THE INFLUENCE OF COPPER ON THE TOTAL SULPHUR AMINO ACIDS REQUIREMENT OF BROILERS DURING TWO GROWING PERIODS

H. Kassim and S. Suwanpradit

Department of Animal Sciences, University Pertanian Malaysia, 43400 Serdang, Selangor, Malaysia

Summary

A study was conducted to assess the influence of copper on the total sulphur amino acid requirements of broiler chickens reared under two growing periods. The TSAA levels used were 0.73, 0.83, 0.93% with copper levels of 0, 125, 250 and 375 mg/kg for the starter period and the TSAA levels of 0.72, 0.79 and 0.86% with copper levels of 0, 125, 250 and 375 mg/kg for the grower period. Total feed consumption, body weight gain and feed : gain ratio were used as the parameters for the assessment. The results showed that adding copper at 250 mg/kg to the diets improved feed : gain ratio of the starter broilers and resulted in small improvement of body weight gain and feed : gain ratio of the grower broilers. Growth was depressed in relation to the reduction of feed intake on the chicks fed diet containing 375 mg/kg copper. There was a significant interaction between dietary TSAA and copper levels for feed intake, hence, indicating that the supplementation of copper at the level of 375 mg/kg increased the TSAA requirement of the starter broilers, although no interference with the requirement of grower broilers.

(**Key Words** : Copper, Total Sulphur Amino Acid, Starter and Grower Broilers, Weight Gain, Feed Intake, Feed : Gain Ratio)

Introduction

Copper is one of the essential trace minerals known to be important in poultry. Broiler chicken's nutritional requirement for copper is 8 mg/kg during starting, growing and finishing periods (NRC, 1984). Copper at levels ranging from 125 mg/kg is routinely added to diets of broilers (Robbins and Baker, 1980) and often fed at much higher pharmacological levels (100 to 300 mg/kg) because of its growth-promoting properties (Fisher et al., 1972).

Jensen and Maurice (1979) and Christmas and Harms (1979) indicated that the growth depressing effect of feeding high levels of copper can be alleviated with supplemental methionine. The total sulphur amino acid requirements were significantly increased by adding 250 or 500 ppm copper to the diets (Robbins and Baker, 1980). Wang et al. (1987) also reported that methionine requirement of broiler chicks increased when pharmacological levels of copper were fed. These suggested that copper may interfere with the utilization of TSAA and it could be of particular importance to broiler producers, since typical corn-soybean meal diets are limiting in TSAA (Baldini and Rosenberg, 1955; Attia and Ladshaw, 1979). Therefore, the addition of high amounts of copper to the diets may exacerbate the problem. There are various reports on the copper and TSAA feedings and some indicated positive responses while there were some negative responses (Jensen et al., 1989; Mabray and Waldroup, 1979; Wang et al., 1987). Therefore this study was undertaken to determine the possible influences of copper on the performances of the chickens during two growth periods reared in the tropics.

Materials and Methods

Starter period (0-3 wk)

Animals and general procedures

Three hundred and sixty one-day old ISA Vadette male broiler chicks were distributed into groups of 10 in 36 raised floor cages. The experimental groups were selected to have the same initial mean body weight and similar weight distribution. Each experimental diet was fed to triplicate groups from day-old until 3 weeks of age *ad*

[1]Address reprint requests to Dr. H. Kassim, Department of Animal Sciences, University Pertanian Malaysia, 43400 Serdang, Selangor, Malaysia.

Received May 26, 1995
Accepted January 23, 1996

libitum. Body weight and feed intake were measured weekly after adjustment for mortality. The ambient temperature was not controlled and it fluctuated from 22 to 39℃.

Diets

A basal diet was calculated to contain 0.73% TSAA, a level inadequate for optimal growth and feed utilization of starter broilers (NRC, 1984). The same diet was supplemented with a commercial DL-methionine to provide the levels of either 0.93% or 1.13% TSAA. The diets were fed with and without supplementation of copper sulphate ($CuSO_4 \cdot 5H_2O$) to provide copper at the levels of 0, 125, 250 and 375 mg/kg for a total of twelve diets. All the diets were fed *ad libitum* in mash form and the composition of the basal diet is given in table 1. Ground yellow corn, soybean meal and palm oil were the principal ingredients. Nutritional values of feedstuffs and the requirements of the animals recommended data used for feed formulation were based on the NRC (1984).

