Nutritional Value of U.S. DDGS in Swine, Poultry, and Aquaculture Diets

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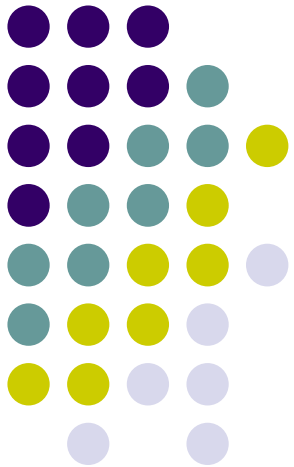
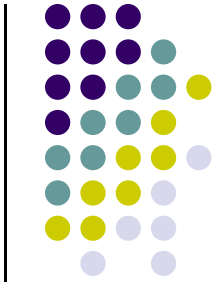


Comparison of Nutrient Composition of High Quality Corn DDGS to Corn Gluten Feed, Corn Gluten Meal, and Brewer's Dried Grains (As Fed Basis)

	High Quality Corn DDGS	Corn Gluten Feed	Corn Gluten Meal	Brewer's Dried Grains
Crude Protein, %	27.2	21.5	60.2	26.5
Crude Fat, %	9.5	3.0	2.9	7.3
NDF, %	38.8	33.3	8.7	48.7
DE, kcal/kg (swine)	3,639	2,990	4,225	2,100
ME, kcal/kg (swine)	3,378	2,605	3,830	1,960
Lys, %	0.74	0.63	1.02	1.08
Met, %	0.49	0.35	1.43	0.45
Thr, %	1.01	0.74	2.08	0.95
Trp, %	0.21	0.07	0.31	0.26
Ca, %	0.05	0.22	0.05	0.32
Available P, %	0.71	0.49	0.07	0.19

DDGS Color and Digestibility Varies Among DDGS Sources

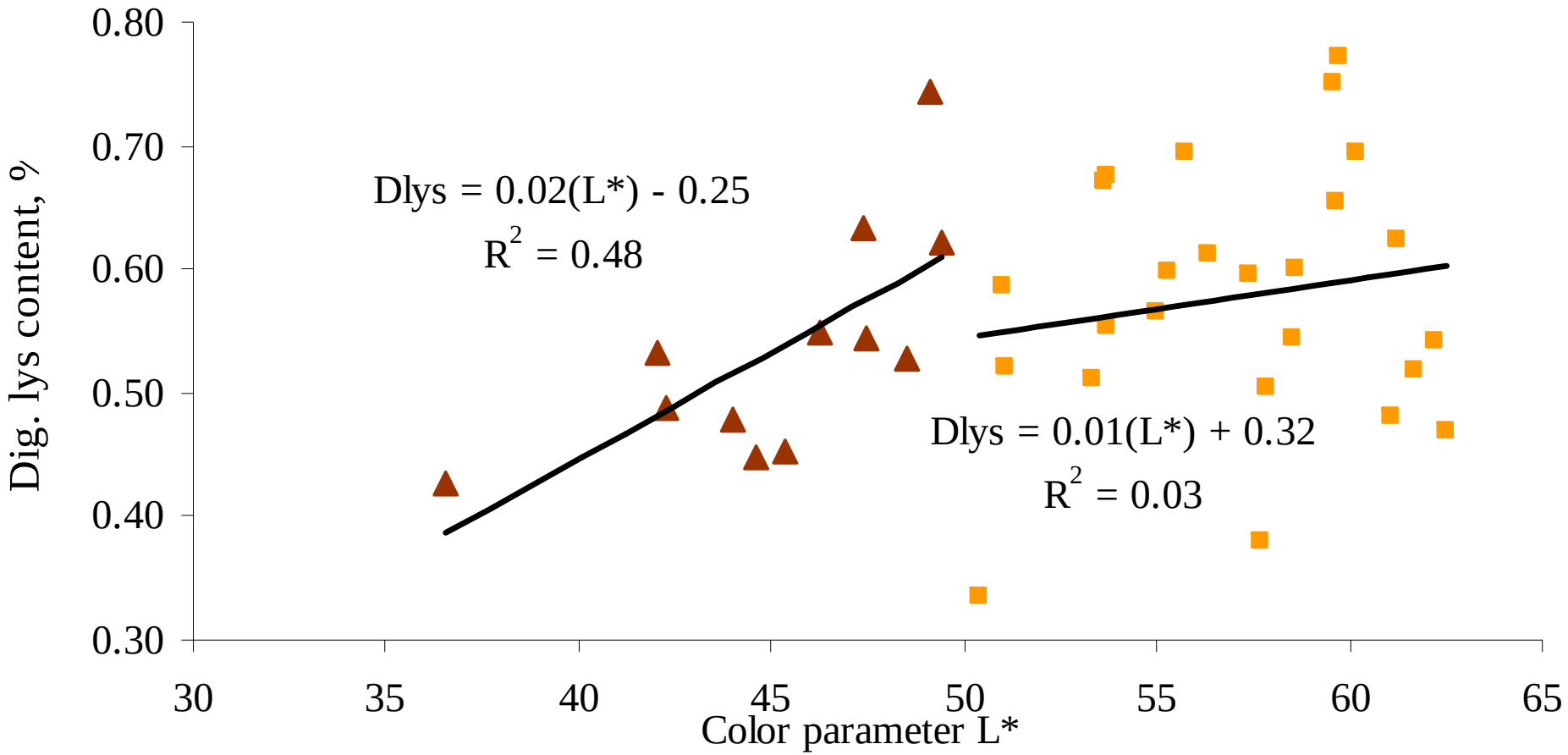
Variation in Digestible Amino Acids in 34 Sources of Corn DDGS (%)



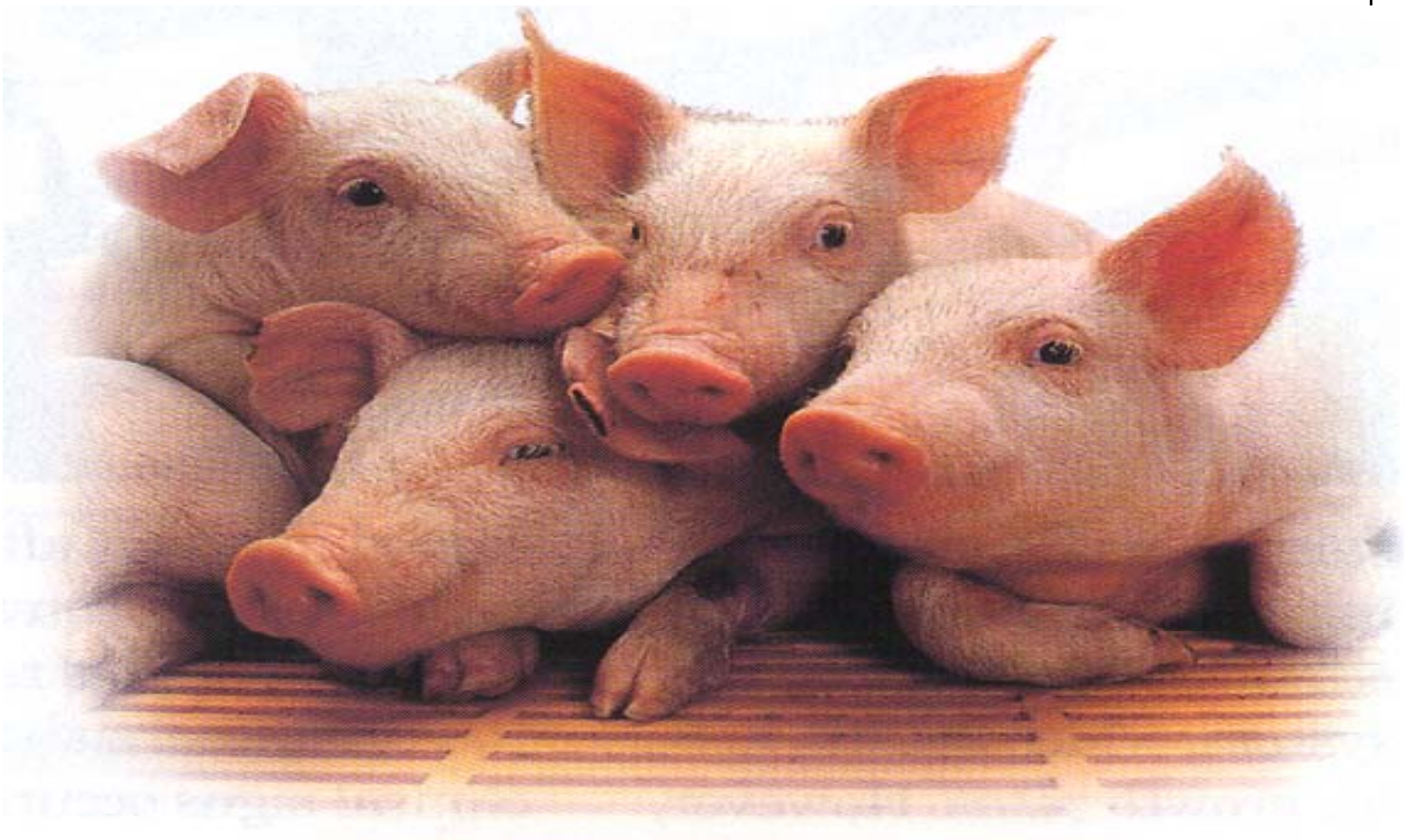
Amino Acid	Max	Min	CV
Lys	0.77	0.33	18.4
Met	0.66	0.40	12.6
Thr	0.96	0.68	10.2
Trp	0.21	0.10	15.8

Urriola et al. (2007)

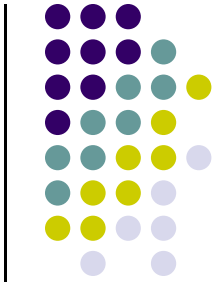
Relationship Between Lightness of Color (L*) and Digestible Lysine Content of Corn DDGS



Use of U.S. Corn DDGS in Swine Diets

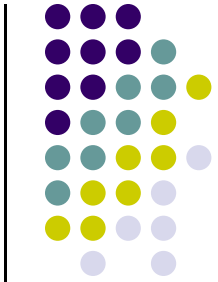


Nutritional Characteristics of DDGS for Swine



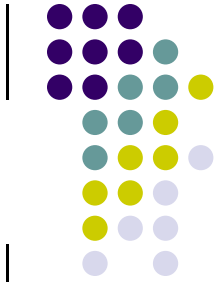
- DDGS ME = corn ME
- Amino acid content and digestibility variable
  - Total lysine (0.61-1.06% DM basis)
  - Standardized true lysine digestibility (44-67%)
- High digestible P
  - Reduce diet inorganic P supplementation
  - May reduce manure P excretion
- Partially replaces some corn, soybean meal, and inorganic phosphate and reduces diet cost

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



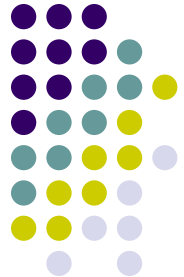
	High Quality DDGS	DDGS NRC (1998)	Corn NRC (1998)
Total P, %	0.78 Range 0.62-0.87	0.73	0.25
P Availability, %	90 Range 88-92	77	14
Available P, %	**0.70**	**0.56**	**0.03**

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

Quick Calculation of Feed Cost Savings



Thumb rule:

Additions/1000 kg diet

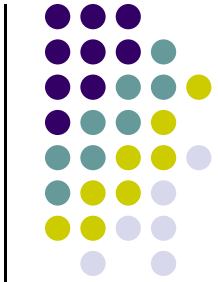
+ 100 kg DDGS x _____ $/kg = $_____
+ 1.5 kg limestone x _____ $/kg = $_____
TOTAL ADDITIONS (A) $_____

Subtractions/1000 kg diet

- 88.5 kg corn x _____ $/kg = $_____
- 10 kg SBM (44%) x _____ $/kg = $_____
- 3 kg dical. phos. x _____ $/kg = $_____
TOTAL SUBTRACTIONS (S) $_____

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

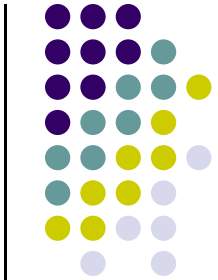
Current U.S. Dietary DDGS Inclusion Rates and Estimated Usage



- Grower-finisher diets ~85-90%
  - 10-40% of the diet
- Sow diets ~5-10%
  - Gestation – 10-40% of the diet
  - 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 Trials)

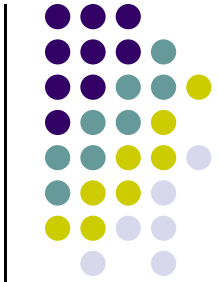


- Nursery pigs (> 7 kg)
  - Up to 30%
- Grow-finish pigs
  - Up to 30%
- Gestating sows
  - Up to 50%
- Lactating sows
  - Up to 30%

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

Feeding High Quality DDGS to Weaned Pigs

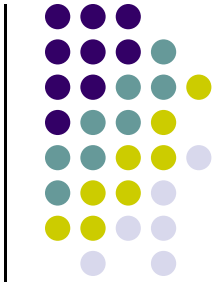
Summary of U.S. University Research Trials



- 7 experiments have been conducted
  - Pigs fed diets containing up to 30% DDGS have resulted in no differences in:
    - ADG
    - ADFI
    - Feed/Gain
      - (feed conversion was improved by adding DDGS in some studies)

Feeding High Quality DDGS to Grower-Finisher Pigs

Summary of Growth Performance Responses from U.S. University Research Trials



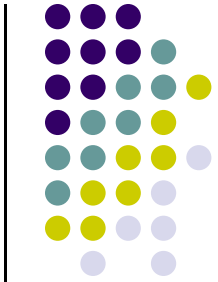
- 17 experiments have been conducted to evaluate adding 0–30% DDGS to corn-soybean meal grower-finisher diets

- ADG
  - Improved in 1 experiment
  - Not affected in 10 experiments
  - Reduced in 6 experiments

- ADFI
  - Improved in 1 experiment
  - Not affected in 10 experiments
  - Reduced in 6 experiments

- Gain:Feed
  - Improved in 4 experiments
  - Not affected in 10 experiments
  - Reduced in 3 experiments

