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EFFECT OF DIETARY SUPPLEMENTATION OF ORGANIC ZINC AND MANGANESE ON THE PRODUCTION PERFORMANCE OF PULLETS

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SUMMARY

An experiment was conducted to evaluate the effect of dietary inclusion of organic zinc and manganese on growing White Leghorn pullet's performance. One hundred-day old birds of White leghorn strain were randomly divided into two treatment groups with 5 replicates of 10 birds in each following completely randomized design (CRD). The experimental birds in treatment group T1 were fed basal diet supplemented with in organic salts of Zn and Mn while the birds in treatment T2 were fed basal diet supplemented with 100% organic salts of Zn and Mn. Basal diet was formulated as per BIS (2007) to meet energy and protein requirement. The experiment was conducted for a period of 18weeks till the laying phase started. Body weight and feed intake data were taken fortnightly and feed conversion ratio was calculated. A metabolic trial for duration of five days was conducted at the end of the experiment for evaluation of metabolizability of different nutrients. For this one bird per replicate was selected. For serum mineral profiling especially for Zn and Mn, blood samples were also collected at the end of the trail and further analyzed on Atomic Absorption Spectrophotometer by following the standard protocol.

Keywords: Organic zinc, organic manganese, pullets, performance

Trace minerals play a crucial role in poultry nutrition, contributing significantly to growth, metabolic activities, immune competence, skeletal development, and reproductive performance. Among these minerals, zinc (Zn) and manganese (Mn) are essential micronutrients involved in numerous physiological and biochemical functions. Zinc acts as a cofactor for various enzymes associated with protein synthesis, cell division, antioxidant defense, and immune responses, whereas manganese is indispensable for bone formation, carbohydrate metabolism, and reproductive efficiency. Adequate supplementation of these trace minerals is therefore necessary to achieve optimal growth and productive performance in poultry.

Traditionally, poultry diets have been supplemented with inorganic mineral sources such as sulfates, oxides, and carbonates. However, the bioavailability of inorganic trace minerals is often limited due to interactions with dietary constituents, resulting in lower absorption and increased mineral excretion into the environment. In recent years, organic trace minerals, in which minerals are complexed or chelated with organic ligands, have gained considerable attention as an alternative source because of their higher bioavailability, improved absorption, and better retention in the body. The use of organic mineral sources has been reported to enhance growth performance, nutrient utilization, mineral status, immune function, and environmental sustainability by reducing mineral losses in excreta.

Growing pullets require balanced nutrition to attain optimum body weight and physiological development before the onset of lay. The pre-laying phase is particularly critical, as inadequate nutrition during this period can adversely affect subsequent egg production and overall reproductive performance. Therefore, improving the efficiency of trace mineral utilization through the use of organic mineral sources may provide significant benefits during the growing period.

Although several studies have evaluated the effects of organic trace mineral supplementation in broilers and laying hens, information regarding the complete replacement of inorganic zinc and manganese with their organic counterparts in growing White Leghorn pullets remains limited. Furthermore, data concerning the influence of organic trace minerals on nutrient metabolizability and serum mineral status under practical feeding conditions are still inadequate.

Therefore, the present study was undertaken to evaluate the effects of dietary supplementation of organic zinc and manganese on growth performance, feed utilization, nutrient metabolizability, and serum mineral profile of growing White Leghorn pullets. The findings of this study are expected to provide valuable insights into the efficacy of organic trace mineral supplementation and its potential role in improving poultry production efficiency.

MATERIALS AND METHODS

The animal experiment was conducted in accordance with guidelines approved by the Institutional Animal Ethics Committee (IAEC), 1669/GO/ReBiBt-S/Re-L/12/CPCSEA06/12/2012 in the Department of Animal Nutrition, Lala Lajpat Rai University of Veterinary and Animal Sciences.

