Kansas State University
College of Agriculture

SWINE DAY
2026

Impacts of Reducing Dietary Crude Protein through Soybean Meal in Grow-Finish Swine Rations

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Summary

A total of 1,030 grow-finish pigs [PIC 800 × (Fast LW × PIC L02), initially 66.8 ± 0.58 lb] were used to determine the impact of reducing dietary crude protein (CP) on growth performance and carcass characteristics. The dietary treatments consisted of graded levels of CP (High, Medium-High, Medium-Low, and Low), accomplished through the reduction of dietary soybean meal (SBM) and inclusion of feed grade amino acids (AA). The dietary CP levels and phase feeding durations were: phase 1 from 60 to 100 lb of body weight (BW), with CP ranging from 21 to 18%; phase 2 from 100 to 175 lb, with CP ranging from 18.3 to 15.3%; phase 3 from 175 to 250 lb, with CP ranging from 16 to 13%; and phase 4 from 250 to market with CP ranging from 14.8 to 11.8%. Pen weights and feed disappearance were recorded every 14 d, and prior to each marketing event, to calculate average daily gain (ADG), average daily feed intake (ADFI), and feed efficiency (F/G). Carcass characteristics were collected for each marketing event. The reduction of CP did not affect BW. In phases 1 and 2, there were no differences among dietary treatments. However, in phase 3, the reduction in dietary CP resulted in a tendency for a quadratic effect on ADG (quadratic, P = 0.054), and tended to decrease ADFI (linear, P = 0.082). Moreover, during phase 4, reducing CP resulted in greater ADG (linear, P = 0.021) and improved feed efficiency (linear, P = 0.002). Overall, reducing dietary CP tended to improve F/G (linear, P = 0.058) but tended to worsen caloric efficiency (linear, P = 0.079). Feeding low levels of CP increased the loin depth (linear, P = 0.022), carcass yield (linear, P = 0.020) of pigs at the first marketing event and increased (linear, P = 0.033) fat depth in the second marketing event. For the overall carcass data, carcass weight (linear, P = 0.075), backfat depth (linear, P = 0.055), and carcass ADG (linear, P = 0.083) tended to increase, carcass yield increased (linear, P = 0.033), and carcass F/G improved (linear, P = 0.017) when reducing dietary CP. In conclusion, reducing dietary CP through increased feed grade AA and reduced SBM in grow-finish pig diets tended to improve F/G and

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increased carcass yield resulting in a tendency for increased carcass weight and improved carcass efficiency but tended to increase caloric efficiency and fat depth.

Key words: carcass characteristics, crude protein, grow-finish pigs, growth performance

Introduction

Feeding low dietary crude protein (CP) diets can reduce nitrogen excretion. However, too much of a reduction in dietary CP can reduce growth performance (Lu et al., 2017)[4]. Interestingly, in a recent study by Kim et al. (2024)[5], the reduction in dietary CP through reduction in SBM improved the performance of grow-finish pigs. This improvement in performance was a result of increased ADFI and, therefore, ADG throughout the majority of the growing period. Previous research has suggested similar results. Giacomini et al. (2025)[6] also demonstrated an increase in ADFI and ADG when dietary CP was reduced via reductions in SBM during the grower period. However, in the study by Giacomini et al. (2025), the reduction of dietary CP was tested during the early finishing period (75 to 130 lb) and the late finishing period (175 lb to market), and the effect of different levels of DDGS was also tested. It should also be noted that both studies evaluating reductions in dietary levels of SBM have indicated a linear increase in carcass yield and backfat depth when decreasing the levels of SBM. For this reason, carcass characteristics and performance should be evaluated to accurately account for the impact of SBM level, and consequently dietary CP. Therefore, the objective of the present study was to evaluate the effects of reducing dietary levels of CP through decreases in SBM inclusion on growth performance and carcass characteristics of grow-finish pigs under commercial production conditions.

Procedures

Animals and diets

The protocol used in this experiment was approved by the Kansas State University Institutional Animal Care and Use Committee. This study was conducted from January to May 2026 at the New Fashion Pork research facility near Round Lake, MN. Pigs were high health with no known adverse health events. The facility is completely enclosed, environmentally controlled, and mechanically ventilated. Each pen (8 × 18.5 ft) contained a 3-hole, dry self-feeder and a cup waterer for ad libitum access to feed and water and approximately 6.49 ft2 per pig.

