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Comparing Increasing Tryptophan:Lysine Ratios in DDGS-Based Diets with or without a DDGS Withdrawal Strategy on Growth Performance and Iodine Value of Growing-Finishing Pigs[1]

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Summary

A total of 6,240 pigs (DNA 600 × PIC 1050; initially 49.7 × 2.23 lb), divided into 2 groups, were used in a 119- or 120-d study to compare increasing the Trp:Lys ratio in diets with DDGS or a DDGS withdrawal strategy on growth performance and carcass fat iodine value of grow-finish pigs. Pigs were randomly allotted to 1 of 7 dietary treatments with 30 to 36 pigs per pen and 26 replications per treatment. Diets were fed in 4 phases (approximately 50 to 96, 96 to 157, 157 to 220, and 220 lb to market). Diets included a control corn-soybean meal-based diet formulated to a 19% SID Trp:Lys ratio; 4 diets with 30% DDGS fed in all four phases and formulated to achieve a 16%, 19%, 22%, or 25% SID Trp:Lys ratio, respectively; and 2 DDGS withdrawal strategy diets: 19% SID Trp:Lys with 30% DDGS in phases 1 through 3 and then 0% DDGS in phase 4 with either a 19 or 25% Trp:Lys ratio. Overall, BW, ADG, ADFI, and F/G improved (linear, $P < 0.05$) as the SID Trp:Lys ratio increased in diets with 30% DDGS fed in all 4 phases. Hot carcass weight and carcass yield increased (quadratic, $P < 0.05$) as the Trp:Lys ratio increased along with backfat depth (linear, $P = 0.040$). Pigs fed diets containing a SID Trp:Lys ratio of 19% and 30% DDGS from phases 1 through 3 and 0% DDGS in phase 4 had the greatest numeric ADG and ADFI for the overall study, but were not different than pigs fed the control, the 25% Trp:Lys withdrawal treatment, or the 30% DDGS diets with 25% Trp:Lys ratio throughout the study. Pigs fed the control diet had decreased ($P < 0.05$) carcass fat iodine value compared to pigs fed DDGS throughout the study, with pigs fed the two DDGS withdrawal strategies having lower ($P < 0.05$) iodine values compared to pigs fed 30% DDGS in all 4 phases. No significant differences ($P > 0.05$) in revenue per pen or IOFC per pen were observed, however, feed cost per lb of gain (quadratic, $P = 0.001$) and feed cost per pig placed (linear, $P = 0.002$) increased and revenue per pig placed tended to increase ($P = 0.064$) as the Trp:Lys ratio increased. In summary, increasing the SID Trp:Lys ratio in diets with 30%

[1] Appreciation is expressed to JBS USA (Greely, CO) for providing animals, facilities, and technical assistance.

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DDGS resulted in a linear improvement in ADG, ADFI, F/G, and BW but did not influence iodine values. Removing DDGS from the diet in the last period reduced carcass fat iodine value and increased growth rate during the withdrawal period compared to pigs fed 30% DDGS throughout, indicating value in a withdrawal strategy.

Introduction

Dried distillers grains with solubles are generally a low cost ingredient and commonly used in grow-finish diets to reduce diet costs. Research has shown that diets containing up to 30% DDGS can be fed to grow-finish pigs without negatively impacting growth performance.[4] However, adding DDGS to grow-finish diets can result in a greater carcass fat iodine value (IV) and can have negative impacts on carcass yield.

Tryptophan is associated with the regulation of appetite, sleep, and stress.[5] Some studies have suggested that increasing Trp above levels typically used to optimize growth can improve carcass yield. Nitikancha et al. (2013) observed that 20% SID Trp:Lys ratio improved carcass yield as DDGS increased in the diet from 0 to 40%, but a reduction in yield was observed when only 16.5% SID Trp:Lys ratio was fed.[6]

Limited research has been conducted to compare high SID Trp:Lys ratios in diets containing DDGS with or without a withdrawal strategy. If a high SID Trp:Lys ratio can reduce or prevent carcass yield losses from feeding diets containing DDGS, then the DDGS could be fed in grow-finish diets all the way to market and achieve lower total feed cost. Therefore, the objective of this study was to determine the impact of feeding increasing SID Trp:Lys ratio in diets containing DDGS compared to a withdrawal strategy with different Trp:Lys ratios on growth performance, carcass composition, carcass fat iodine value, and economics in grow-finish pigs.

Procedures

The Kansas State University Institutional Animal Care and Use Committee approved the protocol used in this experiment. This experiment was conducted at a commercial research grow-finishing facility in Missouri (JBS, Fortuna, MO). The barn was curtain-sided and tunnel ventilated (natural-tunnel) with a fully slatted concrete floor and deep-pit manure storage. Each pen was equipped with a one-sided wet-dry shelf feeder to provide a minimum of 1.5 linear inches of feeder space per pig for *ad libitum* access to feed and water. Feed was delivered by a feeding system (DryExact Pro, Big Dutchman, Holland, MI) that recorded daily feed additions.

