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Effect of Increasing Arginine:Lysine Ratio During Transition and Lactation on Farrowing Kinetics, Milk Composition, and Sow and Litter Performance

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Summary

A total of 90 sows (Line 241, DNA Genetics, Columbus, NE) were used to determine the effect on farrowing kinetics, milk composition, and sow and litter performance of increasing the SID Arginine:Lysine ratio in transition and lactation diets fed to mixed-parity sows. Sows were blocked by parity and body weight (BW) on approximately d 108 of gestation and allotted to 1 of 3 dietary treatments of increasing SID Arg:Lys (90, 105, or 120%). Sows received approximately 6 lb/d of their treatment diet from d 109 of gestation until farrowing after which they were allowed *ad libitum* access to their treatment diet. Litters were cross fostered within 48 h after farrowing to equalize litter size. SID Arg:Lys did not impact ($P > 0.10$) sow BW or backfat change during lactation, nor influence sow ADFI either pre farrow or during lactation. Average SID Arg intake increased (linear, $P < 0.001$) with increasing SID Arg:Lys ratio as expected. Wean to estrus interval decreased then increased (quadratic, $P = 0.044$) with increasing SID Arg:Lys ratio. No differences were observed ($P > 0.10$) for the number of total pigs born or for the percentage of total born alive, stillborn and mummified nor did treatment influence the litter size, litter weight, or prewean mortality at any time point. At d10 the average BW of piglets tended to be lower in the 120% SID Arg:Lys ratio treatment compared to the 90% SID Arg:Lys ratio treatment ($P = 0.061$). Piglet ADG from d0 to d10 tended to be greater in the 90% SID Arg:Lys ratio group compared to the 120% SID Arg:Lys ratio group ($P = 0.084$), while no differences in piglet performance were observed from d 10 to wean or birth to wean. The SID Arg:Lys ratio did not affect ($P > 0.10$) farrowing duration, colostrum yield, or colostrum intake. Increasing SID Arg:Lys ratio did not affect ($P > 0.10$) the concentration of IgG in either colostrum and milk and did not impact milk composition or BUN measured in the sow or piglet. This data suggests that increasing SID Arg:Lys ratio from 90 to 120% will not impact farrowing kinetics or sow and litter performance.

Introduction

Arginine is an amino acid involved in the synthesis of creatine, proline, glutamate, polyamines, and nitric oxide and some consider Arg a conditionally essential amino

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acid even though the NRC (2012)[2] requirement suggests the SID Arg:Lys for gestating and lactating sows is approximately 52 to 58% while common corn/SBM diets result in an SID Arg:Lys of 90 to 100%. While a number of studies have been published that suggest supplemental Arg will benefit gestating sow performance others have not observed benefits from Arg supplementation. Most of the previous studies have utilized extremely high and costly supplementation levels equating to an SID Arg:Lys of 285 to 300%. There is a need for additional research to confirm if increasing the SID Arg:Lys at lower and more economical levels will influence sow and litter performance. Therefore, the aim of this study was to determine the effects of feeding increased Arginine levels in sow transition and lactation diets on farrowing kinetics, colostrum and milk composition, and sow and litter performance.

Materials and Methods

The protocol used for this experiment was approved by the Kansas State University Institutional Animal Care and Use Committee. 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.

A total of 90 sows (Line 241, DNA Genetics, Columbus, NE) were used across three batch farrowing groups from February to May 2024. Due to health issues, 3 sows were removed from the trial. On approximately d108 of gestation, sows were moved into the farrowing house, weighed, blocked by body weight and parity, and assigned to 1 of 3 dietary treatments. Two corn-soybean meal-based experimental diets were formulated to achieve SID Arg:Lys levels of 90% or 120%. A Gestal Quattro Opti feeder (Jyga Technologies, St-Lambert-de-Lauzon, Quebec, Canada) was used to deliver feed to the sows and to blend the two diets to a 50:50 blend (SID Arg:Lys of 105%) to form an intermediate diet. Thus, the 3 treatments were SID Arg:Lys ratios of 90, 105 and 120%. Sows were fed approximately 6 lb/day of their treatment diet from d109 of gestation until farrowing. After farrowing, sows had ad libitum access to their treatment diet. Diets were formulated to meet or exceed NRC (2012) requirements estimate (Table 1).

