# Effects of Replacing Soybean Meal with High-Protein Dried Distillers Grains with Solubles on Growth Performance, Carcass Characteristics, and Carcass Fat Quality in Finishing Pigs[1,2]

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## Summary

A total of 204 barrows and gilts (PIC, 337 × 1050, initially 129.6 lb) were used in a 73-d study to determine the effects of replacing soybean meal (SBM) with high-protein dried distillers grains with solubles (HPDDGS) on growth performance, carcass characteristics, and carcass fat quality in finishing pigs. Pens of pigs (3 barrows and 3 gilts per pen) were randomly allotted by initial BW to 1 of 4 treatments with 8 or 9 replications per treatment. All pigs were fed diets with 15% HPDDGS for 10 d prior to the start of the study. Treatments included: (1) corn-soybean meal diet with 0.15% crystalline lysine, (2) HPDDGS and crystalline amino acids replacing 50% of the SBM in diet 1, and two diets in which 100% of the SBM was replaced by either: (3) HPDDGS and a high amount of crystalline amino acids or (4) a high amount of HPDDGS and low levels of crystalline amino acids. Diets with low amounts of crystalline amino acids (Treatment 4) contained 10% more HPDDGS to replace SBM than diets with high amounts of crystalline amino acids (Treatment 3). Diets were fed in three 28-d phases (130 to 180 lb, 180 to 240 lb, and 240 to 280 lb) for Phases 1, 2, and 3, respectively. Diets 1 and 3 in all phases were blended (50:50) via the FeedPro system (Feedlogic Corp., Willmar, MN) to make diet 2. Overall, replacing 50% of the SBM with HPDDGS and crystalline amino acids had no effect on growth performance; however, replacing 100% SBM with HPDDGS and crystalline amino acids resulted in decreased ($P < 0.02$) ADG and ADFI but no difference ($P > 0.75$) in F/G. In the two diets where 100% of the soybean meal was replaced with HPDDGS, the amount of added crystalline amino acids had no effect on growth performance.

Jowl fat iodine value (IV) increased (linear, $P < 0.0001$) as HPDDGS replaced 50 or 100% of the SBM, but the high amount of added crystalline amino acids resulted in lower ($P < 0.0001$) jowl IV than diets with low amounts of crystalline amino acids. Similarly, carcass yield decreased ($P < 0.01$) as HPPDDGS replaced 100% of the SBM; however, using high amounts of crystalline amino acids increased ($P < 0.01$) carcass yields compared with low amounts of crystalline amino acids. HPDDGS and crystalline amino acids can replace 50% of SBM in finishing pig diets without negatively affecting growth performance or carcass yield. This result suggests that crystalline amino acids

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could play a role in mitigating the negative effects of DDGS, such as increased IV and decreased carcass yields.

Key words: amino acids, high-protein DDGS, finishing pig

## Introduction

The increase in ethanol production in the last 7 years has resulted in the availability of a wide variety of co-products to livestock producers. Corn distillers products vary in CP and oil content depending on the processing method. Dry defractionation is a front-end process that results in the separation of the corn kernel into the bran, germ, and endosperm segments prior to fermentation. Dry defractionation can result in a high-protein DDGS co-product. Due to higher protein than in traditional DDGS, HPDDGS may be able to replace a greater portion of soybean meal in swine diets. Crystalline amino acids also can be used to replace a portion of soybean meal in the diet. Because HPDDGS provides several essential and nonessential amino acids, it is possible that high amounts of crystalline amino acids in combination with HPDDGS could replace SBM entirely in the diet. This experiment was conducted to determine the effects of replacing SBM with HPDDGS and crystalline amino acids on growth performance, carcass characteristics, and carcass fat quality in finishing pigs.

## Procedures

The Kansas State University Institutional Animal Care and Use Committee approved the protocol used in this experiment. The study was conducted at the K-State Swine Teaching and Research Center in Manhattan, KS. The facility was also equipped with the FeedPro computerized feeding system, which delivered daily feed additions to each pen.

