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Supplementing Tryptophan in Late Gestation Diets to Group-housed Sows Under Commercial Conditions: Effects on Aggressive Interactions and Sow and Litter Performance

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Summary

A total of 948 mixed-parity sows and gilts were used to evaluate the effects of supplementing an additional 0.24% SID tryptophan in late gestation on sow performance and behavior. Sows were housed in 18 pens with pens randomly assigned based upon parity and breed date to either a control corn-soybean meal-DDGS-based diet containing 0.11% SID Trp (n = 9 pens/treatment with 52.3 ± 1.6 sows/pen) or the control diet supplemented with an additional 0.24% SID Trp, for a total of 0.35% (n = 9 pens/treatment with 53.6 ± 1.5 sows/pen). Each pen was equipped with three computerized gestation feeders. Pens contained sows with different breed dates and treatments started when the first sows reached d 105 of gestation. Sows were weighed the day prior to the start of treatment and again upon entering farrowing. Sows were video recorded continuously, and video was analyzed on d 3 and 5 in six 2-h timeframes (0100 to 0300, 0500 to 0700, 0900 to 1100, 1300 to 1500, 1700 to 1900, and 2100 to 2300). Aggressive bouts were defined as: 1) sows knocking or pushing pen mates with their head; 2) sows mounting pen mates; or 3) sows forcefully biting ear, face, body, or vulva of pen mates. Sow vulva lesions were also recorded the day before exposure to treatment and then again on d 3 and 5 after exposure and finally upon entry to farrowing. Four sows per pen were selected and had body lesions and tear stain scores recorded the day before exposure to treatment. Body lesions were later assessed on d 3 and 5 after exposure and upon entry into farrowing. Tear stain scores were also recorded upon entry to farrowing. One sow per pen was selected based on average body condition and parity of the pen for determination of salivary cortisol levels on d 3 and 5. Those sows were followed through farrowing with one male and one female piglet of the average

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litter BW being analyzed for plasma and hair cortisol concentrations. Piglets were restrained on their backs for 3 min before blood collection to induce a stress response; immediately after, hair samples were taken from the rump and dorsal area. There were no observed treatment differences in sow BW, ADG, ADFI, or litter characteristics. Treatment induced no effects on sow aggression or salivary cortisol, along with hair and plasma cortisol concentrations in subsequent piglets. Regardless of treatment, there was an observed increase ($P < 0.01$) in vulva lesions as sows approached farrowing. Sows supplemented with an additional 0.24% SID Trp had a lower ($P = 0.029$) tear stain score on average compared with sows fed the control. Overall, a 0.24% increase of SID Trp (0.11% vs. 0.35%) in late gestation diets had no effects on sow performance or aggressive behavior, and minimal influence on physiological stress indicators in a group-housed environment under commercial production conditions.

Introduction

Implementation of gestation group housing has been on the rise in the swine industry with efforts to increase behavioral freedoms of sows. While sows are less restricted, this strategy led to an increased prevalence of aggressive behaviors, adding a new challenge for production systems. Research has been conducted surrounding gestation aggression[4],[5],[6]; however, most efforts have focused on strategies aimed to reduce aggression immediately after mixing when sows are still developing their social hierarchies[5]. Although aggression after mixing is still a concern, field reports have observed increases in vulva and body lesions as sows approach farrowing, attributed to late gestation aggression. Increased aggression just before farrowing is not only a welfare concern but may also lead to potential difficulties during parturition.

Supplementing Trp may be a practical strategy to reduce aggression in group-housed sows during late gestation. An essential amino acid, Trp is also the precursor for synthesis of serotonin, which, in excess, could potentially decrease aggressive behaviors between sows[7]. Previous research showed that supplementing Trp to sows 5 d before mixing and 2 d after mixing decreased aggression leading to a numerical reduction in the number of lesions observed[8]. However, no research has tested the impact of increased Trp on late gestation aggression. Therefore, the objective of this study was to evaluate the effects of increasing SID Trp by 0.24% in late gestation on sow performance, pen behavior, and physiological stress indicators of group-housed sows under commercial conditions.

[4] Stevens, B., G. M. Karlen, R. Morrison, H. W. Gonyou, K. L. Butler, K. J. Kerswell, and P. H. Hemsworth. 2015. Effects of stage of gestation at mixing on aggression, injuries and stress in sows. Anim. Behav. Sci. 165:40–46. doi:10.1016/j.applanim.2015.02.002.

