

Influence of dietary copper supplementation on growth performance, blood profile and carcass characteristics of broiler chicken

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Target Audience: *Animal Scientists, Feed additive producers, Consumers*

Abstract

A 56-day trial was conducted to investigate the influence of dietary copper methionine (Cu-M) supplementation on the growth performance, blood profile and carcass characteristics of broiler chickens. A total of 180 arbor acre chicks were allotted into four dietary treatments of 45 birds each. Each treatment group was further subdivided into three replicates of 15 birds per replicate in a completely randomized design. Cu-M was incorporated at varying levels of; 0, 10, 20 and 30 ppm to formulate four dietary treatments. Data were collected on growth performance, haematological, serum biochemical indices and carcass characteristics. Results revealed that dietary Cu-M supplementation significantly ($P < 0.05$) influenced the average daily feed intake and feed conversion ratio (FCR) of the broiler chicken. Cu-M supplementation significantly ($P < 0.05$) influenced FCR values across the dietary treatments. Birds fed 30 ppm Cu-M supplementation had the lowest FCR values (2.17). Dietary Cu-M supplementation had no significant ($P > 0.05$) influence on all the serum biochemical indices. Cu-M supplementation did not significantly ($P > 0.05$) influence the haematological indices except the haemoglobin (Hb) and white blood cell (WBC) values. The Hb concentration of the birds fed Cu-M supplemental diet was significantly ($P < 0.05$) higher when compared with those birds on control diet. The WBC count varied ($26.64 - 30.89 \times 10^6/\text{mm}^3$) significantly ($P < 0.05$) across the dietary treatments. Dietary Cu-M supplementation had no significant ($P > 0.05$) effect on carcass characteristics. It can be concluded from this study that dietary Cu-M supplementation up to 30 ppm can substantially improve the feed utilization of broiler chickens.

Keywords: *copper-methionine, broiler chickens, supplemented diets, growth performance, carcass quality*

Description of Problem

Trace minerals, such as zinc, copper, and manganese, are necessary for poultry growth due to their involvement in numerous digestive, physiological, and biosynthetic processes within the body. They primarily serve as catalysts in enzyme systems within cells or as components of different enzymes. They are part of hundreds of proteins that are involved in intermediary metabolism, hormone secretion pathways, and immune defense systems. They also participate in a

wide range of physiological processes, making them critical for optimal bird growth and health (1). They act as a catalyst in many enzyme and hormone systems, influencing growth, bone development, feathering, enzyme structure, function, and appetite (2). Copper (Cu) is an essential trace mineral for poultry that is involved in a variety of physiological processes, primarily as a component of several enzyme systems. Cu is involved in oxidative phosphorylation, free radical detoxification, neurotransmitter

synthesis and denaturation, pigment formation, connective tissue synthesis, and iron (Fe) metabolism in mitochondria (3; 4). Trace minerals, such as zinc, manganese, and copper, are involved in numerous physiological processes, making them critical for optimal bird growth and health (1). The recommended copper requirement for broilers is 8 mg/kg diet (5), but prophylactic high doses of copper, up to 250 mg/kg, have traditionally been added to broiler diets due to its antimicrobial and growth promoting effects (6; 7). Alternative antibiotics that have similar effects in terms of intestinal microflora regulation while also providing optimal animal performance are of great interest. Nowadays, livestock is typically fed highly concentrated diets that are designed to provide an abundance of nutrients in order to maximize performance (8). Copper bioavailability and animal effects differ depending on the source or form of copper. Although organic copper and nanosized copper have been shown to be more bioavailable than copper sulphate pentahydrate (9; 10), copper sulphate pentahydrate ($\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$) is the most commonly used copper source for supplementation in poultry diets due to its lower cost and commercial availability. As a result, the current study was designed to investigate the effect of dietary organic copper (methionine) on growth performance, blood profile and carcass characteristics of broiler chicken.

Materials and Methods

Experimental Site

This study was conducted for 56 days at the Teaching and Research Farm of the Federal College of Animal Health and Production Technology, Moor Plantation, Ibadan. The area lies within the rain forest ecological zone and falls within longitude and latitude $7^\circ 27'$ and $3^\circ 25'$ Respectively at

altitude 200 – 300m above the sea level with an annual rainfall of about 1250mm. The temperature and relative humidity ranges from 30 – 35 ° C and 76 – 84% respectively (11).

