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COMPARATIVE EFFECTS OF COPPER SULFATE AND ZINC SULFATE ON PERFORMANCES OF BROILER CHICKENS

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ABSTRACT

To investigate the effects of copper sulfate ($CuSO_4.5H_2O$) and zinc sulfate ($ZnSO_4$) on growth performance, feed intake, feed efficiency and carcass characteristics of commercial broiler an experiment was conducted. Total 80 Cobb-500 of 07 days old chicks were randomly divided into four dietary groups having four replications in each. Four diets were considered: control (T_0); $CuSO_4.5H_2O$ @ 150 mg/kg of commercial diet (T_1); $ZnSO_4$ @100 mg/kg on diet (T_2); and combination of $CuSO_4.5H_2O$ + $ZnSO_4$ @ 150 mg/kg + 100 mg/kg of diet (T_3), respectively. Initial live weight, live weight gain and feed intake were recorded. Carcass characteristics were observed after slaughtering of birds. The final live weight was significantly ($P<0.05$) differed among the experimental groups where highest live weight was recorded in T_2 (2440 g/bird) group. Broilers in T_2 group showed the best feed efficiency (1.67) that varied significantly ($P<0.05$). Daily live weight gain was differed significantly ($P<0.05$) among the experimental groups where highest value at 3rd and 4th weeks of experiment was found in birds of T_2 group. There were no significant ($P>0.05$) differences observed among the dietary treatment groups in terms of de-feathering percentages, liver, heart and abdominal fat weight. On the contrary, significant ($P<0.05$) difference were observed in carcass weight, where highest value was recorded in T_3 group. Thigh and breast weight was also differed significantly ($P<0.05$) in T_3 group compared to control and other groups. Use of copper sulfate pentahydrate in diet was economic in terms of cost benefit analysis.

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INTRODUCTION

Agricultural farming system in Bangladesh now a day's largely depends on poultry sectors and broiler is one of the major harvest of poultry farming. Broiler production plays a vital role to the national economy in case of promoting employment opportunity; improving financial status for households as well as the nutritional level of the people. Approximately 3.47 percent of national income came from animal farming along with broiler production during the 2018/19 financial year (BER, 2019). Large number of broiler farms is being established in different parts of the country. Meat of broiler possesses a tremendous source of protein and nutrients which are necessary for health and growth of the human body (Rana et al., 2012). Various growth promoters have been included in broiler diets to promote growth, protect health and maximize the genetic potential of modern broiler. For example, antibiotics are one of them and have been used at sub-therapaeutic doses in broiler diets to prevent disease, promote growth and feed conversion efficiency (Engberg et al., 2000). Limited use of antibiotic growth promoter (AGP) in food animal has been established worldwide (Turnidge, 2004). Antibiotics induce their effect by stabilizing the intestinal microflora thereby preventing proliferation of specific intestinal pathogens (Shane, 2005). Today the use of antibiotics growth promoter in broiler ration has been eliminated or limited due to the concern of antibiotic resistance development in human. This limitation prompted the search and development of alternatives to antibiotics. Copper sulfate and zinc sulfate can be used as alternatives to antibiotic growth promoter. Copper and zinc act as catalysts in enzyme systems within cells or as parts of enzymes and are considered as constituents of hundreds of proteins involved in intermediary metabolism, hormone secretion pathways and immune defense systems (Dieck et al., 2003) and such trace elements are required in small amounts, usually less than 100 mg/kg dry matter (Bao et al., 2007). There is a practice to supplement an addition of copper sulfate in poultry feed (Cohen, 2002). As copper has antimicrobial properties that improve animal growth performance when fed over the minimum requirement so that this mineral received great attention (Kim et al., 2011). Copper improves the growth and feed efficiency in broilers when it is provided at much higher pharmacological levels.

