


Impact of Increasing Dietary Levels of DDGS and Dietary Withdrawal Pre-Harvest, on Growth Performance, Carcass and Pork Quality of Grower-Finisher Pigs



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Summary of Growth Performance Responses from Feeding Levels up to 30% DDGS in Grower-Finisher Diets

Performance Measure	N	Increased	Reduced	Not Changed
ADG	25	1	6	18
ADFI	23	2	6	15
Gain/Feed	25	4	5	16

Stein and Shurson, 2008

Summary of Carcass Characteristic Responses from Feeding Levels up to 30% DDGS in Grower-Finisher Diets

Performance Measure	N	Increased	Reduced	Not Changed
Dressing %	18	0	8	10
Backfat Thickness	15	0	1	14
Loin Depth	14	0	2	12
% Carcass Lean	14	0	1	13

Stein and Shurson, 2008

Summary of Belly Quality Characteristics from Feeding Levels up to 30% DDGS in Grower-Finisher Diets

Performance Measure	N	Increased	Reduced	Not Changed
Belly thickness	4	0	2	2
Belly firmness	3	0	3	0
Iodine value	8	7	0	1

Stein and Shurson, 2008

Why Is There a Concern About Feeding Diets Containing DDGS on Pork Fat Quality?



Comparison of Selected Nutrients in Corn DDGS and Corn (As Fed Basis)

Nutrient	Corn DDGS	Corn
Swine ME, kcal/kg	3,390	3,420
Crude fat, %	9.6	3.9
Linoleic acid (C18:2), %	5.32	1.92
Oleic acid (C18:1), %	2.47	0.94

Current Pork Fat Quality Standards

- ❑ Based on Iodine Value (IV)
 - ratio of unsaturated:saturated fatty acids
- ❑ Maximum IV
 - 70 – Danish Meat Research Institute
 - 72 – National Pork Producers Council
 - 74 – Boyd et al. (1997)
- ❑ Various adipose tissue sites are affected differently by dietary fatty acid composition

Questions

- ❑ Is IV the best criteria for assessing pork fat quality?
- ❑ What is the maximum IV for acceptable pork fat quality?
- ❑ Which adipose tissue site should be used to measure IV?
- ❑ How much DDGS can be added to corn-soybean meal diets to achieve acceptable pork fat quality?
- ❑ Will removing high levels of DDGS from the diet for a time period prior to slaughter result in acceptable pork fat quality?

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

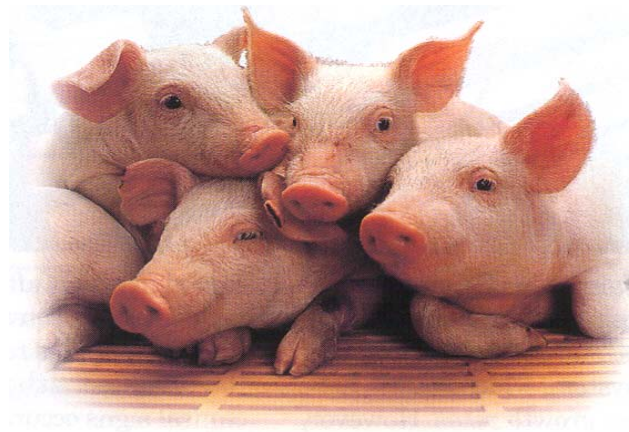
□ Genetics

- Monsanto Genepacker sows
- Monsanto EB terminal semen

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

□ Health

- Positive-stable for PRRS
- Positive for Mycoplasma, but do not vaccinate
- Negative for APP
- Health of pigs was good



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

□ Nutrition

- Provided by Land O' Lakes
- Producer A fed typical corn-SBM diets
- Producer B fed corn-SBM meal diets + 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	10% DDGS
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).

Effects of feeding diets containing
increasing levels of corn DDGS
to grower-finisher pigs on
growth performance, carcass, and
pork fat quality



Objectives

- ❑ To determine the effects of adding 0, 10, 20, and 30% DDGS on:
 - Growth performance
 - Carcass quality
 - Muscle and fat quality
 - Loin fat oxidation
 - Loin and bacon eating characteristics



Animals and Housing

- Pigs
 - 512 crossbred pigs (256 gilts and 256 barrows) from two groups
 - Initial weight = 22 kg
- Housing
 - Environmentally controlled grower-finisher facility
 - 8 pigs per pen
 - Barrows and gilts housed separately
- Feeding program
 - Diets
 - formulated on a dig. lys. basis
 - no supplemental fat
 - Three-phases
 - 20-50 kg
 - 50-80 kg
 - 80-120 kg



Results



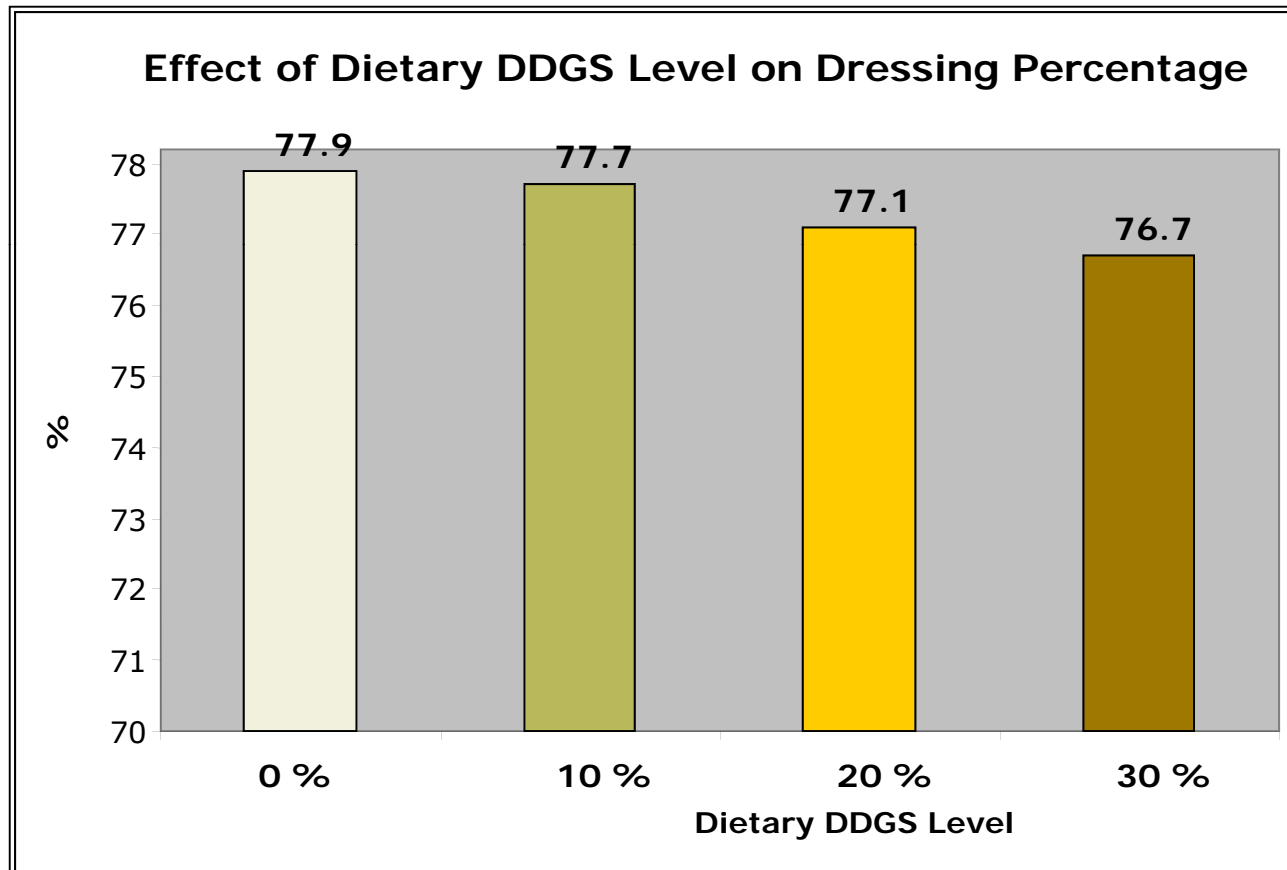
Effect of Formulating G-F Diets on a Digestible Amino Acid Basis, with Increasing Levels of DDGS, on Overall Growth Performance

	0% DDGS	10% DDGS	20% DDGS	30% DDGS
Initial wt., kg	22.5	22.8	22.5	22.5
Final wt., kg	114.3	114.7	113.8	113.4
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

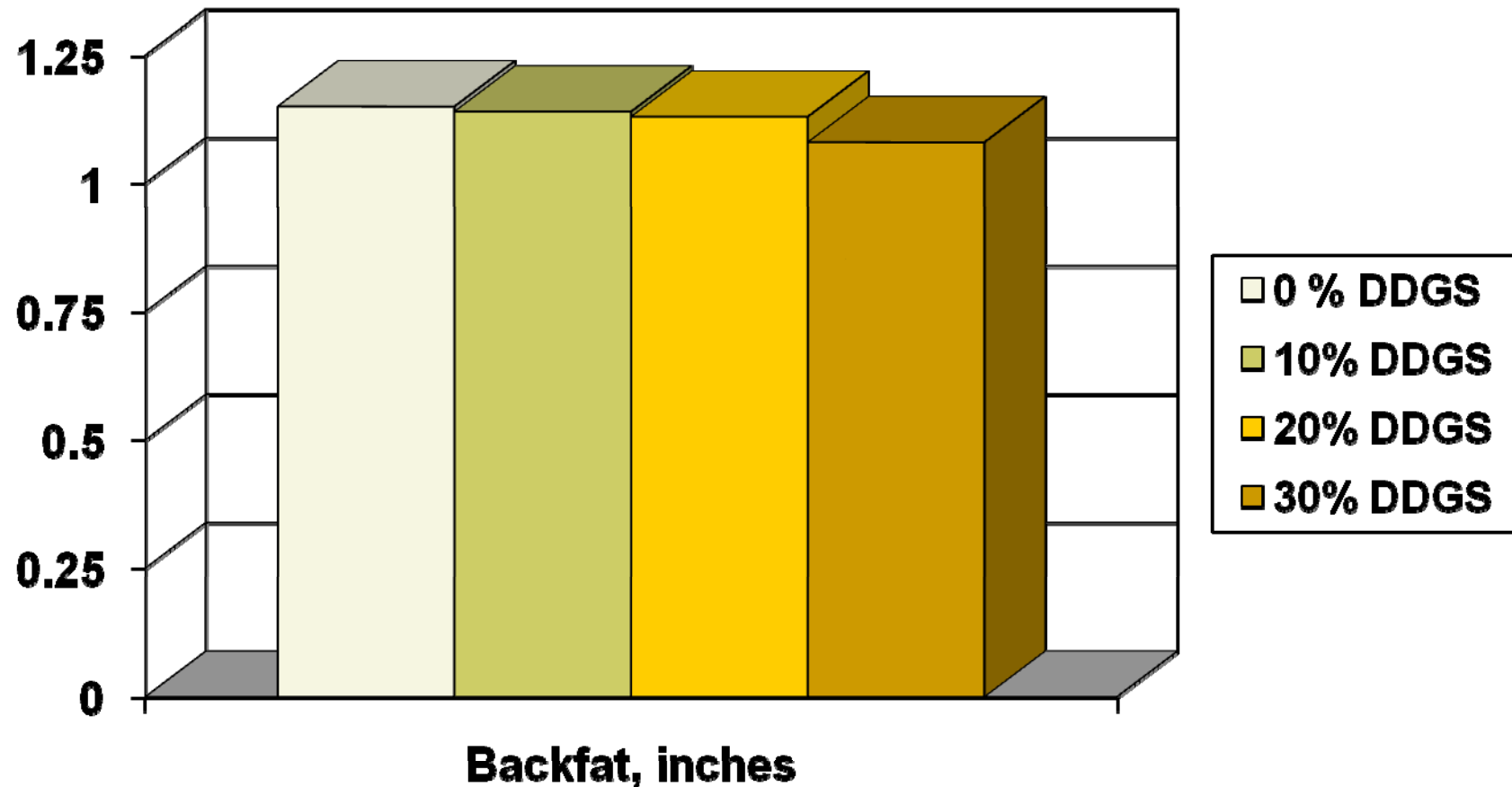
Data from 64 pens, 16 pens/treatment (Xu et al., 2007)

