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Effect of added copper and full fat soybean meal on growth performance and carcass properties in broiler chickens

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ABSTRACT

A 2×3 factorial experiment was conducted using a total of 504, 1 day old, Cob 500® commercial broilers to determine the effect of added copper (0 or 250 ppm) and full fat soybean meal level (10, 20 and 30%) on the growth performance and carcass properties in broiler chickens. The chickens fed 250 ppm copper as copper sulfate had lower ($P<0.05$) average daily gain and lower finally average body weight then chickens fed no added copper diets. Also, added copper impaired ($P<0.05$) feed conversion ratio during 49-d experimental period. The chickens fed with 30% full fat soybean meal in diet had higher ($P<0.01$) average daily gain during day 7 to 49 and higher ($P<0.01$) average body weight at day 49 then those consuming other diets. The addition of 250 ppm of copper improved dressing percentage ($P<0.01$), increased ($P<0.05$) lightness of breast muscle and tended to reduce abdominal fat content ($P<0.06$). The results indicate that the addition of 250 ppm copper to broiler diets have adverse effect on growth performance, but improve dressing percentage and decrease abdominal fat content. Using a 30% of full fat soybean meal in a broiler diet improves growth performance without negative effect on dressing percentage and abdominal fat content in 49 days fattening period.
(Keywords: copper, full fat soybean meal, growth performance, broiler chickens)

INTRODUCTION

Copper (Cu) is the third most abundant essential trace element in animals, after Iron and Zinc. As a part of numbers enzymes, copper is required for a number of physiological functions mostly related to catalytic agents in the active sites of cuproenzymes (*McDowell*, 1992). Numerous investigators have reported that addition of copper above dietary requirements, so called pharmacological level, can stimulate growth and feed efficiency in poultry and alters lipid and cholesterol metabolism (*Pesti* and *Bakalli*, 1996; *Konjfuca et al*., 1997). Copper is both an essential and a toxic element. Excessive feed copper intake results in morphological and functional changes in visceral organs and may even cause death. Several studies with poultry showed that high levels of dietary copper can cause gizzard lining erosion, proventriculitis (*Wideman et al*., 1996), lesions in the oral cavity, tongue and pharynx (*Chiou et al*., 1999) and changes in visceral organs weights (*Jackson et al*., 1979). It has been also reported that the consumption of high fat diets deficient in copper had detrimental effects on copper nutritional status, intermediary metabolism and production performance (*Wapnir* and

Devas, 1995). There is no information about the interaction between high dietary level of fat (vegetable oils) and copper supplementation on growth performance and processing characteristics in broiler chickens. In nursery pigs, *Dove* and *Haydon* (1992) observed an interaction between Cu levels and addition of animal fat. They reported that young pigs fed the diet containing 250 ppm of added copper and 5% added dietary animal fat had increased growth performance, whereas pigs fed the diet containing only 5% added animal fat had decreased growth performance. The objective of the current study was to determine the effect of growth stimulating level of copper (250 ppm) and different levels of full fat soybean meal on growth performance and carcass properties in broiler chickens.

MATERIALS AND METHODS

Birds and diets

A total of 504 Cobb 500®, one day old commercial chickens were purchased from a local hatchery and kept on floor covered with wood shaving in environmentally controlled house during winter. Temperature was set at 1 day old at 30 ^{o}C during the first week, and gradually lowered by 2 ^{o}C per 2 day until a temperature of 20 ^{o}C was reached at the age of 28. The lighting schedule provided 23 h light per day. Until the 7 d of age a standard prestarter diet was provided *ad libitum*. At 7 days of age, birds were individually weighed and randomly allotted by body weight to one of six dietary treatments. Each dietary treatment was randomly allocated to seven replicates of 12 birds each. Experimental treatments were arranged as a 2×3 factorial with two levels of copper (0 or 250 ppm as $CuSO_4 \cdot 5H_2O$) and three levels of full fat soybean meal (10, 20 or 30%). Corn, blend of sunflower and rape seed oil and soybean meal was replaced by full fat soybean meal to keep similar levels of energy and protein among diets. Nutrients levels met at least 90% of the minimum nutritional requirement for broiler chickens as set by the *National Research Council* (1994). The chicken fed mesh starter diets from 8 to 21 day of age followed by feeding a finisher diet from 22 to 49 day. Access to feed was discontinued approximately 16 h before slaughter at 49 d of age. Ingredients and chemical composition of the experimental starter and finisher diets are shown in *Table 1*. Experimental diets and tap water were available *ad libitum.*

