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Effect of Organic Zinc and Manganese on Performance, Hepatic Tissue and Tibia Proximate Compositions of Finisher Broiler Chickens

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ABSTRACT

The effect of varying levels of organic zinc and manganese on performance, hepatic tissue and tibia proximate compositions of finisher broiler chickens were evaluated. A total of 360 heads of mix sexed day-old 'Anak' strain broiler chickens in which at 4 weeks of age were allotted to 9 dietary treatments in a 3×3 factorial experimental design arrangement involving three levels of zinc (0mg, 20 mg and 30 mg/kg diet) and three levels of manganese (0 mg, 20 mg and 30 mg/kg diet. Each treatment was replicated 5 times with 8 birds per replicate. Dietary treatments are as follows: T1: 0 mg of zinc and manganese kg-1 diet, T2: 20mg zinc and 0mg of manganese kg-1 diet, T3: 30mg zinc and 0g manganese kg-1, diet T4: 0 g zinc and 20 g of manganese kg-1 diet, T5: 20 mg zinc and 20 g of manganese kg-1 diet, T6: 30 mg zinc and 20 mg manganese kg-1 diet, T7: 0 mg zinc and 30 mg of manganese kg-1 diet, T8: 20 mg zinc and 30 mg of manganese kg-1 diet, T9: 30mg zinc and 30mg of manganese kg-1 diet. Results indicated that dietary levels of zinc and manganese had no significant ($p>0.05$) effect on initial body weight, average daily feed intake, while weight gain, average daily weight gain and feed conversion ratio were significant ($p<0.05$). while there were significant ($p<0.05$). Chemical analysis of the liver tissue showed that among all the parameters determined such as protein, zinc, manganese, moisture, ether extract ash and nitrogen free extract, only the moisture content and zinc values were significantly ($p < 0.05$) influenced by dietary treatments. Results of the proximate analysis of the right and left tibia showed only significant effect in the zinc content values among the treatments. In conclusion, the results of this present study suggest that the combination of organic zinc and manganese in the diet of broiler chickens up to 30 g/kg for improved growth performance.

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INTRODUCTION

According to Sleman et al. (2015), broiler production is one of the quickest ways to provide quality farm animal protein for human consumption. The most affordable source of farm animal protein is poultry, which significantly contributing to rising demand for food products of animal origin around the world (Farrell, 2013). Poultry is one of the top industries for supplying high-quality sources of animal proteins for human consumption (FAO, 2010).

However, many synthetic feed additives, according to Hassan et al. (2018) have been used not only to increase feed efficiency in poultry but also to improve the performance and health of birds. However, due to the growing issues with antibiotic resistance in birds and its residue in broiler meat, the European Union has banned the use of these goods (antibiotics) in the production of chicken (Carvalho and Santos, 2016). Food has been found to contain compounds that have negative consequences in humans as a result of using antibiotic growth promoters such as penicillin, tetracycline, macrolide, and amphenicol (Diarra and Malouin, 2014). When ingested, antibiotic residues in meat may lead to resistance in human beings according to Landers et al. (2012). Kummerer (2009) found that eating farm animal meat contaminated with tetracycline residue had an impact on young children's tooth development. This is also true of beta-agonists like clenbuterol, which can result in tachycardia, food poisoning, muscle tremors, and palpitations (Brambilla et al., 2000; Hoffman et al., 2001). But in contemporary animal husbandry, the limitation on antibiotic use in animal diets due to its detrimental long-term effects on both animal and human health has prompted scientists to continuously hunt for safe substitute molecules for antibiotics. Several dietary supplements that aren't synthetic antibiotics and have been used as growth promoters in farm animals include: probiotics, prebiotics, organic acids, immunostimulants, amino acids, enzymes, and phytogenic feed additives (Mashayekhi et al., 2018; Abouelezz et al., 2019).

Furthermore, minerals have also been used as non-synthesized-antibiotic to boost performance in poultry nutrition. Some of minerals that have been used to boost performance in farm animals include zinc and manganese. Poultry requires minerals like zinc and manganese for some functions such as skeletal development and maintenance, synthesis of protein, oxygen transport, and activators or components of the enzyme system. Zinc and Manganese are significant in farm animal production especially in broiler in the sense that they enhance growth performance, immune responses and skeletal unassailability (Current Research in Poultry Science, 2013).

