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Effect of Increasing Standardized Ileal Digestible Arginine:Lysine Ratio in Lactation Diets Containing Elevated Histidine:Lysine Ratio on Sow and Litter Performance

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Summary

A total of 124 mixed-parity sows (DNA 241) were used to determine the effect on sow and litter performance when increasing the SID Arg:Lys ratio in lactation diets containing an elevated SID His:Lys ratio. Sows were blocked by parity and balanced for body weight (BW) on approximately d 112 of gestation and allotted to one of three dietary treatments of increasing SID Arg:Lys ratios (90, 110, or 130% of Lys). Sows received approximately 6 lb/d of their treatment diet from d 112 of gestation until farrowing, after which they were provided ad libitum access to their treatment diet until weaning on approximately d 18 after farrowing. The same corn-soybean meal-DDGS-based diets were fed throughout the study and formulated to contain an SID His:Lys ratio of 43.5% by the addition of L-His. Litters were cross-fostered within 48 h of farrowing to equalize litter size within treatment. The SID Arg:Lys ratio did not affect sow BW change, backfat change, loin depth change, caliper score change, ADFI before farrowing or during lactation, or the weaning-to-estrus interval. Arginine intake increased (linear, $P < 0.001$) with increasing SID Arg:Lys ratio as expected. No differences were observed for the number of total pigs born or the percentage of total born alive, stillborn, and mummified, nor did treatment influence the litter size at any timepoint. At d 10, litter weight increased then decreased (quadratic, $P = 0.043$) with increasing SID Arg:Lys ratio, with a similar tendency (quadratic, $P = 0.097$) for weaning weight. From d 0 to weaning, litter weight gain increased (linear, $P = 0.047$) with increased SID Arg:Lys ratio. At d 0, litter weight coefficient of variation (CV) decreased (linear, $P = 0.013$) with increasing SID Arg:Lys ratio, with a similar tendency (linear, $P = 0.097$) for litter weight d 10 CV. At d 2, 10, and weaning, average piglet BW increased then decreased (quadratic, $P \leq 0.034$) with 110% Arg:Lys ratio having the heaviest average piglet BW. From d 2 to 10 and d 2 to weaning, litter ADG increased (linear, $P \leq 0.040$) with increasing SID Arg:Lys ratio. Additionally, from d 2

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to 10 and d 2 to weaning, piglet ADG increased (linear, P ≤ 0.010) with increasing SID Arg:Lys ratio and piglet ADG from d 10 to weaning marginally increased (linear, P = 0.083) with increasing SID Arg:Lys ratio. From d 2 to weaning and birth to weaning, preweaning mortality decreased (linear, P ≤ 0.032) with increasing Arg:Lys ratio. From farrow to weaning, Arg intake/kg of litter gain (g/kg) increased (linear, P < 0.001) with increasing SID Arg:Lys ratio. In conclusion, the study provides evidence that feeding increased SID Arg:Lys ratio, in diets with an elevated His:Lys ratio, improved litter growth performance and reduced preweaning mortality.

Introduction

Arginine is an amino acid involved in the synthesis of creatine, proline, glutamate, polyamines, and nitric oxide. Some studies have shown that an increase in arginine linearly increased concentrations of follicle-stimulating hormone (FSH), prolactin, and insulin.[3] This suggests that increases in dietary Arg could increase milk production through increased prolactin levels. However, other studies have shown no benefit on sow and litter performance when sows were fed diets above the NRC[4] Arg:Lys requirement estimates (52 to 57% SID Arg:Lys ratio).[5] A common corn-soybean meal (SBM)-based diet results in an SID Arg:Lys of approximately 90%. Recently, Jenkins et al. observed that increasing His:Lys ratios in lactation diets increased total milk yield.[6] If His concentrations are low, then this could limit prolactin and milk production. We are unaware of research evaluating the effects of increased SID Arg:Lys ratios in diets containing high concentrations of SID His. Therefore, this study aimed to determine the effects of increased Arg:Lys ratio in sow lactation diets with elevated His:Lys ratio on sow and litter performance.

