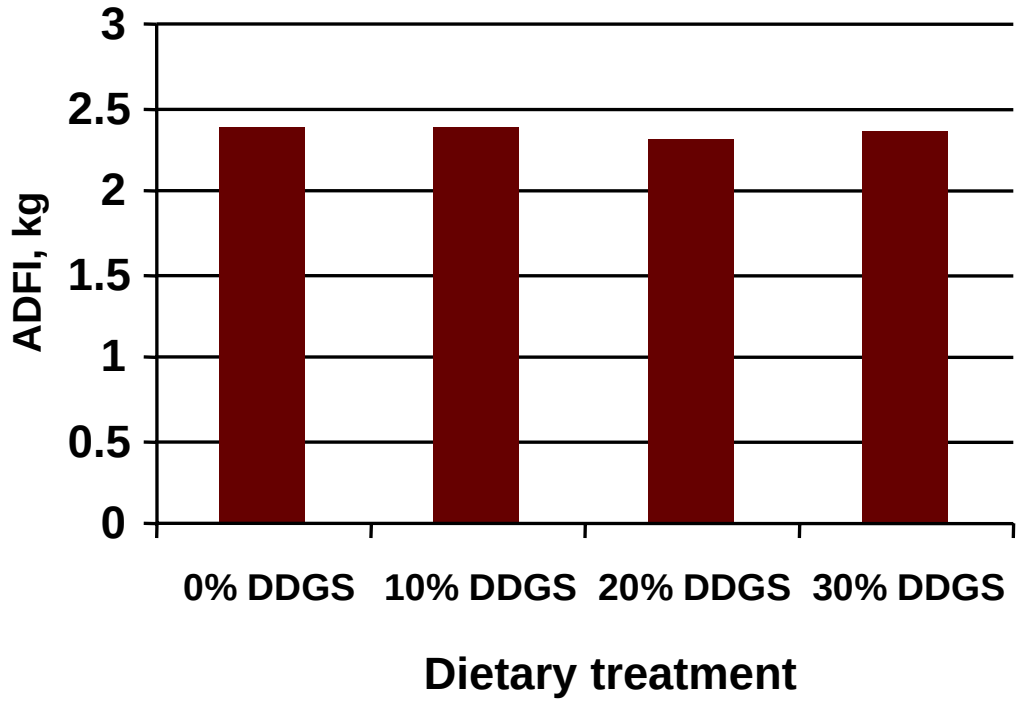
- 240 crossbred pigs (~ 63 lbs initial BW)
  - Grow-finish facilities at WCROC – Morris, MN
  - Blocked by weight, gender and litter
  - Blocks randomly assigned to 1 of 4 diet sequences
    - 5-phase feeding program
  - 0, 10, 20, or 30% DDGS diets **formulated on total lysine basis**
  - **Diets contained up to 4% soybean oil** as a supplemental fat source
  - 24 pens, 10 pigs/pen, 6 replications/trt

# Effect of Dietary DDGS Level on Overall ADG of Grow-Finish Pigs



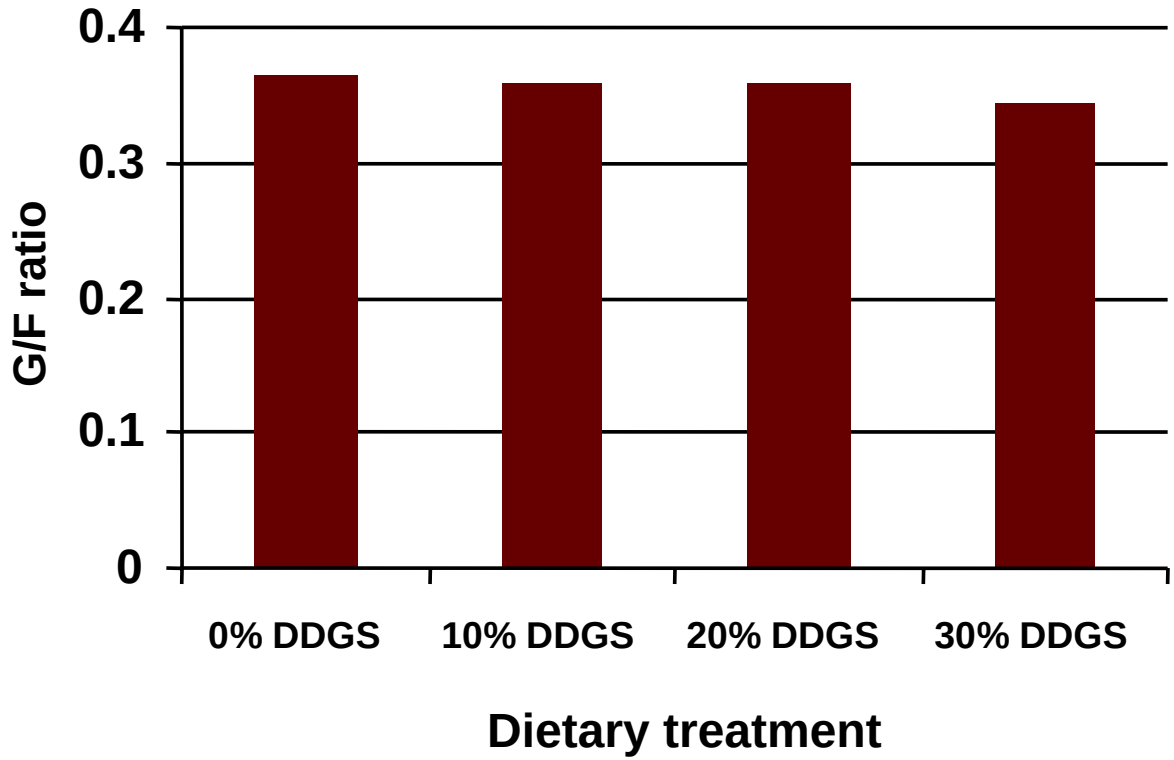

**0 % and 10 % DDGS > 20% and 30% DDGS (P < .10)**

# Effect of Dietary DDGS Level on Overall ADFI of Grow-Finish Pigs



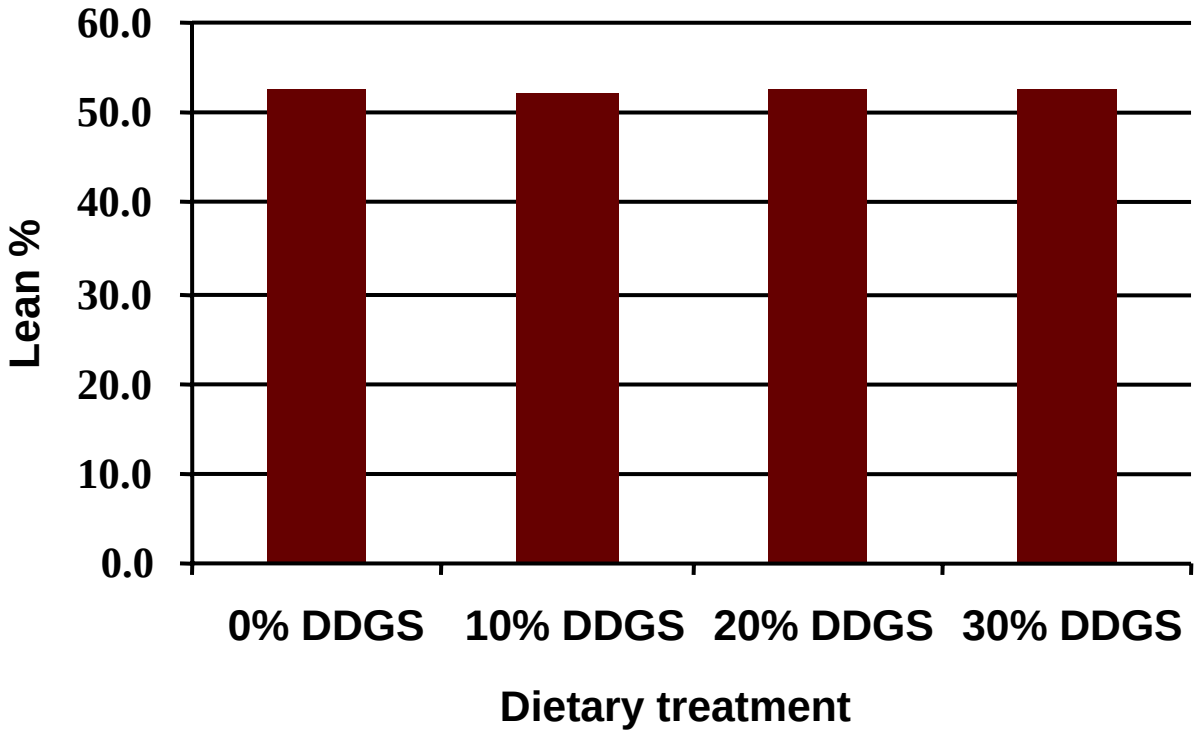

**No significant differences among dietary treatments**

# Effect of Dietary DDGS Level on Overall G/F of Grow-Finish Pigs




**0 %, 10 % and 20% DDGS > 30% DDGS (P < .10)**

# Effect of Dietary DDGS Level on % Carcass Lean




**No significant differences among dietary treatments**

# Effect of Dietary DDGS Level on Carcass Characteristics of Grow-Finish Pigs

| | 0% DDGS | 10% DDGS | 20% DDGS | 30% DDGS |
|---|---|---|---|---|
| **Slaughter weight, lbs** | 258 | 263 | 249 | 247 |
| **Carcass weight, lbs** | 189[c] | 191[c] | 180[d] | 178[d] |
| **Dressing %** | 73.4[c] | 72.8[c] | 72.1[d] | 71.9[d] |
| **Fat depth, in.** | 0.85 | 0.87 | 0.84 | 0.82 |
| **Loin depth, in.** | 2.26[ac] | 2.16[b] | 2.19[c] | 2.06[d] |
| **% Lean** | 52.6 | 52.0 | 52.6 | 52.5 |

[a, b] Means within row with unlike superscripts differ (P < .05).