Animals and diets

Two groups of finishing pigs, totaling 6,240 pigs (DNA 600 × PIC 1050; initially 49.7 × 2.23 lb) were used. Group 1 was on trial for 119 d and group 2 for 120 d. Pens of pigs (30 to 36 pigs per pen) were randomly assigned to 1 of 7 dietary treatments in a randomized complete block design with BW serving as the blocking factor resulting in 26 replications

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[4] Stein H. H., Shurson G. C. 2009. Board-Invited Review: The use and application of distillers dried grains with solubles in swine diets. J. Anim. Sci. 87: 1292-1303. https://doi.org/10.2527/jas.2008-1290.
[5] Kerr, B. J., A. C. Guzik, and L. L. Southern. 2002. Tryptophan: Effects on neurotransmitters, behavior, meat quality and the results of current requirement studies in nursery pigs. Biokyowa Tech. Rev. No. 13. St. Louis, MO.
[6] Nitikanchana, S. 2013. The effects of standardized ileal digestible tryptophan:lysine ratio in nursery and finishing pigs; and regression analysis to predict growth performance from dietary net energy. PhD diss., Kansas State University, Manhattan, KS.

(pens) per treatment. Dietary treatments were fed in 4 phases from approximately 50 to 96 lb, 96 to 157 lb, 157 to 220 lb, and 220 lb to market (Table 1 and 2) and consisted of:

1. Control: Corn-soybean meal-based diets with a 19% SID Trp:Lys ratio fed in phases 1 through 4
2. 30% DDGS diets with 19% SID Trp:Lys ratio fed in phases 1 through 3 followed by 0% DDGS diet with 19% SID Trp:Lys ratio fed in phase 4
3. 30% DDGS diets with 19% SID Trp:Lys ratio fed in phases 1 through 3 followed by 0% DDGS diet with 25% SID Trp:Lys ratio fed in phase 4
4. 30% DDGS diets with 16% SID Trp:Lys ratio fed in phases 1 through 4
5. 30% DDGS diets with 19% SID Trp:Lys ratio fed in phases 1 through 4
6. 30% DDGS diets with 22% SID Trp:Lys ratio fed in phases 1 through 4
7. 30% DDGS diets with 25% SID Trp:Lys ratio fed in phases 1 through 4

All treatment diets were manufactured at the JBS Feed Mill in Centralia, MO. To form the experimental diets, the diets with the lowest and highest Trp:Lys ratio were manufactured first, then blended on the farm to create the intermediate Trp:Lys ratio diets. All diets were formulated to meet or exceed NRC[7] requirement estimates for growing-finishing pigs for their respective weight ranges except for diet D with a formulated SID Trp:Lys ratio of 16%.

Pens of pigs were weighed, and feed disappearance was measured every 2 weeks to determine ADG, ADFI, and F/G. Feed samples were collected for each treatment 3 to 5 days before and after a phase change. Pigs were sent to market in 3 marketing events. Four weeks before the end of the experiment, 7 to 8 pigs per pen were marketed; two weeks after the first marketing event, 10 to 12 pigs per pen were removed; and the remaining pigs were marketed two weeks after the second marketing event. For each marketing event, 3 pigs per pen were chosen for fat sample collection, tattooed with the pen number, and loaded separately on trucks with only pigs selected for fat sample collection. At the plant, fat samples were collected from the dorsal loin-butt junction after carcass was stored overnight in the cooler. All fat samples were immediately frozen after collection and later analyzed for carcass fat iodine value (IV) using near infrared spectroscopy (NIRS). Measurements of hot carcass weight (HCW), percentage lean, loin depth, and backfat depth were measured on carcasses from all 3 marketing events of the second group of pigs (approximately 2,859 pigs).

For the economic analysis, feed cost, feed cost per lb of gain, revenue per pig, and income over feed costs (IOFC) were calculated on a pen and per pig placed basis. The following ingredient prices were used for the economic analysis: corn = \$6.16/bu (\$220/ton); soybean meal = \$360/ton; DDGS = \$200/ton; Biolys = \$0.30/lb; THR-PRO = \$0.67/lb; GF VTM = \$1.53/lb; methionine hydroxy analogue = \$0.71/lb; THR-PRO 80% = \$0.99/lb; and L-tryptophan = \$4.13/lb. Feed cost per pig placed was calculated by dividing the total feed cost by the number of pigs initially placed per pen. Feed cost per lb of gain was calculated by dividing the feed cost per pig by the overall weight gain per pig. Revenue was obtained by multiplying carcass gain (assuming a 75% standard carcass yield for group 1) and using an assumed market value of \$0.80/lb. The IOFC was calculated by taking the revenue per pen minus the feed cost per pen.

[7] National Research Council. 2012. Nutrient Requirements of Swine: Eleventh Revised Edition. Washington, DC: The National Academies Press. https://doi.org/10.17226/13298.

Statistical analysis

Pen was the experimental unit for all growth performance data. Response variables were analyzed using a general linear mixed model. Multiple pairwise comparisons were used to detect differences among all treatments. Additionally, linear and quadratic contrasts were used to evaluate the effect of increasing the SID Trp:Lys ratio (16 to 25% Trp:Lys ratio). Carcass data were analyzed using individual carcass observations and the statistical model incorporated pen to account for the subsampling of multiple observations within each experimental unit. The HCW was used a covariate for lean percent, backfat depth, and loin depth. The experimental data were analyzed using the PROC GLIMMIX procedure of SAS v. 9.4 (SAS Institute, Inc., Cary, NC). Results were considered significant at $P \leq 0.05$ and a tendency at $P \leq 0.10$.

