THE EFFECTS OF PROTEIN LEVELS ON THE TOTAL SULPHUR AMINO ACID REQUIREMENTS OF BROILERS DURING TWO GROWTH PERIODS

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Summary

Studies on the effects of protein levels on the total sulphur amino acid (TSAA) requirements of chickens were conducted on the starter broilers by feeding four levels of crude protein (16, 18, 20 and 23%) at three levels of TSAA (0.83, 0.93 and 1.03%) and on the grower broilers by feeding three levels of crude protein (16, 18 and 20%) at three levels of TSAA (0.72, 0.79 and 0.86%). The metabolisable energy of the diets was maintained constant at 3,200 kcal/kg and the experiments were carried out for two growing periods: starter (0-3 wk) and grower (3-6 wk). The results showed that there were significant differences in body weight gain, feed intake and feed:gain ratio under different protein levels of the starters. Crude protein, ME and TSAA intake were significantly affected by increasing the CP levels. The TSAA requirement of the starter broilers is recommended at 0.93% and it is not influenced by different protein levels used in the experiment. For the grower period, body weight gain and feed:gain ratio improved significantly at higher protein diets. Birds fed higher protein diet consumed greater quantities of protein. Responses to TSAA supplementation for body weight gain, feed intake and feed:gain ratio were not significant. The present results showed that the TSAA level of 0.79 to 0.86% was required for grower diets and that the protein levels of the diet did not influence the the TSAA requirement.

(**Key Words** : Protein, Total Sulphur, Amino Acid, Starter and Grower Broilers, Performance)

Introduction

The growth rate of broilers in the tropics tends to be lower than that in the temperate regions which could be attributed to inadequate levels of essential amino acids or vitamins, Ogunmodede (1977). Investigations by Al-Nasser et al. (1986) on the amino acid requirement of broilers in the tropics under ambient temperatures of 30 to 42℃ showed an increasing requirement of DL-methionine by 10-25% above the level of the control diet, improved body weight gain of the broilers. Almquist (1952) emphasised the influence of protein content on the requirement of the essential amino acids. The work on this relationship has been confirmed for several amino acids including tryptophan, lysine and threonine (Boomgaardt and Baker, 1971; Abebe and Morris, 1990a,b and Robbins, 1987). All the known results had indicated that the amino acids requirement increased with increasing protein content of the diet.

A similar relationship to protein concentration was suggested for sulphur amino acids (methionine and cystine) requirement of young chicks by Nelson et al. (1960). There was an increased in the SAA requirement as dietary protein increased. These results were later confirmed by Hartel (1970), Jensen et al. (1989) and Mendonca and Jensen (1989). Morris et al. (1987) concluded that the diets which contain surplus protein, beyond that needed to maximize growth rate or feed efficiency, need supplementation with methionine beyond that required when dietary protein was adequate.

It is generally accepted that when protein limiting diets were fed to broiler chickens, the optimal concentration of the first-limiting amino acid depends on the supply of the second-limiting amino acid. Thus the requirement for a limiting amino acid, such as TSAA (or methionine) in corn-soyabean base diets, increased in a direct proportion to the protein content of the diets providing that its protein composition is held constant and the overall supply remains limiting.

It has been reported that the requirement for TSAA (methionine + cystine + cysteine) increases as the dietary protein concentration is increased beyond 20% of

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the diet (Jensen et al., 1989; Mendonca and Jensen, 1989). This experiment was conducted to determine the effect of dietary protein concentration on TSAA requirement of broiler chickens during two growth periods reared in the tropics.

Materials and Methods

Starter period (0-3 weeks)

Animals and general procedures

Four hundred thirty two male day-old ISA vadette broiler chicks were randomly distributed into thirty-six groups of twelve chicks each with three replications on the basis of similar weight group. The chicks were reared from day-old until three weeks of age in an open raised floor cages housing. Heating lamps were provided during the brooding period. Twelve diets with four different levels of protein and three levels of TSAA were fed separately to each experimental group. Feed and water were given *ad libitum*. Body weight and feed consumption were recorded weekly from each cage, after corrections for mortality. The environment conditions were not controlled and ambient temperature fluctuated from 23 to 37℃.