[5] Greenwood, E. C., K. J. Plush, W. H. E. J. van Wettere, and P. E. Hughes. 2016. Group and individual sow behavior is altered in early gestation by space allowance in the days immediately following grouping. J. Anim. Sci. 94(1):385–393. doi:10.2527/jas.2015-9427.

[6] Verdon, M., R. S. Morrison, M. Rice, and P. H. Hemsworth. 2016. Individual variation in sow aggressive behavior and its relationship with sow welfare. J. Anim. Sci. 94(3):1203–1214. doi:10.2527/jas.2015-0006.

[7] Fernstrom, J. D. 1974. Modification of brain serotonin by the diet. Annu. Rev. Med. 25:1–8. doi:10.1146/annurev.me.25.020174.000245.

[8] Poletto, R., F. C. Kretzer, and M. J. Hötzel. 2014. Minimizing aggression during mixing of gestating sows with supplementation of a tryptophan-enriched diet. Physiol. Behav. 132:36–43. doi:10.1016/j.physbeh.2014.04.043.

Procedures

The Kansas State University Institutional Animal Care and Use Committee approved the protocol used in this experiment. The experiment was conducted at a commercial sow farm in Carthage, IL. Sows were housed in 18 pens, with each pen (36.66 × 27.66 ft) equipped with three computerized gestation feeders (Gestal; Jyga Technologies, St-Lambert-de-Lauzon, QC, Canada) and four cup drinkers to provide ad libitum access to water. Sows were fed to the set dietary treatment allocation and the allocation of feed each day began at 0100 in the computerized feed system.

Animals and diets

A total of 948 mixed-parity sows and gilts (1050, PIC) were used. Treatments consisted of: 1) control diet (corn-soybean meal-DDGS-based) containing 0.11% SID Trp and 2) control diet supplemented with 0.24% SID Trp (Table 1). All sows were fed 5.5 lb/day. Sows were housed in 18 pens with pens randomly assigned based upon parity and breed date to either the control (n = 9 pens/treatment with 52.3 ± 1.6 sows/pen) or the diet supplemented with Trp (n = 9 pens/treatment with 53.6 ± 1.5 sows/pen). Pens contained sows with different breed dates and treatments started when the first sows reached d 105 of gestation. Sows were weighed the day before the start of treatment and again upon entering the farrowing house. Litter counts were taken upon birth and then again at weaning to determine litter performance data.

Within each pen, four sows were selected based on average parity of the pen and average body condition to serve as the focal sows of the pen. These four sows had body lesions scored at initial weights, d 3, and d 5 after exposure to treatment and then upon entry to farrowing. The same four sows had tear stains scored when recording initial BW and again when entering farrowing. Sow body lesion was recorded on a scale of 0 to 3 with tear stains on a scale of 0 to 5 (Table 2). At initial weight, d 3, and d 5 after exposure to treatment and then upon entry to farrowing, all sows within the pen had vulva lesion scores recorded. Sow vulva lesion was recorded on a scale of 0 to 2. All scores were recorded by the same observers across the duration of the experiment.

Video analysis

Using video cameras (PAR-ALLTXIRA28WL: Fixed lens, IP67 Weatherproof, 2 Megapixel Turret, 2.8mm lens with 30fps (60Hz); Innovative Video Technology, Hauppauge, NY) connected to a network video recording system (PN3A-64FNH: NTSC/PAL, 64 Ch TVI NVR, AC110-240V; Innovative Video Technology, Hauppauge, NY), sows were video recorded continuously. Recorded video was analyzed on d 3 and 5 in six 2-h timeframes (0100 to 0300, 0500 to 0700, 0900 to 1100, 1300 to 1500, 1700 to 1900, and 2100 to 2300). Aggressive bouts were defined as: 1) sows knocking or pushing pen mates with their head; 2) sows mounting pen mates; or 3) sows forcefully biting ear, face, body, or vulva of pen mates and the number of aggressive bouts per h on a per pen basis was calculated.