[c, d] Means within row with unlike superscripts differ (P < .10).

# Muscle Quality Characteristics from Grow-Finish Pigs Fed Diets Containing 0, 10, 20, and 30% DDGS

| Trait | 0 % | 10 % | 20 % | 30 % | RMSE |
|---|---|---|---|---|---|
| L*[a] | 54.3 | 55.1 | 55.8 | 55.5 | 2.9 |
| Color score[b] | 3.2 | 3.2 | 3.1 | 3.1 | 0.8 |
| Firmness score[c] | 2.2 | 2.0 | 2.1 | 2.1 | 0.5 |
| Marbling score[d] | 1.9 | 1.9 | 1.7 | 1.9 | 0.6 |
| Ultimate pH | 5.6 | 5.6 | 5.6 | 5.6 | 0.2 |
| 11-d purge loss, % | 2.1[f] | 2.4[fg] | 2.8[g] | 2.5[fg] | 1.2 |
| 24-h drip loss | 0.7 | 0.7 | 0.7 | 0.7 | 0.2 |
| Cooking loss, % | 18.7 | 18.5 | 18.3 | 18.8 | 2.6 |
| Total moisture loss[e], % | 21.4 | 21.5 | 21.8 | 22.1 | 3.1 |
| Warner-Bratzler sheer force, kg | 3.4 | 3.4 | 3.3 | 3.3 | 0.5 |

[a] 0 = black, 100 = white
[b] 1=pale pinkish gray/white; 2=grayish pink; 3=reddish pink; 4=dark reddish pink; 5=purplish red; 6=dark purplish red
[c] 1 = soft, 2 = firm, 3 = very firm
[d] Visual scale approximates % intramuscular fat content (NPPC, 1999)
[e] Total moisture loss = 11-d purge loss + 24-h drip loss + cooking loss

# Fat Quality Characteristics of Market Pigs Fed Corn-Soy Diets Containing 0, 10, 20, and 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).

# U of M/Land O' Lakes
# Pork Fat Quality Field Study (2006)

- Facilities
  - Two commercial 1000 head finishing barns in southern MN
  - Separate sites, two independent producers
  - Each barn had 40 pens, double sided curtain
    - buildings with 8' pits
    - pit fans for ventilation
    - weighted baffle ceiling air inlets

- Genetics
  - Monsanto Genepacker sows
  - Monsanto EB terminal semen

# U of M/Land O' Lakes
# Pork Fat Quality Field Study (2006)

- **Nutrition**
  - Provided by Land O' Lakes
  - Producer A fed typical corn-soybean meal diets
  - Producer B fed corn-soybean meal diets containing 10% DDGS
  - 7-phase mixed sex feeding program
  - Last finisher diet contained 4.5g Paylean
  - Diets contained similar nutrient levels with and without 10% DDGS
  - All diets contained choice white grease as the supplemental fat source (1.25 to 3.75%).

# Carcass Characteristics of Grow-Finish Pigs Fed 0 or 10% DDGS Diets (UM/LOL Field Trial)

| Measurement | 0% DDGS Diets | 10% DDGS Diets |
|---|---|---|
| Carcass weight, lbs | 212 | 210 |
| Last rib backfat, in. | 1.09 | 1.11 |
| Tenth rib backfat, in. | 1.01 | 0.99 |
| Ham, % | 11.74 | 11.74 |
| Loin, % | 7.93 | 7.91 |
| Belly, % | 10.51 | 10.41 |
| Loin depth, in. | 2.72 | 2.72 |
| Lean % | 56.36 | 56.47 |

No significant differences in carcass characteristics.

# Mid-Belly Fat Quality Characteristics of Carcasses of Grow-Finish Pigs Fed 0 or 10% DDGS Diets (UM/LOL Field Trial)

| Measurement | 0% DDGS Diets | 10% DDGS Diets |
|---|---|---|
| Japanese fat color score (1-4) | 1.76 | 1.81 |
| Mean melting point, °C | 29.26 | 28.70 |
| Iodine value | 66.7[a] | 68.3[b] |
| 14:0, 16:0, 16:1, 17:0, 17:1, 18:0, % | No differences | No differences |
| 18:1 oleic acid, % | 47.39[c] | 45.12[d] |
| 18:2 linoleic acid, % | 11.94[c] | 13.98[d] |
| 18:3, 18:4, 20:0, 20:1, 20:2, 20:4, % | No differences | No differences |
| Saturated fatty acids, % | 33.99 | 34.26 |
| Monounsaturated fatty acids, % | 51.78[c] | 49.47[d] |
| PUFA, % | 14.02[c] | 16.11[d] |
| Total Omega 3, % | 0.98 | 0.96 |
| Total Omega 6, % | 13.02[c] | 15.14[d] |
| Omega 6:Omega 3 ratio | 13.28[c] | 15.78[d] |

[a, b] **Means within rows with unlike superscripts differ (P < .05).**

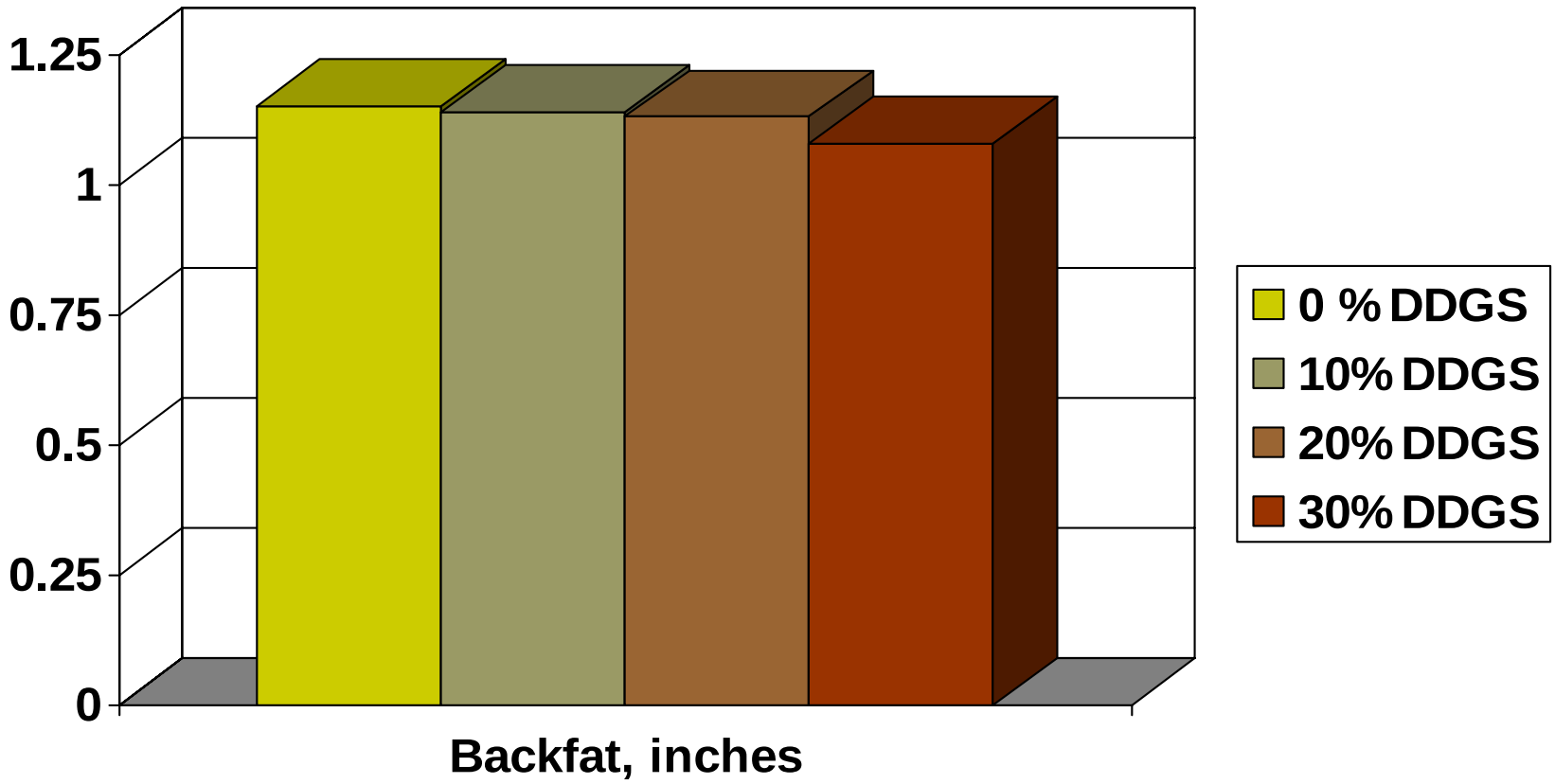
[c, d] **Means within rows with unlike superscripts differ (P < .0001).**