A total of 1,030 grow-finish pigs [PIC 800 × (Fast LW × PIC L02), initially 66.8 ± 0.58 lb] were used in a 112-d study. Pigs were housed in 48 pens, blocked by initial BW and randomly assigned to 1 of 4 dietary treatments in a randomized complete block design (12 pens/treatment). The four dietary treatments consisted of graded levels of

[4] Lu, L., X. Liao, and X. Luo. 2017. Nutritional strategies for reducing nitrogen, phosphorus and trace mineral excretions of livestock and poultry. J. Integr. Agric. 16:2815–2833. doi:10.1016/S2095-3119(17)61701-5.

[5] Kim, T., E. B. Stas, J. L. Smallfield, H. M. Cordoba, M. D. Tokach, R. D. Goodband, J. M. DeRouchey, J. C. Woodworth, J. T. Gebhardt, and K. D. Haydon. 2024. Determining the productive energy of soybean meal relative to corn and feed-grade amino acids. Kansas Agricultural Experiment Station Research Reports 10(6). doi:10.4148/2378-5977.8642.

[6] Giacomini, P., K. N. Gaffield, R. D. Goodband, J. C. Woodworth, M. D. Tokach, J. M. DeRouchey, J. T. Gebhardt, A. Petry, M. Putnam, A. Gaines, R. D. Boyd, C. Shull, and O. Mendoza. 2025. Effects of increasing soybean meal in diets with or without distillers dried grains with solubles on growth performance and carcass characteristics of pigs in early and late finishing phases. Kansas Agricultural Experiment Station. 11(7). doi:10.4148/2378-5977.8770.

dietary CP, accomplished through the reduction of dietary SBM and inclusion of feed grade amino acids (AA). In phase 1 (60 to 100 lb), dietary CP ranged from 21 to 18%; in phase 2 (100 to 175 lb), CP ranged from 18.3 to 15.3%; in phase 3 (175 to 250 lb), CP ranged from 16 to 13%; and in phase 4 (250 lb to market), CP ranged from 14.8 to 11.8%. Two diets were formulated (highest and lowest dietary CP levels within phase) and blended at the feeder level to obtain the intermediate levels of CP. Dietary SID Lys concentrations were formulated to provide approximately 100% of the PIC (2021) estimated requirement and maintained across treatments within phase. Net energy (NE) values assigned to corn and SBM (1,127 and 908 kcal/lb, respectively) were calculated from analyzed nutrient composition using the equations from Noblet et al. (1994)[7] reported in the NRC[8] (2012; page 6, equations 1-8) energy system and were used to formulate dietary NE.

Pens and feeders were weighed every two weeks and at each marketing event to determine ADG, ADFI, and F/G. Caloric efficiency (CE) was determined on an NE basis and was calculated by multiplying total feed intake × energy content of the diet (kcal/lb) and dividing by total gain.

During the first marketing event within the barn, the heaviest four to seven pigs were removed from each pen according to market load size and in an effort to standardize number of pigs per pen remaining within block. Pigs selected for market were weighed collectively with the pen and then also separately in order to calculate carcass yield, carcass ADG, carcass efficiency, and carcass CE. From the processing plant, hot carcass weight (HCW), backfat, loin depth, and percent lean were captured individually. Mortality and removals are reported in Table 3.

Statistical analysis

Experimental data were analyzed using the lmer function in R Studio (Version 4.5.3, R Core Team, Vienna, Austria) with pen serving as the experimental unit in a randomized complete block design. For all data, treatment served as a fixed effect within the statistical model, with block serving as a random effect. For carcass characteristics, pen and block were included as random effects, and HCW was used as a covariate for fat depth, loin depth, and percent lean. Fixed effects were tested using the joint tests function in R, and treatment means were estimated using the emmeans function. Linear and quadratic contrasts were constructed with decreasing levels of CP. Results were considered significant at $P \leq 0.05$ and marginally significant at $P \leq 0.10$.