Birds, Experiment Design, and Management

One hundred-day old birds of White leghorn strain were randomly divided into two treatment groups with 5 replicates of 10 birds in each following completely randomized design (CRD). The experimental birds in treatment group T1 were fed basal diet supplemented with in organic salts of Zn and Mn while the birds in treatment T2 were fed basal diet supplemented with 100% organic salts of Zn and Mn. Basal diet was formulated as per BIS (2007) to meet energy and protein requirement. The experiment was conducted for a period of 18weeks till the laying phase started. The chemical composition and ingredient composition of different rations used during the experiment are depicted in Table 1, 2 and 3, respectively. Floor litter system was followed where the chicks were kept hygienically in separate pens. All the birds were reared adopting uniform management conditions. The chicks were brooded at 35^{o}C during the first week and thereafter the temperature was reduced by 3^{o}C every week until the temperature reached 25±1^{o}C. The birds were vaccinated against prevailing diseases adopting a standard protocol. Individual body weight of chicks was recorded at 0 day age and thereafter weekly.

Blood collection and Analysis

At the end of the feeding trial blood samples were collected from one pullet per replicate, making four samples per treatment and thus a total of 20 samples were analyzed. About 2 ml of blood was collected from each bird via brachial wing vein puncture using sterilized syringes and 5 ml scalp vein needle set into tubes containing EDTA (vacutainer) for blood analysis. Plasma was prepared by centrifuging the blood at 3000 rpm for 10 min. The plasma was then transferred into a microcentrifuge tube using a Pasteur pipette and stored at “20°C until further analysis.

Statistical Analysis

Data were analyzed by one-way ANOVA as a completely randomized design using the GLM procedure of SAS Institute. Differences among means were tested by the least significant difference method, and $P < 0.05$ was considered to be statistically significant group.

TABLE 1
Chemical composition (%DM basis) of different feed ingredients used in the experimental diets

Ingredients	DM%	CP%	EE%	CF%	Total Ash%
Maize	89.18	09.14	1.95	2.36	1.62
Wheat	89.43	12.50	2.60	2.12	1.89
Soyabean meal	89.63	47.74	1.30	6.72	5.92
Groundnut cake	89.48	43.85	8.14	6.62	7.15
Fish meal	89.25	49.38	2.17	1.32	17.03

RESULTS AND DISCUSSION

Growth performance is an important indicator for evaluating the efficacy of dietary mineral supplementation in poultry. The present study demonstrated that supplementation of organic zinc (Zn) and manganese (Mn) in place of their inorganic counterparts positively influenced the body weight of birds during the later stages of growth. The body weight of birds receiving inorganic forms of Zn and Mn ranged from 46.8 g/bird at the start of the experiment to 1753 g/bird at 18 weeks of age, whereas birds supplemented with organic forms of these trace minerals attained a higher final body weight, ranging from 47.0 g/bird to 1817 g/bird.

The results revealed no significant differences in body weight among the dietary treatment groups

TABLE 2
Ingredient composition of different rations

Ingredients (kg)	0-8wk		>08wk	
	T1	T2	T1	T2
Maize	54.30	54.30	60.00	60.00
Wheat	10.00	10.00	18.50	18.50
SBM	9.20	9.20	8.00	8.00
GNC	13.50	13.50	7.00	7.00
Fishmeal	7.00	7.00	2.50	2.50
Shellgrit	3.50	3.50	3.50	3.50
Salt	0.50	0.50	0.50	0.50
Feed additives*	0.783	0.783	0.783	0.783
Mineral mixture	2.00	2.00	2.00	2.00
Zinc sulphate	0.022	0.00	0.022	0.00
Zinc methionine	0.00	0.0494	0.00	0.0494
Manganese dioxide	0.013	0.00	0.013	0.00
Manganese methionine	0.00	0.0524	0.00	0.0524

*100 kg feed contained, Agemix; 500 g (each 5 kg agemix contained Vitamin A: 12.5 MIU; Vitamin D3: 2.5 MIU; Vitamin E:8.0 g; Vitamin K3: 1.0 g; Vitamin B1: 800 mg; Vitamin B2: 5.0 g; Vitamin B6: 1.6 g; Vitamin B12: 20.0 mg; Niacin: 12.0 g; Calcium d-Pantothenate: 8.0 g; Folic Acid: 800.0 mg; Biotin: 6.0 mg; Choline Chloride: 300.0 g; Calcium: 760.0 g; Copper: 15.0 g; Iodine: 1.0 g; Iron: 60.0 g; Manganese: 80.0 g; Zinc: 80.0 g and Selenium: 300.0 mg); Veldot (coccidiostat) 50 g; Choline chloride (60%): 50 g; Lysine (98%): 50 g; DL-methionine (98%): 100 g; Chlortetracycline: 33 g.