Results and Discussion

From d 0 to 70, ADG and ADFI increased (linear, $P < 0.05$) as SID Trp:Lys ratio increased in diets containing 30% DDGS in all 4 phases (Table 3). Feed efficiency tended to improve (linear, $P = 0.100$) as the Trp:Lys ratio increased. During this period (d 0 to 70), three treatments were fed the same diet containing 30% DDGS with a 19% SID Trp:Lys ratio (treatments B, C, and E). Pigs on these three treatments had similar ($P > 0.05$) ADG, ADFI, and F/G when compared to each other and had intermediate ADG between the control corn-soybean meal-based diet and the 16% SID Trp:Lys ratio, 30% DDGS diet, which numerically had the highest and lowest ADG, respectively. All treatments had a similar ADFI, except for pigs fed 19% SID Trp:Lys ratio being greater ($P < 0.05$) than pigs fed the 16% SID Trp:Lys ratio. Pigs fed diets containing 19% SID Trp:Lys ratio with 30% DDGS had a poorer ($P < 0.05$) F/G compared to the control corn-soybean meal-based diet but were similar to all other treatments.

From d 70 to the end of the study (d 119 or 120), increasing the SID Trp:Lys ratio in diets containing 30% DDGS tended (linear, $P = 0.082$) to increase ADG and improve (linear, $P = 0.026$) F/G. Two treatments utilized a DDGS withdrawal strategy during this period and switched from 19% SID Trp:Lys with 30% DDGS to 19 or 25% SID Trp:Lys without DDGS. Pigs fed the 19% Trp:Lys withdrawal diet had greater ($P < 0.05$) ADG and ADFI compared to those fed all other diets except for pigs fed the withdrawal diet with 25% Trp:Lys ratio. Pigs fed the withdrawal diet with 25% SID Trp:Lys also had improved ($P < 0.05$) ADG compared to pigs fed 30% DDGS diets with 16% or 19% SID Trp:Lys ratio and increased ADFI compared to pigs fed all diets containing 30% DDGS in phase 4.

Overall, ADG, ADFI, and F/G improved (linear, $P < 0.05$) with increasing SID Trp:Lys ratio for pigs fed diets with 30% DDGS throughout. For ADG, pigs fed the 19% Trp:Lys ratio withdrawal diet had greater ($P < 0.05$) ADG compared to pigs fed 30% DDGS diets with 16, 19, or 22% Trp:Lys ratios. Pigs fed all dietary treatments were similar ($P > 0.05$) to each other for ADFI, except pigs fed the 19% SID Trp:Lys withdrawal diet had greater intake ($P < 0.05$) than pigs fed the control or 30% DDGS throughout with 16, 19, or 22% Trp:Lys ratios. Pigs fed the control corn-soybean meal-based diet had improved ($P < 0.05$) F/G compared to all other treatments except their F/G was similar to pigs fed the 19% Trp:Lys withdrawal diet or pigs fed the 30% DDGS diet throughout with 25% Trp:Lys ratio.

Increasing SID Trp:Lys in the 30% DDGS diets increased (linear, $P < 0.001$) BW on d 70 and at the end of the study on d 119/120. Pigs fed the 19% Trp:Lys withdrawal diet had the greatest numeric final body weight, being significantly greater ($P < 0.05$) than pigs fed the 30% DDGS diets containing 16% or 22% Trp:Lys throughout. Pigs fed the 25% SID Trp:Lys withdrawal diet had similar ($P > 0.05$) BW to all other treatments on d 70 and final BW, except for a greater ($P < 0.05$) final BW than pigs fed the 16% Trp:Lys ratio.

No differences in BW were observed at the first marketing event of the study. For the second, third, and overall marketing events, BW increased (linear, $P < 0.001$) with increasing Trp:Lys ratio in 30% DDGS diets. Pigs fed the 19% Trp:Lys withdrawal diet had the greatest numeric BW at marketing events 2 and 3. They also had a greater BW ($P < 0.05$) than pigs fed 30% DDGS diets with 16% or 19% Trp:Lys ratio throughout during the second marketing event and pigs fed the 30% DDGS diet with 16% Trp:Lys ratio for the third marketing event. Overall, across all 3 marketing events, pigs fed the withdrawal diet with 19% Trp:Lys ratio had greater ($P < 0.05$) BW at market than pigs fed 30% DDGS diets throughout with 16, 19, or 22% Trp:Lys ratio, but pigs fed the 25% SID Trp:Lys withdrawal diet only had a higher ($P < 0.05$) overall market weight when compared to pigs fed the 30% DDGS diet with 16% Trp:Lys ratio.

As expected, for all time periods, Trp intake per day and intake per kg of gain increased (linear, $P < 0.05$) as SID Trp:Lys ratio increased. From d 0 to 70, Lys intake per day increased (linear, $P = 0.002$) and Lys intake per kg of gain decreased (linear, $P = 0.043$) as the Trp increased in the diet. The Lys intake per kg of gain tended to decrease (linear, $P = 0.069$) as the Trp:Lys ratio increased from d 70 to the end of the trial. Overall, Lys intake per day increased (linear, $P = 0.035$) and Lys intake per kg of gain decreased (linear, $P = 0.003$) as the Trp:Lys ratio increased.

