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Complexed Zinc and Manganese Supplementation on Live and Processing Performance in Broiler Chickens

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Abstract: In this study, the influence of dietary complexed zinc (CZn) and manganese (CMn) supplementation on growth performance (BW, feed conversion and mortality), incidence of foot pad dermatitis (FPD), litter quality, skin quality (bruises, broken wing and leg, cuts and scratches) and processing yield of broilers was assessed at 49 d of age. A total of 1,120 male broilers were assigned to 4 dietary treatments: (1) Inorganic control diet (IC) which provided 80 ppm $ZnSO_4$ and 90 ppm $MnSO_4$; (2) Same as IC, except CZn replaced 40 ppm of Zn from $ZnSO_4$ (IC+CZn-Zn); (3) IC plus additional 40 ppm of CZn (IC+CZn); (4) Same as IC, except CZn and CMn replaced 40 ppm of Zn and Mn (IC+CZn+CMn). Each treatment was provided in a 3-stage feeding program. Broilers reared on IC+CZn and IC+CZn+CMn showed improvement ($p \leq 0.05$) in BW at 28 and 49 d of age when compared to inorganic control diet (IC). No differences in carcass, FPD and component yields were detected because of dietary treatments. In this study, complexed zinc and manganese supplementation only had a significant improvement on broiler BW and feed conversion.

Key words: Broiler, foot pad dermatitis, mineral, skin quality

INTRODUCTION

The poultry industry frequently experiences a high incidence of total and partial carcass condemnations due to skin lesions, resulting in financial losses. The main lesions causing carcass downgrading are: bruises, scratches, dermatitis, dermatosis and cellulitis. Foot pad dermatitis (FPD) also causes significant economic losses because chicken feet are highly valued in Asian markets.

FPD is a type of contact dermatitis (Greene *et al*., 1985) affecting the plantar regions of the feet and has been associated to poor nutrition, high stocking rates and management issues, particularly those related to poor litter quality. The condition is routinely observed in broiler companies during the rainy season, when litter quality frequently deteriorates, but also due to increased water consumption and excretion, as well as viscous excreta (Clark *et al*., 2002). The FPD lesions are usually superficial in nature, but may result in pain and discomfort to the bird when transformed into deep ulcers (Bilgili *et al*., 2009) and as such may predict the bird welfare (Berg and Algers, 2004; National Chicken Council, 2010).

Trace minerals are usually supplemented from inorganic sources in poultry diets, usually as oxides, sulfates, chlorides, etc., (Polli, 2002), although more economical to use, inorganic mineral supplements may have limited bioavailability. The organic forms of trace minerals have increasingly been used in the poultry industry, in order to get optimal growth and flock health with lower levels of mineral intake, thus lowering the amount of minerals excreted into the environment (Bao *et al*., 2006). It has been observed that the use of complexed minerals, such as zinc (Zn) and manganese (Mn) may improve intestinal absorption, metabolic utilization and wound healing, thereby reducing nutrient excretion (Cheng *et al*., 1998; Cao *et al*., 2000; Pierce *et al*., 2005) and consequently improving litter quality, reducing the incidence and severity of FPD, as well as conditions related to skin integrity and carcass quality.

The objective of this study was to evaluate the influence of complexed zinc (CZn) and complexed manganese (CMn) on the incidence and severity of FPD, skin lesions, carcass yield and performance of broilers.

MATERIALS AND METHODS

A total of 1,120 Ross x Ross 708 one-day-old male broilers chicks obtained from a commercial hatchery were randomly placed into 56 floor pens at 20 chicks per pen (14 replicates). The pens were 1.70 x 2.30 m in dimension and bedded with new pine shavings to cover the concrete floors. The experimental diets (Table 1) were provided in a 3-stage feeding program to 49 days of age. The feeding program consisted of a crumbled

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starter (1-14 days) and pelleted grower (14-35 days) and finisher (36-49 days) diets, all diets were formulated as iso-nitrogenous and iso-caloric.

