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Evaluation of Precision Feeding Standardized Ileal Digestible Lysine to Meet the Lactating Sow's Requirement and Maximize Piglet Growth Performance[1]

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Summary

A total of 56 mixed parity sows (DNA 241, Columbus, NE) and litters (DNA 241 × 600) were used across two batch farrowing groups to evaluate the effects of precision feeding SID Lys during lactation. Sows were blocked by parity and allotted to 1 of 3 treatments on day 2 of lactation (the day after the start of farrowing). The first treatment was a control treatment where sows were provided a 1.10% SID Lys diet throughout lactation. The second and third treatments included sows fed either a static blend curve or a dynamic blend curve. Both blend curve treatments utilized the Gestal Quattro Opti Feeder (Jyga Technologies, St-Lambert-de-Lauzon, Quebec, Canada) to blend a low and high Lys diet to target a specific SID g/d of Lys intake for each day of lactation. The only difference between the static blend curve and dynamic blend curve was that the dynamic blend curve of the low and high Lys diet was adjusted every 2 days based on a rolling average of Lys intake to more closely reach target g/d of Lys intake while the static blend curve was not adjusted throughout lactation. Lysine intake curves were based on the NRC (2012)[4] model estimates, but targets were increased by 20% to reach an average Lys intake of approximately 60 g/d across parities. Dietary treatments for sows on the blend curve treatments were formed by blending a low Lys diet (0.40% SID Lys) and the control high Lys diet (1.10% SID Lys). Actual SID Lys intake was 97% of the targeted g/d for sows fed the static blend curve and 96% of targeted g/d for sows fed the dynamic blend curve. Sows fed the control treatment had greater Lys intake (g/day; $P < 0.05$) compared to sows fed either of the blend curve treatments, with no differences between the two blend curve treatments ($P > 0.05$). No differences in sow ADFI or sow body weight, backfat, or loin depth at entry or weaning were observed among treatments ($P > 0.05$). There were no differences among treatments observed in litter size, piglet weight at birth or weaning, ADG, and litter weight or

[1] Appreciation is expressed to Gestal (St-Lambert-de-Lauzon, QC, Canada) for their technical assistance.

[2] Department of Diagnostic Medicine/Pathobiology, College of Veterinary Medicine, Kansas State University.

[3] Gestal, JYGA Technologies (St-Lambert-de-Lauzon, QC, Canada).

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

ADG ($P > 0.05$). Because sows fed either blend curve had a numerically greater ADFI, no differences in sow feed cost were observed ($P > 0.05$). Sows fed the control treatment excreted more N and had a higher serum urea N concentration compared to sows fed either blend curve treatment ($P > 0.05$). Based on the results of the study, blending a low and high Lys diet can be used during lactation to decrease N excretion and achieve similar piglet growth performance compared to results for piglets from sows fed only a high Lys diet throughout lactation. Furthermore, these data would suggest that 60 g/d of SID Lys is sufficient to maximize litter weight gain for litter sizes of 13.5 weaned piglets.

Introduction

In commercial production, sows are usually fed a single diet throughout lactation that does not account for differences in litter size, parity, or feed intake. Blending two different lactation diets can decrease the under-feeding or over-feeding of nutrients in lactation and has the potential to decrease feed cost.[5] Both NRC and INRA[6] have models where sow data such as weight, parity, and litter size can be used to determine Lys requirement for each day of lactation. In a previous experiment, Spinler et al. (2023)[7] determined that sows fed the NRC requirement curve model were deficient in lysine to achieve maximum performance and had decreased litter growth performance compared to litters from sows fed the 1.10% SID Lys diet throughout lactation. However, litters from sows fed the NRC curve model had better growth performance compared to sows on the INRA curve model. Based on this response, it was determined that the NRC model target g/d of Lys intake is a better model to maximize litter growth but should be increased by approximately 20% to achieve 60 g/d SID Lys intake and similar litter growth performance to litters from sows fed the control diet.