A total of 204 pigs (PIC 337 × 1050; initially 129.6 lb) were used in a 73-d growth trial. Pens of pigs (3 barrows and 3 gilts per pen) were randomly allotted by initial BW to 1 of 4 dietary treatments with 8 or 9 replications per treatment. Diets were formulated to a constant SID lysine level within phase. Dietary treatments included: (1) a corn-soybean meal diet with 0.15% crystalline lysine, (2) HPDDGS and crystalline amino acids replacing 50% of the SBM in the diet 1, and two diets where 100% of the SBM was replaced by either: (3) HPDDGS and a high amount of crystalline amino acids or (4) a high level of HPDDGS and low levels of crystalline amino acids. Diets with low amounts of crystalline amino acids contained 10% more HPDDGS to replace SBM than diets with high amounts of crystalline amino acids (Tables 1 and 2). Diets were fed in 3 4-week phases from approximately 130 to 180 lb, 180 to 240 lb, and 240 to 280 lb. Diet 2 in all phases was a 50:50 blend of diets 1 and 3 delivered via the FeedPro system.

All diets were fed in meal form and prepared at the K-State Animal Science Feed Mill in Manhattan, KS. Standardized ileal digestible amino acid coefficients for HPDDGS were previously determined by Jacela et al. (2008[5]) and used in diet formulation. The ME value of corn, 1,551 kcal/lb (NRC, 1998[6]), was used in formulation for the ME value of HPDDGS. Samples of HPDDGS were collected at the time of feed manufac-

[5] Jacela et al., Swine Day 2008, Report of Progress 1001, pp. 140–144.
[6] NRC. 1998. Nutrient Requirements of Swine. 10th ed. Natl. Acad. Press, Washington, DC.

ture, and a composite sample was analyzed by Ward Laboratories, Inc. (Kearny, NE) (Table 3).

Feed samples were collected from all feeders during each phase and subsampled into a composite sample of each treatment for each phase to measure bulk density (Table 4). Pigs and feeders were weighed approximately every 2 wk to calculate ADG, ADFI, and F/G. On d 73, all pigs were individually weighed and tattooed for carcass data collection and transported to Triumph Foods LLC (St. Joseph, MO). Standard carcass characteristics were measured and jowl fat samples were collected and analyzed at the plant for IV.

Data were analyzed as a completely randomized design using the PROC MIXED procedure (SAS Institute, Inc., Cary, NC) with pen as the experimental unit. Linear and quadratic contrasts were used to determine the effects of HPDDGS and synthetic amino acids replacing 50 or 100% of the SBM (Treatments 1, 2, and 3). The effects of low vs. high amounts of synthetic amino acids (Treatments 3 vs. 4), the control treatment compared with the 50% SBM replacement (Treatment 1 vs. 2), as well as the control treatment vs. the combination of both 100% SBM replacements diets were tested (Treatments 1 vs. 3 and 4). Results were considered significant at $P \leq 0.05$ and a trend at $P \leq 0.10$.

## Results and Discussion

Replacing SBM with HPDDGS reduced diet bulk density, with the greatest decrease observed in the diet with HPDDGS and low amounts crystalline amino acids resulting in more HPDDGS in the diet (Table 4; Treatment 4). Overall (d 0 to 73), replacing 50% of the SBM with HPDDGS and crystalline amino acids had no effects on growth performance (Table 5); however, replacing 100% of the SBM with HPDDGS resulted in decreased ADG and ADFI ($P < 0.02$) but did not affect F/G ($P > 0.70$). No differences were observed among pigs fed high or low amounts of crystalline amino acids with HPDDGS to replace 100% of the SBM.

When substituting 50% of SBM with the HPDDGS, no effects on carcass characteristics were observed compared with pigs fed the corn-soybean meal–based diet. On the other hand, replacing 100% of the SBM with HPDDGS resulted in reduced carcass yield, loin depth, and the tendency for reduced HCW. Using high amounts of crystalline amino acids when substituting 100% of the SBM resulted in increased ($P < 0.01$) carcass yield and decreased ($P < 0.01$) jowl IV compared with low amounts of crystalline amino acids. This is a result of lower amounts of HPDDGS used in the diets with high amounts of crystalline amino acids compared with the diet with low amounts of crystalline amino acids.