Procedures

The Kansas State University Institutional Animal Care and Use Committee approved the protocol used for this experiment. The study was conducted at the Kansas State University Swine Teaching and Research Center. All diets were manufactured at the Kansas State University O.H. Kruse Feed Technology Innovation Center (Manhattan, KS) and fed in meal form.

Animals and diets

A total of 124 mixed-parity sows (Line 241, DNA Genetics, Columbus, NE) were used across four batch farrowing groups from August to December 2025. On d 112 of gestation, sows were moved into the farrowing house, weighed, blocked by parity, and assigned to one of three dietary treatments balancing for BW between treatments. Two corn-SBM-DDGS-based experimental diets were formulated to achieve SID Arg:Lys ratios of 90% or 130% of Lys. A computerized lactation sow feeder (Gestal Quattro Opti Feeder, Jyga Technologies, St-Lambert-de-Lauzon, QC, Canada) was used to deliver feed to the sows and to blend the two diets at a 50:50 blend (SID Arg:Lys ratio of 110%) to form the intermediate diet. Therefore, the three experimental diets

[3] Gao, K., et al. 2020. Effect of dietary arginine-to-lysine ratio in lactation on biochemical indices and performance of lactating sows. J. Anim. Sci. 98:1-9. doi:10.1093/jas/skaa261.

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

[5] Craig, S., et al. 2025. Effect of arginine supplementation during lactation on piglet survivability. J. Anim. Sci. 103. doi:10.1093/jas/skaf102.

[6] Jenkins, A. K., et al. 2025. The effect of increasing standardized ileal digestible histidine:lysine ratio during lactation on sow and litter performance. J. Anim. Sci. 103. doi:10.1093/jas/skaf290

provided 90, 110, and 130% SID Arg:Lys ratios. Sows were fed approximately 6 lb/d of their treatment diet from d 112 of gestation until farrowing. After farrowing, sows had ad libitum access to their treatment diet until weaning on approximately d 18. Diets were corn-SBM-DDGS-based, containing an SID His:Lys ratio of 43.5%, and were formulated to meet or exceed NRC (2012)4 requirement estimates for other amino acids relative to Lys (Tables 1 and 2).

Sow BW was measured on d 112 of gestation, after farrowing, and at weaning. Sow backfat and loin depth were measured on d 112 of gestation and at weaning at the last rib, 2 in. from the midline using real-time ultrasound. A sow caliper was used to determine caliper scores at the same timepoints. Piglets were cross-fostered within 48 h of birth within sow treatment to equalize litter size. Piglets were individually weighed at birth, d 2 (48 h), 10, and the day before weaning. All instances of piglet mortalities were recorded to determine preweaning mortality. Sows were tracked after weaning to determine the subsequent breeding date and calculate wean-to-estrus interval.

Statistical analysis

Performance data for the sow portion of the trial were analyzed using the lme4 package of R (Version 4.5.0, R Foundation for Statistical Computing, Vienna, Austria) as a generalized randomized block design. Blocking structure accounted for parity. Sow served as the experimental unit. Treatment was included as a fixed effect with block and farrowing group being included as random effects. Total born was used as a covariate in the statistical model for all litter responses, except percentage born alive, stillborn, and mummies, to account for the difference in total born across treatment. Count data were analyzed using a Poisson distribution using a log link function. Proportion data, including litter born alive, stillborn, born mummified, and preweaning mortality, were analyzed using a binomial distribution using a logit link function. Differences were considered significant at $P < 0.05$ and marginally significant at $0.05 < P < 0.10$.

