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Evaluation of Precision Feeding SID Lysine to Lactating Sows on Sow and Litter Performance, Nitrogen Level, and Feed Cost[1]

Mikayla S. Spinler, Jordan T. Gebhardt,[2] Joel M. DeRouchey, Mike D. Tokach, Robert D. Goodband, Hyatt L. Frobose,[3] and Jason C. Woodworth

Summary

A total of 95 mixed parity sows (DNA 241) and litters (DNA 241 × 600) were used across four batch farrowing groups to evaluate the effects of precision feeding Lys during lactation. Sows were blocked by parity and allotted to 1 of 3 treatments on day 2 (the day after farrowing) of lactation. Dietary treatments were formed by using 2 diets: a low Lys diet (0.25% SID Lys) and a high Lys diet (1.10% SID Lys). Treatments included a control, NRC (2012)[4], or INRA (2009)[5] treatment curve. Sows on the NRC or INRA treatment curves received a blend of the low and high diet using the Gestal Quattro Opti Feeder (Jyga Technologies, St-Lambert-de-Lauzon, Quebec, Canada) to target a specific SID g/d of Lys intake for each day of lactation based on the NRC and INRA models for each sow parity and litter size combination. Sows on the control treatment received only the high Lys diet with no diet blending or specific g/d of Lys target. Sows were allowed *ad libitum* access to feed throughout lactation. Lysine intake was 102% of targeted average g/d of Lys intake during lactation for sows fed the NRC treatment curve and 98% of targeted average g/d for sows fed the INRA treatment curves. Sows fed only the high Lys diet (control) had greater ($P < 0.05$) average g/d of Lys intake compared to sows fed either the NRC or INRA treatment curves. No differences ($P > 0.05$) in sow weight, backfat, caliper score, or loin depth change were observed among treatments. However, litters from sows fed the control treatment had greater ($P < 0.05$) litter weight on d 9 and weaning compared to litters from sows fed either the NRC or INRA treatment curves. Pigs from sows fed the control treatment had greater ($P < 0.05$) BW at weaning and preweaning ADG compared to pigs from sows fed the INRA treatment curve, with pigs from sows fed the NRC treatment curve intermediate. Sows fed the NRC treatment curve had a greater ($P < 0.05$) feed cost per

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

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

lb of litter gain compared to sows fed the control treatment, with sows fed the INRA treatment curve intermediate. This was unexpected because sows fed the NRC treatment curves had a blend of the low and high Lys diets which had a decreased feed cost per lb compared to the control diet. However, this was the result of higher feed intake of sows fed the NRC treatment curve. Sows fed the control treatment had the highest ($P < 0.05$) N excretion and sows fed the INRA treatment curve the lowest, with sows fed the NRC treatment curve intermediate. Sows fed the control treatment had greater ($P < 0.05$) serum urea nitrogen concentration on d 9 and at weaning compared to sows fed the NRC and INRA treatment curves. In summary, pigs from sows fed a single diet (control) that did not utilize feed blending had increased pig growth performance during lactation compared to pigs from sows fed the NRC or INRA treatment curves. This is likely because the NRC and INRA estimated Lys requirements are too low to maximize litter growth performance and not because they were on a feed blending curve. Future research should be aimed at examining the effects of blending high and low Lys diets, while providing daily Lys intakes with greater dietary SID Lys concentrations, to achieve similar litter growth performance compared to conventional feeding of a high Lys diet.

Introduction

Sows are commonly fed a single diet throughout lactation regardless of litter size, parity, or feed intake. This can often result in either the under-feeding or over-feeding of nutrients. Under-feeding nutrients limits sow and litter performance while over-feeding leads to excess nutrient excretion and added diet cost.[6] The NRC and INRA both have models where information such as sow parity, litter size, and sow body weight can be used to calculate daily Lys (g/d) requirement estimates in lactation, thus creating a precision feeding Lys curve. The INRA treatment curve starts at a higher g/d requirement than the NRC treatment curve but is a flatter curve compared to the NRC, with the NRC having a greater g/d of Lys intake at the end of lactation (Figure 1). The NRC treatment curve suggests a higher average g/d of Lys requirement compared to the INRA treatment curve. However, both the NRC and INRA treatment curves result in Lys intakes that are lower than that typically offered to sows in commercial production. Recent research has suggested that precision feeding or phase feeding sows is a better strategy to target a specific nutrient requirement compared to current feeding practices to avoid over-supplementation of nutrients.[6]