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



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

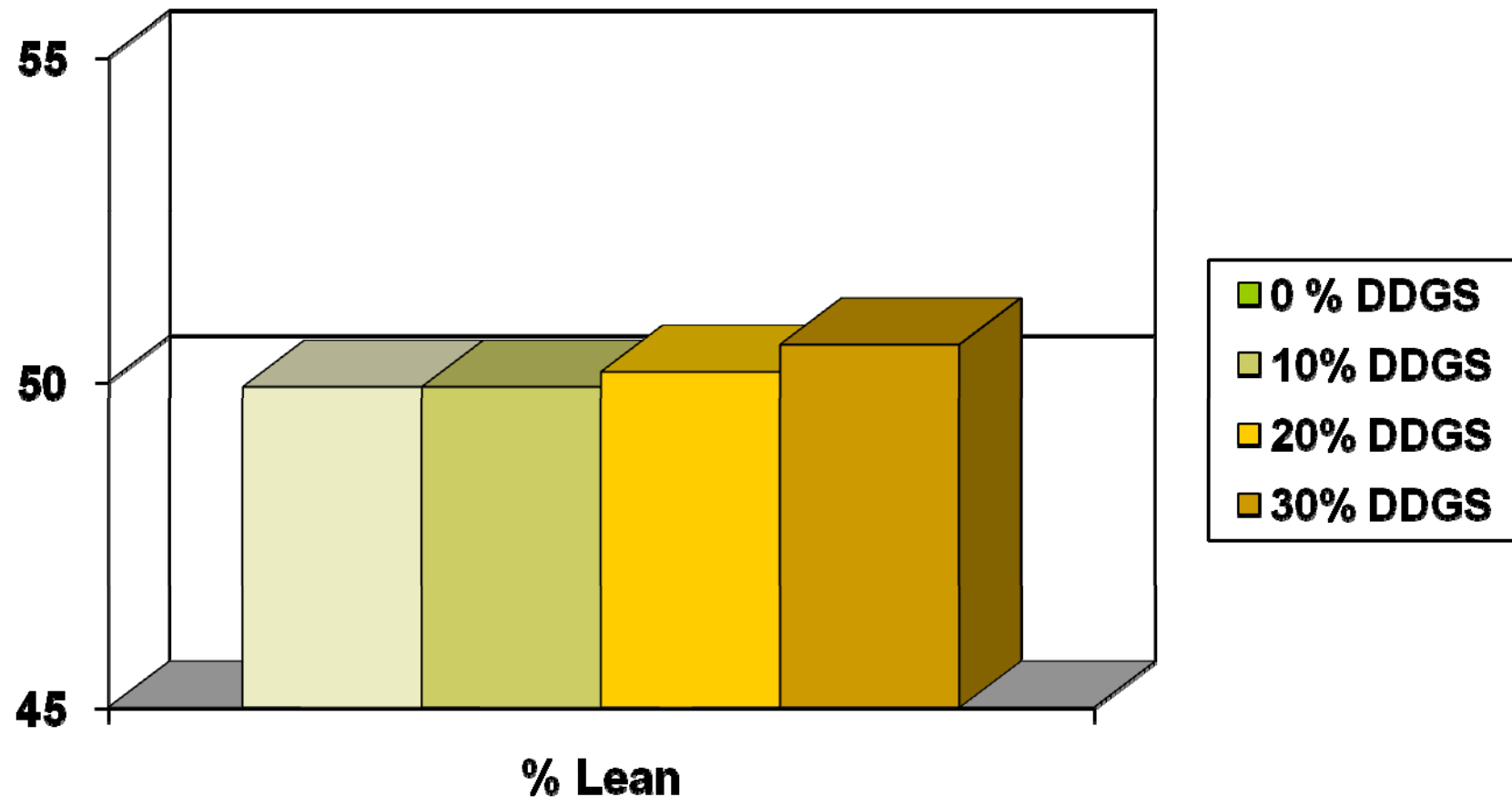
Effects of Dietary DDGS Level on Last Rib Backfat



Xu et al. (2007)

30% DDGS tended to be lower than 0% DDGS ($P = 0.09$)

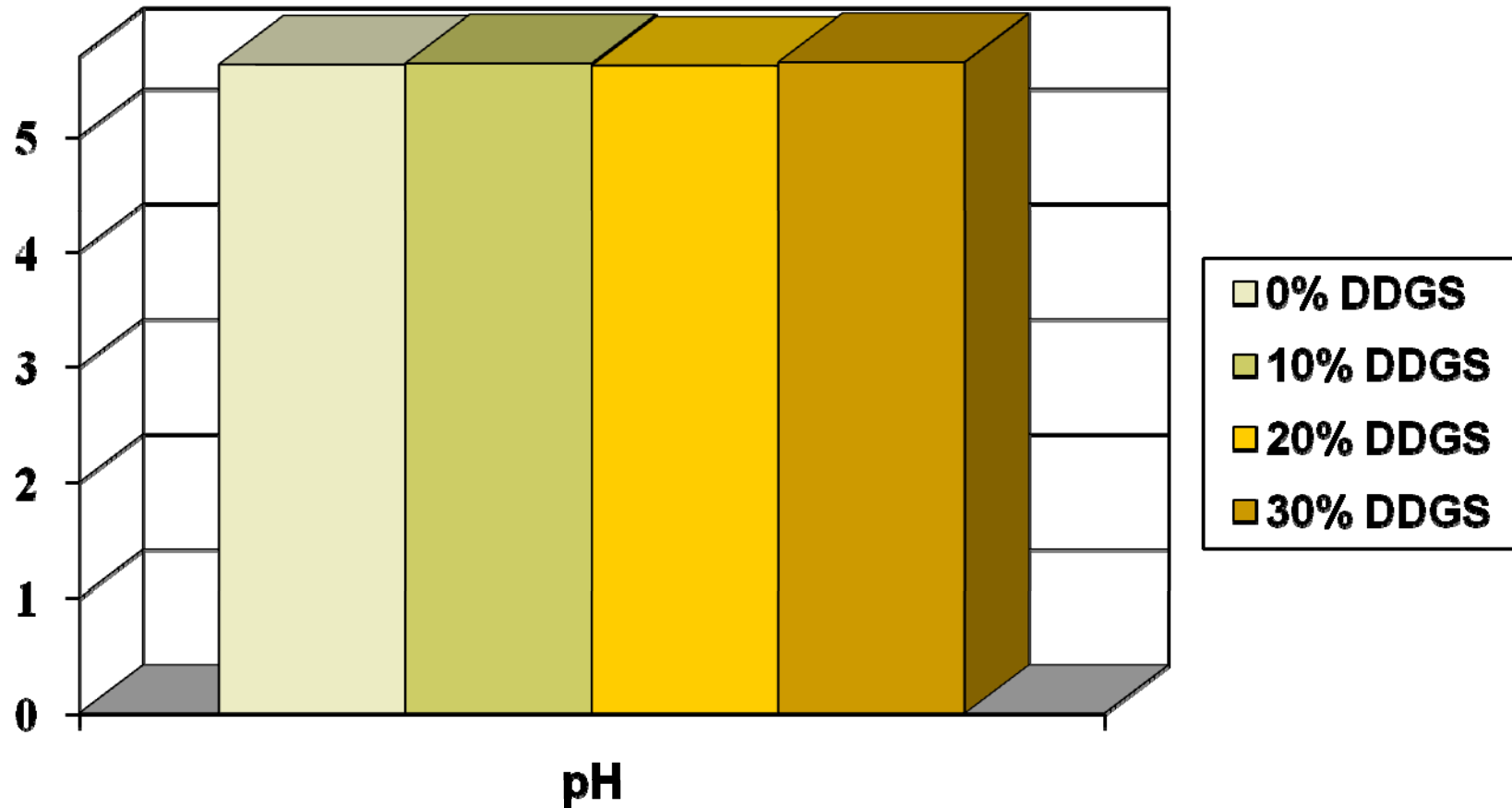
Effects of Dietary DDGS Level on % Carcass Lean