Biology Trace Element Research (2004) in poultry observed that zinc aids not only as a nutrient but can likewise be a dietary supplement to manipulate the reproductive system of birds. Zinc is a vital trace mineral in poultry and thus, contributes to skeletal development (Tomaszewska et al., 2017), and improves growth performance (Liu et al., 2011) and immune function in broiler birds (Kidd et al.,1996). However, the NRC (1994) endorses 40 mg/kg zinc for broilers from 1 to 42 d of age. Feed consumption, efficiency and weight gain responded positively to varying levels of zinc supplementation up to 20 mg/kg (Batal et al., 2001). Huang et al. (2007) discovered that feed intake and weight gain of broiler chickens were significantly enhanced with dietary zinc supplementation. Rossi et al. (2007) findings revealed that carcass yield and body weight gains were not significantly influenced by the increasing inclusion levels of organic zinc in the diet of broiler chickens. Some researchers have included zinc in organic form (Yu et al., 2005) and inorganic form (Edwards and Baker, 2000) in the diet of broiler chickens and observed enhanced growth performance. Manganese is a mineral needed for usual skeletal enlargement and reproduction. Manganese is an important nutrient in poultry nutrition required for normal bone building, brain and muscle function. Manganese stimulates the enzyme accountable for the making of urea, the product of protein degradation waste. In the metabolism of carbohydrate, manganese is essential and also in the gluconeogenic process, that is glucose production from non-carbohydrate sources. Manganese is associated with the function of numerous organ systems. According to Dominguez (2013), manganese is essential for the regulation of blood sugar, digestion, reproduction, normal immunological function, cellular energy production, bone formation, and the body's defense against free radicals. Atypical glucose tolerance, faults in carbohydrate and lipid metabolism, growth issues, impaired bone formation, and skeletal flaws are all consequences of inadequate dietary manganese intake (Freeland-Graves et al., 2016). Since the search for alternative compounds has been the chief focus of scientists, it is therefore, the present study was conducted to determine the effect of varying levels of organic zinc and manganese on finisher broiler chickens.

MATERIAL and METHODS

Ethical consideration

This study was carried out in conformity with the guidelines set forth by the University of Nigeria, Nsukka's Ethical Committee on the Use of Humans and Animals in Biomedical Research (No: MUC271SOYE01.05.02.2021).

Study site

The study was conducted at the University of Nigeria, Nsukka's Department of Animal Science Teaching and Experimental Farm Poultry Unit. Nsukka lies within longitude 6˚ 45′E and 7˚ E and latitude 7˚ 12.5 ′N and at an altitude of 447m above sea level. The climate of the study area is typically tropical with relative humidity ranging from 65 to 80% and a mean daily temperature of 26.8 ˚C (Okonkwo and Akubuo, 2007). Rainfall varies from 1567.05mm to 1846.98mm every year (Metrological Center, Crop Science Department, University of Nigeria, Nsukka Enugu State). The experiment lasted for 4 weeks.

Characteristics of zinc and manganese

The tested organic zinc and manganese were purchased from Virginia chemical stores located at Ogige Market Nsukka Enugu State, Nigeria *Organic zinc is a* compound comprising carbon-zinc chemical bonds, while, manganese is a trace mineral. *Organic mineral sources were* Bioplex® Zn and Mintrex® Mn. Bioplex® Zn is a Zn-Protenate (Bioplex® Zn, Autech Inc. Nicholasville, KY, USA) and Mintrex® Mn used is a Mn. Methionine hydroxy analogue chelate (Mintrex® Mn Novus Inc, St Charles, MO USA). celestine

Experimental birds and management

360 heads of mixed sexed day-old 'Anak' broiler strain chickens were used. Immediately at the age of 4 weeks, the additives (zinc and manganese) were introduced. The birds were divided into 9 dietary treatments using a 3×3 factorial experimental design arrangement. Treatments included three levels of zinc (0 mg, 20 mg, and 30 mg/kg diet) and three levels of manganese (0 mg, 20 mg, and 30 mg/kg of broiler finisher diet). There were 5 replicates of each treatment, each including 8 birds. The brooding house was well cleaned with a powerful disinfectant prior to the arrival of the birds from the hatchery, and then wood shavings were scattered throughout. A charcoal pot was used to pre-heat the brooding pens a few hours before the birds arrived. Additionally, feeding troughs and drinks were bought, cleaned, and placed in ideal locations. The following routine vaccinations and universal flock prophylactic administration were administered: day one: Intra ocular (new castle disease vaccine), week two: Gumboro disease vaccine, week three: Lasota (New Castle disease vaccine), week four: Gumboro disease vaccine, week five: fowl pox vaccine, from week 6-8, Lasota vaccine was repeated because of its dominance new castle disease in the farm. A stress pack was administered to the birds via drinking water at 100 g/50 liters according to manufacturer's recommendation in order to boost appetite and supply of energy. Throughout the duration of the

experiments, feed and fresh water were freely available. A thermometer was used to measure the room's temperature, and a 200-watt bulb was used to provide lighting.

Experimental diets

The 4-week feeding study was conducted after 4 weeks of brooding. The experimental diet's composition and its approximate components are shown in Table 1 and were formulated to satisfy the dietary nutritional needs of the birds (NRC, 1994). The Association of Official Agricultural Chemists' methodologies were used to analyze the chemical (proximate) components of the experimental meals (AOAC, 2012).