Source of Test Ingredient and Preparation of Experimental diet

The test ingredient used in this study was a fully defined structure that delivers 18% Copper as Copper methionine (Cu-M) analogue chelate with a 79.5% methionine value product manufactured by Novus International Incorporation, United States of America but it was obtained in Nigeria from NOJEM Nigeria Limited, Lagos, Nigeria. Copper free premix was purchased from Retinol Nigeria limited. The Cu-M was incorporated at varying levels of 0, 10, 20 and 30 ppm to formulate four dietary treatments

Experimental birds and Management

A total number of one hundred and eighty (180) day-old broiler chicks used in this study were purchased from a commercial hatchery in Ibadan. The birds were randomly assigned into four (4) dietary treatments of 45 birds per treatment. Each treatment group was further subdivided into three replicates of 15 birds per replicate. Brooding commenced immediately the chicks arrived. Feed and clean water were supplied *ad libitum*. The birds were reared intensively on a deep litter housing system and vaccination protocols were strictly adhered to.

Data Collection

Feed intake and live weight changes The growth of the birds in response to the experimental diets was monitored by taking their pre-experimental body weights, followed by weighing on a weekly basis prior to feeding. Feed offered on daily per

bird was recorded and refusal was weighed and recorded to compute feed intake on daily basis.

$$\text{Feed intake} = \text{Feed offered} - \text{left over}$$

$$\text{Weight gain} = \text{Final Weight} - \text{Initial Weight}$$

$$\text{Feed Conversion Ratio} = \frac{\text{Total Feed intake(g)}}{\text{Total Weight gain (g)}}$$

Collection of blood samples

After 56d, blood samples of approximately 6 mL were collected from nine (9) randomly selected experimental birds per treatment via the jugular vein using hypodermic needle and syringe. About 3 mL of blood sample collected was released into the sample bottles containing Ethyl Diamine Tetra Acetic Acid (EDTA) as anticoagulant and the bottles were gently shaken to ensure proper mixing of the blood with EDTA to prevent coagulation and the remaining 3 mL was poured into a plain sample bottle. Blood samples were analyzed according to routinely available clinical methods. The PCV was determined using the wintrobe haematocrit method described by (12). WBC and RBC were determined using haemocytometer after appropriate dilution (13), Haemoglobin (14). Biochemical components of the serum samples estimated were total protein (g/dL) was determined according to Biuret Method (15) while albumin (g/dL) level was obtained using Bromocresol green method as described by (16). Blood glucose (mg/dL) level was determined according to the method recommended by (17), urea (mg/dL),

Carcass Evaluation

At the end of the 56 d experiment, two (2) birds were randomly selected from each

replicate for carcass evaluation. The birds were weighed, slaughtered, bled, scalded and eviscerated to obtain the dressed, eviscerated and carcass weights, while the organs and primal cuts were weighed and expressed as a percentage of the live weight.

Chemical analysis

An aliquot of daily feed samples (concentrates) was collected, oven-dried, ground and sieved through a 2-mm sieve and stored in airtight container for proximate analysis (18). Nitrogen Free Extract (NFE) was determined by subtracting sum of (%Moisture + % Crude Protein + % Ether extract + % Crude fibre + % Ash) from 100.

Statistical analysis

Data collected were subjected to one-way analysis of variance (ANOVA) and significant means among variables were separated by Duncan multiple range test using the statistical package (19). Differences were considered at 5% level of significance.

Results and Discussion

Presented in Table 2 is influence of dietary copper supplementation on the growth performance of broiler chicken. Dietary copper methionine (Cu-M) had no ($P>0.05$) influence on the growth performance of broiler chicken except the average daily feed intake and feed conversion ratio. The average daily feed intake of the experimental birds observed in this study varied significantly across the dietary treatments in which birds fed 30 ppm Cu-M recorded the highest (98.63g/b/d) values while the lowest (88.79 g/b/d) values was obtained in birds on 20 ppm Cu-M based diet. Birds fed 30ppm Cu-M based diet had significantly ($p<0.05$) superior feed conversion ratio (2.17).