TABLE 3
Chemical composition (%DM basis) of different rations

Phases	DM%	CP%	EE%	CF%	Ash%
0-8weeks	89.88	20.09	2.12	5.16	4.67
>08weeks	89.75	16.12	1.98	5.48	4.84

up to 10 weeks of age. This suggests that the mineral reserves available to the birds during the early growth period and the relatively lower mineral requirements at younger ages may have masked the effects of different mineral sources. However, from 12 to 18 weeks of age, birds receiving 100% replacement of inorganic Zn and Mn with their organic forms exhibited significantly ($p < 0.05$) higher body weights compared to those fed inorganic minerals. The improved growth performance observed during the later growth phase may be attributed to the higher bioavailability and absorption efficiency of organic trace minerals. Organic minerals are known to be less susceptible to antagonistic interactions in the gastrointestinal tract, thereby enhancing their utilization and physiological functions.

Likewise, Khatun *et al*. (2019) reported improved growth performance and higher final body weights in broilers supplemented with organic trace minerals compared with those receiving inorganic mineral premixes. The authors attributed these improvements to enhanced mineral retention and nutrient utilization associated with organic mineral supplementation.

The results are further supported by findings of El-Husseiny *et al.* (2012), who observed positive effects of organic zinc, manganese, and copper supplementation on growth performance and mineral deposition in broilers. Recent studies have also demonstrated that organic forms of Zn and Mn improve growth indices and feed efficiency compared with inorganic sources. Supplementation of organic manganese has been shown to optimize body weight gain and feed conversion ratio at lower dietary concentrations than inorganic manganese, further confirming its higher bioavailability. Similarly, organic zinc supplementation improved body weight and average daily gain while requiring lower supplementation levels than inorganic zinc.

Therefore, the higher body weight observed in birds receiving complete replacement of inorganic Zn and Mn with organic forms in the present study corroborates previous research indicating that organic trace minerals enhance growth performance through improved absorption, retention, and metabolic utilization.

The findings of our research work revealed that supplementation of organic zinc (Zn) and manganese (Mn) in the mineral mixture positively influenced body weight gain in birds compared to supplementation with inorganic sources. During the initial growth period up to 12 weeks of age, no

TABLE 4
Mean values of Body weight (g/bird) during progressive age (weeks) under different dietary treatments

Age in weeks	0 day	2 wk	4 wk	6 wk	8 wk	10 wk	12 wk	14 wk	16 wk	18 wk
T_1 (Inorganic Zn+Mn)	46.8± 1.32	114.20± 2.37	276.60± 3.87	485.00± 4.18	711.60± 3.47	872.80± 2.42	1105.00± 5.00	1402.60± 2.36	1596.40± 5.19	1753.00± 1.79
T_2 (100% Organic Zn+ Mn)	47.0± 1.22	118.60± 1.94	285.20± 3.26	498.00± 2.21	713.60± 2.73	875.80± 2.75	1116.80± 3.12	1430.20± 1.28	1661.80± 2.60	1817.80± 1.02
p value	0.914	0.189	0.073	0.055	0.663	0.436	0.08	0.00	0.00	0.00

significant differences in body weight gain were observed between the treatment groups, indicating that both mineral sources were capable of supporting normal growth during the early developmental stages. However, significant differences emerged during the later growth phases, suggesting that the beneficial effects of organic trace minerals become more pronounced as birds mature and nutrient requirements increase.

The overall body weight gain was significantly higher in birds receiving organic Zn and Mn supplementation (1770 g/bird) compared with those receiving inorganic mineral sources. The improved growth performance observed in the organically supplemented group may be attributed to the higher bioavailability and absorption efficiency of organic trace minerals. Organic minerals are generally protected from antagonistic interactions within the gastrointestinal tract, resulting in enhanced mineral utilization and improved metabolic functions that support growth and development. Previous studies have reported similar findings, indicating that organic trace minerals improve body weight gain and feed efficiency due to their superior bioavailability compared with inorganic mineral salts.

Our current study work unveils that complete replacement of inorganic zinc (Zn) and manganese (Mn) with their organic forms in the mineral mixture did not significantly influence feed intake throughout the experimental period. The overall feed intake was comparable between the treatment groups, with birds in T1 and T2 consuming 6807 and 6822 g feed/bird, respectively. These findings suggest that the source of Zn and Mn had no adverse effect on feed palatability or voluntary feed consumption.