Many of the authors support copper sulfate pentahydrate due to cost effectiveness and easy availability, copper sulfate pentahydrate is the main source of copper, however, an excess in the diet may depresses growth and feed efficiency in broilers. On the other hand, zinc (Zn) is a fundamental part of more than 300 enzyme systems that is necessary for chicken's optimum growth, feathering, bone development, skin quality and immunity (O'Dell, 2000). There are two preferred source of zinc and that is zinc oxide (ZnO) and zinc sulfate ($ZnSO_4.H_2O$) where the bioavailability of zinc sulfate ($ZnSO_4$) is 100% in broiler (Puchala et al., 1999). In poultry, deficiency of zinc is responsible for reduction in weight gain, skeletal abnormalities, disturbance in bone mineralization, and immunological abnormalities. Several studies revealed minor disagreements between copper and zinc and that is high zinc intake inhibit intestinal absorption and hepatic accumulation of copper and induce clinical signs of copper deficiency (Gonzalez et al., 2005). Some studies also showed that high zinc intake induces a high level of metallothionein in the intestinal mucosa that has high binding affinity for copper (Santon et al., 2002). However, very limited studies were conducted to observe the dietary effects and identify the optimum and safety levels of copper sulfate and zinc sulfate on performances of broiler. Therefore, the present study was designed to investigate the comparative effects of copper sulfate and zinc sulfate on growth performances, feed intake, feed efficiency and carcass characteristics in broiler chickens.

MATERIALS AND METHODS

Preparation of the research shed

The shed was cleaned and washed using fresh water, soapy water and disinfectant (GPC 8®). Then it was kept open for 5 days before placing the experimental birds. All necessary equipment was set properly to care the broiler chicks properly.

Experimental birds

A total of 80, day old broiler chicks of "Cobb 500" strain were purchased from the dealer of Nourish Poultry and Hatchery Limited®. Then the chicks were properly exposed to heat (Brooding) and other management was carefully maintained as the company manual for upto 7 days. Finally the 7 days old birds were carefully transferred to the experimental shed, in which proper lighting, ventilation and heating arrangement were ensured. One group was comprising of four replication i.e. four cage and 5 birds were occupied in each cage. Each of the cages contained a feeder and a waterer for each of the five birds. Birds were housed in proper atmosphere and hygienic condition. The birds were fed with standard broiler starter and broiler finisher ration throughout the experimental period.

Research layout

Total of 80 of seven (07) days old "Cobb 500" broilers were randomly divided into four groups (T_0, T_1, T_2 and T_3) having 4 replications in each. T_0 was considered as control and fed with only commercial ration and T_1, T_2 and T_3 were denoted as the broiler groups fed the diet supplementation with 150 mg of $CuSO_4.5H_2O$ (Copper Sulfate Pentahydrate), 100 mg of $ZnSO_4$ (Zinc Sulfate) per kg of feed and their combination (150 mg of $CuSO_4.5H_2O$ and 100 mg of $ZnSO_4$), respectively. Initial live weight of each bird was recorded (at day 07) just prior to the dietary grouping and kept them into separate bamboo made cage, the birds were reared on slatted floor (Macha). Live weight and weekly feed intake were recorded at 7 days interval up to the end of the 28 days of experimental period (i.e. 35 days of bird age) and total 16 birds were sacrificed to observe carcass characteristics.

Composition of the commercial diet (kg/100 kg)

Table 1. Formulation of commercial ration

Ingredients	Broiler starter	Broiler finisher
Maize	43.00 kg	43.64 kg
Wheat	10.00 kg	10.00 kg
Rice polish	4.00 kg	10.00 kg
Soybean	26.00 kg	22.50 kg
Meat and Bone meal	9.00 kg	8.00 kg
Oyster shell	1.00 kg	1.00 kg
Salt	300 g	250 g
Methionine	200 g	180 g
Lysine	30 g	30 g
Vitamin Premix (broiler)	250 g	250 g
Feed zyme	-	50 g
Soybean oil	6.5 kg	4.00 kg
DCP	2.50 g	-
Choline chloride	100 g	100 g
Total	100.00 kg	100.00 kg

Source: Nourish Poultry and Hatchery Ltd. ®, Bangladesh.

