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Summary
A total of 105 sows (Line 241, DNA) were used across four batch farrowing groups to evaluate the effects of feeding a feed flavor in lactation diets on sow and litter performance. Sow groups 1 and 2 farrowed in an old farrowing house during the summer months and groups 3 and 4 farrowed in a new farrowing house during the winter months. The farrowing house used for groups 1 and 2 was environmentally regulated by fans and drip coolers to adjust ambient temperature. The farrowing house used for groups 3 and 4 was environmentally controlled to maintain a target temperature by cool cells and fans. Sows were blocked by BW within parity on d 110 of gestation and allotted to 1 of 2 dietary treatments. Dietary treatments were a standard corn-soybean-based lactation diet (control) or the control diet with the addition of 0.05% feed flavor (Krave AP, Adisseo, Alpharetta, GA). Sows were fed their treatment diet from entry to the farrowing house (d 110 of gestation) until weaning at around 19 days of age. Farrowing house environment had a large impact and resulted in many interactions with the lactation feed flavor treatment. Sows fed the flavor treatment had a tendency ($P = 0.093$) for a higher ADFI overall compared with control fed sows. Adding the feed flavor to the diet increased feed intake and piglet ADG in an environment that was warmer where feed intake was suppressed, but had no effect in the new farrowing house where feed intake of all sows was much greater.

Introduction
Maximizing sow lactation feed intake is important to increase litter growth performance and minimize sow weight loss. Krave AP (Adisseo USA, Alpharetta, GA) is a feed additive formulated from a specific combination of natural and artificial flavoring compounds believed to be attractive to pigs. Research conducted in Brazil showed that supplementing sow diets with Krave AP increased lactation ADFI by 29%, resulting in a 4% increase in number of pigs weaned, 19% increase in average piglet weaning weight, and 24% increase in litter weaning weight.[2] If these results can be confirmed in diets

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[2] Silva, B. A. N., R. L. S. Tolentino, S. Eskinazi, D. V. Jacob, F. S. S. Raidan, T. V. Albuquerque, N. C. Oliveira, G. G. A. Araujo, K. F. Silva, & P. F. Alcici. 2018. Evaluation of feed flavor supplementation on performance of lactating high-prolific sows in a tropical humid climate. Animal Feed Science and Technology. 236: 141-148. https://doi.org/10.1016/j.anifeedsci.2017.12.00.

and management styles typical of U.S. production, the opportunity for greater sow feed intake, weaning weights, and post-weaning performance would be well received by producers. However, to our knowledge, there is no research conducted with Krave AP under U.S. conditions. Therefore, the objective of this study was to determine the effect of supplementing Krave AP in sow lactation diets on sow feed intake, sow weight and backfat change, and litter performance.

Procedures

The Kansas State University Institutional Care and Use Committee approved the protocol used in this experiment. The study was done at the Kansas State University Swine Teaching and Research Center in Manhattan, KS. The study began in June 2021, with the first two groups of sows farrowing in the K-State Swine Teaching and Research Center's old farrowing house. Groups 1 and 2 farrowed in June and July, 2021. Groups 3 and 4 farrowed in the K-State Swine Teaching and Research Center's new farrowing house in November 2021, and January 2022. Groups 1 and 2 farrowed in an older farrowing house that was environmentally regulated by using fans and drip coolers to adjust ambient temperature, whereas groups 3 and 4 farrowed in a new farrowing house that utilized cool cells to maintain target temperatures. Daily temperature and humidity measurements were taken at a rate of one measurement per hour during lactation using a USB Logger (EasyLog, EL-USB-2, Erie, PA). The average temperature in the farrowing house for the two groups that farrowed in the summer was 82.1°F with a standard deviation of 5.5°F. The average relative humidity was 62.1% with a standard deviation of 10.5%. The average temperature in the farrowing house for the groups that farrowed in the winter was 74.5°F with a standard deviation of 1.4°F. The average relative humidity was 38.5% with a standard deviation of 5.8%. Sows in groups 1 and 2 were housed in individual farrowing stalls that measured 5 × 7 ft including sow and creep area. Stalls were equipped with a dry self-feeder with feed being delivered, as requested by the sow, through an automated feed system (Gestal Solo Feeder, Jyga Technologies, St-Lambert-de-Lauzon, Quebec, Canada) and a cup waterer. Sows in groups 3 and 4 were housed in individual farrowing stalls that measured 6 × 8 ft including sow and creep area, equipped with a dry self-feeder with a similar automated feed system (Gestal Quattro Opti Feeder, Jyga Technologies, St-Lambert-de-Lauzon, Quebec, Canada) and a pan waterer. Creep feed was not offered to piglets throughout the trial.