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



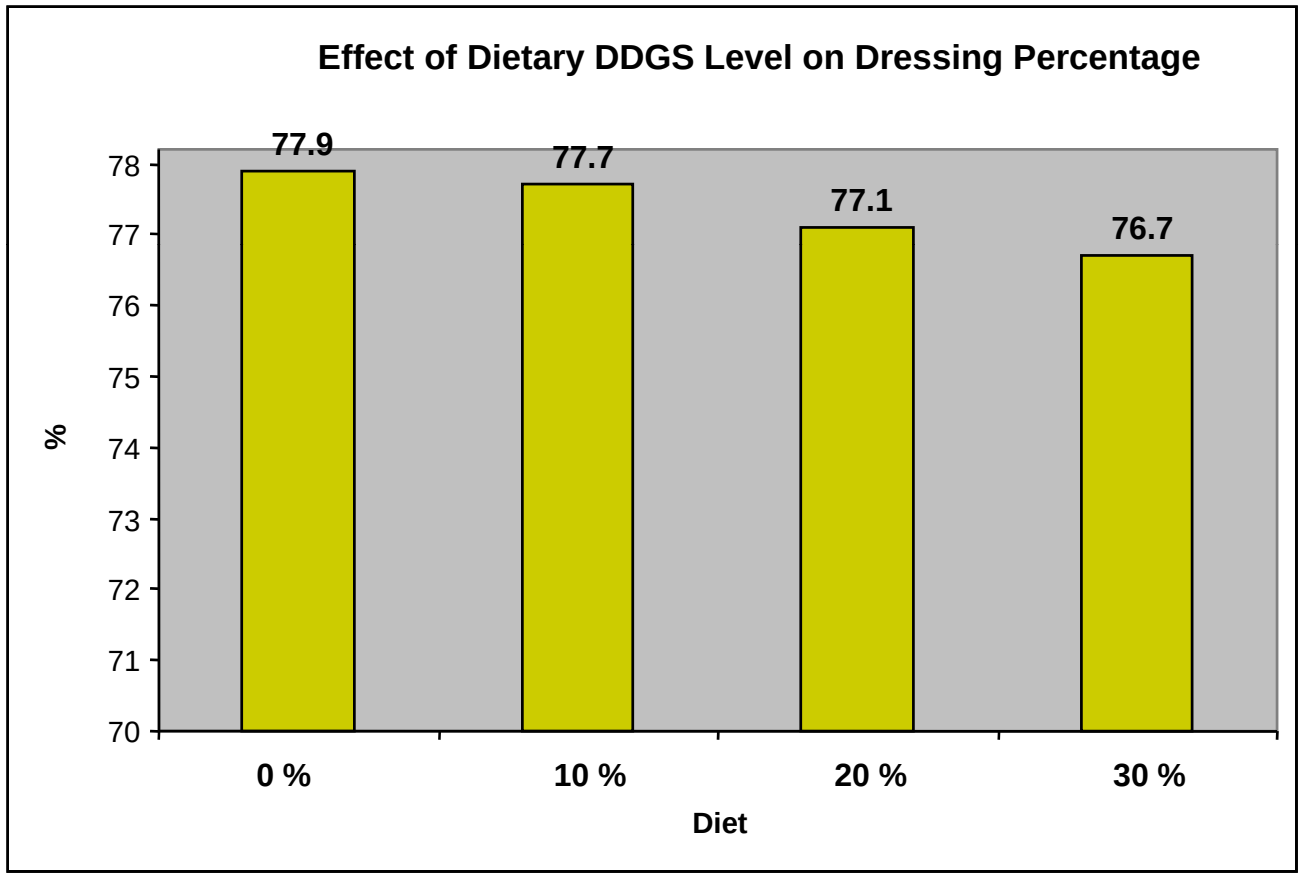
	0% DDGS	10% DDGS	20% DDGS	30% DDGS
Initial wt., kg	22.5	22.8	22.5	22.5
Final wt., kg	114	115	114	113
ADG, kg/d	0.92	0.92	0.92	0.91
ADFI, kg/d[a]	2.57	2.55	2.49	2.46
F/G[a]	2.79	2.76	2.71	2.70

[a] Linear effect of DDGS level

Data from 64 pens, 16 pens/treatment (Xu et al., 2007)

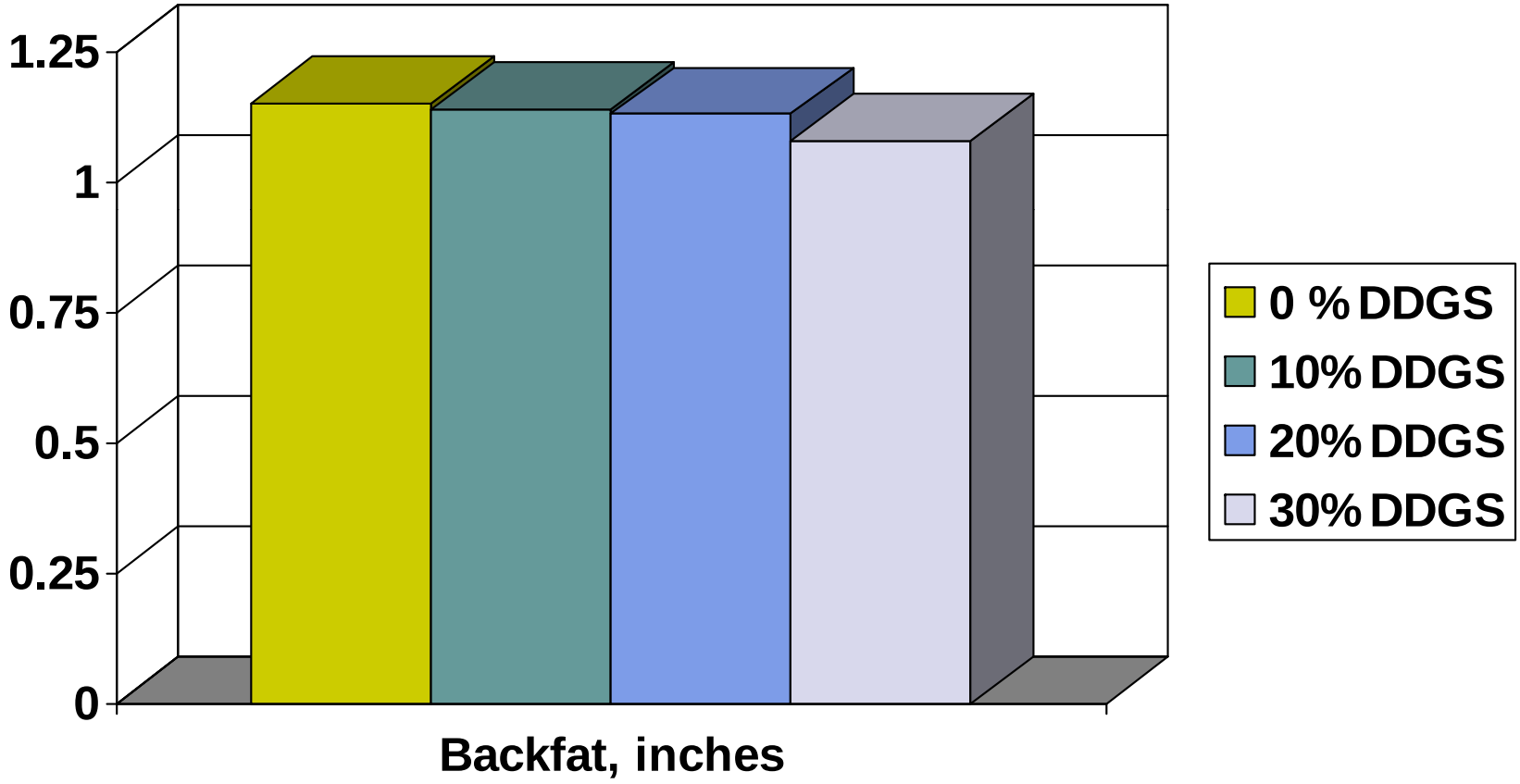
Effects of Feeding Increasing Levels of DDGS on Carcass Composition and Pork Quality

Adding Increasing Levels of DDGS to G-F Diets Slightly Reduces Carcass Yield



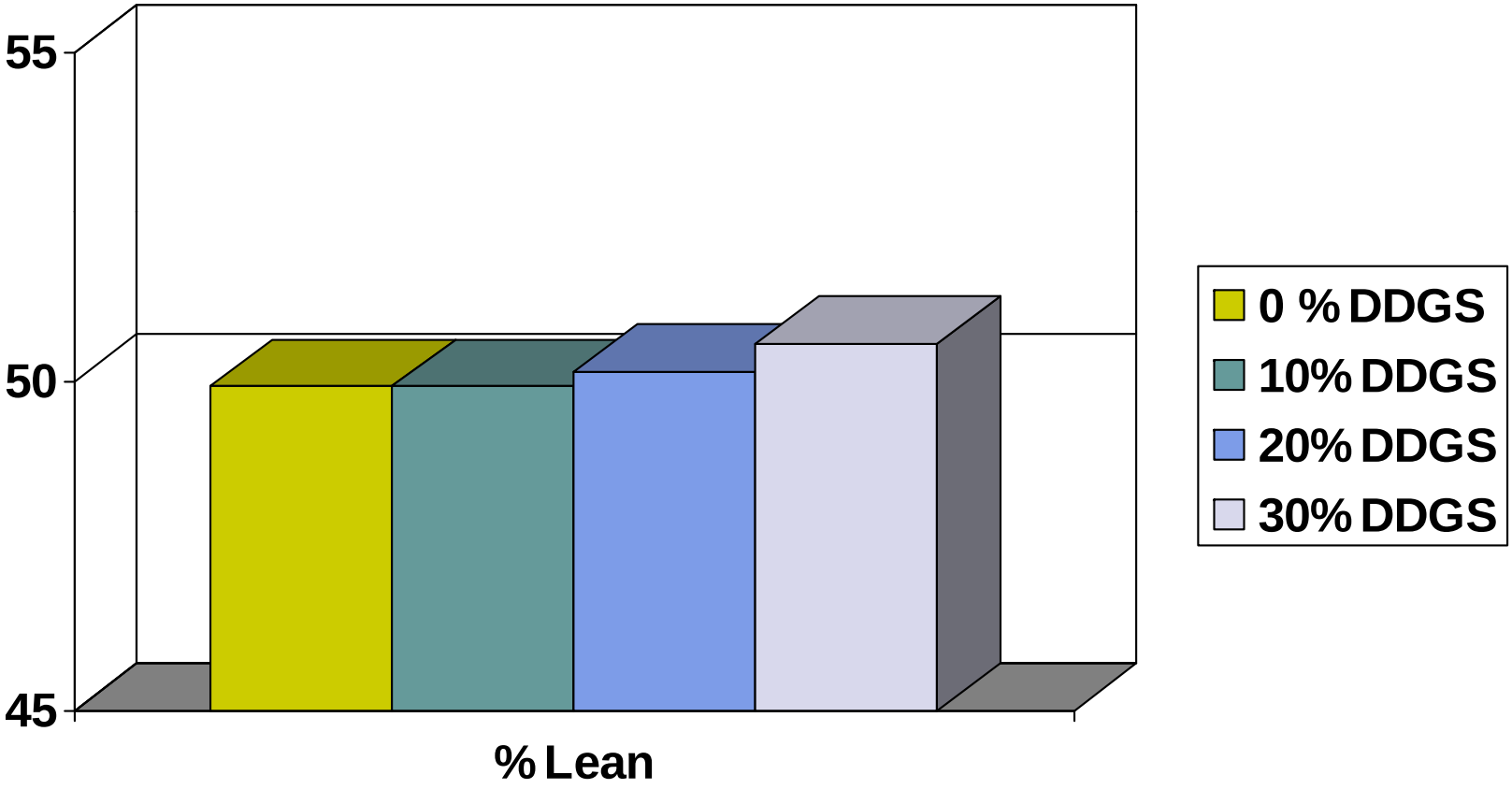
Xu et al. (2007)
Linear effect ($P < 0.01$)

Effects of Dietary DDGS Level on Last Rib Backfat



Xu et al. (2007)
30% DDGS tended to be lower than 0% DDGS (P = 0.09)

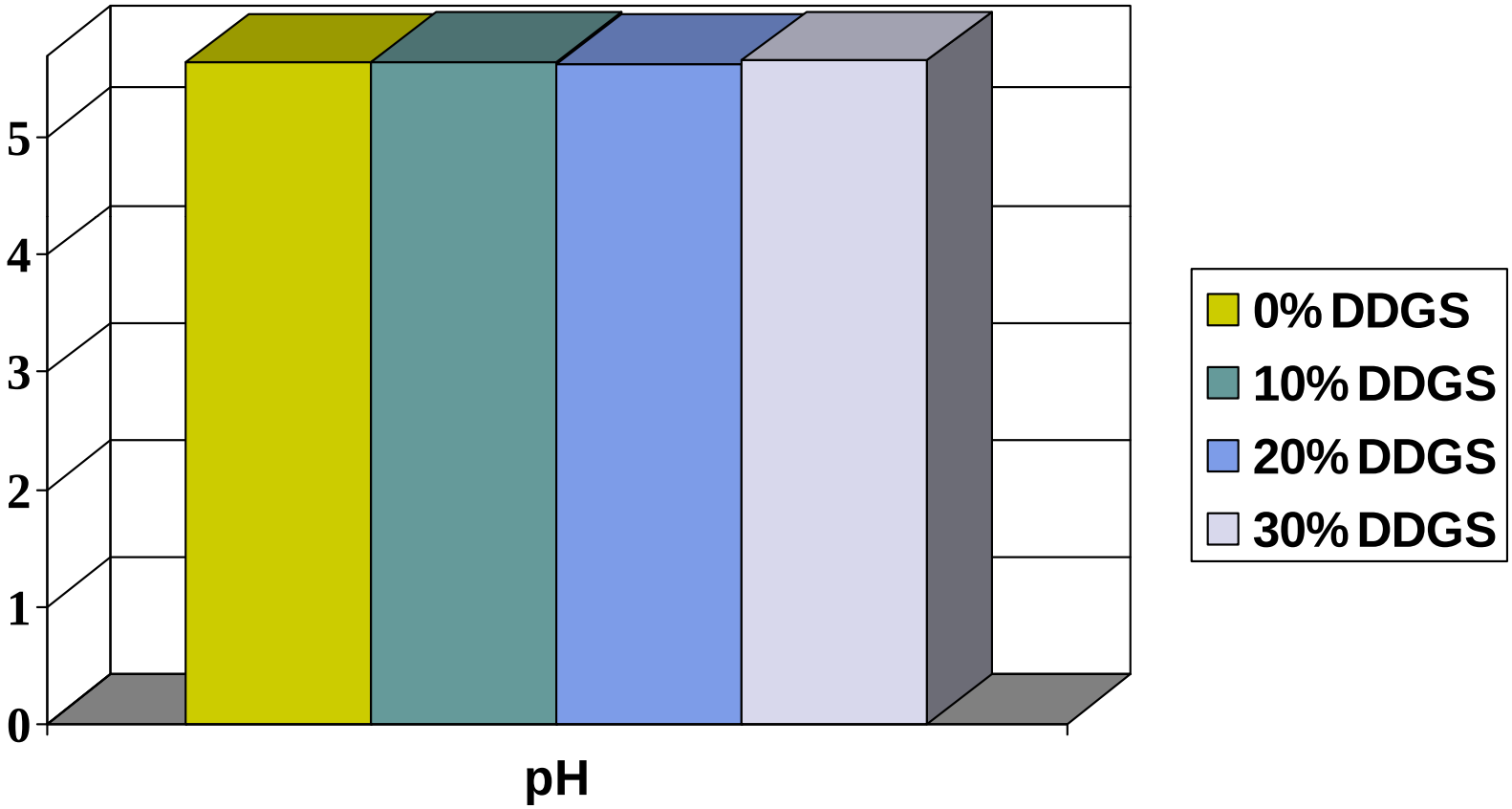
Effects of Dietary DDGS Level on % Carcass Lean



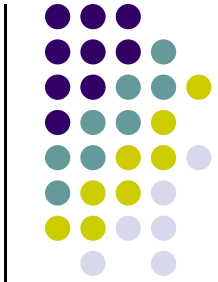
Xu et al. (2007)

30% DDGS tended to be higher than 0% DDGS (P = 0.11)

