THE EFFECTS OF DIETARY ENERGY ON THE TOTAL SULPHUR AMINO ACID REQUIREMENTS OF BROILERS DURING TWO GROWTH PERIODS

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Summary

Three levels of dietary ME (3,000, 3,200 and 3,400 kcal/kg) and four levels of Total Sulphur Amino Acid (TSAA) (0.73, 0.83, 0.93 and 1.03%) were studied in the starter period (0-3 wks) of the broilers. Three levels of dietary ME (3,000, 3,200 and 3,400 kcal/kg) combined with four levels of TSAA (0.65, 0.72, 0.79 and 0.86%) were studied in the grower period (3-6 wks). The crude protein content of the diet of the starter period was 23% while the diet of the grower period was 20%. The performance data of the starter broilers indicated that the dietary energy levels had no significant effects on body weight gain, feed intake and feed:gain ratio. However, TSAA levels had a significant influence on the growth and feed parameters. The response pattern for the grower period was similar to the starter period. The present experiment showed that in the tropics the TSAA requirement for the starter period was between 0.83 to 0.93% which is similar to the values recommended by NRC while for the grower period the TSAA requirement was between 0.79 to 0.86% at all the three energy levels which is higher than the values recommended by NRC.

(**Key Words** : Dietary Energy, Total Sulphur Amino Acid, Starter and Grower Broilers)

Introduction

The major parameter of a feed which determines the amount eaten is the concentration of available energy in the feed because animals eat to satisfy their energy requirements (Hill and Dansky, 1954). In addition, the composition and the availability of the nutrients are major factors influencing voluntary intake. The concentration of protein, the balance of amino acids and the deficiency or excess of minerals or vitamins can all affect intake (Forbes, 1986). Amino acid deficiency and imbalances also depressed voluntary intake of poultry (Boorman, 1979). If the imbalance is severe there is a large decline in growth and intake and this could be induced by adding small amount of one or a few amino acids to a balanced, low protein diet. Carew and Hill (1961) had shown earlier that an amino acid deficiency could cause an increase in feed intake. Okumura and Mori (1979) reported that chicken fed with methionine plus cystine deficient diet showed higher feed intake and heat production and lower nitrogen and energy retention. The increased feed intake was probably an attempt on chicken's part to meet their amino acid needs (Parsons et al., 1984). These increased feed intake resulted in overconsumption of energy (relative to effective amino acid intake) and thus resulted in greater body fat deposition.

Methionine, cystine and cysteine are sulphur amino acids (SAA). Cysteine can be formed by the biochemical dissimulation of methionine: the process is highly efficient in molecular terms, and is not reversible. The requirement for methionine can be met only by methionine, while that for cystine can be met by either cystine or methionine (NRC, 1984). So the requirement of sulphur amino acid could be calculated from the simple addition of methionine and cystine. In practice, a low dietary cystine would be compensated by a high methionine and this situation will not minimise SAA requirement by maximizing efficiency of utilization of the two amino acids.

There had been studies on the levels of SAA in the feed for maximum production. Wheeler and Latshaw (1981) indicated that for the starting period a level of 0.82% TSAA and during the growing stage a level of 0.70-0.76% TSAA were required. These results were again confirmed by Jensen et al. (1989) which suggested that the requirement of 0.72% recommended by NRC was inadequate and that a requirement of 0.78% was suggested. However, methionine requirements as

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percentage of the diet increased linearly with increasing concentrations of the dietary energy (Baldini and Rosenberg, 1955; Ahmed et al., 1979). But, Mitchell and Robbins (1984) found that the TSAA requirement was not affected by dietary energy levels.

The objective of the present studies was to determine the TSAA levels in the broiler starter and grower diets and the effects of dietary energy levels on the TSAA requirements of broilers reared in the tropics.

Materials and Methods

Starter period (0-3 weeks)

Animals and general procedures

The experiment was conducted with 432 day-old ISA Vadette male chicks. The chicks were randomized, 12 birds per cage, and reared from day-old until 21 days of age in 36 raised floor cages. Heating bulbs were used to supply brooding heat and a continuous lighting programme were practiced throughout the experimental period. Twelve diets at three levels of metabolizable energy and four levels of TSAA were given separately to each experimental groups with three replications. Feed and water were provided *ad libitum* to all the birds. Body weight and feed consumption were recorded weekly from each cage. Mortality records were adjusted to account for deaths on a chick day basis. The ambient temperature varied from 23 to 39℃ throughout the experiment.