We hypothesized that blending a low and high Lys diet to target a specific Lys intake based on parity and litter size would lead to less N excretion and lower feed cost throughout lactation. We also hypothesized that increasing the Lys intake target to an average of 60 g/d for sows fed a blend treatment would lead to similar piglet growth performance compared to piglets from sows fed a single, high Lys diet throughout lactation. Therefore, the objective of the study was to determine the correct blend of a low and high Lys diet to target adequate Lys intake for each sow based on parity and litter size to achieve similar litter growth performance to litters from sows fed a high Lys diet with no feed blending.

Procedures

The Kansas State University Institutional Care and Use Committee approved the protocol used in this experiment. The study was conducted at the Kansas State University Swine Teaching and Research Center in Manhattan, KS. Sows were housed in individual farrowing stalls that measured 6 × 8 ft including sow and litter area equipped

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[5] Gauthier, R., C. Largouët, D. Bussières, J. P. Martineau, and J. Y. Dourmad. 2022. Precision feeding lactating sows: implementation and evaluation of a decision support system in farm conditions. J. Anim. Sci. 100: 1-11. doi:10.1093/jas/skac222.

[6] InraPorc. 2009. https://inraporc.inra.fr/inraporc/index_en.html.

[7] Spinler, M. S., J. T. Gebhardt, J. M. DeRouchey, M. D. Tokach, R. D. Goodband, H. L. Frobose, and J. C. Woodworth. 2023. Evaluation of precision feeding SID lysine to lactating sows on sow and litter performance, nitrogen level, and feed cost. Kansas Agricultural Experiment Station Research Reports: Vol. 9: Iss. 7.

with a dry self-automated feed system (Gestal Quattro Opti Feeder, Jyga Technologies, St-Lambert-de-Lauzon, Quebec, Canada) and a pan waterer. Creep feed was not offered throughout the trial.

Animals and diets

A total of 56 mixed parity sows (DNA 241) and litters (DNA 241 × 600) were used across two batch farrowing groups. At approximately d 110 of gestation, sows were moved into the farrowing house. Sow weight, caliper score, backfat, and loin depth measurements were taken upon entry into the farrowing house and at weaning. Sow weight was also taken within 24 h after farrowing. Sow caliper score was taken at the last rib and sow backfat and loin depth measurements were taken at the 3rd rib forward from the last rib, 2.5 in. from the midline on the right side of the sow using an IBEX Pro ultrasound machine (E.I. Medical Imaging, Loveland, CO). From d 110 to 114 of gestation, sows were each fed 6 lb per day of a gestation diet. At day 114 of gestation all sows were fed the high Lys (1.10%) diet until d 2 of lactation (the day after the start of farrowing). Sow ADFI was calculated by taking daily feed disappearance minus 5% to account for feed wastage.

On d 2 of lactation, litters were processed and equalized to have between 12 to 16 piglets. After equalization, sows were fed their treatment diets until weaning. Sows were fed 1 of 3 treatment diets: 1) single lactation diet fed throughout lactation (control) with no feed blending, 2) static blend curve, or 3) dynamic blend curve. The static and dynamic blend curves were set to target a specific Lys intake for each day of lactation based on sow parity and litter size by blending a low and high Lys diet. Target Lys intakes were based on 2012 NRC model estimates for a sow based on weight, parity, and litter size. The NRC's estimated Lys intake targets were increased by 20% to average 60 g/d. All diets were corn-soybean meal-based and fed in meal form.

Dietary treatments for sows on the blend curve treatments were formed by blending a low Lys diet (0.40% SID Lys) and the control high Lys diet (1.10% SID Lys). The two diets were blended using the Gestal Quattro Opti feeders to achieve the target SID Lys intake. Sows fed the control treatment were fed the 1.10% SID high Lys diet throughout lactation with no feed blending. For both blend curves, daily blends of the low and high Lys diets were made based on expected feed intake determined from feed intake data of previous farrowing groups in the same facility. Based on expected feed intake, the correct blend of the low and high Lys diet needed to reach target SID Lys intake was determined. The daily blend of the low and high Lys diet for the static and dynamic blend curve was the same at the start of the trial to target an average SID Lys intake of 60 g/d throughout the study.