Results and Discussion

Sow BW at entry, farrowing, and weaning, as well as sow lactation BW loss from entry-to-weaning or farrowing-to-weaning, was unaffected by dietary treatment (Table 3). Increasing SID Arg:Lys ratio did not affect sow backfat, loin depth, or caliper score changes from entry-to-weaning. There were no SID Arg:Lys ratio effects on sow ADFI, either before farrowing or from farrowing to weaning. Average SID Arg intake (g/d) increased (linear, $P < 0.001$) with increasing SID Arg:Lys ratio as expected. Increasing SID Arg:Lys ratio had no effect on wean-to-estrus interval.

Although there were no statistical differences observed for the number of total born pigs, the response was used as a covariate in the statistical model to ensure the variable was balanced across treatment. No differences were observed for the percentage of total born alive, stillborn, and mummified (Table 4). Litter size remained similar between treatments throughout the study. Litter weight at birth and at d 2 was similar, but at d 10, litter weight increased then decreased (quadratic, $P = 0.043$) with increasing SID Arg:Lys ratio, with a similar tendency (quadratic, $P = 0.097$) for litter weaning weight. From d 0 to weaning, litter weight gain increased (linear, $P = 0.047$) with increased SID Arg:Lys ratio. Litter weight coefficient of variation (CV) at d 2 and at weaning was similar, but at d 0, litter weight CV decreased (linear, $P = 0.013$) with increasing SID Arg:Lys ratio, with a similar tendency (linear, $P = 0.097$) for litter weight d 10 CV. At d 2, 10, and weaning, average piglet BW increased then decreased (quadratic,

P ≤ 0.034) with the heaviest average piglet BW observed in sows fed an SID Arg:Lys ratio of 110%. From d 2 to 10 and d 2 to weaning, litter ADG increased (linear, P ≤ 0.040) with increasing SID Arg:Lys ratio. Additionally, from d 2 to 10 and d 2 to weaning, piglet ADG increased (linear, P ≤ 0.010) with increasing SID Arg:Lys ratio. Piglet ADG from d 10 to weaning was marginally improved (linear, P = 0.083) with increasing SID Arg:Lys ratio. From d 2 to weaning and birth to weaning, preweaning mortality decreased (linear, P ≤ 0.032) with increasing SID Arg:Lys ratio. From farrow to weaning, Arg intake/kg of litter gain (g/kg) increased (linear, P < 0.001) with increasing SID Arg:Lys ratio.

In conclusion, this study provides evidence that increased SID Arg:Lys ratio in sow lactation diets with an elevated His:Lys ratio improved litter growth performance and preweaning mortality.

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Table 1. Diet composition (as-fed basis)[1]		
	SID Arg:Lys, %	
Ingredient, %	90	130
Corn	61.15	60.70
Soybean meal (47.5% CP)	18.45	18.45
Corn DDGS (>6 and <9% oil)	15.00	15.00
Soybean oil	1.00	1.00
Calcium carbonate	1.48	1.48
Monocalcium P (21.5% P)	1.05	1.05
Sodium chloride	0.50	0.50
L-Lys-HCl	0.47	0.47
L-Trp	0.04	0.04
L-Val	0.09	0.09
Thr[2]	0.18	0.18
L-Met	0.06	0.06
L-His	0.05	0.05
L-Arg	---	0.43
Vitamin and trace mineral premix	0.50	0.50
Total	100	100
Calculated analysis		
Standardized ileal digestible (SID) amino acids, %		
Lys	1.05	1.05
Ile:Lys	58	58
Leu:Lys	144	143
Met:Lys	31	31
Met and Cys:Lys	55	55
Thr:Lys	65	65
Trp:Lys	19	19
Val:Lys	75	75
His:Lys	43.5	43.5
Arg:Lys	90	130
SID Arg, %	0.94	1.36
Total Lys, %	1.20	1.20
Total Arg, %	1.05	1.47
Total His, %	0.53	0.53
NE, kcal/lb	1,121	1,116
SID Lys:NE, g/Mcal	4.25	4.27
CP, %	18.7	19.5
Ca, %	0.90	0.90
STTD P, %	0.50	0.50

[1]Diets were fed from approximately d 112 of gestation until weaning. The 90 and 130% SID Arg:Lys ratio diets were blended at a 50:50 ratio to form the 110% treatment.