We hypothesize that blending a low and high Lys diet to meet a specific sow's Lys requirement estimate based on her parity and litter size will lead to more efficient amino acid utilization with less N excretion and lower feed cost across the entire lactation period. Therefore, the objective of the study was to determine the impact of blending a low and high Lys diet to meet a sow's specific g/d of SID Lys target compared to feeding a single diet throughout lactation on sow and litter performance and feed cost.

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 Univer-

[6] 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.

sity 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 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 95 mixed parity sows (DNA 241) and litters (DNA 241 × 600) were used across four batch farrowing groups. Sows were moved into the farrowing house on d 110 of gestation. Upon entry to the farrowing house and at weaning, sow weight, caliper score, backfat, and loin depth measurements were recorded. Caliper scores were taken at the last rib. Caliper scores above 18 mm were recorded and analyzed as a score of 18 due to equipment restrictions of only measuring up to 18. Backfat and loin depth measurements were taken at the 3rd rib forward from the last rib, 2.5 inches from the midline on the right side of the sow using an IBEX Pro ultrasound machine (E.I. Medical Imaging, Loveland, CO). Sow weight was also recorded post-farrowing. From day 110 of gestation until day 2 of lactation (the day after farrowing), sows were fed a gestation diet. Sows were given 6 lb of gestation diet pre-farrow and then allowed *ad libitum* access to feed post-farrowing. Sow ADFI was calculated by taking feed disappearance minus 5% to account for feed wastage.

On day 2 of lactation, litters were processed and equalized to have 12 to 16 piglets per sow. After equalization, diets were changed from the gestation diet to treatment diets and sows were fed 1 of 3 treatments: a single lactation diet fed throughout lactation (control), or either NRC or INRA Lys curves. Dietary treatments were fed from d 2 of lactation until weaning. To create the treatment curves, two corn-soybean meal-based diets were fed in meal form. One was a low Lys (0.25% SID Lys) and the other a high Lys diet (1.10% SID Lys). The two diets were blended using the Gestal Quattro Opti feeders to achieve the required SID Lys target based on either the NRC or INRA model. Sows on the control diet were fed only the 1.10% SID Lys diet with no feed blending. Sows fed the control treatment were expected to have the highest g/d of Lys intake because they were given *ad libitum* access to only the high Lys diet, as opposed to sows on the NRC or INRA treatment curves that were given a blend of the low and high Lys diets to target a specific daily Lys intake during lactation. Sows fed the NRC treatment curve were expected to have a higher overall average g/d of Lys intake compared to sows on the INRA treatment curve due to differences in each of the models' requirement estimates and shape of the Lys intake curves. Five feeders each week during lactation were calibrated and the average calibration value for each diet was used. Daily feed intake was recorded during lactation for each individual sow using the Gestal volumetric feeder and confirmed by hand weighing and recording daily feed additions and the weight of any feed removed from the feed pan.

Daily feed blends of the low and high Lys diet for sows on the NRC and INRA treatment curves were created based on expected feed intake determined from feed intake data of past farrowing groups at K-State. Feed curve blends were then adjusted throughout the trial based on actual sow feed intake to meet the target Lys intake more closely. Feed intakes were analyzed every 2 days, starting on d 5 of lactation and using a 2-day rolling average to determine if a sow was meeting her daily Lys g/d target. Feed intake was analyzed assuming 5% feed wastage. 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 requirement based on the NRC or INRA model. If a sow was above or below her target g/d Lys by 0 to 10%, no changes to the feed blends were made. Any differences above target g/d of Lys by 10% or greater resulted in a 10% decrease in diet blend of the high Lys diet. Any differences below target g/d of Lys by 10% or greater resulted in a 10% increase in diet blend of the high Lys diet.