In summary, HPDDGS can be used in combination with crystalline amino acids to replace 50% of the SBM in finishing diets without negatively affecting growth performance and carcass yield. High amounts of crystalline amino acids also may play an important role in mitigating some of the negative effects such as reduced carcass yields and increased jowl IV of corn fermentation co-products.

**Table 1. Phase 1 and 2 diet composition (as-fed basis)[1]**

| | Phase 1 | | | | Phase 2 | | | |
|---|---|---|---|---|---|---|---|---|
| HPDDGS[2] replacement of SBM, %: | 0 | 50 | 100 w/ high AA[3] | 100 w/ low AA | 0 | 50 | 100 w/ high AA | 100 w/ low AA |
| Ingredient, % | | | | | | | | |
| Corn | 76.13 | 71.74 | 67.35 | 57.40 | 81.55 | 75.85 | 70.14 | 60.19 |
| Soybean meal, 46.5% CP | 21.62 | 10.82 | -- | -- | 16.44 | 8.23 | -- | -- |
| HPDDGS | -- | 15.00 | 30.00 | 40.00 | -- | 13.75 | 27.50 | 37.50 |
| Monocalcium P, 21% P | 0.40 | 0.20 | -- | -- | 0.25 | 0.13 | -- | -- |
| Limestone | 1.00 | 1.05 | 1.10 | 1.20 | 0.96 | 1.02 | 1.09 | 1.18 |
| Salt | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 |
| Vitamin premix | 0.13 | 0.13 | 0.13 | 0.13 | 0.10 | 0.10 | 0.10 | 0.10 |
| Trace mineral premix | 0.13 | 0.13 | 0.13 | 0.13 | 0.10 | 0.10 | 0.10 | 0.10 |
| L-lysine HCl | 0.15 | 0.39 | 0.64 | 0.57 | 0.15 | 0.32 | 0.49 | 0.42 |
| L-threonine | -- | 0.06 | 0.11 | 0.05 | -- | 0.03 | 0.05 | -- |
| L-tryptophan | -- | 0.04 | 0.08 | 0.07 | -- | 0.03 | 0.06 | 0.05 |
| Phytase 600[4] | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 |
| Total | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| | | | | | | | | |
| Calculated analysis | | | | | | | | |
| Standardized ileal digestible (SID) amino acids,% | | | | | | | | |
| Lysine | 0.86 | 0.86 | 0.86 | 0.86 | 0.73 | 0.73 | 0.73 | 0.73 |
| Methionine:lysine | 29 | 31 | 34 | 39 | 31 | 35 | 38 | 45 |
| Met & Cys:lysine | 60 | 62 | 65 | 75 | 64 | 69 | 74 | 85 |
| Threonine:lysine | 62 | 62 | 62 | 62 | 63 | 63 | 63 | 65 |
| Tryptophan:lysine | 19.2 | 19.2 | 19.2 | 19.2 | 18.8 | 18.8 | 18.8 | 18.8 |
| Total lysine, % | 0.97 | 0.99 | 1.00 | 1.03 | 0.83 | 0.85 | 0.87 | 0.90 |
| ME, kcal/lb | 1,515 | 1,521 | 1,527 | 1,525 | 1,520 | 1,524 | 1,527 | 1,525 |
| SID lysine:ME, g/Mcal | 2.57 | 2.56 | 2.55 | 2.56 | 2.18 | 2.17 | 2.17 | 2.17 |
| CP, % | 16.7 | 16.5 | 16.4 | 18.7 | 14.7 | 15.2 | 15.6 | 17.9 |
| Ca, % | 0.55 | 0.50 | 0.46 | 0.50 | 0.49 | 0.47 | 0.45 | 0.49 |
| P, % | 0.45 | 0.41 | 0.37 | 0.40 | 0.39 | 0.38 | 0.36 | 0.39 |
| Available P, % | 0.26 | 0.27 | 0.27 | 0.32 | 0.22 | 0.24 | 0.26 | 0.31 |

[1] Phase 1 diets were fed from approximately 130 to 180 lb.; Phase 2 diets from 180 to 240 lb.
[2] HPDDGS: high-protein dried distillers grains with solubles.
[3] AA: amino acid.
[4] Phyzyme 600 (Danisco Animal Nutrition, St. Louis, MO) provided 272.4 phytase units (FTU)/lb., with a release of 0.11% available phosphorus.