Table 1. Ingredients (%) and chemical composition (g/kg DM) of experimental diets

Ingredients (%)	Diet Starter	Diet Finisher
Maize	45.00	48.00
Wheat offal	10.00	11.00
Soybean meal	20.00	14.25
Groundnut cake	10.00	10.00
Palm kernel cake	7.25	10.00
Fish meal	2.00	1.00
Bone meal	3.00	3.00
Palm oil	2.00	2.00
Vitamin premix	0.25	0.25
Methionine	0.25	0.25
Lysine	0.25	0.25
Total	100	100
Calculated composition (%)		
Crude protein (%)	22.75	19.87
Energy (Mcal/KgME)	2870.00	3000
Crude fibre (%)	4.75	5.07
Crude fat (%)	4.28	4.87
Proximate compositions (%)		
Crude matter	90.30	91.11
Crude fibre	4.81	5.21
Crude protein	23.00	20.09
Moisture	9.70	8.89
Crude fat	4.21	4.87
Crude ash	8.90	8.00
Nitrogen Free Extract	49.38	52.94

T1: 0g of zinc and manganese kg-1 diet, T2: 20mg zinc and 0mg of manganese kg-1 diet, T3: 30mg zinc and 0mg manganese kg-1 diet,T4: 0mg zinc and 20mg of manganese kg-1 diet,T5: 20mg zinc and 20mg of manganese kg-1 diet,T6: 30mg zinc and 20mg manganese kg-1 diet,T7: 0mg zinc and 30mg of manganese kg-1 diet,T8: 20mg zinc and 30mg of manganese kg-1 diet,T9: 30mg zinc and 30mg of manganese kg-1 diet. *Each 2.kg of vitamin premix contains: vitamin A: 1000000 IU; vitamin D3: 2,200.000 mg; vitamin B1: 1500mg; vitamin B2: 5000mg; vitamin K3:2000mg, vitamin B12: 10mg; vitamin B6:1500mg, vitamin E: 10000mg; Biotin: 20mg; Niacin: 15,000mg, Folic acid: 500mg and 5000mg calpan.

DATA COLLECTION

Growth performance parameters

At the start of the study, live body weights of birds were taken and also were taken weekly using a precision weighing balance with a capacity of 10.1 kg (models A and D), a Chinese-made industrial balance. From the first day of the trial until the last, feed intake was calculated. Weighing the feed before giving it to the birds allowed us to determine how much was consumed. Then, in order to calculate the daily feed intake per bird for each replicate, the difference between the feed that was delivered the day before and the leftover feed in the feeding trough the following morning was divided by the number of birds in each replicate. The feed conversion ratio was estimated by dividing the bird's feed consumption by their body weight gain. The average daily feed intake was calculated by dividing the number of days the feeding trial lasted. By dividing the weight gained by the birds by the number of days the feeding trial lasted, the average daily weight gain was calculated.

Left, right and hepatic tissue analysis

After the end of the 4 weeks feeding trial, two birds each from each replicate were killed in conformity with the guidelines set forth by the University of Nigeria, Nsukka's Ethical Committee on the use of Humans and Animals in Biomedical Research, their left and right tibia and liver were removed, oven dried, ground to fine particles and was used to determine their proximate compositions using (AOAC,

2012) methods to ascertain their chemical compositions. Zinc and manganese concentrations in the liver were measured by Gajula et al. (2011).

Statistical design and analysis

In this experiment, data collected was analyzed using the PROC GLM procedure (SAS 1999) in accordance with a 3 x 3 factorial arrangement of treatment in a completely randomized design (CRD) with the linear model as outlined by Steel and Torrie (1960).

The statistical model used to test the effects of treatments on the growth performance of the starter, finisher broilers in this present study and the results of the proximate analysis of the left, right and hepatic tissue was:

$$X_{ijk} = \mu + P_i + E_j + (PE)_{ij} + e_{ijk}$$

X_{ijk} = Overall observation of the effects of treatments on each individual.

μ = Population mean

P_i = Effect of zinc (Z) on the ith group of individuals.

E_j = Effect of manganese (M) on the jth group of individuals.

$(TI)_{ijk}$ = Individual effect between zinc and manganese of the ith and jth group of individuals.

e_{ijk} = Random error.

Significant differences in means were separated using the Duncan's procedure in the same statistical package.

RESULTS

Table 2 and Figure 1-4 show the results of the effect of organic zinc and manganese on the performance of finisher broiler chickens. Initial body weight and average daily feed intake values among the treatments were not significant ($P<0.05$), while body weight gain values and average daily weight gain and feed conversion ratio values among the treatments were significant (p<0.05). Body weight gain of T1, T2, T3, and T4 were the same (P>0.05), but lower than the values of 1600, 1715, 1590 and 1860 observed for T5, T6, T7, T8 and T9 birds respectively. The average daily weight gain values of birds among the treatments followed the same trend as observed for body weight gain. Feed conversion ratio values of T1, T2, T3, T4, T5, T6 and T7 were the same (p>0.05), but significantly lower than the values observed for birds on T8 and T9.

