Vet.Med.J.,Giza. Vol.43,No.1.(1995):77 -85 .

POTENCY OF COPPER AS GROWTH PROMOTER IN BROILER CHICKENS

BY

HODA, A. ALI and MAHA, M. HADY

Dept. of Nutrition and Clinical Nutrition, Fac. of Vet. Med. Cairo University.

SUMMARY

An experiment was conducted to study the efficacy of certain copper sources and levels as growth promoter in broiler chickens. On hundred and seventy five day old Cobb broiler chicks were divided into seven equal groups. One group was kept on unsupplemented basal diet and considered as control. The other groups were offered the basal diet supplemented by copper at two levels (75-150 ppm) from either copper carbonate (CuO3), copper oxide (CuO) or coper sulfate ($CuSO_4$). The experiment lasted for six weeks, during which body weight development (BWD) and feed consumption of chicks were recorded weekly, then body gain (BG) and feed conversion efficiency were calculated. At the end of the experiment, liver copper concentration was determined as well as the cecal appearance and intestinal histological morphology morphology were measured.

Both levels of CuCO3 supplementation achieved significant increase in BWD and improved feed conversion. Low level of $CuSO_4$ had no influence on BWD which was markedly improved with the high level. CuO failed to improve BWD significantly. Liver Cu concentration was significantly increased by CuSO4 supplementation which was insignificant in CuCO3, while the oxide form had no effect. Liver weight was not affected by any of the dietary treatments, meanwhile, caecum weight was increased markedly in all treated groups. Cecal apperance was affected markedly by $CuSO_4$ supplementation and it was mildly affected in case of CuCO3, but oxide form did not exert such effect. Intestinal histological morphology indicated that copper has antimicrobial action whithin the gut.

INTRODUCTION

The essentiality of copper as one of the trace elements for maintenance of health and its deficiency problems are well documented (Hill and Matrone, 1961 and Daived and Mertz, 1987). Moreover, the use of copper sulfate as growth promotant at pharmacological level in swine, turkey and poultry is well established by many investigators. Feeding copper at 125 to 250 ppm as copper sulfate has been shown to improve performance of weanling and growing finishing swine (Stahly et al., 1980; Cromwell et al., 1989), There is a general tendency for copper supplementation in range between 75 and 225 ppm to stimulate chick growth (Smith, 1969; Jenkins et al., 1970). Fisher (1973) found that supplementation of 169 ppm Cu was optimum to stimulate growth while using 140 ppm was optimum to improvel feed efficiency in broilers. In contrast, supplementation of 125 ppm Cu had no effect on performance of chicks (Briones, 1963) and 500 ppm level of supplemental copper depressed growth of chicks (Poupoulis and Jensen, 1976).

Although, coper sulfate produces growth response in young pigs, poults and chicks at level of 100 ppm or more, continued feeding of these copper levels causes marked accumulation of copper in the liver of animals (Funk and Baker, 1991). Jenkins et al., (1970) suggested that if the advantageous effect of copper is in the intestinal tract, its accumulation in the liver may be incipiently detrimental to chicks.

Not only copper sulfate as source of copper proved to have growth promotant effect for swines and chicks, but also other sources like carbonate, chloride and oxide salts had shown similar effect (Stansbury et al., 1990 and Aoyagi and Baker, 1993). Bunch et al., (1961 and 1963) compared sulfate to oxide form of copper as growth promoters in pigs and concluded that oxide was nearly as effective as sulfate form, yet, liver copper levels were not elevated. Guenthner et al., (1978) suggested that copper supplied either as oxide or sulfate form will stimulate the growth rate of turkey.

Jackson and Stevenson (1981) and Baker et al., (1991) found that copper sulfate markedly increased copper content of liver, while cupric oxide did not. Similarly Bunch et al., (1965) and Ledoux et al., (1991) reported that liver copper was not affected by dietary copper from oxide source, but it increased significantly with carbonate and sulfate forms.

On the other hand, the consistency and colour of intestinal and cecal contents of broilers at the time of processing affect the incidence of carcass contamination resulting in increasing condemnation rates. Some dietary factors including dietary copper supplementation caused this problem. Jensen and Maurice (1978) found that including 120-250 ppm additional copper from sulfate, chloride or carbonate sources in broiler rations significantly affected the cecal appearance, but oxide form did not exert such effect.

From the previous studies, one can notice that the selection of copper level and source for use as growth promotant to achieve the beneficial effect without showing adverse effect in poultry diet is critical.

