Korean Journal Of Agricultural Science

pISSN : 2466-2402
eISSN : 2466-2410

ANIMAL

Influences of betaine supplementation on growth performance and fecal score in sows and their piglets fed a corn soybean meal-based diet

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Abstract

A total of twenty-four multiparous sows (Landrace × Yorkshire) and their litters were used in this 21-day experimental trial. Based on their body weight, sows were randomly allocated into one of three treatments with eight replicates. The dietary betaine supplementation contained three levels: (i) CON (Basal diet + 0% Bet), (ii) Bet 0.05% (CON + 0.05% Betaine), and (iii) Bet 0.15% (CON + 0.15% Betaine). The supplementation of betaine had no effect ($p > 0.05$) on body weight and feed intake of lactating sow. Moreover, no significant response was observed on backfat thickness, body condition score, and weaning of the estrus interval with the dietary supplementation of betaine. In addition, the litter weaning weight, litter weight gain, average litter daily gain, and survivability rate at birth showed no significant difference with the dietary betaine supplementation of the sow diet. Fecal scores of the lactating sows and suckling piglets were not affected ($p > 0.05$) with the dietary betaine supplementation compared with the control diet during the experimental periods. The findings of this study showed that betaine supplementation does not boost growth performance, feed intake, body conditions, and fecal score in lactating sows and suckling piglets fed a corn-soybean meal-based diet.

Keywords: betaine, fecal score, growth performance, lactating sow

OPEN ACCESS

Citation: Sureshkumar S, Baek DH, Kim IH. 2021. Influences of betaine supplementation on growth performance and fecal score in sows and their piglets fed a corn soybean meal-based diet. Korean Journal of Agricultural Science 48:1-9. https://doi.org/10.7744/kjoas.20200030

Received: April 17, 2020

Revised: June 8, 2020

Accepted: June 17, 2020

Introduction

Betaine was engaged in a number of biochemical reactions that are essential to critical functions and its metabolism is nearly related to that of methionine and choline (Lowry et al., 1987; Eklund et al., 2005). The unique chemical characteristics of betaine act on methyl groups that chemically react with bipolar properties and can be contributed in methylation reactions it can be generated by chemical synthesis or as a by-product of sugar beet production (Peter, 1994). It is also an osmotic active compound that control water flow and electrolyte stability, offering osmotic protection for many cells, including intestinal cells and muscle fibers (Eklund et al., 2005). The role of betaine was not only resulted in the production of amino acid and lipid metabolism but also shows significant effect on animal functional development (Fernández et al., 1998; Verreschi et al., 2000; Kim et al., 2003; Zulkifli et al., 2004). Limited experiments have showed that using betaine with chicken and pigs (Pesti et al.,1980; Campbell et al.,1995) can function as a methyl donor in methionine-deficient diets and increase the growth rates related to those of animals fed methionine-adequate food.

Earlier study reported that sow reproductive performance has been improved with supplementation of betaine, (van Wettere et al., 2012) during the gestation periods. In addition, Ramis et al. (2011) stated that dietary betaine treatment could be reduce the heat stress on lactating sows through multiple biological activity. Earlier research reported that betaine supplementation decrease carcass backfat thickens and improve lean mass and feed quality in swine (Campbell et al., 1997; Casarin et al., 1997; Cromwell et al., 1999). Most of the studies indicated that betaine supplementation enhanced feed productivity, growth efficiency and meat quality of finishing pigs (Peter, 1994; Cere and Schinckel, 1995; Smith, 1995). However, in contrast Harms and Russell (2002) reported that dietary supplementation of betaine had no impact on growth efficiency or carcass characteristics in pigs (Harms and Russell, 2002). There is a partial information on the effects of betaine supplementation in lactating sow diets. Hence, we assumed that dietary supplementation of betaine can affect the growth performance, feed intake, and fecal score in sows and suckling piglet. Therefore, the aim of this study was to evaluate the effect of betaine supplementation in corn soybean meal-based diet on growth performance, feed intake, body conditions and fecal score in lactating sows and sucking piglets.