# Effect of Formulating G-F Diets on a Digestible Amino Acid Basis, with Increasing Levels of DDGS, on Overall Growth Performance

| | 0% DDGS | 10% DDGS | 20% DDGS | 30% DDGS |
|---|---|---|---|---|
| **Initial wt., lbs** | 49.7 | 50.3 | 49.7 | 49.7 |
| **Final wt., lbs** | 252 | 253 | 251 | 250 |
| **ADG, lbs** | 2.00 | 2.00 | 1.99 | 1.99 |
| **ADFI, lbs** | 5.76 | 5.58 | 5.55 | 5.45 |
| **F/G** | 2.88 | 2.80 | 2.79 | 2.75 |

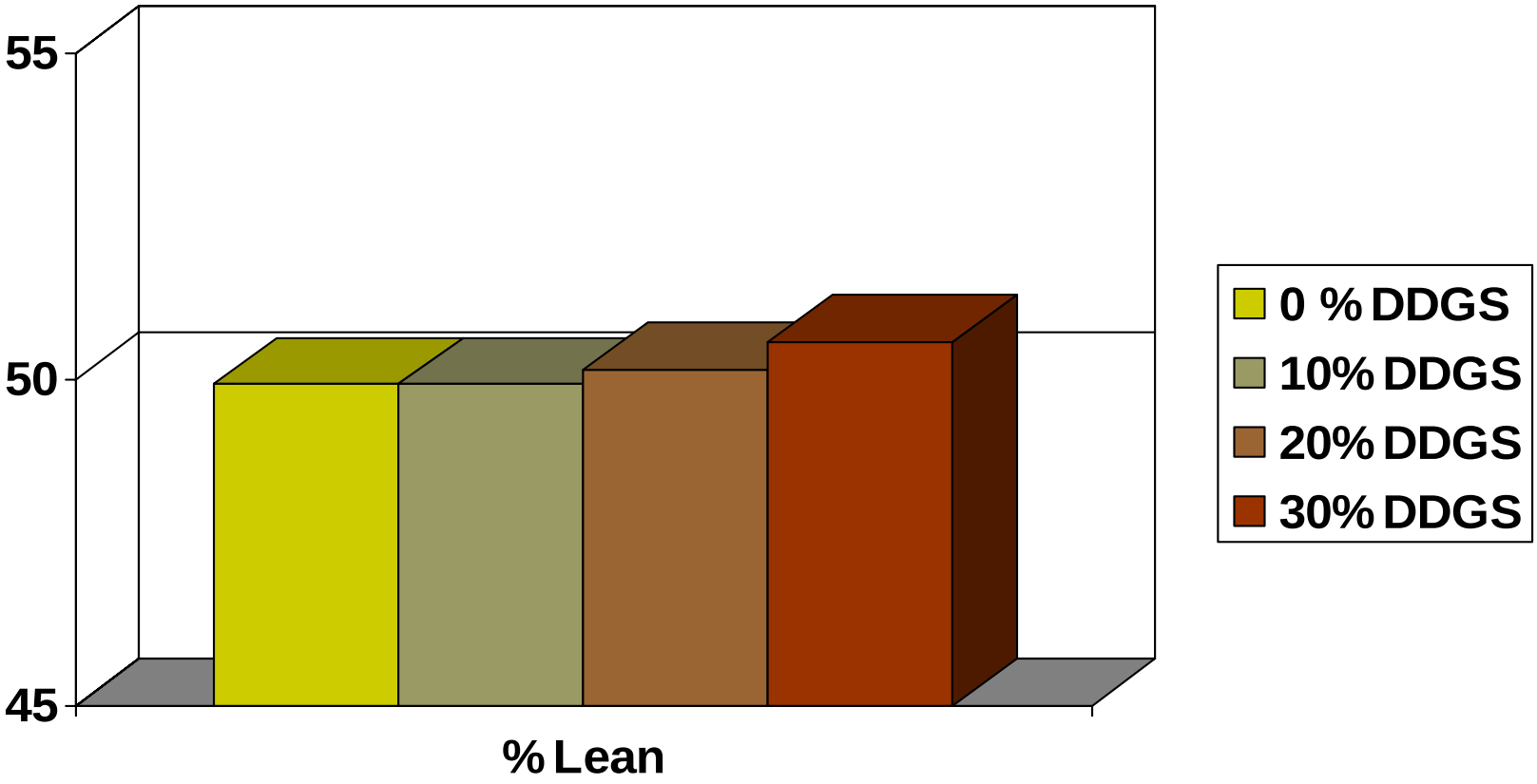
Xu et al. (2006) unpublished
Data from 32 pens, 8 pens/treatment

# Effects of Dietary DDGS Level on Last Rib Backfat



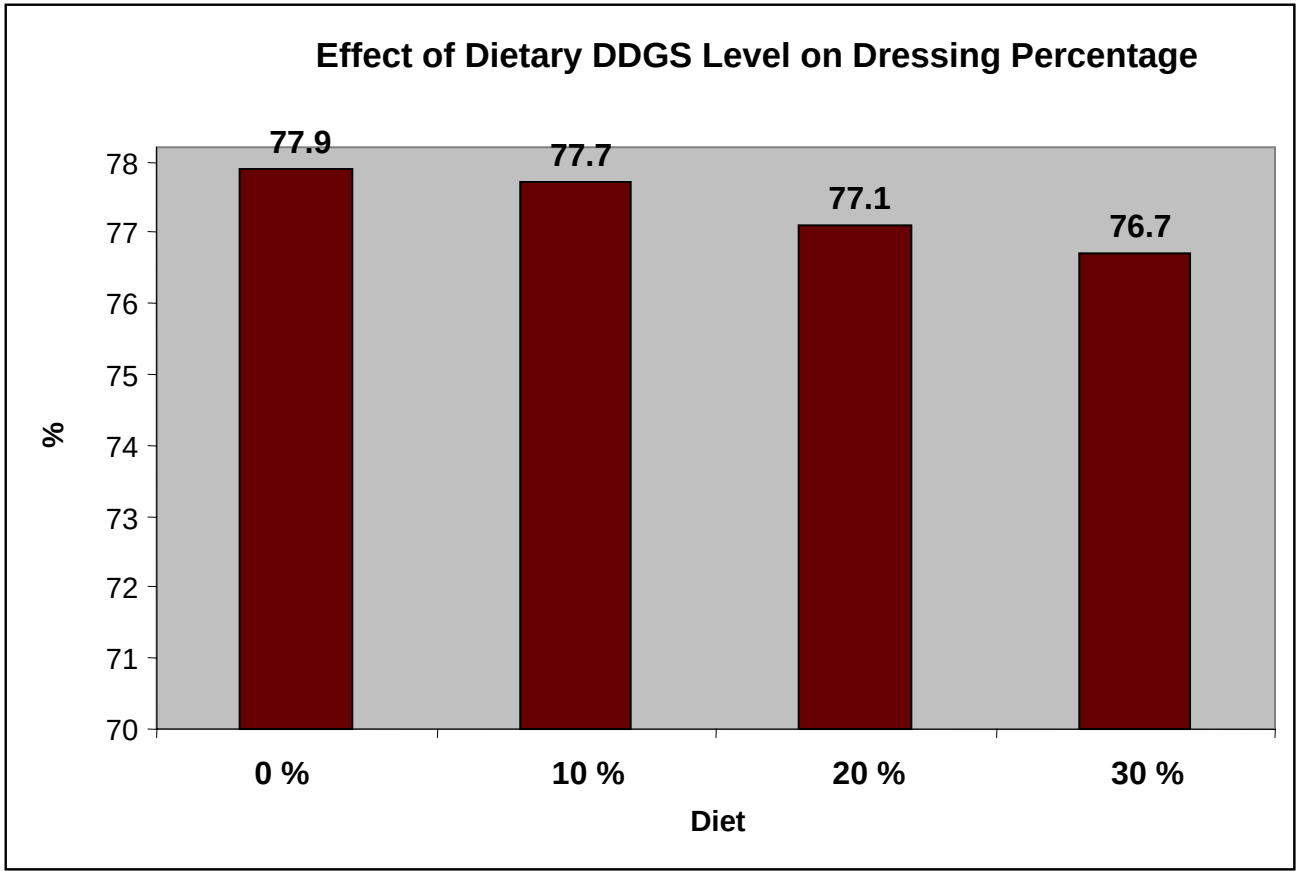

Xu et al. (2006) unpublished
30% DDGS tended to be lower than 0% DDGS (P = 0.09)

