

Effect of Feeding a Low Crude Protein Diet on Growth Performance of Finishing Pigs at a High Ambient Temperature

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Abstract

The effects of reducing dietary crude protein (CP) in a high temperature environment (32°C) on growth performance and back fat deposition were investigated in finishing pigs. Twelve barrows (80.9 ± 7.6 kg) were allotted randomly to two dietary regimens (13.9% CP vs 11.8% CP) and were fed the diets for 4 weeks. The low-CP diet (11.8% CP) was supplemented with amino acids to meet the nutritional requirements. At the end of the experiment, back fat thickness, plasma urea nitrogen, and amino acid concentration were measured for all the barrows. The dietary CP level did not have any effect on growth performance, back fat thickness, or the plasma urea nitrogen concentration of the finishing pigs. Plasma free lysine, threonine, and methionine concentrations were higher in pigs that were fed the low-CP diet. These results indicate that reducing dietary CP by two percentage points does not alleviate the negative effect of heat stress and may not affect fat deposition.

Discipline: Animal industry

Additional key words: amino acids, fat deposition

Introduction

According to the prediction of the Intergovernmental Panel on Climate Change (2013), average global temperature may increase by up to 4.8°C by 2100. This indicates that the negative effects of heat stress on livestock production will become more apparent in the future as average global temperature increases. Finishing pigs are susceptible to high ambient temperatures due to their poor ability to dissipate heat (Renaudeau et al. 2011). To alleviate heat stress in finishing pigs, several dietary strategies have been evaluated (Renaudeau et al. 2012). Growth performance improved in heat-stressed finishing pigs fed fat-supplemented diets (Stahly & Cromwell 1979, Katsumata et al. 1996). Reduction in the dietary CP level in feeds may be another method to improve growth performance in heat-stressed finishing pigs, because digestion of dietary protein and protein (amino acids)

metabolism increases animal heat production (Forbes & Swift 1944, Stahly et al. 1979). Stahly et al. (1979) reported improvement in growth performance through feeding low-CP diet in a high temperature environment. Spencer et al. (2005) also observed 7.4% higher average daily gain in finishing pigs fed an 11.3% CP diet compared to pigs fed a 13.6% CP diet, under temperature variations between 27°C and 35°C. However, an increase in carcass fat content occurred when pigs consumed feeds with reduced dietary CP but with constant energy content (Tous et al. 2014). Dauncey & Ingram (1983) and Christon (1988) demonstrated that body fat accumulation was greater in pigs kept at high ambient temperatures than those kept at low ambient temperatures. Thus, feeding low-CP diets to finishing pigs in a high temperature environment may accelerate fat storage and may affect meat quality.

The objective of this study was to determine whether

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feeding a low-CP diet fortified with amino acids could improve growth performance, as well as affect backfat thickness.

Materials and methods

All the experimental procedures were carried out in accordance with animal experiment regulations and the approval of the Animal Experiment Committee of Kyushu Okinawa Agricultural Research Center.

Twelve barrows (Duroc × (Large White × Landrace cross breed)) with an initial average body weight of 80.9 ± 7.6 (S.D.) kg were used in this experiment, although one barrow from the control treatment group was withdrawn from the experiment in the first week due to a leg abnormality. For the first seven days, the pigs were assigned to individual pens (1.30 × 2.46 m) with concrete flooring in a temperature-controlled room (22°C) and were fed a conventional corn-soybean meal based diet. Then, the pens were randomly allocated to two dietary regimens (control and low-CP diet, Table 1), with six pens per dietary regimen. At 1000 h in the first day of the experiment, room temperature was increased to 32°C,

with relative humidity around 60%. Pigs had free access to diets and water, and the diets were added to each feeder at 0900 h each day. The remaining uneaten diet in each feeder was collected and weighed once a week. Both diets were mash formed and fortified with the nutritional requirements of the Japanese Feeding Standard for Swine (2013), with the exception of the CP content for the low-CP diet.