Materials and Methods

The study was performed under protocols approved by the Animal Care and Use Committee of Dankook University, Cheonan, Republic of Korea, for animal experimentation. The betaine supplementation used for the present experiment was proved by a commercially available (natural betaine anhydrous 96%; CTC BIO Inc., Seoul, Korea) containing (0.05 or 0.15%).

Experimental design, animals, housing and diets

In this experiment, we had used 24 multiparous sows (Landrace × Yorkshire) were assigned to three dietary treatments with eight replicates per treatment. Treatments were based on bodyweight and parity according to a randomized complete block design. The dietary treatments contained three levels of betaine: (i) CON (basal diet); (ii) Bet 0.05% (CON + 0.05% betaine); and (iii) Bet 0.15% (CON + 0.15% betaine). During gestation period, the sows were caged in separate stalls, which had partially slatted floors consisting of a 0.80 m × 1.05 m specific strips floor. The sows were weighted and transfer to farrowing room at 108th day of pregnancy, each day sows were fed 2.5 kg of diet before lactation. However, during farrowing day the sows were not fed. Dietary components have been designed to follow or exceed the guidelines of the National Research Council (NRC, 2012) (Table 1). On each side, the farrowing crate (2.1 m × 0.6 m) was air-conditioned for newborn pigs at the same time temperature of farrowing house was maintained at least 20℃ with additional ventilation generated by heat lamps. Within 24 h postpartum, all piglets were treated with iron injection, ear notching, needle teeth clipping and tail docking. within 5 days postpartum male piglets were castrated. Throughout lactation period, the average feed intake was slowly raised until the sow's exposure to ad libitum feed for 14 days. During Lactation the feed intake of sow will be raised up to 7 kg, until day 21 the piglets were continued for weaning. Throughout the trail period sows were provided with free access to drinking water but the piglets did not get any creep meal.

Table 1. Ingredient and chemical composition of the experimental diet (as-fed basis).

Items	Lactation
Corn	34.01
Wheat	23
Rice bran	2
Wheat bran	8.31
Soybean hull	-
Parm kernell meal	-
Soybean meal	6
Dehulled soybean meal	12.96
Soybean oil	3.74
Molasses	2
Bakery by product	4
Limestone	1.23
Monocalcium phosphat	0.68
Salt	0.5
Methionine 98%	-
Threonine 98%	0.05
Lysine 25%	0.6
Choline chloride 50%	0.12
Vitamin[y]/mineral[z] mixture	0.8
Total	100.00
Chemical composition	
Digestible energy ($kcal\cdot kg^{-1}$)	3,540
Metabolic energy ($kcal\cdot kg^{-1}$)	3,250
Crude protein (%)	16.30
Crude fat (%)	6.70
Crude ash (%)	5.00
Crude fiber (%)	3.60
Total lysine (%)	0.93
Calcium (%)	0.75
Phosphorus (%)	0.54

[y] Provided per kilogram of complete diet: Vitamin A, 12100 IU; vitamin D_3, 2000 IU; vitamin E, 48 IU; vitamin K_3, 1.5 mg; riboflavin, 6 mg; niacin, 40 mg; d-pantothenic, 17 mg; biotin, 0.2 mg; folic acid, 2 mg; choline, 166 mg; vitami n B6, 2 mg; and vitamin B12, 28 µg.

[z] Provided per kilogram of completediet: Fe (as $FeSO_4\cdot 7H_2O$), 90 mg; Cu (as $CuSO_4\cdot 5H_2O$), 15 mg; Zn (as $ZnSO_4$), 50 mg; Mn (as MnO_2), 54 mg; I (as KI), 0.99 mg; and Se (as $Na_2SeO_3\cdot 5H_2O$), 0.25 mg. [Correction added on 26 October, 2015, after first online publication: The gestation diet and lactation diet for metabolizable energy, $MJ\cdot kg^{-1}$ in the table above have been corrected from '3.20' and '3.47' to '13.05' and '14.47', respectively.]