Sow body weight (BW) was measured on d 108 of gestation, after farrowing, and at weaning. Sow backfat depth and loin depth were measured on d 108 of gestation and at weaning at the last rib, two inches from the midline using real-time ultrasound and the sow caliper was used to determine caliper score at the same timepoints. Piglets were cross fostered within 48 h of birth within sow treatment to equalize litter size. Piglets were weighed individually at birth, on d 1 (24 hours), d 10, and the day before weaning. All instances of piglet mortalities were recorded to determine pre-weaning mortality.

Farrowing duration was calculated considering the time between the first and the last piglet that was born. At farrowing, samples of colostrum were collected from a subset of sows from each treatment (approximately 15) with similar amounts obtained from the 3rd, 4th, and the 5th functional teats on either side of the underline, and immediately frozen at -4°F until analyzed for immunoglobulin (IgG) concentration. The day before weaning, blood and milk were collected from a total of 15 sows per treatment. Blood was collected from the jugular vein and refrigerated until processing for plasma

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

analysis of BUN concentration. Milk was collected from the 3rd, 4th, and 5th functional teats utilizing 0.5 ml of Oxytocin administered in the ear vein to initiate milk letdown, immediately frozen at -4°F and analyzed for proximal composition and IgG concentration. From the litter of the same sows, a barrow was selected for blood collection. Blood was collected from the jugular vein, stored at -4°F and analyzed for BUN concentration.

Colostrum yield was estimated utilizing the model developed by Theil et al. (2014)[3]. This model utilized the piglet birth weight and the ADG from birth to d 2 and considered the period of suckling as the firsts 24 hours of life of the piglets.

Statistical analysis

Performance data for the sow portion of the trial were analyzed using the lme4 package of R (Version 4.0.0, R Foundation for Statistical Computing, Vienna, Austria) as a randomized complete block design. Blocking structure accounted for parity and BW. Sow served as the experimental unit. Treatment was included as a fixed effect and block was included as a random effect. Count data was analyzed using a Poisson distribution using a log link function. Proportion data, including litter born alive, stillborn, born mummified, and pre-weaning 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 and weaning as well as sow lactation BW loss did not differ ($P > 0.10$; Table 2) based on the dietary treatment. Increasing SID Arg:Lys did not affect sow backfat, caliper score or loin depth upon entry into the farrowing house or at weaning, nor the entry-to-wean change ($P > 0.10$). There were no linear or quadratic effects ($P > 0.10$) on the sows' ADFI, either in the pre-farrow or farrow-to-wean periods. Average SID Arg intake (g/d) increased (linear, $P < 0.001$) with increasing SID Arg:Lys ratio as expected. Wean to estrus interval (WEI) decreased then increased (quadratic, $P = 0.044$) with increasing SID Arg:Lys ratio. No differences were observed ($P > 0.10$; Table 3) for the number of total born pigs or for the percentage of total born alive, stillborn and mummified. The SID Arg:Lys did not affect the litter size nor the litter weight at any time point ($P > 0.10$). At d10 the average BW of piglets tended to be lower ($P = 0.061$) in the 120% SID Arg:Lys ratio group compared to the 90% SID Arg:Lys ratio group. There were no differences ($P > 0.1$) in litter ADG throughout the study. Piglet ADG from d0 to d10 tended to be higher ($P = 0.084$) in the 90% SID Arg:Lys ratio treatment compared to the 120% SID Arg:Lys ratio treatment, while no differences were observed during the other periods ($P > 0.10$). The dietary treatment did not affect farrowing duration, colostrum yield nor colostrum intake ($P > 0.10$). No differences were observed ($P > 0.10$) for preweaning mortality based on SID Arg:Lys ratio.

Increasing SID Arg:Lys ratio did not affect the concentration of IgG in either the colostrum or milk ($P > 0.10$; Table 4). No differences were observed ($P > 0.10$) for milk composition among the experimental treatments. Finally, the SID Arg:Lys ratio did not affect ($P > 0.10$) BUN concentration in either sows or piglets. In summary, this data

[3] Theil, P. K., C. Lauridsen, and H. Quesnel. 2014. Neonatal piglet survival: impact of sow nutrition around parturition on fetal glycogen deposition and production and composition of colostrum and transient milk. Anim. 8:1021–1030. doi:10.1017/S1751731114000950

suggests that increasing SID Arg:Lys ratio from 90 to 120% will not impact farrowing kinetics or sow and litter performance.