Similar observations have been reported in poultry studies where supplementation of organic trace minerals did not significantly alter feed intake compared with inorganic sources. Saber and Kutlu (2019) reported no significant differences in feed intake when inorganic trace minerals were partially or completely replaced with organic minerals in broiler breeder diets. Likewise, studies evaluating organic trace mineral supplementation in broilers observed comparable feed consumption among birds receiving organic and inorganic mineral sources.

Although feed intake remained unaffected, the feed conversion ratio (FCR) showed significant improvement during the later growth stages (12–14 and 14–16 weeks) in birds receiving organic Zn and Mn. The overall FCR was significantly better in T2 (3.85) compared with T1 (3.98), indicating more efficient utilization of feed when organic trace minerals were provided. The improved FCR observed in the present study may be attributed to the higher bioavailability and absorption efficiency of organic minerals. Organic trace minerals are less susceptible to antagonistic interactions within the gastrointestinal tract and are absorbed more efficiently, resulting in improved nutrient utilization and growth performance. Research has shown that organic Mn supplementation can optimize FCR at lower dietary inclusion levels compared with inorganic Mn sources due to superior bioavailability.

The significant improvement in overall FCR observed in the present study indicates that replacing inorganic Zn and Mn with their organic counterparts can enhance production efficiency without increasing feed consumption. This improvement may be associated with better mineral absorption, enhanced

TABLE 5

Mean values of Body weight gain (g/bird) during progressive age (weeks) under different dietary treatments

Age in weeks	0-2wk	2-4wk	4-6wk	6-8wk	8-10wk	10-12wk	12-14wk	14-16wk	16-18wk
T_1 (Inorganic Zn+Mn)	67.40± 1.08	162.40± 3.01	208.40± 3.39	226.60± 5.34	161.20± 3.02	232.20± 3.37	297.60± 3.47	193.80± 5.18	156.60± 4.81
T_2 (100% Organic Zn+ Mn)	71.60± 1.96	166.60± 2.48	212.80± 2.20	215.60± 3.20	162.20± 3.65	241.00± 2.10	313.40± 2.09	231.60± 3.01	156.00± 3.05
P value	0.098	0.287	0.778	0.115	0.838	0.057	0.005	0.00	0.919

TABLE 6

Mean values of Feed intake (g/bird) during progressive age (weeks) under different dietary treatments

Age in weeks	0-2wk	2-4wk	4-6wk	6-8wk	8-10wk	10-12wk	12-14wk	14-16wk	16-18wk	Overall
T_1 (Inorganic Zn+Mn)	243.40± 1.89	405.40± 5.31	527.84± 3.00	647.96± 2.29	794.08± 6.24	935.20± 3.62	1011.32± 4.93	1071.84± 4.40	1170.16± 4.63	6807.20± 6.42
T_2 (100% Organic Zn+ Mn)	249.80± 2.31	409.76± 3.63	540.68± 3.74	652.12± 3.66	783.72± 4.86	941.36± 6.27	1019.76± 7.59	1074.08± 5.80	1151.20± 1.62	6822.48± 18.14
P value	0.064	0.532	0.084	0.363	0.226	0.42	0.378	0.766	0.005	0.45

enzyme activity, improved metabolic functions, and more efficient utilization of nutrients. Therefore, supplementation of organic Zn and Mn appears to be a beneficial nutritional strategy for improving feed efficiency in growing birds while maintaining normal feed intake patterns.

The nutrient metabolizability data presented in Table 8 revealed that replacement of inorganic zinc (Zn) and manganese (Mn) with their organic forms in the mineral mixture had no significant effect on dry matter metabolizability. The mean dry matter metabolizability was 63.75% in the control group (T1) and 63.89% in the treatment group (T2). Similarly, no significant differences were observed in the metabolizability of most nutrients between the two dietary treatments. However, gross energy metabolizability was significantly ($P<0.05$) higher in birds receiving organic Zn and Mn supplementation (61.60%) compared to those fed inorganic mineral sources (61.13%).