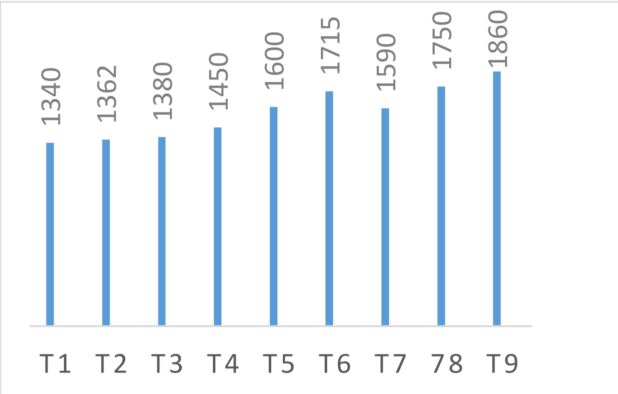

Figure 1. Body weight gain of finisher broilers fed organic zinc and manganese from 5-8weeks of age

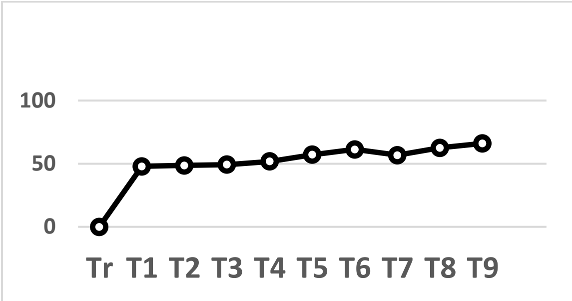

Figure 2. Average daily weight gain of finisher broilers fed organic zinc and manganese from 5-8weeks of age

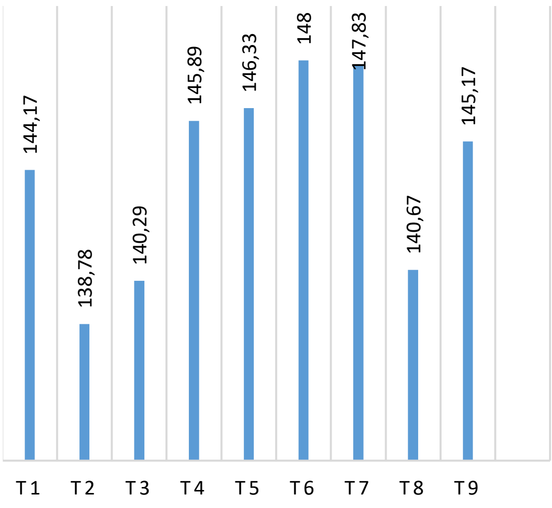

Figure 3. Average daily feed intake of finisher broilers fed organic zinc and manganese from 5-8weeks of age

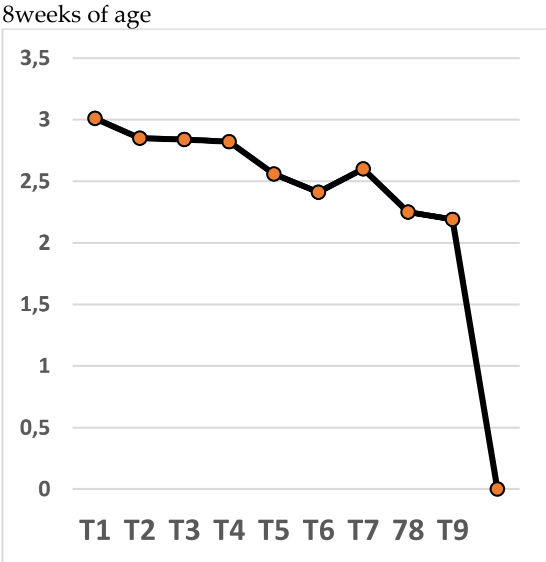

Figure 4. Feed conversion ratio intake of finisher broilers fed organic zinc and manganese from 5-8weeks of age

Table 2. Effect of organic zinc and manganese on the performance of broiler finishers from 5-8 weeks of age

Parameters	T1	T2	T3	T4	T5	T6	T7	T8	T9	SEM	P-values
IBW (g/bird)	1676.00	1680.00	1700.00	1742.00	1793.00	1685.00	1767.00	1687.00	1696.00	38.00	0.07
BWG (g/bird)	1340.00c	1362.00c	1380.00c	1450.00c	1600.00b	1715.00ab	1590.00b	1750.00a	1860.00a	63.00	0.04
ADWG(g/bird)	47.85c	48.64c	49.28c	51.78c	57.14b	61.25a	56.78b	62.50a	66.07a	2.19	0.02
ADFI (g/bird)	144.17	138.78	140.29	145.89	146.33	148.00	147.83	140.67	145.17	6.45	0.73
FCR (g/g)	3.01a	2.85a	2.84a	2.82a	2.56a	2.41ab	2.60a	2.25b	2.19b	0.28	0.03

[a-c] Means with different superscripts in a row are significantly (p<0.05) different , T1: 0mg of zinc and manganese kg-1 diet,T2: 20mg zinc and 0mg of manganese kg-1 diet, T3: 30mg zinc and 0g manganese kg-1 diet,T4: 0mg zinc and 20mg of manganese kg-1 diet,T5: 20mg zinc and 20mg of manganese kg-1 diet,T6: 30mg zinc and 20mg manganese kg-1 diet,T7: 0mg zinc and 30mg of manganese kg-1 diet,T8: 20mg zinc and 30mg of manganese kg-1 diet, Treatment 9: 3m0g zinc and 30mg of manganese kg-1 diet, IBW=initial body weight, BWG=Body weight gain, ADWG=Average weight gain, ADFI=Average daily feed intake, FCR=Feed conversion ration

The results of the effect of organic zinc and manganese on the proximate analysis of mineral concentration in the hepatic tissue (liver) of broiler finisher chickens are presented in Table 3 and Figure 5-8. Protein, ether extract, manganese, ash and nitrogen free extract values among the treatment were not significant (P>0.05). Moisture values of T1 and T2 were the lowest, followed by T4, T9 (p>0.05), T5, T6, T7 (P>0.05) and T9. Zinc hepatic values of T1 were lower than the values recorded in T2-T9.