Biological tissue and fluid analyses

Within each pen, one sow was chosen to have salivary cortisol levels analyzed. Saliva was collected between 0700 and 0900 on d 3 and 5 after exposure to treatment. Saliva samples were collected using Oasis Diagnostics Super-SAL Universal Saliva Collection Kit (Oasis Diagnostics, Vancouver, WA). Sows voluntarily chewed on the collection device until fully saturated. Samples were compressed into 2-mL containers and stored at -4.0°F on farm until samples were moved to the University of Missouri and stored at

-112.0°F until analysis. Samples were analyzed using a commercially available ELISA kit for salivary cortisol (IBL Cortisol Free in Saliva ELISA; Minneapolis, MN) following the manufacturer's instructions.

Sows selected for saliva collection were also tracked through farrowing for collection of piglet blood and hair cortisol. The day before weaning, all piglets within the litter were weighed and the male and female closest to the average weight of the litter were chosen for collection. Piglets were restrained on their back for 3 min to induce a stress response, and then blood samples were taken in tubes containing an anticoagulant (Greiner Bio-One North America Inc., Monroe, NC). Blood samples were spun down within 4 h of sample collection with plasma samples being stored at -112.0°F until further analysis. Cortisol analysis was performed on all plasma samples using an IBL America Cortisol ELISA Kit (IBL ELISA; Minneapolis, MN).

At the same time as blood collection, hair samples were collected for additional cortisol analysis. A hair sample was collected from the rump and dorsal area of the piglets and processed as previously described by Byrd et al.[9].

Statistical analysis

Sow performance data were analyzed using the lmer function from the lme4 package in RStudio [Version 4.0.2 (2020-06-22), R Core Team, R Foundation for Statistical Computing, Vienna, Austria] with pen serving as the experimental unit and sow as the observational unit. Treatment was used as a fixed effect in the model with pen serving as a random effect. Sow parity and days exposed to treatment were included as covariates in the model. Count data, including subsequent litter characteristics (total born, liveborn, stillborn, mummies, and weaned) were analyzed using a negative binomial distribution using a log link function.

Sow aggressive bouts, vulva lesions, body lesions, tear stains, sow salivary, piglet hair and plasma cortisol levels were summarized using the GLIMMIX procedure of SAS OnDemand for Academics (SAS Institute, Inc., Cary, NC). Aggressive bouts were reported as the number of interactions per h of video viewed. The model for aggressive bouts included treatment, day, time, and their interactions as fixed effects with time of pen loading as a random effect. Treatment, day, and their interactions were considered fixed effects for sow vulva, body lesion, and tear stain scores with initial scores used as a covariate. Sow salivary cortisol levels were log-transformed and then back-transformed to give estimated means. The model included treatment, day, and their interactions as fixed effects with time of pen loading as a random effect. The model for piglet plasma and hair cortisol levels included treatment as a fixed effect with time of pen loading and liveborn as random effects. Piglet plasma cortisol levels were log-transformed and then back-transformed to give estimated means. All results were considered significant with $P \leq 0.05$ and marginally significant with $0.05 < P \leq 0.10$.

[9] Byrd, M. H., L. F. Brito, J. Musa, S. Diggs, L. K. Senn, H. Wen, P. H. F. Freitas, J. L. Byrd, F. Tiezzi, C. Maltecca, Y. Huang, A. P. Schinckel, and J. S. Johnson. 2025. Characterizing the effects of gestational heat stress on reproductive efficiency and thermoregulation in replacement gilts divergently selected for thermotolerance in the F1 generation. J. Anim. Sci. 103:skaf353. doi:10.1093/jas/skaf353.

Results and Discussion

As expected, supplementing Trp in the experimental diet led to increased analyzed dietary Trp (0.12 vs. 0.41%; Table 1).

There were no differences in sow BW, ADG, or ADFI between treatments during late gestation (Table 3). No differences were observed in total born, born alive, mummies, stillborn, and number weaned.

There were no observed differences in body or vulva lesion scores between treatments. Regardless of treatment, there was an observed increase ($P < 0.001$) in vulva lesions as sows approached farrowing (Figure 1). Sows supplemented with 0.24% SID Trp had a lower ($P = 0.029$) tear stain score on average compared with sows fed the control diet (Figure 2).