Results and Discussion

Reducing dietary CP did not affect the BW of grow-finish pigs at any time point (Table 3). No differences were observed between the dietary treatments during phases 1 and 2 for ADG, ADFI, and F/G. In phase 3, reducing CP tended to reduce ADG (quadratic, $P = 0.054$) and ADFI (linear, $P = 0.082$). During phase 4, reducing CP resulted in greater ADG (linear, $P = 0.021$) and improved feed efficiency (linear, $P = 0.002$). Moreover, a tendency for a quadratic effect was observed on ADFI (quadratic, $P = 0.092$). Overall, reducing CP did not affect ADG or ADFI, but tended to improve F/G (linear, $P = 0.058$). Reducing CP tended to increase CE (linear, $P = 0.079$) when assuming an NE value of 80.6% for SBM relative to corn. For carcass characteristics, an increase in

[7] Noblet, J., H. Fortune, X. S. Shi, and S. Dubois. 1994. Prediction of net energy value of feeds for growing pigs. J. Anim. Sci. 72:344–354.
[8] NRC. 2012. Nutrient requirements of swine. 11th rev. ed. Natl. Acad. Press, Washington, DC

loin depth (linear, P = 0.022) and carcass yield (linear, P = 0.020) were observed when reducing dietary levels of CP for the first marketing event (Table 4). For the second marketing event, an increase in backfat depth was observed when decreasing dietary CP levels (linear, P = 0.033). For the overall carcass characteristics, there was a tendency for increased HCW (linear, P = 0.075), backfat depth (linear, P = 0.055), and carcass ADG (linear, P = 0.083) when dietary CP was decreased. Additionally, carcass yield increased (linear, P = 0.033) and carcass F/G improved (linear, P = 0.017) as dietary CP was reduced. The reduction of dietary CP did not influence carcass CE.

In conclusion, reducing dietary CP through increasing feed grade AA and reducing SBM in grow-finish pigs tended to improve feed efficiency but worsened caloric efficiency, while carcass weight, carcass yield, and backfat depth were increased and carcass feed efficiency improved.

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Table 1. Diet composition of phases 1 and 2 (as-fed basis)[1]

		Phase 1		Phase 2	
Item	CP[2], %	21.0	18.0	18.3	15.3
Ingredient, %					
Corn		60.60	68.99	67.88	76.17
Soybean meal, 45.5% CP		36.37	27.07	29.47	20.30
Calcium carbonate		1.17	1.13	1.18	1.11
Dicalcium phosphate, 21% P		0.57	0.73	0.29	0.53
Sodium chloride		0.59	0.60	0.63	0.64
L-Lys HCl		0.15	0.43	0.10	0.38
DL-Met		0.15	0.22	0.08	0.16
Thr[3]		0.10	0.24	0.05	0.19
L-Val		--	0.15	--	0.11
L-Ile		--	0.06	--	0.05
L-Trp		--	0.05	--	0.05
L-His HCl		--	0.02	--	0.01
KSU Vitamin Premix[4]		0.15	0.15	0.15	0.15
KSU Trace mineral premix		0.15	0.15	0.15	0.15
Calculated analysis					
SID AA %					
Lys, %		1.14	1.14	0.94	0.94
Ile:Lys		66	58	69	58
Leu:Lys		133	113	144	121
Met:Lys		35	39	33	37
Met & Cys:Lys		58	58	58	58
Thr:Lys		65	65	65	65
Trp:Lys		20.3	20.3	20.7	20.7
Val:Lys		70	70	74	70
His:Lys		41	35	43	35
Arg:Lys		107	85	110	85
Phe:Lys		75	61	78	61
Phe+Tyr:Lys		119	97	125	98
CP, %		21.0	18.0	18.3	15.3
SID Lys:CP		5.43	6.33	5.15	6.16
NE, kcal/lb		1,018	1,040	1,036	1,056
SID Lys:NE, g/Mcal		4.77	4.66	3.86	3.78
Ca:P		1.39	1.42	1.45	1.45
STTD P[5], %		0.39	0.39	0.33	0.34

[1] Phase 1 diets were fed from approximately 60 to 100 lb; phase 2 diets were fed from approximately 100 to 175 lb. Diets were blended to obtain the intermediate levels of dietary crude protein.

[2] CP, crude protein.

[3] Thr Pro; CJ America-Bio, Downers Grove, IL.

[4] Phytase (Empirical, ADM, Chicago, IL) was included in the vitamin premix to achieve 852 FTU/kg of diet with an estimated release of 0.125% STTD P.

[5] STTD P, standardized total tract digestible phosphorus.