General management practices

Fresh, clean and cool drinking water was made available for all times. Each bamboo cage was 2.5 ft × 2 ft and was allotted for 5 birds. Fresh and dry rice husk was used as litter at a depth of about 5 cm from day 1 to day 10 and after 10 days when the birds are free from the risk of being trapped, the litter materials were removed. The birds were exposed to a continuous lighting of 12 hours a day. The experimental birds were vaccinated against Newcastle (Ranikhet) disease and Infectious bursal disease (Gumboro) as per Table 2.

Table 2. The vaccination schedule of commercial broiler

Age of birds (day)	Name and type of vaccine	Preparation ofdilution	Dose and route of administration
5	BCRDV freeze dried live vaccine	1 ampoule was diluted with 6 ml of distilled water	One drop in each eye
11	Nobilis Gumboro D 78 freeze dried live vaccine	1 ampoule was diluted with 36 ml of distilled water	One drop in each eye
18	BCRDV (Booster dose) freeze dried live vaccine	As used in day 5	One drop in each eye
21	Nobilis Gumboro D 78 (Booster dose) freeze dried live vaccine	As used in day 11	One drop in each eye

Source: BCRDV- Livestock Research Institute (LRI), Mohakhali, Dhaka, Nobilis Gumboro D 78®- Intervet, International B.V.,Boxmeer, Holland.

Record keeping and data processing

Experimental birds were weighed initially and weekly basis for all birds from each replication. Feed intake was calculated as the total feed consumed in each replication divided by the number of birds. Body weight gain of the broiler in each replication was calculated by deducting initial body weight from the final body weight. Feed efficiency (FE) was calculated as the amount of feed consumed per unit of weight gain.

Statistical analysis

Data of body weight, body weight gain, feed consumption, feed efficiency, carcass characteristics were subjected to analysis of variance (ANOVA) in a completely randomized design (CRD) using SPSS (version 20) statistical package program and data were considered significant at 5% level of significance.

RESULTS AND DISCUSSION

Performance of broiler

The results of feeding copper as copper sulfate pentahydrate ($CuSO_4.5H_2O$), zinc as zinc sulfate ($ZnSO_4$) and their combination on broiler are presented in Table 3 under the following sub-headings:

Table 3. Effect of $CuSO_4.5H_2O$, $ZnSO_4$ and their combination on broiler live weight

Parameter	Dietary treatment				Level of significance
	Control	$CuSO_4.5H_2O$	$ZnSO_4$	$CuSO4.5H_2O + ZnSO_4$	
ILW at 7 days (g/bird)	166.5 ± 0.52	167.5 ± 0.96	167.5 ± 0.97	168.8 ± 0.89	NS
FLW at 35 days (g/bird)	1926.0 ± 6.53^a	2312.0 ± 5.23^b	2440.0 ± 30.82^c	2415.0 ± 17.09^c	*
Total LWG (g/bird)	1759.35 ± 6.88^a	2144.95 ± 5.32^b	2272.90 ± 30.89^c	2246.65 ± 17.93^c	*
Total FI (g/bird)	4006.0 ± 13.59	4081.0 ± 37.98	4073.0 ± 42.39	4161.0 ± 14.34	NS
FE	2.077 ± 0.01^c	1.767 ± 0.01^b	1.668 ± 0.01^a	1.722 ± 0.01^b	*

$CuSO4.5H_2O$= Copper sulfate pentahydrate, $ZnSO_4$= Zinc sulfate, ILW = Initial live weight, FLW = Final live weight, LWG=Live weight gain, FI=Feed intake, FE= Feed efficiency, NS= Non-significant at 5% level of probability, Values indicate Mean ± Standard Error of Mean (SEM). $^{a, b, c}$means bearing different superscripts in a row differ significantly. *= ($P<0.05$).