Litter size and weights were taken at d 2 of lactation after equalization, d 9 of lactation, and at weaning (d 18.8). Wean-to-service interval for each sow was recorded for sows that remained in the herd after weaning. Pre-weaning mortality was calculated by taking the number of pigs weaned divided by the litter size on d 2.

Ten mL of blood was taken from the jugular vein from each sow on d 9 of lactation and at weaning using a Monoject blood collection tube (Covidien, Minneapolis, MN). Sow blood was collected after a 6-hour fasting period overnight. Blood samples were centrifuged, and serum was collected and stored at -4°F (-20°C) until analysis. Serum was analyzed for serum urea nitrogen (Urea Nitrogen Colorimetric Detection Kit, Arbor Assays, Ann Arbor, MI). Urine samples were also collected on d 9 of lactation and at weaning using the free-catch method during the middle of urination. A sample of 40 to 45 mL was collected, mixed with 0.5 mL of HCl to prevent ammonia volatilization, and stored at -4°F (-20°C) until analysis. Urine samples were analyzed for creatinine concentration (Creatinine Colorimetric Assay Kit, Cayman Chemical, Ann Arbor, MI).

Feed cost per sow was calculated 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 lb of litter weight gain was calculated by taking the feed cost per sow divided by lb of litter weight gain per sow. Feed cost per pig weaned was also calculated by taking the feed cost per sow divided by the number of pigs weaned per sow.

Nitrogen balance differences among treatments were calculated to determine differences in N utilization. Nitrogen balance was calculated by determining N intake (N content in feed × feed intake) and estimating N content in milk and N mobilized from body reserves. Nitrogen content in milk and N mobilized from body reserves were estimated based on equations in the NRC. Total N excreted was calculated by taking N intake plus N from body reserves minus N in milk.

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 nitrogen and urinary creatinine were analyzed as a repeated measure using the lmer function of R software with treatment, sample timepoint, 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, the g/d of Lys intake was 102% of the targeted g/d of Lys intake for sows fed the NRC treatment curve and 98% of the targeted g/d of Lys for sows fed the INRA treatment curve. These results indicated that the blending strategy with adjustments made every other day was successful in meeting the targeted Lys intake throughout lactation.

There were no differences among treatments in sow BW at entry, farrowing, or weaning and no differences in BW change at any timepoint ($P > 0.05$; Table 2). No differences among treatments in sow backfat, caliper score, and loin depth were observed at entry, weaning, or changes from entry to weaning ($P > 0.05$). No differences were observed in ADFI from d 2 to d 9 or d 9 to weaning ($P > 0.05$); however, a tendency was observed ($P = 0.093$) where sows fed the NRC treatment curve had the numerically greatest ADFI from d 2 to weaning. As expected, sows fed the control treatment that received the high Lys diet with no feed blending, had the highest ($P < 0.05$) Lys intake and it was greater than sows fed either the NRC or INRA treatment curves. Sows fed the NRC treatment curve had greater ($P < 0.05$) Lys intake than sows fed the INRA treatment curve. A tendency ($P < 0.092$) for differences in wean-to-estrus intervals was observed, but values only ranged from 4.1 to 4.4 days.

No differences in litter size were observed at d 2, 9, or at weaning. Litter weight was similar ($P > 0.05$) among all treatments at d 2. However, at d 9 and at weaning, litters from sows fed the control treatment had greater ($P < 0.05$) litter weight than litters from sows fed the NRC or INRA treatment curves. There were no differences ($P > 0.05$) observed for pig BW at d 2. At d 9, a tendency ($P = 0.085$) for differences among treatments was observed. At weaning, pigs from sows fed the control treatment had greater ($P < 0.05$) BW compared to pigs from sows fed the INRA treatment curves, with pigs from sows fed the NRC treatment curve intermediate. Litters and pigs from sows fed the control treatment had a greater ($P < 0.05$) ADG compared to litters and pigs from sows fed the INRA treatment curve, with those fed the NRC treatment curve intermediate. Sows fed the control treatment had greater ($P > 0.05$) Lys intake per lb of litter weight gain than sows fed the NRC treatment curve, with sows on the INRA treatment having the lowest Lys intake per lb of litter weight gain. No differences ($P > 0.05$) were observed for preweaning mortality.