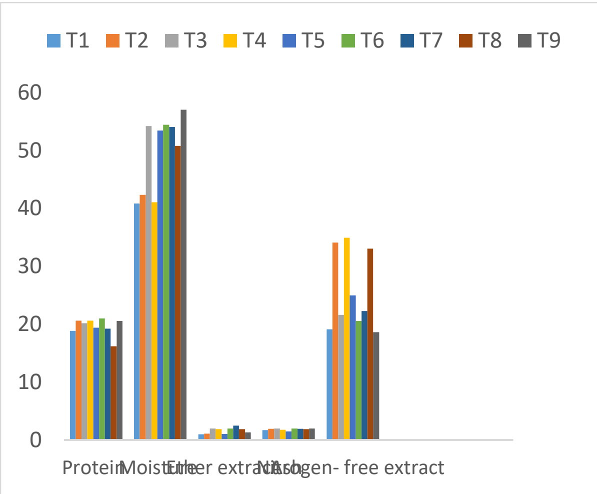

Figure 5. Effect of organic zinc and manganese on proximate compositions of mineral concentration in the Hepatic Tissue (Liver) of broiler finisher chickens from 5-8weeks of age

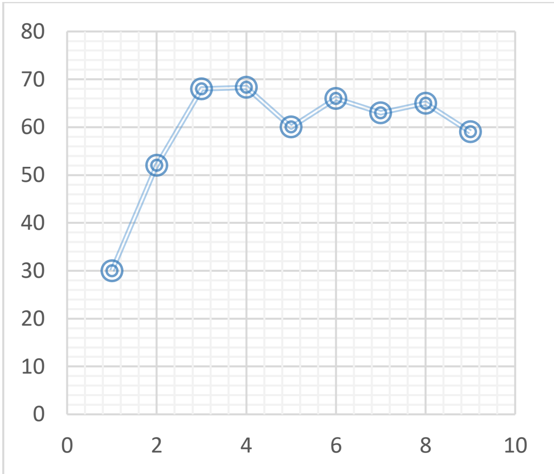

Figure 6. Effect of organic zinc and manganese on mineral (zinc) concentration in the Hepatic Tissue (Liver) of broiler finisher chickens from 5-8weeks of age

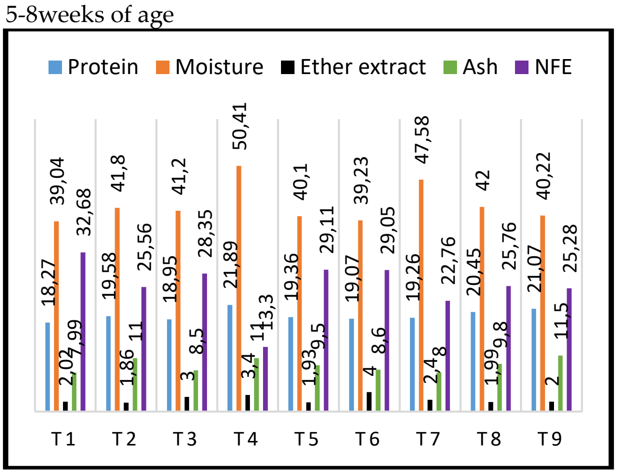

Figure 6. Effect of organic zinc and manganese on proximate compositions of the right tibia in finisher broiler chickens from 5-8 weeks of age

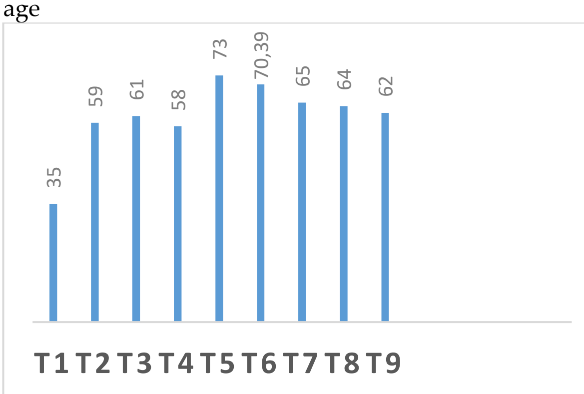

Figure 7. Effect of organic zinc and manganese on zinc concentration in right tibia of broiler chickens from 5-8 weeks of age

Table 3. Effect of organic zinc and manganese on proximate compositions and mineral concentration of the Hepatic Tissue (Liver) of broiler finisher chickens from 5-8weeks of age