The present research was conducted to detect the efficacy of certain sources of copper commonly used as growth promotant in broiler diets (carbonate, oxide and sulfate) at two levles (75 and 150 ppm) to achieve maximal growth response without adverse effect.

MATERIALS AND METHODS

On hundred and seventy five, day old Cobb broiler chicks with an average weight of 48 gm were used. They were reared on deep litter system in Nut and Clin. Nut, Dept, Fac. Vet. Med. Cairo Univ. The chicks were maintained on a constant lighting schedule and allowed ad-libitum access to feed and water. The chicks were divided randomly into 7 equal groups, 25 each. They were fed on commercial diet in which copper content was determined (Table 1). One group was kept on the commercial basal diet and considered as control. The other groups were offered basal diet supplemented by copper at two levels (75 and 150 ppm) from either copper carbonate (57 %), Cupric oxide (80 %) or copper sulfate (25%). The copper supplement was thoroughly mixed with small portion of the diet using electric blender then completely mixed with the whole amount of the diet before offering to chicks. Different copper sources were used after being subjected for relative solubilities test (Table 2) as described by

Ledoux et al., (1991).

The experiment was conducted for 6 weeks, during this period body weight development (BWD) and body gain (BG) as well as feed conversion were calculated.

At the end of the experiment, 5 birds from each group were weighed, then killed by cervical dislocation and their livers were removed. Livers were weighed, dried for 24 h at 100°C then ashed at 550°C. Liver samples as well as basal diet were asayed for copper content using atomic absorption spectrophotometer.

The two ceca of each examined bird were removed, weighed (with contents) and scored for colour and consistency according to (Jenson and Maurice, 1978). About 2 cm from duodenum, jejunum and ileum were cut and preserved in 10% formalin saline for further histological examination. Villus height and thickness of duodenum, jejunum and ileum were measured using an ocular micrometer (Shurson et al., 1990).

The obtained data were subjected to statistical analysis by ANOVA and t-test according to Snedecor (1986).

RESULTS AND DISCUSSION

Body weight development (BWD)

The results concerning the BWD of different groups throughout the experimental period are presented in table (3). The first and second weeks showed inconsistent BWD in the diferent groups. Starting from the third week up to the end of experiment both groups which were fed on CuCO3 (75-150 ppm Cu) showed significant ($P < 0.05$) increase in BWD. A similar results was also recorded by Stansbury et al. (1990) in Swine. Aoyagi and Baker (1993) recorded that Cu supplemented form analytical grade sources of carbonate and cholride significantly increase body gain in broiler chickens.

Throughout the experimental period, groups fed on low level of CuO and high level of $CuSO_4$ showed a slight increase in BW which was insignificant compared to control. Meanwhile, BWD was neither affected by the high level of CuO nor by the low level of $CuSO_4$ source. The failure of CuO to induce significant growth was in-agreemeent with the finidngs of Cromwell et al., (1989) whose work was on weanling pigs.

Differences observed regarding BWD as a result of CuCO3 and CuO supplementation might be attributed to their solubilities (Table 2). The lowest solubility within Cu sources was in CuO (16.3%) which revealed no growth action, while CuCO3 was of moderate solubility (72.9%) achieved the best growth stimulation at its both elvels. This finding supported by the work of Cromwell et al., (1989) who indicated that solubility of Cu is essential for its growth promoting action. Interstingly, $CuSO_4$ was highly soluble (97.8 %) but it didn't follow the same growth promoting manner as exhibited by CuCO3. This might be due to the level used whereas 75 ppm Cu as $CuSO_4$ had no effect on BWD, by increasing the level to 150 Cu, BWD began to exert marked improvement. This suggestion depends on the results of Guenthner et al., (1978) who concluded that 60 that ppm Cu from $CuSO_4$ was ineffective as growth promotant, whereas 120 ppm Cu stimulated growth of turkey up to 10%.

Overall performence of broilers

Table (4) showed a low feed intake in all treated groups compared to control. This result was in general agreement with that of Baker et al., (1991) when used $CuSO_4$ and CuO sources. Both levels

Table (1): Composition of the basal diet.