# Effects of Dietary DDGS Level on % Carcass Lean



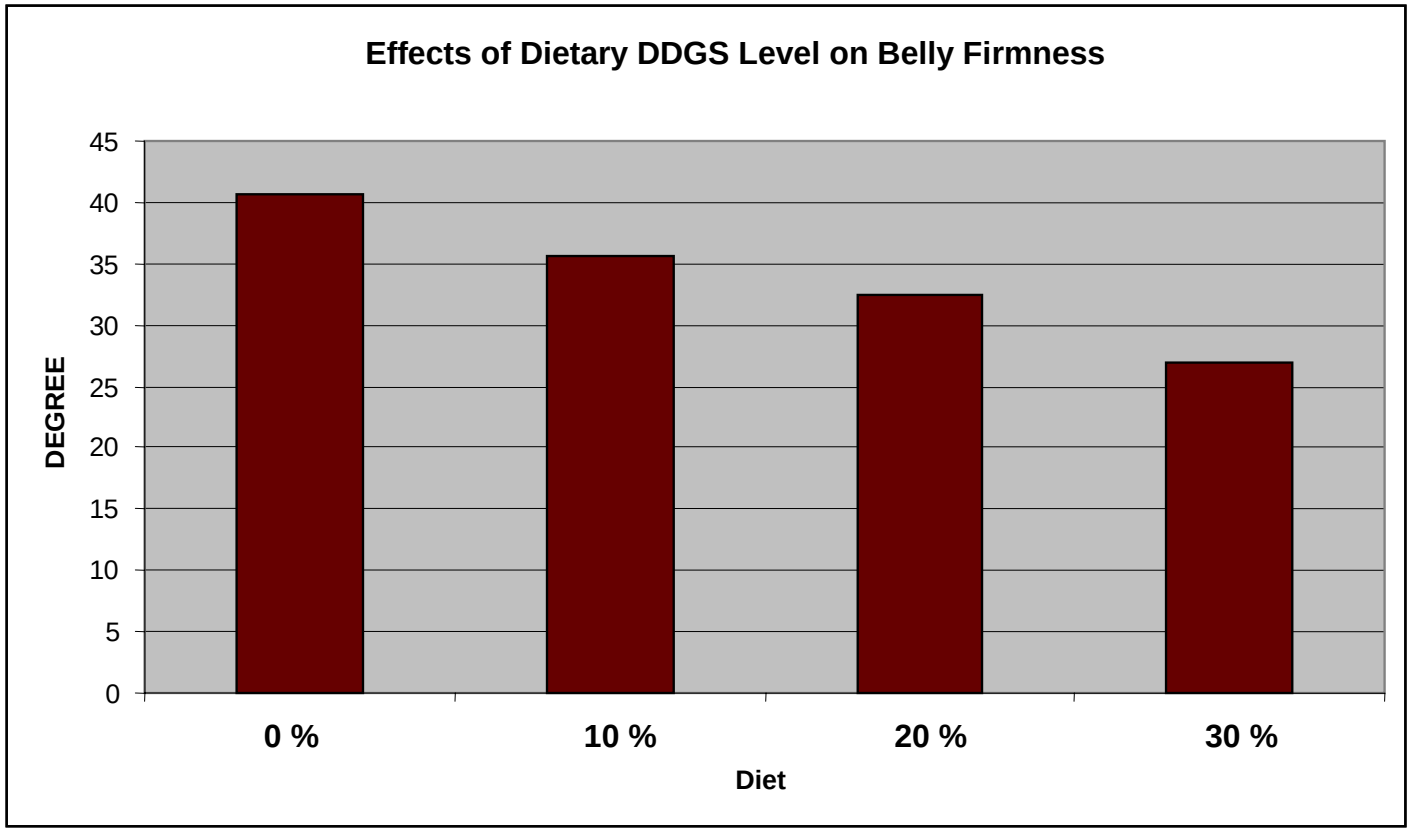

Xu et al. (2006) unpublished
30% DDGS tended to be higher than 0% DDGS (P = 0.11)

# Adding DDGS to Grower-Finisher Diets Slightly Reduces Carcass Yield




Xu et al. (2006) unpublished
Linear effect ($P < 0.01$)

# Adding Increasing Levels of DDGS to G-F Diets Reduces Belly Firmness



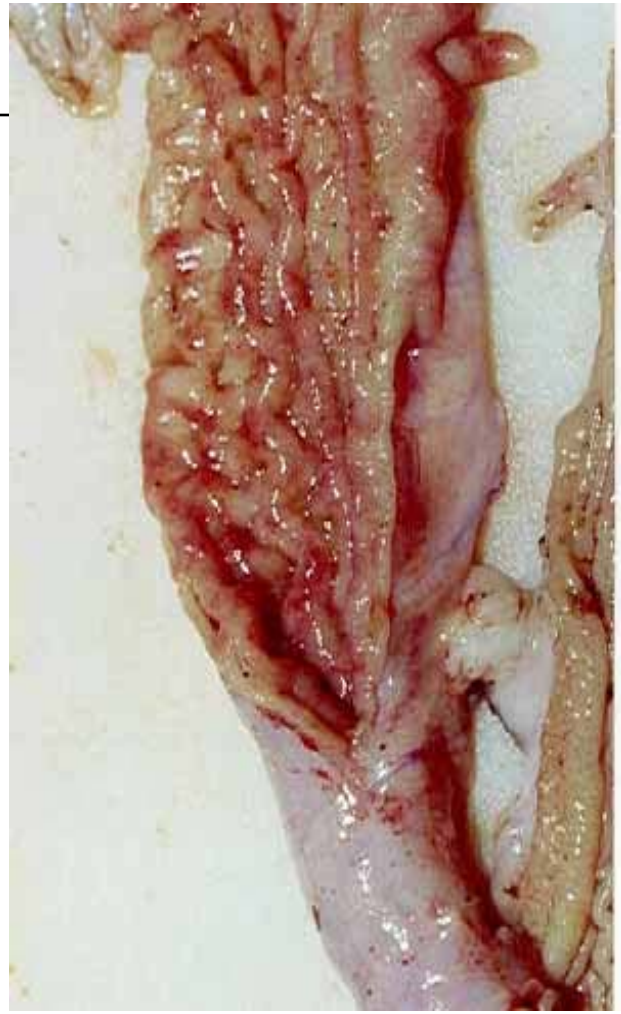

Xu et al. (2006) unpublished

# Unique, Value-Added Attributes of DDGS Have Been Identified

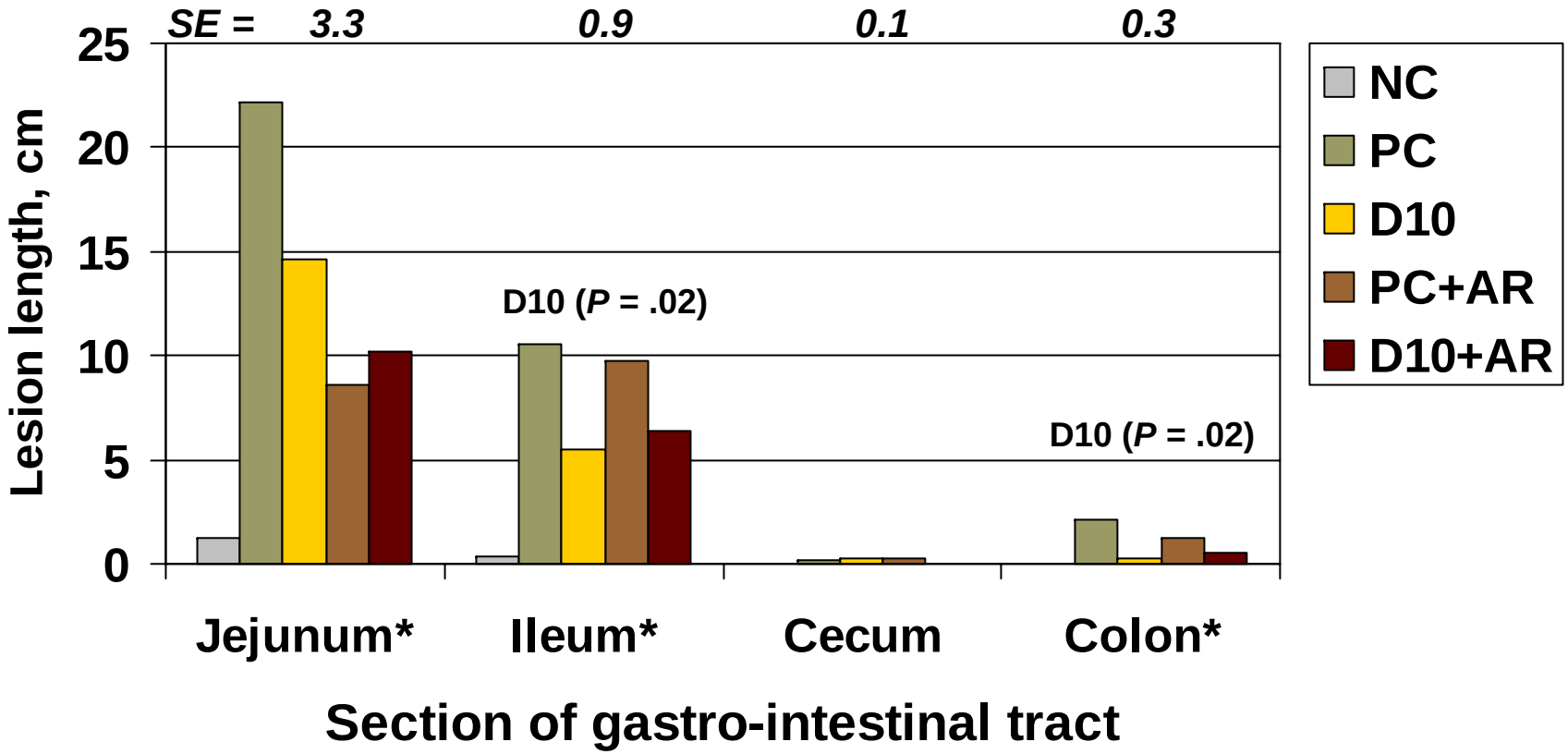
- DDGS may improve gut health related to *Lawsonia intracellularis*
- Phytase and DDGS can reduce manure P excretion
- Feeding high levels of DDGS to sows may improve litter size weaned