Grower period (4-6 wk)

Animals and general procedures

Three hundred and sixty three-week old male broiler chickens were selected and separated into similar weight groups and randomly distributed into growing cages. All the chickens in the groups were selected to have the same initial mean body weight and a similar weight distribution. Each experimental diet was fed to triplicate groups of ten chickens from three weeks until six weeks of age. The chickens were given feed and water *ad libitum* and the body weight and feed intake were recorded weekly after correction for mortality. The ambient temperature fluctuated from 22 to 38℃ during the experiment.

Diets

A corn-soybean meal-palm oil based diets were calculated to contain 0.72% TSAA. The same diet was supplemented with a commercial DL-methionine to provide the levels of either 0.79 or 0.86% TSAA. The diets were supplemented with or without copper sulphate ($CuSO_4 \cdot H_2O$) at the levels of providing 0, 125, 250 and 375 mg/kg of copper for a total of twelve diets and were fed in mash form (table 1).

Statistical analysis

All data were statistically analysed for the analysis of variance by using the Statistical Analysis System (SAS, 1982). The differences between the resultant means were examined by Duncan's new multiple range test (Steel and Torrie, 1980).

TABLE 1. COMPOSITION OF STARTER BASAL DIET AND GROWER BASAL DIET

Ingredients	Starter (%)	Grower (%)
Ground yellow corn	42.50	54.20
Soybean meal (44%)	43.70	34.60
Palm oil	9.66	7.38
Dicalcium phosphate	1.55	1.45
Limestone	1.41	1.40
Salt	0.50	0.50
Vitamin premix	0.25	0.25
Trace mineral mix	0.05	0.05
Selenium premix	0.05	0.05
Coccidiostat	0.05	0.05
Kaolin clay	0.28	–
DL-methionine	–	0.07
Total	100.00	100.00
Calculated analysis (%)		
Protein	22.97	19.99
ME (kcal/kg)	3,200	3,200
Calcium	1.00	0.95
Available phosphorus	0.45	0.42
Lysine	1.38	1.15
TSAA	0.73	0.72

Results and Discussion

Starter period

The results of the performances of the broilers are presented in table 2. All parameters except feed intake showed significant variations ($p < 0.05$) at various levels of TSAA. Significant improvements ($p < 0.05$) in body weight gain and feed:gain ratio were realized for the diets containing 0.83 and 0.93% TSAA over 0.73% TSAA. Increasing dietary TSAA levels increased growth, improved feed:gain ratio as compared to the observations of Wheeler and Latshaw (1981).

Increasing copper levels in the feed resulted in an increase of body weight gain and feed intake, though not significant, while there was no change in the feed:gain ratio. Growth rate and feed intake were significantly depressed ($p < 0.05$) when the birds were fed on diets with 375 mg/kg copper. These results were similar to the previous findings of Greek and Helbacka (1967), Smith (1969) and Fisher et al. (1972) who reported that chicks fed high dietary level of copper depressed feed intake and growth rate. These results were later confirmed by Ledoux et al. (1989) who demonstrated that supplementation of copper at the level of 300 mg/kg to starter diets depressed

TABLE 2. EFFECT OF DIETARY TSAA AND CU LEVELS ON PERFORMANCE OF STARTER BROILERS (0-3 WK)

Treatment	Weight gain (g/bird/day)	Feed intake (g/bird/day)	Feed/gain
TSAA (%)			
0.73	25.71[a]	50.54	1.97[a]
0.83	27.16[b]	50.22	1.85[b]
0.93	28.24[b]	51.23	1.81[b]
Cu (mg/kg)			
0	27.09[a]	51.13[a]	1.89[a]
125	27.45[a]	51.69[a]	1.88[a]
250	28.04[a]	51.27[a]	1.83[b]
375	25.58[b]	48.27[b]	1.90[a]
TSAA × Cu			
	NS	S	NS

[a,b] Means in each column within treatment followed by the same superscript letter do not differ significantly ($p > 0.05$).
NS = Nonsignificant.
S = Significant difference ($p < 0.01$).

growth rate and feed intake. Feed:gain ratio was found to improve with copper supplementation (250 mg/kg) as similarly reported earlier by Jensen and Maurice (1979).