Table 2. Diet composition of phases 3 and 4 (as-fed basis)[1]

		Phase 3		Phase 4	
Item	CP[2], %	16.0	13.0	14.8	11.8
Ingredient, %					
Corn		74.05	82.40	77.49	85.78
Soybean meal, 45.5% CP		23.76	14.60	20.61	11.51
Calcium carbonate		0.97	0.93	0.78	0.75
Dicalcium phosphate, 21% P		0.19	0.35	0.18	0.33
Sodium chloride		0.61	0.62	0.61	0.63
L-Lys-HCl		0.06	0.33	0.04	0.31
DL-Met		0.05	0.12	0.02	0.09
ThrPro[3]		0.03	0.18	0.01	0.15
L-Val		---	0.09	---	0.07
L-Ile		---	0.06	---	0.05
L-Trp		---	0.05	---	0.05
KSU Vitamin Premix[4]		0.15	0.15	0.13	0.13
KSU Trace mineral premix		0.15	0.15	0.15	0.15
Calculated analysis					
SID AA %					
Lys, %		0.77	0.77	0.68	0.68
Ile:Lys		72	60	75	60
Leu:Lys		159	130	169	137
Met:Lys		33	35	31	36
Met and Cys:Lys		60	60	60	60
Thr:Lys		68	68	68	68
Trp:Lys		21.3	21.3	21.7	21.7
Val:Lys		79	72	83	72
His:Lys		46	36	48	37
Arg:Lys		115	84	119	83
Phe:Lys		82	61	85	61
Phe+Tyr:Lys		133	100	138	101
CP, %		16.0	13.0	14.8	11.8
SID Lys:CP		4.81	5.92	4.61	5.79
NE, kcal/lb		1,052	1,073	1,061	1,081
SID Lys:NE, g/Mcal		3.11	3.04	2.72	2.66
Ca:P		1.30	1.34	1.12	1.17
STTD P[5], %		0.28	0.28	0.27	0.27

[1] Phase 3 diets were fed from approximately 175 to 250 lb; phase 4 diets were fed from approximately 250 lb to market (average 305.6 lb). Diets were blended to obtain the intermediate levels of dietary crude protein.

[2] CP, crude protein.

[3] ThrPro, CJ America-Bio, Downers Grove, IL.

[4] Phytase (Empirical, ADM, Chicago, IL) was included in the vitamin premix to achieve 852 FTU/kg of diet in phase 3 and 710 FTU/kg of diet in phase 4 with an estimated release of 0.125% STTD P for phase 3 and 0.104% STTD P for phase 4.

[5] STTD P, standardized total tract digestible phosphorus.

Table 3. Effect of crude protein (CP) level on growth performance of grow-finish pigs[1]

	Dietary CP, %[2,3]						
Phase 1	21.0	20.0	19.0	18.0			
Phase 2	18.3	17.3	16.3	15.3			
Phase 3	16.0	15.0	14.0	13.0		*P* =	
Phase 4	14.8	13.8	12.8	11.8	SEM	Linear	Quadratic
BW, lb							
d 0	66.8	66.8	66.8	66.8	0.58	0.812	0.541
d 14	92.0	92.4	92.1	91.9	0.76	0.455	0.216
d 55	181.3	181.1	183.0	182.3	1.23	0.362	0.093
d 84	254.6	254.6	255.0	254.7	1.27	0.875	0.893
d 112	305.1	305.3	304.7	307.2	2.03	0.374	0.412
d 0 to 14 (phase 1)							
ADG, lb	1.80	1.83	1.80	1.79	0.018	0.353	0.110
ADFI, lb	3.47	3.52	3.48	3.48	0.039	0.948	0.295
F/G	1.93	1.92	1.93	1.95	0.016	0.262	0.484
d 14 to 55 (phase 2)							
ADG, lb	2.18	2.21	2.22	2.20	0.016	0.292	0.141
ADFI, lb	5.24	5.33	5.28	5.28	0.049	0.789	0.308
F/G	2.41	2.41	2.38	2.40	0.017	0.398	0.689
d 55 to 84 (phase 3)							
ADG, lb	2.52	2.46	2.48	2.48	0.017	0.109	0.054
ADFI, lb	7.21	7.07	7.10	7.08	0.052	0.082	0.174
F/G	2.86	2.88	2.87	2.86	0.023	0.988	0.518
d 84 to 112 (phase 4)							
ADG, lb	2.09	2.05	2.11	2.14	0.022	0.021	0.092
ADFI, lb	7.54	7.33	7.40	7.45	0.073	0.530	0.092
F/G	3.62	3.58	3.52	3.49	0.032	0.002	0.988
d 0 to 112 (overall)							
ADG, lb	2.20	2.19	2.21	2.21	0.010	0.310	0.625
ADFI, lb	6.04	6.00	6.00	6.00	0.043	0.423	0.529
F/G	2.75	2.74	2.72	2.72	0.015	0.058	0.645
Caloric efficiency, kcal/lb[4]	3,071	3,083	3,081	3,106	16.3	0.079	0.620
Removals, n	1	3	2	4	---	---	---
Mortality, n	3	2	1	1	---	---	---