Live weight and live weight gain

In the present study, the live weight at 35 days of age was significantly higher in the broilers fed diet supplemented with $ZnSO_4$ (2440 g/bird), compared to control (1926 g/bird), $CuSO_4.5H_2O$ (2312 g/bird) and combination of $CuSO_4.5H_2O$ and $ZnSO_4$ (2415 g/bird) shown in Table 3. This finding agrees with Burrell et al., (2004) who conducted a study in broiler chickens with the supplementation of 110mg/kg zinc and observed optimum live weight. Midilli et al., (2014) found increasing live weight while supplying inorganic and organic form of zinc alone or in combination with microbial phytase. A significant effect on live weight increase in groups fed with 80 mg/ kg of zinc from 21-45 days of age was reported by Sahoo et al., (2016).

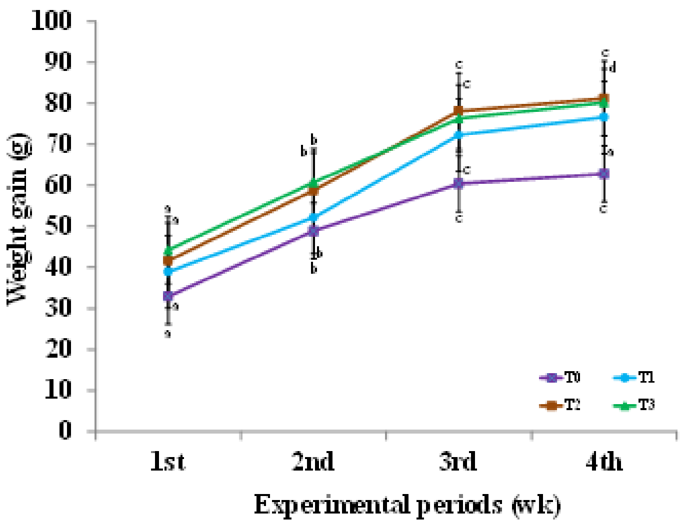

Figure 1. Weight gain of broilers supplemented with $CuSO_4.5H_2O$, $ZnSO_4$ and their combination (T_0, Control; T_1, containing $CuSO_4.5H_2O$ @ 150 mg/kg; T_2, containing $ZnSO_4$ @ 100 mg/kg and T_3, containing $CuSO_4.5H_2O$ @ 150 mg and $ZnSO_4$ @ 100 mg/kg). Each line with error bar represents Mean ± Standard Error of Mean (SEM). Differences were significant ($P<0.05$) among the groups. ^{a,b,c,d}means bearing different superscripts in a row differ significantly ($P<0.05$).

Total live weight gain with regard to $ZnSO_4$ (T_2-2272.90 g/bird) compared with the broiler group fed diet supplemented with $CuSO_4.5H_2O$ (T_1-2144.95 g/bird), control (T_0-1759.35 g/bird) and combination of $CuSO_4.5H_2O$ and $ZnSO_4$ (T_3-2246.65 g/bird) were significant ($P<0.05$) presented in Table 3 and Figure 1. The result is similar with Ezzati et al., (2013) who explained improved live weight gain with the supplementation of 100 mg/kg zinc on diet. Salabi et al., (2011) found significant live weight gain when they added zinc at the level of 90 mg/kg of diet. On the contrary, Liu et al., (2011) reported no differences in average daily weight gains with the addition of 60, 120 and 180 mg/kg of zinc in diet.

Feed intake

Feed intake of experimental broilers was not significantly ($P>0.05$) differed among the groups during the experimental period (Table 3 and Figure 2). Although a little higher feed intake was observed in T_1 (4081 g/bird), T_2 (4073 g/bird) and T_3 (4161 g/bird) groups but it was not significantly ($P>0.05$) higher than that of the control group (T_0-4006 g/bird). The findings of the present study partially agreed with the result of Anil et al., (2012) who concluded as the supplementation of zinc in the form of inorganic and organic at 20, 40, 60, 80 mg/kg on diet did not influence much with regard to the feed intake. But Ezzati et al., (2013) reported decreased feed intake without affecting feed efficiency when zinc was added at the level of 100 mg/kg on diet.

