Effects of dietary threonine on growth performance and carcass traits of Yangzhou geese

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ABSTRACT: A dose-response experiment with 5 total dietary threonine (Thr) levels (0.54, 0.64, 0.74, 0.84 and 0.94%) was conducted to study the effect of dietary Thr on growth performance and carcass traits of Yangzhou geese from 0 to 8 weeks of age. Three hundred 1-day-old Yangzhou goslings were randomly allocated to 15 pens with 20 birds (10 males and 10 females) per pen according to similar pen weight. There were 5 dietary treatments, consisting of 3 replicate pens. Weight gain, feed intake and feed/gain of geese from each pen were measured at 2-week intervals from 0 to 8 weeks. At 56 days of age, four geese (2 males and 2 females) were selected randomly from each pen and slaughtered to evaluate the carcass quality. The results showed that an increase in dietary Thr resulted in an increase and then a decrease in daily weight gain in both periods. Peak daily weight gain responses appeared in geese fed the 0.74%Thr diet in both periods (36.120 and 61.96 g, respectively). Thr supplementation significantly affected feed/gain in the 0–4 week period ($P \le 0.045$) and daily feed intake in the 5–8 week period ($P \le 0.012$). No significant linear or quadratic responses from Thr supplementation were observed in growth performance and carcass traits of geese except for eviscerated carcass percentage (quadratic effect, $P \le 0.016$). The optimal Thr requirement of Yangzhou geese from 0 to 8 weeks of age was 0.726% for eviscerated carcass percentage. The results of our experiment reported herein would document that the Thr requirements suggested by NRC (1994) for geese up to 8 weeks of age are safe estimates; they may slightly overestimate the requirements but not by a large margin.

Keywords: threonine; geese; growth performance; carcass traits

The Yangzhou goose is a major breed in China and was approved as the first national goose breed by the National Examination and Approval Committee of Domestic Animal and Poultry Breeds in 2006. They are medium in body size and it is a dual-purpose breed for meat and egg production. Traditionally, farmers kept a small number of geese to produce meat and eggs for their own consumption. With the development of animal husbandry in China, goose production is becoming specialised and more widespread. However, due to the absence of feeding standards for geese, farmers have to rely on personal experience and feeding standards for chickens in determining the feeding allowances. It is therefore necessary to study the requirement and establish more precise feeding standards for this new breed of geese to ensure its effective production.

The dietary amino acid concentration should closely meet maintenance and tissue accretion

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needs of poultry, especially toward the middle and end of the grow-out period. Hence, the under- and over-formulation of amino acids will decrease performance and increase nitrogen excretion, respectively. The former effects are exacerbated in the latter period of rearing because the bird's feed consumption increases with age (Kidd et al., 2004).

The nutrient threonine (Thr) must be considered in dietary formulations for poultry because its excess is costly and its deficiency will decrease the efficiency of sulphur amino acid (SAA) and lysine use (Kidd, 2000). In addition, Thr is typically the third limiting amino acid behind SAA and lysine in poultry diets composed of maize or sorghum, soybean meal, and meat meal (Fernandez et al., 1994; Kidd, 2000).

Currently, Thr requirement studies are mostly focused on chickens and turkeys (Kidd et al., 1997, 2004; Lehmann et al., 1997; Rosa et al., 2001; Samadi and Liebert, 2007). However, little information has been published describing the Thr

Table 1. Composition of threonine-deficient basal diets

Ingredient	Starter, 0–4 week (g/kg)	Grower, 4–8 week (g/kg)
Maize	600	560
Peanut meal	320	260
Lucerne meal	30	130
Diclacium phosphate	13	14
Limestone (ground)	20	16.5
NaCl	4	4
L-lysine-HCL	5	4.5
DL-methionine	2.5	2.5
Vitamin and trace mineral premix[1]	5.5	8.5
Nutrient concentrations		
Crude protein	198.02	177.33
Metabolizable energy[2] (kcal/kg)	2 806	2 617
Crude fibre	28.9	48.6
Calcium	11.5	11.7
Available phosphorus	4.2	4.1
Methionine	4.9	4.8
Lysine	10.1	9.6
Methionine + cystine	7.1	7.0
Threonine	5.4	5.4