Effects of Dietary DDGS Level on Ultimate Muscle pH

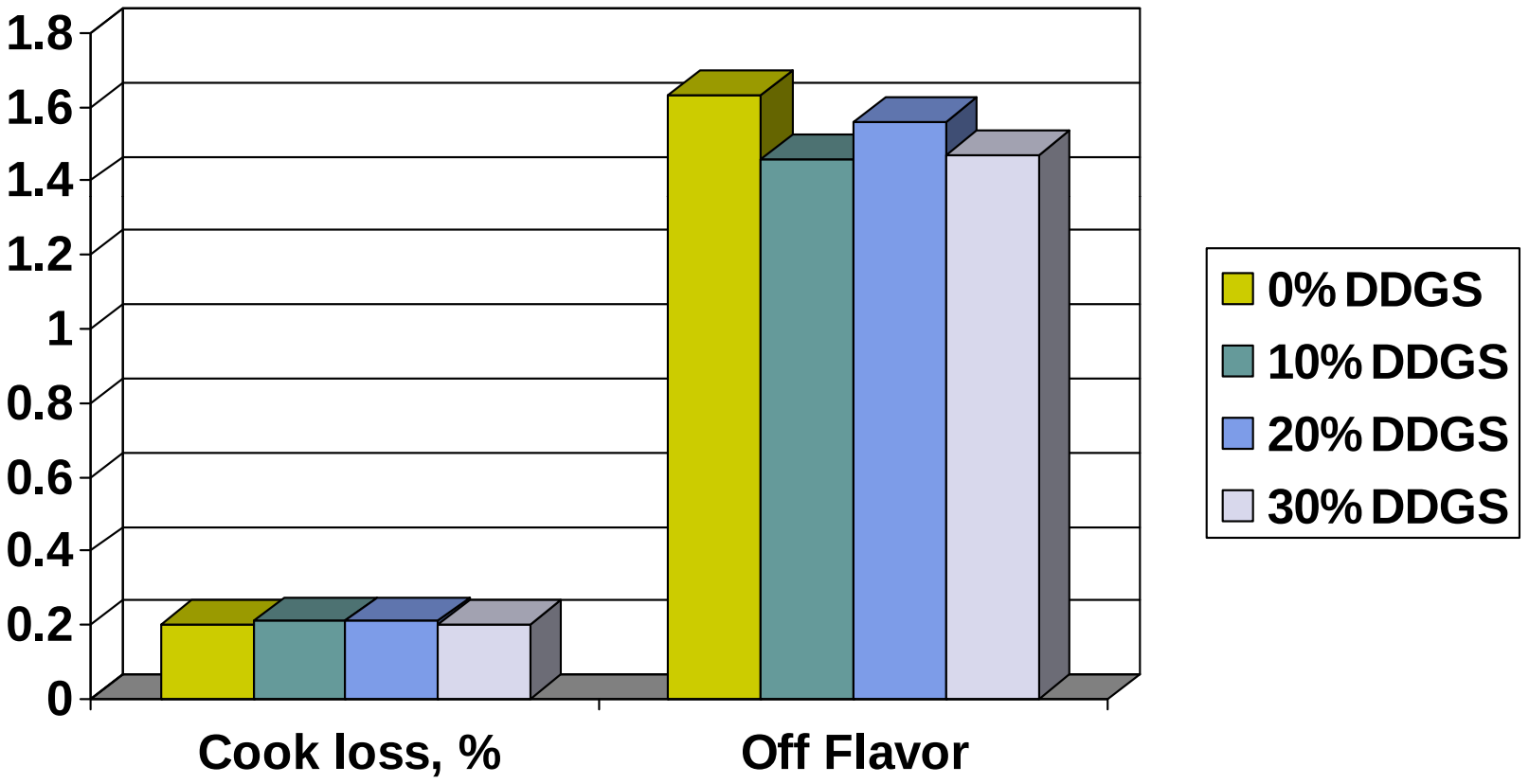


Effects of Increasing Dietary DDGS Level on Loin Characteristics



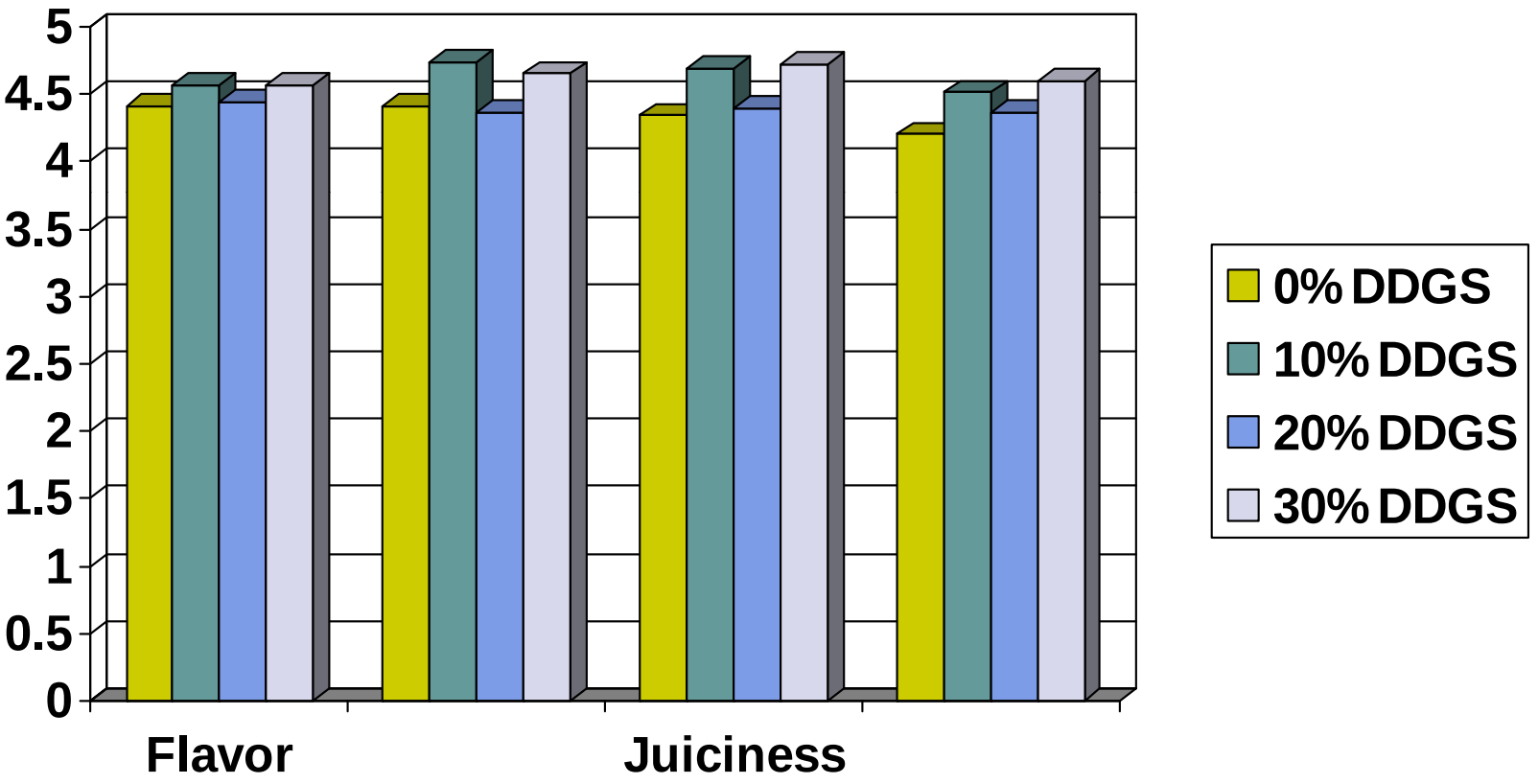
- Loin firmness was linearly reduced
  - Due to reduced marbling
  - Within accepted U.S. quality standards
- Marbling was linearly reduced
  - Due to trend for reduced backfat
  - Within accepted U.S. quality standards
- Pigs fed the 30% DDGS diets had loins that were slightly less red
  - Within accepted U.S. quality standards
- No overall differences in subjective color score
- No differences in drip loss on day 0, 14, 21, or 28 post-harvest
- No differences in lipid oxidation in loins at 28 days of shelf storage

Effects of Increasing Dietary DDGS Level on Cook Loss and Off Flavor of Pork Loins



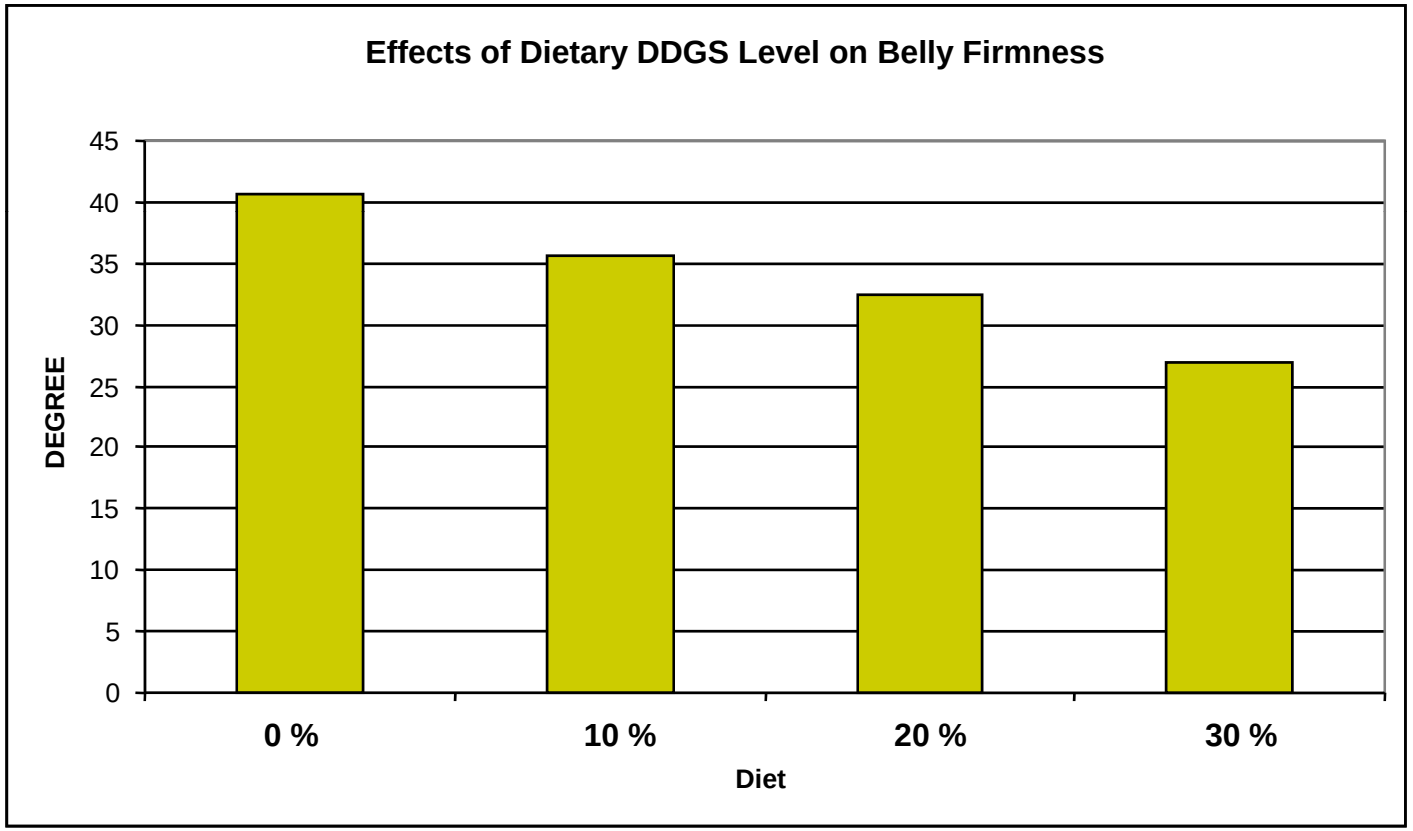
No significant differences among dietary treatments.

Effects of Increasing Dietary DDGS Level on Eating Characteristics of Pork Loins



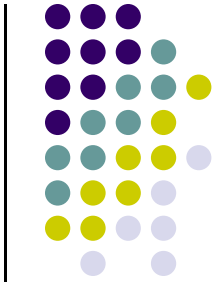
No significant differences among dietary treatments.

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



Xu et al. (2007)

Effects of Increasing Dietary DDGS Level on Belly and Backfat Characteristics

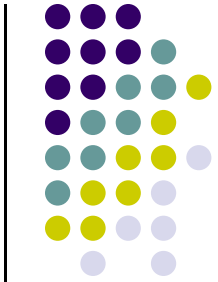


- No effect on belly thickness

- No differences in belly fat color
  - Japanese color score
  - Minolta L*, a*, b*

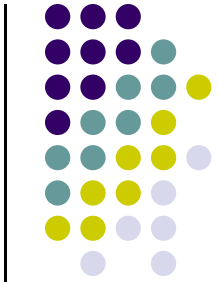
- No differences in backfat color
  - Japanese color score
  - Minolta a*, b*

Effects of Increasing Dietary DDGS Level on Belly and Backfat Characteristics



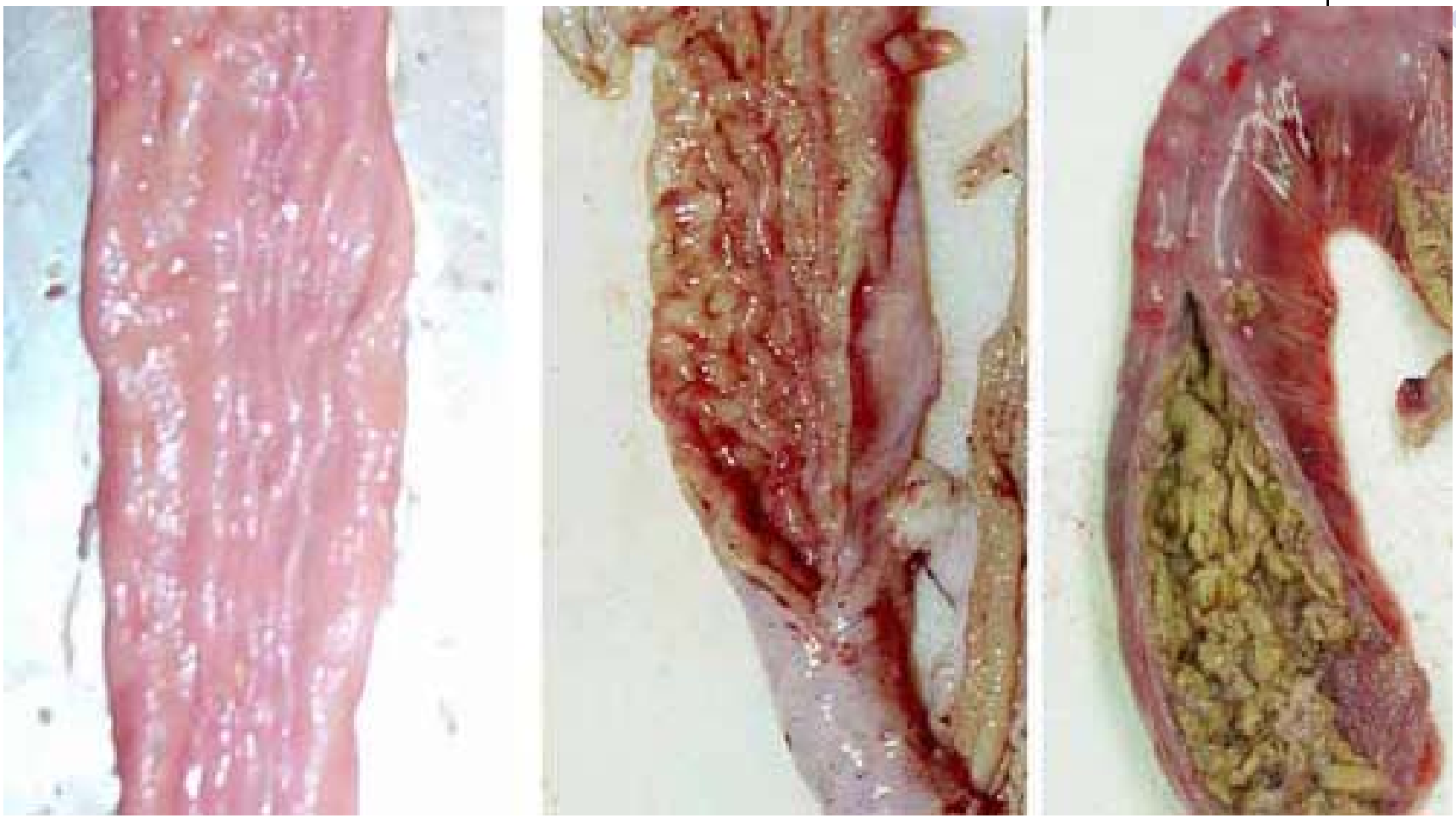
- Backfat thickness is unaffected, and may be slightly reduced, with increasing dietary levels of DDGS
- Bellies will be less firm as higher dietary levels of DDGS are fed
- Belly thickness may or may not be affected by increasing dietary DDGS levels
- No concern about reduced shelf life and fat oxidation in loins under typical retail storage conditions for at least 28 days.