The improvement in gross energy metabolizability observed in the organic mineral-supplemented group may be attributed to the greater bioavailability and absorption efficiency of organic trace minerals. Organic forms of Zn and Mn are less susceptible to antagonistic interactions in the gastrointestinal tract and therefore may enhance digestive enzyme activity and nutrient utilization. Zinc plays an important role in the activation of several enzymes involved in carbohydrate, protein, and lipid metabolism, while manganese functions as a cofactor for numerous metabolic enzymes. Enhanced availability of these minerals could contribute to improved energy utilization by the birds.

The findings of the present study are in agreement with those of Bao *et al.* (2007), who reported improved nutrient utilization and metabolizable energy values in broilers supplemented with organic trace minerals. Similarly, Nollet *et al.* (2007) observed that replacing inorganic trace minerals with organic sources improved nutrient digestibility and retention, which was attributed to their higher biological availability.

The serum concentration of zinc and manganese in broiler chickens as influenced by dietary supplementation of organic trace minerals is presented in Table 9. The results indicated that supplementation of zinc and manganese in organic form significantly increased their serum concentrations compared to the inorganic mineral sources. The serum zinc concentration was 0.46 mg/dl in T_1 (inorganic Zn and Mn) and 0.542 mg/dl in T_2 (organic Zn and Mn), while serum manganese concentration was also significantly higher in birds receiving organic manganese supplementation (3.79 µg/dl). The increased serum mineral concentrations observed in the T_2 group indicate superior absorption and bioavailability of organically complexed trace minerals.

The higher serum zinc concentration in birds fed organic zinc may be attributed to its greater stability in the gastrointestinal tract and reduced antagonistic interactions with other dietary components, leading to enhanced intestinal absorption. Similarly, organic manganese complexes are absorbed more efficiently than inorganic salts, resulting in higher circulating manganese levels.

Likewise, El-Husseiny *et al.* (2012) found significantly higher serum concentrations of zinc and

TABLE 7

Mean values of Feed Conversion Ratio at fortnightly interval under different dietary treatment groups

Age in weeks	0-2wk	2-4wk	4-6wk	6-8wk	8-10wk	10-12wk	12-14wk	14-16wk	16-18wk	Overall
T_1 (Inorganic Zn+Mn)	3.61± 0.06	2.50± 0.03	2.53± 0.03	2.86± 0.06	4.93± 0.06	4.03± 0.07	3.39± 0.03	5.54± 0.15	7.50± 0.24	3.98± 0.01
T_2 (100% Organic Zn+ Mn)	3.50± 0.09	2.46± 0.03	2.54± 0.02	3.03± 0.06	4.84± 0.08	3.90± 0.05	3.25± 0.03	4.64± 0.07	7.39± 0.14	3.85± 0.01
P value	0.294	0.364	0.702	0.097	0.398	0.171	0.016	0.001	0.7	0.00

TABLE 8

Mean values of nutrients metabolizability under different dietary treatment groups

Treatment	Dry Matter Metabolizability %	Gross Energy Metabolizability %	Nitrogen Metabolizability %
T1: (Inorganic (Zn+ Mn)	63.75±0.03	61.13±0.09	62.81±0.14
T2: (100% Organic Zn+Mn)	63.89±0.06	61.60±0.13	63.07±0.12
P value	0.067	0.021	0.206

TABLE 9
Mean values of Serum concentration of Manganese and Zinc under different dietary treatment groups

Treatments	Serum Mn (µg/dl)	Serum Zn (mg/dl)
T_1 (Inorganic (Zn+ Mn)	3.62±0.01	0.46±0.01
T_2 (100%OrganicZn+Mn)	3.79±0.02	0.54±0.01
P value	0.0002	0.0022

manganese in broilers receiving organic mineral supplementation than those fed inorganic sources. The researchers concluded that organic trace minerals effectively improve mineral status and availability, which may positively influence growth, immunity, and metabolic functions. Thus it can be suggested that mineral-protein complexes protect trace minerals from undesirable interactions within the digestive tract, thereby enhancing their absorption.

CONCLUSION

Thus, from our research findings, it can be concluded that 100% replacement of inorganic salts of Zinc and Manganese with their organic form resulted in improved body weight gain, better feed conversion ratio with a significant improvement in serum Zn and Mn concentration without affecting the feed intake in growing pullets. Therefore, the present study demonstrates that replacing inorganic zinc and manganese with their organic forms significantly improves serum mineral concentrations, confirming the superior bioavailability and utilization of organic trace minerals in broiler nutrition.

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