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Summary

A total of 131 sows (Line 241; DNA, Columbus, NE) were used in a study to evaluate the effect of increasing soybean meal concentration in lactating sow diets on sow and litter performance. Sows were blocked by body weight (BW) and parity on d 112 of gestation, and allotted to 1 of 3 treatments of increasing soybean meal (25%, 30%, or 35% of total diet). Diets were formulated to 1.05% standardized ileal digestible (SID) lysine with L-lysine HCl decreasing as soybean meal increased. All other amino acids and nutrients were formulated to meet nutrient requirement recommendations.² Diets were fed from d 112 of gestation until weaning (d 20 ± 2). Litters were cross-fostered up to 48 h after farrowing to equalize litter size. Increasing soybean meal concentration increased (linear, $P = 0.017$) sow BW loss and tended to increase (quadratic, $P = 0.052$) sow backfat loss from farrowing to weaning. Sow average daily feed intake from d 0 to 7 was similar ($P > 0.10$) across dietary treatments. However, from d 7 to 14, d 14 to weaning, and overall, average daily feed intake decreased (linear, $P = 0.01$) as soybean meal concentration increased. There was no evidence for difference ($P > 0.10$) in wean to estrus interval, litter size, litter weight, or litter weight gain between dietary treatments. Sow serum urea nitrogen concentrations taken on d 14 of lactation increased (linear, $P = 0.001$) as soybean meal concentration increased. However, there was no difference ($P > 0.05$) for sow creatinine concentration, regardless of dietary treatment, suggesting the increased urea nitrogen was a reflection of the increased dietary crude protein (CP) as opposed to increased protein catabolism. In summary, sow feed intake was decreased and weight loss increased with increasing soybean meal concentration from 25 to 35%, with no difference in litter performance observed.

Introduction

Encouraging feed intake in lactating sows is one of the most critical factors in achieving maximum productivity in the farrowing house. Increased feed intake is associated with

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

improved litter performance and sow reproductive performance.³ It is important that diet composition does not deter maximum lactation feed intake, and one of the possible deterrents could be soybean meal concentration. A previous study⁴ observed a decrease in average daily feed intake (ADFI) as total lysine increased from 0.60 to 1.60%. While the researchers hypothesized the decrease in intake was due to elevated serum urea nitrogen levels and varying branch chain amino acid ratios across their experimental diets, the soybean meal concentration also increased from 12.6 to 48.5% of the diet. A more recent study⁵ conducted on a commercial sow farm observed a decrease in feed intake when soybean meal increased from 19 to 34% of the total diet as total lysine concentration was increased. To meet the standardized ileal digestible (SID) lysine requirement of the high-producing sow, both soybean meal and crystalline lysine are typically added to the diet; however, is there a maximum concentration of soybean meal that should be considered? To our knowledge, there is no previous literature that has evaluated this question. Therefore, the objective of the current study was to determine if the soybean meal level in lactation diets affects sow performance and feed intake.

Procedures

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

A total of 131 sows (Line 241; DNA, Columbus, NE) were used across five batch farrowing groups at the Kansas State University Swine Teaching and Research Center in Manhattan, KS. On d 112 of gestation, sows were weighed and moved into the farrowing house. Females were blocked by initial BW and parity and allotted to one of the three dietary treatments within farrowing group. Dietary treatments were corn-soybean meal-based and consisted of three concentrations of soybean meal (25%, 30%, or 35% of the diet). L-Lysine HCl was decreased in the diets as soybean meal increased in order to formulate all diets to 1.05% SID lysine. Other feed-grade amino acids (Met, Thr, Trp, Val) were added as needed to maintain a similar ratio to lysine. All other nutrients met or exceeded the NRC² requirement estimates (Table 1). Gestation diets fed prior to the study contained 0.56% SID lysine, and 15% soybean meal.

Diets were manufactured at the Kansas State University O.H. Kruse Feed Mill in Manhattan, KS. A new batch of each treatment diet was manufactured for each farrowing group and packaged in 50 lb bags. During bagging, feed samples were collected from every fifth bag, pooled, and used for nutrient analysis.

From d 112 of gestation until farrowing (approximately d 115), sows were fed 6 lb of their respective treatment diets. Postpartum, sows were allowed *ad libitum* access to feed, which was recorded by weighing the amount of feed placed in the feeder and the amount remaining every 7 d until weaning. Sow BW and backfat depth (measured 4 in.

³ Koketsu, Y., G. D. Dial, J. E. Pettigrew, V. L. King. 1996. Feed intake pattern during lactation and subsequent reproductive performance of sows. J. Anim. Sci. 74: 2875-2884.