Does Feeding DDGS Improve Gut Health of Growing Pigs?

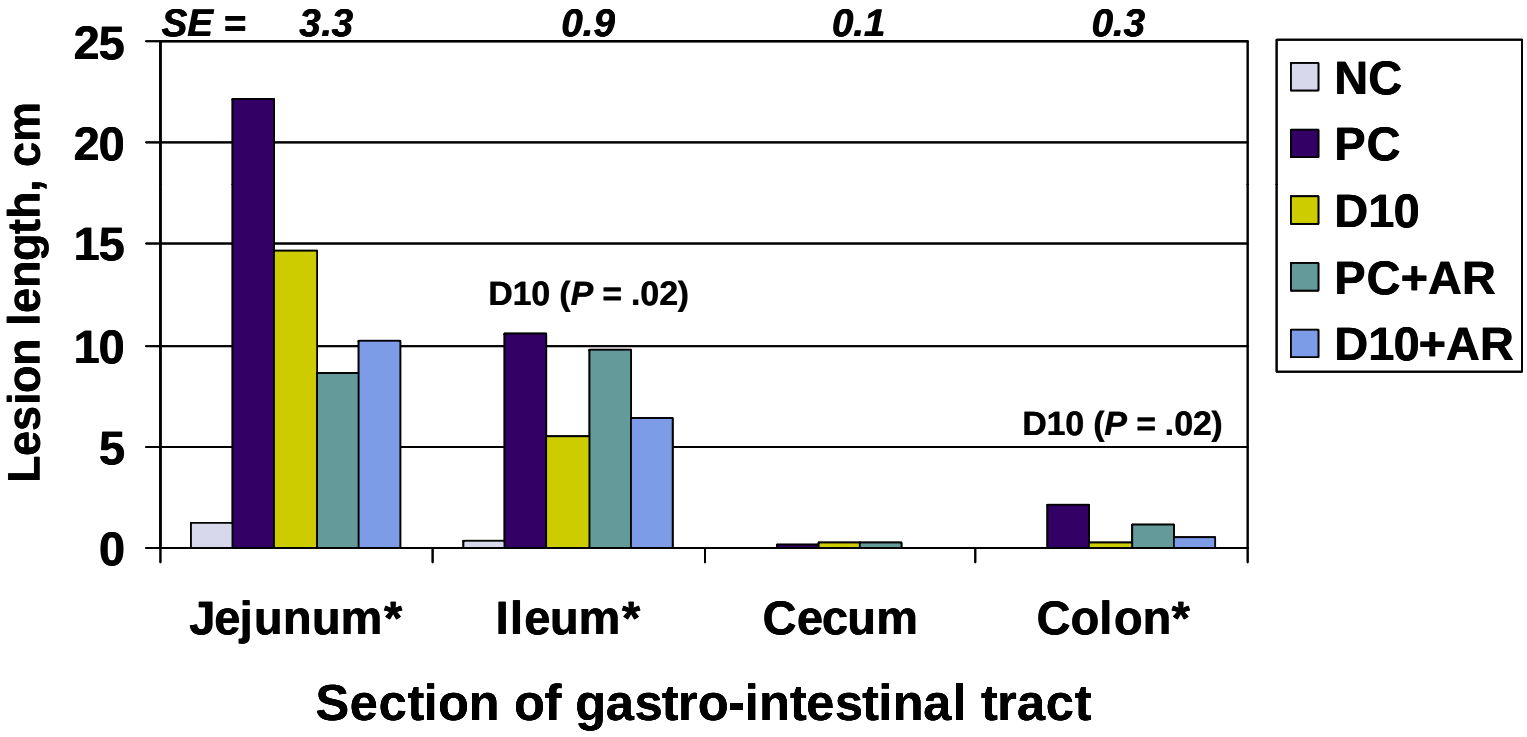


Healthy

Ileitis

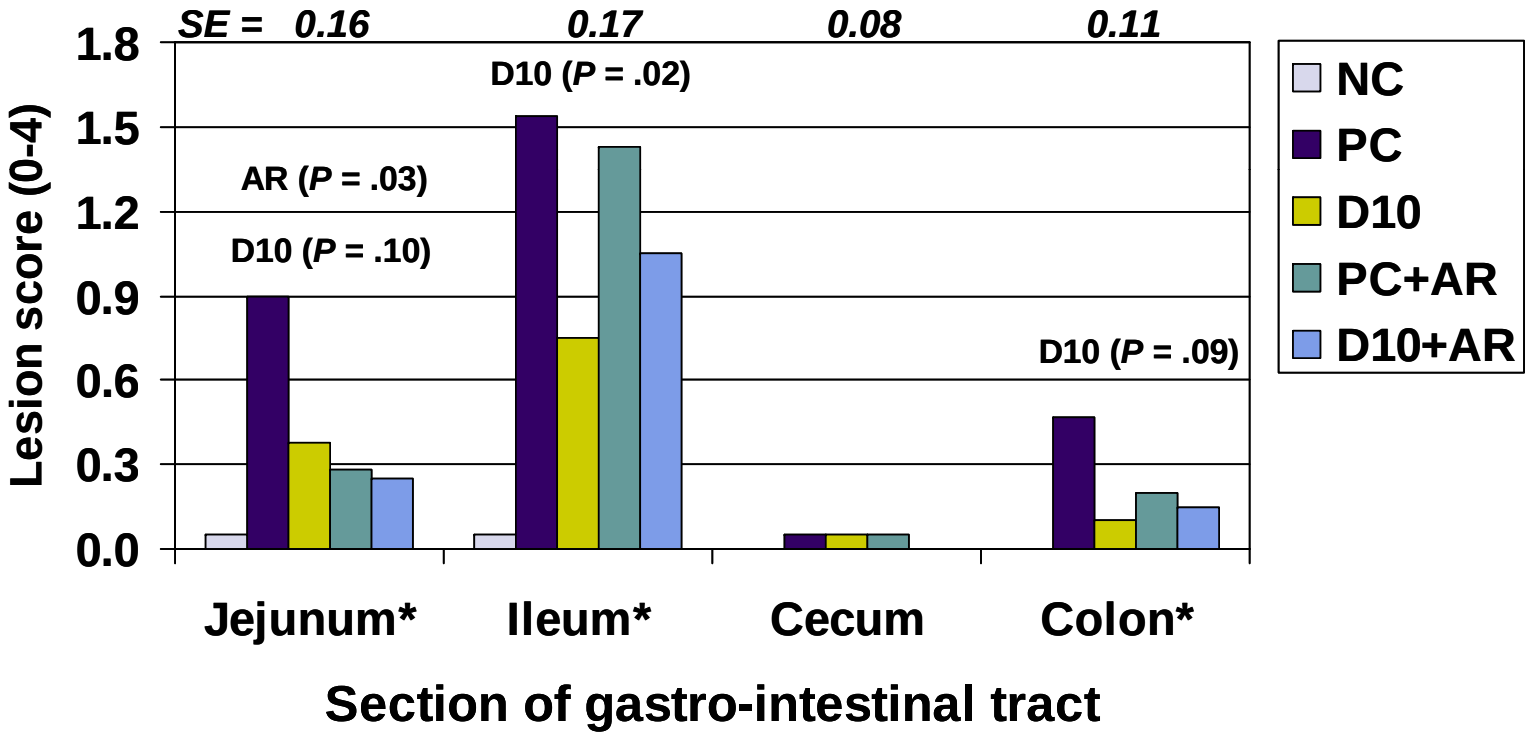


Effect of Dietary Treatment on Lesion Length (21 d Post-Challenge)



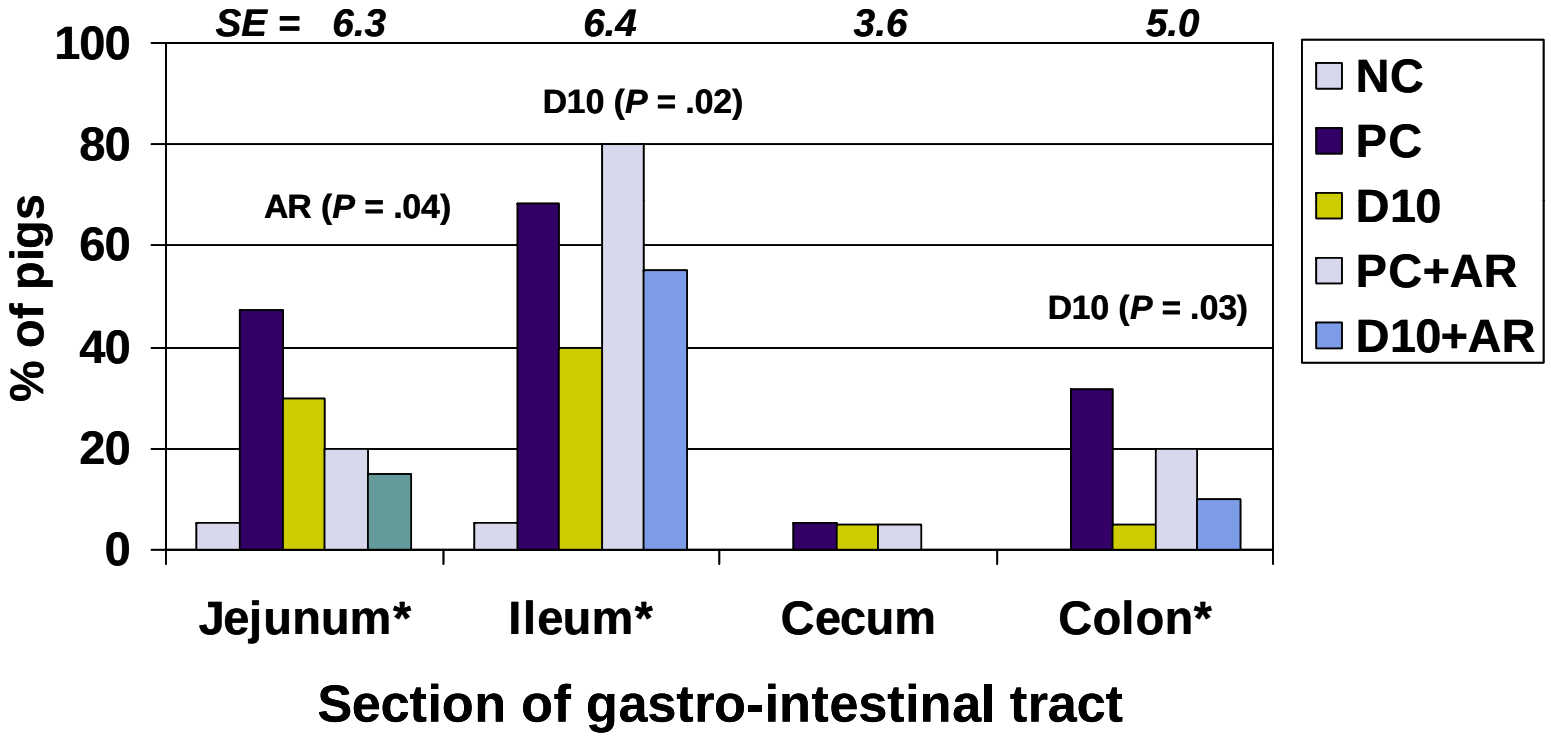
* Effect of disease challenge ($P < .01$).

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



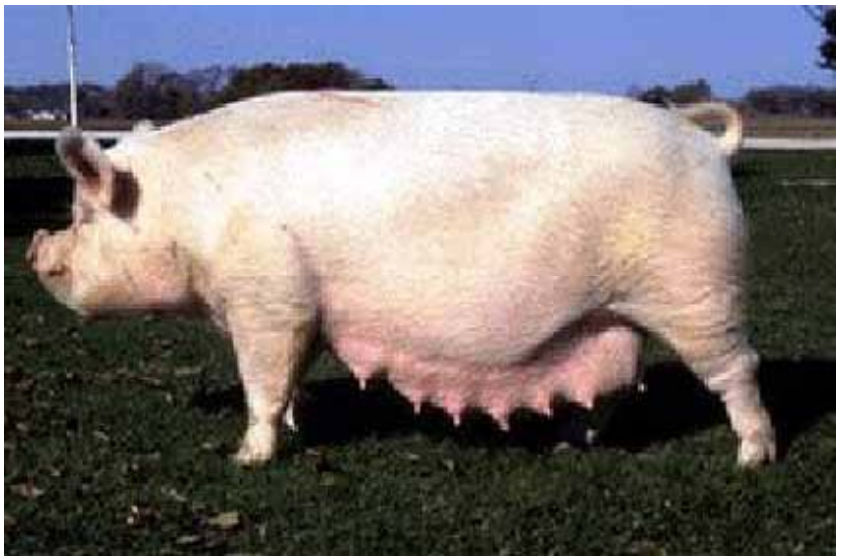
* Effect of disease challenge ($P < .01$).

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

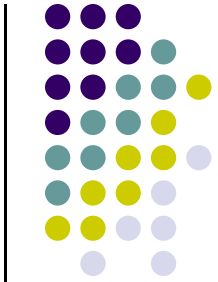


* Effect of disease challenge ($P < .01$).