Parameters/	T1	T2	T3	T4	T5	T6	T7	T8	T9	SEM	P-values
Protein (%)	18.83	20.58	20.18	20.58	19.39	21.02	19.25	16.20	20.53	2.87	0.97
Moisture (%)	40.86d	42.30d	54.20b	41.08c	53.45b	54.44b	54.06b	50.76c	57.00a	1.23	0.02
Ether extract (%)	1.00	1.10	2.00	1.90	1.05	2.00	2.50	1.87	1.30	0.90	1.21
Ash (%)	1.69	1.93	2.00	1.78	1.50	2.00	1.95	1.88	2.00	0.86	0.08
Nitrogen- free extract (%)	19.11	34.09	21.62	34.93	24.98	20.54	22.24	33.03	18.64	9.34	0.76
Zinc (mg)	30.00f	52.00e	68.00a	68.30a	60.00d	66.00b	63.00c	65.00b	59.00d	0.90	0.03
Manganese (mg/100g)	0.02	0.05	0.04	0.06	0.05	0.04	0.06	0.04	0.06	0.07	0.09

[a--- f] Means with different superscripts in a row are significantly ($p<0.05$) different T1: 0mg of zinc and manganese kg-1 diet,T2: 20mg zinc and 0mg of manganese kg-1 diet, T3: 30mg zinc and 0g manganese kg-1 diet,T4: 0mg zinc and 20mg of manganese kg-1 diet,T5: 20mg zinc and 20mg of manganese kg-1 diet,T6: 30mg zinc and 20mg manganese kg-1 diet,T7: 0mg zinc and 30mg of manganese kg-1 diet,T8: 20mg zinc and 30mg of manganese kg-1 diet, Treatment 9: 30mg zinc and 30mg of manganese kg-1 diet.

The results of the effect of organic zinc and manganese on proximate compositions of the right tibia in finisher broiler chickens are shown in Table 4. Protein, ash and nitrogen free extract and manganese values among the treatments were not significant (P>0.05), while moisture and ether extract values were significant (p<0.05). Moisture values of T1, T2, T 3, T5, T6, T8 and the T9 were the same (p>0.05), but lower than values of 47.58 and 50.41 recorded in T4 and T7 respectively. Ether extract values of T1, T2, T5T7, T8 and T9 were the same (p>0.05), but lower than 3.00 and 3.40 recorded in T6 and T3 respectively. Zinc values were higher in the treatment group compared to the control group.

Table 5 and Figure 8 show the results of the effect of varying dietary levels of organic zinc and manganese on proximate compositions of the left tibia of finisher broiler chickens. Protein, ash, zinc, manganese, nitrogen free extract and moisture values among the treatments were not significant(P>0.05), while ether extract values were significant (p>0.05).

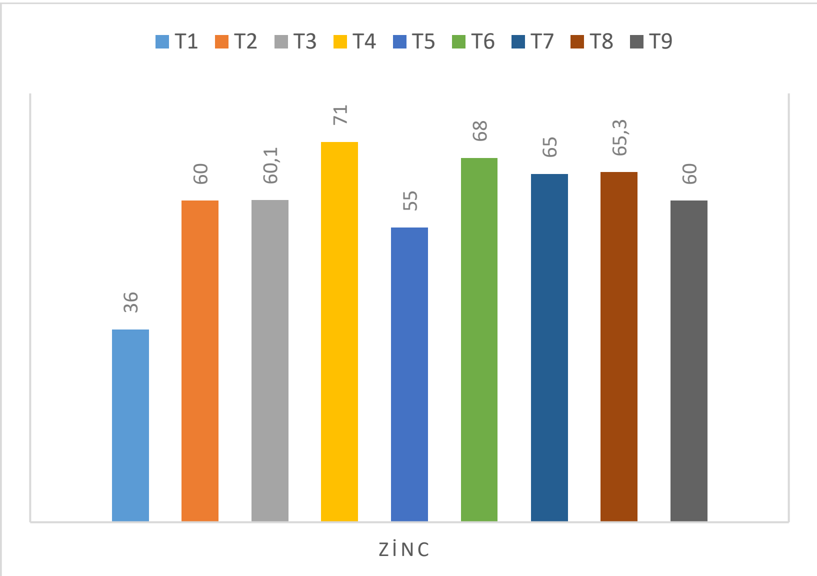

Figure 8. Zinc concentration in the left tibia of finisher broiler chickens fed dietary levels of organic zinc and manganese from 5-8 weeks of age

Table 4. Effect of varying levels of organic zinc and manganese on proximate and mineral concentration of the right tibia in finisher broiler chickens from 5-8 weeks of age

Parameters	T1	T2	T3	T4	T5	T6	T7	T8	T9	SEM	P-values
Protein (%)	18.27	19.58	18.95	21.89	19.36	19.07	19.26	20.45	21.07	4.87	1.32
Moisture (%)	39.04b	41.80b	41.20b	50.41a	40.10b	39.23b	47.58a	42.00b	40.22b	2.00	0.02
Ether extract (%)	2.02	1.86	3.00	3.40	1.93	4.00	2.40	1.99	2.00	1.80	0.67
Ash (%)	7.99	11.00	8.50	11.00	9.50	8.60	8.00	9.80	11.50	3.76	0.08
NFE (%)	32.68	25.56	28.35	13.30	29.11	29.05	22.76	25.76	25.28	12.87	1.23
Zinc (mg)	35.00c	59.00b	61.00b	58.00bc	73.00a	70.39a	65.00b	64.00b	62.0b	2.50	0.02
Manganese (mg/100g)	0.02	0.03	0.04	0.03	0.04	0.04	0.05	0.05	0.06	0.05	0.06