Ingredients	%
Yellow corn ground	63.00
Soybean meal dehulled (48 %)	31.00
Meat & bone meal	3.00
Bone meal	1.60
Calcium carbonate	0.38
Dl-methionine	0.70
Salt	0.32
Total	100.00
Chemical analysis	
CP %	21.4
Cu mg/kg	10.1

* Supplied per Kg of diet: Vit A, 6, 600 IU; Vit D3, 2,200 IU; riboflavin 4.4 mg; pantothenic acid, 13.2 mg; niacin, 39.6 mg; choline chloride, 500mg; Vit B12, .022 mg, Mn, 55 mg; Fe, 50 mg, Cu, 4 mg; Zn, 40 mg.

Table (2): Relative solubility (%) of examined copper sources.

Source	H_2O	Relative solubility* (%)			Average %
		Neutral ammonium citrate	0.4 % HCl	2 % citric acid	
Carbonate	0	97.3	96.8	97.6	72.9
Oxide	0	6.4	48.7	10.2	16.3
Sulfate	97.2	98.5	97.1	98.7	97.9

* Relative solubility of 0.1 g in 100 ml solvent at 37°C for 1 h. with constant stirring.

Table (3): Effect of copper sources and levels (ppm) on body weight development (g) of broiler chickens

Treatment / Weeks	Control	$CuCO_3$ 75	$CuCO_3$ 150	Cu O 75	Cu O 150	$CuSO_4$ 75	$CuSO_4$ 150
0	48.4 ±1.2	48.4 ±1.2	48.4 ±1.2	48.4 ±1.2	48.4 ±1.2	48.4 ±1.2	48.4 ±1.2
1	146.4 ±2.8	151.0 ±3.0	141.7 ±2.6	146.8 ±2.8	140.0 ±1.7	137.9 ±2.1	147.5 ±3.7
2	255.2 ±7.8	277.8 ±6.4	276.6 ±6.9	267.6 ±3.6	260.0 ±5.1	242.7 ±5.2	272.5 ±7.6
3	399.0 ±10.1	438.8* ±11.4	452.7* ±9.2	421.6 ±13.0	379.4 ±9.8	353.4 ±8.7	427.7 ±12.6
4	555.7 ±15.3	625.6* ±17.8	632.2* ±14.0	613.2 ±19.8	517.8 ±18.3	534.3 ±19.0	629.5 ±25.5
5	845.3 ±7.8	958.3* ±15.1	943.1* ±19.4	981.4 ±22.9	826.2 ±21.8	834.4 ±24.4	880.1 ±33.4
6	1097.7 ±23.4	1286.1* ±16.7	1228.3* ±23.1	1170.5 ±24.1	1088.7 ±19.4	1090.4 ±19.7	1127.3 ±32.6

± Standard error

* Significant difference at $P < 0.05$ compared to control

Table (4): Effect of copper sources and levels (ppm) on overall performance of broiler chickens.

Treatment / Item	Control	$CuCO_3$ 75	$CuCO_3$ 150	Cu O 75	Cu O 150	$CuSO_4$ 75	$CuSO_4$ 150
Gain (g)	1049.3	1237.7	1179.9	1122.1	1040.3	1042.0	1078.9
Feed intake (g)	2602	2590	2598	2548	2393	2450	2430
Feed conversion	2.47	2.09	2.20	2.27	2.30	2.35	2.25

Table (5): Effect of copper sources and levels (ppm) on liver weight, liver Cu concentration, cecal weight and appearance in broiler chickens.

Treatment / Item	Control	Cu CO_3		Cu O		Cu SO_4	
		75	150	75	150	75	150
Liver wt g/100 g BW	2.42 ±.42	2.12 ±.04	2.5 ±.1	2.3 ±.12	2.5 ±.1	2.25 ±.15	2.23 ±.16
Liver Cu Conc.	21.42 ±1.4	23.21 ±2.11	29.07 ±3.2	20.5 ±2.4	22.32 ±2.3	34.6* ±1.17	54.08* ±4.4
Ceacum wt g/100 g BW	0.58 ±.065	0.86* ±.073	0.84* ±.068	0.82* ±.020	0.95* ±.081	0.80* ±0.035	0.83* ±.050
Cecal score	0.4 ±.24	1.0 ±0.31	1.2 ±.37	0.6 ±.24	0.6 ±.24	2.2* ±.37	2.6* ±.24

± Standard error * Sig. at $P < 0.05$

ceca were scored from 1-3

1 = intermediate in colour ; 2 = intermediate in colour and slightly distended and 3 = dark in colour and distended.

