Effects of Betaine on Growth Performance and Carcass Characteristics in Growing Pigs*

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ABSTRACT : Ninety six growing pigs (Duroc×Landrace×Jia) were used to investigate the effects of betaine on growth, nutrient utilization, carcass composition and meat quality at different levels of betaine in the diet. The pigs were randomly assigned by weight to four groups, each of which was replicated three times with eight pigs per replicate. Four groups were fed with diets supplemented with 0, 1,000, 1,500 and 2,000 mg/kg betaine. The pigs were grown from 20 kg live weight to approximately 64 kg. The 1,000 mg/kg and 1,500 mg/kg betaine treated groups increased average daily gain by 13.20% ($p<0.01$) and 9.28% ($p<0.05$) and average daily feed intake by 7.30% ($p<0.05$) and 7.33% ($p<0.01$) respectively and decreased feed conversion ratio by 7.93% ($p<0.01$) and 6.55% ($p<0.05$) respectively compared to the control group. However, these differences were not found in the other betaine treated groups. The 1,000 mg/kg betaine treated group significantly elevated carcass lean proportion by 7.49% ($p<0.05$) and *longissimus* muscle area by 19.12% ($p<0.05$) and contents of ether extract and myoglobin in *longissimus dorsi.* by 34.21% ($p<0.01$) and 29.56% ($p<0.01$) respectively, reduced carcass fat proportion and fat depth by 27.21% ($p<0.05$) and 14.86% ($p<0.05$) respectively compared to the control group. It is concluded that betaine supplementation in the diets may improve growth performance and carcass characteristics in growing pigs. ***(Asian-Aust. J. Anim. Sci. 2004. Vol 17, No. 12 : 1700-1704)***

Key Words : Betaine, Pigs, Growth Performance, Carcass Characteristics

INTRODUCTION

Betaine is a natural compound having important functions in animal metabolism. Chemically, betaine (glycine betaine, trimethylglycine) is a quaternary ammonium compound (Yancey, 1982) (Figure 1).

The unique chemical properties of betaine are due to its bipolar structure and its chemically reactive methyl groups, which it can donate in methylation reactions. Betaine is chemically stable and nontoxic. Hence betaine is not present in large quantities in most feedstuffs. Numerous reports have indicated that betaine improved growth performance and feed efficiency and pork quality for finishing pigs (Peter et al., 1994; Cere et al., 1995; Smith et al., 1995). Betaine plays an important function in the amino acid, lipid metabolism and antibody production in practical animal production (Fernández et al, 1998; Esteve et al., 2002; Verreschi et al., 2002; Kim et al., 2003; Zulkifli et al., 2004). Whether betaine as a growth promoter for pigs needs further validation.

The objective of this study was to assess the growth, feed efficiency, carcass composition and pork quality response of growing pigs to betaine.

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MATERIALS AND METHODS

Animals and experimental design

The feeding trial was carried out in Jiaxin Xushan breeding farm during 5 October-10 December 2002. Ninety-six crossbred barrows (Duroc×Landrance×Jia) weighing approximately 20 kg were randomly assigned by weight to four groups, each of which was replicated three times with eight pigs per replicate. Four groups were fed with four diets supplemented with 0, 1,000, 1,500 and 2,000 mg/kg betaine. Complete diets were formulated to meet all nutrient requirements (NRC, 1998). Except for the content of betaine, all diets with each experimental group were equal in digestible energy (DE), dry matter (DM), crude protein (CP), essential amino acids, minerals, trace minerals and vitamins. The composition of basal diets and their main contents are shown in Table 1. The dietary DE, CP, lysine and Methionine levels were 3.175 kcal/kg, 17.62%, 1.05% and 0.45% in each experiment, respectively. Pigs were allowed to consume feed and water from nipple waterers on an *ad libitum* basis.

The pigs were weighed and feed intake was determined weekly up to 64 kg BW. Average daily gain (ADG), average daily feed intake (ADFI), and feed conversion ratio (FCR) were calculated for all pigs for the experimented period.