However, for sows on the dynamic blend treatment, the feed blend curve of the low and high Lys diet was adjusted based on actual sow feed intake to more closely meet the target Lys intake. Feed intake was analyzed every 2 days starting on d 5 of lactation using a 2-day rolling average to determine if target Lys intake was achieved. Target Lys intake was the same for each of the blend curve treatments and did not change throughout the study. Changes to sow diet blends were made by either increasing or decreasing the blend of the high Lys diet by 10% to target a specific sow's g/d of Lys target and account for differences in predicted vs actual feed intake. For example, if a sow was above or below her target g/d Lys by 0 to 10%, no changes to the feed blends of the low and high Lys diets were made. Any differences that were above the target g/d of Lys by 10% or greater resulted in a 10% decrease in diet blend of the high Lys diet. Any differences that were below the target g/d of Lys by 10% or greater resulted in a 10% increase in diet blend of the high Lys diet. The blend of the low and high Lys diets for sows on the static blend curve treatments were not adjusted during the lactation period.

Because sows on the control treatment were fed only the 1.10% SID Lys diet, they were expected to have the highest average g/d of Lys intake. Sows fed either the static or dynamic blend curve treatments were expected to have similar g/d of Lys intake because they had the same target g/d of Lys. Each week, 5 feeders were calibrated for feed delivery and the average calibration value for each diet was used. Daily feed intakes were recorded using the Gestal volumetric feeders and confirmed by hand weighing the daily feed additions and the weight of any feed that was removed from the pan during the lactation period.

Litter weight and size were measured on d 2 of lactation after equalization, d 9 of lactation, and at weaning (d 18). The wean-to-service interval for each sow was recorded for all sows that remained in the herd after weaning. Pre-weaning mortality of each sow was calculated by taking the number of pigs weaned divided by the litter size on day 2.

On d 9 and at weaning, 10 mL of blood was collected from the jugular vein of each sow using a Monojets blood collection tube (Covidien, Minneapolis, MN). Sow blood was collected after a 6-h fasting period. Whole blood was centrifuged, and serum was collected and stored at -4°F (-20°C) until analysis. Serum was analyzed for urea N concentration using a Urea Nitrogen Colorimetric Detection Kit (Arbor Assays, Ann Arbor, MI).

For the economic analysis, feed cost per sow was calculated by using a feed cost of $0.24/lb for the low Lys diet and $0.27/lb for the high Lys diet. Feed cost per sow divided by litter weight gain per sow was used to calculate the feed cost per lb of litter weight gain. Feed cost per pig weaned was calculated by taking the feed cost per sow divided by the number of pigs weaned per sow.

Statistical analysis

Performance data were analyzed using the lmer function of R software, version 1.4.171, as a randomized complete block design. Sow and litter were considered the experimental unit. Treatment was a fixed effect. Block (sow parity) and group were considered random effects. Pairwise comparisons were used to detect differences among treatments. Pre-weaning mortality and percentage of N excreted were analyzed using a binomial distribution. Serum urea N was analyzed as a repeated measure using the lmer function of R software with treatment, sample time point, and their interaction included as a fixed effect. Plate and group were included as a random effect. Results are considered significant at $P \leq 0.05$ and marginally significant at $0.05 < P \leq 0.10$.

Results and Discussion

Over the entire lactation period, actual SID Lys intake for sows fed the static blend curve treatment was 97% of the targeted intake. Actual SID Lys intake for sows fed the dynamic blend curve treatment was 96% of the targeted Lys intake. These results indicate that either of the blending strategies was successful in meeting the targeted Lys intake throughout lactation. Adjusting the blend of the two diets for sows that were fed the dynamic blend treatment did not result in the average Lys intake being closer to the target.