[1]provided per kg of diets: starter: vitamin A (retinyl acetate) 0.33mg; vitamin D_3 (cholecalciferol) 0.0062 mg; vitamin E (di-α-tocopheryl acetate) 1.65 mg; vitamin K (2-methyl-1, 4-naphthoquinone) 1.1 mg; thiamine 0.55 mg; riboflavin 6.6 mg; pyridoxine 1.1 mg; vitamin B_{12} (cobalamin) 0.011 mg; nicotinic acid 33 mg; pantothenic acid 9.9 mg; folic acid 0.55 mg; folate 0.55 mg; biotin 0.044 mg; choline 0.385 g; Fe 0.066 g; Cu 0.011 g; Mn 0.1045 g; Zn 0.099 g; I 0.55 mg; Se 0.33mg
Grower: vitamin A (retinyl acetate) 0.51 mg; vitamin D_3 (cholecalciferol) 0.0096 mg; vitamin E (di-α-tocopheryl acetate) 2.55 mg; vitamin K (2-methyl-1,4-naphthoquinone) 1.7 mg; thiamine 0.85 mg; riboflavin 10.2 mg; pyridoxine 1.7 mg; vitamin B_{12} (cobalamin) 0.017 mg; nicotinic acid 51 mg; pantothenic acid 15.3 mg; folic acid 0.85 mg; folate 0.85 mg; biotin 0.068 mg; choline 0.595 g; Fe 0.102 g; Cu 0.017 g; Mn 0.1615 g; Zn 0.153 g; I 0.85 mg; Se 0.51 mg
[2]the values are calculated according to the AME of chickens

requirements of geese. The values for geese in NRC (1994) are missing, and they only represent an estimate based on values obtained for other ages or species.

The empirical method most commonly used to determine amino acid responses in growing poultry involves the addition of graded supplements of the amino acid under test to a basal diet deficient in that amino acid (D'Mello, 1982). Therefore, through the dose-response relationship for Thr, the objective of our study was to study the effect of dietary Thr on growth performance and carcass traits of Yangzhou geese from 0 to 8 weeks of age.

MATERIAL AND METHODS

Animals and procedures

Three hundred 1-day-old Yangzhou goslings (150 males and 150 females) from one commercial hatchery (Yangzhou, Jiangsu, P.R. China) were randomly distributed to 15 pens of 20 birds (10 males and 10 females), each according to similar pen weight. There were 5 dietary treatments, each containing 3 replicate pens. Two maize-peanut meal basal diets (starter 0–4 weeks, and grower 5–8 weeks) were formulated to provide adequate levels of all nutrients for geese except Thr (Table 1) (NRC, 1994).The basal diets were supplemented with 5 levels of L-Thr (0, 0.1, 0.2, 0.3 and 0.4%) to provide 0.54, 0.64, 0.74, 0.84 and 0.94% of total Thr in the diet.. Feed and water were provided *ad libitum*, the experiment was conducted from 0 to 8 weeks of age.

Weight gain, feed intake and feed/gain of geese were measured at 2-week intervals from 0 to 8 weeks of age. At 56 days of age, after being deprived of feed overnight, 4 geese with the average body weight of the pen (2 males and 2 females, including thigh and drumstick) were selected randomly from each pen and slaughtered by exsanguination. Birds were eviscerated manually, body weight was recorded, carcass weight and eviscerated carcass weight, abdominal fat, breast meat (including the pectoralis major and pectoralis minor muscles), leg meat (including thigh and drumstick) were equally measured. Carcass weight measurement was done after exsanguination and defeathering. The percentages of weights of breast meat (BMP), leg meat (LMP) and abdominal fat (AFP) were calculated relative to the eviscerated carcass weight.

