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ANIMAL

Effects of varying the dietary valine : lysine ratios on the performance of lactating sows and their litters

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Abstract

A total of 18 sows with an average body weight (BW) of 211.6 kg (within 24 h after farrowing) were used for a 5-week experiment to determine the effects of the dietary valine : lysine (V : L) ratios on the performance and fecal score in lactating sows and litters. Sows were raised in individual pens and assigned to one of three experimental diets consisting of different V : L ratios (0.83, 0.85, and 0.88%). Sows BW was improved with the 0.85% V : L ratio compared to the 0.83 and 0.88%. However, no significant difference was observed for BW loss, average daily feed intake, back fat thickness and days to return to estrus among the three treatment groups during the experiment period. Furthermore, the growth performance of the piglets, the weaning weight, was improved in the group receiving the diet with the 0.85% V : L ratio compared to the 0.83 and 0.88%. Moreover, the average daily gain of the piglets was increased when the V : L ratio was 0.88% compared to 0.83 and 0.85%. The fecal score of the sows was better ($p > 0.05$) when the V : L ratio was 0.85% compared to the V : L ratio of 0.83%. In the piglets, the V : L ratios 0.88 and 0.85% had a better fecal score compared to the V : L ratio of 0.83% at day 14. In conclusion, the V : L ratio had no effect on the gut microflora shown by the fecal scores of the sows during lactation.

Keywords: estrus, lactating sows, litters, lysine, valine

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Introduction

The essential amino acids (EAA) are very important in the animal product industry, because the relative deficiency of one or more of the EAA in animal diets would have a limiting effect on animal growth and thus on animal feed conversion ratio. Thus, several feed stuffs may be fed in combination to improve net protein utilization, or a supplement of a separate amino acid (AA) can be mixed to the feed. Valine is the second limiting AA in higher protein diets for the lactating sows (Tokach et al., 1993). It is a part of the branch-chain AA (BCAA) group, BCAAs are known to repair tissues, control blood sugar, and supply energy to the animal's body (Greiner et al., 2019). Moreover, Lysine is the first limiting AA in corn and soybean diets-based sows feeds, although maternal growth accounts for a higher daily nutrient intake in primiparous sows consume less feed than multi parous sows (Gourley

et al., 2017). Although, Paulicks et al. (2003) and Strathe et al. (2016) reported an effect on only piglet growth, milk yield, and sow body weight (BW) by increasing the total valine : lysine (V : L) ratio from 0.45 : 1 to 0.55 : 1, but no effect was observed when further increasing the ratio from 0.64 : 1 to 1.44 : 1. Moreover, Eggum et al. (1998) reported that feeding growing pigs with a diet supplying an optimal AA composition (i.e., without too much amounts of non-limiting AAs) had increase the utilization of dietary protein by pigs and control the incidences of diarrhea. In the present study, the dietary supplementation of increasing level of valine to corn-soybean meal-based diet calculated to have variable V : L ratios (0.83, 0.85, and 0.88) were evaluated for their effects on the performance of lactating sows and their litters.

Materials and Methods

The animal care protocol was approved by the Laboratory Animal Care Committee of the Dankook University, South Korea.

Experimental animal preparation

A total of 18 sows (Landrace × Yorkshire) with an average BW of 211.6 kg (within 24 h after farrowing) were selected for this study. Basal gestation diet were provided to the gestating sows until farrowing, and also same diet followed during lactation period from 1st day of weaning to 6th day. Sows were moved into farrowing crates regulated in the farrowing house. All sows were allocated into one of the three treatments (6 sows·treatment^{-1}).

Formulated diets

Diets were based on corn and soy bean meal (Table 1) and formulated with V : L ratios of 0.83, 0.85, and 0.88. Dietary valine was increased by the addition of L-valine. The calculated ratio of various essential AA to lysine and different nutrients exceeded the NRC (2012) recommendations.

Animal husbandry

Farrowing cage (2.1 m × 0.6 m) contained an area for newborn pigs on each side after birth, and the minimum temperature in the farrowing room was maintained at 20 ± 2℃. Supplemental heat was provided for piglets. Each farrowing cage had a water nibble and a feeder. Piglets were treated according to repeating management practices that included tail docking, ear notching, teeth clipping, and subcutaneous iron dextran injections (50 mg·pig^{-1}) within 24 h. On the day of parturition, sows were not offered any feed. Sows were fed with 1.2 kg lactation diet on the first day and 2.4 kg on the second day after farrowing. The daily feed allowance was increased gradually by 1.2 kg·day^{-1}. After 6 days of farrowing, sows were provided *ad libitum* feed and water until lactation. After weaning, per day 4 kg feed was provide to each sow.