[2] ThreoPro, CJ America-Bio, Downers Grove, IL.

Table 2. Analyzed composition of experimental diets (as-fed basis)[1]

	SID Arg:Lys, %	
Item, %	90	130
CP[2]	17.98	18.97
Dry matter	87.94	88.12
Crude fat	4.35	4.63
Crude fiber	2.65	2.31
Ash	4.65	4.97
Essential AAs		
Arg	0.95	1.40
His	0.55	0.56
Ile	0.73	0.73
Leu	1.73	1.72
Lys	1.28	1.19
Met	0.36	0.36
Phe	0.88	0.88
Thr	0.82	0.84
Trp	0.20	0.20
Val	0.90	0.92
Non-essential AAs		
Ala	1.03	1.02
Asp	1.52	1.52
Cys	0.32	0.31
Glu	3.18	3.18
Gly	0.71	0.71
Pro	1.26	1.25
Ser	0.78	0.78
Tyr	0.54	0.59

[1] Samples were analyzed for proximate analysis and complete amino acid profile at the University of Missouri Agricultural Experiment Station Chemical Laboratory.

[2] CP = % N × 6.25.

Table 3. Effects of increasing SID Arg:Lys ratio with an elevated SID His:Lys ratio in lactation diets on sow performance[1]

	SID Arg:Lys ratio, %[2]				*P* =	
Item	90	110	130	SEM	Linear	Quadratic
Count, n	41	41	42	---	---	---
Parity	1.96	1.93	1.96	0.333	0.998	0.886
Lactation length, d	17.4	17.9	17.7	0.241	0.250	0.070
Sow BW, lb						
Entry	517.3	520.6	522.3	18.26	0.484	0.894
Farrow	486.5	486.3	493.4	18.40	0.337	0.553
Weaning	482.8	481.8	488.6	19.92	0.445	0.550
Lactation change (entry to weaning)	-34.3	-38.1	-33.0	8.20	0.823	0.394
Lactation change (farrow to weaning)	-3.4	-4.0	-4.3	3.88	0.850	0.974
Sow backfat, mm						
Entry	11.2	11.4	11.8	0.51	0.226	0.852
Weaning	10.3	10.1	10.6	0.48	0.608	0.443
Lactation change (entry to weaning)	-0.9	-1.3	-1.2	0.38	0.415	0.467
Sow loin depth, mm						
Entry	44.1	45.9	46.2	1.44	0.031	0.380
Weaning	41.8	43.7	43.7	1.28	0.057	0.266
Lactation change (entry to weaning)	-2.0	-2.0	-2.3	0.87	0.814	0.876
Sow caliper score, caliper units						
Entry	15.5	15.7	16.1	0.32	0.125	0.686
Weaning	14.0	14.1	15.0	0.37	0.006	0.202
Lactation change (entry to weaning)	-1.6	-1.6	-1.1	0.37	0.103	0.290
Sow ADFI, lb						
Pre-farrow	5.76	5.71	5.89	0.137	0.335	0.352
Farrow to weaning	15.38	16.02	15.86	0.559	0.255	0.269
Pre-farrow to weaning	13.04	13.75	13.59	0.501	0.127	0.160
Average SID Arg intake, g/d (farrow to weaning)	56.1	73.3	86.2	2.76	< 0.001	0.201
Wean-to-estrus interval, d	5.24	5.16	5.24	0.101	0.959	0.382

[1] A total of 124 mixed-parity sows (Line 241, DNA, Columbus, NE) and litters were used from d 112 of gestation until weaning. Litters were cross-fostered within treatment group to equalize litter size up to 48 h after farrowing. Total born was used as a covariate in the statistical model for all responses.