<https://doi.org/10.2527/1996.74122875x>

⁴ Yang, H., J. E. Pettigrew, L. J. Johnston, G. C. Shurson, and R. D. Walker. 2000. Lactational and subsequent reproductive responses of lactating sows to dietary lysine concentration. J. Anim. Sci. 78:348-357.

⁵ Gourley, K. M., G. E. Nichols, J. A. Sonderman, Z. T. Spencer, J. C. Woodworth, J. M. DeRouchey, M. D. Tokach, S. S. Dritz, R. D. Goodband, S. J. Kitt, and E. W. Stephenson. 2017. Effects of increasing lysine in lactating sows. Trans. Anim. Sci. 1: 426-436. Doi:10.2527/tas2017.0043.

from the midline of the last rib) were measured 24 h after farrowing and at weaning (d 20 ± 2). Cross fostering occurred regardless of dietary treatment until 48 h post-partum in an attempt to equalize litter size (minimum of 12 pigs per litter). Litters were weighed on d 2, 7, 14, and at weaning. Pre-weaning mortality was calculated as the number of pigs weaned per sow divided by the number of pigs on d 2.

On d 14 of lactation, sows were fasted for 10 h and 10 mL of blood was collected via jugular venipuncture. Blood samples were centrifuged, serum was collected and then stored at -80°C until analysis. Serum was analyzed for serum urea nitrogen (Urea Nitrogen Colorimetric Detection Kit, Arbor Assays, Ann Arbor, MI) and creatinine (Creatinine Colorimetric Assay Kit; Cayman Chemical; Ann Arbor, MI).

At weaning, sows were moved to a breeding barn, individually housed, and checked daily for signs of estrus using a boar. The wean-to-estrus interval (WEI) was determined as the number of days between weaning and when sows were first observed to show a positive response to the back-pressure test.

Chemical Analysis

Five samples (1 pooled sample per farrowing batch) per dietary treatment were sent to a commercial laboratory and analyzed in duplicate (Ward Laboratories, Kearney, NE) for CP (AOAC 990.03, 2006), Ca (Campbell and Plank, 1991; Kovar, 2003), and P (Campbell and Plank, 1991; Kovar, 2003) analysis.

Statistical Analysis

Data were analyzed using generalized linear mixed models where dietary treatment was a fixed effect, with the random effects of farrowing group and block. Statistical models were fitted using the GLIMMIX procedure of SAS (Version 9.4, SAS Institute, Inc. Cary, NC). Pre-planned linear and quadratic contrast statements were used to evaluate increasing soybean meal concentrations.

Sow ADFI, BW, backfat depth, litter weight, litter gain, lactation length, serum urea nitrogen, and creatinine were evaluated assuming a normal distribution of the response variable. Litter weight on d 2 was used as a covariate for d 7, 14, and weaning litter weights, and litter weight gain to improve the fit of the model. In these cases, assumptions for normal distribution were checked using standardized residuals.

Litter counts and the WEI were fit using a negative binomial distribution. Piglet survivability was fitted using a binomial distribution. Statistical models were implemented using the GLIMMIX procedure of SAS (Version 9.4, SAS Institute, Inc., Cary, NC). All results were considered significant at $P \leq 0.05$, and marginally significant at $0.05 \leq P \leq 0.10$.

Results and Discussion

Chemical analysis of CP, Ca, and P were similar to formulated values (Table 2). There was no evidence for difference among treatments in initial BW or backfat depth measured after farrowing (Table 3). Increasing soybean meal concentration increased (linear, $P = 0.017$) sow BW loss and tended to increase (quadratic, $P = 0.052$) sow

backfat loss from farrowing to weaning. Sow average daily feed intake from d 0 to 7 was similar ($P > 0.05$) across treatments. However, from d 7 to 14, d 14 to wean, and overall, ADFI decreased (linear, $P < 0.001$) as soybean meal concentration increased. These results are similar to a lactation lysine titration conducted by Yang et al.³ where increasing lysine concentration by increasing soybean meal concentration from 14.5% to 48.5% resulted in a linear decrease ($P < 0.05$) in sow feed intake. Interestingly, we also observed that the range in ADFI within treatment was also greater as the concentration of soybean meal increased (Figure 1). This might indicate that some sows can tolerate higher levels of soybean meal compared to others and warrants further investigation.