Table 1. Ingredient composition of experimental diets.

Ingredient	VL 0.83	VL 0.85	VL 0.88
Corn	65.12	65.08	65.05
Soybean meal	26.10	26.10	26.10
Animal fat	1.73	1.73	1.73
Molasses	3.20	3.20	3.20
Dicalcium phosphate	1.40	1.40	1.40
Limestone	1.05	1.05	1.05
L-lysine	0.13	0.14	0.14
DL-methionine	0.10	0.10	0.10
L-threonine	0.20	0.20	0.20
L-tryptophan	0.03	0.03	0.03
L-valine	0.06	0.09	0.12
Salt	0.60	0.60	0.60
Vitamin premix[y]	0.10	0.10	0.10
Mineral premix[z]	0.10	0.10	0.10
Choline	0.08	0.08	0.08
Total	100.00	100.00	100.00
Calculated composition			
Metabolizable energy (kcal·kg^{-1})	3.30	3.00	3.00
Crude protein (%)	17.40	17.40	17.40
Crude fiber (%)	3.21	3.21	3.21
SID lysine (%)	0.98	0.98	0.98
SID methionine (%)	0.34	0.34	0.34
SID valine (%)	0.81	0.84	0.87
SID valine : lysine	0.83	0.85	0.88
Ca (%)	0.84	0.84	0.84
P (%)	0.58	0.58	0.58

VL, valine and lysine; SID, standardized ileal digestible.

[y] Provided per kg of complete diet: 11,025 IU vitamin A; 1,103 IU vitamin D3; 44 IU vitamin E; 4.4 mg vitamin K; 8.3 mg riboflavin; 50 mg niacin; 4 mg thiamine; 29 mg d-pantothenic; 166 mg choline; 33 μg vitamin B12.

[z] Provided per kg of complete diet: 12 mg Cu (as $CuSO_4 \cdot 5H_2O$); 85 mg Zn (as $ZnSO_4$); 8 mg Mn (as MnO_2); 0.28 mg I (as KI); 0.15 mg Se (as $Na_2SeO_3 \cdot 5H_2O$).

Sampling and measurements

Sows were weighed within 24 h after farrowing, at weaning (d 21) and after weaning 6 days. Back fat of sows was measured 6 cm off the center on two sides of the body at the tenth rib to determine back fat thickness within 24 h after farrowing, at weaning and after weaning 6 days. Sows feed intake was recorded every day to determine the daily feed intake during lactation and from the weaning day to after weaning 6 days. On the day of weaning, sows were transferred to an environmentally maintained breeding facility for observation. The return-to-estrus gap was recorded for individual sow up to 7 days after weaning. Sows were not expressing estrus within 7 days after weaning were assigned a value of 7 days for return to estrus.

After farrowing, piglets were sorted to each sow 10 piglets. The number of piglets for every sow was recorded at the day of farrowing to the weaning day (d 24) to evaluate the survival rate of piglets at weaning. To ensure that all piglets maintain the same number of piglets (approximately 10 piglets per sow), litter levels were adjusted by divided piglets within 24 hours of birth. Weight gain of litters was calculated by withdrawing birth weight from weaning weight. Feed was not offered to litters. Sows fecal score was observed and recorded at farrowing, weaning and after weaning 6 days. Fecal score of litters was observed and recorded from 7, 14, and 21 d of age.

Statistical analysis

All data were analyzed by GLM procedures of SAS (2000). Each pig was used as the experimental unit. Differences among all treatments were tested by Duncan's multiple range test. A probability level of ($p < 0.05$) was considered to be statistically influenced.

Results

Reproduction performance of sows

The result of the reproduction performance of sows is presented in Table 2. Sows BW, after farrowing, weaning and finishing were significantly improved ($p > 0.05$) by V : L ratio 0.85 compared to V : L. 0.83 and 0.88. However, BW loss, average daily feed intake and sows back fat thickness, were not affected by varied dietary V : L ratios during the experiment period. Days of returning to estrus and parity also not affected by the three dietary treatments.

Table 2. Effect of the standardized ilegal digestible (SID) valine: lysine ratios on reproduction performance in lactation sows[x].

Item	VL 0.83	VL 0.85	VL 0.88	SEM	p-value
Parity	3.0	3.0	3.0	0.00	0.000
Sow's body weight (kg)					
After farrowing	211.6	222.7	200.4	0.28	< 0.0001
Weaning	205.3b	216.4a	194.2c	0.13	< 0.0001
Finishy	210.9b	221.6a	199.3c	0.27	< 0.0001
Body weight loss1[y]	6.3a	6.3a	6.2b	0.14	0.643
Body weight loss2[y]	5.6a	5.2b	5.2b	0.21	0.360
Average daily feed intake (kg)					
Lactation	6.65	6.93	6.63	0.19	0.496
Finish	3.38	3.40	3.39	0.17	0.990
Back fat thickness (mm)					
After farrowing	19.6	19.8	20.3	0.16	0.740
Weaning	17.0b	17.7a	17.8a	0.24	0.105
Finish	17.6c	18.3b	18.6a	0.29	0.103
Back fat thickness loss1[z]	2.6	2.2	2.5	0.12	0.119

SEM, standard error of means.