[a, b, c] Means with different superscripts in a row are significantly ($p<0.05$) different, NFE=Nitrogen free extract. T1: 0mg of zinc and manganese kg-1 diet,T2: 20mg zinc and 0mg of manganese kg-1 diet, T3: 30mg zinc and 0g manganese kg-1 diet,T4: 0mg zinc and 20g of manganese kg-1 diet,T5: 20mg zinc and 20mg of manganese kg-1 diet,T6: 30mg zinc and 20mg manganese kg-1 diet,T7: 0mg zinc and 30mg of manganese kg-1 diet,T8: 20mg zinc and 30g of manganese kg-1 diet, Treatment 9: 30mg zinc and 30mg of manganese kg-1 diet.

Table 5. Effect of organic zinc and manganese on proximate and mineral concentration of the left tibia of broiler finisher chickens

Parameters	T1	T2	T3	T4	T5	T6	T7	T8	T9	SEM	P-values
Protein (%)	17.19	20.58	19.26	18.32	21.39	18.39	19.57	20.5	21.26	3.78	0.98
Moisture (%)	41.35	40.44	45.03	40.90	39.00	39.80	43.04	41.23	39.94	5.65	0.79
Ether extract (%)	1.30	1.86	2.00	1.50	2.50	3.00	1.20	1.40	3.20	1.6	0.54
Ash (%)	8.98	11.00	8.40	11.20	9.50	8.30	7.66	9.86	11.00	3.34	0.49
NFE (%)	31.18	26.12	28.08	28.08	27.61	29.27	28.53	27.04	24.54	6.23	0.85
Zinc (mg)	36.00e	60.00c	60.10c	71.00a	55.00d	68.00a	65.00b	65.30b	60.00c	2.00	0.03
Manganese(mg/100g)	0.02	0.05	0.02	0.05	0.05	0.02	0.05	0.04	0.04	0.04	0.85

[a, b, c ,d] Means with different superscripts in a row are significantly ($p<0.05$)different, NFE=Nitrogen free extract. T1: 0mg of zinc and manganese kg-1 diet,T2: 20mg zinc and 0g of manganese kg-1 diet, T3: 30mg zinc and 0mg manganese kg-1 diet,T4: 0mg zinc and 20mg of manganese kg-1 diet,T5: 20mg zinc and 20mg of manganese kg-1 diet,T6: 30mg zinc and 20mg manganese kg-1 diet,T7: 0mg zinc and 30mg of manganese kg-1 diet,T8: 20mg zinc and 30mg of manganese kg-1 diet, Treatment 9: 30mg zinc and 30mg of manganese kg-1 diet.

DISCUSSION

The effect of organic zinc and manganese on the performance of broiler finishers from 5-8 weeks of age is presented in Table 2. Increased production performance of broilers characteristics, such as body weight gain, average daily weight gain, and feed conversion ratio, when compared to control (Table 2) may be linked to Zinc and manganese dietary supplementation. An earlier study revealed that the main trace mineral involved in the metabolism of proteins, lipids, and carbohydrates is zinc (Sahin, 2003). As an enzyme cofactor, zinc helps in the metabolism of nutrients so they may be used more effectively for better growth outcomes. Zinc and manganese, two organic trace minerals employed in this study may have function as catalysts in a number of hormone and enzyme systems (Suttle, 2010) and, thus, enhancing growth performance. Additionally, more than 300 enzymes that take part in the metabolism of several nutrients such as carbohydrates, proteins, and nucleic acids (Abd El-Hack et al., 2017, 2018) depend heavily on zinc. Broilers specifically use the zinc they consume to promote the metabolic functions that enable the growth performance of birds. Since zinc and manganese are essential for nutrient metabolism, birds on zinc and manganese supplements performing better in terms of weight gain when compared to control birds may be due to improved feed digestion, absorption, and nutrient utilization as well as improved protection from the harmful effects of free radicals. Zinc intake has been shown to positively affect broiler growth by Batal et al. (2001). Some researchers have found improved growth in broiler chickens when added zinc to their meals in both organic and inorganic forms (Yu et al., 2005; Edwards and Baker, 2000). Huang et al. (2007) observed that weight gain and feed intake of broiler chickens considerably enhanced with the dietary inclusion of zinc. The same authors observed improved feed consumption and weight gain in the birds with zinc supplementation up to 20 mg/kg.

