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Effects of Different Levels of Zinc on the Performance and Carcass Characteristics of Broiler Rearedunder Heat Stress Condition

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Abstract: About 288, 1day old Ross 308 broiler were used to evaluate the effect of zinc on performance and carcass characteristics of broiler during Heat Stress (HS). Broilers raised in either a thermoneutral (TN, 23.9°C constant) or HS (23.9-35°C cycling) environment were fed an adequate zinc diet (45 mg kg^{-1}) and high zinc diets (90 and 135 mg kg^{-1}), accomplished by adding a zinc from $ZnSO_4.7H_2O$ to the ration. The HS birds consumed less feed, gained less weight and had lower feed efficiency when compared to TN birds. Dietary zinc levels did significantly influence broiler growth performance. Lymphoid organs, breast and leg meat yield and liver weights were all reduced by HS. These results indicate that the performance, carcass characteristics of broiler and immune response of broilers can be influenced by the level of zinc in the diet and by environmental conditions.

Key words: Broiler, growth performance, Zinc and heat stress, immune response, lymphoid organs, Iran

INTRODUCTION

Chronic Heat Stress (HS) is of great concern in all types of poultry production. Feed Intake (FI), BW, hatchability, mortality, carcass characteristics and other important traits governing the prosperity of the industry are adversely affected by severe heat stress. Broilers exposed to an environmental temperature of 32°C showed a 14% decrease in feed intake by 4 weeks of age and a 24% reduction by 6 weeks of age (Geraert *et al.*, 1996). The concentration of nutrients required to maintain health and productivity of the chicken is challenged due to the reduction in feed intake under HS conditions.

There is evidence suggesting a redistribution of zinc during immunological stress. It is therefore possible that the requirement for zinc is increased during exposure to HS conditions. Heat stress also increases mineral excretion whereas it decreases serum and liver concentrations of minerals (e.g., Fe, Zn, Se and Cr). Moreover, mobilization of minerals and vitamins from tissues and their excretion are increased under stress conditions and consequently, stress may exacerbate a marginal vitamin and mineral deficiency or lead to increased mineral and vitamin requirements (Bartlett and Smith, 2003; Sahin *et al.*, 2005). An experiment was conducted to evaluate the effect of temperature and zinc levels on performance and carcass characteristics of broilers raised under HS or thermoneutral (TN) conditions.

MATERIALS AND METHODS

Diets and birds: About 288, 1 day old Ross 308 broiler were used in the 42 days experiments. Chicks were randomly assigned to 12 experimental units with 12 chicks per pen for the 1st 3 weeks. They were fed 1 of 3 dietary treatments (Table 1) randomly assigned to each pen with 4 replications of each treatment. Water and feed were provided *ad libitum* and feed intake and BW were recorded weekly. Experimental diets were as follows: adequate in zinc (45 mg kg^{-1}) and high in zinc (90 and 135 mg kg^{-1}), accomplished by adding a zinc from $ZnSO_4$ $7H_2O$ to the ration.

Temperature treatments: After 3 weeks at recommended brooding temperatures, 7 chicks per replicate from each dietary treatment (a total of 28 birds per treatment) were randomly selected and weighed. They were divided into 2 groups and transferred to individual cages in 2 environmental chambers. In one chamber, the ambient temperature was adjusted so that daily fluctuations were between 23.9 and 37°C, simulating diurnal temperature

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Table 1: Composition of basal diet (%)

Ingredients	Starter diets	Grower diets
Corn	54.60	66.24
Soybean meal	38.00	30.00
Soy oil	3.00	0.00
Dicalcium phosphate	1.85	1.27
Shell grit	1.28	1.40
Salt	0.45	0.34
Mineral mix[1]	0.25	0.25
Vitamin mix[2]	0.25	0.25
Nutrient composition		
ME (kcal kg^{-1})	3011.00	2996.00
Crude protein	21.62	18.79
Crude fat	5.38	2.76
Methionine	0.50	0.40
TSAA	0.89	0.75
Lysine	1.30	1.11
Arginine	1.53	1.30
Calcium	1.00	0.87
Phosphorus (available)	0.48	0.36
Zinc (mg kg^{-1})	25.78	23.63
Sand[3]	-	-