No differences in carcass characteristics were observed at the first marketing event ($P > 0.05$; Table 4) except for a decrease (quadratic, $P = 0.047$) in carcass yield in pigs fed diets with increasing SID Trp:Lys ratio. The HCW and loin depth increased (quadratic, $P > 0.05$) in pigs as the SID Trp:Lys ratio increased as well as a tendency for an increase in lean percent (quadratic, $P = 0.091$) and increase (linear, $P = 0.068$) in carcass yield during marketing event 2. During marketing event 3, HCW and carcass yield increased quadratically ($P < 0.05$) as well as backfat depth (linear, $P = 0.003$) increased in pigs fed diets containing 30% DDGS with an increasing SID Trp:Lys ratio. A tendency for a decrease (quadratic, $P = 0.070$) in percent lean was also observed as the Trp level increased in the diet. Overall, HCW and carcass yield increased (quadratic, $P < 0.05$) in pigs fed the diet containing 30% DDGS with an increasing Trp:Lys ratio as well as backfat depth (linear, $P = 0.040$). The greatest increase in HCW occurred as SID Trp:Lys increased from 16 to 19% with a further increase as the ratio increased from 22 to 25%. Pigs fed the 16% Trp:Lys ratio had decreased HCW ($P < 0.05$) compared to all other treatments for marketing events 2, 3, and overall.

When comparing carcass fat iodine values, pigs fed diets which contained 30% DDGS throughout the study had greater ($P < 0.05$) iodine values for all 3 marketing events, as well as overall, than the control or DDGS withdrawal treatments (Table 5). Pigs fed either of the two withdrawal treatments, which contained 30% DDGS from phases 1 to 3 and then 0% in phase 4, had greater ($P < 0.05$) iodine values than pigs fed the control diet. Pigs fed the control diet containing no DDGS throughout the study had the lowest iodine value. There was a tendency ($P = 0.057$) for a linear increase in iodine value for the third cut as the Trp level increased in the diet.

No differences ($P > 0.05$) in revenue per pen, IOFC, or IOFC per pig placed were observed (Table 6). Pigs fed the control corn-soybean meal-based diet had the greatest numeric feed cost per pen, and pigs fed the 16% Trp:Lys ratio had the lowest feed cost per pen, with all other treatments intermediate. As the SID Trp:Lys ratio increased (quadratic, $P = 0.001$), feed cost per lb of gain also increased. Pigs fed the control diet had greater ($P < 0.05$) feed cost per lb of gain compared to pigs fed diets with 30% DDGS with 19 or 22% SID Trp:Lys ratios. Revenue per pig placed tended to improve (linear, $P = 0.064$) as the Trp:Lys ratio increased in the diet. Feed cost per pig increased (linear, $P = 0.002$) as SID Lys:Trp ratio increased. Pigs on the control diet and 30% DDGS diet with 25% Trp:Lys ratio fed throughout had greater ($P < 0.05$) feed cost per pig placed compared to pigs fed 30% DDGS with 16% Trp:Lys ratio, with all other treatments intermediate.

In summary, ADG, ADFI, F/G, and BW improved linearly as SID Trp:Lys ratio increased in diets containing 30% DDGS fed all the way to marketing. Furthermore, HCW, loin depth, and backfat depth quadratically increased as the SID Trp:Lys increased in diets containing 30% DDGS, but no statistical differences in carcass yield were observed between treatments. Pigs fed the diet without DDGS had the lowest carcass fat iodine value, and pigs fed a DDGS-withdrawal strategy had a lower iodine value than pigs fed diets containing 30% DDGS throughout the entire study. A quadratic effect for feed cost per lb of gain and a linear increase in revenue per pig placed and feed cost per pig placed were observed as the SID Trp:Lys ratio increased in diets containing 30% DDGS in all 4 phases. These results demonstrate the relative value of withdrawing DDGS from the diet before market. Feeding a high SID Trp:Lys ratio does not replace a DDGS withdrawal strategy. The results also indicate different dietary DDGS and SID Trp:Lys strategies can be used depending on ingredient and market prices and the importance of carcass fat iodine value.

Table 1. Composition of phase 1 and 2 diets (as-fed basis)[1]

	Phase 1			Phase 2		
DDGS, %[2]:	**0**	**30**		**0**	**30**	
SID Trp:Lys, %[2]:	**19**	**16[3]**	**25**	**19**	**16**	**25**
Ingredients, %						
Corn	69.79	50.72	50.66	79.28	56.73	56.69
Soybean meal	26.30	13.30	13.31	17.06	7.82	7.83
DDGS, 5.5% oil	---	30.00	30.00	---	30.00	30.00
Choice white grease	---	2.14	2.10	---	2.24	2.20
Calcium carbonate	1.40	1.26	1.26	1.26	1.17	1.17
Monocalcium P (21% P)	0.63	0.20	0.20	0.47	---	---
Salt	0.54	0.41	0.41	0.55	0.42	0.42
Biolys liquid 32.5%	0.87	1.55	1.55	0.94	1.34	1.34
Methionine hydroxy analog	0.14	0.08	0.08	0.10	0.01	0.01
THR-PRO 80%	0.15	0.17	0.17	0.15	0.10	0.10
L-Trp	0.021	0.02	0.12	0.04	0.02	0.10
Mineral-vitamin premix	0.15	0.15	0.15	0.15	0.15	0.15
Calculated analysis						
SID amino acids, %						
Lys	1.11	1.11	1.11	0.91	0.91	0.91
His:Lys	40	38	38	39	41	41
Ile:Lys	60	56	56	57	59	59
Leu:Lys	129	148	148	134	168	168
Met:Lys	34	32	32	33	30	30
Met and Cys:Lys	57	57	57	57	58	58
Thr:Lys	62	62	62	62	62	62
Trp:Lys	19	16	25	19	16	25
Val:Lys	67	67	67	65	72	72
Total Lys, %	1.24	1.29	1.29	1.01	1.07	1.07
NE, kcal/lb	1,149	1,149	1,149	1,161	1,161	1,161
SID Lys:NE, g/Mcal	4.38	4.38	4.38	3.54	3.54	3.54
CP, %	18.54	19.71	19.80	15.06	17.51	17.57
Ca, %	0.75	0.62	0.62	0.64	0.53	0.53
P, %	0.51	0.49	0.49	0.43	0.42	0.42
STTD P, %	0.39	0.39	0.39	0.34	0.34	0.34

[1]Phases 1 and 2 were fed from 50 to 96 and 96 to 157 lb, respectively.
[2]While the formulation strategy was the same between groups, minor differences in feed formulas existed between groups based on differences in loading values of ingredients.
[3]The two diets containing 30% DDGS with either 16 or 25% SID Trp:Lys ratio were blended on the farm to form the 19 and 22% SID Trp:Lys ratio diets.