Ostensibly, owing to the tall ambient temperature and relative humidity occurring in the tropical regions, zinc as anti-oxidant can aid in reducing the negative effect of free radical on growth in birds. It had been reported that the inclusion of zinc in the diet of broiler chickens reared under heat stress enhanced the performance and decreased the feed conversion ratio (Kucuk et al., 2003, Sahin, 2003). This shows that zinc addition may be more important for broiler production in the tropics in order to minimize the negative impacts related to such high temperature conditions and thus, increase performance. Dominguez (2013) affirmed that manganese is central for the regulation of sugar in the blood, digestion, reproduction, normal immune function, cellular energy production, growth of bone, and it supports the defense mechanism against free radicals, especially in the humid tropics. Research findings have shown that organic trace mineral supports improvement in the growth of broiler chickens due to their inherent high bioavailability. Improved weight gain recorded in this present study is in agreement with Gheisari et al. (2010) who reported that body weight gain and feed conversion ratio were enhanced by supplementing broilers diet with organic Zinc and Manganese. The increased weight gain observed in this present study also agrees with the work of Burrell et al. (2004) who added varying levels of zinc to the basal diet of broiler chickens and observed significant increase in weight gain in favor of the treatment groups. Furthermore, the present results are not in tandem with the earlier reports of (Sunder et al., 2006; Huang et al., 2007, Sunder et al., 2013, Vieira et al., 2013). Perhaps the form of minerals used in the present study might have contributed to the observed contradictions. Furthermore, it may have been due to the concentration of trace minerals, environmental variation, growth phase and strain of birds used by both authors.

Reduced weight gain recorded in the control group compared to the treatment group could be the result of insufficient dietary consumption of manganese and zinc. Trace minerals are vital to animals for improved growth and production (Richards et al., 2010). It is well documented in the literature that insufficient dietary manganese results to growth problems, decreased bone growth and skeletal imperfections, reduced fertility and birth alterations, atypical glucose tolerance, and defects in carbohydrate and lipid metabolism (Freeland-Graves et al., 2016). The average daily feed intake among the treatment in this present study was not significant. This agrees with Baloch et al. (2017) who stated that organic trace mineral supplementation did not significantly affect the feed intake of broiler birds. Sunder et al. (2013) also found that feed intake was not significantly affected by feeding organic trace minerals which also agrees with the results of this present study. The lack of significant differences observed in this work with regard to feed intake could be that the levels of zinc and manganese used may not have been enough to either increase or decrease feed intake in broilers.

The effect of organic zinc and manganese on mineral concentration of the Hepatic Tissue (Liver), left and right tibia of broiler finisher chickens are shown in Table 3 and 4. Mineral concentrations in tissues serve as markers for body storage. The body carefully maintains mineral homeostasis, which is mostly accomplished by tissue storage and excretion (Suttle, 2010). The concentration of trace minerals in animal liver, tibia and other tissues is commonly used as the main index to evaluate the biological efficiency of trace minerals in food (Martin et al., 2011). Organic trace minerals are stable and not ionized prior to absorption, after entering the digestive tract, they can avoid the precipitation or adsorption by precipitants in the intestinal cavity. According to Ao et al. (2009) dietary level and source of trace minerals significantly affected bone mineral concentration. The increased bioavailability of zinc and manganese in T1-T9 may be due to the availability and improved absorption compared to T1. Bao et al. (2007) reported that tibia Zinc concentrations were strongly related to the dietary organic zinc intake. Bones have been established as a functional reserve of zinc in broiler chickens, which can be used during zinc deficiency (Suttle, 2010). However, though manganese concentration in hepatic tissue and tibia were not significant, but significant increase in zinc values observed for the birds on T2-T6 that got one or both of the trace mineral used in this present study compared to control is supported by the literature documentation that organic trace minerals are environment-friendly because of their lower excretion rate, longer time remaining in the gut and consequently improving the growth performance (Leeson and Caston, 2008). They are highly bioavailable because they have higher retention rate in the body compared with inorganic minerals (Nollet et al., 2007). Non-significant results recorded with regards to the ash values among the treatments in the hepatic and tibia disagrees agrees with Vieira et al. (2013) who reported that the tibia ash concentration was significantly decreased when chicks were fed a diet without supplemental zinc. Furthermore, significant increases in zinc concentration both in the liver and tibia were in tandems with Sunder et al. (2008) who reported a linear rise in the liver zinc deposition from broiler chicks fed a diet supplemented with graded levels of zinc sulfate. Also, in this present study, the significant increase in zinc in broiler fed zinc supplemental diet in hepatic tissue disagree with Sunder et al. (2013) who reported that the zinc retention in the hepatic tissue increased significantly when broilers were fed zinc supplemental diet and also disagrees with the same authors who stated that manganese retention in the hepatic tissues in broiler chicks increased significantly when fed 160 and 240 mg manganese/kg diet, respectively. These researchers concluded that higher dietary zinc and manganese supplementation were required for a significant increase in mineral concentration in the hepatic tissue in birds and bones (Table 5).

CONCLUSION

In this present study, it was concluded that zinc and manganese supplementation significantly improved the broiler's performance. Based on the outcome of this study, it was recommended that organic zinc and manganese supplementation at 30mg zinc and 20mg manganese kg-1 diet (T6) should be used by broiler producers for improving performance and in order to exploit the genetic potential of broiler chickens.

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Conflict of interest satement

The authors declare no competing interest.

Authors' Contributions

Ezenwosu Celestine contributed to the collection of the data during the experiment and preparation of the first draft and sending of the paper. Osita C.O analyzed the data and also involved in the first draft preparation. Professor A.O Ani read and edited the entire manuscript. J.C. Ogbu helped in the collection of data and feeding of the experimental birds.

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