Table 1. Diet composition (as-fed basis)[1]

Ingredient, %	Control	High Arginine
Corn	72.85	72.55
Soybean meal, 46.5% CP	22.05	22.05
Soybean oil	1.00	1.00
Calcium carbonate	1.15	1.15
Monocalcium P, 21.5% P	1.23	1.23
Sodium chloride	0.50	0.50
L-Lys-HCl	0.43	0.43
DL-Met	0.08	0.08
L-Thr	0.17	0.17
L-Trp	0.03	0.03
L-Val	0.03	0.03
KSU Sow VTM w/ Phytase	0.50	0.50
L-Arginine	--	0.32
Total	100.00	100.00
Calculated analysis		
SID AA, %		
Lys	1.05	1.05
Ile:Lys	56	56
Leu:Lys	125	125
Met:Lys	30	30
Met and Cys:Lys	53	53
Thr:Lys	64	65
Trp:Lys	19	19
Val:Lys	65	65
His:Lys	38	38
Arg:Lys	90	120
SID Arg	0.95	1.26
Total Lys, %	1.09	1.09
Total Arg, %	1.03	1.34
NE, kcal/lb	1,137	1,133
SID Lys:NE, g/Mcal	4.19	4.20
CP, %	17.1	17.1
Ca, %	0.81	0.81
STTD P, %	0.50	0.50

[1]Diets were fed from approximately d 109 of gestation until weaning. Control and high Arg diets were blended at a 50:50 ratio to form the intermediate treatment.

Table 2. Effects of increasing SID Arg:Lys ratio in transition and lactation diets on sow performance[1]

	SID Arg:Lys ratio, %[2]:				*P* =	
	90	105	120	SEM	Linear	Quadratic
Count, n	29	29	29	---	---	---
Parity	2.3	2.1	2.0	0.31	0.445	0.905
Lactation length, d	17.4	17.7	17.0	0.20	0.162	0.053
Sow BW, lb						
Entry	509.8	514.8	515.6	13.56	0.245	0.616
Wean	490.4	488.8	492.4	13.61	0.796	0.687
Lactation change (entry to wean)	-19.7	-25.0	-22.7	5.75	0.692	0.567
Sow backfat, mm						
Entry	12.9	12.7	13.8	0.54	0.249	0.272
Wean	11.9	12.0	12.1	0.48	0.684	0.953
Lactation change (entry to wean)	-1.12	-0.75	-1.58	0.42	0.401	0.211
Sow caliper score, caliper units						
Entry	15.7	15.9	16.1	0.30	0.252	0.910
Wean	14.5	14.6	15.1	0.38	0.156	0.571
Lactation change (entry to wean)	-1.20	-1.24	-0.96	0.31	0.525	0.627
Sow loin depth, mm						
Entry	55.1	55.9	56.4	0.92	0.306	0.867
Wean	53.9	55.2	55.2	0.88	0.306	0.532
Lactation change (entry to wean)	-1.14	-0.69	-1.21	1.11	0.965	0.724
Sow ADFI, lb						
Pre-farrow	5.75	6.08	6.01	0.15	0.209	0.273
Farrow to wean	17.1	16.8	16.8	0.43	0.521	0.676
Average SID Arg intake, g/d	55.2	66.7	74.0	1.75	< 0.001	0.287
Wean to estrus interval, d	5.22	4.99	5.38	0.14	0.372	0.044

[1]A total of 87 mixed-parity sows (Line 241, DNA, Columbus NE) and litters were used from day 109 of gestation until weaning. Litters were cross-fostered within treatment group to equalize litter size up to 48-h post farrowing.

[2]Sow treatment consisted of providing a control diet (90% SID Arg:Lys ratio), a high Arginine diet, accomplished by adding feed-grade Arginine (120% SID Arg:Lys ratio), or a 50:50 blend of the two diets (105% SID Arg:Lys ratio) from d 109 of gestation until weaning.