Table 2. Composition of phase 3 and 4 diets (as-fed basis)[1]

	Phase 3			Phase 4			
DDGS, %[2]:	0	30		0		30	
SID Trp:Lys, %[2]:	19	16[3]	25	19	25	16	25
Ingredients, %							
Corn	85.03	58.11	58.07	85.25	85.20	57.46	57.43
Soybean meal	11.74	6.65	6.65	11.67	11.68	7.64	7.64
DDGS, 5.5% oil	---	30.00	30.00	---	---	30.00	30.00
Choice white grease	---	2.52	2.48	---	---	2.48	2.45
Calcium carbonate	1.14	1.16	1.16	1.17	1.17	1.17	1.17
Monocalcium P, 21% P	0.26	---	---	0.34	0.34	---	---
Salt	0.56	0.42	0.42	0.56	0.56	0.42	0.42
Biolys liquid, 32.5%	0.89	0.97	0.97	0.73	0.73	0.73	0.73
Methionine hydroxy analog	0.06	---	---	0.03	0.03	---	---
THR-PRO, 80%	0.14	0.02	0.02	0.12	0.12	---	---
L-Trp	0.04	0.02	0.07	0.03	0.07	---	0.05
Mineral-vitamin premix	0.15	0.15	0.15	0.10	0.10	0.10	0.10
Calculated analysis							
SID amino acids, %							
Lys	0.76	0.76	0.76	0.70	0.71	0.70	0.70
His:Lys	40	48	48	43	43	53	53
Ile:Lys	56	67	67	60	60	75	75
Leu:Lys	143	197	197	154	154	216	216
Met:Lys	32	34	34	31	31	38	38
Met and Cys:Lys	58	67	67	59	59	73	73
Thr:Lys	64	64	64	66	66	68	68
Trp:Lys	19	16	25	19	25	16	25
Val:Lys	66	84	83	71	71	92	92
Total Lys, %	0.85	0.92	0.92	0.80	0.80	0.87	0.87
NE, kcal/lb	1,170	1,170	1,170	1,170	1,170	1,170	1,170
SID Lys:NE, g/Mcal	2.94	2.94	2.94	2.73	2.73	2.73	2.73
CP, %	13.02	16.83	16.89	12.91	12.95	17.11	17.15
Ca, %	0.55	0.52	0.52	0.57	0.57	0.53	0.53
P, %	0.36	0.42	0.42	0.38	0.38	0.42	0.42
STTD P, %	0.29	0.34	0.34	0.26	0.26	0.30	0.30

[1]Phases 3 and 4 were fed from 157 to 220 and 220 to market lb, respectively.
[2]While the formulation strategy was the same between groups, minor differences in feed formulas existed between groups based on differences in loading values of ingredients.
[3]The two diets containing 30% DDGS with either 16 or 25% SID Trp:Lys ratio were blended on the farm to form the 19 and 22% SID Trp:Lys ratio diets.

Table 3. Effects of increasing Trp:Lys ratios and DDGS withdrawal strategies on growth performance of growing finishing pigs[1]