Table 1: Gross Composition and Proximate Analysis of Experimental Diet

Ingredients	Broiler Starter	Broiler Finisher
Maize	55.00	60.00
Soybean meal	22.00	24.00
Wheat offal	8.00	9.00
Groundnut cake	3.00	5.00
Fish meal	3.50	3.50
Bone meal	2.00	2.00
Oyster shell	1.50	1.50
Copper free premix	0.25	0.25
Methionine	0.25	0.25
Lysine	0.25	0.25
Salt	0.25	0.25
Total	100.00	100.00
Determined Analysis		
Dry matter	87.95	89.62
Crude Protein	23.04	19.90
Crude fibre	4.88	5.66
Ether extract	5.63	4.81
Ash	6.86	8.66
Nitrogen free extract	47.72	50.59
Metabolizable Energy (MJ/Kg)	11.85	12.43
Basal Dietary Cu (mg/Kg)	30.80	41.10

Premix composition: Vitamin A: 4000000IU. Vit D3: 2500000IU Vit E: 40000mg. Vit. K3: 800mg. Vit B3:3000mg, Vit B2: 6000mg. Vit.B6: 5000mg. Vit B12: 25mg. Niacin 6000mg. Pantothenic; 2000MG. Folic acid: 800mg. Biotin: 8mg. Manganese: 300000mg. Iron: 800mg. Zinc: 20000mg. Cobalt 80mg. Iodine: 400mg. Selenium: 40mg. Chlorine: 800000mg

Table 2: Influence of dietary copper supplementation on the growth performance of broiler chickens

Parameters	Dietary Copper Supplementation(ppm)				SEM
	0	10	20	30	
Initial Weight (g/bird)	42.50	42.62	42.80	42.80	0.05
Final Weight (g/bird)	2050.00	2150.00	2220.00	2545.00	39.90
ADWG (g/bird/day)	36.61	38.39	39.64	45.45	0.98
ADFI (g/bird/day)	90.79 ^{ab}	91.37 ^{ab}	88.79 ^b	98.63 ^a	0.28
FCR	2.48 ^a	2.38 ^a	2.24 ^{ab}	2.17 ^b	0.05

^{a,b,c} Means along the same row with different superscripts are significantly different (P<0.05).

Indicated in Table 3 is influence of dietary copper supplementation on the serum biochemical indices of Broiler chickens.

Dietary copper methionine (Cu-M) had no (P>0.05) effect on the serum biochemical indices of broiler chicken.

Table 3: Influence of dietary copper supplementation on the serum biochemical indices of broiler chickens

Parameters	Dietary Copper Supplementation (ppm)				SEM
	0	10	20	30	
Total Protein (g/dL)	42.00	43.91	44.90	42.59	1.77
Albumin (g/dL)	24.10	24.70	24.91	24.62	0.15
Globulin(g/dL)	17.90	20.20	20.95	20.90	1.74
Glucose (g/dL)	220.0	217.30	227.60	215.10	4.48
Triglyceride (mg/dL)	206.10	183.30	184.82	183.40	5.26
Cholesterol (mg/dL)	22.04	19.86	18.58	18.62	4.47
Urea Acid (mg/dL)	5.90	4.90	4.92	4.94	0.36

Table 4 shows the influence of dietary copper supplementation on the haematological indices of Broiler Chickens. Dietary copper methionine (Cu-M) did not significantly ($P>0.05$) influence the haematological indices of broiler chicken observed in this study except the haemoglobin and white blood cell. Birds on dietary Cu-M based diet recorded similar values but significantly higher than those on

control diet. The white blood cell values obtained in this study varied significantly across the dietary treatments in which birds fed 0ppm Cu-M based diet had the highest values ($30.89 \times 10^6/\text{mm}^3$) while the lowest values were obtained in birds fed 20 ppm ($27.10 \times 10^6/\text{mm}^3$) and 30 ($28.50 \times 10^6/\text{mm}^3$) ppm Cu-M based diet having statistically similar values

Table 4: Influence of dietary copper supplementation on the Hematological indices of Broiler Chickens

Parameters	Dietary Copper Supplementation(ppm)				SEM
	0	10	20	30	
Packed Cell Volume (%)	27.90	27.50	28.10	28.21	1.13
Haemoglobin (g/dL)	9.10 ^b	9.50 ^a	9.70 ^a	9.60 ^a	0.12
White Blood Cell ($10^6/\text{mm}^3$)	30.89 ^a	26.64 ^{bc}	27.10 ^b	28.50 ^b	1.23
Red Blood Cell ($10^6/\text{mm}^3$)	24.00	25.10	32.33	33.00	3.64

^{a,b,c} Means along the same row with different superscripts are significantly different ($P<0.05$).

Indicated in Table 5 is the influence of dietary copper supplementation on the carcass characteristics of broiler chicken. Dietary copper methionine (Cu-M) had no significant influence ($p>0.05$) on the carcass characteristics of broiler chickens.