[x] VL 0.83, SID valine : lysine ratio = 0.83; VL 0.85, SID valine : lysine ratio = 0.85; VL 0.88, SID valine : lysine ratio = 0.88.

[y] Finish, after weaning 6 days; Body weight loss: 1, after farrowing to weaning; 2, weaning to finish.

[z] Backfat thickness loss: 1, after farrowing to weaningz, weaning to finish. Each treatment was used in 6 sows.

a - c: Means in the same row with different superscripts differ ($p < 0.05$).

Growth performance of piglets

The survivability rate of piglets was significantly improved by V : L ratio of 0.85 compared to the V : L ratio of 0.83 and 0.88 (Table 3). Moreover, the number of litter per head at weaning was as well as BW at weaning were significantly higher in piglets born to sows fed diet having V : L ratio of 0.85 ratio compared to the V : L ratio of 0.83 and 0.88. However, the BW of piglets born to sows fed diet having varying V : L ratio diets were not affected at farrowing. However, BW of farrowing and weaning were not affected by 0.83, 0.85 and 0.88% of V : L ratio. And average daily gain was significantly improved ($p < 0.05$) by V: L 0.88 compared to the Val : Lys ratio of 0.83 and 0.85.

Table 3. Effect of dietary valine: lysine ratios on growth performance in nursery pigs[z].

Item	VL 0.83	VL 0.85	VL 0.88	SEM	p-value
SUR (%)	92.9	98.3	91.7	0.08	< 0.0001
Litter (head)					
Initial	10.0	10.0	10.0	0.00	0.000
Weaning	9.3b	9.8a	9.2b	0.12	0.025
Body weight (kg)					
Farrowing	1.30	1.26	1.27	0.10	0.968
Weaning	7.72b	7.75b	7.92a	0.36	0.910
Average daily gain (g)	268c	270b	277a	0.40	< 0.0001

Each treatment was used in 6 sows.

SEM, standard error of means; SUR, survival rate at farrowing to weaning.

[z] V L0.83, standardized ilegal digestible (SID) valine : lysine ratio = 0.83; VL 0.85, SID valine : lysine ratio = 0.85; VL 0.88, SID valine : lysine ratio = 0.88.

a - c: Means in the same row with different superscripts differ ($p < 0.05$).

Fecal score of sows and nursery pigs

The effect of dietary V : L ratios on fecal scores of sows and nursery pigs is shown in (Table 4). After farrowing sows fecal score was significantly ($p < 0.05$) improved by V : L 0.88 compared to the V : L ratio of 0.83 and 0.85. However, at weaning and finish (6 days after weaning) sow's fecal score was not affected by dietary treatments. The fecal score of piglets on the 14th day was significantly ($p < 0.05$) improved by V : L 0.83 ratio compared to the V : L ratio of 0.85 and 0.88% and during 17th, 21 day, fecal score in piglets were not significantly affected by varying valine and lysine ratios.

Discussion

In the present study, we evaluated the effect of different V : L ratios on the reproduction performance of sows, growth performance of piglets and fecal score of sows and nursery pigs.

In present study the sow's BW was significantly higher receiving diet 0.83, 0.85, and 0.88 V : L ratio. Richert et al. (1997a; 1997b) reported that dietary V : L ratios 0.75 to 1.20% did not affect sows BW. In addition, varying 0.80 and 0.85 of V : L ratio had no effected on sow BW (Devi et al., 2015). The inconsistency in the findings may be due to the different age and different BW of the sows.

Table 4. Effect of dietary Valine: Lysine ratios on fecal score in sows and nursery pigs[y].

Item	VL 0.83	VL 0.85	VL 0.88	SEM	p-value
Sows					
Farrowing	2.8b	2.7c	2.9a	0.04	0.021
Weaning	2.8	2.8	2.8	0.00	0.000
Finish[z]	2.8	2.8	2.8	0.00	0.000
Piglets					
d 7	3.5a	3.5a	3.4b	0.04	0.196
d 14	3.5a	3.1c	3.2b	0.07	0.013
d 21	3.4a	3.2b	3.4a	0.08	0.220

Each treatment was used in 6 sows.

SEM, standard error of means.