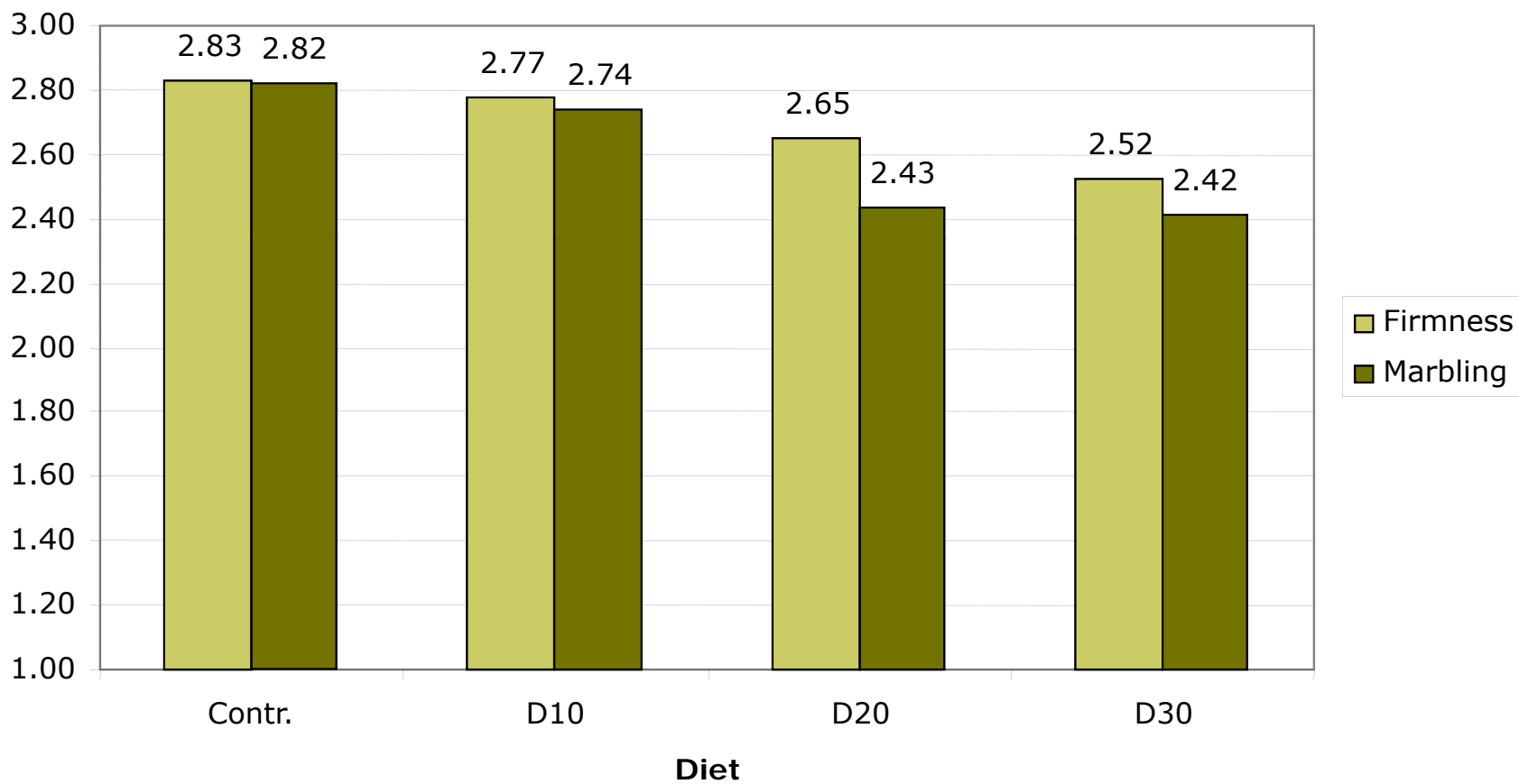
Xu et al. (2007)

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

Effects of Dietary DDGS Level on Ultimate Muscle pH



Effect of DDGS level on loin firmness and marbling score



Effects of Increasing Dietary DDGS Level on Loin Characteristics

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

Muscle Quality is Not Affected by Feeding DDGS Diets to Grower-Finisher Pigs

□ No effects on muscle:

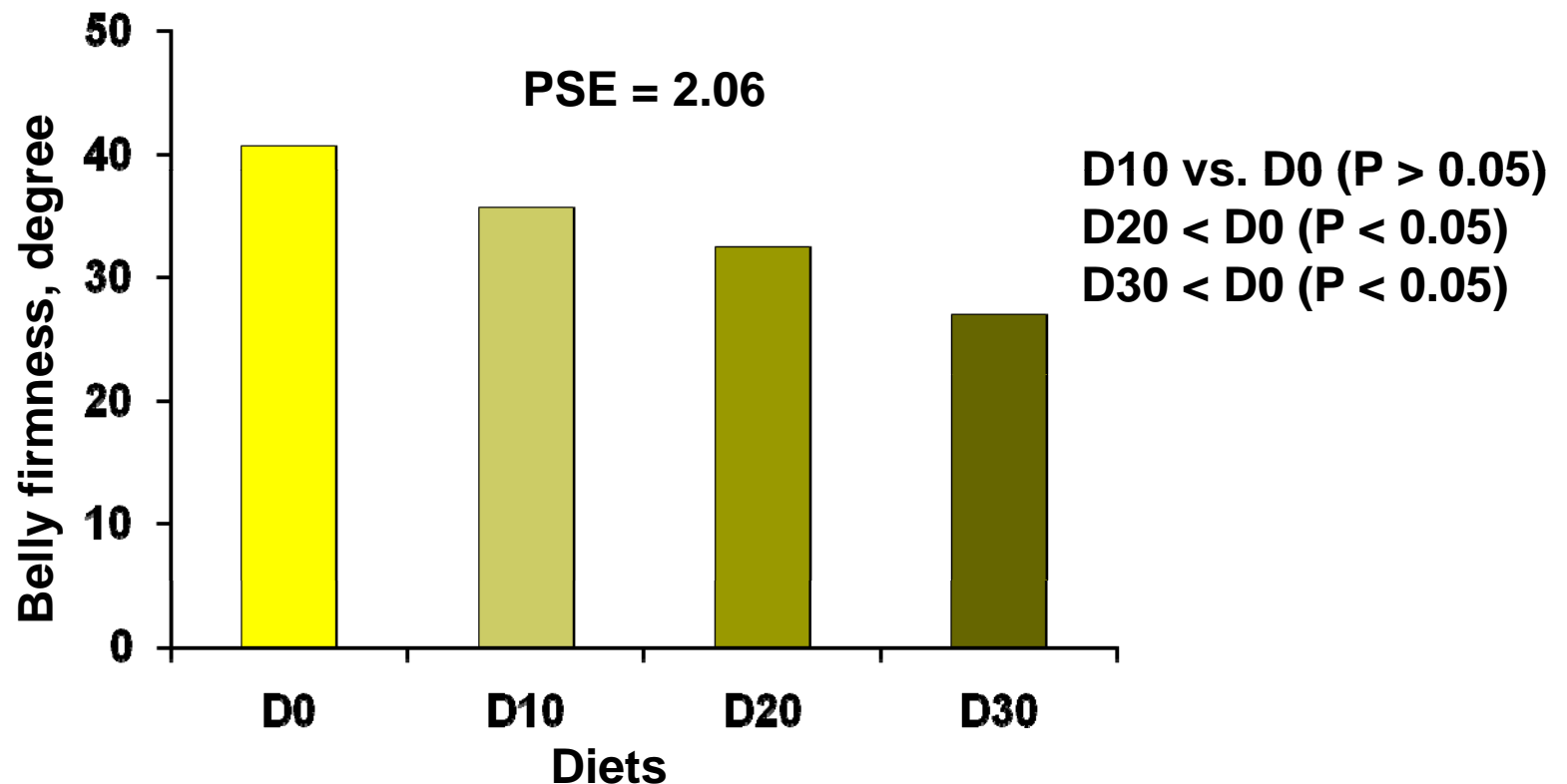
- Color
- Firmness
- Marbling
- Ultimate pH
- Drip loss
- Cooking loss
- Tenderness



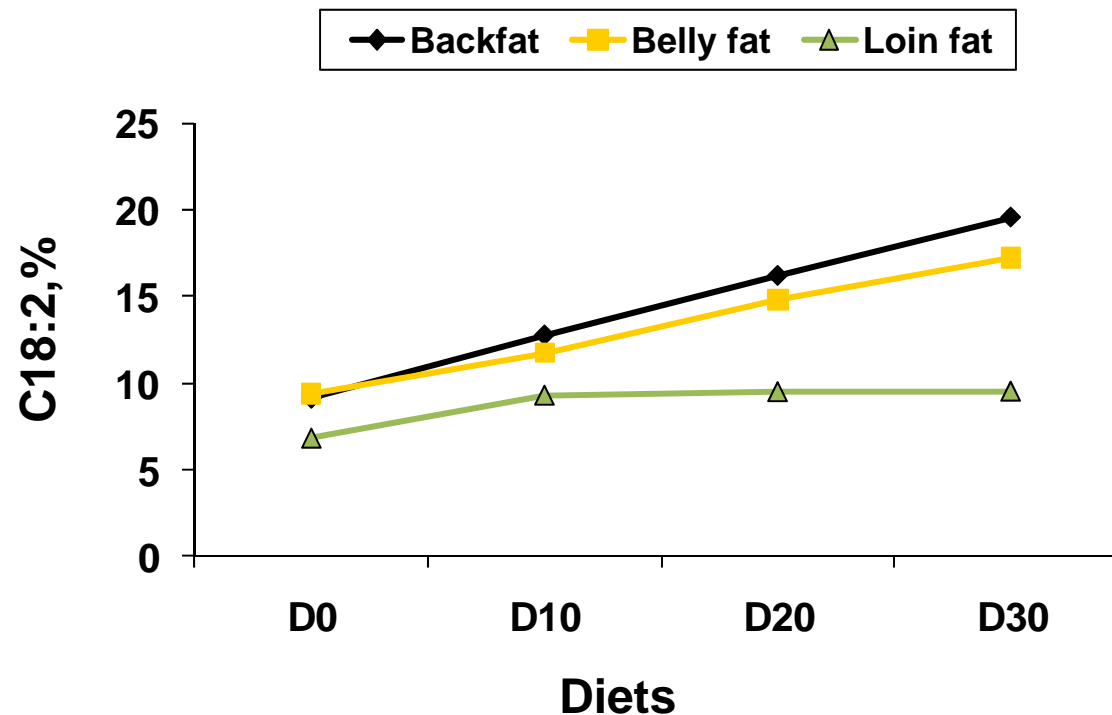
Effects of Increasing Dietary DDGS Level on Belly and Backfat Characteristics

- ❑ No effect on belly thickness
- ❑ No differences in belly fat color
 - Japanese color score
 - Minolta L^* , a^* , b^*
- ❑ Backfat was slightly darker (lower L^*) for pigs fed the 20% and 30% DDGS diets
- ❑ No differences in backfat color
 - Japanese color score
 - Minolta a^* , b^*