Discussion

Dietary copper sources affect the biological availability of copper to animals for absorption and utilization. The higher feed intake values observed in birds fed

dietary Cu-M based diet could be attributed to the dietary copper in the diet influencing the feed intake. Birds fed diets supplemented with Cu consumed more feed than those on the control diet which was in agreement with the findings of (20). The current study indicated that copper methionine supplementation improved the growth rate of broiler chicken as it influenced the feed conversion ratio values obtained across the dietary treatments. Birds fed dietary Cu-M showed better growth performance than

those on control diet. This suggests that copper may have growth promoting influence on broiler chickens simply because pharmacological concentrations of copper act as a growth stimulant thereby improving growth performance, including increase in feed intake (21). This finding was in accordance with previous researchers (22; 23; 24) who reported that broiler chickens fed copper supplemented diet grew faster and utilized feed better than those on control diets. Although the result obtained in this study contradicted the observation of other

researchers (25; 26), who noted that copper supplemental diet had little or no effect on growth performance and feed utilization of boiler chickens. According to (27), the mechanisms by which Cu can enhance the productive traits may include: 1) effect on microflora population; 2) increased mitogenic activity; 3) increased growth hormone secretion of the pituitary gland; 4) increased secretion of nerve peptide; or 5) modified post-translational regulatory peptides.

Table 5: Influence of dietary copper supplementation on the carcass characteristics of broiler chickens

Parameters	Dietary Copper Supplementation (ppm)				SEM
	0	10	20	30	
Live weight (g)	2400.00	2530.00	2266.70	1966.90	74.24
Plucked Weight (g)	2100.00	2130.10	1947.70	1684.30	66.81
Eviscerated Weight (g)	1866.70	1871.26	1654.52	1474.10	61.81
Dressed Weight (%)	85.76	82.76	82.85	81.78	0.98
Primal Cuts (% LW)					
Breast	12.58	11.42	11.96	9.76	0.23
Back	0.05	0.04	0.05	0.04	0.00
Thigh	12.95	12.21	12.36	12.77	0.30
Spleen	6.61	6.79	6.64	6.04	0.20
Drumsticks	6.38	5.88	6.34	6.45	0.17
Shank	0.80	0.82	0.84	0.94	0.05
Relative organ weight (%)					
Heart	1.84	1.71	0.65	1.83	0.05
Liver	5.24	4.85	4.35	6.65	0.18
Lungs	1.02	1.46	1.50	1.40	0.66

Serum biochemical indices of broiler chickens observed in this study were not affected by copper methionine (Cu-M) supplementation. Thus, birds on dietary Cu-M supplementation recorded higher numerical values (Total protein, Albumin and Globulin) and lower numerical values were observed in glucose, cholesterol, triglycerides and urea acid when compared with those on control diet. The higher numerical serum protein recorded in broiler chickens fed Cu-M supplemented diet may indicate faster biosynthesis of tissue protein,

or a slowing down of protein metabolism. Complexes of elements with amino acids or proteins can be ingested in a non-altered form the intestine mucous membrane using the amino acid transportation system, which is higher absorbed by organisms. This still buttress the fact that copper as a trace element plays a direct role in many biochemical events such as growth, connective tissue synthesis and haematopoiesis in organism (28).

In Cu supplemented birds, higher haemoglobin values recorded could be

attributed to the major role of Cu as cofactor in haematogenesis (29) and being the most critical trace elements in livestock enhancing haemoglobin formation, iron absorption from GI-tract and iron mobilization from tissue stores (30). High concentration of haemoglobin in the cytoplasm of red blood cell gives an indication of effective oxygen carrying capacity of the blood. The result obtained in this study corroborated the findings of previous researchers (29; 30). This present study concurred with the studies conducted by (31) who reported that supplementing turkey's diet with Cu lysine chelate has a significant effect on the level of hematological indices.

The dressed yield of broiler chicken measured at the end of the feeding trial in this study were not influenced by copper methionine (Cu-M) supplementation. These results confirmed the findings of the previous researchers (32; 22; 25) who reported that addition of Cu had no significant influence on carcass yields.

Conclusion and Application

The result of the present finding indicates that;

- i. Dietary Cu-M supplementation up to 30ppm is beneficial to improve the growth performance in terms of feed intake and feed conversion ratio
- ii. Dietary Cu-M supplementation up to 30ppm influenced the haemoglobin concentration of the broiler chicken
- iii. Dietary Cu-M supplementation had no effect on the serum biochemical indices and carcass weights of the broiler chicken

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