**Table 2. Phase 3 diet composition (as-fed basis)[1]**

| | Phase 3 | | | |
|---|---|---|---|---|
| HPDDGS[2] replacement of SBM, %: | 0 | 50 | 100 w/ high AA[3] | 100 w/ low AA |
| Ingredient | | | | |
| Corn | 84.87 | 82.61 | 80.34 | 70.40 |
| Soybean meal, 46.5% CP | 13.24 | 6.62 | -- | -- |
| HPDDGS | -- | 8.75 | 17.50 | 27.50 |
| Monocalcium P, 21% P | 0.20 | 0.10 | -- | -- |
| Limestone | 0.94 | 0.96 | 0.99 | 1.08 |
| Salt | 0.35 | 0.35 | 0.35 | 0.35 |
| Vitamin premix | 0.08 | 0.08 | 0.08 | 0.08 |
| Trace mineral premix | 0.08 | 0.08 | 0.08 | 0.08 |
| L-lysine HCl | 0.15 | 0.30 | 0.45 | 0.39 |
| L-threonine | -- | 0.04 | 0.08 | 0.01 |
| L-tryptophan | -- | 0.03 | 0.05 | 0.04 |
| Phytase 600[4] | 0.10 | 0.10 | 0.10 | 0.10 |
| Total | 100.0 | 100.0 | 100.0 | 100.0 |
| | | | | |
| Calculated analysis | | | | |
| Standardized ileal digestible (SID) amino acids,% | | | | |
| Lysine | 0.65 | 0.65 | 0.65 | 0.65 |
| Methionine:lysine | 32 | 34 | 36 | 43 |
| Met & Cys:lysine | 67 | 68 | 70 | 83 |
| Threonine:lysine | 64 | 64 | 64 | 64 |
| Tryptophan:lysine | 18.5 | 18.5 | 18.5 | 18.5 |
| Total lysine, % | 0.74 | 0.75 | 0.76 | 0.79 |
| ME, kcal/lb | 1,523 | 1,526 | 1,529 | 1,527 |
| SID lysine:ME, g/Mcal | 1.94 | 1.93 | 1.93 | 1.93 |
| CP, % | 13.5 | 13.3 | 13.1 | 15.5 |
| Ca, % | 0.46 | 0.44 | 0.41 | 0.45 |
| P, % | 0.37 | 0.35 | 0.33 | 0.36 |
| Available P, % | 0.21 | 0.22 | 0.22 | 0.26 |

[1] Phase 3 diets were fed from approximately 240 to 280 lb.
[2] HPDDGS: high-protein dried distillers grains with solubles.
[3] AA: amino acid.
[4] Phyzyme 600 (Danisco Animal Nutrition, St. Louis, MO) provided 272.4 phytase units (FTU)/lb, with a release of 0.11% available phosphorus.

**Table 3. Chemical analysis of high-protein dried distillers grains with solubles (HPDDGS; as-fed basis)**

| Item | HPDDGS |
|---|---|
| Nutrient, % | |
| DM | 91.04 |
| CP | 33.0 (33.0)[1] |
| Fat (oil) | 11.4 |
| Crude fiber | 11.2 (9.0) |
| ADF | 14.7 |
| NDF | 31.7 |
| Ca | 0.06 (0.06) |
| P | 0.59 (0.59) |

[1] Values in parentheses indicate those used in diet formulation.