[2] Sow treatment consisted of providing a control diet (90% SID Arg:Lys ratio), a high Arg diet, accomplished by adding feed-grade Arg (130% SID Arg:Lys ratio), or a 50:50 blend of the two diets (110% SID Arg:Lys ratio) from d 112 of gestation until weaning. Diets were corn-SBM-DDGS-based and contained an SID His:Lys ratio of 43.5%.

Table 4. Effects of increasing SID Arg:Lys ratio with an elevated SID His:Lys ratio in lactation diets on litter performance[1]

	SID Arg:Lys ratio, %[2]				*P* =	
Item	90	110	130	SEM	Linear	Quadratic
Litter characteristics						
Total born, n	17.4	16.9	16.0	0.65	0.109	0.800
Born alive, %	89.28	89.65	89.68	1.395	0.807	0.905
Stillborn, %	8.15	7.78	7.28	1.191	0.540	0.953
Mummy, %	2.49	2.56	2.95	0.694	0.603	0.839
Litter size, n						
d 0	14.8	14.7	14.5	0.60	0.681	0.889
d 2	14.8	14.4	14.2	0.60	0.456	0.962
d 10	14.3	14.0	13.9	0.59	0.630	0.839
Weaning	14.2	13.9	13.9	0.59	0.722	0.824
Litter weight, lb						
d 0	49.1	49.8	49.3	1.35	0.897	0.627
d 2	53.2	54.7	51.8	1.72	0.386	0.142
d 10	107.2	116.2	111.8	2.98	0.235	0.043
Weaning	170.3	180.5	176.6	3.49	0.202	0.097
d 0 to weaning gain	116.9	125.7	124.7	2.96	0.047	0.148
Litter weight CV, %						
d 0	19.6	18.9	17.1	0.87	0.013	0.520
d 2	19.2	19.4	17.6	0.87	0.156	0.270
d 10	19.3	18.1	17.4	0.96	0.097	0.808
Wean	18.7	17.3	17.5	0.93	0.355	0.451
Mean piglet BW, lb						
d 0	3.34	3.40	3.41	0.068	0.423	0.765
d 2	3.63	3.82	3.68	0.074	0.637	0.034
d 10	7.48	8.34	8.10	0.208	0.012	0.010
Weaning	12.03	13.09	12.84	0.290	0.014	0.018
Litter ADG, lb						
d 2 to 10	5.39	5.84	5.88	0.146	0.015	0.232
d 10 to weaning	8.37	8.58	8.64	0.188	0.183	0.663
d 2 to weaning	6.69	7.00	7.07	0.136	0.040	0.421
Piglet ADG, lb						
d 2 to 10	0.38	0.42	0.43	0.014	0.001	0.190
d 10 to weaning	0.60	0.63	0.63	0.019	0.083	0.379
d 2 to weaning	0.48	0.51	0.51	0.014	0.010	0.256
Preweaning mortality, %						
Birth to d 2	1.88	2.20	1.34	0.576	0.397	0.301
d 2 to weaning	4.26	4.02	2.11	2.691	0.032	0.248
Birth to weaning	6.16	6.37	3.54	4.376	0.028	0.115
Arg intake/kg litter gain, g/kg	22.13	27.14	31.69	1.155	< 0.001	0.763

[1] A total of 124 mixed-parity sows (Line 241, DNA, Columbus, NE) and litters were used from d 112 of gestation until weaning. Litters were cross-fostered within treatment group to equalize litter size up to 48 h after farrowing. Total born was used as a covariate in the statistical model for all responses other than percentage born alive, stillborn, and mummies to account for the difference in total born as sows farrowed across treatment.

[2] Sow treatment consisted of providing a control diet (90% SID Arg:Lys ratio), a high Arg diet, accomplished by adding feed-grade Arg (130% SID Arg:Lys ratio), or a 50:50 blend of the two diets (110% SID Arg:Lys ratio) from d 112 of gestation until weaning. Diets were corn-SBM-DDGS-based and contained an SID His:Lys ratio of 43.5%.