Diets

Twelve diets, comprised primarily of corn soyabean meal formulated to be isocaloric at 3,200 kcal/kg, with four levels of protein (16, 18, 20 and 23%) and three levels of TSAA (0.83, 0.93 and 1.03%) were fed in a mash form to the chicks from day-old till three weeks of age. The treatments (diets) were completely randomised to each group. The composition of the basal diets are shown in table 1. The amounts of corn and soyabean meal were adjusted to achieve the protein levels while commercial DL-methionine was supplemented to provide additional quantities of TSAA. A minimum lysine concentration of 1.20% (NRC, 1984) was specified resulting in the addition of L-lysine to the three lower protein diets. Nutrient values and requirements given by NRC (1984) were used in the feed formulation.

TABLE 1. COMPOSITION OF STARTER BASAL DIETS

Ingredients (%)	Crude protein (%)			
	16	18	20	23
Ground yellow corn	54.70	51.20	47.70	42.50
Soybean meal (44%)	25.50	30.70	36.00	43.77
Palm oil	9.64	9.64	9.64	9.64
Premix (Vitamins & minerals)[1]	0.25	0.25	0.25	0.25
Salt	0.50	0.50	0.50	0.50
Coccidiostat	0.05	0.05	0.05	0.05
Limestone	1.50	1.42	1.42	1.41
Dicalcium phosphate	1.80	1.72	1.64	1.55
DL-methionine	0.30	0.24	0.18	0.09
L-lysine	0.32	0.18	0.03	–
Kaolin clay	5.44	4.10	2.59	0.24
Total	100.00	100.00	100.00	100.00
Calculated analysis :				
Protein (%)	16.03	18.01	20.04	23.00
ME (kcal/kg)	3,201	3,200	3,201	3,200
Calcium (%)	1.03	1.00	1.00	1.00
Available phosphorus (%)	0.46	0.45	0.45	0.45
TSAA (%)	0.83	0.83	0.83	0.83

[1] Vitamin & mineral premix contain the following per kg diet. Vit. A 10,000 IU, D_3 2,000 IU, E 15 IU, K_3 1.5 mg, B_1 1.5 mg, B_2 5 mg, B_6 2 mg, B_{12} 10 μg, Pantothenic acid 12 mg, Biotin 10 μg, Niacin 25 mg, Choline Chloride 900 mg, Folic acid 0.5 mg, Cu 10 mg, Mn 52.5 mg, Zn 60 mg, Fe 100 mg, I 1.5 mg, Co 0.25 mg.

Grower period (4-6 weeks)

Animals and general procedures

The experiment was conducted with male broiler chicks of a commercial strain ISA Vadette. The chicks were reared together up to three weeks of age in deep litter system and given a standard commercial diet containing 3,100 kcal/kg and 23% crude protein.

At three weeks of age the birds were separated into similar weight groups and randomly distributed into growing cages. Each treatment was replicated three times with twelve birds per replicate. Nine diets with different levels of protein and TSAA were randomly given to each experimental group. Feed and water were offered *ad libitum* until six weeks of age. Body weight and feed intake data were weekly collected after adjustment for mortality. The housing and environmental conditions were similar to those of the starter period.

Diets

Diets were formulated encompassing three levels of protein (16, 18 and 20%) and three levels of TSAA (0.72, 0.79 and 0.86%) at 3,200 kcal/kg ME were offered in a mash form. The composition of corn and soybean meal basal diets is given in table 2. Levels of corn and soybean meal were adjusted to achieve the percentage of crude protein levels while commercial DL-methionine was supplemented to provide additional quantities of TSAA. A

TABLE 2. COMPOSITION OF GROWER BASAL DIETS

Ingredients (%)	Crude protein (%)		
	16	18	20
Ground yellow corn	54.70	51.20	47.70
Soybean meal (44%)	25.50	30.70	36.00
Palm oil	9.64	9.64	9.64
Premix (Vitamins & minerals)[1]	0.25	0.25	0.25
Salt	0.50	0.50	0.50
Coccidiostat	0.05	0.05	0.05
Limestone	1.32	1.30	1.30
Dicalcium phosphate	1.48	1.45	1.38
DL-methionine	0.19	0.13	0.07
L-lysine	0.12	–	–
Kaolin clay	6.25	4.78	3.11
Total	100.00	100.00	100.00
Calculated analysis :			
Protein (%)	16.03	18.01	20.04
ME (kcal/kg)	3,201	3,200	3,201
Available phosphorus (%)	0.40	0.40	0.40
Lysine	1.00	1.02	1.17
TSAA (%)	0.72	0.72	0.72