Record keeping, sample collection and analysis

Individual body weight (BW) and feed intake (FI) were recorded and corrected for mortality on day 7, 21, 42 and 49 of age. At the end of the experiment, two broilers with average body weights were selected, individually weighed and sacrificed by cervical dislocation and then were immediately bled. After evisceration proventriculus, gizzard, pancreas and liver were removed and weighed. Carcass yield and abdominal fat content were also determined. Abdominal fat was defined as the fat surrounding the gizzard extending within the ischium and surrounding the *Bursa Fabricii*, cloaca and adjacent abdominal muscle. On the breast muscle, after 10 min blooming time, meat color was measured using Minolta CR-410 chrome meter.

Statistical analysis

The data were analyzed as a 2×3 factorial arrangement with the cage as an experimental unit (n=7) using the GLM procedure of SAS (*SAS*, 1999). The model included the main effects of full fat soybean meal (FFSBM) and dietary copper concentration, and their interaction. The effects were considered significant if $P<0.05$.

Table 1

Composition of experimental diets

	Broiler starter[a]			**Broiler finisher**[b]		
Full Fat Soya, %	10	20	30	10	20	30
Corn	48.00	46.80	44.30	59.00	57.60	55.60
Full fat soybean	10.00	20.00	30.00	10.00	20.00	30.00
Soybean meal (44%)	34.00	27.50	21.00	24.00	17.00	10.00
Vegetable oil	2.00	1.00	0.00	2.00	1.00	0.00
DL methionine	0.30	0.30	0.30	0.30	0.30	0.30
HCl Lysine	0.10	0.10	0.10	0.10	0.10	0.10
Limestone	0.90	0.90	0.90	0.60	0.60	0.60
Monocalcium phosphate	1.40	1.40	1.40	1.40	1.40	1.40
Sodium chloride	0.60	0.60	0.60	0.60	0.60	0.60
Ca-formiat	1.00	1.00	1.00	1.00	1.00	1.00
Vitamin-mineral premix[c]	0.50	0.50	0.50	0.50	0.50	0.50
$CuSO_4{\cdot}5H_2O$[d]	-	-	-	-	-	-
Calculated nutritive value[e]						
ME (MJ/kg)	12.19	12.26	12.34	12.70	12.78	12.88
Crude protein, %	22.99	23.12	23.34	19.27	19.26	19.26
Crude fat, %	6.05	6.94	7.84	6.15	7.11	7.90
Crude fiber, %	3.50	3.58	3.66	3.18	3.25	3.31
Lysine, %	1.37	1.39	1.40	1.11	1.11	1.12
Methionine + cysteine, %	0.96	0.97	0.98	0.86	0.87	0.87
Treonine, %	0.80	0.81	0.82	0.68	0.68	0.68
Tryptophane, %	0.28	0.28	0.29	0.22	0.22	0.23
Calcium, %	0.91	0.94	0.96	0.80	0.80	0.81
Phosphorus , %	0.70	0.73	0.74	0.68	0.69	0.69

[a]Fed from 7 to 21 day of age; [b]Fed from 22 to 49 day of age; [c]Vitamin-mineral premix provided per kg of diet: vitamin A, 15 000 UI; vitamin D_3, 2 000 UI; vitamin E, 30 mg; vitamin K_3, 2 mg; vitamin B_1, 1 mg; vitamin B_2, 6 mg; vitamin B_6, 3 mg; Vitamin B_{12}, 10 µg; biotin, 100 µg; niacin 30 mg; pantothenic acid, 12 mg; folic acid, 0,5 mg; Fe, 50 mg; Cu, 8 mg; Mn, 80 mg; Zn 50 mg; J, 0,5 mg; Co, 0,2 mg; Se, 0,15 mg; [d]$CuSO_4{\cdot}5H_2O$ contains 25,0% Cu, and was substituted for 0.10% corn in high-Cu diets to provide 250 ppm Cu; [e]Calculated on the basis of composition of Feedstuffs, *NRC* (1994).