Only for feed intake that there was a significant TSAA × Cu interaction, resulted from the decline in feed intake of the group fed basal diet, as opposed to the response of feed intake observed with the increasing dietary TSAA for the copper supplemented diets. The results were similar to the findings of Mabray and Waldroup (1979).

Within the dietary copper level of 375 mg/kg, there was a significant difference ($p < 0.01$) between feed intake of chicks on 0.73% TSAA compared to those on 0.93% TSAA indicated that increasing dietary TSAA increased the feed intake of the chicks, resulted in a trend to restore growth and feed efficiency in the chicks fed on 375 mg/kg of copper. The TSAA was able to alleviate the growth depressing effect of copper as similarly reported earlier (Jensen and Maurice, 1979; Christmas and Harms, 1984) and as explained earlier by Robbins and Baker (1980) that compounds with free SH- groups (eg. cysteine and glutathione) readily chelate copper to form copper-SH bond which cannot be easily dissociated. The formation of cysteine copper chelate would also have the effect of lowering SAA availability and/or lowering copper toxicity. The results of the present studies would support this general concept that chicks fed high dietary levels of copper (>250 mg/kg) increased SAA requirement.

Grower period

Body weight gain and feed:gain ratio showed significant variations ($p < 0.05$) under various TSAA levels while feed intake was unaffected (table 3). Body weight gain of birds fed 0.79 and 0.86% TSAA were significantly higher ($p < 0.05$) than those fed 0.72% TSAA.

TABLE 3. EFFECT OF DIETARY TSAA AND CU LEVELS ON PERFORMANCE OF GROWER BROILERS (4-6 WK)

Treatment	Weight gain (g/bird/day)	Feed intake (g/bird/day)	Feed/gain
TSAA (%)			
0.72	56.28[a]	110.23	1.96[a]
0.79	57.85[b]	111.33	1.93[ab]
0.86	59.01[b]	111.25	1.89[b]
Cu (mg/kg)			
0	58.15[a]	111.40	1.92[ab]
125	58.03[a]	112.16	1.93[ab]
250	59.45[a]	111.61	1.88[b]
375	55.23[b]	108.58	1.97[a]
TSAA × Cu			
	NS	NS	NS

[a,b] Means in each column within treatment followed by the same superscript do not differ significantly ($p > 0.05$).
NS = Nonsignificant.

Adding dietary copper also resulted in significant variations ($p < 0.05$) in body weight gain and feed:gain ratio of the birds. Growth rate was depressed significantly ($p < 0.05$) by adding copper at the level of 375 mg/kg in the diets, as similarly shown by Coates and Harrison (1959), Greek and Helbacka (1967), and Fisher et al. (1972) who reported that the addition of copper, either as oxide or sulphate, in concentration greater than 300 mg/kg produced increasingly severe growth depression. This depression could be due to copper toxicosis per se, however, Ledoux et al. (1987), found that dietary copper failed to affect serum enzyme glutamic oxaloacetate transaminase (SGOT) activity and concluded that the reduction in performance of the chickens was primarily due to a copper-mediated reduction in feed intake and not to copper toxicosis per se.

Feed consumption showed no significant differences between dietary copper levels, however, the birds fed on the 375 mg/kg copper diet consumed the least amount of feed. Supplementation of copper at 250 mg/kg feed seemed to be the optimum level owing to the best performance of the highest weight gain with the lowest feed:gain ratio. There were no significant differences in

the feed:gain ratio between 0, 125 and 250 or between 0, 125 and 375 mg/kg copper. Birds fed on 0.86% TSAA with 125 mg/kg copper diet had the best body weight gain while birds on the same TSAA with 250 mg/kg copper had the best feed:gain ratio. The different responses to dietary copper supplementation could possibly be explained by the different levels of TSAA in the feed and through an action of the gut flora which might produce different level of growth depressing infection. The results shown above weakly support that copper supplementation increased the requirement of broilers for TSAA.