Diets

The diets were calculated to be isonitrogenous at 23% by maintaining the amount of ground corn and soyabean meal at a constant level. The energy concentration of the diets was attained by varying the amount of palm oil while the commercial DL- methionine was supplemented to provide the varying levels of TSAA. The corn and soyabean meal used were intially analysed for crude protein and SAA (Methionine and Cystine) prior to formulating and mixing of the diets. The other nutrient values and the requirements were as given by NRC (1984) were used in the formulation. The composition of the basal diets are shown in table 1. The energy levels of the feed were 3,000, 3,200 and 3,400 kcal/kg while the TSAA levels were 0.73, 0.83, 0.93 and 1.03%.

Grower period (4-6 weeks)

Animals and general procedures

Three hundred sixty-3 week-old ISA Vadette male broilers were used. For the first three weeks, all the chicks were reared together in a deep litter housing and fed on standard commercial diet having ME of 3,100 kcal/kg and 23% crude protein. At three weeks of age, the birds were weighed and randomly assigned to treatment in such a way that the average starting weight was similar for each replicate. The birds were reared in raised floor cages. Each treatment was applied to three replicate cages of 10 birds each. Feed and water were provided *ad libitum* to all the birds and were subjected to continuous lighting. Body weight and feed consumption were recorded weekly and were adjusted for mortality.

TABLE 1. COMPOSITION OF STARTER BASAL DIETS

Ingredients	ME (kcal/kg)		
	3,000	3,200	3,400
Ground yellow corn	37.88	37.88	37.88
Soyabean meal (44%)	44.70	44.70	44.70
Palm oil	8.85	11.26	13.67
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	1.40	1.40	1.40
Dicalcium phosphate	1.55	1.55	1.55
Kaolin clay	4.82	2.41	–
Total	100.00	100.00	100.00
Calculated analysis			
Protein (%)	23.00	23.00	23.00
ME (kcal/kg)	3,000	3,200	3,400
Calcium (%)	1.00	1.00	1.00
Available phosphorus (%)	0.45	0.45	0.45
Lysine (%)	1.40	1.40	1.40
Methionine (%)	0.37	0.37	0.37
Cystine (%)	0.36	0.36	0.36
TSAA (%)	0.73	0.73	0.73

[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.

Diets

Diets were formulated primarily of ground yellow corn and soyabean meal to be isonitrogenous at 20% and adequate in all nutrients as recommended by NRC (1984). The energy levels of the diets were attained by varying the amount of palm oil while different amounts of commercial DL-methionine were added to provide the varying levels of TSAA (table 2). The energy levels of the feeds were 3,000, 3,200, 3,400 kcal/kg while TSAA levels were 0.65, 0.72, 0.79 and 0.86%. The birds were on the experimental diets until 42 days of age.

TABLE 2. COMPOSITION GROWER BASAL DIETS

Ingredients	ME (kcal/kg)		
	3,000	3,200	3,400
Ground yellow corn	49.35	49.35	49.35
Soybean meal (44%)	35.70	35.70	35.70
Palm oil	6.63	9.04	11.45
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	1.30	1.30	1.30
Dicalcium phosphate	1.40	1.40	1.40
Kaolin clay	4.82	2.41	–
Total	100.00	100.00	100.00
Calculated analysis			
Protein (%)	20.07	20.07	20.07
ME (kcal/kg)	3,000	3,200	3,400
Calcium (%)	0.90	0.90	0.90
Available phosphorus (%)	0.41	0.41	0.41
Lysine (%)	1.16	1.16	1.16
Methionine (%)	0.33	0.33	0.33
Cystine (%)	0.32	0.32	0.32
TSAA (%)	0.65	0.65	0.65

[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.

Statistical analysis

All the data were subjected to analysis of variance using Statistical Analysis System (SAS) (1982). The differences between treatment means were determined by using Duncans new multiple range test (Steel and Torrie. 1980).