# Healthy

# Ileitis

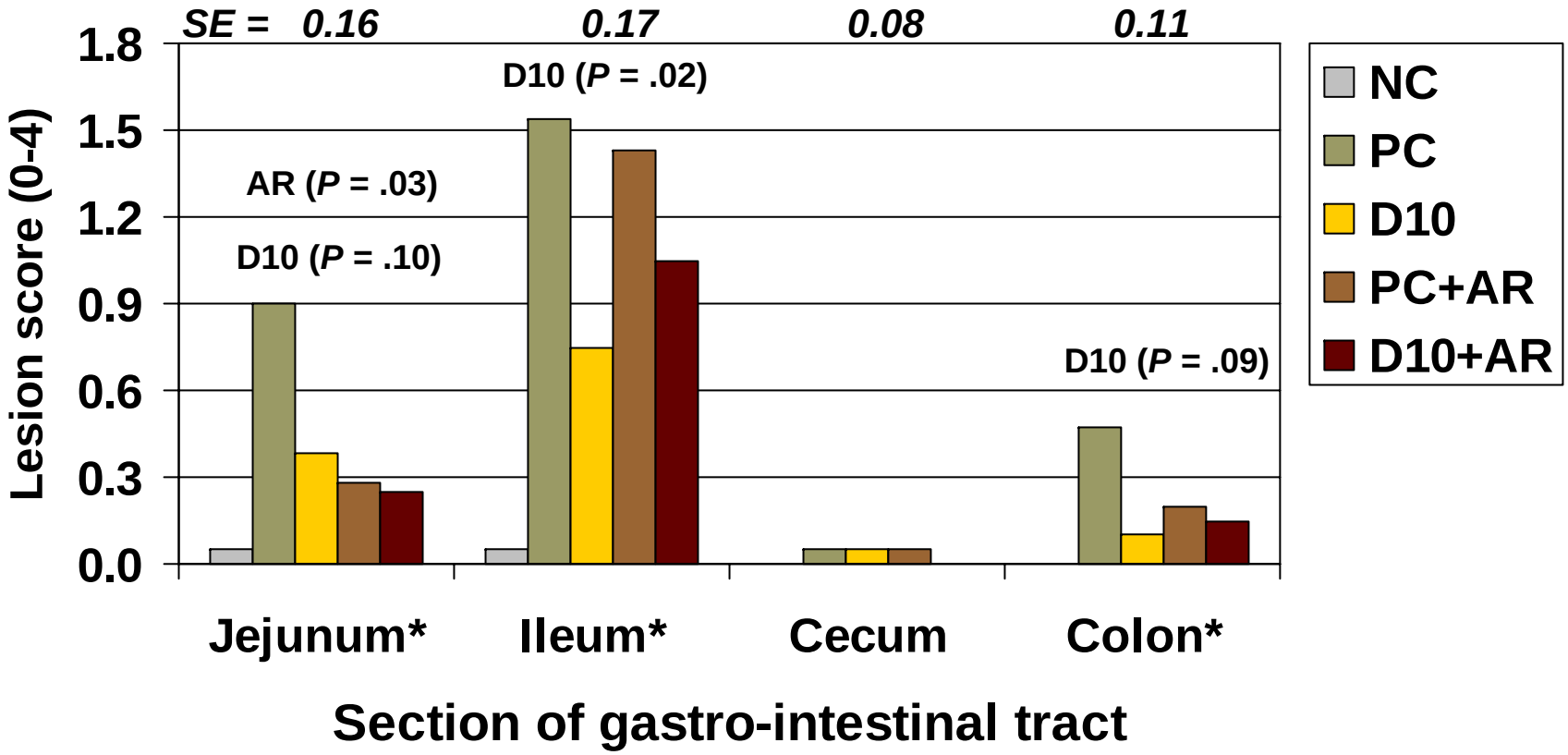


# Effect of Dietary Treatment on Lesion Length (21 d Post-Challenge) Experiment 2



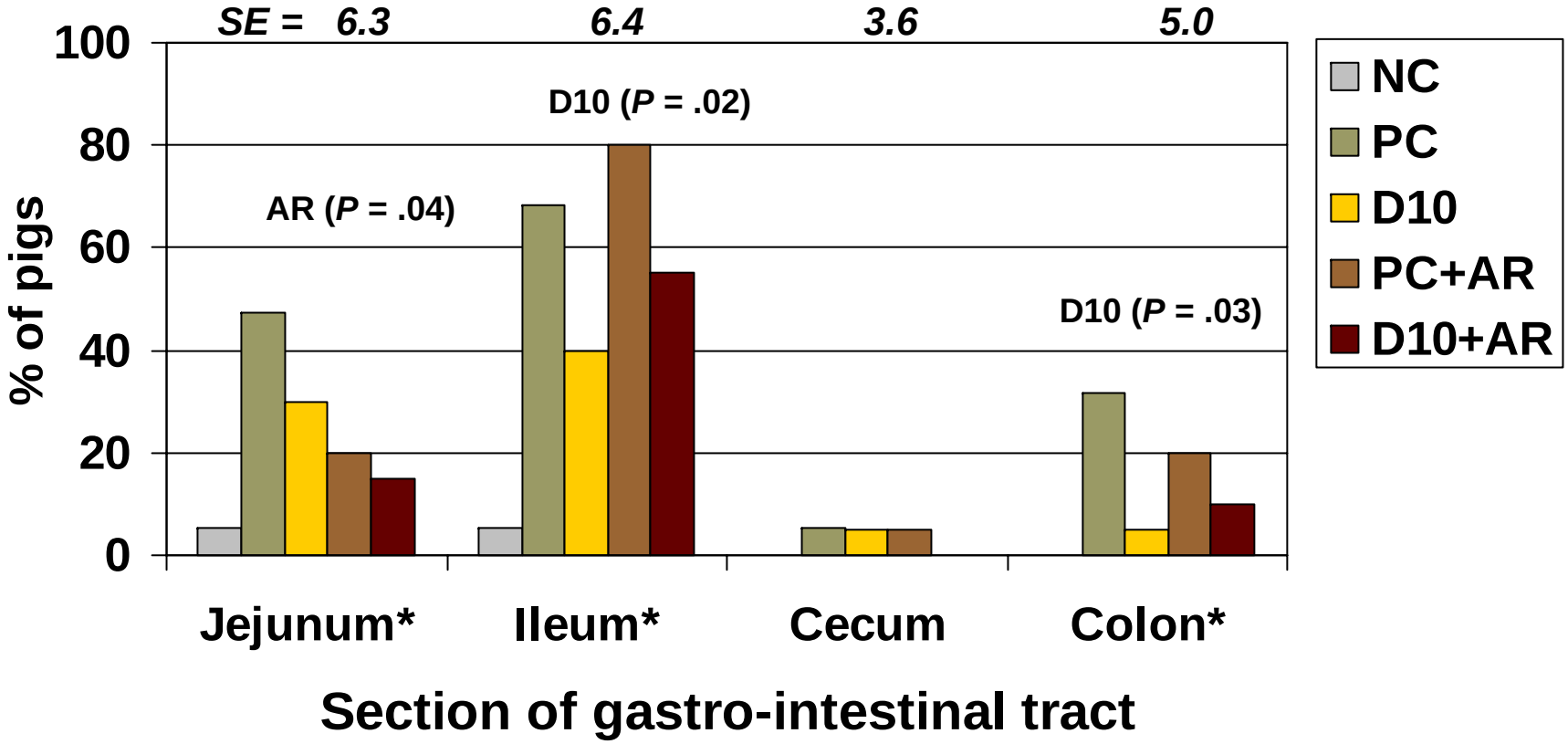

* Effect of disease challenge ($P < .01$).