The ability of TSAA to alleviate the growth depressing effect of copper had been reported previously by Jensen and Maurice (1979), Christmas and Harms (1984). The present study showed that 0.93% TSAA completely restored growth and feed intake in chicks fed 375 mg/kg copper as similarly shown by Robbins and Baker (1980).

In grower period, statistical analysis failed to show the interaction between TSAA × Cu, thus, indicating that the TSAA was not the first-limiting factor in the test diets containing high copper. It appeared that the normal level of copper as copper sulphate did not interfere with the TSAA requirements of the chickens.

Literature Cited

Attia, A. M. N. and J. D. Latshaw. 1979. Amino acid requirements of broiler starter diets with different energy levels. Nutr. Rep. Int. 19:299-306.

Baldini, J. T. and H. R. Rosenberg. 1955. The effect of productive energy levels of the diet on the methionine requirement of the chicks. Poultry Sci. 34:1301-1307.

Christmas, R. B. and R. H. Harms. 1984. The value of protein, methionine or other nutrients for the alleviation of copper toxicity in the broiler chick diet. Nutr. Rep. Int. 29:1217-1222.

Coates, M. E. and G. F. Harrison. 1959. The effect on chick growth of inactivated penicillin, mineral sulphates or furrazolidone supplements. Brit. J. Nutr. 13:345-355.

Fisher, H., D. Wise and D. G. Filmer. 1972. The effect of copper on the growth of broilers and the interaction of copper with zinc and iron. 14th. World Poult., Madrid, 2:759-764.

Greek, R. D. and N. V. Helbacka. 1967. Copper sulphate in broiler rations. Proc. Md. Nutr. Conf. Fd. Manuf's. p. 77-78.

Jensen, L. S. and D. V. Maurice. 1979. Influence of sulphur amino acids on copper toxicity in chicks. J. Nutr. 109:91-97.

Jensen, L. S., C. L. Wyatt and B. I. Fancher. 1989. Sulphur amino acid requirement of broiler chickens from 3 to 6 weeks of age. Poultry Sci. 68:163-168.

Ledoux, R. D., P. R. Henry, C. B. Ameran and R. D. Miles. 1989. Effect of dietary copper on tissue mineral composition as an estimate of copper bioavailability in broiler chicks. Nutr. Rep. Int. 39:1117-1126.

Ledoux, R. D., R. D. Miles, C. B. Ammeran and R. H. Harms. 1987. Interaction of dietary nutrient concentration and supplemental copper on chick performance and tissue copper concentrations. Poultry Sci. 66:1379-1384.

Mabray, C. T. and P. W. Waldroup. 1979. Interrelationships of copper and methionine in broiler diets. Poultry Sci. (abstr.) 58:1018-1019.

National Research Council. 1984. Nutrient requirement of poultry. 8th. rev. ed. National Academy Press, Washington, D.C.

Robbins, K. S. and D. H. Baker. 1980. Effect of sulphur amino acid level and source on the performance of chicks fed high levels of copper. Poultry Sci. 59:1246-1253.

SAS. 1982. User's guide: Statistics. SAS Inst., Inc., Cary, North Carolina, USA.

Smith, M. S. 1969. Responses of chicks to dietary supplements of copper sulphate. Brit. Poultry Sci. 10:97-108.

Steel, R. G. D. and J. H. Torrie. 1980. Principles and procedures of statistics. 2nd. Ed. McGraw-Hill Book Co., Inc., New York.

Wang, J. S., S. R. Rogers and G. M. Pasti. 1987. Influence of choline and sulphate on copper toxicity and substitution of and antagonism between methionine and copper supplements to chick diets. Poultry Sci. 66:1500-1507.

Wheeler, K. B. and J. D. Latshaw. 1981. Sulphur amino acid requirements and interactions in broilers during two growth periods. Poultry Sci. 60:228-236.