Analytical procedures

The amino acid contents of diets were determined using a Waters ion-exchange HPLC system according to the AOAC method 994.12, samples were hydrolysed by 6M HCl at 110°C for 24 h[10]. Methionine and cystine were determined as methionine sulphone and cysteine acid after oxidation with performic acid. The oxidation process was carried out according to the AOAC method (AOAC, 1995).

Statistical analysis

Data were analyzed as a completely randomized design by the GLM procedure of SAS software (SAS, 1996). Differences among treatment means were compared by Duncan's multiple-range test when probability values were significant ($P < 0.05$). The quadratic and linear models were analyzed by the REG procedure of SAS software.

RESULTS

Growth performance

The effect of dietary Thr on the growth performance of Yangzhou geese is shown in Table 2. An increase in dietary Thr resulted in an increase and then a decrease in daily weight gain in both periods. Peak daily weight gain responses appeared in the geese fed the 0.74%Thr diet in both periods (36.12 and 61.96 g for 0 to 4 and 5 to 8 weeks, respectively). Thr supplementation significantly affected feed/gain in the 0–4 week period ($P \leq 0.045$) and daily feed intake in the 5–8 week period ($P \leq 0.012$). Feed/gain reached a numerical maximum at 0.54% dietary Thr and numerical minimum at 0.74% dietary Thr in both periods.

No significant linear or quadratic responses from Thr supplementation occurred for daily weight gain, daily feed intake and feed/gain.

Carcass traits

The effect of dietary Thr on carcass measurements of Yangzhou geese at 8 weeksof age is shown in Table 3. Geese fed the 0.74%Thr diet reached the highest ECP, BMP and AFP, while the highest

Table 2. Effect of dietary threonine on the growth performance of Yangzhou geese[1]

Growth period	Thr (%)	Daily weight gain (g/bird)	Daily feed intake (g/bird)	Feed/gain (g/g)
0–4 week	0.54	29.56	67.02	2.27
	0.64	34.18	74.14	2.17
	0.74	36.20	77.81	2.15
	0.84	33.40	72.50	2.17
	0.94	33.04	72.77	2.21
	SEM	1.55	3.26	0.03
	probability			
	Thr	0.12	0.30	0.05
	Thr linear	0.50	0.50	0.49
	Thr quadratic	0.16	0.23	0.05
5–8 week	0.54	57.38	242.63	4.28
	0.64	55.85	231.67	4.18
	0.74	61.96	253.07	4.15
	0.84	59.35	213.41	3.61
	0.94	58.47	230.03	3.94
	SEM	3.68	6.25	0.28
	probability			
	Thr	0.82	0.01	0.50
	Thr linear	0.51	0.43	0.15
	Thr quadratic	0.66	0.78	0.42

[1]results are means with $n = 3$ per treatment

LMP was recorded in geese fed the 0.84% Thr diet.

No significant linear or quadratic responses from Thr supplementation were observed for carcass traits except for ECP (quadratic effect, $P \leq 0.016$). The quadratic model of Thr response to ECP is: (Y (eviscerated carcass percentage) = 65.801X (dietary Thr) – 43.050X^2 + 42.655, $R^2 = 0.984$). According to this model, the optimal Thr requirement, set at 95% of the asymptote, was 0.726% (95% of the dietary Thr level at maximum eviscerated carcass percentage) for eviscerated carcass percentage.

DISCUSSION

The experimental Thr-deficient basal diets consisted of a mixture of peanut meal and maize so that diets would contain approximately 70% of the NRC (1994) Thr recommendations (0.80% Thr of diet as referred to broilers). The inferior growth rate and feed conversion of geese fed the unsupplemented basal diets in both periods indicated that these diets were indeed deficient in Thr. It was also confirmed in many other previous Thr studies involving chickens and turkeys (Lehmann et al., 1997; Kidd et al., 1999; Samadi and Liebert, 2007). In our study, an increase in dietary Thr resulted in an increase and then a decrease in daily weight gain in both periods. This pattern suggested that excess Thr caused an imbalance in the amino acid profile of the diet, which altered the body metabolism. It was consistent with methionine requirement studies in which Han and Baker (1993) and Acar et al. (2001) found that excess methionine was toxic to chickens. Wang et al. (2009) also observed a similar phenomenon in a methionine study with Yangzhou geese.