Feeding DDGS to Sows

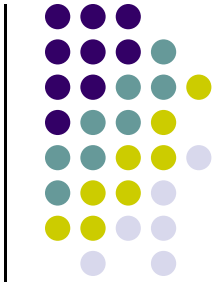


Producer Perceptions and Observations



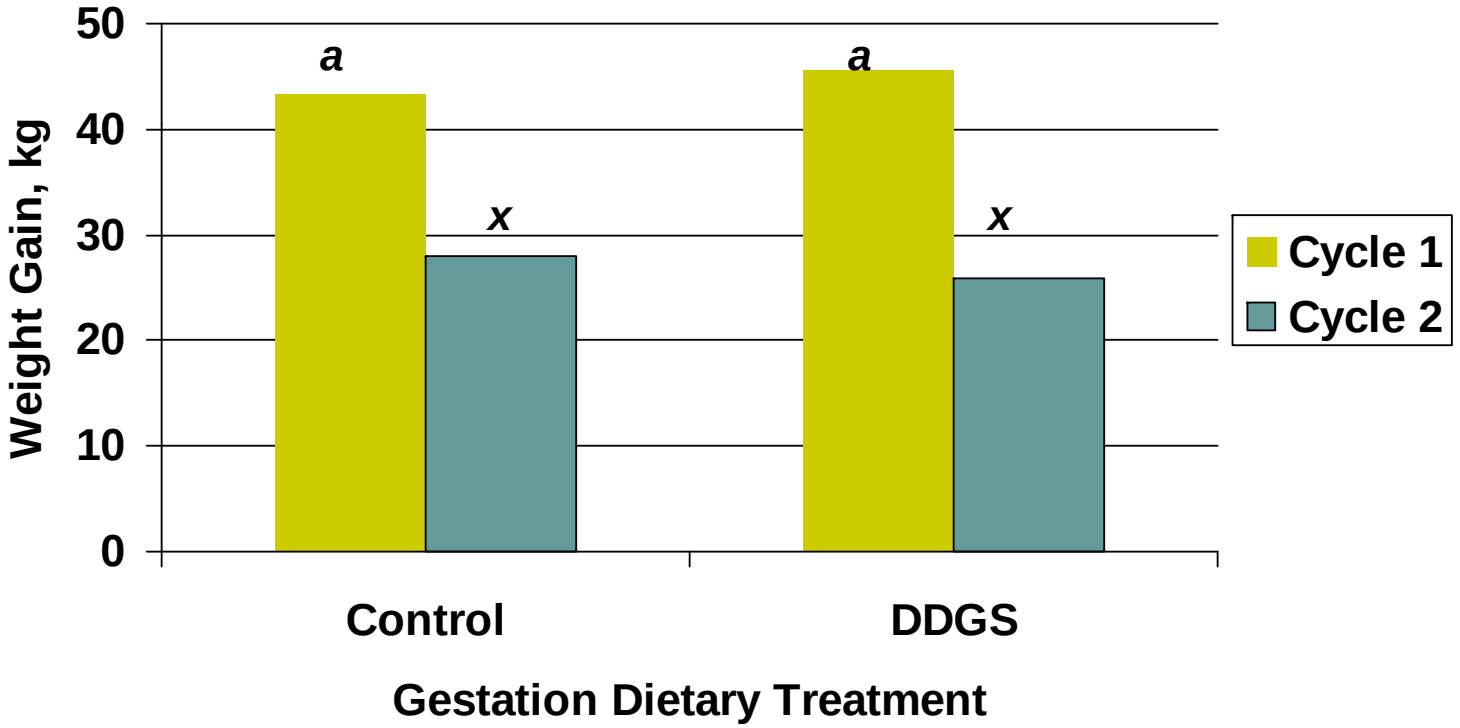
- Perception
  - DDGS is a risky ingredient because of mycotoxin concerns
    - Has limited DDGS use compared to potential
- Observations
  - Increased lactation feed intake
  - Sows are more content
  - Fewer constipation problems

University of Minnesota – Wilson et al. (2003)



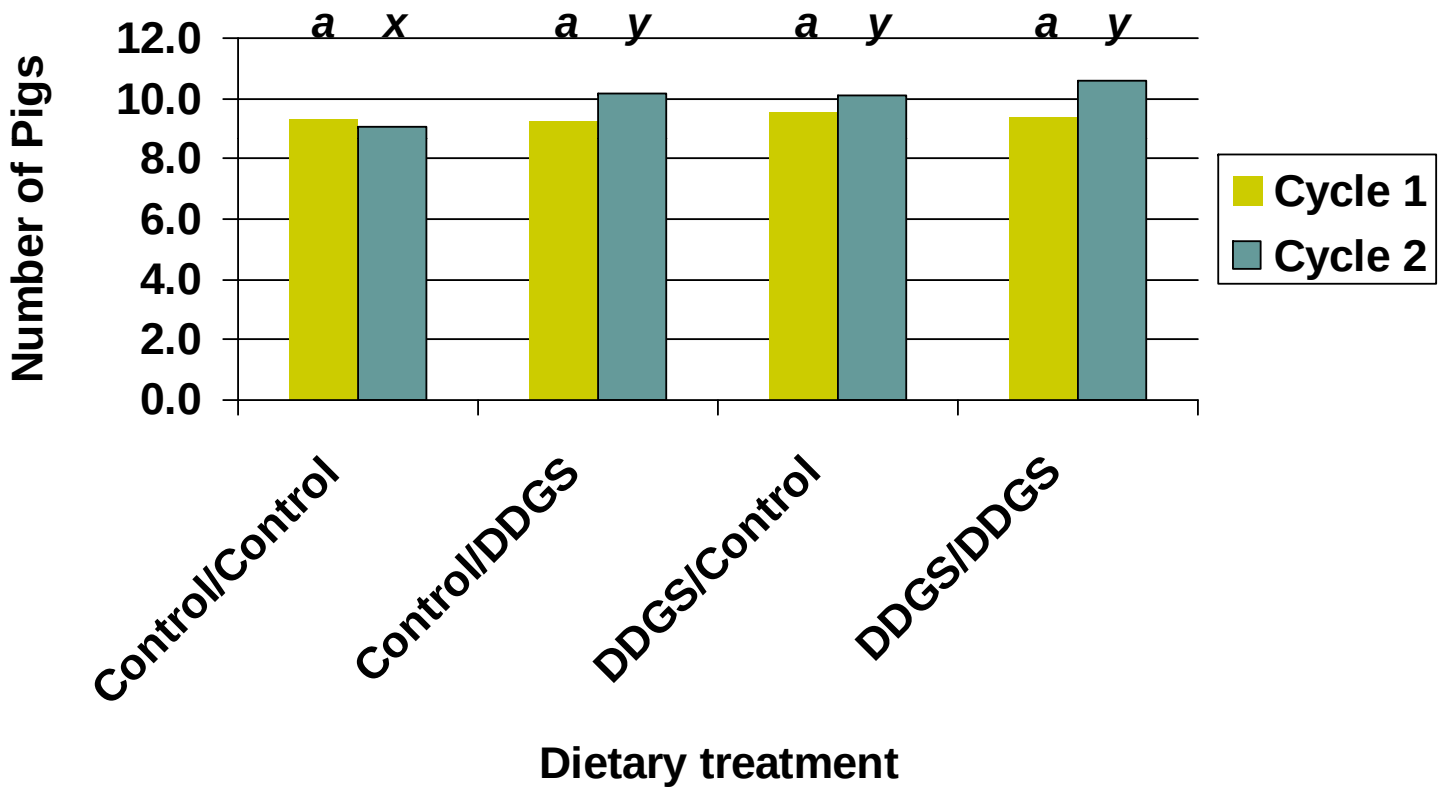
- Used 93 sows
  - randomly assigned to 1 of 4 dietary treatment combinations
  - sows remained on dietary treatments through 2 reproductive cycles
- Each dietary treatment combination consisted of both a gestation and lactation diet
  - Corn-SBM Gestation and Corn-SBM Lactation
  - Corn-SBM Gestation and 20% DDGS Lactation
  - 50% DDGS Gestation and Corn-SBM Lactation
  - 50% DDGS Gestation and 20% DDGS Lactation

Effect of Feeding a 50% DDGS Diet on Sow Weight Gain During Gestation



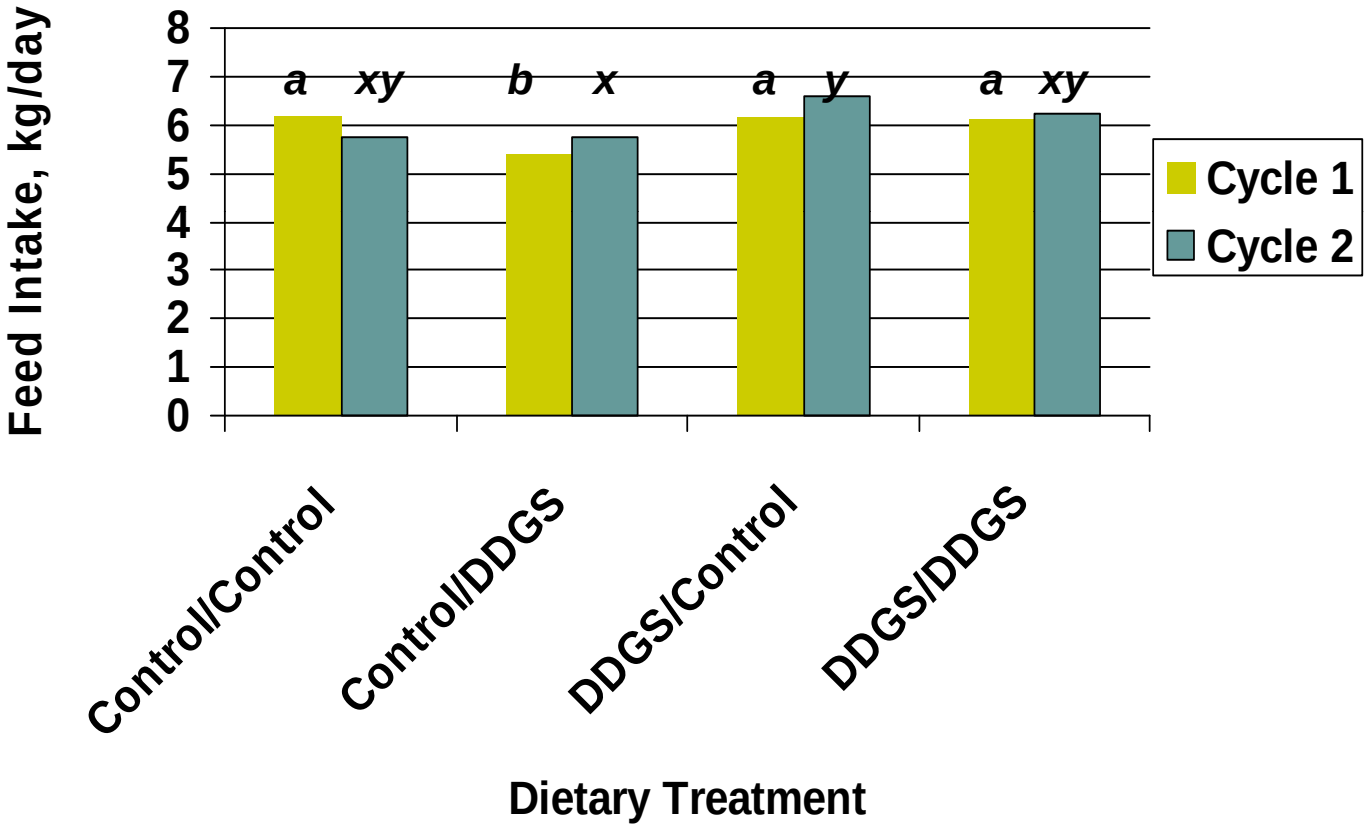
[a,b,x,y] Different superscripts indicate significant difference (P < .10).

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



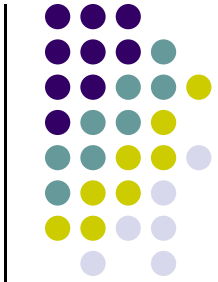
[a,b,x,y] Different superscripts indicate significant difference (P < .10).

Effect of Dietary Treatment Combination on Sow Lactation ADFI



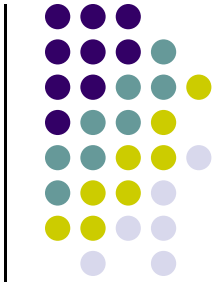
[a,b,x,y] Different superscripts indicate significant difference (P < .10).

University of Minnesota – Song et al. (2007)



- To determine the effects of increasing levels of DDGS in lactation diets on:
  - Sow and litter performance
  - Energy and nitrogen balance in sows
  - Milk fat and protein concentrations

Analyzed Nutrient Composition of Experimental Diets



	Control	10% DDGS	20% DDGS	30% DDGS	30% DDGS HP
Crude protein, %	**17.81**	**18.00**	**17.33**	**16.99**	**20.27**
ADF, %	8.94	4.37	5.29	6.98	8.48
Total calcium, %	0.88	0.88	0.84	0.82	0.76
Total phosphorus, %	0.81	0.78	0.75	0.74	0.73
Gross energy, Mcal/kg	3.95	4.03	4.10	4.18	4.02
Metabolizable energy, Mcal/kg	3.34	3.37	3.51	3.57	3.42

Song et al. (2007)

Genetics and Housing

- Used 307 mixed parity sows

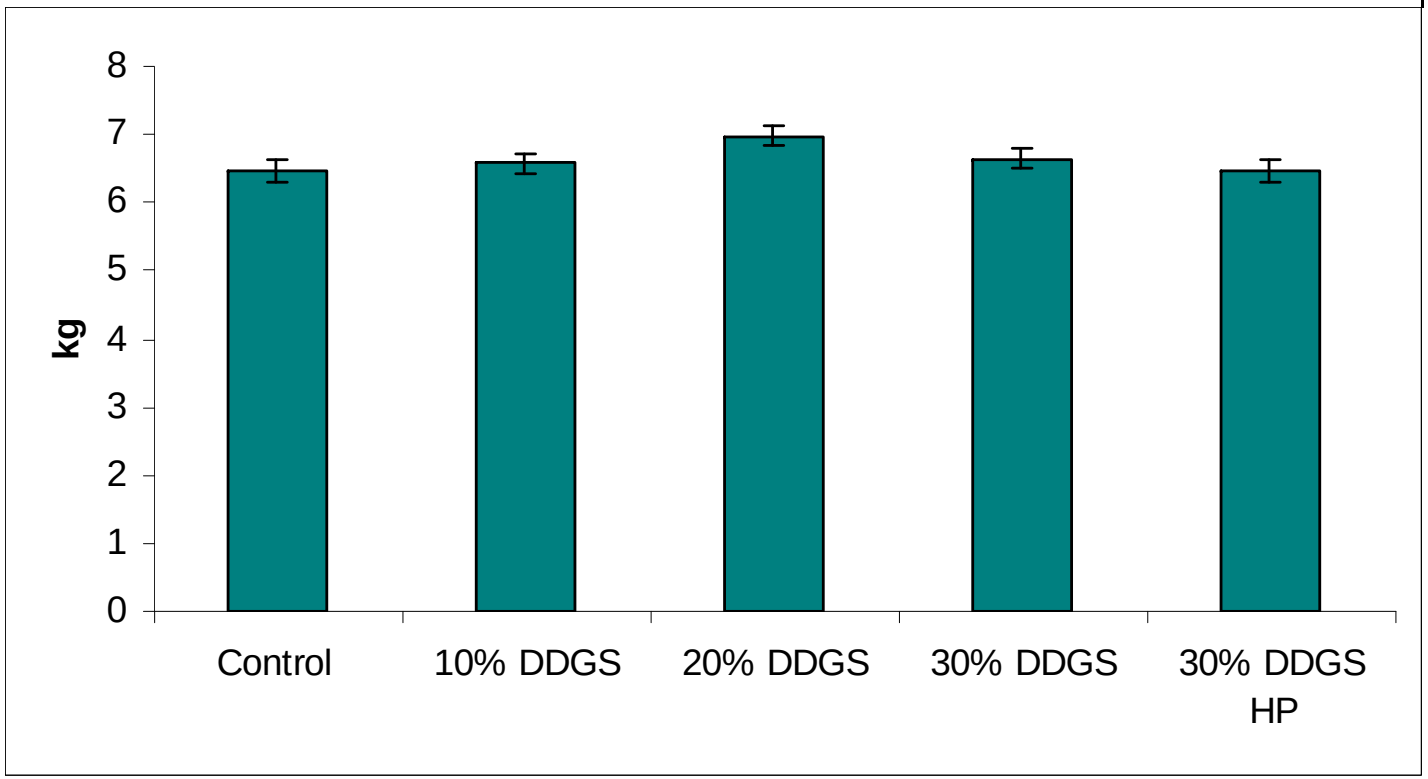
  - Group housed = 147 sows
  - Individual crates = 160 sows