The body weights of the pigs were measured once a week. Back fat depth was estimated at the P2 position (65 mm below the left side from the midline over the last rib), using an ultrasonic scanner (HS-101V, Fujihira Industry Co., Ltd., Tokyo, Japan) at weeks 0 (the day before heat exposure), 2, and 4 (the day before the end of the experiment). On the final day prior to the end of the experiment, blood samples were collected at 0930 h from all pigs via jugular vein puncture. Plasma was obtained by centrifuging at 1,800 × g (4°C for 15 min), and it was stored at -80°C until analysis. Plasma urea nitrogen concentration was determined at LSI Medience Corporation (Tokyo) according to the method of urease-leucine dehydrogenase. Plasma was deproteinized with 6% 5-sulfosalicylic acid solution, and free amino acid concentrations were determined with a high-speed amino acid analyzer (L-8800E, Hitachi High Technologies Co., Tokyo, Japan). Dietary CP content was determined according to the method described by AOAC (2003). Amino acid content of the experimental diet was determined at Japan Food Research Laboratories according to the method described by AOAC (2003).

A computer-generated SAS application package (SAS Institute 1988) was used for statistical calculations. Student's t-test was used to analyze the data. The level of significance used was $P < 0.05$.

Results and discussion

The results of this study suggest that growth performance of finishing pigs was not improved with a reduction of two percentage points of dietary CP (Table 2). In contrast, Spencer et al. (2005) observed approximately 7% improvement in average daily gain with feeding

Table 1. Composition of experimental diets

	Control	Low-CP
Corn	80.85	86.47
Soybean meal	15.00	9.00
Fish meal	1.00	1.00
Alfalfa meal	1.00	1.00
Ca ₃ (PO ₄) ₂	1.60	1.60
NaCl	0.30	0.30
L-Lysine-Cl	-	0.20
L-Threonine	-	0.09
DL-Methionine	-	0.06
L-Tryptophan	-	0.03
Vitamin mineral mixture ¹⁾	0.25	0.25
Nutritional content ²⁾		
Digestible Energy (kcal/g)	3.40	3.43
Crude Protein (%)	13.90	11.80
Lysine (%)	0.66	0.67
Methionine + Cystine (%)	0.48	0.46
Threonine (%)	0.53	0.53
Tryptophan (%)	0.16	0.15

¹⁾ Vitamin mineral mixture provided the following (per kg of diet): vitamin A, 2,000 U; vitamin D₃, 300 U; DL- α -tocopheryl acetate, 10 mg; menadione sodium bisulphate, 534 μ g; riboflavin, 2 mg; D-calcium pantothenate, 2.2 mg; nicotinic acid, 2.6 mg; choline chloride, 100 mg; pyridoxine hydrochloride, 1.2 mg; folic acid, 250 μ g; thiamine mononitrate, 600 μ g; cyanocobalamin, 3.0 μ g; iron, 30 mg; manganese, 25 mg; zinc, 35 mg; copper, 6.5 mg; iodine, 0.5 mg

²⁾ Analyzed value; only digestible energy content is a calculated value.

Table 2. Effect of dietary CP level on growth performance of finishing pigs at high ambient temperature

	Control ¹⁾	Low-CP ²⁾
Average daily gain (g/day)	824 ± 114 ³⁾	813 ± 175
Average daily feed intake (g/day)	2966 ± 446	2853 ± 598
Feed efficiency (gain/feed)	28.1 ± 4.6	28.6 ± 2.8

¹⁾ n = 5

²⁾ n = 6

³⁾ Average ± S.D.

low-CP diets (also reduced by two percentage points) in finishing pigs; however, their methods included cycling high ambient temperatures (27°C from 1900 to 1000 h, 35°C from 1000 to 1900 h), while the pigs in the present study were kept at a constant high ambient temperature of 32°C. The variation in the results of the two experiments could also be attributed to the differences in other experimental conditions such as strain of pigs, relative humidity, or composition of experimental diets. Le

Table 3. Effect of dietary CP level on plasma urea nitrogen and plasma free amino acid concentration of finishing pigs at high ambient temperature