Sampling and measurements

At the beginning of the experiment, before farrowing, after farrowing, and during a weaning period sows body weight and backfat thickness were observed. The backfat thickness of sows was measured (6 cm off the midline at the 10th rib) by using a real-time ultrasound instrument (Piglot 105; SFK Technology, Herlev, Denmark). After farrowing liter size were recorded according to numbers of alive piglets or dead litter to calculate survival ratio. Before feeding the sow during

Table 2. Effect of dietary supplementation of Betaine (Bet) on growth performance in lactating sows.

Items	CON	Bet 0.05%	Bet 0.15%	SEM[w]	p-value
Parity	3.8	3.9	3.9	0.6	0.947
Litter size					
Total birth (head)	11.0	11.3	11.3	0.4	1.000
Total alive (head)	10.7	10.5	10.9	0.4	0.731
Stillbirth (head)	0.3	0.3	0.1	0.2	0.769
Mummification (head)	0.3	0.5	0.3	0.2	0.709
SUR[x] (%)	94.2	93.0	96.9	2.3	0.644
Body weight (kg)					
After farrowing	216.0	208.1	204.4	7.1	0.553
Weanning	199.3	191.7	187.8	6.8	0.323
Finish	201.5	194.5	190.3	7.0	0.344
Body weight difference 1[y]	16.8	16.5	16.6	0.5	0.374
Body weight difference 2[y]	2.2	2.8	2.5	0.4	0.966
ADFI (kg)					
Pregnant	2.7	2.7	2.7	0.02	0.789
Lactation	5.7	5.6	5.6	0.03	0.504
Finish	3.8	3.7	3.8	0.03	0.277
Backfat thickness (mm)					
After farrowing	18.5	19.0	18.1	0.9	0.422
Weanning	16.2	17.3	16.8	1.1	0.556
Finish	16.3	17.6	17.1	0.9	0.901
Backfat thickness difference 1[z]	2.3	1.8	1.4	0.5	0.913
Backfat thickness difference 2[z]	- 0.2	- 0.4	- 0.4	0.5	0.488
Body condition score					
After farrowing	3.3	2.9	3.1	0.2	0.419
Weanning	2.9	2.7	2.8	0.1	0.380
Finish	2.9	2.8	2.9	0.1	0.872
Estrus interval (d)	4.5	4.5	4.0	0.3	0.704

CON, basal diet + 0% betaine; Bet 0.05%, CON + 0.05% betaine; Bet 0.15%, CON + 0.15% betaine.
[w] Standard error of means. Values are represented by eight pigs per treatment.
[x] Survival rate of number of alived pig per number of total born pigs.
[y] Body weight difference: 1, before farrowing; 2, before farrowing to after farrowing; 3, after farrowing to weaning.
[z] Backfat thickness difference: 1, before farrowing; 2, before farrowing to after farrowing; 3, after farrowing to weaning.

lactating period it is mandatory to check the weight of unconsumed feed and feed intake. Body condition score was recorded within a few hours after day of farrowing, after farrowing to weaning and weaning to 25 day of lactation. Each piglet body weight was measured at initial birth and 21 days of lactating (weaning). In order to determine the survival rate of piglet were recorded to report on farrowing day to weaning day. After weaning, the weaning to estrus interval was recorded for each sow. Throughout this study, the indicated of diarrhea in piglets was noticed and record thrice a day. After weaning, sows were transferred to pens which is very near to mature boar and also, they have direct exposer two times a day (08:00 and 16:00 h) for estrus detection. In the presence of a boar, a sow was assumed to be in estrus when displaying a standing reaction caused by a back-pressure test.

Table 3. Effect of dietary supplementation of betaine (Bet) on growth performance in litters.