Effect of Dietary DDGS Level on Belly Firmness

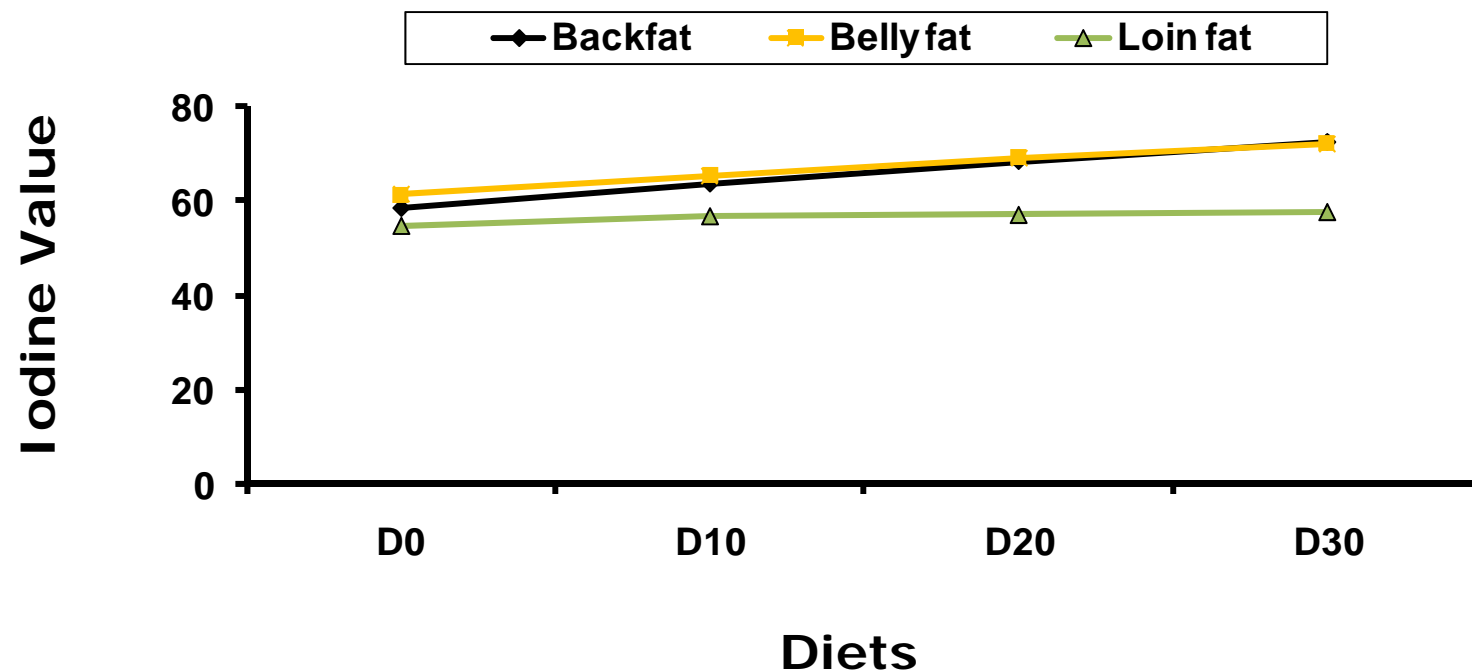


Effect of Dietary DDGS Level on C18:2 Content of Pork Fat



Linear effect of DDGS for all fat depot sites ($P < 0.01$)
Diet \times site ($P < 0.01$)

Effect of Dietary DDGS Level on Iodine Value of Pork Fat

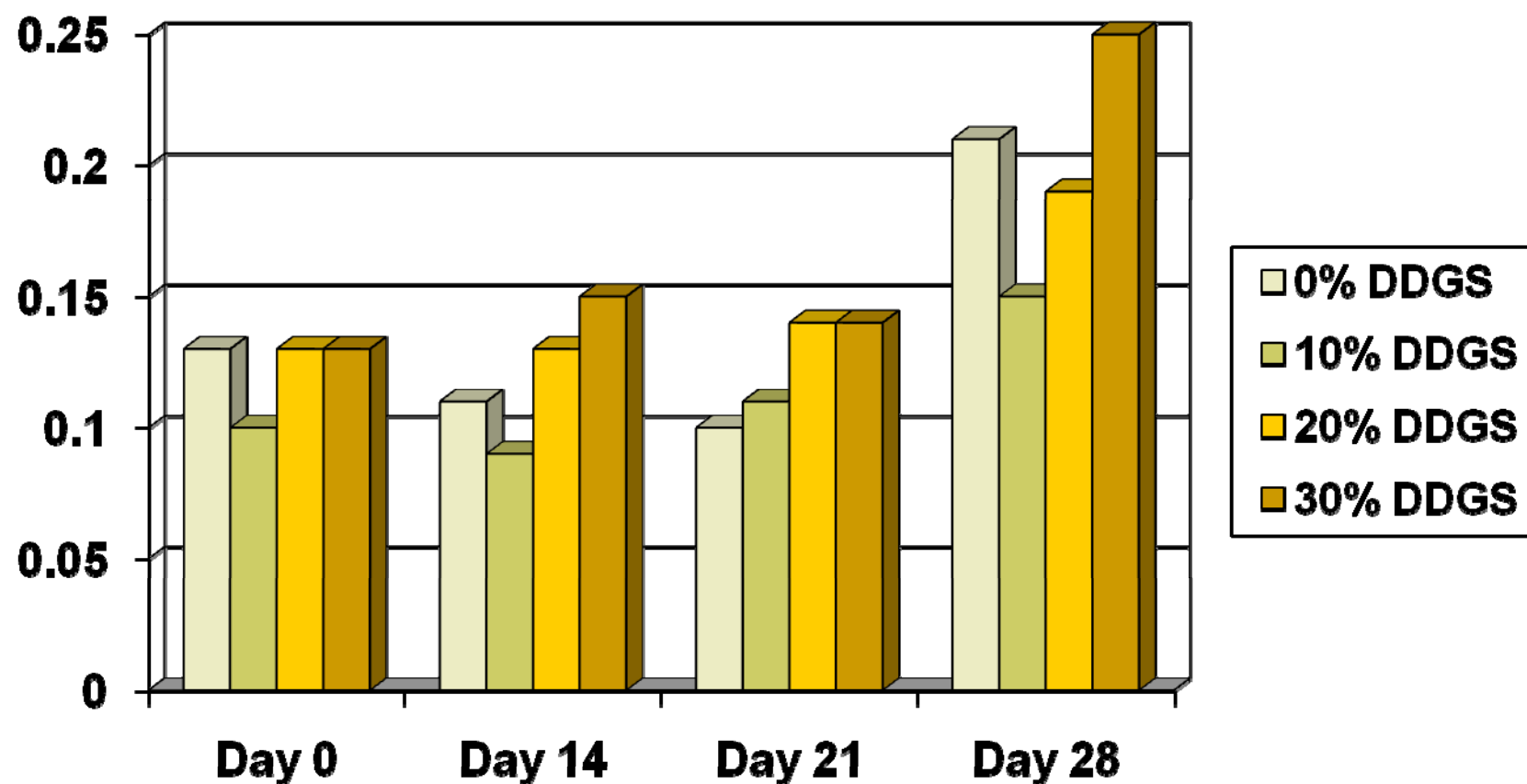


Linear effect of DDGS level for all fat depot sites ($P < 0.01$)
Diet \times site ($P < 0.01$)

Effect of Increasing Dietary DDGS Level on Fatty Acid Content of Pork Fat

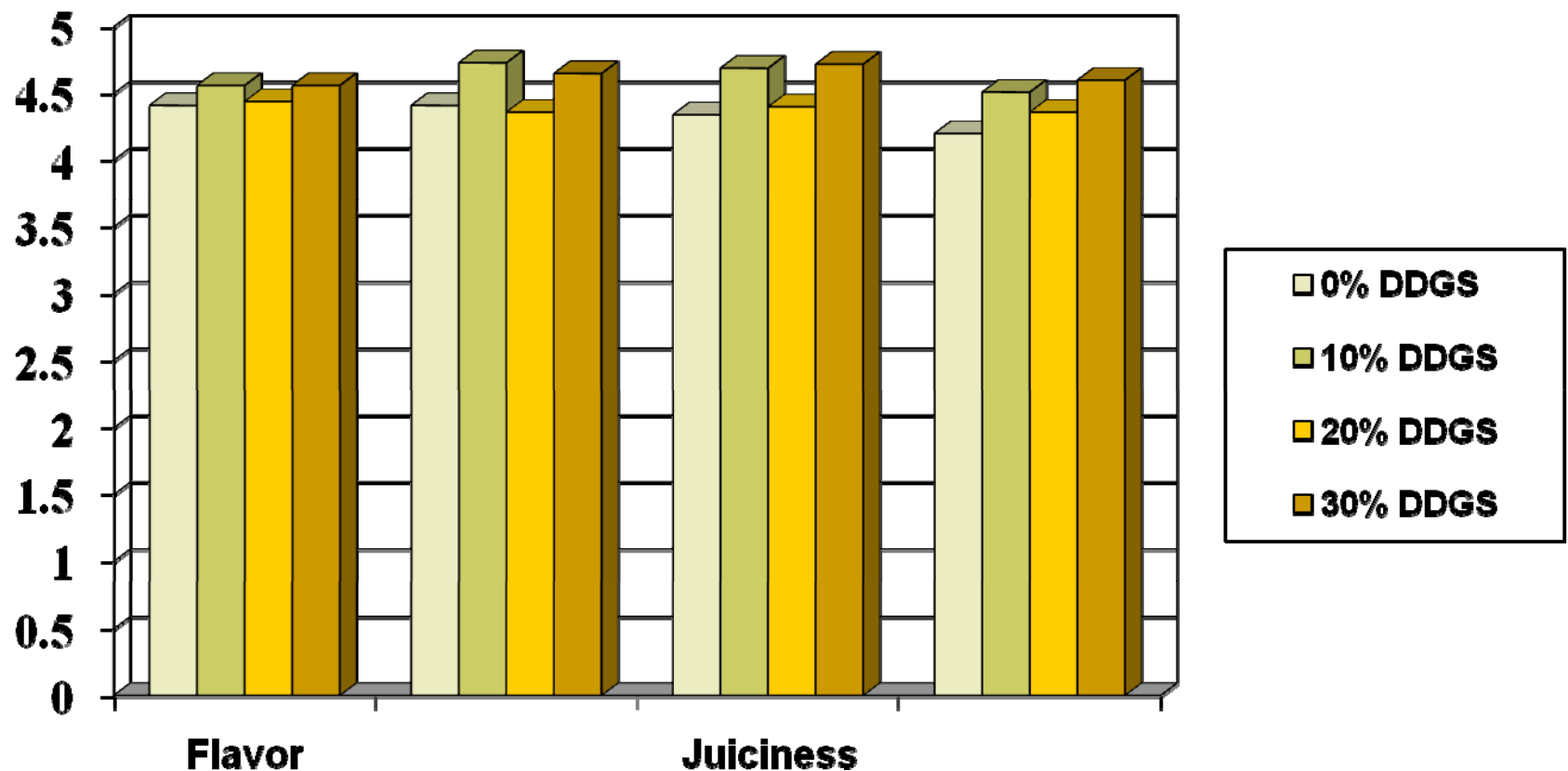
- Linear increase in PUFA
- Linear increase in IV
 - Backfat (58, 63, 68, 72)
 - Belly fat (61, 65, 69, 72)
 - Loin fat (52, 57, 57, 58)
- Linear decrease in monounsaturated fatty acids
- Linear decrease in saturated fatty acids