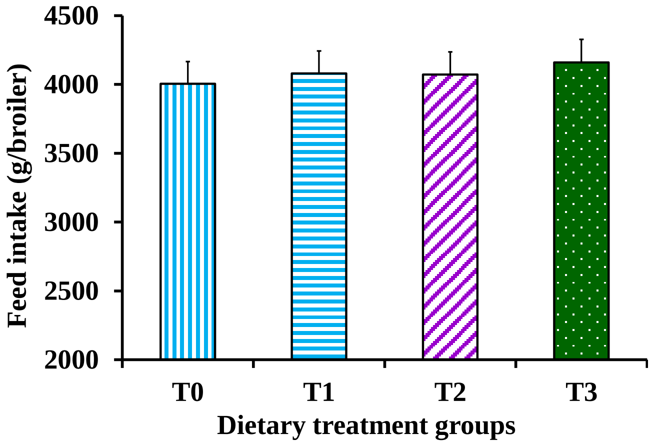

Figure 2. Feed intake of broilers fed $CuSO_4.5H_2O$, $ZnSO_4$ and their combination (T_0, Control; T_1, containing $CuSO_4.5H_2O$ @ 150 mg/kg; T_2, containing $ZnSO_4$ @ 100 mg/kg and T_3, containing $CuSO_4.5H_2O$ @ 150 mg and $ZnSO_4$ @ 100 mg/kg). Each bar with error bar represents Mean ± Standard Error of Mean (SEM). Differences were non-significant (P>0.05) among the groups.

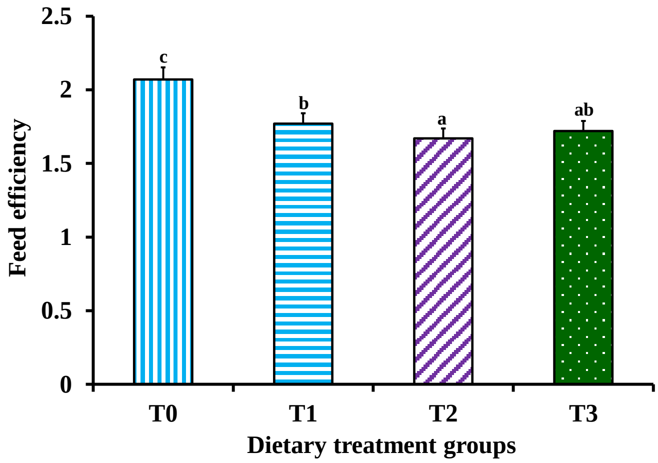

Figure 3. Feed efficiency (FE) of broilers fed $CuSO_4.5H_2O$, $ZnSO_4$ and their combination (T_0, Control; T_1, containing $CuSO_4.5H_2O$ @ 150 mg/kg; T_2, containing $ZnSO_4$ @ 100 mg/kg and T_3, containing $CuSO_4.5H_2O$ @ 150 mg and $ZnSO_4$ @ 100 mg/kg). Each bar with error bar represents Mean ± Standard Error of Mean (SEM). Differences were significant (P<0.05) among the groups. ^{a,b,c} means bearing different superscripts in a row differ significantly (P<0.05).