No differences among treatments were observed in sow BW at entry, after farrowing, and weaning, caliper score, backfat, or loin depth at entry or weaning ($P > 0.05$; Table 2). There were no differences in ADFI among treatments throughout the trial ($P > 0.05$), although sows fed either of the blend treatments had a numerically greater feed intake compared to sows fed the control treatment. As expected, sows fed the control treatment had the highest average Lys intake because they were fed the high Lys diet with no feed blending ($P < 0.05$). Sows fed the static blend curve and dynamic blend curve had similar Lys intake.

There were no differences in litter size among treatments at d 0, 2, 9, or at weaning ($P > 0.05$). Litter and mean piglet BW as well as litter and piglet ADG were not different among treatments at any time point during the study ($P > 0.05$). Sows fed the control treatment had higher Lys intake per lb of litter gain ($P < 0.05$) compared to sows fed either of the blend curve treatments, with no differences among sows fed either of the blend curve treatments ($P < 0.05$). No differences were observed in preweaning mortality among treatments. These results would indicate that sows fed either of the blend curve treatments were able to wean piglets that had similar growth performance compared to pigs from sows fed the control treatment, even though they had decreased Lys intake throughout lactation.

Sows fed the control diet and either of the blend curve treatments had similar feed cost, feed cost per lb of litter weight gain, and feed cost per pig weaned. This was unexpected because pigs on the blend curve treatments received a blend of the lower cost low Lys and higher cost high Lys diet. However, sows fed the 2 blend curve treatments had a numerically greater ADFI resulting in a similar feed cost compared to sows fed the control diet.

Nitrogen balance was calculated for each sow based on equations in the NRC[4] (Table 2). Sows fed the control diet had a higher N intake compared to sows fed either of the blend curve treatments ($P < 0.05$). Sows fed the static blend curve treatment had a higher N intake than sows fed the dynamic blend curve treatment ($P < 0.05$); however, there was only a 1.7 g difference. No differences were observed among treatments for N in milk or N from body reserves ($P > 0.05$) because no changes in litter gain or sow body tissue mobilization were observed. Thus, sows fed the control diet had greater ($P < 0.05$) estimated N excretion compared to sows fed either of the blend curve treatments with the two blend curve treatments having similar ($P > 0.05$) N excretion. Sows fed the control diet had the highest ($P < 0.05$) percentage of N excreted relative to intake, followed by sows fed the static blend curve, and sows fed the dynamic blend curve had the lowest.

There was no interaction ($P = 0.786$) between day and treatment for serum urea N (Table 4). Sows fed the control diet had higher ($P < 0.05$) serum urea N concentration compared to sows fed both of the blend curve treatments, and no differences were observed between sows fed either of the blend curve treatments. This indicates that sows fed the control diet had a greater concentration of urea, a waste product from protein breakdown.

In summary, there were no differences in sow weight, backfat, loin depth change, or litter performance among treatments. Differences were observed among treatments for serum urea N concentration and N balance, in which sows fed the control diet had a greater serum urea N concentration, N intake, and N excretion. No differences in feed cost were observed among treatments because sows fed either of the blend treatments had numerically higher feed intake compared to sows fed the control diet. The results of this study indicated that a low and high Lys diet can be to target a sow's specific Lys requirement and decrease the sow's N excretion while maintaining similar piglet growth performance compared to feeding a standard high Lys diet. These data also suggests that SID Lys intake of approximately 60 g/d is sufficient to maximize litter weight gain with a litter size of approximately 13.5 weaned pigs.

Table 1. Composition of lactation diet (as-fed basis)[1]

Ingredient, %	Low Lys	High Lys
Corn	84.96	63.40
Soybean meal, 46.5% CP[2]	9.49	30.70
Corn oil	2.00	2.00
Calcium carbonate	1.30	1.30
Monocalcium P, 21% P	1.25	1.00
Sodium chloride	0.50	0.50
L-Lys-HCl	-	0.25
DL-Met	-	0.07
L-Thr	-	0.12
L-Trp	-	0.01
L-Val	-	0.15
Vitamin and trace mineral premix	0.50	0.50
Total	100	100
Calculated analysis		
SID amino acids, %		
Lys	0.40	1.10
Ile:Lys	90	62
Leu:Lys	247	130
Met:Lys	45	31
Met and Cys:Lys	92	56
Thr:Lys	81	65
Trp:Lys	24	20
Val:Lys	112	85
His:Lys	66	40
Total Lys, %	0.49	1.24
NE, kcal/lb	1,188	1,137
SID Lys:NE, g/Mcal	1.53	4.39
CP, %	11.5	20.4
Ca, %	0.83	0.85
P, %	0.56	0.60
STTD P, %	0.47	0.47