Supplementing an additional 0.24% SID Trp did not affect sow salivary cortisol or piglet plasma and hair cortisol concentrations. There was no effect of treatment on total aggressive bouts. Regardless of treatment, aggressive interactions were reduced ($P < 0.01$) from d 3 to d 5 after treatment administration, with sows averaging 25.1 ± 1.2 versus 20.2 ± 1.2 aggressive interactions/h.

Overall, a 0.24% increase in SID Trp (0.11% vs. 0.35%) in late gestation diets had no effects on sow performance or aggressive behavior, and minimal influence on physiological stress indicators in a group-housed environment under commercial production conditions.

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Table 1. Diet composition (as-fed basis)

Item[1]	0.11% SID Trp	0.35% SID Trp
Ingredient, %		
Corn	62.59	62.35
Soybean meal, 47.7% CP	4.75	4.75
Corn DDGS	29.00	29.00
Calcium carbonate	1.89	1.89
Monocalcium phosphate, 21% P	0.22	0.22
Salt	0.47	0.47
L-Lys-HCl	0.28	0.28
L-Thr	0.05	0.05
L-Trp	0.02	0.26
Choline chloride, 60%	0.12	0.12
Vitamin and trace mineral with phytase[2]	0.25	0.25
Engage M[3]	0.05	0.05
Sal-curb[4]	0.33	0.33
Total	100.00	100.00
Calculated analysis		
Standardized ileal digestible amino acids, %		
Lys	0.58	0.58
Ile:Lys	76	76
Leu:Lys	246	246
Met & Cys:Lys	78	78
Thr:Lys	76	76
Trp:Lys	20	60
Val:Lys	95	95
His:Lys	58	58
NE, kcal/lb	1,117	1,119
CP, %	15.42	15.60
Crude fiber, %	3.5	3.5
NDF, %	13.90	13.88
ADF, %	5.35	5.35
Ca, %	0.84	0.84
STTD P, %	0.40	0.40
Chemical analysis[5]		
CP, %	15.37	15.53
Crude fiber, %	3.28	3.09
Trp, %	0.12	0.41

[1] Treatments consisted of: 1) control diet containing 0.11% SID Trp and 2) control diet supplemented with 0.24% SID Trp for total of 0.35% SID Trp.

[2] Quantum Blue (AB Vista, Plantation, FL), provided an assumed release of 0.14% STTD P with 750 FTU/kg in both diets.

[3] Calcium aluminosilicate, United Animal Health, Sheridan, IN.

[4] Formaldehyde solution and propionic acid, Kemin Industries, Des Moines, IA.

[5] Crude protein, crude fiber, and Trp analysis were analyzed in duplicate by University of Missouri Agricultural Experiment Station Chemical Laboratory.

Table 2. Scoring scale used to determine body lesions, vulva lesions, and tear staining

Body lesion scoring	
0	No injuries.
1	≤ 4 superficial injuries.
2	5 to 10 superficial injuries and/or less than 2 deep wounds.
3	≥ 11 superficial injuries and/or more than 3 deep wounds.
Vulva scoring	
0	No damage to the vulva.
1	Recent damage, including fresh or scabbed bite wounds but not including old scarring. Vulva lesion > 3 cm length or 1 cm diameter.
2	Deep tissue injury.
Tear stain scoring	
0	No signs of staining.
1	Staining is barely detectable and area stained does not extend below eyelid.
2	Staining is obvious and area stained is approximately < 50% of total eye area.
3	Staining is obvious and area stained is approximately 50 to 100% of total eye area.
4	Staining is severe, area stained is approximately ≥ 100% of total eye area, and area stained does not extend below the mouth line.
5	Staining is severe, area stained is > 100% of total eye area, and area stained extends below the mouth line.

Table 3. Effects of supplemental dietary tryptophan during late gestation on sow performance, litter characteristics, cortisol responses, and aggression in commercially group-housed sows

Item	0.11% SID Trp	0.35% SID Trp	SEM	*P* =
Sow performance[1]				
Initial BW, lb	566.3	556.3	5.58	0.224
Farrow entry BW, lb	591.3	582.9	6.11	0.346
ADG, lb	2.42	2.58	0.092	0.233
ADFI, lb	5.39	5.29	0.078	0.426
Litter characteristics				
Total born, n	17.04	17.34	0.200	0.297
Born alive, n	15.17	15.32	0.198	0.598
Stillborn, n	1.46	1.51	0.101	0.681
Mummies, n	0.39	0.46	0.040	0.208
Weaned, n	13.14	13.10	0.176	0.853
Cortisol[2]				
Sow salivary, ng/mL	6.9	7.2	0.79	0.800
Piglet plasma, ng/mL	43.4	40.3	6.82	0.750
Piglet hair, pg/mg	5.7	7.8	1.46	0.160
Aggression				
Total bouts, interactions/h	22.6	22.6	1.40	0.710