No differences in feed cost per sow or feed cost per pig weaned were observed among treatments (Table 2). Sows fed the NRC treatment curve had the highest feed cost per lb of litter weight gain, and greater ($P < 0.05$) cost than sows fed the control treatment, with sows fed the INRA treatment curve intermediate.

As expected, sows fed the control treatment had the highest ($P < 0.05$) N intake followed by sows fed the NRC treatment curve, with sows fed the INRA treatment curve having the lowest (Table 2). Sows fed the control treatment had greater ($P < 0.05$) milk N output compared to sows fed the INRA treatment curve, with sows fed the NRC treatment curve intermediate. No differences ($P > 0.05$) in N mobilization from body reserves were observed between treatments. Nitrogen excretion (g/d) and percentage of N excreted were greatest for sows fed the control treatment, followed by sows fed the NRC treatment curve, and sows fed the INRA treatment curve were lowest.

There was no interaction (P = 0.786) between day and treatment for serum urea nitrogen (Table 4). Sows fed the control treatment had higher (P < 0.05) serum urea nitrogen concentration compared to sows fed the NRC and INRA treatment curves, and no differences were observed between sows fed either the NRC or INRA treatment curves. There were no differences (P > 0.05) in urinary creatinine concentration among treatments.

In summary, sows fed the control treatment had the greatest Lys intake followed by sows fed the NRC, and then INRA treatment curves. This was expected based on anticipated Lys intake per day for the control vs. curve treatments. Sows fed the NRC treatment curve had the highest feed cost per lb of litter weight gain, which was reflective of these sows having greater feed intake and lower weaning weights than control sows. Sows fed the control treatment had greater serum urea nitrogen and nitrogen excretion compared to sows fed the NRC and INRA treatment curves, indicating excess nitrogen intake. Overall, sow body weight changes were similar among treatments, but litters from sows fed the control treatment had the best growth performance during lactation, indicating that sows fed the NRC and INRA treatment curves were deficient in Lys. The NRC and INRA models underestimated the g/d of SID Lys intake needed to maximize litter growth performance. Future research should evaluate diet blending with greater dietary SID Lys concentrations to achieve similar litter growth performance compared to conventional feeding of a high Lys diet. Future research should also evaluate the effects of diet blending on an older parity herd with an older weaning age as the low Lys diet will likely provide the greatest diet savings in late lactation.

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

Ingredient, %	Low Lys	High Lys
Corn	91.05	63.40
Soybean meal, 46.5% CP[2]	3.20	30.70
Corn oil	2.00	2.00
Calcium carbonate	1.20	1.15
Monocalcium P, 21% P	1.40	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 premix with phytase	0.25	0.25
Sow add pack	0.25	0.25
Trace mineral premix	0.15	0.15
Total	100	100
Calculated analysis		
SID amino acids, %		
Lys	0.25	1.10
Ile:Lys	106	62
Leu:Lys	342	130
Met:Lys	62	31
Met and Cys:Lys	125	56
Thr:Lys	98	65
Trp:Lys	25	20
Val:Lys	138	85
His:Lys	85	40
Total Lys, %	0.32	1.24
NE, kcal/lb	1,202	1,137
SID Lys:NE, g/Mcal	0.94	4.39
CP, %	9.0	20.4
Ca, %	0.86	0.86
P, %	0.56	0.60
STTD P, %	0.47	0.47

[1]Feed was manufactured by a commercial feed mill (Hubbard Feeds, Beloit, KS) for sow groups 1 to 3 and the Kansas State University O.H. Kruse Feed Technology Innovation Center (Manhattan, KS) for sow group 4.
[2]CP = crude protein.