Results and Discussion

Starter period

Data on the performance for the main treatment effects are presented in table 3. Dietary energy levels had no significant ($p < 0.05$) effects on body weight gain, feed intake and feed:gain ratio. However, the effect of dietary ME levels on feed:gain ratio approached statistical significance ($p = 0.075$). There was a trend to improve feed:gain ratio by increasing dietary energy over the level of 3,000 kcal ME/kg. Birds fed on feed with a dietary energy of 3,400 kcal/kg consumed less feed than those fed on lower ME diets as similarly shown by Waldroup et al. (1976), Hurwitz et al. (1978), Kubena et al. (1974) and Jackson et al. (1982). A significant reduction in body weight gain of the group fed 1.03% TSAA might be due to the lower feed intake with a trend to reduce the amount of feed intake. The amount of amino acids in excess of the chicks maximum requirement may impair feed intake and growth, especially under heat stress condition as also suggested by Waldroup et al. (1976) and Al-Nasser et al. (1986).

TSAA levels had significant influences ($p < 0.05$) virtually on every performance examined (table 3). Body weight gain was significantly improved for the diet containing 0.83 and 0.93% TSAA over the 0.73% TSAA. However growth rate was depressed when TSAA level was increased to a higher level of 1.03%. Feed intake of birds on 0.73% TSAA were significantly lower than those on higher TSAA levels. In conclusion, it was shown that birds fed with 0.93% TSAA had the best body weight gain and feed:gain ratio. These observations are closely related to the findings of Wheeler and Latshaw (1981).

The interaction between ME and TSAA was significant ($p < 0.05$) only for feed intake (table 3). Feed intake decreased with increasing energy level only when the diet contained 0.93% TSAA. At the other TSAA concentration the responses were not consistent. Increasing dietary ME levels resulted in a significant increase of ME intake while the intake of protein and TSAA tended to decrease. The ME intake of the birds averaged 114.78, 122.20 and 127.90 kcal/bird · day, respectively for the three different dietary energy. Levels of SAA supplementation had significant ($p < 0.05$) effects on protein, ME and TSAA intake. Protein, TSAA and ME intake were the least when birds were fed the lowest TSAA level (0.73%) compared to the higher TSAA levels. Increasing TSAA in the diets resulted in a significant ($p < 0.05$) increase in TSAA intake. The TSAA intake averaged 259.11, 323.28, 363.50 and 395.35 mg/bird.day respectively for the four levels of TSAA diets.

In general, severe amino acid deficiency and imbalance depressed voluntary intake in poultry (Boorman, 1979; Forbes, 1986). On the other hand Okumura and Mori (1979) reported that chicks fed on the SAA deficient diet had a higher feed intake. From this experiment, it could be pointed out that the TSAA at 0.73% was not adequate for meat production and growth performances of the starter broilers. The SAA requirement for maximal body weight gain and feed efficiency was estimated to be 0.83 to 0.93% at all three energy levels or about 4% of CP, which is in agreement with Boomgaardt and Baker (1973) and Attia and Latshaw (1979).

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

Treatment	Weight gain (g/bird.day)	Feed intake (g/bird.day)	Feed:gain ratio	Protein intake (g/bird.day)	ME intake (kcal/bird.day)	TSAA intake (mg/bird.day)
ME (kcal/kg)						
3,000	22.63	38.26	1.69	8.80	114.78[a]	337.88
3,200	23.31	38.06	1.63	8.75	122.20[b]	336.74
3,400	23.03	37.62	1.64	8.65	127.90[c]	331.31
TSAA (%)						
0.73	21.04[c]	35.49[a]	1.69[a]	8.16[a]	114.16[a]	259.11[a]
0.83	23.22[ab]	38.95[b]	1.68[a]	8.96[b]	124.68[b]	323.28[b]
0.93	24.71[a]	39.09[b]	1.58[b]	8.99[b]	124.92[b]	363.50[c]
1.03	22.97[b]	38.38[b]	1.67[a]	8.83[b]	122.75[b]	395.35[d]
ME × TSAA						
	NS	S	NS	S	S	S