[1] A total of 948 mixed-parity sows and gilts (1050, PIC) were used to evaluate the effects of supplemental dietary tryptophan fed the last two weeks of gestation. ADG and ADFI were measured from when first sows within pen reached d 105 of gestation, until all sows entered farrowing.

[2] All samples were analyzed for cortisol at the University of Missouri Stress Physiology Lab, Columbia, MO.

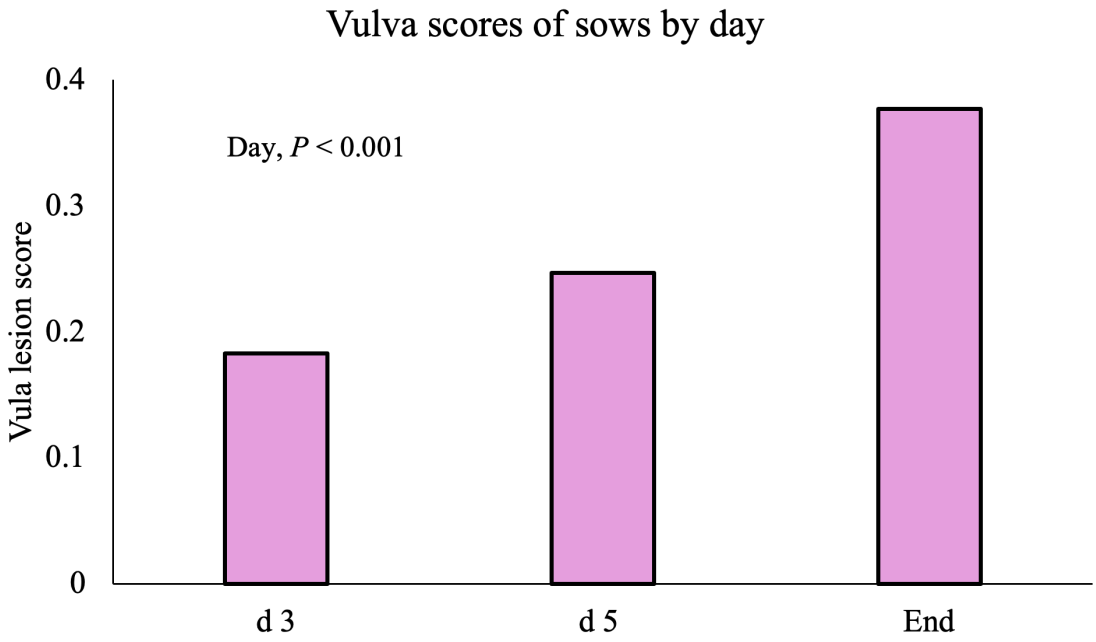


Figure 1. Vulva scores presented on 0 to 2 scale: 0 = No damage to vulva; 1 = Recent damage, including fresh or scabbed bite wounds but not including old scarring, vulva lesion > 3 cm length or 1 cm diameter; and 2 = Deep tissue injury. Scores of sow vulvas were recorded the day before starting treatment (d 0), then on d 3 and 5 after exposure to treatment, and upon entry into farrowing. Treatment × day, P = 0.491; Treatment, P = 0.856.



Figure 2. Tear stain scores of focal sows presented on 0 to 5 scale. 0 = no signs of staining; 1 = staining is barely detectable and area stained does not extend below eyelid; 2 = staining is obvious and area stained is approximately < 50% of total eye area; 3 = staining is obvious and area stained is approximately 50 to 100% of total eye area; 4 = staining is severe, area stained is approximately ≥ 100% of total eye area, and area stained does not extend below the mouth line; and 5 = staining is severe, area stained is > 100% of total eye area, and area stained extends below the mouth line. Scores of sow tear stains were recorded the day before starting treatment, and again upon entry into farrowing.