Animals and diets

A total of 105 mixed parity sows (DNA 241) and litters (DNA 241 × 600) were used. Sows were blocked by BW within parity and allotted to 1 of 2 dietary treatments that included a standard corn-soybean-based lactation diet (control), or the control diet with the addition of 0.05% feed flavor (Krave AP, Adisseo, Alpharetta, GA) added at the expense of corn. All diets were formulated to meet or exceed the NRC[3] requirement estimates and were manufactured at Hubbard Feeds (Beloit, KS; Table 1). Sows were fed approximately 6 lb of their allotted diet from d 110 until farrowing (approximately d 116) and provided *ad libitum* access to water. After farrowing, sows were given *ad libitum* access to their dietary treatment and water. Sows were moved to the farrowing house on d 110 of gestation, at which time they were weighed, backfat was measured

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

using a backfat probe (Renco Lean-Meater, Golden Valley, MN), and caliper scores were recorded. Backfat and caliper scores were measured at the last rib, with the backfat probe measurement being taken four inches from the midline on both sides of the sow and then averaged to derive one composite measurement per sow. After farrowing and weaning, sow weights were also recorded. Backfat measurements and caliper scores were recorded again at weaning. Feed was provided with the Gestal volumetric feeders previously mentioned and intake was confirmed by feed additions and weigh back of feed tubs at farrowing, d 10, and at weaning.

Piglet processing and cross fostering was done within treatment group to equalize litter size within 48 hours of birth. Litter size and weight were recorded at farrowing, on d 2 and 10 after farrowing, and at weaning. Piglet survivability was determined by dividing the number of piglets weaned by the number of piglets after cross fostering. The wean-to-service interval (WEI) of each sow was recorded.

Statistical analysis

Performance data were analyzed using R software, version 1.4.171 a randomized complete block design. Sow and litter were considered the experimental unit. Treatment was a fixed effect and block (sow BW within parity) was considered a random effect. Litter born alive, stillborn, born mummified and pre-weaning mortality were analyzed using a binomial distribution. Treatment comparisons were determined considering the interaction of the diet by season and farrowing location (groups 1 and 2 vs. groups 3 and 4). Four sows on the flavor diet had to be taken off test due to refusal to eat the treatment diet, all housed in the older farrowing house during the summer months. Results are considered significant at $P \le 0.05$ and marginally significant at $0.05 < P \le 0.10$.

Results and Discussion

There were interactions observed between dietary treatment and season/farrowing house for both sow and litter performance (Table 2 and 3). There was a tendency ($P = 0.061$) for an interaction between sow treatment and season/farrowing house on sow BW change from entry to farrow. Sows fed the control diet in the new farrowing house during winter had lower BW change compared to those fed the flavor diet, but there was no difference between dietary treatments when sows were housed in the older farrowing house during the summer months. An interaction was observed for sow ADFI from farrow to d 10 ($P = 0.048$) as well as tendency from farrow to wean ($P = 0.058$) where sows fed the diet with the flavor had increased feed intake in the old farrowing house in the summer months whereas the opposite was observed when sows were in the new farrowing house in winter months. A tendency for an interaction for WEI was observed ($P = 0.084$) where feed flavor reduced WEI in the old farrowing house in the summer, but increased WEI in the new farrowing house during the winter months. Even though an interaction was found, average WEI only ranged from 4.1 to 4.3 d for all treatments.

Interactions between dietary treatment and season/farrowing house were found on litter performance for litter size at d 2, d 10, and wean ($P < 0.05$) where larger litter sizes were observed in the old farrowing house for both the control and flavor diet compared to the new farrowing house, with the sows on the flavor diet in the old farrowing house having the highest litter size for all time points. There was an interaction ($P = 0.026$) for litter weight at d 2 with litters from sows fed the flavor diet in the new farrowing house during winter having greater d 2 litter weight compared to those litters from sows fed the control diet. There was no difference in d 2 litter weight when sows were housed in the old farrowing house during the summer months. An interaction was observed for mean piglet body weight at weaning ($P = 0.026$) where piglet BW increased when sows were fed the flavor diet in the old farrowing house in summer months but decreased in sows fed the flavor diet in the new farrowing house in winter months when compared to the control sow litters. There was an interaction ($P = 0.001$) for piglet ADG from d 2 to weaning where piglets from sows on the flavor diet had a greater ADG compared to piglets from sows on the control diet in the old farrowing house but the opposite was observed in the newer farrowing house. There was a tendency for an interaction ($P = 0.095$) for preweaning mortality from birth to d 2, where piglets from sows fed the flavor diet had a greater percent mortality when housed in the old farrowing house during the summer months compared to the new farrowing house during the winter months. Lastly, an interaction ($P = 0.001$) was observed between treatment and season/farrowing house environment on preweaning mortality from d 2 to weaning with piglets from sows fed the flavor diet having lower mortality when housed in the old farrowing house in the summer months compared to piglets from sows fed the control diet, but higher mortality when housed in the new farrowing house in the winter months.