There was no evidence for a difference in lactation length or WEI ($P > 0.10$) across dietary treatments. Sow serum urea nitrogen concentrations increased (linear, $P < 0.001$) as soybean meal concentration increased; however, there was no evidence for difference ($P > 0.10$) in creatinine concentration. Serum urea nitrogen measures the circulating nitrogen concentration, which is derived from both dietary (nitrogen from metabolism of CP in the diet) and muscle catabolism. Circulating creatinine is used to indicate if body protein catabolism is occurring. An increase in serum urea nitrogen with no change in creatinine is reflective of an increase in nitrogen from dietary CP as soybean meal increased without a change in body protein mobilization.

There was no evidence for litter count at d 2 or weaning to be different ($P > 0.10$, Table 4), and as a result, no evidence for piglet survivability to be influenced ($P > 0.10$) across dietary treatments. There was no evidence for difference ($P > 0.10$) in litter weight on d 2, 7, 14, or at weaning, or litter average daily gain, regardless of dietary treatment. Similarly, Gourley et al.⁴ did not observe a difference in litter growth as soybean meal concentration increased from 19.3% to 34%. This would suggest modern sow genotypes will support high litter growth, even when feed intake is limited. The greater BW loss and backfat loss observed with sows fed the high soybean meal diet in this trial would support this conclusion.

In summary, increasing soybean meal concentration from 25% to 35% decreased voluntary feed intake in lactating sows, with the greatest magnitude of change occurring after 30%. Interestingly, there was no evidence for feed intake to be affected in the first 7 days after farrowing. This suggests the decreased feed intake is not a result of palatability or the transition from a relatively low soybean meal level in the gestation diet compared to the lactation diet. There was no impact on litter growth or wean-to-estrus interval; however, sows fed diets with 35% soybean meal had the greatest farrow-to-wean weight loss and backfat loss, which could impact future reproductive performance or longevity within the herd.

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Table 1. Diet composition¹

Ingredient, %	Soybean meal concentration, %		
	25	30	35
Corn	67.97	63.38	58.84
Soybean meal, 46.5% CP	25.00	30.00	35.00
Choice white grease	2.00	2.00	2.00
Limestone	1.28	1.25	1.23
Monocalcium phosphate, 21%	1.80	1.78	1.73
Salt	0.50	0.50	0.50
L-Lysine-HCl	0.34	0.18	0.03
DL-Methionine	0.09	0.05	0.00
L-Threonine	0.17	0.10	0.03
L-Tryptophan	0.03	0.00	0.00
L-Valine	0.20	0.12	0.03
Trace mineral premix	0.15	0.15	0.15
Sow add pack	0.25	0.25	0.25
Vitamin premix	0.25	0.25	0.25
Total	100	100	100
Calculated analysis			
Standardized ileal digestible (SID) amino acids, %			
Lysine	1.05	1.05	1.05
Isoleucine:lysine	60	68	76
Leucine:lysine	130	141	153
Methionine:lysine	32	30	28
Methionine and cysteine:lysine	56	56	56
Threonine:lysine	67	67	67
Tryptophan:lysine	20	20	23
Valine:lysine	85	85	85
Total lysine, %	1.18	1.19	1.20
Metabolizable energy, kcal/lb	1,511	1,507	1,504
Net energy, kcal/lb	1,139	1,124	1,110
SID Lys:NE, g/Mcal	4.25	4.31	4.37
Crude protein, %	18	20	22
Ca, %	0.89	0.89	0.89
P, %	0.74	0.76	0.77
STTD P, %	0.50	0.50	0.50

¹Sows were fed 6 lb per day from d 112 of gestation until farrowing, then *ad libitum* from farrowing until weaning. STTD = standardized total tract digestible.

Table 2. Chemical analysis of the diets (as-fed basis)¹

Item, %	Soybean meal concentration, %		
	25	30	35
Dry matter	88.6	88.9	89.9
Crude protein	18.3	20.1	22.1
Ca	1.03	1.04	1.08
P	0.71	0.72	0.78

¹Diet samples were collected from each batch of feed at manufacturing from every fifth bag. Nutrient analysis was conducted in duplicate on composite samples (Ward Laboratories, Kearney, NE). Thus, each sample is a mean of 10 observations.