# 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



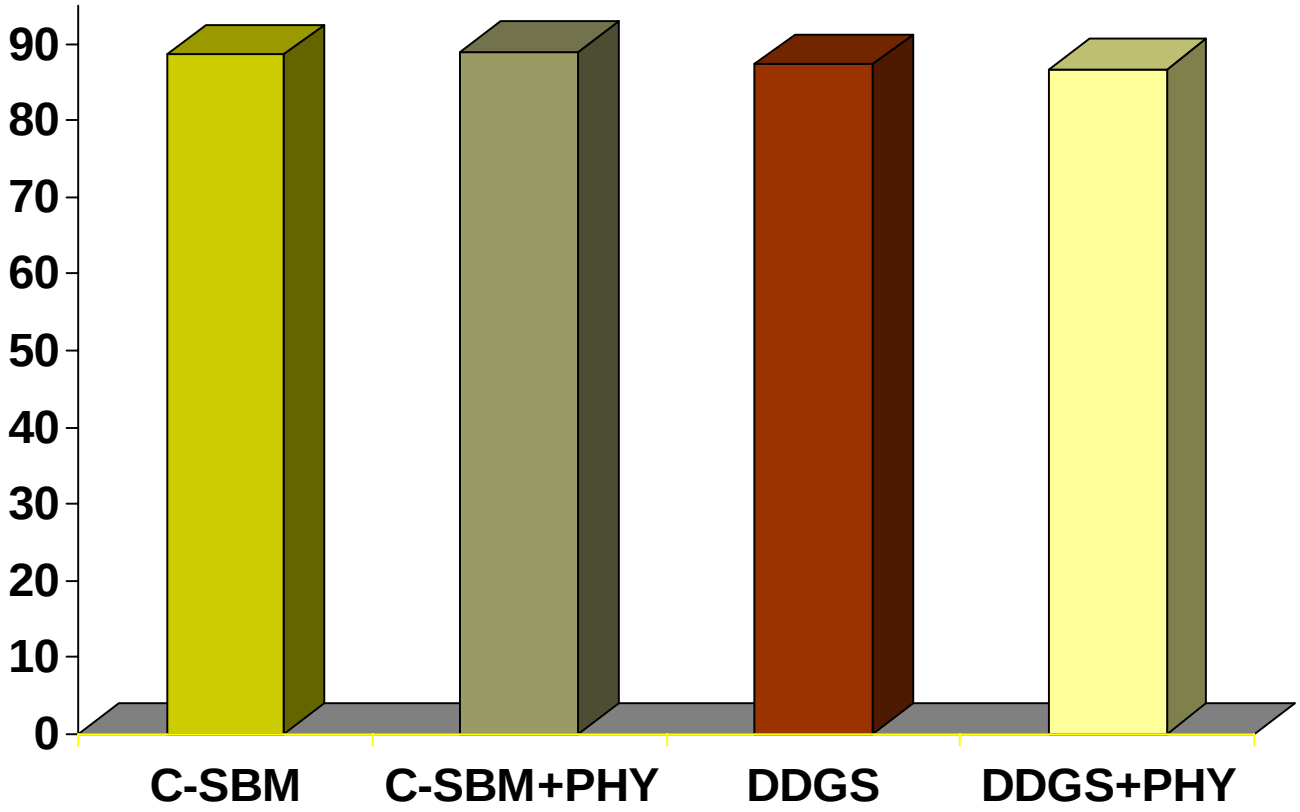

* Effect of disease challenge ($P < .01$).

# Effects of Feeding DDGS to Swine on Dry Matter Digestibility (Manure Volume)

# Diet Composition When 18.8% DDGS and Phytase are Added to a Swine Grower Diet

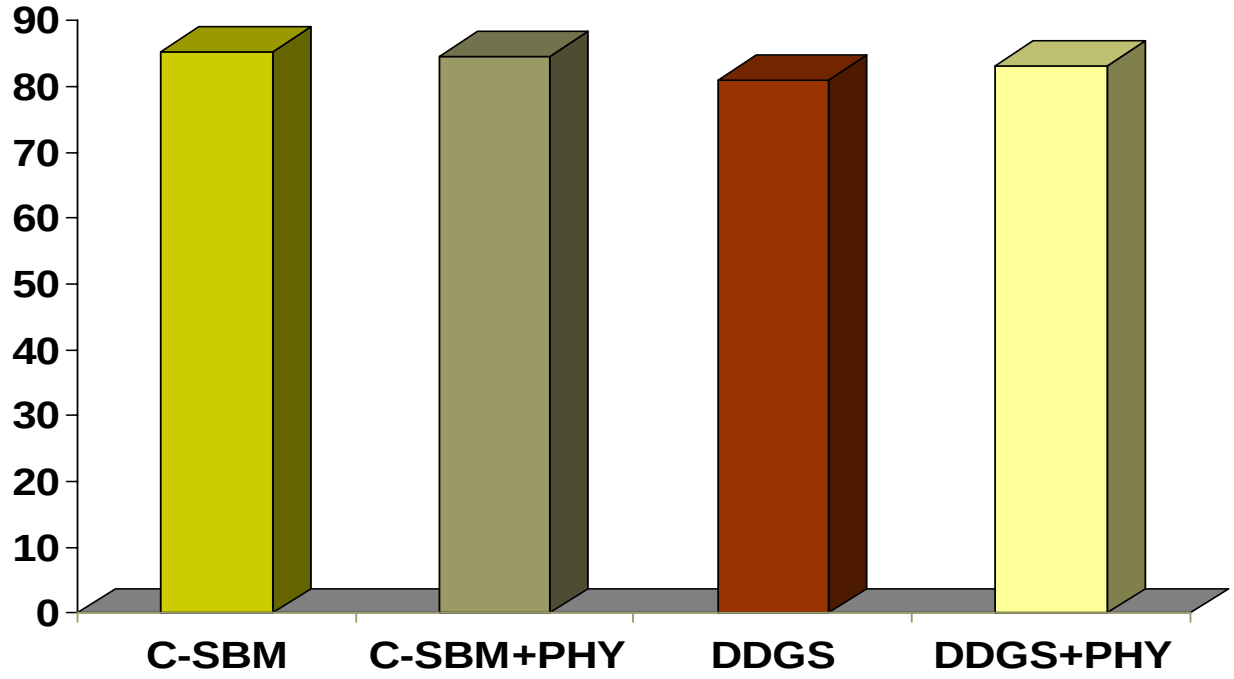
| Ingredient | Corn-SBM-1.5 kg Lysine | 18.8% DDGS + Phytase |
|---|---|---|
| Corn, kg | 798.3 | 636.3 |
| Soybean meal 44%, kg | 176.9 | 159.4 |
| DDGS, kg | 0.0 | 188 |
| Dicalcium phosphate, kg | 11.6 | 0.0 |
| Limestone, kg | 7.2 | 9.8 |
| Salt, kg | 3.0 | 3.0 |
| L-lysine HCl, kg | 1.5 | 1.5 |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

# Effects of Adding Phytase and/or 20% DDGS to Corn-SBM Diets on DM Digestibility in G-F Pigs



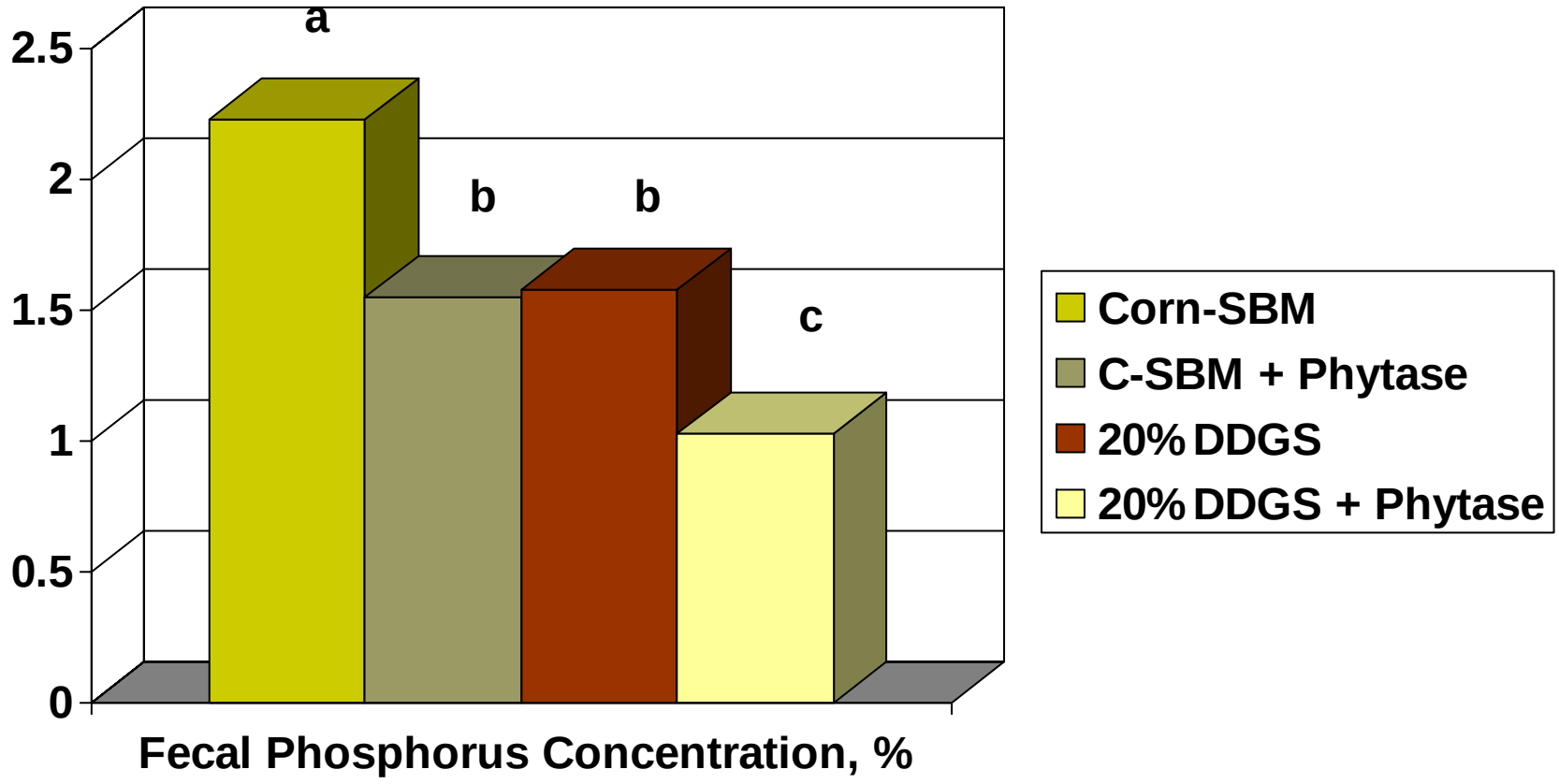

Xu et al. (2006)