- English Belle, GAP genetics, Winnipeg, MB, Canada
- Average initial weight of about 222 ± 15 kg

Group housing

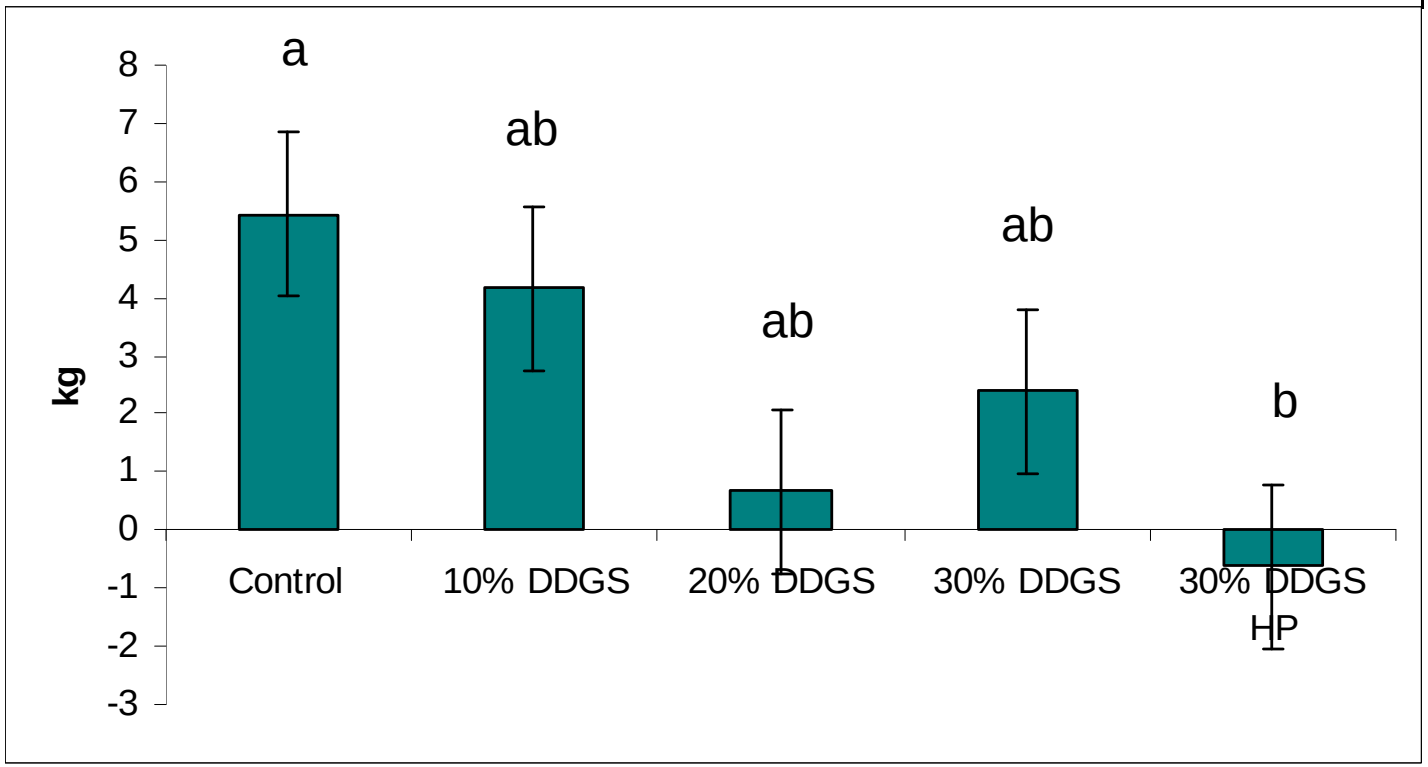
Individual housing

Effect of Increasing Dietary DDGS Level on Sow ADFI in Lactation



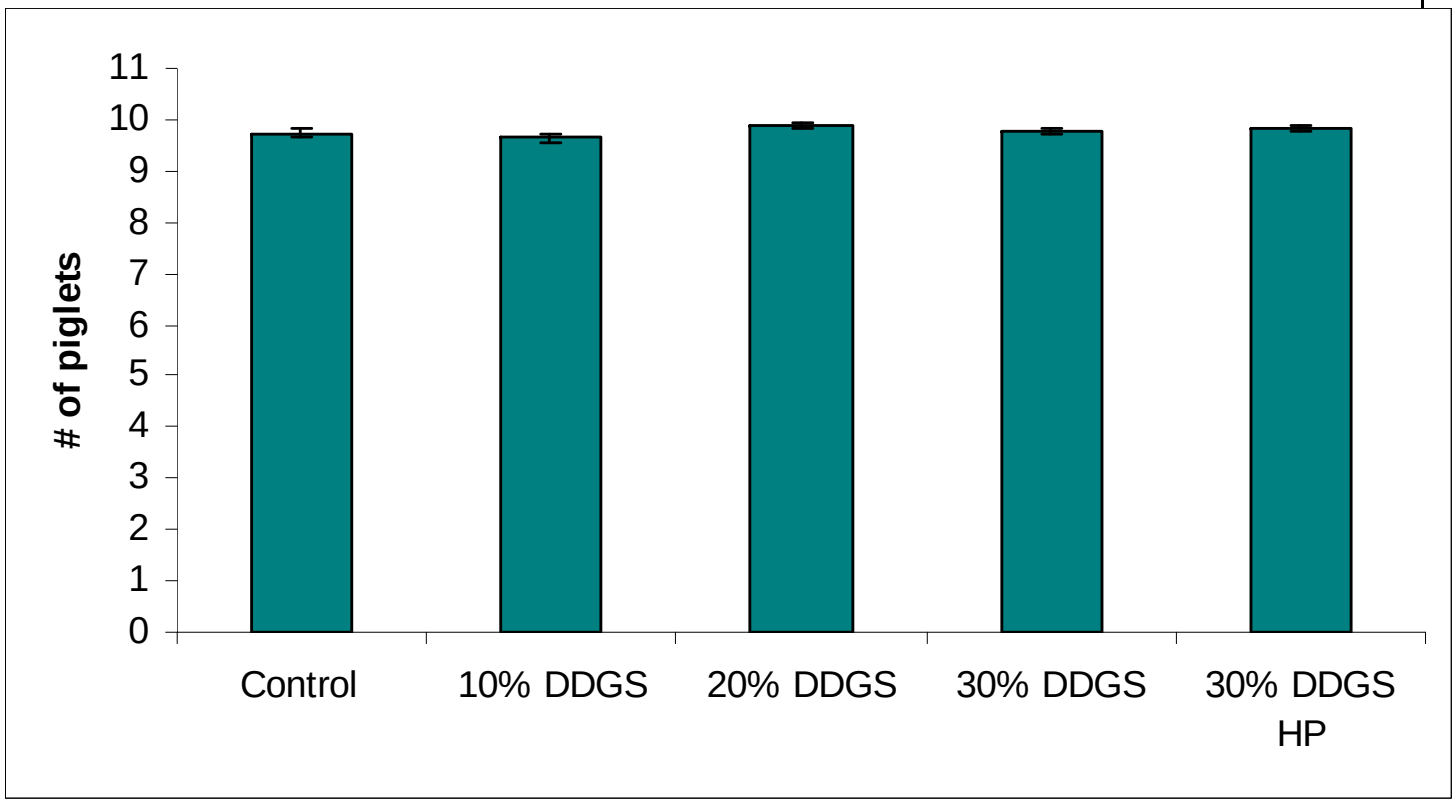
No significant difference (P = 0.10)

Effect of Increasing Dietary DDGS Level on Sow Body Weight Change



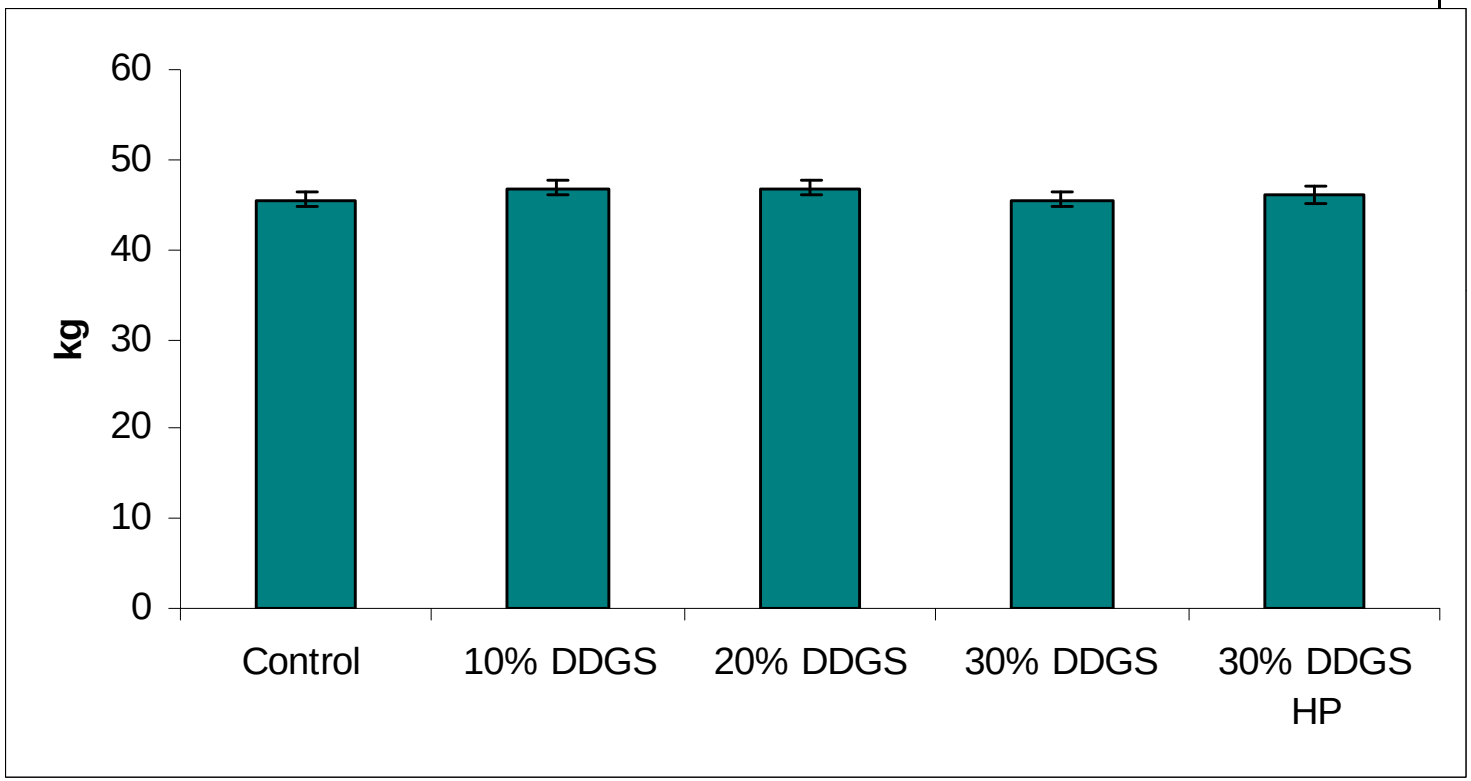
[a,b] Means with different superscripts are significantly different (P < 0.05)

Effect of Increasing Dietary DDGS Level on Litter Size at Weaning



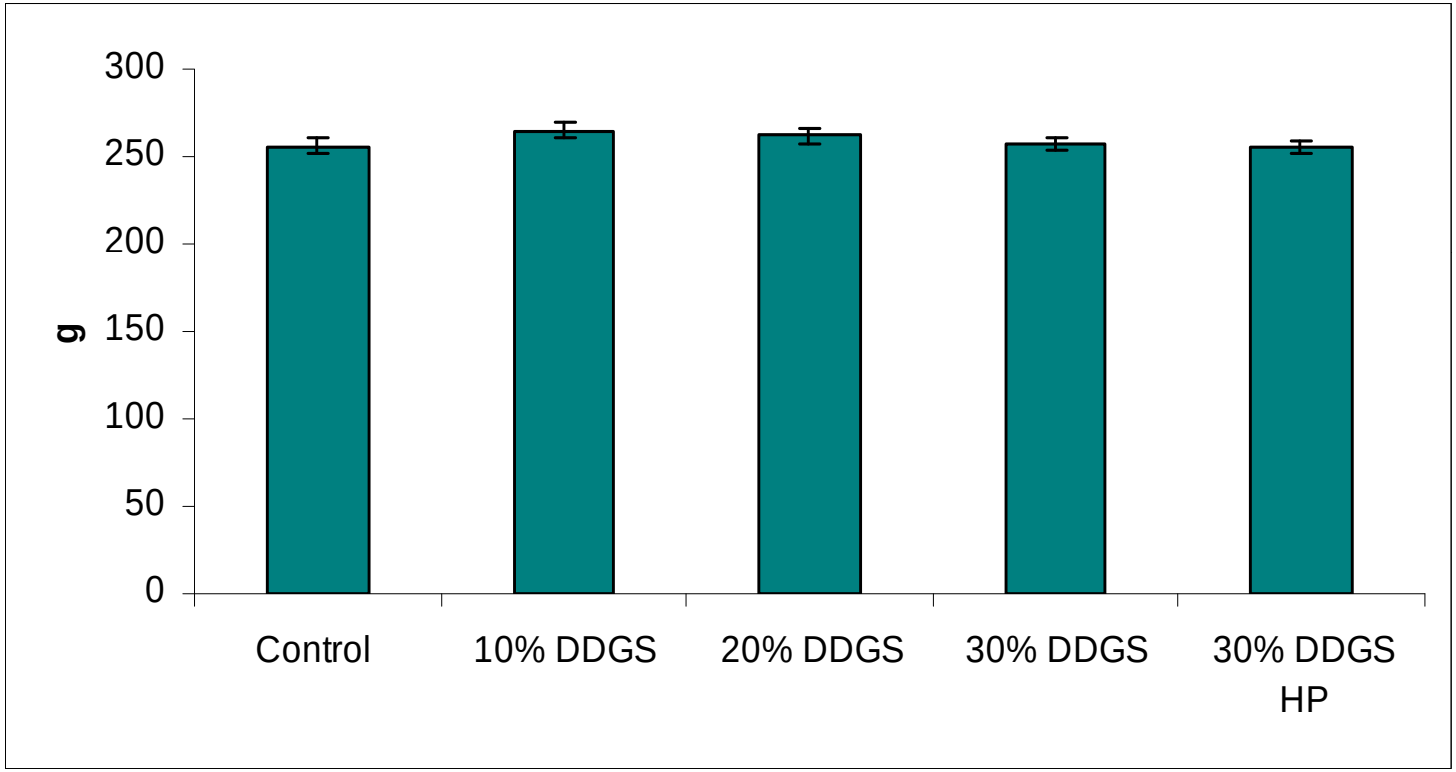
No significant difference (P = 0.31)