DDGS, %[2]:	0	30-0 withdrawal		30 throughout					*P* =		
Item SID Trp:Lys, %[2]:	**19**	**19**	**19-25**	**16**	**19**	**22**	**25**	**SEM**	**Treatment**	**Linear[3]**	**Quadratic[3]**
BW, lb											
d 0	49.7	49.7	49.7	49.7	49.7	49.7	49.7	0.45	0.999	0.972	0.787
d 70	212.0[a]	211.2[a]	208.6[ab]	206.1[b]	209.4[ab]	209.2[ab]	211.6[a]	1.34	< 0.001	< 0.001	0.591
d 119/120	297.0[ab]	300.8[a]	296.2[ab]	285.5[c]	294.5[ab]	292.5[bc]	297.4[ab]	2.43	< 0.001	< 0.001	0.252
Market weight, lb											
1st cut (d 91/92)[4]	290.2	289.8	286.7	289.3	288.4	288.0	288.1	1.80	0.728	0.576	0.729
2nd cut (d 105)[5]	300.5[ab]	303.4[a]	299.0[ab]	292.6[c]	296.1[bc]	298.4[abc]	300.1[ab]	2.04	< 0.001	< 0.001	0.524
3rd cut (d 119/120)[6]	297.0[a]	300.8[a]	296.2[a]	285.5[b]	294.5[a]	293.4[a]	297.2[a]	2.46	< 0.001	< 0.001	0.146
Overall[7]	296.9[ab]	299.3[a]	295.1[ab]	289.3[c]	293.8[bc]	294.0[bc]	296.2[ab]	1.46	< 0.001	< 0.001	0.309
d 0 to 70											
ADG, lb	2.31[a]	2.29[ab]	2.25[bc]	2.22[c]	2.27[abc]	2.26[abc]	2.29[ab]	0.02	< 0.001	< 0.001	0.489
ADFI, lb	5.59[ab]	5.64[a]	5.58[ab]	5.50[b]	5.60[ab]	5.58[ab]	5.65[a]	0.04	0.016	0.002	0.571
F/G	2.43[b]	2.46[a]	2.48[a]	2.48[a]	2.47[a]	2.47[a]	2.46[a]	0.02	< 0.001	0.100	0.801
Trp intake, g/d	4.17[c]	4.19[c]	4.14[c]	3.44[d]	4.16[c]	4.80[b]	5.54[a]	0.03	< 0.001	< 0.001	0.590
Trp intake, g/kg gain	4.15[d]	4.19[cd]	4.23[c]	3.56[e]	4.21[cd]	4.87[b]	5.54[a]	0.03	< 0.001	< 0.001	0.395
Lys intake, g/d	22.79[ab]	22.93[ab]	22.70[ab]	22.37[b]	22.77[ab]	22.70[ab]	22.98[ab]	0.24	0.018	0.002	0.602
Lys intake, g/kg gain	22.71[b]	23.01[ab]	23.19[a]	23.22[a]	23.07[a]	23.09[a]	23.00[ab]	0.33	< 0.001	0.043	0.664
d 70 to 119/120											
ADG, lb	2.28[bc]	2.37[a]	2.33[ab]	2.23[c]	2.24[c]	2.26[bc]	2.27[bc]	0.03	< 0.001	0.083	0.806
ADFI, lb	7.51[bc]	7.82[a]	7.70[ab]	7.46[c]	7.49[c]	7.48[c]	7.50[c]	0.08	< 0.001	0.696	0.889
F/G	3.30	3.30	3.31	3.35	3.36	3.32	3.31	0.02	0.071	0.026	0.503
Trp intake, g/d	4.96[d]	5.16[c]	6.44[a]	4.15[e]	4.95[d]	5.70[b]	6.48[a]	0.09	< 0.001	< 0.001	0.693
Trp intake, g/kg gain	5.01[d]	5.02[d]	6.37[a]	4.28[e]	5.11[d]	5.84[c]	6.60[a]	0.14	< 0.001	< 0.001	0.336
Lys intake, g/d	24.44[bc]	25.41[a]	25.04[ab]	24.28[c]	24.34[c]	24.20[c]	24.21[c]	0.79	< 0.001	0.592	0.857
Lys intake, g/kg gain	24.73[ab]	24.76[b]	24.82[ab]	25.03[ab]	25.22[a]	24.87[ab]	24.78[ab]	0.97	0.109	0.069	0.292

continued

Table 3. Effects of increasing Trp:Lys ratios and DDGS withdrawal strategies on growth performance of growing finishing pigs[1]

	DDGS, %[2]:	0	30-0 withdrawal		30 throughout					*P* =		
Item	SID Trp:Lys, %[2]:	19	19	19-25	16	19	22	25	SEM	Treatment	Linear[3]	Quadratic[3]
Overall												
ADG, lb		2.30[ab]	2.32[a]	2.28[ab]	2.22[c]	2.26[bc]	2.26[bc]	2.29[ab]	0.01	< 0.001	0.001	0.699
ADFI, lb		6.26[bc]	6.39[a]	6.31[ab]	6.18[c]	6.26[bc]	6.23[bc]	6.29[abc]	0.04	< 0.001	0.020	0.655
F/G		2.72[b]	2.76[ab]	2.77[a]	2.78[a]	2.77[a]	2.76[a]	2.75[ab]	0.01	< 0.001	0.004	0.964
Trp intake, g/d		4.44[de]	4.52[d]	4.93[c]	3.69[f]	4.43[e]	5.11[b]	5.87[a]	0.04	< 0.001	< 0.001	0.818
Trp intake, g/kg gain		4.43[e]	4.47[de]	4.97[c]	3.80[f]	4.50[d]	5.19[b]	5.89[a]	0.03	< 0.001	< 0.001	0.922
Lys intake, g/d		23.37[abc]	23.80[a]	23.51[ab]	23.04[c]	23.33[bc]	23.23[bc]	23.42[abc]	0.21	< 0.001	0.035	0.636
Lys intake, g/kg gain		23.34[b]	23.55[ab]	23.67[a]	23.78[a]	23.71[a]	23.59[ab]	23.50[ab]	0.15	< 0.001	0.003	0.888
Removals, %												
Removals, %		2.4	3.0	3.9	2.9	2.9	3.4	3.2	0.73	0.629	0.579	0.827
Mortality, %		1.6	1.5	0.9	1.3	0.8	1.1	0.7	0.42	0.480	0.293	0.948
Total removals, %		3.9	4.5	4.8	4.2	3.7	4.6	3.9	0.81	0.889	0.971	0.929

[1]A total of 6,240 pigs (initially 49.7 lb) were used with 30-36 pigs per pen and 26 replications per treatment.

[2]Pigs were either fed diets containing 0% DDGS with 19% standardized ileal digestible (SID) Trp:Lys ratio from day 0 to 119/120, 30% DDGS from d 0 to 70 and 0% DDGS from d 70 to 119/120 with SID Trp:Lys ratios of 19% from d 0 to 119/120 or 19% from d 0 to 70 and 25% SID Trp:Lys from d 70 to 119/120, or fed 30% DDGS from d 0 to 119/120 with levels of SID Trp:Lys ratio of 16, 19, 22, and 25%, respectively.