Effects of Increasing Dietary DDGS Level on Fat Stability of Pork Loins (TBARS, mg malonaldehyde/kg)



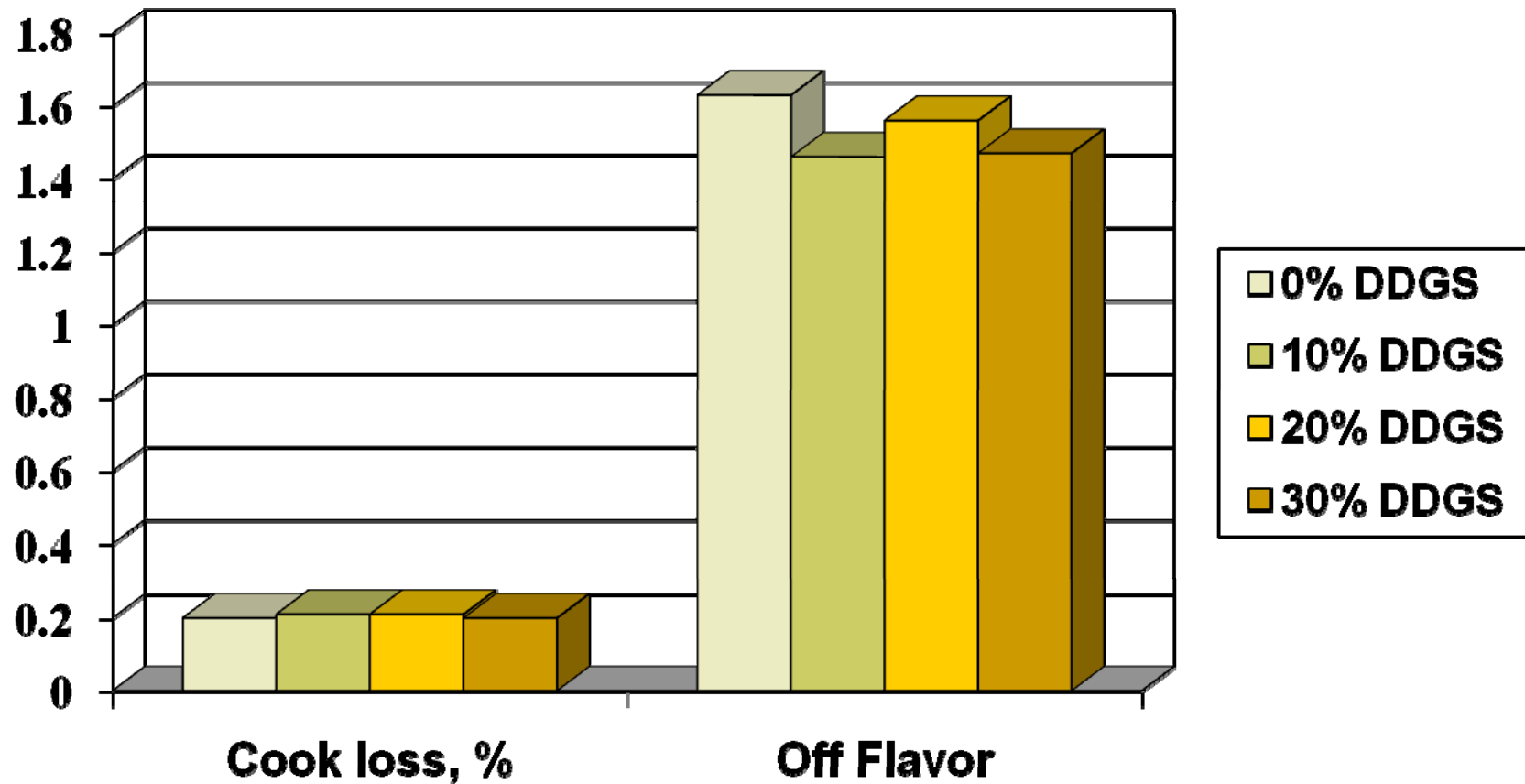
No significant differences among dietary treatments.

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



No significant differences among dietary treatments.

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



No significant differences among dietary treatments.

Effects of Dietary DDGS Level on Bacon Sensory Test

	Diets					P-value	
	D0	D10	D20	D30	PSE	Linear	Quadratic
Flavor	5.17	5.33	5.62	5.20	0.14	0.54	0.04
Tenderness	4.99	5.04	4.99	4.64	0.12	0.04	0.10
Fattiness	2.61	2.80	2.60	2.07	0.14	<0.001	0.01

Flavor: High = intense

Tenderness: High = tough

Fattiness: High = fatty

Effects of Dietary DDGS Level on Loin and Bacon Sensory Test

- ❑ Loin sensory test
 - No difference
 - ❑ Cooking loss
 - ❑ Flavor
 - ❑ Off-flavor
 - ❑ Tenderness
 - ❑ Overall acceptability

- ❑ Bacon sensory test
 - No difference
 - ❑ Cooking yield
 - ❑ Crispiness
 - ❑ Off-flavor
 - ❑ Overall acceptability

Summary and Conclusions

- ▣ Feeding diets containing up to 30% DDGS has no adverse effects on growth performance of grower-finisher pigs.
- ▣ Loin characteristics met NPPC target values.
- ▣ Loin fat oxidation was not different among dietary treatments.
- ▣ PUFA content and IV of pork fat were linearly increased with increasing dietary DDGS level.
- ▣ The highest IV = 72 (D30)
 - exceeded the NPPC standard of 70
 - less than 74 for IV threshold suggested by Boyd et al. (1997)

Summary and Conclusions

- Loin eating quality was not different with increasing dietary DDGS level
- Bacon taste was not negatively affected when pigs were fed increasing the levels of dietary DDGS from 0 to 30%.
- Maximum usage rate of DDGS in grower-finisher swine diet could be 30%.

The effects of feeding diets containing 0, 15, and 30% corn dried distillers grains with solubles (DDGS), and DDGS withdrawal intervals, on growth performance, pork quality, and pork fatty acid composition in grower-finisher pigs



Alternative Strategies to Improve Pork Fat Quality

- Pork adipose tissue C18:2 incorporation and elimination rate following a dietary fat source change

- 60 to 70% change in 2 wks
- > 90% in 6 to 8 wks

(Wiseman and Agunbiade, 1998; Warnants et al., 1999)

- Alternative strategies to improve pork fat quality
 - Growing phase
 - Feed high levels of DDGS
 - Finish phase
 - Reduce feeding level or withdrawal DDGS from the diet

Specific Objectives

- Determine the effects of the feeding level and withdrawal interval of DDGS on
 - Growth performance
 - Carcass quality
 - Belly fat fatty acid profile

Materials and Methods



This study was conducted at
WCROC, Morris, MN

Animals and Housing

- Pigs
 - 432 crossbred pigs
 - Initial weight = 29.8 kg
- Housing
 - Environmentally controlled grower-finisher facility
 - 9 pigs per pen mixed sex (5 barrows and 4 gilts)
- Feeding program
 - Diets
 - Formulated on a digestible lysine basis
 - No supplemental fat
 - Three-phases
 - 20-50 kg
 - 50-80 kg
 - 80-120 kg



Experimental Design

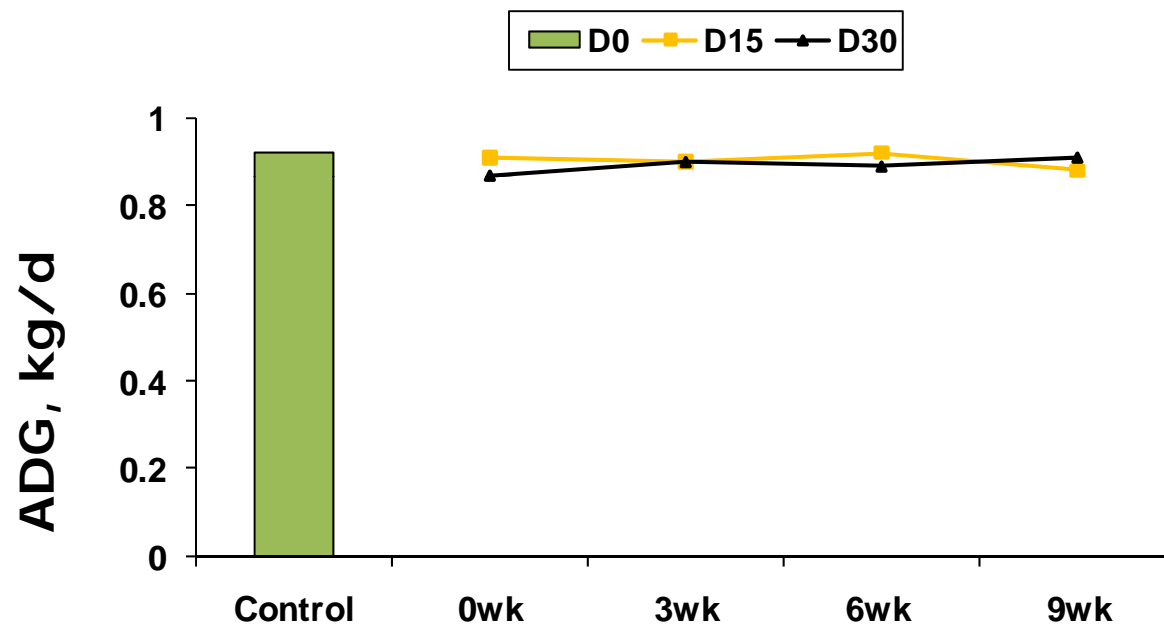
- ❑ Completely randomized arrangement with 9 treatment combinations
- ❑ Nine treatment combinations include:
 - Control: D0-0wk (8 pens)
 - D15-0wk (5 pens)
 - D15-3wk (5 pens)
 - D15-6wk (5 pens)
 - D15-9wk (5 pens)
 - D30-0wk (5 pens)
 - D30-3wk (5 pens)
 - D30-6wk (5 pens)
 - D30-9wk (5 pens)