A completely randomized experimental design was used with four dietary treatments: (1) Inorganic control diet (IC) which provided 80 ppm of $ZnSO_4$ and 90 ppm of $MnSO_4$; (2) Same as IC, except CZn replaced 40 ppm of Zn from $ZnSO_4$ (IC+CZn-Zn); (3) IC plus additional 40 ppm of CZn (IC+CZn); (4) Same as IC, except CZn and CMn replaced 40 ppm of Zn and Mn (IC+CZn+CMn). All birds were weighed at 15, 35 and 48 d of age on a per-pen basis, to calculate body weight (BW) and feed conversion (FCR) rates adjusted for mortality. At 48 d of age, all birds were evaluated to determine the incidence and severity of FPD by using a visual ranking system based in a 3-point scoring system, in which 0 = no lesion, 1 = mild lesion and 2 = severe lesion, as described by Bilgili *et al.* (2006).

At 35 and 49 days of age, five birds randomly selected from each pen (280 birds in each processing day) were individually weighed before slaughter and were processed at the Auburn University Poultry Pilot Processing Plant simulating commercial processing practices. Carcasses were static slush-ice chilled for 2 hours, weighed, individually graded for defects, including bruises, scratches, skin cuts, scabs/dermatosis, broken wings and legs. To assess carcass yields, front half and saddle weight and yields were calculated as a percentage of BW (day 35) and boneless-skinless breast fillet, tender, leg quarters (thigh plus drumstick) and wing weights were obtained at day 49. Yields were calculated relative to live weight [i.e., chilled carcass yield % = (carcass weight*100)/live weight] and parts yield [PY% = (part weight*100)/live weight].

Litter samples were collected from each pen from under the nipple drinkers, around the feeders and in the middle of the pen at the beginning and end of the study, pooled by pen and analyzed for moisture according to Hoskins *et al.* (2003). Ammonia volatilization was measured using a closed container (36 x 46 x 12 cm) inverted over the litter and determined using a Drager CMS Analyzer (Drager Inc., Pittsburgh, PA), equipped with a remote air-sampling pump and ammonia sampling chip (10 to 150 ppm). The sampling pump was voided (calibrated) for 60 s, followed by a measurement period of up to 300 s most readings were usually achieved within 60 s after evacuation (Bilgili *et al.*, 2009).

The experiment was conducted according to the guidelines and approval of the Institutional Animal Care and Use Committee of Auburn University.

Statistical analysis: The data was subjected to the General Linear Model (GLM) procedure of SAS 9.0 software (SAS, 2004). All percentage data were transformed to arcsine values prior to analysis and the Tukey's test was used to compare and separate means when main effects were significant ($p \le 0.05$).

RESULTS AND DISCUSSION

For the performance data (Table 2), broilers reared on the IC+CZn and IC+CZn+CMn showed improvements ($p \le 0.05$) in BW at 28 and 49 days of age when compared to IC (inorganic control). These results agree with Saenmahayak *et al.* (2010) who showed that birds supplemented with complexed Zn had higher BW and better feed conversion ($p \le 0.05$) as compared with those in the inorganic control treatment. By contrast, Salim *et al.* (2012), Rossi *et al.* (2007) and Owens *et al.* (2009) could not measure effects of complexed Zn on growth performance of broiler chicks. The IC+CZn+CMn had the best FCR at 28 days of age compare to IC+CZn diet. No differences ($p > 0.05$) were detected in mortality between the treatments throughout the study.