In addition to the interactions, there were main effects observed for season/farrowing house. When sows and litters were housed in the older farrowing house during the summer months, they tended ($P = 0.073$) to lose more weight from entry to farrow and have a lower ($P = 0.078$) caliper score at weaning; sow ADFI was lower ($P < 0.05$) from farrow to weaning; total born was higher ($P = 0.036$); litter size was higher for all 4 timepoints ($P < 0.05$); litter weight at d 2 was higher ($P = < 0.001$); piglet BW was lower at d 10 ($P = 0.044$) and weaning ($P = 0.005$); litter ($P = 0.019$) and piglet ($P = < 0.001$) ADG was lower and preweaning mortality from d 2 to wean was greater ($P = 0.001$) compared to sows and litters housed in the newer farrowing house during the winter months.

Main effects were also observed for the feed flavor treatment. When sows were fed diets containing the feed flavor, ADFI from farrow to d 10 ($P = 0.052$), farrow to wean ($P = 0.052$), and overall lactation ADFI tended to be greater ($P = 0.093$). Litter size was greater ($P = 0.012$) on d 2 and tended to be greater ($P = 0.063$) on d 10 when sows were fed the flavor diet. Day 10 piglet BW of piglets from sows fed the flavor diet tended to be greater ($P = 0.087$) and was significantly greater ($P = 0.039$) at weaning compared to piglets from sows fed control diets. Litter ADG tended ($P = 0.093$) to be greater and piglet ADG was greater ($P = 0.005$) for piglets from sows fed the flavor diet overall. Preweaning mortality of piglets from sows fed diet containing a fed flavor were greater from birth to d 2 ($P = 0.038$) and d 2 to wean ($P = 0.005$) compared to piglets from sows fed the control diet.

In conclusion, sows fed the flavor diet tended to have greater overall ADFI. The differences in feed flavor response between season and environment suggests that adding Krave AP to the lactation diet in situations where sow lactation ADFI is lower than optimal, could lead to improvements in sow and litter performance.

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

Ingredients, %	Lactation diet
Corn	64.50
Soybean meal	30.00
Corn oil	2.00
Calcium carbonate	0.90
Monocalcium P (21% P)	1.15
Sodium chloride	0.50
L-Lys-HCl	0.20
DL-Met	0.05
L-Thr	0.07
L-Trp	0.01
Vitamin premix with phytase	0.25
Trace mineral premix	0.15
Sow add pack	0.25
Feed flavor[2]	+/-
Total	100.0
Calculated analysis	
SID amino acids, %	
Lys	1.07
Ile:Lys	67
Leu:Lys	140
Met:Lys	30
Met and Cys:Lys	56
Thr:Lys	63
Trp:Lys	20.7
Val:Lys	73
His:Lys	44
Total Lys, %	1.21
ME, kcal/lb	1,526
SID Lys:NE, g/Mcal	4.25
CP, %	19.9
Ca, %	0.77
P, %	0.63
STTD P, %	0.52

[1]Feed was manufactured by a commercial feed mill (Hubbard Feeds; Beloit, KS).

[2]Krave AP, Adisseo (Alpharetta, GA) included at 0.05% in feed flavor diet.

Table 2. Interactive effects of lactation diets with or without a feed flavor and farrowing house environment on sow performance[1]