[1]Feed was manufactured at the Kansas State University O.H. Kruse Feed Technology Innovation Center (Manhattan, KS).
[2]CP = crude protein.

Table 2. Evaluation of precision feeding standardized ileal digestible lysine on sow performance[1]

	Control[2]	Static blend	Dynamic blend	SEM	*P*
Count, n	19	18	19		
Parity	2.0	2.0	2.1	0.49	0.982
Lactation length, d	18.3	18.5	18.4	0.27	0.864
Sow BW, lb					
Entry	560.9	564.3	566.8	27.09	0.912
Farrow	512.3	522.5	522.7	26.16	0.696
Wean	497.9	509.2	517.8	23.57	0.492
Sow BW change, lb					
Entry to farrow	-49.3	-41.1	-44.7	6.34	0.307
Farrow to wean	-15.8	-17.7	-5.7	7.51	0.232
Entry to wean	-65.5	-56.6	-50.6	8.21	0.263
Sow back fat, mm					
Entry	14.3	14.4	14.8	0.74	0.729
Wean	13.2	13.9	14.3	0.69	0.286
Change (entry to wean)	-1.2	-0.6	-0.5	0.36	0.295
Sow caliper score					
Entry	16.8	17.0	17.0	0.50	0.826
Wean	15.5	15.9	16.0	0.54	0.675
Change (entry to wean)	-1.4	-1.1	-1.0	0.33	0.654
Sow loin depth, mm					
Entry	45.9	45.9	46.8	1.23	0.552
Wean	45.7	46.6	46.8	0.85	0.449
Change (entry to wean)	-0.3	0.7	0.0	1.96	0.622
Sow ADFI, lb					
d 2 to d 9	12.2	12.8	12.0	0.88	0.526
d 9 to wean	17.1	17.8	17.9	0.66	0.579
d 2 to wean	15.0	15.7	15.5	0.56	0.661
Lys intake, g/d	77.7[a]	60.1[b]	59.7[b]	2.6	< 0.001
Wean-to-estrus interval, d	4.2	4.4	4.1	0.14	0.092

continued

Table 2. Evaluation of precision feeding standardized ileal digestible lysine on sow performance[1]

	Control[2]	Static blend	Dynamic blend	SEM	*P*
Economics					
Feed cost, $/sow[3]	75.94	76.30	75.13	2.64	0.944
Feed cost, $/lb of litter weight gain[4]	0.64	0.66	0.68	0.03	0.650
Feed cost, $/pig weaned[5]	5.60	5.66	5.64	0.23	0.980
N balance, g/d					
Intake[6]	247.0[a]	149.4[b]	147.7[c]	9.41	< 0.001
In milk[7]	96.1	88.6	91.6	5.29	0.370
From body reserves[8]	7.6	10.0	2.5	5.15	0.260
Excreted[9]	159.5[a]	66.2[b]	58.6[b]	4.02	< 0.001
Excreted, %[10]	63.9[a]	43.9[b]	39.7[c]	1.59	< 0.001