Results



Effects of Dietary DDGS Level and Withdrawal Interval on ADG



PSE = 0.01

P-value

D = 0.11

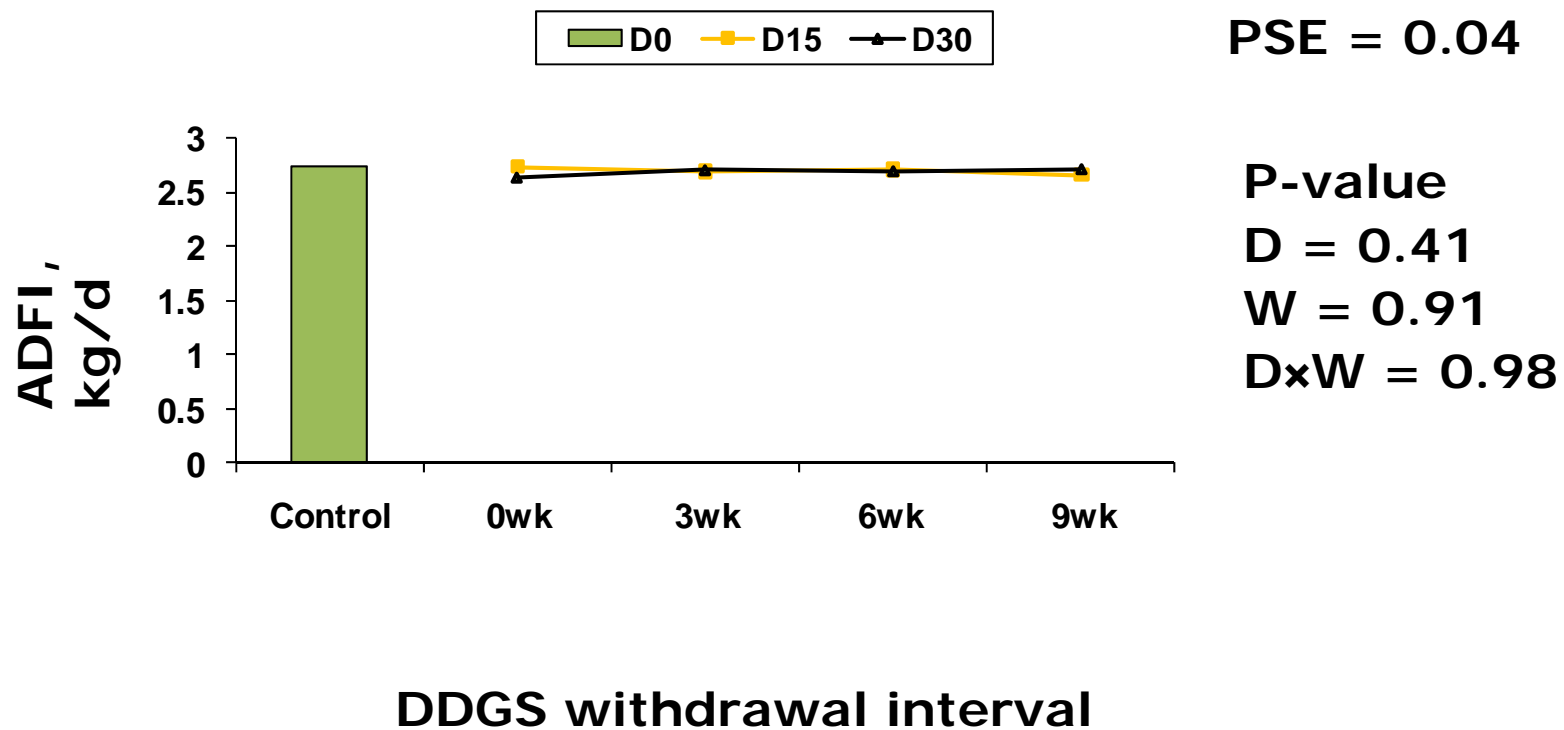
W = 0.76

D × W = 0.02

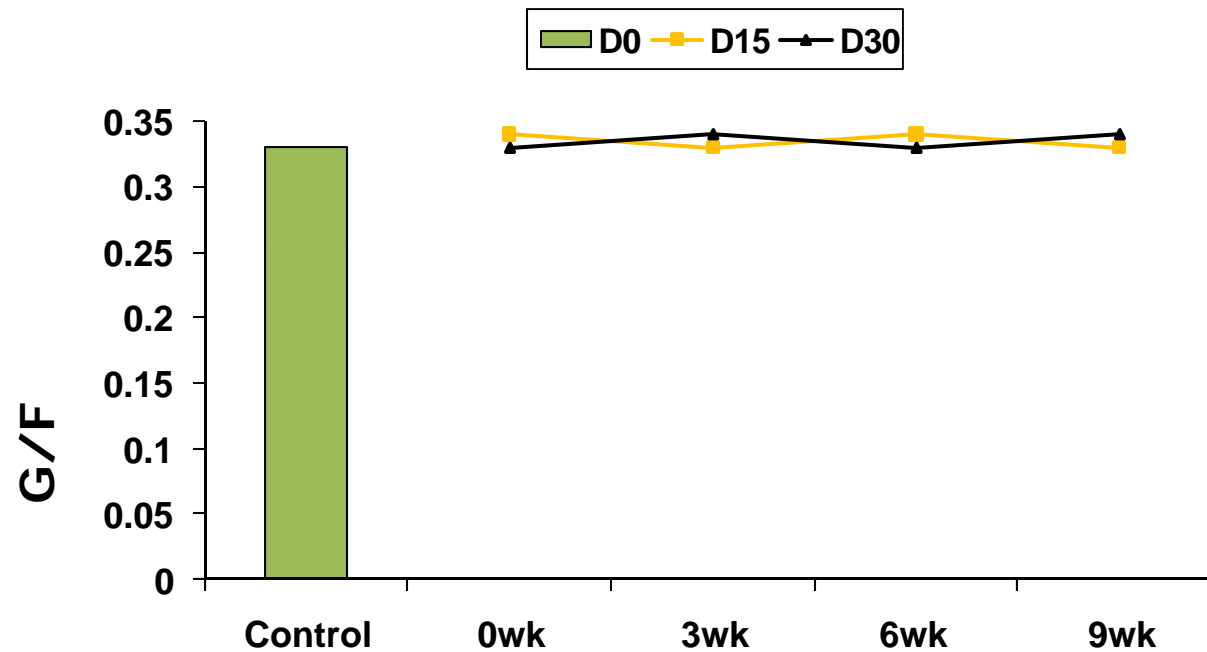
DDGS withdrawal interval

D30-0wk < control (P < 0.05)

Effects of Dietary DDGS Level and Withdrawal Interval on ADFI



Effects of Dietary DDGS Level and Withdrawal Interval on G/F



PSE = 0.003

P-value

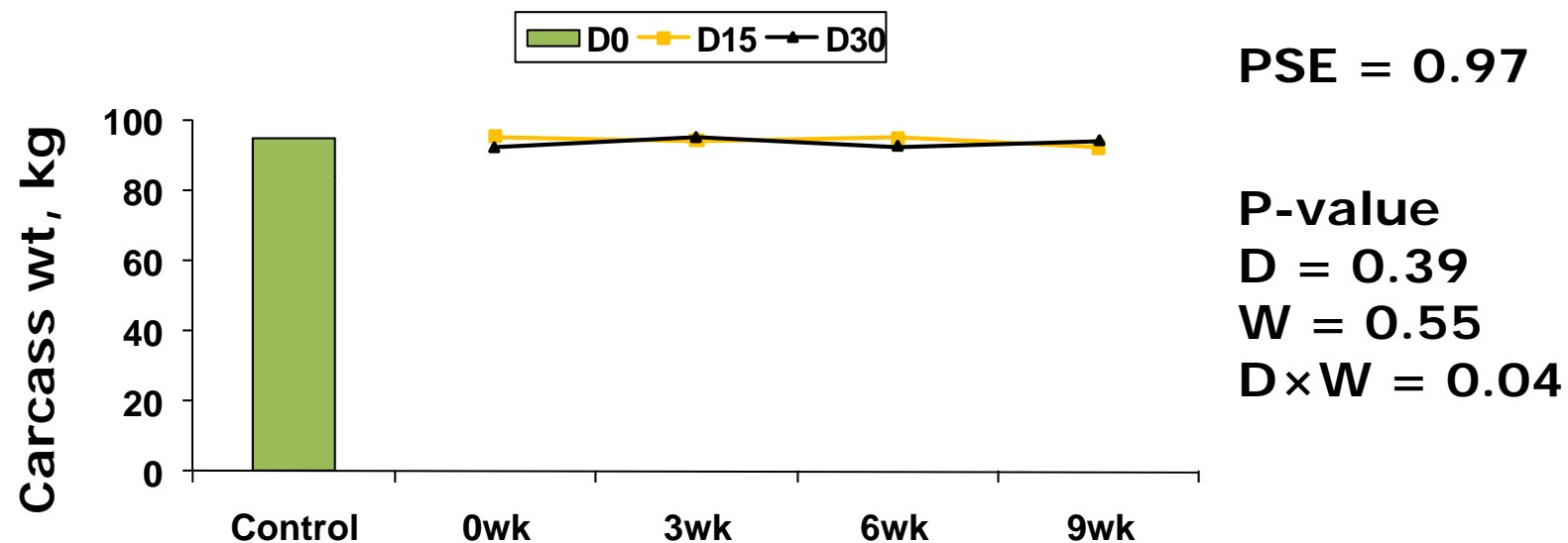
D = 0.94

W = 0.56

D×W = 0.17

DDGS withdrawal interval

Effects of Dietary DDGS Level and Withdrawal Interval on Carcass Weight



DDGS withdrawal interval

D30-0wk < control (P < 0.05)

Effects of Dietary DDGS Level and Withdrawal Interval on Growth Performance and Carcass Weight

- No effect on ADG except
 - Control > D30 (0.92 kg/d vs. 0.87 kg/d, respectively)
- No effect on ADFI
- No effect on G/F
- No effect on carcass weight except
 - Control > D30 (94.9 kg vs. 92.4 kg, respectively)