[1] Vitamin & mineral premix contain the following per kg diet.
Vit. A 10,000 IU, D_3 2,000 IU, E 15 IU, K_3 1.5 mg, B_1 1.5 mg, B_2 5 mg, B_6 2 mg, B_{12} 10 μg, Pantothenic acid 12 mg, Biotin 10 μg, Niacin 25 mg, Choline Chloride 900 mg, Folic acid 0.5 mg, Cu 10 mg, Mn 52.5 mg, Zn 60 mg, Fe 100 mg, I 1.5 mg, Co 0.25 mg.

minimum lysine concentration of 1.00% (NRC, 1984) was specified resulting in the addition of L-lysine to the 16% crude protein diet.

Statistical analysis

Performance data were analysed using the Statistical Analysis System (SAS, 1982). The significant parameter means were separated using Duncan's new multiple range test (Steel and Torrie, 1980)

Results and Discussion

Starter period

Data on the performance of the main treatment effects are presented in table 3. Significant differences ($p < 0.05$) in body weight gain, feed intake and feed : gain ratio were observed under different protein levels. Body weight gain and feed : gain ratio were significantly improved for birds fed diet containing protein up to 23% over those fed 16% protein. Although, feed intake was significantly higher in birds fed 20% protein than those fed 16%, there was no significant difference among 16, 18, and 23% protein. It was generally recognised that body weight gain and feed : gain ratio improved with the increasing protein level (Salmon, 1983; Summers and Leeson, 1985 and Leeson et al., 1988). These results demonstrated that optimal male broiler performance (table 3) could be achieved if their essential amino acid requirements were satisfied regardless to a particular minimum dietary protein, despite 4% dietary CP differences between starter diets. Reduction in feed intake at 16% CP, as similarly shown by Jackson et al. (1982), indicated that voluntary intake was not affected by protein content although intake was depressed by diets of low protein concentration.

Responses to SAA supplementation of all performances were not significant ($p < 0.05$). Birds consumed 0.93% TSAA diet had the highest body weight

TABLE 3. EFFECT OF DIETARY PROTEIN AND TSAA LEVELS ON PERFORMANCE OF STARTER BROILERS (0-3 weeks)

Treatment	Weight gain (g/bird · day)	Feed intake (g/bird · day)	Feed/gain	Protein intake (g/bird · day)	ME intake (kcal/bird · day)	TSAA intake (g/bird · day)
CP (%)						
16	26.83[a]	47.69[a]	1.78[a]	7.63[a]	152.60[a]	443.00[a]
18	29.30[b]	48.76[ab]	1.66[b]	8.78[b]	155.99[ab]	454.22[ab]
20	30.58[b]	49.88[b]	1.63[b]	9.98[c]	159.63[b]	464.02[b]
23	30.23[b]	49.07[ab]	1.62[b]	11.29[d]	157.03[ab]	456.16[ab]
TSAA (%)						
0.83	29.16	48.55	1.67	9.36	155.35	402.93[a]
0.93	29.76	49.34	1.66	9.51	157.90	458.88[b]
1.03	28.79	48.66	1.69	9.38	155.70	501.23[c]
CP × TSAA	NS	NS	S	NS	NS	NS

[a,b] Means in each column within treatment followed by the same superscript letter do not differ significantly ($p < 0.05$).
NS; Non significant.
S; Significant.

gain and the lowest feed : gain ratio. The CP × TSAA interaction was detected in only feed : gain ratio, owing to differential response of 16% protein diet to the SAA supplementation.

Table 3 also showed the effects of dietary CP and TSAA on the intake of CP, ME and TSAA. Crude protein, ME and TSAA intake were significantly ($p < 0.05$) affected by increasing the CP levels of the diet from 16 to 23%. SAA supplementation had no effect on the CP and ME intake with the exception of TSAA intake which was significanlty increased with increasing TSAA. However, there were no significant interactions between CP and TSAA.