Table 3. Effect of increasing soybean meal concentration in lactating sow diets on sow performance¹

	Soybean meal, %			SEM	Probability, <i>P</i> <	
	25	30	35		Linear	Quadratic
Number of sows, n	44	43	44	--	--	--
Parity	2.0	2.0	2.0	0.15	0.998	0.157
Sow body weight, lb						
Farrow	504.3	502.7	507.0	9.20	0.619	0.537
Wean	487.7	486.5	481.9	8.81	0.363	0.768
Change (farrow to wean)	-16.1	-15.3	-25.7	2.85	0.017	0.110
Sow backfat, mm						
Farrow	15.9	15.4	16.1	0.51	0.702	0.195
Wean	13.7	13.5	13.3	0.41	0.379	0.985
Change (farrow to wean)	-2.3	-1.9	-2.8	0.31	0.100	0.052
Sow ADFI, lb						
d 0 to 7	8.0	7.9	7.9	0.24	0.684	0.798
d 7 to 14	14.4	14.1	13.2	0.30	0.001	0.234
d 14 to wean	16.0	15.7	14.4	0.35	0.001	0.227
Farrow to wean	12.6	12.3	11.6	0.25	0.001	0.314
Lactation length, d	19.5	19.5	19.3	0.14	0.319	0.299
Wean to estrus, d	4.5	4.4	4.4	0.12	0.618	0.891
Serum urea nitrogen, ² mg/dl	20.41	25.37	28.09	1.137	0.001	0.318
Creatinine, ² mg/dl	3.67	3.61	3.80	0.191	0.580	0.584

¹A total of 131 sows and their litters were used in a 21-d study. There were 43 or 44 sows per treatment.

²On d 14 of lactation sows were fasted for 10 h then bled. Samples were centrifuged after collection and serum was used in analysis.

ADFI = average daily feed intake.

Table 4. Effect of increasing soybean meal concentration in lactating sows on litter performance¹

	Soybean meal, %			SEM	Probability, <i>P</i> <	
	25	30	35		Linear	Quadratic
Number of sows	44	43	44	--	--	--
Litter count, n						
d 2 ²	13.7	13.6	13.6	0.56	0.863	0.988
Wean	13.0	12.9	12.9	0.04	0.963	0.955
Piglet survivability, ³ %	95.2	95.0	95.7	1.00	0.654	0.651
Litter weight, lb						
d 2	47.1	46.5	45.4	1.19	0.297	0.886
d 7 ⁴	75.7	74.5	75.9	0.82	0.867	0.134
d 14 ⁴	126.5	124.0	127.4	1.75	0.697	0.128
Wean ⁴	161.3	158.9	161.3	2.94	0.995	0.414
Litter ADG, ⁴ lb	6.62	6.47	6.67	0.158	0.724	0.288

¹A total of 131 sows and their litters were used in a 21-d study. There were 43 or 44 sows per treatment.

²Cross-fostering occurred irrespective of treatment in an attempt to equalize litter size. Litters were weighed at 48 h, after cross-fostering.

³Piglet survivability = litter count at weaning/litter count on d 2.

⁴Litter weight on d 2 was used as a covariate to improve the fit of the model.

ADG = average daily gain.

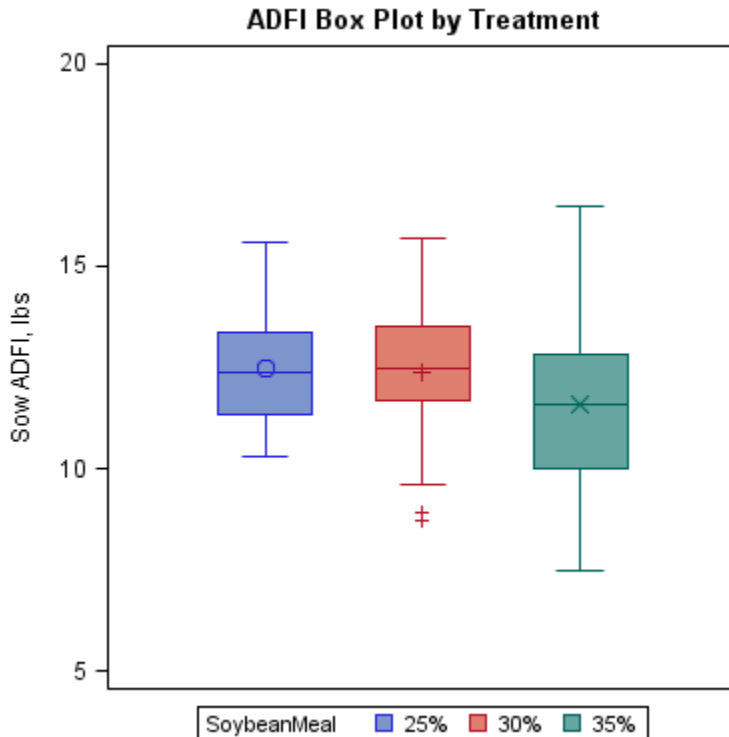


Figure 1. Box plot of overall sow average daily feed intake by soybean meal treatment. The symbol in each box denotes the treatment mean feed intake. The whiskers demonstrate the range of feed intakes in their respective dietary treatments.