Effect of Increasing Dietary DDGS Level on Litter Weight Gain



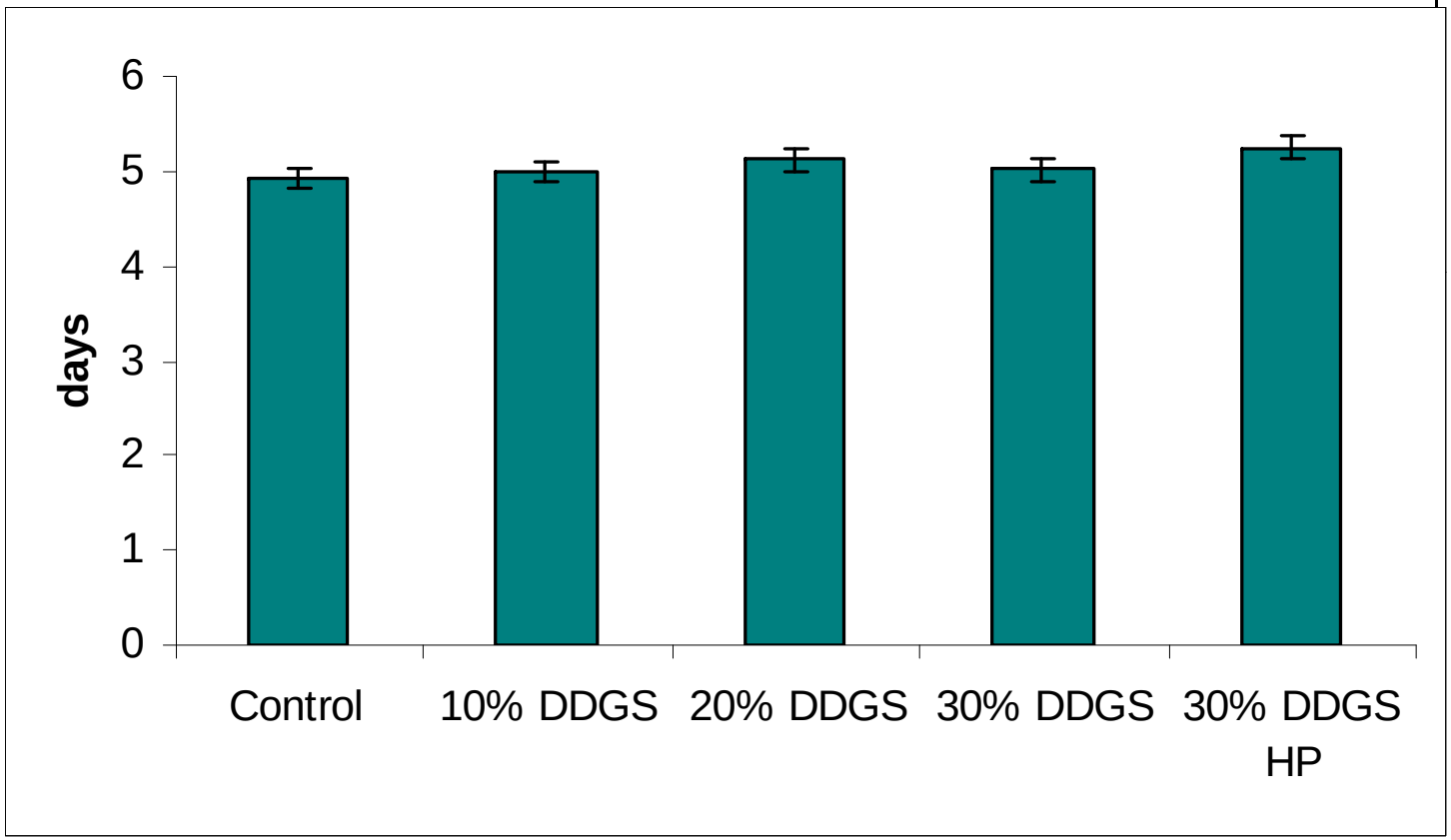
No significant difference (P = 0.67)

Effect of Increasing Dietary DDGS Level on Average Daily Piglet Weight Gain



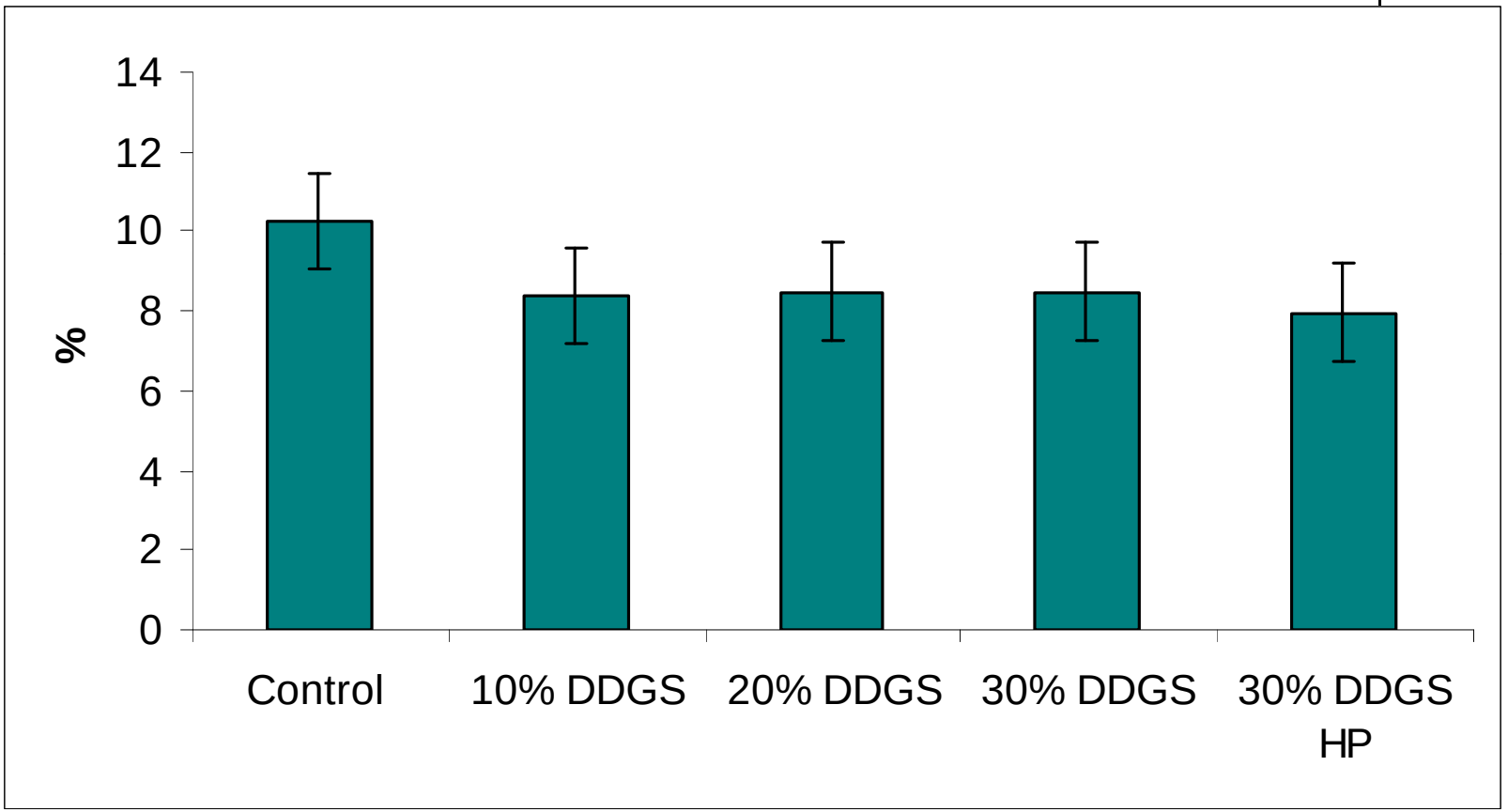
10, 20, and 30% DDGS vs. 30% DDGS HP ($P < 0.1$)
10, 20, and 30% DDGS vs. Control ($P < 0.1$)

Effect of Increasing Dietary DDGS Level on Wean to Estrus Interval



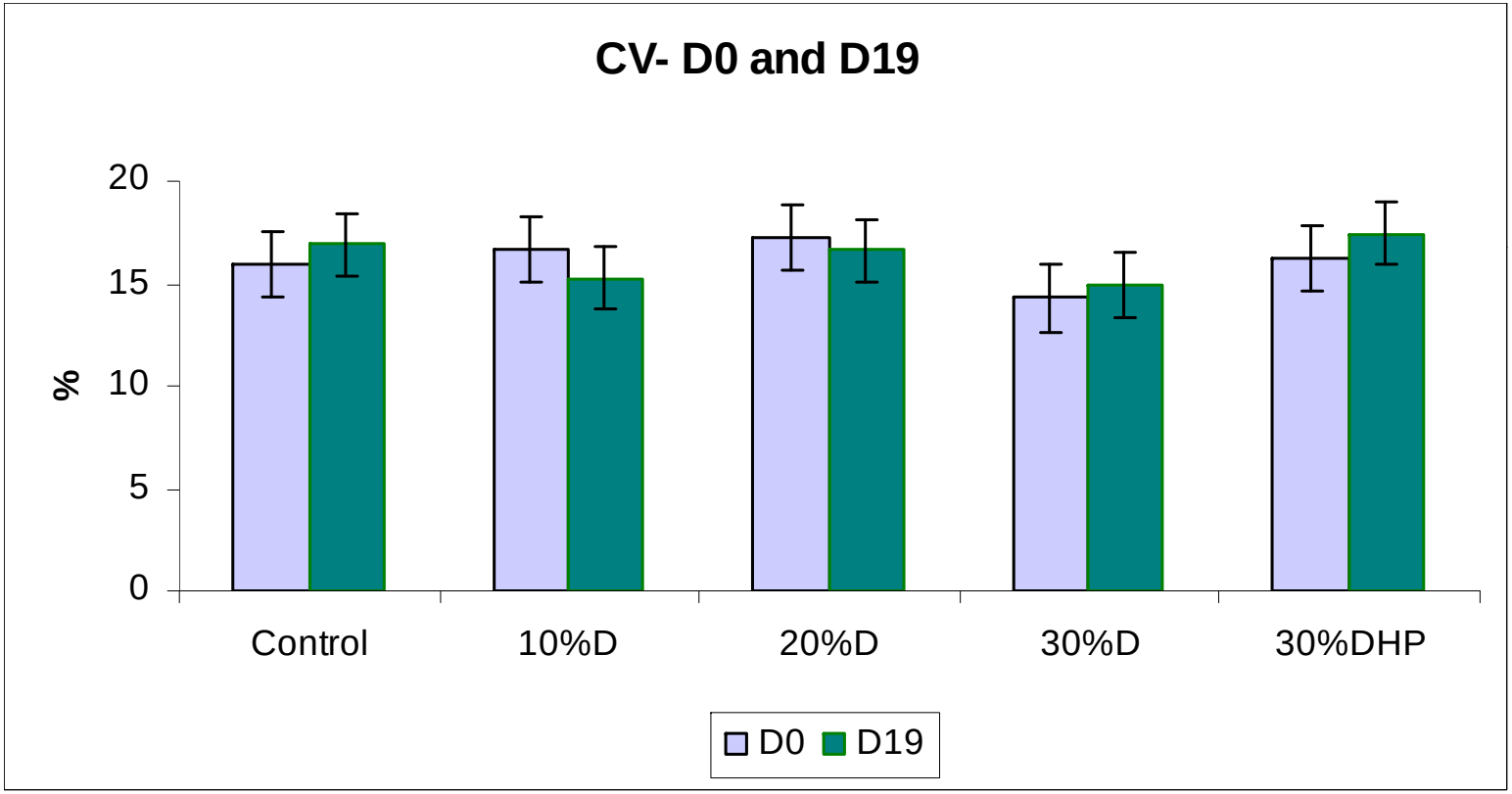
No significant difference (P = 0.35)

Effect of Increasing Dietary DDGS Level on Pre-Weaning Mortality



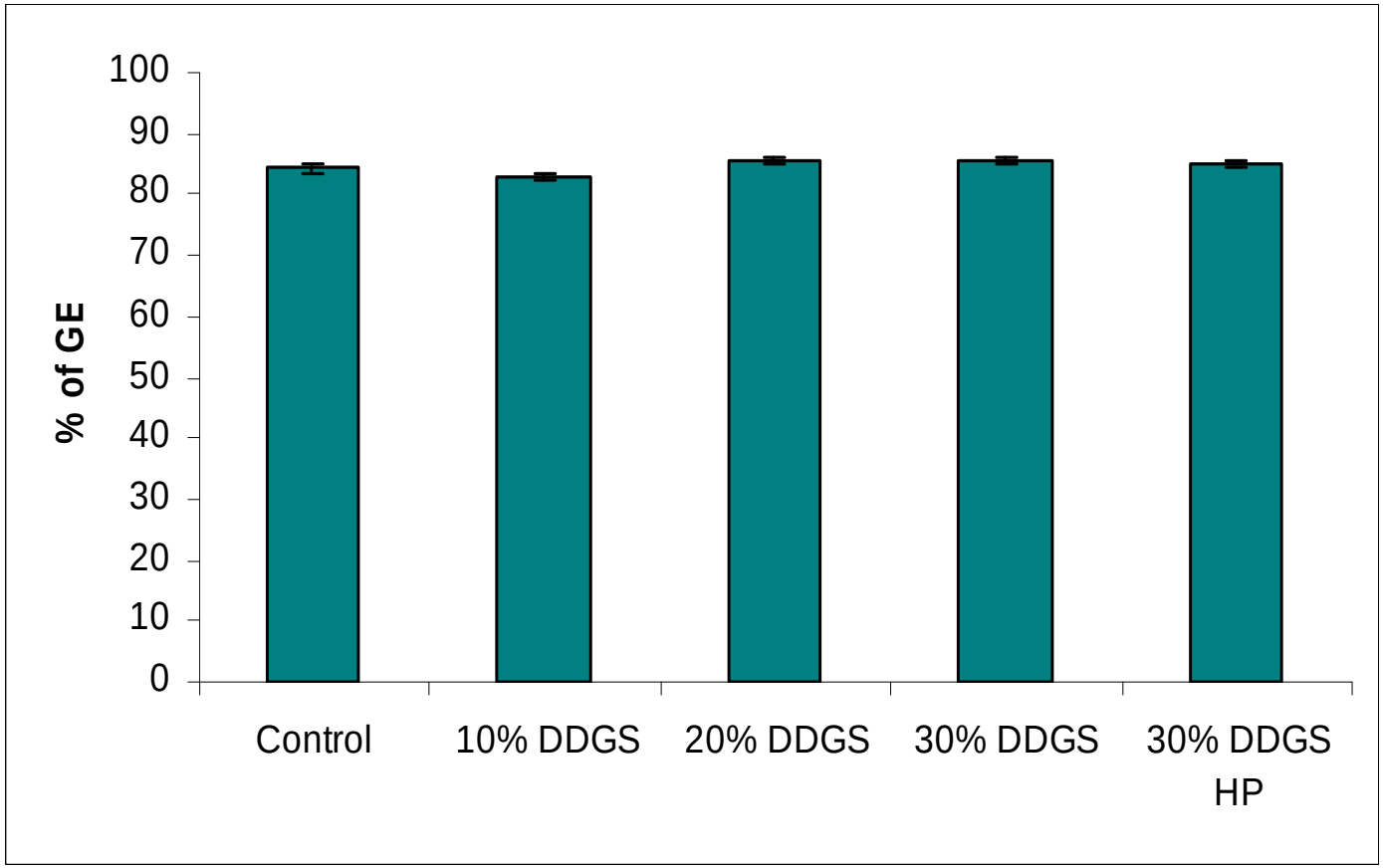
No significant difference (P = 0.71)