Table (6): Effect of copper sources and levels (ppm) on intestinal histological morphology (mm) in broiler chickens

Treatment / Item	Control	Cu CO_3		Cu O		Cu SO_4	
		75	150	75	150	75	150
Duodenum							
Villus height	462 ±52	462 ±44	460 ±39	454 ±67	455 ±46	458 ±57	462 ±40
Thickness	824 ±72	804 ±76	810 ±63	818 ±46	832 ±55	828 ±64	812 ±71
Jujenum							
Villus height	519 ±39	578 ±52	565 ±38	548 ±41	528 ±62	543 ±54	551 ±52
Thickness	769 ±71	723 ±62	742 ±54	736 ±56	772 ±67	776 ±82	733 ±62
Ileum							
Villus height	423 ±32	450 ±54	447 ±55	433 ±50	438 ±39	436 ±38	440 ±41
Thickness	765 ±63	720 ±65	736 ±42	744 ±64	754 ±51	761 ±84	733 ±72

± Standard error

of CuCO3 improved feed conversion slightly as reported by many investigators (Jenkins et al., 1970 and Cromwell et al., 1989).

Liver copper concentration

The data presented in table (5) showed singificant ($P < 0.05$) increase in liver Cu concentration as a result of both levels of $CuSO_4$ supplementation, while it was not affected by oxide form. Similar results were reported by Jackson and Stevenson (1981) and Baker et al., (1991). Copper carbonate additive showed insignificant increase in liver Cu concentration compared to control. The difference in liver Cu concentration can be partially attributed to the fact that Cu from different copper compounds is metabolized differently after absorption. Although, CuCO3 is well known to be absorbed, much amount is readily excreted in the urine soon. Buescher et al., (1961) who observed increasing in urinary excretion of Cu from carbonate form (3.4 %) rather than sulfate (1.4 %) and oxide (1.0 %).

Liver and ceacum weights

Liver weight g/100 g BW was not affected by any of the dietary treatments (Table 5). Meanwhile ceacum weight with content g/100 g BW increased signifiantly ($P < 0.05$) in all treated groups as reportd by Jensen and Maurice (1978).

Cecal appearance

Table (5) revealed that cecal content was significant ($P < 0.05$) darker in colour and of pasty consistency as a result of Cu supplementation from sulfate as compared to control. This colour was intermediate in case of CuCO3 source, but oxide form did not cause such effect as reported by Jensen and Maurice (1978).

The mechanism by which Cu changes the colour and consistency of the cecal contents in chicks is not clear, but it may be related to an inhibition of normal fermentation that occurs in this part of gastro intestinal tract (Fisher, et al., 1973).

Intestinal histological morphology

Copper supplementation to commercial diet tended to increase villus height of jejunum follewed by ileum, but did not affect villus height of duodenum (Table 6). This finding coincided with the work of Shurson et al., (1990). The marked increase of villus height as result of CuCO3 feeding was parallel to the results of growth obtained (Table 3). Coates and Fuller (1977) showed that increase in villus height may be due to slower turnover of epithelial cells which resulted in greater number of mature cells, consequently a higher amount of enzymes and absorptive capacity will be achieved.

General decrease of jujenum and ileum thickness was observed in all treated groups that will give an idea about the mode of action of copper as antimicrobial agent. Visek et al. (1960) proposed that growth stimulator factors alter intestinal bacterial population, so that less ammonia is formed. The lack of ammonia leads to decrease intestinal wall thickness and thus allowing high absorptive capacity.

It is noticed that CuCO3 had achieved beneficial effect as growth promotion, yet, liver copper concentration did not elevate significantly and it had a mild effect on cecal appearance. It is concluded that CuCO3 can be safely used as Cu source for growth promotion in broiler chicken diets.

ACKNOWLEDGEMENT

The authors would like to express their deepest appreciation and sincere gratitute to Prof. Dr. O. E. Mohamed Professor of Animal Nutrition, Faculty of Veterinary Medicine, Cairo University, for his kind help, advice and criticism.

REFERENCES

Aoyagi, S. and D. H. Baker (1993): Bioavailability of copper in analytical-grade and feed grade inorganic copper sources when fed to provide copper at levels at levels below the chicks requirement Poult, Sci. 72: 1075-1083.

Baker, D. H. J. Odle, M. A. Funk, and T. M. Wieland (1991): Bioavailability of copper in cupric oxide, cuprous oxide and in a copper-lysine complex, Poult, Sci, 70: 177-179.