Items	CON	Bet 0.05%	Bet 0.15%	SEM[z]	p-value
Initial	10.7	10.5	10.9	0.3	0.731
Final	10.2	10.0	10.4	0.3	0.771
Survival rate at birth (%)	95.3	95.4	95.8	2.1	0.991
Body weight (kg)					
Birth weight	1.30	1.23	1.23	0.05	0.657
Weaning	5.54	5.82	5.68	0.32	0.864
Average daily gain (g)					
Overall	202	219	212	16	0.800

CON, basal diet + 0% betaine; Bet 0.05%, CON + 0.05% betaine; Bet 0.15%, CON + 0.15% betaine.
[z] Standard error of means. Values are represented by eight pigs per treatment.

Table 4. Effect of dietary supplementation of betaine (Bet) on fecal score in lactating sows and suckling piglets.

Items	CON	Bet 0.05%	Bet 0.15%	SEM[y]	p-value
Fecal score[z]					
Lactating sow					
Week 1	2.99	2.99	2.97	0.03	0.917
Week 2	2.99	2.98	2.97	0.03	0.985
Week 3	2.98	2.94	2.96	0.04	0.816
Suckling piglets					
Week 1	3.69	3.67	3.70	0.02	0.625
Week 2	3.64	3.63	3.62	0.02	0.921
Week 3	3.62	3.57	3.60	0.02	0.417

CON, basal diet + 0% betaine; Bet 0.05%, CON + 0.05% betaine; Bet 0.15%, CON + 0.15% betaine.
[y] Standard error of means. Values are represented by eight pigs per treatment.
[z] Fecal scores were determined using the following fecal scoring system: 1 hard, dry pellet; 2 firm, formed stool; 3 soft, moist stool that retains shape; 4 soft, unformed stool that assumes shape of container; 5 watery liquid that can be poured.

Lactating sows and suckling piglets fecal score were observed and recorded daily per pen throughout the experiment periods. The fecal score was determined by estimating moisture content of feces of each pig (Hart and Dobb, 1988). Fecal scores were determined using the following fecal scoring system: 1 hard, dry pellet; 2 firm, formed stool; 3 soft, moist stool that retains shape; 4 soft, unformed stool that assumes shape of container; 5 watery liquid that can be poured. The average fecal score per diet and day was determined by Montagne et al. (2004).

Statistical analysis

By using the GLM procedure SAS/STAT®9.2 (SAS Inst. Inc., Cary, NC, USA), All the results were evaluated and totally randomized. The experimental unit were represented by suckling piglets and a specific sow. Variability in the results was interpreted as a standard error mean (SEM) and considered as $p < 0.05$. Differences between treatment means is calculated using the Tukey's range test.

Results

Growth performance of lactating sows and suckling piglets

In this present study, the result of growth performance of lactating sow was showed in Table 2. During betaine supplementation there were no significant difference ($p > 0.05$) in Litter weaning weight and survival rate. While lactation there was no effect on sow body weight and backfat thickness in after farrowing, weaning and finishing. In addition to that there was no significant ($p > 0.05$) difference was observed in body weight and backfat thickness during the experimental periods. During experimental period sows feed intakes were not affected ($p > 0.05$) by betaine supplementation. Furthermore, the study showed that no significant effects on body condition score and weaning to estrus interval of sow. However, no difference was observed in litter size, body weight, backfat thickness, feed intake, weaning to estrus interval of sows, piglet body weight, and survivability of betaine treatments. There was no significant difference in treatments for Initial number of total piglets, live piglets at birth, survivals rate during lactation, litter and piglet weight at birth (Table 3). The average litter daily gain in the dietary betaine supplementation were not statistically significant.

Fecal score in lactating sows and suckling piglets

Fecal score of lactating sows and suckling piglets were not affected ($p > 0.05$) with the dietary betaine supplementation compared with control diet during the experimental periods (Table 4).