**Table 4. Bulk density of experimental diets (as-fed basis)[1]**

| | HPDDGS[2] replacement of soybean meal, % | | | |
|---|---|---|---|---|
| Bulk density, lb/bu[3] | 0 | 50 | 100 w/ high AA[4] | 100 w/ low AA |
| Phase 1 | 57 | 53 | 50 | 48 |
| Phase 2 | 58 | 53 | 51 | 48 |
| Phase 3 | 56 | 53 | 51 | 51 |

[1] Diet samples were collected from each feeder during each phase.
[2] HPDDGS: high-protein dried distillers grains with solubles.
[3] Phase 1 d 0 to 27; Phase 2 d 27 to 54; Phase 3 d 54 to 73.
[4] AA: amino acid.

**Table 5. Effect of replacing soybean meal (SBM) with high-protein dried distillers grains with solubles (HPDDGS) on finishing pig performance[1]**

| | HPDDGS replacement of SBM, % | | | | | Probability, *P*< | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Item | 0[2] | 50[3] | 100 w/ high AA[4] | 100 w/ low AA[5] | SEM | Low-level DDGS linear[6] | Low-level DDGS quadratic[7] | Low vs. high AA | Control vs. 50% replace | Control vs. 100% replace |
| Initial wt, lb | 129.5 | 129.7 | 131.1 | 129.7 | 2.1 | 0.60 | 0.79 | 0.63 | 0.96 | 0.74 |
| d 0 to 73 | | | | | | | | | | |
| ADG, lb | 2.10 | 2.10 | 2.01 | 1.98 | 0.03 | 0.04 | 0.13 | 0.56 | 0.84 | 0.01 |
| ADFI, lb | 6.39 | 6.43 | 6.14 | 6.09 | 0.09 | 0.05 | 0.12 | 0.73 | 0.74 | 0.02 |
| F/G | 3.05 | 3.06 | 3.06 | 3.07 | 0.03 | 0.88 | 0.91 | 0.76 | 0.86 | 0.73 |
| Final wt, lb | 282.3 | 283.3 | 277.7 | 275.5 | 3.3 | 0.33 | 0.40 | 0.63 | 0.83 | 0.16 |
| Carcass characteristics | | | | | | | | | | |
| Carcass yield, %[8] | 73.1 | 72.7 | 72.5 | 71.6 | 0.23 | 0.11 | 0.75 | 0.01 | 0.26 | 0.01 |
| HCW, lb | 206.4 | 206.6 | 201.5 | 197.9 | 2.79 | 0.22 | 0.42 | 0.36 | 0.95 | 0.06 |
| Backfat depth, in. | 0.82 | 0.83 | 0.82 | 0.79 | 0.02 | 0.87 | 0.61 | 0.32 | 0.72 | 0.45 |
| Loin depth, in. | 2.3 | 2.3 | 2.2 | 2.2 | 0.04 | 0.06 | 0.74 | 0.45 | 0.48 | 0.01 |
| Lean, % | 51.8 | 51.5 | 51.5 | 51.7 | 0.28 | 0.47 | 0.68 | 0.65 | 0.47 | 0.56 |
| Jowl fat iodine value | 69.8 | 72.1 | 74.8 | 78.0 | 0.440 | 0.0001 | 0.71 | 0.0001 | 0.0006 | 0.0001 |

[1] A total of 204 pigs (PIC 327 x 1050, initial BW 130 lb) were used in a 73-d study with 6 pigs per pen and 8 or 9 pens per treatment.
[2] Corn-soybean meal diet with 0.15% crystalline lysine.
[3] HPDDGS and high amounts of crystalline amino acids replacing 50% of the SBM in diet 1.
[4] HPDDGS and high amounts of crystalline amino acids replacing 100% of the SBM in diet 1.
[5] HPDDGS and low amounts of crystalline amino acids replacing 100% of the SBM in diet 1.
[6] Linear comparisons of low-DDGS treatments (Treatments 1, 2, and 3).
[7] Quadratic comparisons of low-DDGS treatments (Treatments 1, 2, and 3).
[8] Percentage carcass yield was calculated by dividing HCW by the live weights obtained at the farm before transported to the packing plant.