[a,b,c] Means in the same row that do not have a common superscript differ ($P < 0.05$).
[1]A total of 56 mixed-parity sows (Line 241 DNA) and litters were used from day 2 of lactation (the day after farrowing) until weaning.
[2]Sows were allotted to 1 of 3 treatments on d 2 of lactation. A control high Lys diet (1.10% SID Lys) or 1 of 2 blends, the static blend curve or dynamic blend curve, of a low (0.40% SID Lys) and high Lys diet to target a specific Lys requirement based on the NRC recommendations +20%. The only difference between the static blend curve treatment and a dynamic blend curve was that the blend of the low and high Lys was adjusted every 2 days based on a rolling average of Lys intake for sows on the dynamic blend curve.
[3]Feed cost of the low Lys diet = $0.24/lb and high Lys diet = $0.27/lb.
[4]Feed cost, $ per lb of litter weight gain = feed cost ÷ lb of litter weight gain per sow.
[5]Feed cost, $ per pig weaned = feed cost ÷ pigs weaned per sow.
[6]Calculated by N content in feed × feed intake.
[7]Calculated from mean litter gain and litter size according to equations in NRC (2012).
[8]Calculated from empty sow body weight and backfat according to equations in NRC (2012).
[9]Calculated from: (N intake + N from body reserves - N in milk).
[10]Calculated from: (N intake + N from body reserves - N in milk) ÷ intake.

Table 3. Evaluation of precision feeding standardized ileal digestible lysine on litter performance[1]

Litter characteristics	Control[2]	Static blend	Dynamic blend	SEM	*P* =
Litter size, n					
d 0	14.5	14.4	14.1	0.90	0.946
d 2	13.9	14.2	14.1	0.89	0.984
d 9	13.8	13.8	13.6	0.87	0.981
Wean	13.6	13.6	13.5	0.87	0.996
Litter weight, lb					
d 2	56.0	54.4	55.8	2.07	0.776
d 9	100.7	97.1	95.2	3.79	0.379
Wean	175.0	172.7	170.0	6.26	0.669
Mean piglet BW, lb					
d 2	4.0	3.9	4.0	0.15	0.653
d 9	7.3	7.0	7.0	0.37	0.394
Wean	12.8	12.6	12.6	0.61	0.816
Litter ADG d 2 to wean, lb/d	6.9	6.7	6.6	0.32	0.526
Piglet ADG d 2 to wean, lb/d	0.50	0.49	0.49	0.03	0.646
Lys intake, g/lb of litter gain	10.6[a]	8.5[b]	8.7[b]	0.40	< 0.001
d 2 to wean mortality, %	2.6	4.7	3.4	0.01	0.444

[a,b,c]Means in the same row that do not have a common superscript differ (P < 0.05).
[1]A total of 56 mixed-parity sows (Line 241 DNA) and litters were used from day 2 of lactation until weaning.
[2]Sows were allotted to 1 of 3 treatments on d 2 of lactation. A control high Lys diet (1.10% SID Lys) or 1 of 2 blend treatments, the static blend curve or dynamic blend curve, of a low (0.40% SID Lys) and high Lys diet to target a specific Lys requirement based on the NRC recommendations +20%. The only difference between the static blend curve treatment and a dynamic blend curve treatment was that the blend of the low and high Lys was adjusted every 2 days based on a rolling average of Lys intake for sows on the dynamic blend curve treatment.

Table 4. Evaluation of precision feeding standardized ileal digestible lysine on blood urea nitrogen[1]

	Treatment				*P* =		
	Control[2]	Static blend	Dynamic blend	SEM	Treatment × sample	Treatment	Sample
Serum urea N, mg/dL							
d 9[3]	19.2[a]	13.1[b]	12.3[b]				
Weaning	19.0[a]	13.5[b]	13.7[b]	0.63	0.286	< 0.001	0.710

[1]A total of 56 mixed-parity sows (Line 241 DNA) and litters were used from day 2 of lactation (the day after farrowing) until weaning.
[2]Sows were allotted to 1 of 3 treatments on d 2 of lactation. A control high Lys diet (1.10% SID Lys) or 1 of 2 blend treatments, the static blend curve or dynamic blend curve, of a low (0.40% SID Lys) and high Lys diet to target a specific Lys requirement based on the NRC recommendations +20%. The only difference between the static blend curve treatment and a dynamic blend curve was that the blend of the low and high Lys was adjusted every 2 days based on a rolling average of Lys intake for sows on the dynamic blend curve.
[3]Blood samples were taken on d 9 of lactation and at weaning to measure blood urea N.