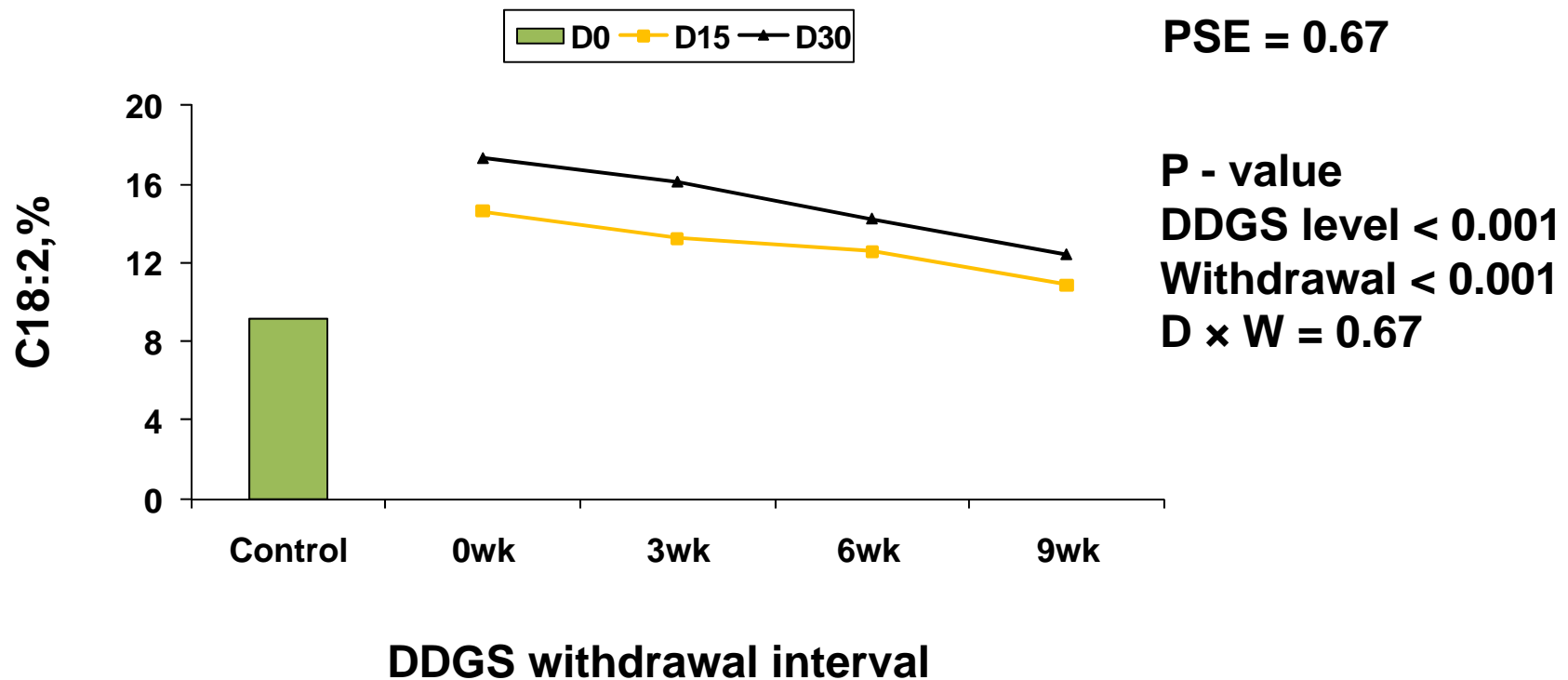
Effects of Dietary DDGS Level and Withdrawal Interval on Carcass and Loin Quality

- No difference
 - Dressing %
 - Last rib backfat depth
 - Lean percentage
 - Loin firmness
 - Loin marbling
 - Subjective color score
 - Minolta color L*

Effects of Dietary DDGS Level and Withdrawal Interval on Fatty Acid Content of Belly Fat and Belly Firmness

- PUFA
 - Increased with DDGS level
 - Decreased with DDGS withdrawal
 - Control = D15-9
- Iodine value
 - Increased with DDGS level
 - Decreased with DDGS withdrawal
 - Control = D15-9 and D30-9
- Monounsaturated fatty acids
 - Increased with DDGS level
- Saturated fatty acids
 - Decreased with DDGS level
 - Increased with DDGS withdrawal
- Belly firmness
 - D30-0 < control

Effects of Dietary DDGS Level and Withdrawal Interval on C18:2 Content of Belly Fat

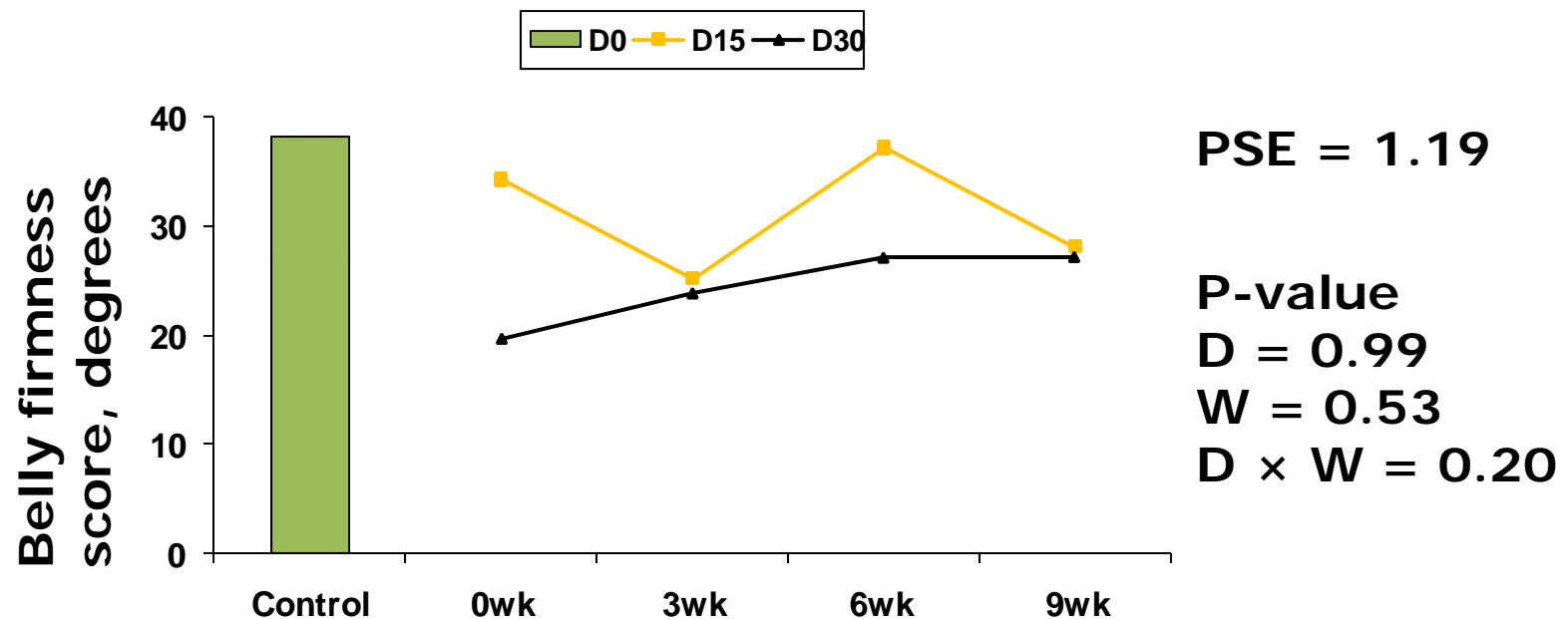


All treatments > control (P < 0.05)

Effects of Dietary DDGS Level and Withdrawal Interval on Fat Color

- No difference:
 - Japanese color score
 - Minolta color
 - L* (lightness)
 - a* (redness)
 - b* (yellowness)

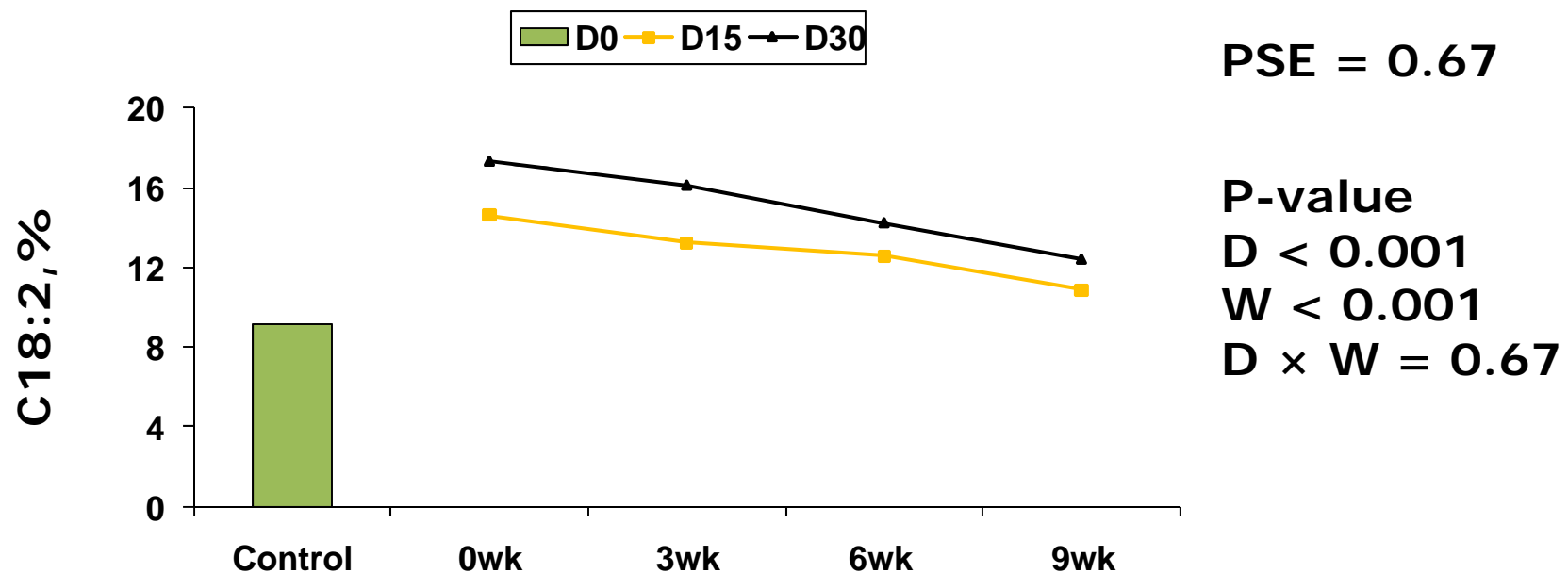
Effects of Dietary DDGS Level and Withdrawal Interval on Belly Firmness