[1]Provided the following per kilogram of diet: 50 mg of Fe as $FeSO_4.7H_2O$, 6 mg of Cu as $CuSO_4.5H_2O$; 4 mg of Mn as $MnSO_4H_2O$; 140 mg of I as KIO_3; .3 mg of Se as Na_2SeO_3. Dextrose was used as carrier (15.3 g kg^{-1} of diet); [2]Provided the following amounts per kilogram of diet: vitamin A, 4,950 IU; vitamin D3, 660 IU; vitamin E, 33 IU; vitamin K, 6 mg; riboflavin, 3.3 mg; niacin, 35.2 mg; d-pantothenic acid, 19.8 mg; vitamin B12, .022 mg; choline chloride, 1,184 mg; thiamin, 2.6 mg; vitamin B6, 3 mg; d-biotin, .4 mg; folacin, 2 mg.jDynamate contained (minimum) 22% S, 18% K and 11% Mg. Pitman-Moore Inc., Mundelein, IL; [3]Appropriate amount of zinc was added at the expense of an equivalent amount of sand in diets

during HS. They were exposed to 12 h of 23.9°C, 3 h of 23.9-37°C, 6 h of 37°C and 3 h of 37-23.9°C. In the other chamber, temperature was maintained at a constant 23.9°C. Relative humidity was allowed to fluctuate but not fall below 45%. For the next 4 weeks birds were given the same dietary treatments as they received in the initial 3 weeks of the study and feed intake and BW were monitored weekly.

Growth performances and organ collection: Feed intake and weight gain were recorded for each pen and corrected for mortality at the end of every week after a food deprivation of 10 h. Feed conversion ratio was calculated from 0-6 weeks. At the end of the experiment, chicks were individually weighed and 4 birds from each pen were selected according to the average BW of the pen. Each of these birds was deprived of feed for 10 h and individually weighed just prior to slaughter. Chicks were immediately killed by cervical dislocation. Birds were slaughtered on 43 days and spleen, liver and bursa of Fabricius were excised and weighed. Breast and leg meat yield were determined as percentage of live body weight.

Statistical analyses: The trial was conducted as a Complete Randomized Design (CRD) with a 3×2 factorial arrangement of treatments with four replicates per treatment. The pen mean was used as the experimental unit. The results of the experiments were analyzed by ANOVA using the GLM procedure of SAS software to assess the effects of different levels of bet substitute to Met, zinc and their interactions on performance and carcass characteristics of Broiler under heat stress. Statistical significance of differences between treatment means was determined with Duncan test. All statements of significance are based on a probability of <0.05 ($p<0.05$).

RESULTS AND DISCUSSION

Growth performance: The impact of dietary zinc on broiler growth performance during the entire experiment period (1-42 days) is shown in Table 2. The level of zinc in the diet did significantly influence broiler growth performance during the entire 6 weeks of the study. The weight gain and feed intake of chicks fed the 90 mg kg^{-1} total dietary Zn was significantly higher than that of chicks fed the 45 mg kg^{-1} total dietary Zn and other treatments ($p<0.05$). Diets supplemented with 90 mg of Zn kg^{-1} diet, tend to improve the feed conversion of the birds. No additional response was observed at greater Zinc concentrations. Pimental in one experiment found no differences in feed intake and growth of broilers fed up to 88 μg zinc g^{-1} diet whereas Bartlett and Smith (2003) report no differences in BW and feed conversion of broilers supplemented with 140 or 164 μg zinc g^{-1} diet. Reports by Bartlett and Smith (2003) show that diets low in zinc lead to depressed appetite resulting in lowered feed intake and reduced weight gain.

There was a significant reduction in BW, feed conversion and intake when the birds were exposed to HS (Table 2). This result was consistent with the general trend observed in HS broilers (Geraert *et al*., 1996). Geraert *et al.* (1996) saw a 14% reduction in BW at 2-4 weeks of age and a 24% reduction at 4-6 weeks of age when birds were exposed to 32°C and suggested that the reduced efficiency could be due to changes in metabolic utilization of nutrients.

Zinc positively affects feed utilization through participating in the metabolism of carbohydrates, lipids and proteins (MacDonald, 2000). Sahin and Kucuk (2003) reported linear increases in FI and egg production and improved feed efficiency and egg quality upon $ZnSO_4$ supplemention (30 and 60 mg kg^{-1} of diet) to quail reared under heat stress conditions. There are conflicting reports on the influence of Zn on performance in stressed birds.

Table 2: BW Gain, feed conversion and feed intake of 1-42 days broilers fed different levels of zinc under Thermoneutral (TN) and Heat Stress (HS) conditions

Diets[1]	Temperature	BWG (g)	FI (g)	FC
Z1	HS	2386.6400	4434.9000	1.8600
	TN	2469.6700	4508.0000	1.8200
Z2	HS	2458.7000	4481.2600	1.8200
	TN	2545.8600	4566.7100	1.7900
Z3	HS	2370.4100	4417.3600	1.8600
	TN	2453.0400	4488.6200	1.8300
Pooled SEM	-	9.1100	11.3300	0.0100
Probability				
Diet	-	<.0001	<.0001	0.0008
Temperature	-	<.0001	<.0001	0.0001
Diet x temperature	-	0.9600	0.7900	0.9000
Main effect means				
Z1	-	2428.1600^{a}	4471.4500^{b}	1.8400^{a}
Z2	-	2502.2800^{b}	4523.9900^{a}	1.8100^{b}
Z3	-	2411.7300^{b}	4452.9900^{b}	1.8500^{a}
Temperature				
TN	-	2489.5200^{a}	4521.1100^{a}	1.8200^{b}
HS	-	2405.2500^{b}	4444.5100^{b}	1.8500^{a}