RESULTS AND DISCUSSION

In the first 7 day dead or underfed chickens were not observed, therefore all 504 chickens were included in the experiment. Overall mortality was 0.8% for the 49 d experimental period, which was within the expected loss for Cob 500® broilers up to 49 day of age. In starter period (7–21 days) one broiler died in group with added copper and 10% of FFSBM in the diet. In period from 22 to 42 day of fattening no chickens died, in the late finishing period (43 to 49 days) three chickens died, one in group with no added copper and 10% FFSBM and one in both groups with added copper and 20 and 30% FFSBM in broilers diet. There is no effect of dietary treatment on survival rate, but higher mortality was observed with prolongation of fattening period from 42 to 49 days.

The effects of added copper and FFSBM level on growth performance are shown in *Table 2*.

Table 2

Effect of added copper and full fat soybean meal level on growth performance in broiler chickens[a]

Copper	0 ppm			250 ppm			SEM	Cu (C)	Soya (S)	CxS
FFS (%)	10	20	30	10	20	30				
Body weight (g)										
7 d	151.1	151.3	150.9	151.1	152.3	151.6	1.89	NS	NS	NS
21 d	647.8	662.6	668.9	648.1	654.3	639.3	9.02	0.10	NS	NS
42 d	2107.9	2130.5	2220.4	2080.6	2049.2	2058.8	31.87	0.01	NS	NS
49 d	2613.0	2615.4	2772.5	2527.9	2529.8	2568.4	37.97	0.01	0.01	NS
Weight gain (g/day)										
7–21 d	35.5	36.5	37.0	35.4	35.8	35.0	0.55	0.05	NS	NS
21–42 d	69.5	69.9	73.9	68.14	66.4	67.6	1.38	0.01	NS	NS
7–42 d	55.9	56.5	59.1	55.1	54.2	54.5	0.89	0.01	NS	NS
7–49 d	58.6	58.7	62.4	56.5	56.6	57.6	0.89	0.01	0.01	NS
Feed intake (g)										
7–21 d	67.0	65.4	67.7	67.5	67.8	65.5	1.52	NS	NS	NS
21–42 d	128.8	128.1	128.6	126.4	128.3	121.3	2.81	NS	NS	NS
7–42 d	104.1	103.0	104.2	102.9	104.1	97.8	2.02	NS	NS	NS
7–49 d	119.6	118.2	119.6	117.9	119.9	114.5	2.48	NS	NS	NS
Feed/gain (g/g)										
7–21 d	1.89	1.79	1.83	1.91	1.89	1.79	0.04	NS	NS	NS
21–42 d	1.85	1.83	1.74	1.85	1.93	1.80	0.04	0.08	0.01	NS
7–42 d	1.86	1.82	1.77	1.87	1.92	1.79	0.03	0.09	0.01	NS
7–49 d	2.04	2.02	1.92	2.08	2.12	1.99	0.04	0.05	0.01	NS

[a]Least square means representing 7 replications per treatment; SEM: Standard Error Mean; NS: Not Significant; FFS: full fat soya.

There was no copper x FFSBM interactions for any of the performance characteristics measured during the experimental period (P>0.05). Added copper had significant effect on daily gain (DG) during all phases of the experiment. Also, copper affected BW at day 42 and day 49 and tended to affect (P<0.09) BW at day 21. Chicks fed 250 ppm copper as copper sulfate had lower (P<0.05) DG and lower finally BW then chicks fed no added copper diets. During 7 to 21 day, the addition of copper had no effect on the efficiency of feed utilization. However, feed conversion ratio (FCR) was impaired (p<0.05) by the addition of copper during 49-d experimental period. On the contrary to these results, *Miles et al*. (1998) reported that BW and FCR did not differ in chicks fed up to 400 ppm copper from copper sulfate. Also, *Pesti* and *Bakalli* (1996) reported that 125 or 250 ppm added copper into the diet had growth promoting effect, but 375 ppm added copper provided no further benefit. High level of added copper as copper sulfate into chicken diet could have a growth depression effect (*Wang et al*., 1987). Similar to our results, *Banks et al*. (2004) founded lower DG and BW in chicks fed 250 ppm copper as copper sulfate from 9 to 22 day of age. The same authors explained this with reduction in feed intake and thus WG of chickens. In our study, the addition of copper had no effect on daily feed intake during the 49-d experiment. Previous results indicated that addition 450 ppm copper as copper sulfate into diets decrease feed intake of chickens vs. those fed 300 ppm copper or less.