None of the carcass and parts yield indices (data not showed) were affected ($p > 0.05$) by dietary treatments at

Table 1: Nutrient composition of basal diet[1]

	---------------- Stages	----------------	----------------
Ingredients (%)	Starter	Grower	Finisher
Corn	56.69	60.37	68.56
Soybean meal (48%)	33.07	29.10	23.16
Poultry by-product meal	4.00	5.00	4.00
Poultry oil	2.13	2.10	1.14
Dicalcium phosphate	1.08	0.92	0.87
Ground limestone	1.58	1.45	1.28
Salt (NaCl)	0.45	0.45	0.45
Trace mineral premix[1]	0.05	0.05	0.05
Vitamin premix[2]	0.05	0.05	0.05
DL-Methionine	0.28	0.20	0.21
L-Lysine	0.18	0.08	0.08
Coccidiostat[3]	0.05	0.05	-
Choline	0.05	0.05	0.05
Calculated analysis			
Crude protein (%)	21.46	20.01	17.50
ME (kcal/kg)	1.385	1.410	1.420
Calcium (%)	0.94	0.84	0.74
Available P with phytase (%)	0.35	0.32	0.30
Lysine (%)	1.30	1.12	0.95
Methionine (%)	0.64	0.55	0.53
Methionine+cystine (%)	0.97	0.86	0.80
Sodium (%)	0.20	0.20	0.20

[1] Trace mineral premix supplied the following per kilogram of diet: IC= Inorganic control diet: 80 ppm of $ZnSO_4$ and 90 ppm of $MnSO_4$; IC+CZn-Zn = Zn, 80 mg (complexed 40+40 mg inorganic); Mn, 90 mg; IC+CZn = 120 mg Zn (complexed 40+80 mg inorganic); Mn, 90 mg; IC+CZn+CMn-Zn = Zn, 80 mg (complexed 40+40 mg inorganic); Mn, 90 mg (complexed 40+50 mg inorganic). *Same for all treatments: Fe, 13 mg; Cu, 13 mg; I, 2.2 mg and Se, 0.7 mg.

[2] Vitamin premix supplied the following per kilogram of diet: vitamin A, 16,183 IU; vitamin D_3, 4,851 IU; vitamin E, 16.6 IU; vitamin B_{12}, 0.04mg; riboflavin, 12 mg; biotin, 0.05 mg; niacin, 80 mg; pantothenic acid, 29 mg; choline, 1,102 mg; menadione, 4.8 mg; folic acid, 1.1 mg; pyridoxine, 4.4 mg and thiamine, 2.2 mg.

[3] Coban 60, Elanco Products Inc., Indianapolis, IN

Table 2: Effect of Zn source on broiler live performance from 1 to 49 days of age

	1 to 28 d of age			1 to 49 d of age		
	BW gain (g)	FCR[2]	Mortality (%)	BW gain (g)	FCR	Mortality (%)
Diet[1]	***	*	NS	*	NS	NS
IC	1967^{b}	1.51^{ab}	3.57	3152^{b}	1.70	4.27
IC+CZn-Zn	2025^{ab}	1.51^{ab}	3.21	3369^{ab}	1.73	5.71
IC+CZn	2067^{a}	1.54^{a}	5.36	3446^{a}	1.71	5.36
IC+CZn+CMn	2082^{a}	1.49^{b}	5.00	3282^{ab}	1.70	4.64
SEM[3]	0.02	0.01	1.1	0.07	0.02	1.2

[1] IC = Inorganic control diet (80 ppm of $ZnSO_4$ and 90 ppm of $MnSO_4$); IC+CZn-Zn = Same as IC, except CZn replaced 40 ppm of Zn from $ZnSO_4$; IC+CZn = IC plus additional 40 ppm of CZn; IC+CZn+CMn = Same as IC, except CZn and CMn replaced 40 ppm of Zn and Mn.
[2] FCR = Feed conversion ratio adjusted for mortality.
[3] SEM = Pooled Standard Error of Mean.
*$p<0.05$; ***$p<0.001$; NS, $p>0.05$.
[a,b] Means within a treatment and column with different superscript letters differ significantly ($p \leq 0.05$)