Carcass measurements

At the end of the feeding trial, twelve pigs (six pigs each group with two pigs per replicate) were selected to

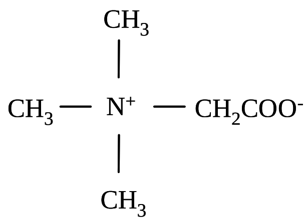

Figure 1. The structure of betaine.

determine carcass composition and meat quality from control group and 1,500 mg/kg betaine treated group, respectively. Pigs were humanely killed, dehaired, and eviscerated. The head was removed and the carcass was split longitudinally. One half of the carcass was dissected by separating bone, muscle, fat, and skin, each component was respectively weighed. Tenth rib fat thickness was determined at three-fourths of the distance from the midline to the end of the *longissimus* muscle, and *longissimus* muscle area at the 10th rib was determined using image analysis of acetate tracings. Marbling score and color score were evaluated on the cut surface of the *longissimus* muscle between the 10th and 11th rib by a trained individual (NPPC, 2000). Visual marbling scores were determined on a scoring system of 1-6 (1=1% intramuscular fat, 2=2% intramuscular fat, 3=3% intramuscular fat, 4=4% intramuscular fat, 5=5% intramuscular fat, 6=6% intramuscular fat). Visual color scores were evaluated using a scoring system of 1-6 (1=pale pinkish gray to white, 2=grayish pink, 3=reddish pink, 4=dark reddish pink, 5=purplish red, 6=dark purplish red). pH of *longissimus* muscle (approximately 10th rib) was determined from each pig at 45 min postmortem with an portable pH model AP61 (Pittsburgh, PA). Water-holding capacity was determined for each pig at 24 h postmortem by the method of Sutton et al. (1997).

Carcass dressing % was calculated by the following formula: hot carcass weight divided by final live weight×100. Carcass skin, bone, lean and fat proportions were calculated by the following formula: dissected yield divided by cold carcass weight×100.

Chemical analysis

Longissimus muscle samples from each animal were taken for chemical analysis. All the samples were freeze-dried and then ground through a sieve (mesh size 2 mm). Protein, fat, and ash are reported on DM basis. Protein was determined using the macro-Kjeldahl method (AOAC, 1984). The fat content was analyzed by ether extraction (AOAC, 1984). Ash was determined by the AOAC (1984) method. Myoglobin was analyzed by the method of Trout and Gutzke (1996). Amino acid compositions in *Longissimus* muscle were analyzed using a Beckman model 126 amino acid auto analyzer (Beckman Instruments, Palo, CA).

Table 1. Composition and nutritive value of basal diets

Ingredients (%)	
Corn	63.0
Soybean meal	22.0
Wheat bran	7.0
Fish meal	3.0
Calcium phosphate	2.0
Ground limestone	0.7
Salt	0.3
Premix[1]	2.0
Chemical composition[2]	
Digestible energy (kcal/kg)	3.175
Crude protein (%)	17.62
Calcium (%)	0.96
Phosphorus (%)	0.51
Lysine (%)	1.05
Methionine (%)	0.45

[1] Supplied the following in mg/kg of diet: Fe: 160, Cu: 10, Mn: 20, Zn: 100, Vit. A: 5,000 IU, Vit. D_3: 700 IU, Vit. E: 78.4 IU, Vit. K: 4.4 mg, Vit. B_2: 8.8 mg, niacin: 30 mg, D-patothenic acid: 25 mg, biotin: 80 mg, thiamin: 2.2 mg, choline chloride: 350 mg.
[2] All of the data are analytic values except digestible energy.

Statistical analysis

A completely randomized design with four treatments was used. Data were analyzed by analysis of variance (ANOVA) using the general liner model procedures of the SAS software (1989). For all data, the model included treatment as main effect. Comparisons were considered significantly different if $p<0.05$.