Discussion

The current research was aimed at evaluating the effect of betaine supplementation on growth performance, feed intake, body conditions and fecal score, of lactating sows and suckling piglets. Previous reports indicate that supplementation of betaine in pig and poultry diet can improve growth benefit, feed gain, improve the health quality in growing pig, growing chicks and reducing body fat (Baker and Czarnecki, 1985; Saunderson and Mackinlay, 1990). In the present study no difference was found in body weight gain in lactating sows, which agree with pervious report Lawrence et al. (2002) stated that no significant effect was observed on body weight (BW) gain of betaine supplementation with lactating sow. Similarly, Ramis et al. (2011) reported that no significant difference was found with betaine treatments on sow BW. On the other hand, Matthews et al. (1997) and Sales (2011) reported that the addition of betaine decreased weight gain and feed intake in healthy chicks and lactating sow, in contrast with our study inclusion of betaine supplementation did not affect the feed intake during the experimental periods on before farrowing, lactation period and after farrowing. Similarly, Casarin et al. (1997) reported that different betaine supplementation level and final live weight could be partially explained in average daily feed intake (ADFI) presented heterogeneity and they observed inclusion of betaine treatment was more pronounced when feed intake was reduced, but suggesting that the effect was grater once dietary energy was limited. Previous study Renaudeau et al. (2011) reported that during heat stress sow feed intake was decreases by up to 50 %. Beneficial effects of betaine may be more apparent under stressful conditions such as heat stress (Zulkifli et al., 2004) and coccidiosis challenge (Augustine and Danforth, 1999).

According to Eissen et al. (2003) described that increase in feed intake during lactation could help to reduce body weight loss and back fat thickness loss by supplementation of betaine diet. which agree with our study backfat thickness were no significant deference differences during the experimental periods on before farrowing, before farrowing to after farrowing and after farrowing to weaning periods. Additionally, the previous study stated that not influence on backfat thickness in different level of betaine supplementation. Although, Cadogan et al. (1993) and Casarin et al. (1997) reported that betaine has been decrease backfat thickness. Moreover, other reports have specified that 1.0% betaine supplementations not affect carcass traits (Matthews et al., 1997). In the present research, body weight gain and average daily gain (ADG) of piglets was not affected by betaine supplementation to the diet of sows. In agreement with the current results, Cabezón et al. (2016) No increase in ADG and body weight of piglets born from betaine supplementation dietary therapies was found. A relation was also observed betaine treatments did not affect the growth performance of the piglets Grenier et al. (2014). On the contrast, a previous study exposed that gestation feed with betaine supplementation enhance litter size, total birth and alive piglets during summer time (Van wettere et al., 2012). Similarly, Ramis et al. (2011) stated that litter weight at weaning was greater in betaine supplemented than control sows. The study about the effect of betaine on fecal score in lactating sow are limited. In this present study, dietary supplementation of betaine had no effect on fecal score in lactating sows and suckling piglets. Eklund et al. (2005) reported that supplementary betaine reduces the digestibility of ether extract in methionine and appropriate diets at both the ileal and fecal levels.

Addition of betaine to sow diets has been demonstrated to potentially improve reproductive performance, but there is little evidence to support consistent effects (Ramis et al., 2011; van Wettere et al., 2013). Betaine is believed to improve lactation feed intake, reduce wean-to-estrus interval, and enhance embryo survival during heat stress (van Wettere et al., 2012, Cabezón et al., 2016). It's been suggested that betaine may ameliorate the effect of heat stress on sows due to an energy-sparing effect that improves energy utilization and an osmo-protectant effect that increases water retention and regulates electrolyte balance (Cabezón et al., 2016). In conclusion, the results of the present study indicate that dietary betaine supplementation not getting better growth performance, feed intake, body conditions and fecal score in lactating sows and suckling piglets fed corn-soybean meal-based diet. However, the benefits of betaine supplementation on growth performance of sows require further research before a clear finding could be need.

Conflict of Interests

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

Acknowledgments

We gratefully acknowledge the financial support granted by Dankook University, Department of Animal Resource & Science, Cheonan, Choongnam, South Korea.

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