[1] A total of 1,030 grow-finish pigs (initially 66.8 ± 0.58 lb) were used in 112-day study. Pens of pigs were assigned to 1 of 4 dietary treatments in a randomized complete block design (12 pen/treatment).

[2] SID Lys was consistent across the treatments and equal to 1.14%, 0.94%, 0.77%, and 0.68% in phases 1, 2, 3, and 4, respectively.

[3] Phase 1 was fed from 60 to 100 lb of BW, phase 2 was fed from 100 to 175 lb, phase 3 was fed from 175 to 250 lb, and phase 4 was fed from 250 lb to market (average 305.6 lb).

[4] Caloric efficiency was determined on an NE basis and was calculated by multiplying total feed intake × energy content of the diet (kcal/lb) and dividing by total gain.

Table 4. Effect of crude protein (CP) level on carcass weight and characteristics[1]

	Dietary CP, %[2,3]						
Phase 1	21.0	20.0	19.0	18.0			
Phase 2	18.3	17.3	16.3	15.3			
Phase 3	16.0	15.0	14.0	13.0		*P* =	
Phase 4	14.8	13.8	12.8	11.8	SEM	Linear	Quadratic
First marketing event							
HCW[4], lb	220.8	219.2	224.6	221.7	1.86	0.292	0.696
Fat depth, in	0.65	0.64	0.68	0.64	0.012	0.959	0.272
Loin depth, in	2.47	2.53	2.51	2.55	0.020	0.022	0.755
Lean, %	53.8	54.1	53.7	54.2	0.16	0.206	0.601
Carcass yield, %	72.5	72.9	73.1	73.2	0.20	0.020	0.475
Second marketing event							
HCW, lb	221.7	222.3	222.7	224.1	1.67	0.180	0.741
Fat depth, in	0.60	0.61	0.61	0.63	0.008	0.033	0.429
Loin depth, in	2.57	2.57	2.59	2.57	0.015	0.917	0.601
Lean, %	54.6	54.5	54.6	54.3	0.11	0.245	0.447
Carcass yield, %	72.6	72.9	73.2	73.0	0.22	0.198	0.282
Overall							
HCW, lb	221.4	221.3	223.3	223.4	1.27	0.075	0.908
Fat depth, in	0.62	0.62	0.63	0.63	0.007	0.055	0.953
Loin depth, in	2.55	2.56	2.57	2.56	0.012	0.227	0.608
Lean, %	54.3	54.4	54.3	54.3	0.09	0.661	0.820
Carcass performance							
Carcass yield, %	72.6	72.9	73.2	73.0	0.16	0.033	0.211
Carcass ADG[5], lb	1.60	1.60	1.62	1.61	0.008	0.083	0.834
Carcass F/G[6]	3.78	3.76	3.72	3.73	0.023	0.017	0.362
Carcass CE[7], kcal/lb gain	4,229	4,231	4,212	4,253	25.5	0.590	0.377

[1] A total of 1,030 grow-finish pigs (initially 66.8 ± 0.58 lb) were used in a 112-d study. Pens of pigs were assigned to 1 of 4 dietary treatments in a randomized complete block design (12 pens/treatment). For statistical analysis, treatment served as a fixed effect within the statistical model, pen and block included as random effects, and HCW as a covariate for fat depth, loin depth, and percent lean.

[2] SID Lys was consistent across the treatments and equal to 1.14%, 0.94%, 0.77%, and 0.68% in phases 1, 2, 3, and 4, respectively.

[3] Phase 1 was fed from 60 to 100 lb of BW; phase 2 was fed from 100 to 175 lb, phase 3 was fed from 175 to 250 lb; phase 4 was fed from 250 lb to market (average 305.6 lb).

[4] Hot carcass weight.

[5] Carcass ADG = overall ADG × carcass yield.

[6] Carcass F/G = ADFI / carcass ADG.

[7] Carcass CE = Total NE intake / total carcass gain.