Table 3. Effects of increasing SID Arg:Lys ratio in transition and lactation diets on litter performance[1]

	SID Arg:Lys ratio, %[2]				*P* =	
	90	105	120	SEM	Linear	Quadratic
Litter characteristics						
Total born, n	16.0	16.4	16.2	0.75	0.819	0.749
Born alive, %	91.3	91.8	91.0	1.37	0.866	0.690
Stillborn, %	4.84	4.08	6.85	1.24	0.191	0.176
Mummy, %	3.61	3.89	2.00	1.00	0.130	0.211
Litter size, n						
d 0	14.6	15.0	14.8	0.72	0.864	0.679
d 2	14.5	14.9	14.5	0.72	0.972	0.648
d 10	14.1	14.5	14.2	0.71	0.917	0.673
Wean	13.9	14.4	14.0	0.71	0.888	0.600
Litter weight, lb						
d 0	50.7	51.7	52.6	1.95	0.422	0.949
d 10	105.5	107.7	99.5	2.96	0.121	0.119
Wean	171.5	174.1	165.4	4.34	0.253	0.225
Mean piglet BW, lb						
d 0	3.53	3.45	3.60	0.10	0.622	0.326
d 10	7.52	7.45	7.05	0.19	0.061	0.437
Wean	12.4	12.1	11.8	0.29	0.110	0.983
Litter ADG, lb/d						
d 2 to d 10	7.39	7.17	6.95	0.22	0.116	0.975
d 10 to wean	8.26	8.29	8.25	0.22	0.977	0.874
d 2 to wean	7.84	7.74	7.64	0.20	0.411	0.993
Piglet ADG, lb/d						
d 0 to d 10	0.53	0.50	0.49	0.02	0.084	0.439
d 10 to wean	0.60	0.58	0.59	0.02	0.811	0.272
d 0 to wean	0.57	0.54	0.55	0.01	0.238	0.253
Farrowing duration[3], min	245.0	248.5	250.0	21.01	0.848	0.965
Colostrum yield[4], lb	11.18	11.82	11.55	0.42	0.465	0.317
Colostrum intake[4], g/pig	361.1	363.7	363.3	7.91	0.843	0.874
Preweaning mortality, %						
Birth to d 2	2.95	2.09	2.87	0.93	0.947	0.370
d 2 to wean	3.58	3.25	2.38	0.91	0.310	0.749

[1]A total of 87 mixed-parity sows (Line 241, DNA, Columbus NE) and litters were used from day 109 of gestation until weaning. Litters were cross-fostered within treatment group to equalize litter size up to 48-h post farrowing.
[2]Sow treatment consisted of providing a control diet (90% SID Arg:Lys ratio), a high Arginine diet, accomplished by adding feed-grade Arginine (120% SID Arg:Lys ratio), or a 50:50 blend of the two diets (105% SID Arg:Lys ratio) from d 109 of gestation until weaning.
[3]Farrowing duration was calculated as the time between the first and the last piglet that farrowed.
[4]Colostrum yield and intake were estimated utilizing the model developed by Theil et al., (2014)

Table 4. Effects of increasing SID Arg:Lys ratio in transition and lactation diets on colostrum, milk and blood characteristics.[1]

	SID Arg:Lys ratio, %[2]:				*P* =	
	90	105	120	SEM	Linear	Quadratic
Count, n	15	14	12	---	---	---
Colostrum IgG, mg/ml	66.0	68.7	57.5	9.70	0.509	0.522
Milk IgG mg/ml	0.29	0.31	0.27	0.03	0.618	0.301
Milk composition						
Fat, %	6.98	6.72	6.59	0.33	0.362	0.859
Protein, %	4.04	4.13	4.16	0.12	0.454	0.841
Lactose, %	5.48	5.52	5.51	0.09	0.824	0.804
MUN[3], mg/dl	23.1	26.0	24.7	1.62	0.356	0.137
SCC[4], n/dl	826.4	1310.4	1120.8	250.7	0.328	0.191
BUN[5] sow, mg/dl	14.1	14.6	14.6	0.78	0.635	0.805
BUN[5] piglet, mg/dl	7.53	7.07	8.07	0.83	0.633	0.445

[1]A total of 87 mixed-parity sows (Line 241, DNA, Columbus NE) and litters were used from d 109 of gestation until weaning. Litters were cross-fostered within treatment group to equalize litter size up to 48-h post farrowing.
[2]Sow treatment consisted of providing a control diet (90% SID Arg:Lys ratio), a high Arginine diet, accomplished by adding feed-grade Arginine (120% SID Arg:Lys ratio), or a 50:50 blend of the two diets (105% SID Arg:Lys ratio) from d 109 of gestation until weaning.
[3]MUN, milk urea nitrogen
[4]SCC, somatic cells
[5]BUN, blood urea nitrogen