# Effect of Adding Phytase and/or 20% DDGS to Corn-SBM Diets on DM Digestibility in Nursery Pigs



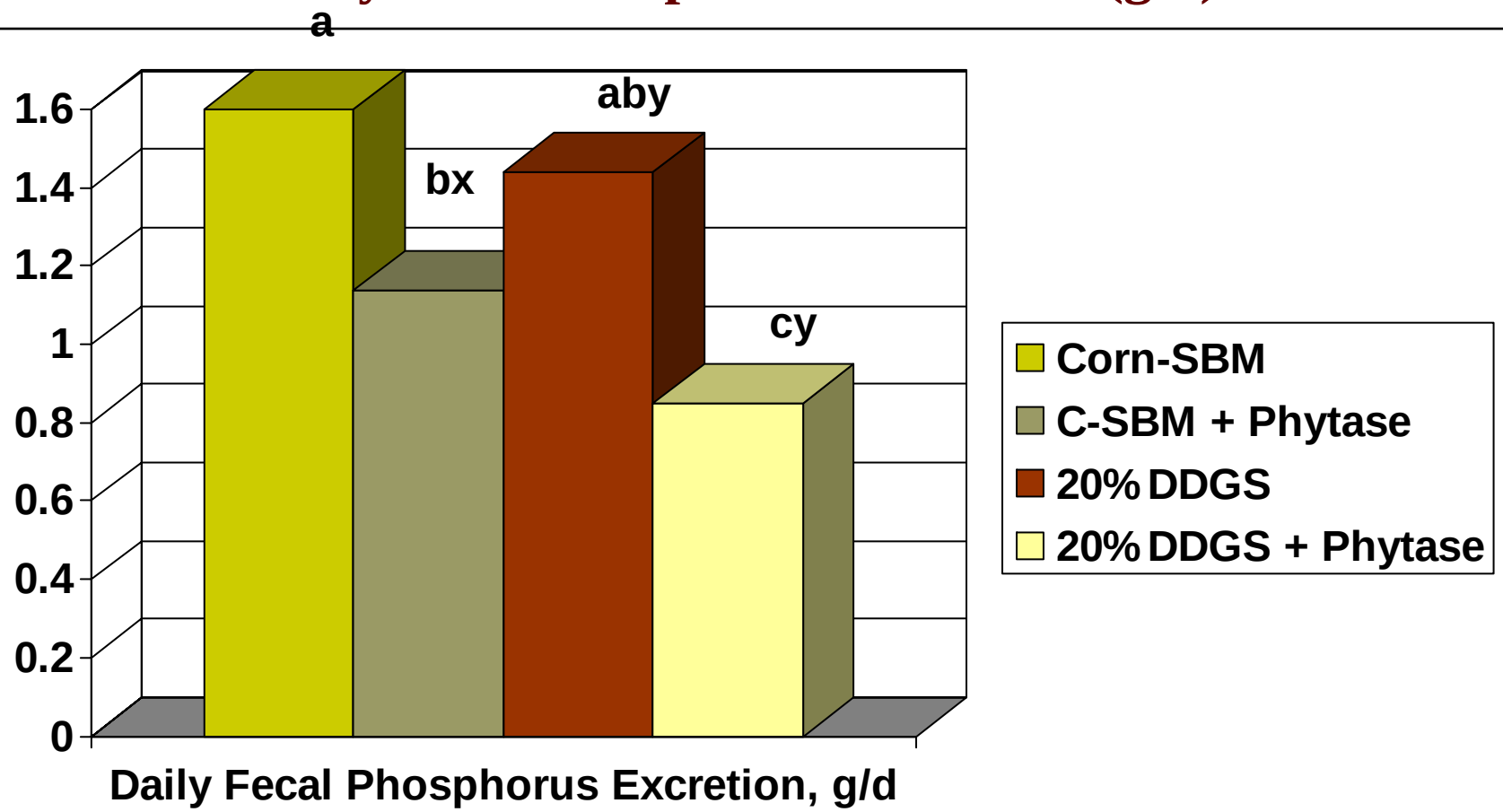

**DDGS reduced DM digestibility 3.3% (P = .01)**

# Effect of Feeding Corn-SBM Diets With or Without 20% DDGS or Phytase to Nursery Pigs on Fecal Phosphorus Concentration (%)



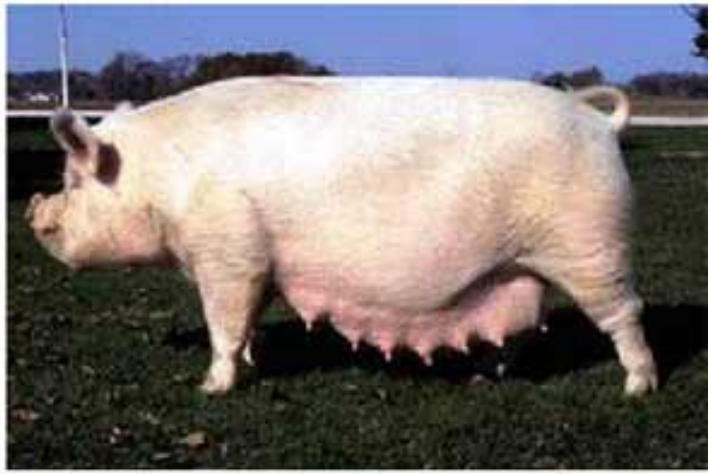

a,b Means with different superscripts are significantly different (P < .05).

# Effect of Feeding Corn-SBM Diets With or Without 20% DDGS or Phytase to Nursery Pigs on Daily Fecal Phosphorus Excretion (g/d)

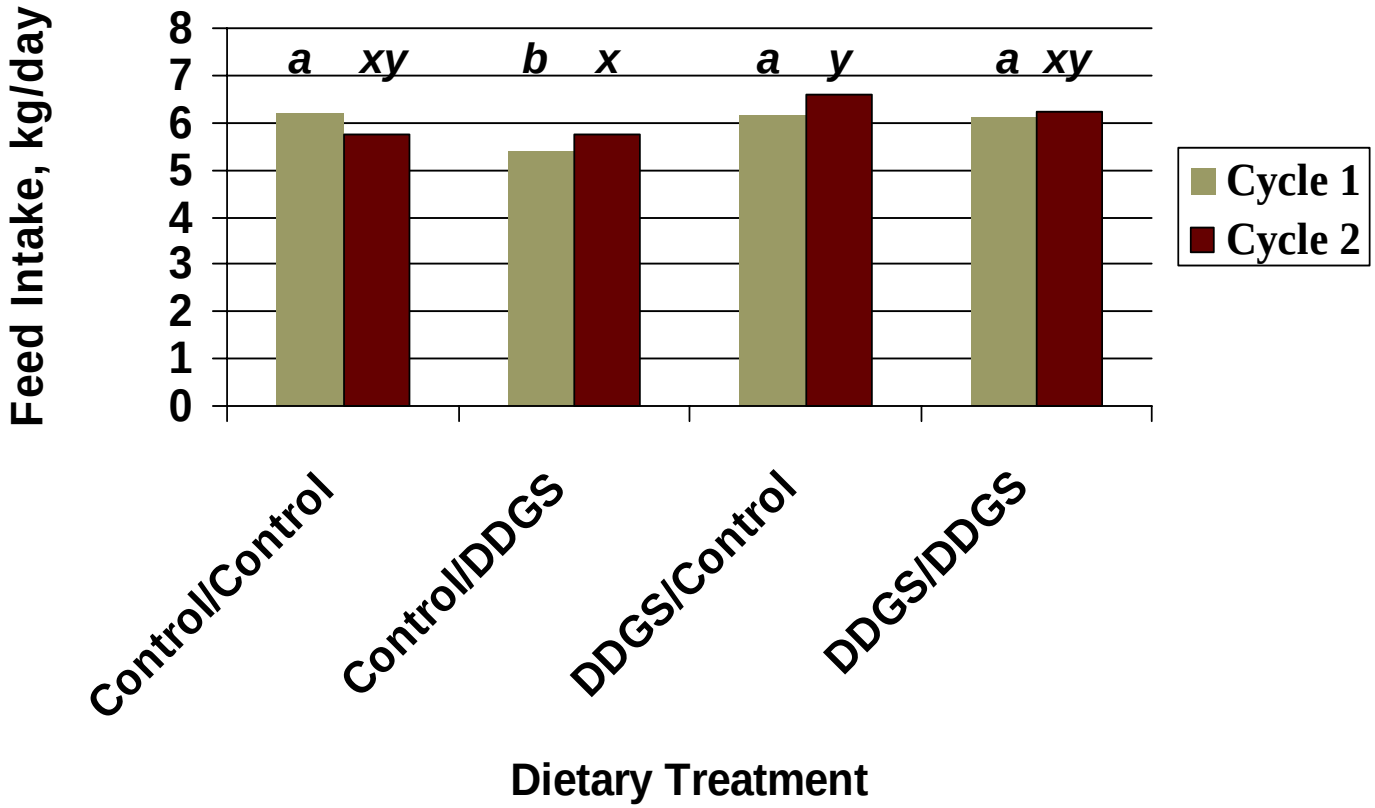



a,b,c Means with different superscripts are significantly different (P < .05).
x,y Means with different superscripts are significantly different (P < .15).