Table 3. Effect of dietary threonine on carcass traits of Yangzhou geese at 8 weeks of age[1]

Thr (%)	Eviscerated carcass (%)	Breast meat (%)	Leg meat (%)	Abdominal fat (%)
0.54	65.70	5.10	18.15	2.75
0.64	66.97	4.62	17.60	2.60
0.74	67.90	5.51	18.91	2.92
0.84	67.55	5.30	19.14	2.74
0.94	66.45	4.60	18.79	2.51
SEM	0.67	0.39	0.88	0.30
Probability				
Thr	0.18	0.39	0.73	0.90
Thr linear	0.53	0.84	0.18	0.57
Thr quadratic	0.02	0.72	0.48	0.55

[1]results are means with n = 3 per treatment

Threonine, besides its role as an essential amino acid in protein synthesis, is a metabolic precursor of glycine (Bender, 1975). There are apparently no data on the glycine and serine requirements in the poults. The latest experiments with starting broiler chicks indicated much higher requirements for glycine and serine than the current NRC recommendation for broilers until 21 days of age (Schutte et al., 1997). Glycine is required for the synthesis of uric acid. In diets with excess protein, the glycine requirement may be very high, because one molecule of glycine is lost with each molecule of uric acid excreted. This loss of glycine might be of particular importance in turkey starters with their extremely high levels of crude protein. Hence, it is possible that a part of the live weight response to supplemental threonine in the first 4 weeks of age may be due to a metabolic transfer of threonine to glycine. Clearly, more research is needed to test this hypothesis.

Supplemental Thr did not significantly affect carcass traits in our experiment (Table 3), but it only improved ECP – an unexpected result, since pen weights at 56 days of age did not differ among treatments. However, the selection of two males and two females from each pen for slaughter eliminated sex as a source of variation. Moreover, the limited sample size of 12 carcasses per dietary treatment wording significance of this effect. And the birds selected for slaughter were near the pen mean, which may have not elevated the significance level (Dorfman et al., 1993). A similar phenomenon was previously observed in chickens and turkeys by other researchers (Kidd and Kerr, 1996; Lehmann et al., 1997).

The estimated total dietary threonine requirement of this study is higher than those reported by Kidd et al. (0.726% vs 0.67%; Kidd et al., 1999) in broilers and Lehmann et al. (0.726% vs 0.64%, Lehmann et al., 1997) in turkeys during the same time period for carcass traits. This could be related to the physiological characteristics of geese which may be different from chickens and turkeys (Shi et al., 2007). However, it was lower than NRC (1994) Thr recommendations for geese (0.80% Thr of diet as referred to broilers). The NRC values for Thr may be high estimates to allow for safety factors in dietary formulation.

Webel et al. (1996) concluded that Thr requirements for broilers from 3 to 8 weeks of age should be expressed as 70% of the dietary lysine level (Webel et al., 1996). Although it was not our intention to determine the digestible Thr:lysine ratio in this experiment, it is interesting to note that our total Thr recommendation of 0.726 corresponds to 71.2% of dietary lysine (when extrapolated on a digestible basis, 0.623%:0.875%). We supplemented the experimental diets with 110% of the NRC (1994) lysine recommendation so that the Thr responses would not be limited. Total dietary lysine of 110% of NRC may be a good estimation of the lysine requirement based on the experimental conditions and genetic strain of the birds in this study (Kidd et al., 1996).

CONCLUSIONS

(1) Thr may be an important factor in diets for geese of various ages;
(2) Thr requirements suggested by NRC (1994) for geese up to 8 weeks of age are safe estimates; they may slightly overestimate the requirements but not by a large margin.

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