Feed efficiency (FE)

Through supplementation of $CuSO_4$, $ZnSO_4$ and their combination, feed efficiency of broiler in different experimental group differed significantly (Table 3 and Figure 3). It was found that FE was lowest but best in the groups supplemented with $ZnSO_4$ (T_2-1.67) compared to other treatment groups i.e. $CuSO_4.5H_2O$ (T_1-1.77), combination of $CuSO_4.5H_2O$ and $ZnSO_4$ (T_3-1.72) and control group (T_0-2.07). This finding is similar with the observation of Midilli et al., (2014) who found improved feed efficiency while supplied inorganic and organic form of zinc separately or combination with microbial phytase. Ao et al., (2007) found improved weight gain and feed intake ratio in broilers by dietary supplementation of zinc compared to the control (basal diet) group. Huang et al., (2007) reported highest weight gain to feed intake ratio when zinc was added at the level of 20 mg/kg in diet.

Table 4. Carcass characteristics of broilers fed diet with $CuSO_4.5H_2O$, $ZnSO_4$ and their combination

Variables	Dietary treatments				Level of significance
	Control	$CuSO_4.5H_2O$	$ZnSO_4$	$CuSO_4.5H_2O$ + $ZnSO_4$	
Defeathering percentages (%)	93.49 ± 0.45[a]	93.99 ± 0.77[a]	92.63 ± 0.29[a]	92.87 ± 0.40[a]	NS
Carcass weight (g)	1398.87 ± 14.93[a]	1712.50 ± 9.87[b]	1758.62 ± 20.15[b]	1876.25 ± 44.37[c]	*
Thigh weight (g)	233.81 ± 6.81[a]	290.88 ± 3.30[b]	300.0 ± 4.39[b]	304.5 ± 2.95[b]	*
Breast weight (g)	376.3 ± 3.38[a]	466.8 ± 4.91[b]	439.0 ± 23.80[b]	503.9 ± 8.87[c]	*
Liver weight (g)	49.75 ± 0.52	49.00 ± 0.57	51.37 ± 0.71	51.87 ± 1.70	NS
Heart weight (g)	11.62 ± 0.13	11.62 ± 0.24	11.75 ± 0.14	12.12 ± 0.24	NS
Abdominal fat weight (g)	49.00 ± 0.73	49.75 ± 0.52	50.75 ± 1.01	50.25 ± 1.05	NS

$CuSO_4.5H_2O$= Copper sulfate pentahydrate, $ZnSO_4$= Zinc sulfate, NS= Non-significant at 5% level of probability, values indicate Mean ± Standard Error of Mean (SEM). [a,b,c] means bearing different superscripts in a row differ significantly.
*= (P<0.05).

Carcass characteristics

In the present study, the treatments showed no significant (P>0.05) effect on defeathering percentage, liver, heart and abdominal fat weight among the experimental birds (Table 4). Defeathering weight percentages was slightly higher in group treated with dietary supplementation of $CuSO_4.5H_2O$ (T_1-93.99 %) compared to other experimental group i.e. control (T_0-93.49 %), combination of $CuSO_4.5H_2O$ and $ZnSO_4$ (T_3-92.87 %) and $ZnSO_4$ (T_2-92.63 %). The finding agreed with Prajapati et al., (2010) who observed improvement on dressing weight of copper treated group as compared to the control. Whereas, Waldroup et al., (2003) tested with the supplementation of 55 and 250 mg/kg copper as copper sulfate and found unaffected dressing percentage in broiler chicken. On the contrary, Arias and Koutsos (2006) did not observe any change on weight of liver when supplemented copper at 188 mg/kg through tri-basic copper chloride or copper sulfate and 128 mg/kg of copper through copper sulfate (Sunder et al., 2009).