Table 2. The effect of precision feeding SID lysine on sow performance[1]

Item	Control[2]	NRC	INRA	SEM	*P* =
Count, n	31	32	32		
Parity	2.0	2.0	2.0	0.35	0.985
Lactation length, d	19.1	18.7	18.6	0.25	0.375
Sow BW, lb					
Entry	562.2	570.4	576.7	20.41	0.389
Farrow	516.7	522.9	525.0	19.77	0.697
Wean	494.2	501.6	502.4	18.61	0.691
Sow BW change, lb					
Entry to farrow	-44.1	-45.4	-48.6	5.48	0.589
Farrow to wean	-23.4	-21.9	-23.3	5.34	0.954
Entry to wean	-66.0	-67.7	-72.2	7.51	0.590
Sow back fat, mm					
Entry	15.2	15.0	14.6	0.47	0.655
Wean	13.9	14.4	13.6	0.46	0.412
Change (entry to wean)	-1.3	-0.6	-1.0	0.30	0.248
Sow caliper score					
Entry	16.4	16.6	16.2	0.34	0.494
Wean	15.2	15.4	14.8	0.39	0.414
Change (entry to wean)	-1.2	-1.2	-1.3	0.32	0.841
Sow loin depth, mm					
Entry	47.9	47.3	47.6	0.85	0.830
Wean	46.8	46.4	45.9	0.77	0.587
Change (entry to wean)	-1.1	-0.8	-1.5	0.57	0.673
Sow ADFI, lb					
d 2 to 9	11.1	11.6	10.6	0.68	0.122
d 9 to wean	17.5	18.2	17.3	0.66	0.270
d 2 to wean	14.7	15.5	14.5	0.60	0.093
Lys intake, g/d	76.7[a]	53.1[b]	42.8[c]	2.22	< 0.001
Wean-to-estrus interval, d	4.2	4.4	4.1	0.14	0.092

continued

Table 2. The effect of precision feeding SID lysine on sow performance[1]

Item	Control[2]	NRC	INRA	SEM	*P* =
Economics					
Feed cost, $ per sow[3]	76.94	76.48	72.76	1.95	0.128
Feed cost, $ per lb of litter weight gain[4]	0.63[b]	0.69[a]	0.68[ab]	0.02	0.034
Feed cost, $ per pig weaned[5]	5.64	5.73	5.43	0.16	0.243
N balance, g/d					
Intake[6]	231.1[a]	155.8[b]	114.7[c]	14.05	< 0.001
In milk[7]	90.0[a]	84.2[ab]	80.4[b]	2.47	0.004
From body reserves[8]	11.8	12.6	12.2	3.37	0.975
Excreted[9]	154.2[a]	84.2[b]	48.0[c]	12.51	< 0.001
Excreted, %[10]	66.6[a]	53.2[b]	42.3[c]	2.28	< 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 95 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 a blend of a low (0.25% SID Lys) and high Lys diet to target a specific Lys requirement estimates based on NRC or INRA models.
[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, $/sow ÷ lb of litter weight gain per sow.
[5]Feed cost, $ per pig weaned = feed cost, $/sow ÷ 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) ÷ N intake.
NRC = National Research Council. 2012. Nutrient Requirements of Swine: Eleventh Revised Edition. Washington, DC: The National Academies Press. *https://doi.org/10.17226/13298*.
INRA = InraPorc. 2009. *https://inraporc.inra.fr/inraporc/index_en.html*.

Table 3. The effect of precision feeding SID lysine on litter performance[1]

Item	Control[2]	NRC	INRA	SEM	*P* =
Litter characteristics					
Litter size, n					
d 0	13.9	15.3	14.5	0.69	0.330
d 2	14.3	14.2	14.3	0.65	0.985
d 9	14.1	13.7	13.6	0.59	0.692
Wean	13.8	13.5	13.5	0.65	0.892
Litter weight, lb					
d 2	52.3	51.5	51.3	1.30	0.841
d 9	102.3[a]	92.1[b]	92.4[b]	2.59	0.004
Wean	176.6[a]	164.8[b]	160.1[b]	3.89	0.003
Mean piglet BW, lb					
d 2	3.7	3.7	3.6	0.10	0.912
d 9	7.3	6.8	6.8	0.25	0.085
Wean	12.9[a]	12.3[ab]	11.9[b]	0.32	0.005
Litter ADG d 2 to wean, lb/d	6.9[a]	6.4[ab]	6.1[b]	0.20	0.004
Piglet ADG d 2 to wean, lb/d	0.50[a]	0.48[ab]	0.46[b]	0.02	0.005
g of Lys intake/ lb of litter gain	10.6[a]	8.0[b]	7.0[c]	0.35	< 0.001
Preweaning mortality, %					
d 2 to wean	3.8	5.0	5.7	1.2	0.395