DDGS withdrawal interval

D30-0 < control ($P < 0.05$)

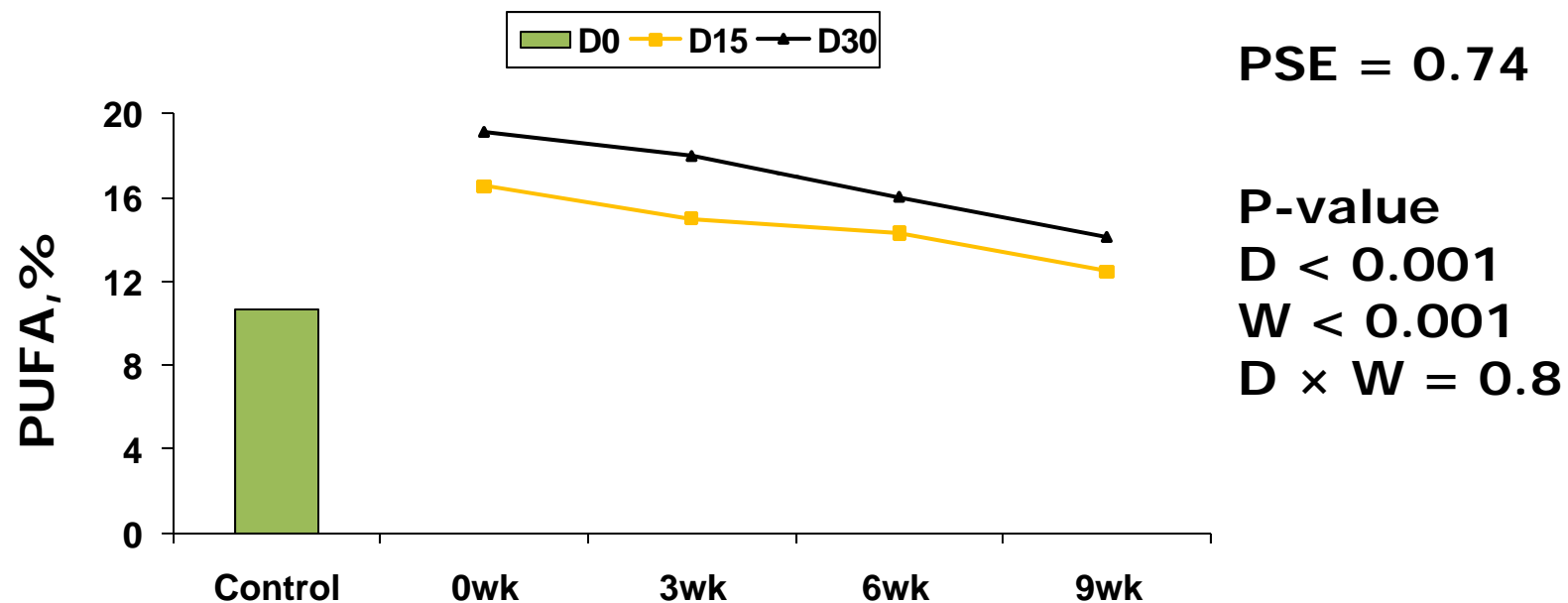
Effects of Dietary DDGS Level and Withdrawal Interval on C18:2 Content of Belly Fat



DDGS withdrawal interval

All treatments > control (P < 0.05)

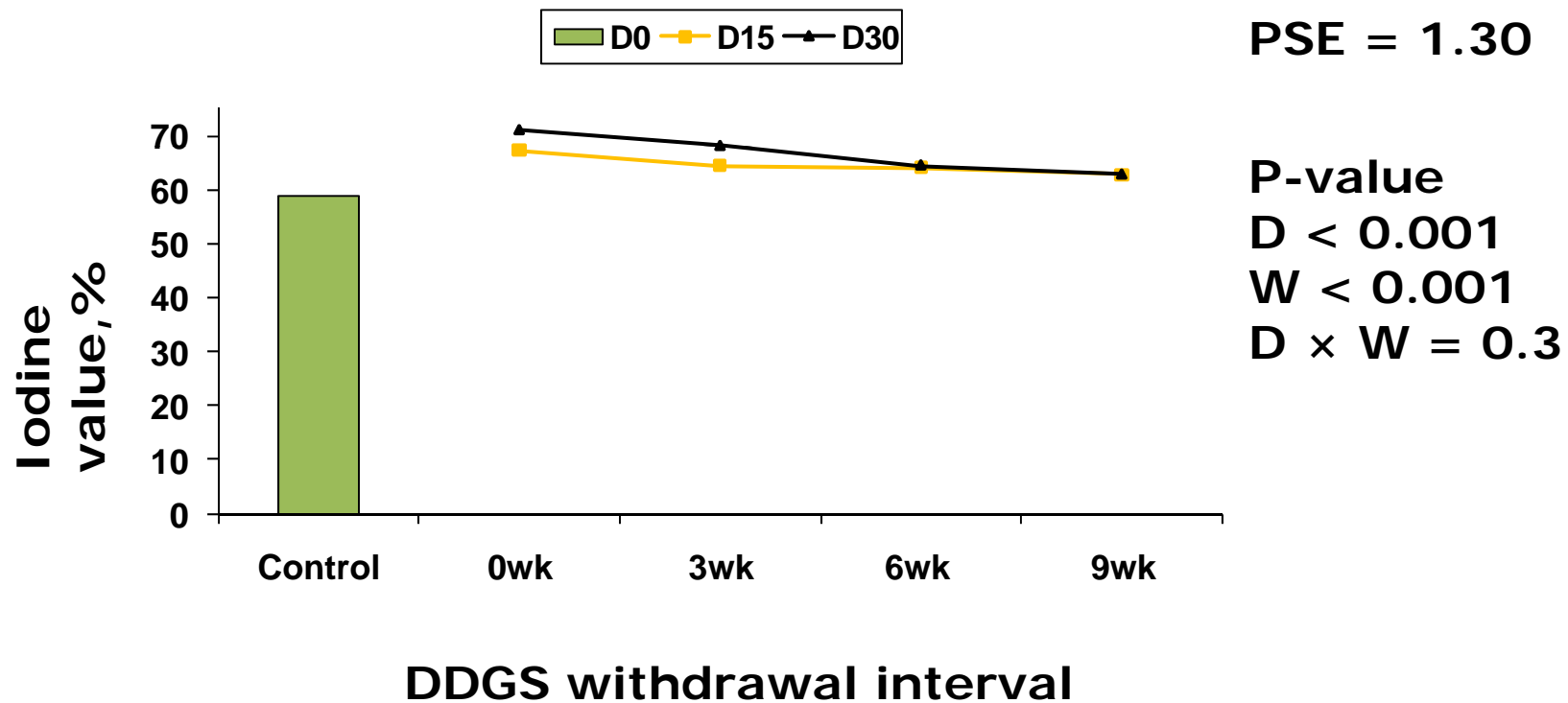
Effects of Dietary DDGS Level and Withdrawal Interval on PUFA of Belly Fat



DDGS withdrawal interval

D15-9 wk = control, others > control (P < 0.01)

Effects of Dietary DDGS Level and Withdrawal Interval on IV of Belly Fat



D15-9 wk and D30-9 wk = control, others > control
(P < 0.05)

Summary and Conclusions

- ❑ Increasing DDGS level from 0 to 30% in grower-finisher swine diets
 - Has minimal effects on pig growth performance
 - Linearly increases C18:2 content and IV of belly fat
 - Reduces belly firmness at 30% dietary DDGS level
- ❑ Withdrawing DDGS from the diet
 - C18:2 and IV of belly fat are reduced linearly
 - Acceptable pork fat quality (IV < 70) can be achieved in pigs
 - ❑ 15% dietary DDGS
 - ❑ 30% dietary DDGS with a 3 wk withdrawal interval

Summary of the Effects of Feeding DDGS Diets on Pork Quality

- **Bellies** will be **less firm**
 - Increased iodine value (linoleic acid content)
- **Bacon** will have an **oily appearance** from pigs fed > 20% DDGS diets
- **Belly thickness** may, or may **not**, be **affected**
- **Shelf life** and fat oxidation in fresh pork loins is **unaffected** with typical retail storage conditions for 28 days.
- **Muscle quality** is **not affected**
- **Consumer taste** panel acceptability is **unaffected**
 - Cooked pork loin
 - Cooked bacon
- Backfat **iodine value of 70** can be met when feeding **30% DDGS** in growing-finishing and **withdrawing** it **3 wks pre-harvest**

Michigan State University Study on DDGS Withdrawal Pre-harvest

- Hill et al. (2008)
 - N = 308 pigs
 - 4 dietary treatments (contained 4% CWG)
 - 0 % DDGS
 - 10% DDGS until 30 d pre-harvest then 0%
 - 20% DDGS until 30 d pre-harvest then 0%
 - 30% DDGS until 30 d pre-harvest then 0%

DDGS Withdrawal – Hill et al. (2008)

- ❑ No differences in:
 - ADG
 - G:F (except 10% > 0%)
 - Dressing %
 - Standardized fat free lean
- ❑ IV increased for pigs fed 20 and 30% DDGS diets vs. 0%
- ❑ Conclusions
 - IV may not be reflective of fatty acid composition of pork fat
 - removing DDGS from the diet 30 d pre-harvest results in acceptable carcasses

Other Potential Dietary Modifications

- ❑ Conjugated linoleic acid
 - FDA has approved for use in grower-finisher diets
 - Diet inclusion rate will likely be 1% and be fed the last 10-30 days pre-harvest
 - Currently cost prohibitive

Effects of Feeding CLA and DDGS

- Purdue study (White et al., 2007)
- Fed 0, 20, or 40% DDGS diets during the final finishing phase
 - n = 36 pigs
- Half of each group (n = 6) were fed 1% CLA during last 10 d pre-harvest

Effects of Feeding CLA and DDGS

- No differences in:
 - Loin eye area
 - 10th rib backfat depth
 - Last rib midline back fat depth
 - Loin color
 - Marbling
 - Firmness
 - Drip loss
- IV and ratio of n6:n3 fatty acids increased with increasing levels of DDGS
- IV and ratio of n6:n3 fatty acids decreased when 1% CLA was added to 20% and 40% DDGS diets
- % lean:fat in bacon decreased when pigs were fed DDGS diets

Acknowledgements

- ❑ Minnesota Pork Board
- ❑ Hormel Foods Corp.
- ❑ Agricultural Utilization Research Institute, Marshall, MN



Agricultural Utilization Research Institute