RESULTS AND DISCUSSION

Overall growth performance data for the grower period were presented in Table 2. The addition of betaine to the

Table 2. Effects of betaine on growth performance of growing pigs[1]

	Betaine (mg/kg)				SEM[2]
	0	1,000	1,500	2,000	
Initial weight (kg)	22.20	21.47	21.24	22.50	0.56
Final weight (kg)	61.23	64.11	65.41	63.68	0.63
ADG (g)	629.38[a]	687.79[b]	712.48[b]	664.13[a]	10.63
ADFI (g)	1.82[a]	1.85[a]	1.83[a]	1.95[b]	0.07
FCR	2.90[a]	2.71[b]	2.67[b]	2.93[a]	0.06

[1] Values are presented as means; n=3 for ADG, ADFI and FCR per treatment. Means in a row with different letters differ significantly ($p<0.05$).
[2] Standard error of the mean.

Table 3. Carcass characteristic of growing pigs[1]

	Betaine (mg/kg)		SEM[2]
	0	1,500	
Dressing percentage	69.38	71.87	0.50
Carcass skin proportion	5.41	5.38	0.51
Carcass bone proportion	9.87	9.83	0.52
Carcass lean proportion	59.14[a]	63.57[b]	0.44
Carcass fat proportion	14.42[a]	13.59[b]	0.52
BFD (10th rib) (cm)	1.35[a]	1.15[b]	0.19
LMA (10th rib) (cm)	25.74[a]	30.66[b]	0.83
Leaf fat (kg)	2.97[a]	2.35[b]	0.31
Color score of lean	3.17[a]	3.72[b]	0.07
pH value	6.19	6.22	0.08
Water holding capacity (%)	75.51	76.09	0.81
Marbling score	3.08[a]	3.58[b]	0.18

[1] Values are presented as means; n=3 per treatment. Means in a row with different letters differ significantly (p<0.05).
[2] Standard error of the mean.

Table 4. Chemical composition of *longissimus* muscle[1]

	Betaine (mg/kg)		SEM[2]
	0	1,500	
Protein (%)	85.13	87.80	0.89
Total lipid (%)	9.20[a]	12.21[b]	0.47
Non-lipid solids (%)	20.43	19.97	0.59
Ash (%)	9.87	9.83	0.51
Myoglobin (mg/g)	3.57[a]	4.63[b]	0.09

[1] Values are presented as means; n=3 per treatment. Means in a row with different letters differ significantly (p<0.05).
[2] Standard error of the mean.

diet resulted in a 13.20% (p<0.01) and 9.28% (p<0.05) in ADG in the 1,000 mg/kg and 1,500 mg/kg group compared with the control, respectively. The ADG for pigs fed 1,000 mg/kg and 1,500 mg/kg diets were significantly higher (p<0.05) than the ADG for control group, but there was no significant different in the 2,000 mg/kg group. Compared to the control group, ADFI of fed the 2,000 mg/kg diet was show to be higher (p<0.01), but this effect was not found in the other groups. FCR of pigs raised on the 1,000 mg/kg and 1,500 mg/kg diets were lower (p<0.05) than the control, but there was no significant deference (p>0.05) observed in the 2,000 mg/kg group.

Numerous researchers have reported that ADG and FCR were improved when a betaine supplemented diet was fed to pigs (Campell et al., 1995; Smith et al., 1995). The effects of betaine in the 1,000 mg/kg and 1,500 mg/kg groups on ADG and FCR observed in this research were comparable to previous reports. As for the 2,000 mg/kg group, betaine treatments had no significant effects on ADG and FCR, but improved ADFI, which was in agreement with the results in fishes of Lu (2001). It is suggested that adding a high dose of betaine to the diet may have produced some negative responses for pigs: further studies should be conducted to confirm this. These results indicated that 1,000 mg/kg and 1,500 mg/kg betaine supplementation could improve growth performance and feed efficiency. But several studies showed no improvement in ADG (Kitt et al., 1999; Matthews et al., 2001; Lawrence et al., 2002). Little if any of the aforementioned literature mentions the choline and methionine levels used. In this study, we used levels in excess of the requirement for pigs. The researches in the previous literature may have used diets deficient in choline or methionine, which could affect the response to dietary betaine.