^{a,b}Values within a column with no common superscript are significantly different ($p<0.05$); [1]Data are means of 4 replicate pens of 12 chicks per pen

Bartlett and Smith (2003) reported that dietary Zn levels did not affect growth performance in broilers reared under heat stress whereas Sahin *et al.* (2005) reported that $ZnSO_4$ or Zn picolinate supplementation (30 or 60 mg kg^{-1}) improved performance and carcass quality in quails reared under heat stress temperature. Ao *et al.* (2007) reported that dietary Zn supplementation linearly increased FI, weight gain, feed efficiency, plasma and liver Zn concentrations, tibia Zn content and tibia ash weight in broilers kept under TN conditions.

Organs weights: Organ weights were measured as a percentage of BW (Table 3). Dietary Zn significantly affected the bursa and liver weights ($p<0.05$) but not the breast, leg meat yield and spleen weights (Table 3). The bursa weight of chicks fed the 135 mg of Zn kg^{-1} diet was significantly heavier than that of chicks fed the 90 and 45 mg of Zn kg^{-1} diet ($p<0.05$). Bartlett and Smith (2003) observed none of these organs (thymus, bursa, spleen or liver) were significantly affected by the level of zinc in the diet. This finding was inconsistent with this study.

All organ weights were reduced by HS but not significant for leg meat yield and spleen weight as a percentage of BW. This could have been a result of the reduction in feed intake thereby providing less nutrients for the proper development of these organs. These results indicate that the immune response of broilers can be influenced by the level of zinc in the diet and by environmental conditions. Supplementing the zinc in the diets did not seem to improve the weight of these organs under HS conditions. The HS birds consumed Z1 and Z3 diet had significantly lower BMY when compared to TN birds. Results showed that dietary supplemental zinc at the level of 90 mg kg^{-1} increased spleen weight on

Table 3: Lymphoid organs, liver weight, Breast and Leg Meat Yield (BMY and LMY) of 43 old broilers fed different levels of Zinc under Thermoneutral (TN) and Heat Stress (HS) conditions

Diets[1]	Temperature	Bursa (BW %)	Spleen (BW %)	Liver (BW %)	BMY[2] (BW %)	LMY[2] (BW %)
Z1	HS	0.1050	0.191^{a}	3.98	33.3100^{cd}	43.170
	TN	0.1370	0.175^{ab}	4.40	37.8700^{ab}	44.990
Z2	HS	0.1250	0.147^{b}	3.88	36.2000^{bc}	42.740
	TN	0.1550	0.206^{a}	4.22	37.5400^{ab}	43.610
Z3	HS	0.1370	0.179^{ab}	3.55	31.4700^{d}	43.250
	TN	0.1670	0.189^{a}	3.90	41.4300^{a}	46.310
Pooled SEM	-	0.0030	0.010	0.16	1.4400	1.230
Probability						
Diet	-	<.0001	o.790	0.02	0.6600	0.430
Temperature	-	<.0001	0.067	0.01	<.0001	0.064
Diet x temperature		0.8900	0.007	0.97	0.0200	0.670
Main effect means						
Z1	-	0.1210^{c}	0.183	4.19^{a}	35.5900	44.080
Z2	-	0.1400^{b}	0.177	4.05^{ab}	36.8700	43.180
Z3	-	0.1520^{a}	0.184	3.72^{b}	36.4500	44.780
Temperature						
TN	-	0.1530^{a}	0.190	4.17^{a}	38.9500^{a}	44.970
HS		0.1220^{b}	0.170	3.80^{b}	33.6600^{b}	43.050

^{a,b}Values within a column with no common superscript are significantly different ($p<0.05$); [1]Data are means of 4 replicate pens of 12 chicks per pen; [2]With bones and skin; [3]Bursa, liver and spleen are expressed relative to BW

TN birds. Dietary zinc levels did not impact LMY and Liver weights. Although, bursa weight significantly increased with increasing zinc levels but decreasing with temperature (Table 3). There was a significant reduction in BMY when the birds were exposed to HS.

CONCLUSION

The heat stress causes significant decreases in performance, nutrient utilization and organ weights which result in increases in disease incidences and economic losses in poultry operations. Dietary manipulations are among the methods to alleviate these negative adverse effects of heat stress. Because it has several significant functions as well as antioxidant properties, Zn is one of the most important components of the poultry diet during times of heat stress.

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