[3]Linear and quadratic contrasts included treatments containing 30% DDGS and an SID Trp:Lys ratio of 16, 19, 22, and 25%, respectively.

[4]6-9 pigs per pen were marketed on d 84/92.

[5]10-12 pigs per pen were marketed on d 98/105.

[6]9-15 pigs per pen were marketed on d 119/120.

[7]Weighted average of pigs marketed on d 84/92, 98/105 and 119/120 by pen.

[a,b,c,d]Means in the same row that do not have a common superscript differ ($P < 0.05$).

Table 4. Effects of increasing Trp:Lys ratios and DDGS withdrawal strategies on carcass characteristics of growing finishing pigs[1]

DDGS, %[2]:	0	30-0 withdrawal		30 throughout					P =		
Item / SID Trp:Lys, %[2]:	19	19	19-25	16	19	22	25	SEM	Treatment	Linear[3]	Quadratic[3]
Cut 1											
HCW, lb	206.2	205.6	203.2	206.0	206.9	205.3	205.8	1.91	0.786	0.764	0.895
Carcass yield, %	71.4	71.2	70.9	70.8	71.1	71.1	70.3	0.74	0.135	0.205	0.047
Lean, %[4]	53.1	52.4	52.8	52.5	52.5	52.6	52.6	0.20	0.241	0.574	0.876
Loin depth, in.[4]	2.44	2.35	2.40	2.39	2.39	2.40	2.40	0.03	0.448	0.549	0.758
Back fat depth, in.[4]	0.77	0.80	0.78	0.79	0.80	0.81	0.79	0.01	0.443	0.801	0.533
Cut 2											
HCW, lb	211.1[a]	212.9[a]	208.7[a]	200.2[b]	208.0[a]	212.3[a]	213.1[a]	1.83	< 0.001	< 0.001	0.022
Carcass yield, %	72.0	71.9	71.4	71.2	71.6	71.9	71.7	0.75	0.088	0.068	0.199
Lean, %[4]	52.8	52.4	52.7	52.5	53.0	52.7	52.7	0.18	0.155	0.706	0.091
Loin depth, in.[4]	2.36	2.32	2.36	2.29	2.37	2.36	2.34	0.02	0.110	0.138	0.029
Back fat depth in.[4]	0.74	0.77	0.75	0.74	0.72	0.75	0.74	0.01	0.323	0.509	0.639
Cut 3											
HCW, lb	221.3[a]	223.3[a]	217.9[a]	205.7[b]	219.0[a]	218.1[a]	223.0[a]	2.31	< 0.001	< 0.001	0.024
Carcass yield, %	73.0[a]	72.6[ab]	72.1[bc]	71.6[c]	72.7[ab]	72.0[bc]	72.2[abc]	0.01	< 0.001	0.177	0.043
Lean, %[4]	53.2[a]	52.6[ab]	52.5[b]	53.1[ab]	52.5[b]	52.6[ab]	52.4[b]	0.15	< 0.001	< 0.001	0.070
Loin depth, in.[4]	2.52[a]	2.47[ab]	2.46[ab]	2.44[b]	2.41[b]	2.46[ab]	2.42[b]	0.02	< 0.001	0.831	0.809
Back fat depth in.[4]	0.76[ab]	0.80[a]	0.80[a]	0.73[b]	0.77[ab]	0.79[ab]	0.79[ab]	0.02	0.007	0.003	0.181
Overall[5]											
HCW, lb	214.1[a]	215.3[a]	211.2[a]	203.8[b]	212.4[a]	212.9[a]	215.3[a]	1.76	< 0.001	< 0.001	0.014
Carcass yield, %	72.3[a]	72.0[ab]	71.6[bc]	71.3[c]	72.0[ab]	71.8[abc]	71.7[abc]	0.16	< 0.001	0.192	0.012
Lean, %[4]	53.0[a]	52.5[b]	52.6[ab]	52.7[ab]	52.7[ab]	52.6[b]	52.6[b]	0.11	< 0.001	0.259	0.868
Loin depth, in.[4]	2.45[a]	2.39[b]	2.41[ab]	2.37[b]	2.39[b]	2.41[ab]	2.39[b]	0.01	0.004	0.277	0.119
Back fat depth, in.[4]	0.76	0.79	0.78	0.75	0.76	0.78	0.78	0.01	0.019	0.040	0.372

[1]A total of 3,055 pigs (initially 51.0 lb) were used with 30-36 pigs per pen and 13 replications per treatment to collect carcass data.

[2]Pigs were either fed diets containing 0% DDGS with 19% standardized ileal digestible (SID) Trp:Lys ratio from day 0 to 119/120, 30% DDGS from d 0 to 70 and 0% DDGS from d 70 to 119/120 with SID Trp:Lys ratios of 19% from d 0 to 119/120 or 19% from d 0 to 70 and 25% SID Trp:Lys from d 70 to 119/120, or fed 30% DDGS from d 0 to 119/120 with levels of SID Trp:Lys ratio of 16, 19, 22, and 25%, respectively.

[3]Linear and quadratic contrasts included treatments containing 30% DDGS and an SID Trp:Lys ratio of 16, 19, 22, and 25%, respectively.

[4]Adjusted using HCW as a covariate.

[5]Weighted average of carcass characteristics for the overall study.

[a,b,c]Means in the same row that do not have a common superscript differ ($P < 0.05$).