Table 3: Effect of Zn source on broiler carcass quality at 35 and 49 d of age

	35 d of age				49 d of age			
			Broken				Broken	
	Skin Cuts	Bruises	Wing	Scratches	Skin cuts	Bruises	Wing	Leg
Diet[1]	NS	NS	NS	NS	NS	NS	NS	NS
IC	2.9	22.9	7.1	7.1	1.4	39.6	17.1	7.1
IC+CZn-Zn	4.3	17.9	8.6	1.4	2.9	35.0	17.1	0.0
IC+CZn	5.7	15.5	4.3	10.0	4.3	43.9	24.6	1.4
IC+CZn+CMn	2.9	17.5	10.4	2.9	4.3	40.0	28.6	5.7
SEM[2]	1.1	2.1	1.6	1.3	1.0	3.3	2.8	1.1

[1] IC = Inorganic control diet (80 ppm of $ZnSO_4$ and 90 ppm of $MnSO_4$); IC+CZn-Zn = Same as IC, except CZn replaced 40 ppm of Zn from $ZnSO_4$; IC+CZn = IC plus additional 40 ppm of CZn; IC+CZn+CMn = Same as IC, except CZn and CMn replaced 40 ppm of Zn and Mn.
[2] SEM = Pooled Standard Error of Mean. NS, $p>0.05$

Table 4: Effect of Zn source on the incidence of FPD, litter moisture and ammonia volatilization

	Foot pad dermatitis (%)				Litter moisture (%)		
	None[2]	Mild	Severe	Total	Initial	Final	Ammonia (ppm)
Diet[1]	NS	NS	NS	NS	NS	NS	NS
IC	56.5	22.8	20.7	43.5	18.2	27.2	54.9
IC+CZn-Zn	51.9	28.7	19.4	48.1	15.7	27.8	42.7
IC+CZn	46.5	26.0	26.0	52.0	15.9	27.4	50.2
IC+CZn+CMn-Zn	39.8	31.1	29.1	60.2	16.9	28.6	49.7
SEM[3]	8.8	4.9	5.9	8.7	0.8	1.1	4.4

[1] IC = Inorganic control diet (80 ppm of $ZnSO_4$ and 90 ppm of $MnSO_4$); IC+CZn-Zn = Same as IC, except CZn replaced 40 ppm of Zn from $ZnSO_4$; IC+CZn = IC plus additional 40 ppm of CZn; IC+CZn+CMn = Same as IC, except CZn and CMn replaced 40 ppm of Zn and Mn.
[2] None = no lesion present; Mild = lesion = 7.5 mm; Severe = lesion >7.5 mm.
[3] SEM = Pooled Standard Error of Mean. NS, $p>0.05$

35 and 49 d. Effect of complexed zinc on carcass and parts yield in this study are similar to Collins and Moran (1999) and Rossi *et al.* (2007). On the other hand, Saenmahayak *et al.* (2010) and McNaughton and Shugel (1991) showed improvements in breast meat yield in broilers when complexed Zn and Mn were fed to broilers. The carcass and skin quality evaluations are summarized in Table 3. No differences ($p>0.05$) were detected between the dietary treatments. However, Hess *et al.* (2001) reported lowest incidence of back bruising in male broilers fed Zn-methionine and attributed these improvements to the influence of Zn on red blood cell stability (O'Dell *et al.*, 1987; Johanning and O'Dell, 1989). More recently, Saenmahayak *et al.* (2010) showed improvements in proportion of carcasses with skin sores, scabs and scratches with complexed Zn and attributed this effect to improved wound healing through the involvement of Zn in collagen metabolism (Rossi *et al.*, 2007).

The incidence and severity of FPD was not influenced ($p>0.05$) by the treatments at 48 d of age (Table 4) in accordance with the litter parameters (litter moisture and ammonia volatilization) that not differ amongst treatments. This observation was contrary to previous studies (Saenmahayak *et al.*, 2010; Hess *et al.*, 2001) where birds supplemented with complexed Zn reduced the incidence and severity of FPD. Hess *et al.* (2001) supplemented birds with complexed zinc and observed reduction of FPD in females but not in male birds. In conclusion, the use of CZn and CMn in the diet improved the BW and feed conversion ratio but were not effective in improving FPD, carcass quality and yield of broilers.

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