The carcass data are shown in Table 3. Pigs fed the diet with supplementation 1,500 g/kg betaine exhibited an increase in carcass lean proportion (CLP) (p<0.05) and LMA (p<0.05) compared with control group. In the previously cited reports (Peter et al., 1994; Xu et al., 1998), the increase in CLP and LMA in finishing pigs fed 1,750 mg/kg averaged 5.71% and 12%, respectively, which is comparable to the 7.49% and 19.12% average for the betaine group in this study.

The pigs treated with betaine had approximately 5.76% less carcass fat proportion (CFP) (p<0.05) than the control. Similar results were observed for back fat depth (BFD) at the 10th rib and leaf fat weight. The BFD and leaf fat weight of betaine treated group were reduced by 14.81% (p<0.05) and 20.88% (p<0.05) compared with the control. This was in agreement with reports of Hall et al. (1995) and Peter et al. (1994).

In agreement with our previous results in finishing pigs (Wang et al., 2001) and broiler (Zhan et al., 1999), there were apparent effects of betaine on muscle color score (p<0.05), marbling score (p<0.05), but no significant effects on pH value and water holding capacity in the present research (Table 3).

In the present study, no significant effects of betaine on dressing percentage, carcass skin proportion and carcass bone proportion were observed. The results implied that adding 1,500 mg/kg betaine had a consistent increase in CLP and a decrease in CFP of growing pigs, which were comparable to previous studies noted above.

Chemical analysis of *longissimus* muscle showed that the contents of ether extract and myoglobin were higher (p<0.05) than those of control (Table 4), but these results had not been found in earlier studies. The present results indicated that betaine affected protein and lipid partitioning in animal's body (Mattews et al., 1998; Schrama et al., 2003), accelerated the synthesis of myoglobin and deposit of fat in *longissimus* muscle, and improved the color and tenderness of meat (Xu et al., 1998). It was assumed that betaine improved the pork quality, which deserves further investigation.

Puchala et al. (1995) reported that the amino acid composition in serum of sheep were changed by betaine-treated diet. There was no information on the effect of betaine on amino acid composition of *longissimus* muscle in previous literatures. In the present study (Table 5),

Table 5. Amino acid composition of *longissimus* muscle[1, 2]

	Betaine (mg/kg)		SEM[3]
	0	1,500	
Lysine	6.31	6.44	0.29
Methionine	1.62	1.96	0.15
Arginine	4.34	4.71	0.24
Histidine	3.20	3.02	0.19
Leucine	5.78	5.97	0.20
Isoleucine	3.31	3.63	0.17
Phenylalanine	3.83	4.11	0.14
Threonine	3.41	3.54	0.16
Valine	3.76	4.16	0.13
Glycine	3.33	3.5	0.20
Serine	3.71	3.49	0.16
Aspartic acid	7.14	7.40	0.27
Glutamic acid	11.07	11.53	0.35
Alanine	4.59	4.87	0.31
Tyrosine	3.28	3.52	0.16

[1] Values are presented as means; n=3 per treatment. Means in a row with different letters differ significantly (p<0.05).
[2] Data are expressed as g/100 g DM of muscle.
[3] Standard error of the mean.

although no significant changes of amino acid composition in longissimus muscle of pigs were found, we observed that there was an increasing tendency of essential amino acids (methionine, arginine, valine, leucine) and non-essential amino acids (serine and glycine). As amino acid composition of muscle is important to its palatability, the changes of amino acids composition of muscle following betaine treatment are worth further study.

CONCLUSION

Supplementing betaine in the diets improved growth performance and carcass composition in growing pigs. 1,500 mg/kg added in the diet improved mostly ADG and FCR, compared with control group, 2,000 mg/kg adding diet was most effective on ADFI. In addition, 1,500 mg/kg supplemented diet increased significantly the carcass lean proportion, LMA, color score of lean, marbling score, and reduced carcass fat proportion, BFD, leaf fat. Generally, betaine improved the meat quality of pigs. Mechanisms for increasing the content of myoglobin in *longissimus* muscle from added betaine in the diet is not clear.

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