Effect of Increasing Dietary DDGS Level on Coefficient of Variation of Individual Pig Weight within Litters



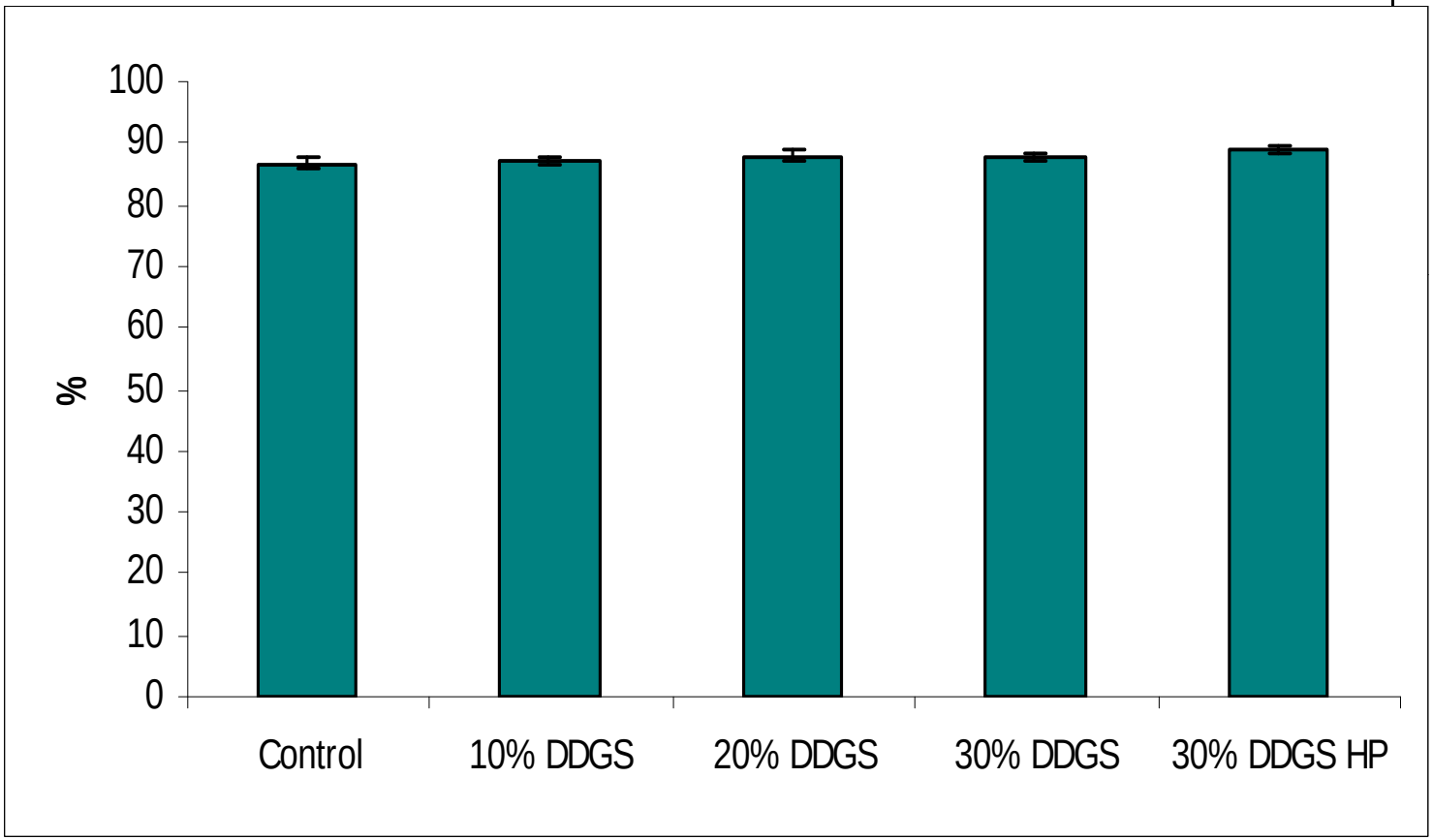
No significant difference on Day 0 (P = 0.85) and Day 19 (P = 0.53)

Effect of Increasing Dietary DDGS Level on Metabolizable Energy



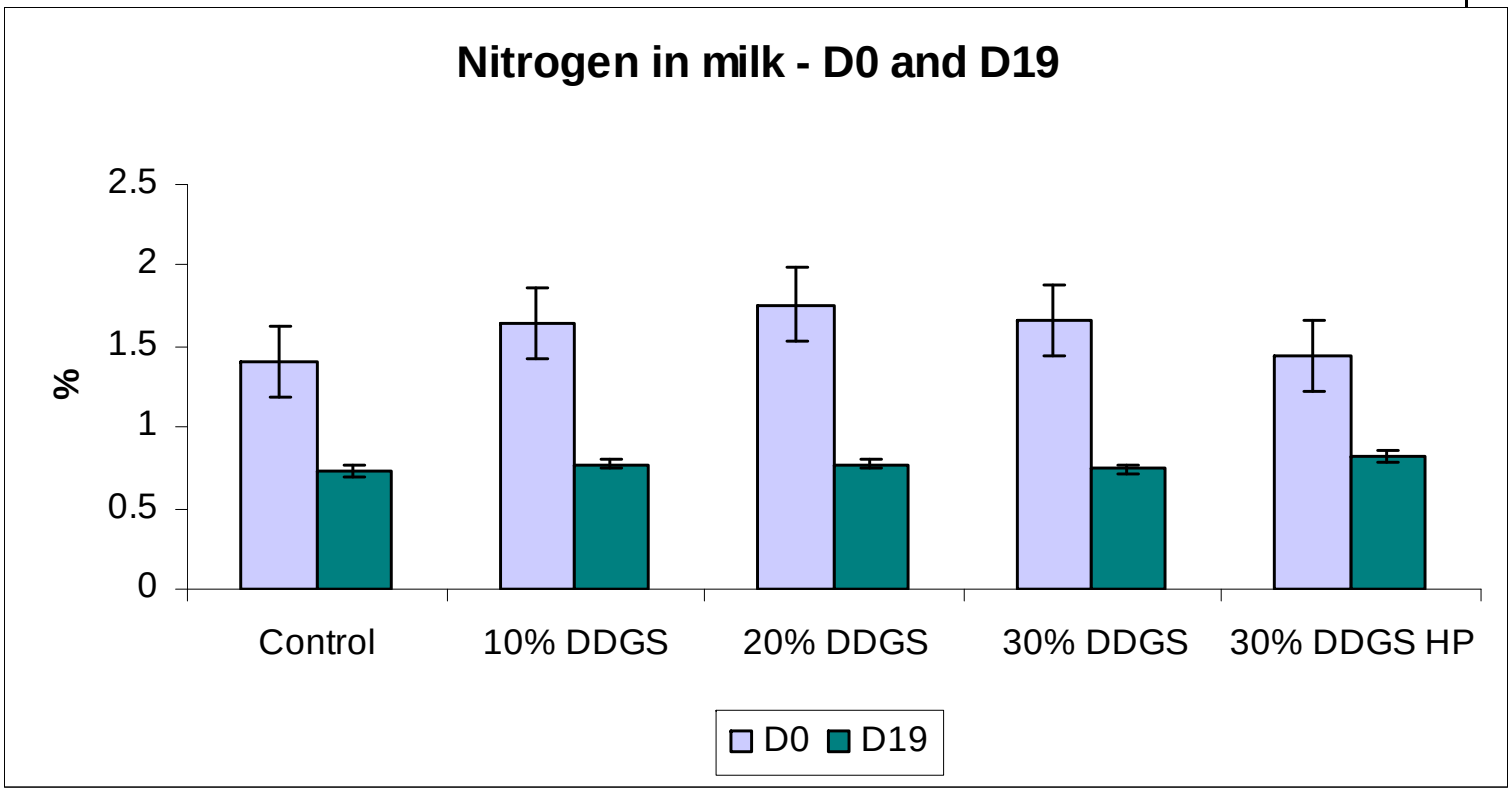
No significant difference (P = 0.37)

Effect of Increasing Dietary DDGS Level on Nitrogen Digestibility



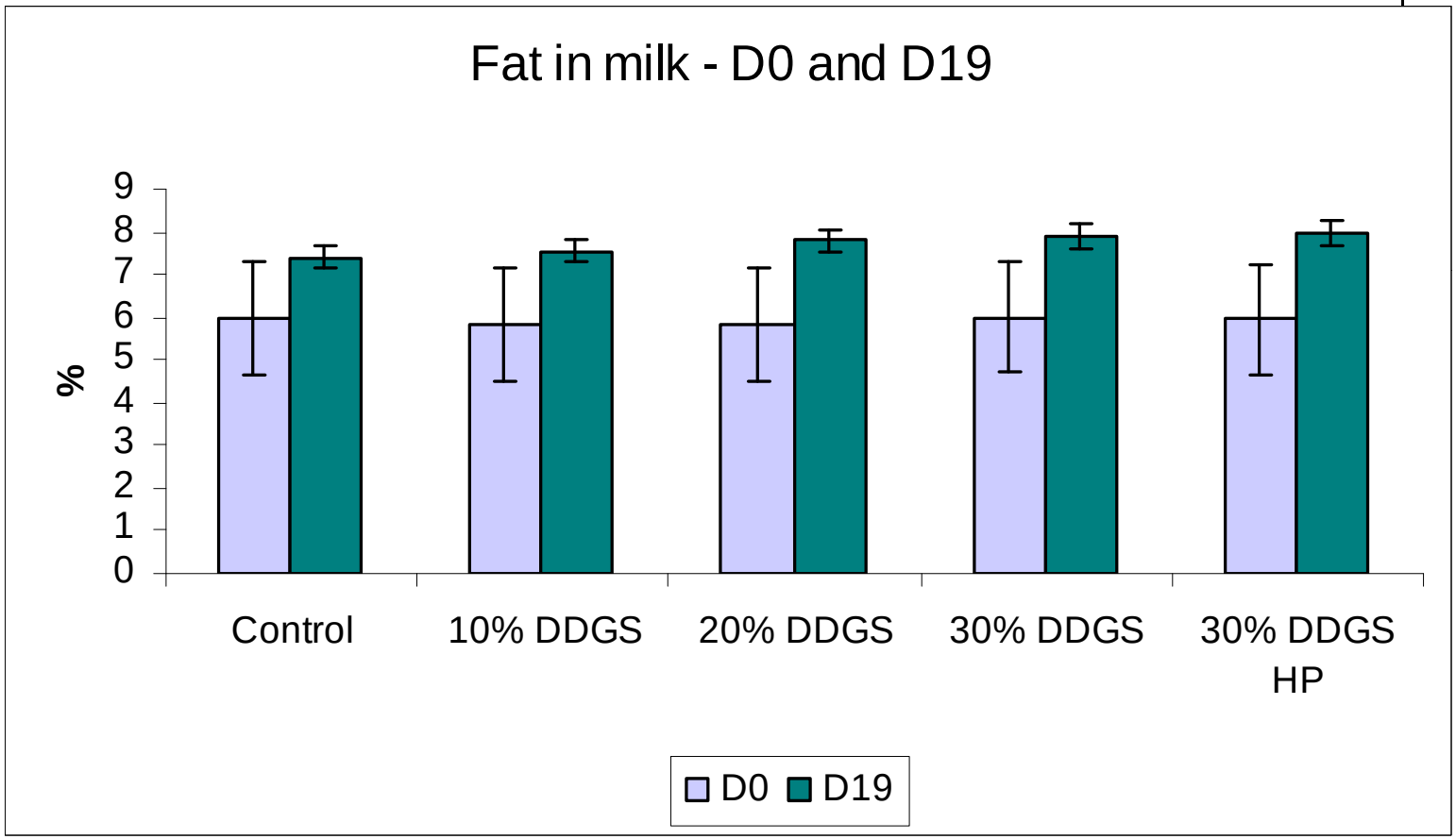
No significant difference (P = 0.29)

Effect of Increasing Dietary DDGS Level on Nitrogen Content of Sow Milk



No significant difference at Day 0 (P = 0.73) and Day 19 (P=0.41)

Effect of Increasing Dietary DDGS Level on Fat Concentration in Sow Milk



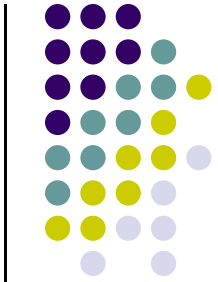
No significant difference on Day 0 (P = 0.99) and Day 19 (P = 0.59)

Conclusion

- Inclusion of up to 30% DDGS in sow lactation diets did not affect:
  - Sow and litter performance
  - Digestible and metabolizable energy
  - Nitrogen retention and digestibility
  - Milk nitrogen and fat concentration

Use of Corn DDGS in Poultry Diets

Benefits and Limitations for Poultry



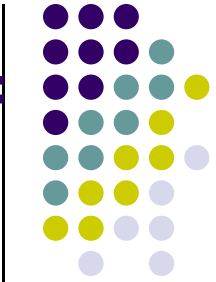
Benefits

- Good energy and amino acid source when limited to < 15% of the diet
- Source of highly available P
  - Reduce manure P
- May improve egg yolk and skin color (xanthophyll)
- Source of “unidentified growth factors”?
- “Golden” DDGS gives best performance
- Highly palatable

Limitations

- Energy value ~ 84% of corn
- Low protein quality
  - add other supplements high in lys, arg, trp
- Sources high in sodium may increase litter moisture if adjustments to dietary salt levels are not made

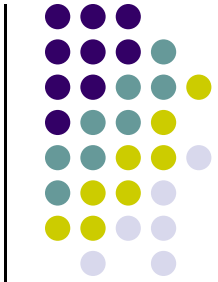
Recommended Inclusion Rates of DDGS for Poultry



- Broilers
  - 10% inclusion rates
    - Without energy adjustments
  - > 10%
    - With adjustments for lys, met, thr, trp, and energy
- Chicken Egg Layers
  - 10% inclusion rate
  - > 10%
    - With adjustments for lys, met, thr, trp, and energy

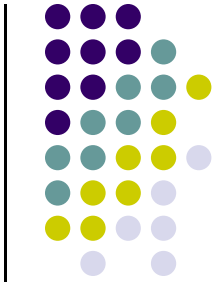
Use of Corn DDGS in Aquaculture Diets

Current Recommendations for Maximum Dietary Inclusion Rates of DDGS for Various Species of Fish



Species	% DDGS	Comments
Catfish	Up to 30%	
Trout	Up to 15%	Without synthetic lys and met supplementation
Trout	Up to 22.5%	With synthetic lys and met supplementation
Salmon	Up to 10%	
Freshwater Prawns	Up to 40%	Can replace some or all of the fish meal in the diet
Shrimp	Up to 10%	No studies are available but based upon research results with freshwater prawns, a minimum of 10% DDGS in shrimp should be acceptable.
Tilapia	Up to 35%	Without synthetic lys and supplementation in high protein diets (40% CP)
Tilapia	Up to 82%	With synthetic lys and trp supplementation in low protein diets (28% CP)

University of Minnesota 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