	Control ¹⁾	Low-CP ²⁾
Plasma urea nitrogen (mg/dl)	14.6 ± 2.7 ³⁾	11.2 ± 3.5
Plasma essential amino acids (nmol/ml)		
Arginine	273 ± 29	261 ± 34
Histidine	114 ± 9	108 ± 16
Isoleucine	148 ± 19 ^a	127 ± 10 ^b
Leucine	302 ± 26	311 ± 17
Lysine	259 ± 46 ^b	364 ± 62 ^a
Methionine	68.8 ± 4.5 ^b	95.5 ± 20.4 ^a
Cystine	62.7 ± 3.0	62.7 ± 6.6
Phenylalanine	132 ± 9	122 ± 7
Tyrosine	162 ± 10	163 ± 9
Threonine	248 ± 46 ^b	310 ± 21 ^a
Tryptophan	82.2 ± 2.2	92.5 ± 10.9
Valine	348 ± 45	306 ± 31
Plasma non-essential amino acids (nmol/ml)		
Alanine	562 ± 64	588 ± 105
Aspartic acid	4.45 ± 1.20	4.11 ± 0.57
Glutamic acid	53.4 ± 13.6	64.9 ± 17.1
Glycine	1172 ± 122	1402 ± 312
Serine	191 ± 14	229 ± 37
Proline	439 ± 73	419 ± 28

¹⁾ n = 5

²⁾ n = 6

³⁾ Average ± S.D.

^{a,b)} Means in the same row with different superscripts differ significantly ($P < 0.05$)

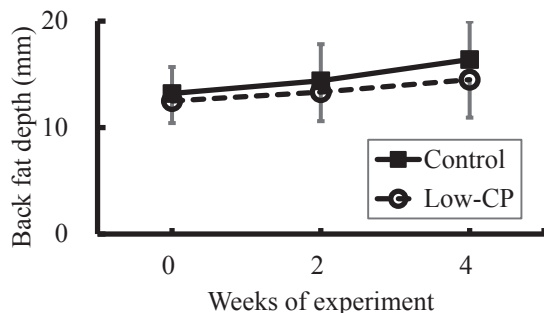


Fig. 1. Effect of dietary CP level on back fat depth (P2 position) of finishing pigs at high ambient temperature.

Data are expressed as mean ± S.D.

Bellego et al. (2002) reported that growth performance of finishing pigs was not affected by the reduction in the dietary CP level (reduced by four percentage points). They compared feed intake of pigs fed the same diet at different environmental temperatures (22°C vs 29°C), and observed that relative feed intake decreased with increased fattening in pigs fed the control CP diet; however, the relative feed intake did not decrease with growth in pigs fed the low-CP diet. Their results indicate that feeding a low-CP diet might alleviate the loss of appetite under high ambient temperatures; however, these effects may be too insignificant to affect growth performance.

Plasma urea concentration may be an index to monitor dietary protein sufficiency and dietary amino acid pattern in growing pigs (Coma et al. 1995), since increasing amino acid utilization decreases urea synthesis and, thus, decreases plasma urea concentrations. In the present study, there was no significant difference in plasma urea concentration between dietary treatments (Table 3), which confirms that the protein level of the low-protein diet was adequate and the amino acid pattern was suitable for finishing pigs. Although the expected advantages of the low-CP diet on finishing pigs were not observed, growth performance of finishing pigs was not hampered by the reduction of two percentage points of dietary CP level with essential amino acid supplementation (Kerr et al. 1995). Dietary supplementation with lysine, threonine, and methionine in the low-CP diet increased plasma levels of these free amino acids, and may be related to the higher supplementation of synthetic formed those amino acids in low-CP diet.

Figure 1 illustrates the change in back fat depth in pigs fed the low-protein and control diets, and suggests that the low-CP diet does not accelerate back fat accumulation. Similarly, Tachibana & Ubagai (1997) found that there was no difference in fat thickness at the shoulder, back, and loin between pigs fed a low-CP diet (11.5% CP) compared to pigs fed a 14% CP diet. However, Tous et al. (2014) reported that finishing barrows fed an amino acid-fortified low protein diet tended to have increased back fat thickness. They speculated that the change in carcass composition may be attributed to the replacement of the protein source by carbohydrates in the diet, and the energy for nitrogen excretion was distributed to fat synthesis. Further studies are necessary to clarify the different results of these experiments.

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