The FFSBM affected DG and BW if fattening period is 49, but not 42 days. The chickens fed 30% FFSBM in diet had higher DG during day 7 to 49 and higher BW at day 49 then those consuming other diets. These results may indicate that with prolongation of fattening period from 42 to 49 days the genetic potential for maximum growth of broilers could be limited with energy level in diet. As expected, increasing the FFSBM level and thus higher dietary energy content improve FCR.

Table 3

Effect of added copper and full fat soybean meal level on processing characteristics, meat color and visceral organs weight in broiler chickens [a]

Copper (mg/kg)	**0**			**250**			**SEM**	**Cu (C)**	**Soya (S)**	**CxS**
FFS (%)	10	20	30	10	20	30				
Dressing, %	72.7	71.4	71.3	76.7	74.9	74.5	2.1	0.01	NS	NS
AF, %	1.92	1.58	1.74	1.19	1.52	1.36	0.24	0.06	NS	NS
Meat color										
L	56.60	55.71	55.06	58.58	57.70	55.58	0.73	0.01	0.01	NS
a	11.65	11.98	11.57	11.17	11.01	11.34	0.58	NS	NS	NS
b	12.15	11.86	13.24	10.90	13.60	11.86	1.02	NS	NS	NS
Visceral organs weight (%)										
Gizzard	1.43	1.50	1.35	1.66	1.67	1.65	0.09	0.01	NS	NS
PV	0.29	0.29	0,19	0.31	0.32	0.21	0.02	NS	0.01	NS
Heart	0.48	0.45	0.37	0.51	0.46	0.35	0.03	NS	0.01	NS
Liver	2.34	2.33	2.14	2.50	2.49	2.41	0.10	0.05	NS	NS
Pancreas	0.23	0.22	0.19	0.22	0.23	0.21	0.01	NS	0.07	NS

[a] Least Square Means; SEM: Standard Error Mean; NS: Not Significant; FFS: full fat soya; AF: Abdominal fat; PV: Proventriculus.

The copper addition improved dressing percentage ($P<0.01$) and tended to reduce abdominal fat content ($P<0.06$). Similar findings have been observed for the comparison of abdominal fat content in chickens fed diets containing 125 and 250 mg Cu/kg of added copper (*Tangtaweewipat*, 2004). It has been reported that pharmacological concentrations of copper may altered lipid and cholesterol metabolism in rats and chickens. *Konjfuca et al.* (1997) observed reduction in fatty acid synthetase activity in chicks fed supplemented copper. The decrease in fatty acid synthesis could explain the reduction in abdominal fat deposition. Also, the observed reduction in abdominal fat content in copper supplemented chickens could be caused by reduced growth performance observed in these chickens.

The copper addition had significant effect ($P<0.05$) on gizzard and liver weight (*Table 3*). The increase gizzard and liver weight with addition of 250 mg Cu/kg diet were in agreement with a study in laying hens fed 400 mg supplemented Cu/kg diet or higher (*Jackson et al*., 1979). On the contrary to our results, *Tangtaweewipat* (2004) did not find any significant effect of added 125 or 250 mg Cu/kg diet on visceral organs weights in broiler chickens. FFSBM affected proventriculus and heart weight. The chickens fed 30% FFSBM in diet had lower heart and proventriculus weight then those consuming other diets.

Meat color is an important criterion that can be used by consumers to evaluate meat quality. Lightness (L* value) is important in white muscles and correlate with initial pH and drip loss (*Barbut*, 1997). In our study, L* value was affected by added copper and FFSBM. The copper addition increased ($P<0.05$) lightness of breast muscle, whereas higher level of FFSBM decreased it ($P<0.01$).

CONCLUSIONS

The results of the present study indicate that the addition of 250 mg Cu/kg diet in the form of copper sulfate has adverse effect on growth performance, but improves dressing percentage and tends to decrease abdominal fat content. Using the 30% of FFSBM in a broiler diet improves growth performance without negative effect on dressing percentage and abdominal fat content in 49 days fattening period.

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