Briones, F. B. (1963): High levels of copper cupplement in feeds for table poultry Revta Nutr. Anim., Madrid, 1:83-89.

Buescher, R. G. S. A Griffin and M. C. Bell, (1961): Copper availability to swine from CuO4 labelled inorganic compounds. J. Anim. Sci.; 20: 529.

Bunch, R. J. J. T. McCall, V. S., Speer and V. W. Hays (1965): Copper supplementation for weanling pigs. J. Anim. Sci., 24: 995.

Bunch, R. J. V. C. Speer, V. W. Hays and J. T. McCall (1963): Effects of high levels of copper and chlortetracycline on performance of pigs. J. Anim. Sci. 22: 56.

Bunch, R. J. V. C., Speer, V. W. Hays, J. H. Hawbaker and D. V. Catron (1961): Effects of copper sulfate, copper oxide and chlortetracycline on baby pig performance. J. Anim. Sci. 20: 723.

Coates, M. E. and R., Fuller, (1977): The gnotobiotic animal in the study of gut microbiology. In : R. T. J. Clarke and T. Bavchop 9Ed.) Microbial Ecology of the Gut Academic Press. New York.

Cromwell, G. L., T. S. Stahly and H. J. Monegue (1989): Effects of source and level of copper on performance and liver copper stores in weanling pigs. J. Anim. Sci., 67: 2996-3002.

Daived, G. K. and W. Mertz (1987): Copper. In Elements In Human And Animal Nutrition. Vol. 301-364. Academic Press, New York.

Fisher C. (1973): Use of copper sulfate as a g promoter for broilers. Feed stuffs, 16: 24-25..

Fisher, O. A. P. Laursen-Jones, K. J. Hill and W. S. H (1973): The effect of copper sulfate on performance the structure of the gizzard in broilers. Brit. Poult. 14: 55-58.

Funk, M. A. and D. H. Baker (1991): Toxicity and ti accumulation of copper in chicks fed corn soya-based diets. J Anim. Sci. 69;: 4505-4511.

Guenthner, E., C., W. Canlson and R. J. Emerick (19 Copper salts for growth stimulation and alleviatio aortic rupture losses in turkey. Poult. Sci. 57: 1313-1

Hill, C. H. and Matrone, G. (1961): Studies on copper iorn deficiencies in growing chickens. J. Nutr., 425-431.

Jackson, N. and M. H. Stevenson (1981): A study of effects of dietary added cupric oxide on the layi domestic fowl and a comparison with the effects hydrated copper sulfate. Br. J. Nutr. 45: 99.

Jenkins, N. K., T. R. Morris and D. Valamotis (1970): T effect of dietary copper supplementation on chi growth Br. Poult. Sci. 11: 241-238.

Jensen, L. S. and D. V. Maurice (1978): Effect of hi dietary copper on the ceca of chicks. Poult. Sc 166-170.

Ledoux. D. R.; Henry. P. R.; Ammerman, C. B.; Rao, P. V and Miles, R. D. (1991): Estimation of the relativ bioavailability of inorganic copper sources for chick using tissue uptake of copper. J Anim. Sci: 69: 215-222.

Poupoulic, C. and L. S. Jensen (1976): Effect of high dietar copper on gizzand intregrity of the chicks. Poult. Sci. 55 113-121.

Shurson, G. C. P. K. Ku, G. L. Waxler, M. T. Yokoyama and E. R. Miller (1990): Physiological relationships between microbiological status and dietary copper levels in the pig. J. Anim. Sci. 68: 1061-1071.

Smith, M. S. (1969): Responses of chicks to dietary supplements of copper sulfate, Br. Poult, Sci. 10: 97-108.

Snedecor, G. M. (1986): Statistical Methods. 4th ed., Iowa

State. Univ. Press, Iowa, 129-130.

Stahly, T. S., G. L. Cromwell and H. J. Monegue (1980): Effects of the dietary inclusion of copper and (or) antibiotics on the performance of weanling pigs. J. Anim. Sci. 51: 1347.

Stansbury, W. F., L. F. Tribble and D. E. Orreja. (1990): Effect of chelated copper sources on performance of nursery and growing pigs. J. Anim. Sci, 68: 1318-1322.

Visek, W. J., J. M. Baron, and D. M. Switz (1960): Urea metabolism and intestinal ureolytic activity of rats fed antimicrobial agent, J. Pharmacol. Exptl. Therap. 126: 359-365.