In general, birds fed on higher protein content diets consumed greater quantities of protein (Jackson et al., 1982 and Leeson et al., 1988). Since the significant reduction in feed intake was noted for birds on 16% CP relative to those on 20% CP, there was a significant reduction in ME and TSAA intake for birds on 16% CP compared with those on 20% CP.

The results from this study showed that the TSAA requirement for starter broilers at 0.93% as recommended by the NRC (1984) was adequate. In addition, the TSAA requirements as a percentage of the diet remained constant at the different dietary CP examined.

Grower period

The results on performance as influenced by the main treatment of dietary protein and TSAA are presented in table 4. Body weight gain significantly improved for birds consuming 18 and 20% protein diets over those on 16% protein. Feed conversion improved significantly when 20 % protein diets were fed to the birds comparing to 16 and 18% protein (table 4). Increasing dietary protein did not exert any effect on feed intake. Although feed : gain ratio of birds on 18% CP diet was higher than those on 20%, their body weight gain was similar. This result showed a possible trend on the reduction of approximately 2% CP from NRC (1984) suggested level (20%) for grower broilers without adverse effect on their growth rate.

The present data further support the reports of Jackson et al. (1982) and Leeson et al. (1988) that birds fed on higher protein content diets consumed greater quantities of protein. However, no significant differences in feed mass intake, TSAA and ME intake were noted, as similarly observed by Sinurat and Balnave (1985).

Responses to SAA supplementation for body weight gain, feed intake, feed : gain ratio were not significant (table 4). Body weight gain, however, increased by increasing TSAA in the diets for birds fed on 0.79 and 0.86% TSAA compared to those on 0.72% TSAA. Feed : gain ratio improved slightly, but not significantly, by increasing TSAA levels. Birds fed on 0.79% TSAA had the highest body weight gain while those on 0.86% TSAA had the lowest feed : gain ratio.

Table 4 also showed the effects of dietary CP and TSAA main treatments on CP, ME and TSAA intake. There were no significant differences ($p < 0.05$) in ME or TSAA intake due to the increasing dietary CP level from 16 to 20%, but protein intake increased significantly ($p < 0.05$) as dietary CP increased. Although CP and ME intake were unaffected by dietary TSAA levels, however, TSAA intake was significantly increased ($p < 0.05$) as dietary TSAA increased. No significant interactions between dietary protein and TSAA were observed for the performances studied.

In conclusion, the present studies showed that the TSAA level of 0.72% (NRC recommendation) for grower

TABLE 4. EFFECT OF DIETARY PROTEIN AND TSAA LEVELS ON PERFORMANCE OF GROWER BROILERS (4-6 weeks)

Treatment	Weight gain (g/bird · day)	Feed intake (g/bird · day)	Feed/gain	Protein intake (g/bird · day)	ME intake (kcal/bird · day)	TSAA intake (g/bird · day)
CP (%)						
16	59.09[a]	126.80	2.15[a]	20.29[a]	405.76	1,002.57
18	61.20[b]	129.01	2.11[a]	23.22[b]	412.84	1,018.85
20	62.23[b]	125.90	2.02[b]	25.18[c]	402.89	993.95
TSAA (%)						
0.72	59.76	126.86	2.13	22.85	405.95	913.38[a]
0.79	61.72	128.61	2.08	23.14	411.57	1,016.28[b]
0.86	61.03	126.25	2.07	22.70	403.99	1,085.71[c]
CP × TSAA	NS	NS	NS	NS	NS	NS

[a,b] Means in each column within treatment followed by the same superscript letter do not differ significantly ($p < 0.05$).
NS; Non significant.

broilers was inadequate as similarly concluded by Jensen et al. (1989) and Hickling et al. (1990), and a level of 0.79 to 0.86% is recommended as shown by body weight gain and feed : gain ratio. In addition the requirement of TSAA per unit of diet remained constant at the three dietary CP levels. In an Attempt to reduce the protein levels of the diets, thus reducing the feed cost, this study indicated that the optimal performances could be obtained by reducing 5% and 2% of dietary CP below the recommended levels for the starter and grower periods respectively, provided the limiting amino acids, e.g. methionine and/or lysine, were adequate.

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