Farrowing environment[2]:	Old/Summer		New/Winter			*P* =		
Sow treatment[3]:	Control	Flavor	Control	Flavor	SEM	Flavor × farrowing house	Flavor	Farrowing house
Count, n	27	23	28	27				
Parity	2.5	2.5	2.5	2.5	0.42	0.376	0.266	0.997
Lactation length, d	19.0	19.1	18.8	19.2	0.20	0.525	0.908	0.491
Sow BW, lb								
Entry	579.7	586.2	577.5	579.5	24.2	0.762	0.640	0.949
Farrow	524.9	532.3	535.6	525.9	23.2	0.236	0.286	0.748
Wean	502.5	505.0	510.5	508.8	23.9	0.807	0.807	0.814
Sow BW change, lb								
Entry to farrow	-54.8	-53.8	-39.1	-53.9	6.1	0.061	0.208	0.073
Farrow to wean	-22.3	-25.7	-29.0	-16.9	6.2	0.189	0.317	0.414
Entry to wean	-77.1	-79.9	-67.5	-71.2	7.6	0.945	0.922	0.360
Sow backfat, mm								
Entry	15.2	14.8	15.5	15.4	0.42	0.686	0.566	0.575
Wean	13.5	12.8	14.0	13.7	0.44	0.707	0.473	0.370
Change (entry to wean)	-1.7	-1.9	-1.5	-1.7	0.36	0.973	0.821	0.668
Sow caliper score								
Entry	15.9	15.6	16.1	16.3	0.31	0.450	0.437	0.527
Wean	14.0	13.5	14.8	14.7	0.36	0.629	0.453	0.078
Change (entry to wean)	-1.9	-2.1	-1.3	-1.6	0.28	0.821	0.911	0.107
Sow ADFI, lb								
Pre-farrow	6.4	6.5	5.9	6.1	0.27	0.890	0.908	0.216
Farrow to d 10	9.4	10.4	14.6	13.9	0.48	0.048	0.052	< 0.001
d 10 to wean	13.4	14.3	19.1	18.9	0.62	0.256	0.205	< 0.001
Farrow to wean	11.3	12.2	16.7	16.3	0.47	0.058	0.052	< 0.001
Overall	10.3	11.0	14.4	14.2	0.39	0.125	0.093	< 0.001
Wean-to-estrus interval, d	4.2	4.1	4.1	4.3	0.09	0.084	0.171	0.326

[1]A total of 105 mixed-parity sows (DNA 241) and litters were used from day 110 of gestation until weaning.
[2]Two different farrowing houses were used in this study. Sow groups 1 and 2 were farrowed in an older farrowing house in June and July 2021, and groups 3 and 4 were farrowed in a new farrowing house in November 2021 and December 2022.
[3]Sow treatment consisted of providing a control diet or the control diet with added Krave AP at 0.05% of diet (Adisseo, Alpharetta, GA) from entry into the farrowing house (d 110 of gestation) until weaning.

Table 3. Interactive effects of lactation diets with or without a feed flavor and farrowing house environment on sow performance[1]

Farrowing environment[2]	Old/Summer		New/Winter			*P* =		
Sow treatment[3]	Control	Flavor	Control	Flavor	SEM	Flavor × farrowing house	Flavor	Farrowing house
Litter characteristics								
Total born, n	17.0	17.6	14.3	16.7	0.92	0.140	0.500	0.036
Born alive, %	90.2	91.0	90.4	88.5	0.02	0.354	0.438	0.911
Stillborn, %	6.8	8.2	6.3	9.5	0.01	0.527	0.967	0.790
Mummy, %	2.6	0.6	2.9	1.6	0.01	0.297	0.098	0.796
Litter size, n								
d 0	15.3	15.9	12.8	14.8	0.76	0.246	0.691	0.019
d 2	14.8	14.8	12.3	14.3	0.34	< 0.001	0.012	< 0.001
d 10	14.0	14.1	12.1	13.6	0.26	0.002	0.063	< 0.001
Wean	13.5	13.7	12.0	13.4	0.27	0.027	0.238	< 0.001
Litter weight, lb								
d 2	53.4	53.7	44.6	50.9	1.74	0.026	0.188	< 0.001
d 10	98.8	105.2	95.5	104.4	3.83	0.650	0.668	0.533
Wean	154.2	164.2	161.3	169.2	5.83	0.802	0.360	0.380
Mean piglet BW, lb								
d 2	3.6	3.7	3.6	3.6	0.13	0.613	0.642	0.879
d 10	7.1	7.5	7.9	7.7	0.30	0.111	0.087	0.044
Wean	11.4	12.1	13.5	12.8	0.49	0.026	0.039	0.005
Litter ADG d 2 to wean, lb/d	5.29	5.78	6.21	6.17	0.27	0.162	0.093	0.019
Piglet ADG d 2 to wean, lb/d	0.39	0.43	0.52	0.47	0.02	0.001	0.005	< 0.001
Preweaning mortality, %								
Birth to d 2	2.8	6.2	3.4	3.2	0.01	0.095	0.038	0.680
d 2 to wean	8.7	6.4	2.0	7.4	0.02	0.001	0.005	0.001

[1]A total of 105 mixed-parity sows (Line 241, DNA, Columbus NE) and litters were used from day 110 of gestation until weaning. Litters were cross fostered to equalize litter size up to 48-h post farrowing within treatment group.
[2]Two different farrowing houses were used in this study. Sow groups 1 and 2 were farrowed in an older farrowing house in June and July 2021, and groups 3 and 4 were farrowed in a new farrowing house in November 2021 and December 2022.
[3]Sow treatment consisted of providing a control diet or the control diet with inclusion of Krave AP at 0.05% of diet (Adisseo, Alpharetta, GA) from entry into the farrowing house (d 110 of gestation) until weaning.