[a,b,c] Means in the same row that do not have a common superscript differ (*P* < 0.05).
[1] A total of 95 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 a blend of a low (0.25% SID Lys) and high Lys diet to target a specific Lys requirement estimates based on NRC or INRA models.
NRC = National Research Council. 2012. Nutrient Requirements of Swine: Eleventh Revised Edition. Washington, DC: The National Academies Press. *https://doi.org/10.17226/13298*.
INRA = InraPorc. 2009. *https://inraporc.inra.fr/inraporc/index_en.html*.

Table 4. The effect of precision feeding SID lysine on blood urea nitrogen and urine creatinine concentration[1]

					P =		
Item	Control[2]	NRC	INRA	SEM	Treatment × day	Treatment	Day
Serum urea nitrogen concentration, mg/dL							
Day 9[3]	19.8[a]	14.0[b]	14.4[b]				
Weaning	19.7[a]	14.4[b]	14.0[b]	0.90	0.786	< 0.001	0.855
Urine creatinine concentration, mg/dL							
Day 9	117.9	112.4	136.9				
Weaning	117.2	112.6	139.5	18.35	0.982	0.263	0.953

[a,b] Means in the same row that do not have a common superscript differ ($P < 0.05$).
[1] A total of 95 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 a blend of a low (0.25% SID Lys) and high Lys diet to target a specific Lys requirement estimate based on NRC or INRA models.
[3] Blood and urine samples were taken on d 9 of lactation (sample 1), and at weaning (sample 2), to measure blood urea nitrogen and urine creatinine concentration.
NRC = National Research Council. 2012. Nutrient Requirements of Swine: Eleventh Revised Edition. Washington, DC: The National Academies Press. *https://doi.org/10.17226/13298*.
INRA = InraPorc. 2009. *https://inraporc.inra.fr/inraporc/index_en.html*.

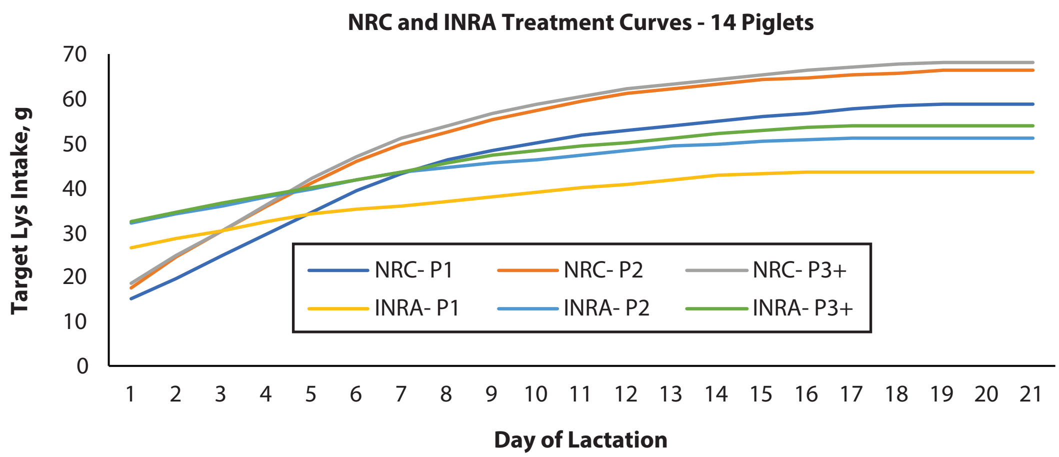

Figure 1. Target Lys intake by parity with a litter size of 14 at equalization for NRC and INRA treatment curves.
NRC = National Research Council. 2012. Nutrient Requirements of Swine: Eleventh Revised Edition. Washington, DC: The National Academies Press. *https://doi.org/10.17226/13298*.
INRA = InraPorc. 2009. *https://inraporc.inra.fr/inraporc/index_en.html*.