Table 5. Effects of increasing Trp:Lys ratios and DDGS withdrawal strategies on carcass fat iodine value of growing finishing pigs[1]

	DDGS, %[2]:	0	30-0 withdrawal		30 throughout					*P* =		
Item	SID Trp:Lys, %[2]:	19	19	19-25	16	19	22	25	SEM	Treatment	Linear[3]	Quadratic[3]
Iodine value, %												
Number of pigs		76	72	73	75	70	80	74	-	-	-	-
1st cut		64.66[c]	72.91[b]	73.52[b]	75.37[a]	75.75[a]	75.45[a]	75.59[a]	0.47	< 0.001	0.824	0.741
Number of pigs		73	74	72	71	73	68	76	-	-	-	-
2nd cut		64.04[c]	70.78[b]	71.40[b]	76.14[a]	75.32[a]	75.65[a]	75.20[a]	0.37	< 0.001	0.117	0.589
Number of pigs		52	48	63	58	55	51	52	-	-	-	-
3rd cut		63.93[c]	70.31[b]	70.81[b]	76.12[a]	76.80[a]	77.33[a]	77.27[a]	0.49	< 0.001	0.057	0.422
Overall[4]		63.13[c]	71.23[b]	71.80[b]	75.97[a]	75.82[a]	75.26[a]	75.92[a]	0.25	< 0.001	0.798	0.515

[1]A total of 6,240 pigs (initially 49.7 lb) were used with 30-36 pigs per pen and 26 replications per treatment. Fat samples were collected from the dorsal loin-butt junction and were immediately frozen and later analyzed for iodine value using near infrared spectroscopy (NIRS).

[2]Pigs were either fed diets containing 0% DDGS with 19% standardized ileal digestible (SID) Trp:Lys ratio from day 0 to 119/120, 30% DDGS from d 0 to 70 and 0% DDGS from d 70 to 119/120 with SID Trp:Lys ratios of 19% from d 0 to 119/120 or 19% from d 0 to 70 and 25% SID Trp:Lys from d 70 to 119/120, or fed 30% DDGS from d 0 to 119/120 with levels of SID Trp:Lys ratio of 16, 19, 22, and 25%, respectively.

[3]Linear and quadratic contrasts included treatments containing 30% DDGS and an SID Trp:Lys ratio of 16, 19, 22, and 25%, respectively.

[4]Weighted average of carcass fat iodine value by pen.

[a,b,c] Means in the same row that do not have a common superscript differ ($P < 0.05$).

Table 6. Effects of increasing Trp:Lys ratios and DDGS withdrawal strategies on economics of growing finishing pigs[1]

	DDGS, %[2]:	0	30-0 withdrawal		30 throughout					*P* =		
Item	**SID Trp:Lys, %[2]:**	**19**	**19**	**19-25**	**16**	**19**	**22**	**25**	**SEM**	**Treatment**	**Linear[3]**	**Quadratic[3]**
Economics												
Revenue, $/pen[4]		5,329	5,287	5,231	5,124	5,251	5,212	5,157	64.7	0.186	0.818	0.121
Feed cost, $/pen		2,994[a]	2,960[ab]	2,953[ab]	2,860[b]	2,902[ab]	2,897[ab]	2,906[ab]	54.8	0.008	0.255	0.535
IOFC, $/pen[5]		2,334	2,327	2,279	2,265	2,350	2,315	2,251	76.5	0.340	0.634	0.038
Feed cost/lb gain[6]		0.360[a]	0.356[abc]	0.358[abc]	0.357[abc]	0.354[c]	0.355[bc]	0.359[ab]	0.01	< 0.001	0.300	0.001
Revenue, $/pig placed[7]		152.64	152.44	149.36	146.99	151.36	149.61	151.48	2.23	0.061	0.064	0.376
Feed cost, $/pig placed[8]		85.54[a]	85.06[ab]	84.07[ab]	81.78[b]	83.33[ab]	82.93[ab]	84.91[a]	1.04	< 0.001	0.002	0.732
IOFC, $/pig placed[9]		67.11	67.38	65.30	65.22	68.03	66.68	66.57	2.57	0.255	0.505	0.111

[1]A total of 6,240 pigs (initially 49.7 lb) were used with 30-36 pigs per pen and 26 replications per treatment.

[2]Pigs were either fed diets containing 0% DDGS with 19% standardized ileal digestible (SID) Trp:Lys ratio from day 0 to 119/120, 30% DDGS from d 0 to 70 and 0% DDGS from d 70 to 119/120 with SID Trp:Lys ratios of 19% from d 0 to 119/120 or 19% from d 0 to 70 and 25% SID Trp:Lys from d 70 to 119/120, or fed 30% DDGS from d 0 to 119/120 with levels of SID Trp:Lys ratio of 16, 19, 22, and 25%, respectively.

[3]Linear and quadratic contrasts included treatments containing 30% DDGS and an SID Trp:Lys ratio of 16, 19, 22, and 25%, respectively.

[4]Revenue, $/pen = (HCW × $0.80 × pigs marketed/pen) + (culls × $0.45). A 75% yield was assumed and HCW was calculated from final body weight for group 1.

[5]Income over feed cost, $/pen = revenue, $/pen – feed cost, $/pen.

[6]Feed cost/lb gain = total feed cost per pig divided by total gain per pig.

[7]Revenue, $/pig placed = revenue, $/pen divided by number of pigs placed per pen.

[8]Feed cost, $/pig placed = feed cost, $/pen divided by number of pigs placed per pen.

[9]Income over feed cost, $/pig placed = revenue, $/pig placed – feed cost, $/pig placed.

[a,b,c]Means in the same row that do not have a common superscript differ ($P < 0.05$).