# Feeding High Quality DDGS to Sows

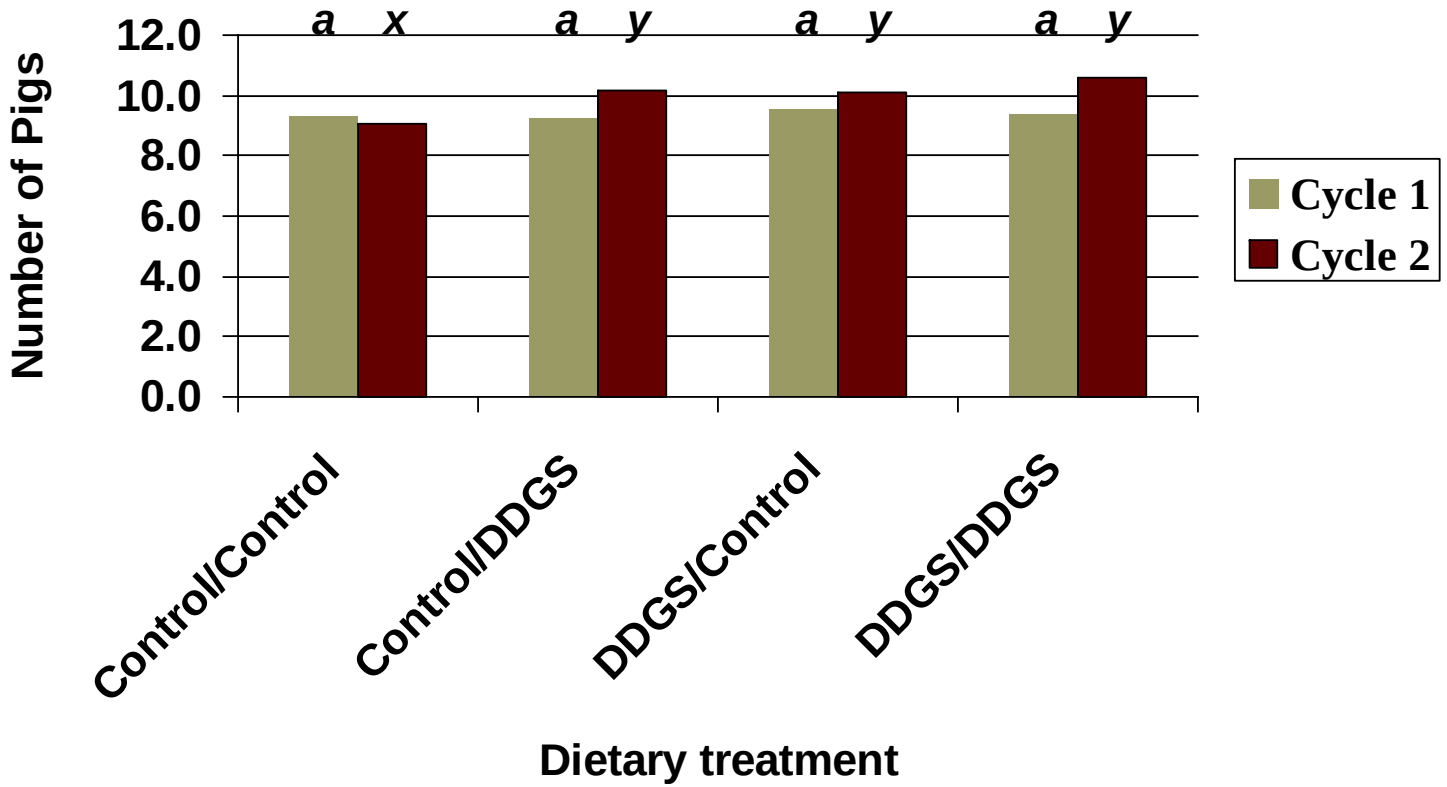


# Effect of Feeding 0 and 50% DDGS Gestation Diets and 0 and 20% DDGS Lactation Diets on Sow Lactation ADFI



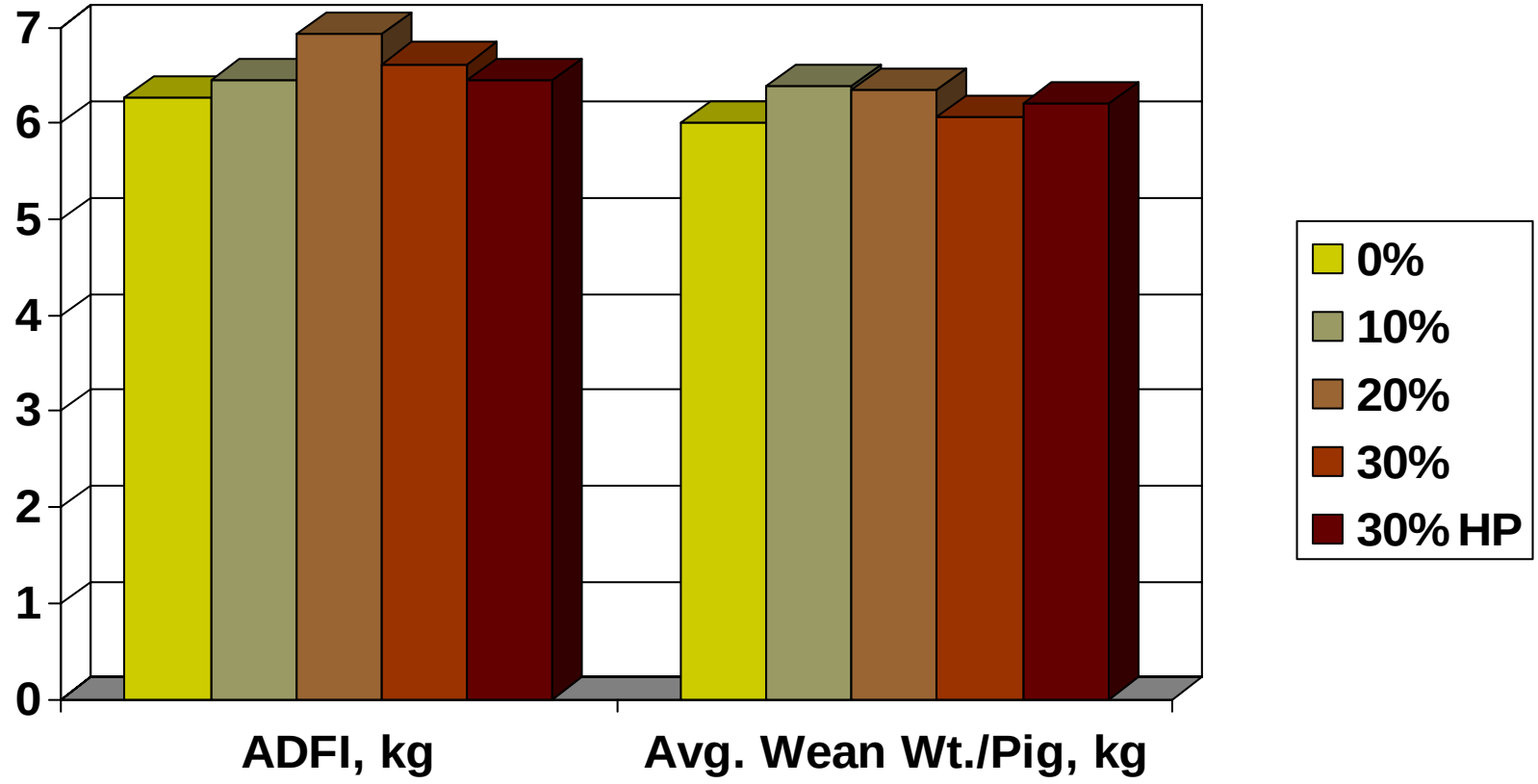

[a,b,x,y] Different superscripts indicate significant difference (P < .10).

# 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).

# Effects of Feeding Increasing Levels of DDGS to Lactating Sows on Average Daily Feed Intake and Average Pig Weight at Weaning




Utilized 323 lactating sows (65 sows/dietary treatment)
Song et al. (2006), unpublished

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

We have developed a DDGS web site featuring:

* nutrient profiles and photos of DDGS samples
* research summaries
    - swine, poultry, dairy, & beef
    - DDGS quality
* presentations given
* links to other DDGS related web sites
* international audiences