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

Grower period

The results indicated that dietary energy levels had no significant ($p < 0.05$) effects on body weight gain, feed intake and feed:gain ratio in the growers (table 4). However, birds fed 3,200 and 3,400 kcal/kg diets tended to improve body weight gain and feed:gain ratio more than those fed 3,000 kcal/kg diet. Birds on 3,400 kcal/kg consumed less feed (113.15 g/d) than those on 3,200 (115.87 g/d) and on 3,000 (114.97 g/d) kcal/kg ME although the differences were not significant. The energy levels used in this study were based on report of Farrell et al. (1973) who indicated that diets with ME levels in the range of 3,200 and 3,400 kcal/kg were necessary to support maximal growth rate and efficiency. It appeared that the differences in dietary energy levels used in this study were not big enough to produce a statistical significance. Hill and Dansky (1954) and Farrell et al. (1973) stated that the chicken eats to meet their energy requirements and under different dietary energy levels the ME consumption was constant. However, the present study showed that the ME consumptions were significantly higher with increasing dietary energy levels. This overconsumption of energy was as similarly observed by Jackson et al. (1982) and Summers et al. (1992). The improvement in body weight and/or feed efficiency through increased dietary energy was a well accepted fact (Donaldson et al., 1956; Jackson et al., 1982; Yo and Tawfik, 1990). Although no significant differences were found in body weight gain and feed:gain ratio of the birds due to energy levels of the diets, however, the significant increased in ME intake tended to result in small improvements in body weight gain and feed:gain ratio. Hence, body weight gain increased by 2.30% as dietary energy increased from 3,000 to 3,200 to 3,400 kcal/kg while feed : gain ratio decreased by 3.81% as the dietary energy levels increased.

Dietary TSAA levels had significant effects ($p < 0.05$) on body weight gain and feed:gain ratio with the exception of feed intake. TSAA intake averaged 749.26, 827.91, 896.44 and 988.23 mg/bird.day, respectively for birds fed with diets of different levels of TSAA (table 4). Increasing dietary TSAA levels up to 0.86% resulted in a significant increase in body weight gain and feed:gain ratio compared to the level of 0.65%. Body weight gain of birds fed on 0.86% TSAA increased by 2.40% from those fed on 0.72% TSAA. Feed:gain ratio improved by 2.80% in the group fed on 0.79% TSAA as compared to those fed on 0.72% TSAA, although the values were not significantly different. Hence, the NRC (1984) recommendation of 0.72% TSAA for grower broilers appeared to be inadequate. Similarly, Jensen et al. (1989) suggested that the value of 0.78% TSAA would be appropriate as a minimum TSAA level for grower broilers and Hickling et al. (1990) demonstrated that increasing dietary methionine to 12% above the NRC (1984) recommendation which was equal to 0.786% TSAA, increased weight gain and feed efficiency of the grower broilers.

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

Treatment	Weight gain (g/bird.day)	Feed intake (g/bird.day)	Feed:gain ratio	Protein intake (g/bird.day)	ME intake (kcal/bird.day)	TSAA intake (mg/bird.day)
ME (kcal/kg)						
3,000	52.65	114.97	2.19	23.00	344.91[a]	868.20
3,200	53.98	115.87	2.15	23.17	370.79[b]	874.88
3,400	53.74	113.15	2.11	22.63	384.70[c]	853.34
TSAA (%)						
0.65	50.54[a]	115.27	2.28[a]	23.05	369.14	749.26[a]
0.72	53.76[b]	114.99	2.14[b]	23.00	367.51	827.91[b]
0.79	54.48[b]	113.47	2.08[b]	22.70	362.91	896.44[c]
0.86	55.05[b]	114.92	2.09[b]	22.98	367.64	988.23[d]
ME × TSAA						
	NS	NS	NS	NS	NS	NS

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

The results of the present studies indicated that the TSAA at a level of 0.65% was not adequate for grower broilers. Although, there were no significant differences in the body weight gain between the levels of 0.72, 0.79 and 0.86% TSAA, however, the TSAA requirement for grower broilers tended to increase more than 0.72%, consistent with the previous reports (Jensen et al., 1989; Hickling et al., 1990) and the values were obtained by using maximal performances and body composition as the criteria. It is, thus, suggested that the TSAA requirement was between 0.79 to 0.86% at all the three energy levels. Further, the present study indicated that the TSAA requirement was not affected by dietary energy levels in agreement with Mitchell and Robbins (1985).

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