[y] VL 0.83, standardized ilegal digestible (SID) valine : lysine ratio = 0.83; VL 0.85, SID valine : lysine ratio = 0.85; VL 0.88, SID valine : lysine ratio = 0.88; Fecal score: 1 = hard, dry pellets in a small, hard mass; 2 = hard, formed stool that remains firm and soft; 3 = soft, formed, and moist stool that retains its shape; 4 = soft, unformed stool that assumes the shape of the container; 5 = watery, liquid stool that can be poured.

[z] after weaning.

a - c: Means in the same row with different superscripts differ ($p < 0.05$).

In the current research, sows BW loss, ADFI, back fat thickness, and back fat thickness loss were not affected by different V : L ratios. Similarly, Strathe et al. (2015) also reported that increasing dietary V : L ratio in lactating sows diet, showed no effects on sow BW loss, litter performance or back fat loss among dietary treatments as standardized ilegal digestible (SID) V : L ratios of 0.76, to 0.97. However, Xu et al. (2016) reported that the V : L ratio (63, 83, 103, and 123%) of SID did not affect the sows BW loss and decreased back fat thickness loss. However, Moser et al. (1998) showed that sows BW loss and ADFI were unaffected, also higher concentration of valine from 80% to 1.20% sows back fat loss increased. Gourley et al. (2017) showed that SID Lys increasing to 1.20% decreased sows BW loss. Boessen et al. (2018) and Devi et al. (2015) reported that sows back fat thickness, back fat thickness loss, and ADFI was not affected by different level of V : L (0.50 to 1.00 %). Moreover, the previous experiment demonstrated an increased in sows ADFI when the V : L ratio increased by (Xu et al., 2016). The reason of the present study may be due to the V : L concentration and room environmental conditions.

In the current study the survival rate was significantly improved in piglets born to weaning stage sows fed with V : L 0.85. Similarly, the previous result was observed by on the other hand Devi et al. (2015) piglet survival rate was not affected by 0.80 and 0.85 V : L ratio. It may be due to the piglet's health condition and environmental conditions.

The results of this study show that litter weaning weight was significantly observed by V : L ratio. Similarly, Siri and Tidchai (2001) reported that litter weaning weight had a significant linear relationship with lysine: valine ratio (V : L = 0.83 to 1.25). However, Richert et al. (1996) and Richert et al. (1997a; 1997b) showed that litter weaning weights improved when the dietary valine concentration higher from 0.75 to 1.15. Furthermore, no effects were observed due to the increase of dietary V : L in the litter performance (Carter et al., 2000). The increased branched chain AA and milk protein content might have increased piglet growth.

The present research demonstrated a significant increase in piglets ADG when the dietary V : L ratio increased. Similarly, growth performance of nursery pigs ADG was linearly improved by different level of Lys ratios (57.4, to 69.6) as reported by Nemechek et al. (2012) and Xu et al. (2018). Rousselow and Speer (1980) reported that average piglets weight gain during lactating is linearly affected by increasing dietary valine as 0.40, to 1.17. However, Dong and Pluske (2007) and Kahindi et al.

(2016) reported that ADG was not affected by lysine content, low feed intake commonly found in piglets immediately after lactation may be responsible for such effect. The possible reason for increase in ADG may be due to enough feed intake by the piglets.

During lactation, the sows usually have constipation problems and the incidence of diarrhea is often seen in piglets. Fecal score is an intuitive and easy way to judge the sow constipation and piglet diarrhea. In pigs, the microbial ecosystem of the gastrointestinal tract (GIT) is affected by various factors, such as application methods, farm hygiene, diet formation, farm hygiene, administration level, environmental conditions, stress and pig age; however, variations in diet composition have been identified as one of the very important determinants (Rist et al., 2013), diets with a much-crude protein level a high buffering capacity (Partanen and Mroz, 1999) and will improve small intestinal pH, thereby the proliferation of pathogenic bacteria (Htoo et al., 2007). In our study, the fecal score of farrowing sows and 14 days age piglets were significantly affected. Moreover, adverse effect in fecal score of sows and litters among the dietary treatments, was observed V : L ratios 0.83 and 0.88. Thus, it can be concluded that protein in the diet can be partially reduced by supplementing the basal diet with synthetic amino acids such as V : L with the ratio of 0.85.

Conclusion

The varying level of dietary V : L ratio of 0.83, 0.85, and 0.88 affected the lactating performance of sows or growth performance of nursery pigs and fecal score of sow and litter during lactation. However, to determine the optimal V : L ratios on lactating sows and litters' growth performance, the V : L ratios with a wider range is worth further study.

Conflict of Interests

No potential conflict of interest relevant to this article was reported.

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