The carcass weight was significantly differing among the experimental group (Table 4) where the highest value was recorded in groups fed diet supplemented with combination of $CuSO_4.5H_2O$ and $ZnSO_4$ (T_3-1876.25 g/bird) followed by $ZnSO_4$ (T_2-1758.62 g/bird), $CuSO_4.5H_2O$ (T_1-1712.50 g/bird) and the lowest was found in control (T_0-1398.87 g/bird) group. The thigh weight value differed significantly in treatment group i.e. T_1 (290.88 g/bird), T_2 (300 g/bird) and T_3 (304.5 g/bird) when compared with control (T_0-233.81 g/bird). On the other hand, breast weight was significantly differing among the experimental group. The highest value was recorded in groups fed diet supplemented with combination of $CuSO_4.5H_2O$ and $ZnSO_4$ (T_3- 503.9 g/bird) followed by $ZnSO_4$ (T_2-439 g/bird), $CuSO_4.5H_2O$ (T_1-466.8 g/bird) and the lowest was found in control (T_0-376.3 g/bird) group. The result is partially similar with the findings of Arias and Koustos (2006) who reported an improvement in the carcass weight when used either recycled or fresh litter with the supplemented copper (@188 mg/kg) in broiler birds. Liu *et al.* (2011) reported a positive effect of dietary supplementation of $ZnSO_4$ on percentage of eviscerated yield and also found numerically higher (P=0.17) percentage of breast muscle than broilers fed with basal diets (control).

Table 5. Cost effective analysis of dietary effect of $CuSO_4.5H_2O$, $ZnSO_4$ and their combination on broilers

Description	To (Control)	T_1 ($CuSO_4.5H_2O$)	T_2 ($ZnSO_4$)	T_3 ($CuSO_4.5H_2O + ZnSO_4$)
Cost/chick (Taka)	55	55	55	55
Average feed consumed kg/birds	4	4.08	4.07	4.16
Feed price/kg (Taka)	42	42	42	42
Cost of $CuSO_4.5H_2O$ (Tk./bird)	0	9	0	9
Cost of $ZnSO_4$ (Tk./ bird)	0	0	26	26
Feed cost (Tk./ bird)	168	171.36	170.94	174.72
Miscellaneous (Tk./ bird)	16	16	16	16
Total cost/broiler (Taka)	239	251.36	267.94	280.72
Average live weight (kg)	1.91	2.35	2.3	2.45
Sale price/Kg live wt. (Taka)	130	130	130	130
Sale price/broiler (Taka)	248.3	305.5	299	318.5
Net profit/broiler (Taka)	9.3	54.14	31.06	37.78
Benefit over control/ broiler (Taka)	0	44.84	21.76	28.48

Cost benefit analysis of production

Table 5 shows the cost benefit analysis for broiler production fed on $CuSO_4.5H_2O$, $ZnSO_4$ and their combination. Total production cost in terms of per bird was 239 Tk. for control, 251.36 Tk. for $CuSO_4.5H_2O$, 267.94 Tk. for $ZnSO_4$ and Tk. 280.72 for the group fed $CuSO_4.5H_2O$ and $ZnSO_4$ combinedly. The profit in terms of per bird of broiler were slightly higher in $CuSO_4.5H_2O$ (54.14 Tk.) group followed by combined (37.78 Tk.), $ZnSO_4$ (31.06 Tk.) and the lowest in control (9.30 Tk.). Net profit over control was highest for the group fed $CuSO_4.5H_2O$ (44.84 Tk.), this might be due to the minimum cost of $CuSO_4.5H_2O$, followed by combined group (28.48 Tk.) and group fed diet supplemented with $ZnSO_4$ (21.76 Tk.). It is therefore clear that additional supplementation of $CuSO_4.5H_2O$ and $ZnSO_4$ is profitable over control group. The result is agreed with the findings of Abdallah et al., (2009) who showed the comparatively better economic efficiency compared to the control when treated with organic copper in diet. Single growth promoter has the more profitability over the combination with another (Roy and Chowdhury, 2013).

CONCLUSION

The research showed that the addition of copper sulfate and zinc sulfate to broiler diets had positive effect on performances of broiler chickens. Addition of copper sulfate and zinc sulfate improve performances of broiler in terms of growth and carcass characteristics whether they are used individually or in combination. By analyzing the cost benefit, it can be concluded that copper sulfate pentahydrate may be economically used as a growth promoter in commercial broiler ration.

CONFLICT OF INTEREST

The author declares that there is no conflict of interests regarding the publication of this paper.

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