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Physiological Responses of Broiler Chicks Fed Various Level of Dopamine and Zinc

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Abstract: The influences of dopamine (DA) and zinc (Zn) on some physiological parameters of plasma such as growth hormone, cholesterol, 3-glyceride and growth rate, feed conversion ratio and abdominal fat of broilers between the ages of 21 to 42 day were investigated. The experiment was designed on a total of 180 commercial meat-type chicks as a randomized complete block with a 3×2×2 factorial arrangement of treatments with three levels of DA (0, 50 and 100 mg kg^{-1}) and two levels of Zn (0 and 40 mg kg^{-1}) in each sex. At the first day of trial, chicks were randomly distributed in 36 boxes at the same condition until day 15. Then, the treatments were administered in a low dosage for acclimating of chicks to them. From day of 21, the main dose of treatments was used. The effects of DA and Zn and interaction between them on cholesterol concentration of plasma were significant ($p<0.05$). But the effects on concentration of growth hormone (GH) and 3-glyceride of plasma were not significant. The maximum concentration of cholesterol in plasma was observed in male chicks administered 40 mg kg^{-1} of Zn and the minimum concentration was related to female chicks administered 50 mg kg^{-1} of DA. In this period, the main and interaction effects of all treatments on weight gain mean of chicks were significant. Also, Zn and DA and interaction of DA×sex improved feed conversion ratio ($p<0.05$). The results of this experiment confirmed the lipolytic effect of DA on plasma cholesterol and abdominal fat and also showed that consumption of 100 mg kg^{-1} of DA plus 40 mg kg^{-1} of Zn cause to improve growth performance of male chicks.

Key words: Dopamine, zinc, broiler, physiological parameters, performance

INTRODUCTION

Modern broiler-type chickens have been intensively selected for rapid body weight and high meat yield. As a result they grow more rapidly and eat greater than layer-type chickens. It is well known that feeding behavior is regulated by the Central Nervous System (CNS). Especially the hypothalamus plays an important role in the feeding regulation in chickens through its content of monoamines (Yamasaki *et al*., 2003).

Dopamine, a sympathomimetic amine vasopressor, is the naturally occurring immediate precursor of epinephrine. As a chemical messenger, DA is similar to adrenaline with a molecular formula of $C_8H_{11}NO_2$. Several DA cell groups have been identified among a variety of hypothalamic region, suprachiasmatic nucleus, lateral hypothalamic area, paraventricular nucleus, lateral mamillaris nucleus and dorsomedial nucleus (Reiner *et al.*, 1994; Chaiseha and El Halawani, 2005). Dopamine receptors have been identified in the chick brain (Sun and Reiner, 2000), although the intestinal dopaminergic system is believed to be a localized no neuronal system (Lucas-Teixeira *et al*., 2000). Dopamine D2 receptors have a role to inhibit of ceramide formation by growth hormone (Liu *et al*., 2002). DA administration has been reported to decrease intestinal contractions and motility in the chicks (Lot, 1993; Dive *et al*., 2000). DA decreases Na^+, K^+-ATPase in rat jejunal enterocytes (Lucas-Teixeira *et al*., 2000). Experiment is shown that DA can decrease significantly serum triglyceride and cholesterol level (Kimura *et al*., 2002).

Zinc has been reported to act as a neuromodulator at excitatory synapses and has a considerable role in the stress response (Patricia and Pandolf, 2005). It is believed that Zn is essential in all aspects of immunity (Chandra and Dayton, 1982; Sherman, 1992) and function through its association with the enzymes is critical for the integrity of the cells involved in the immune response (Dardenne *et al*., 1985). Reports by Miller *et al*. (1968) and Swinkels *et al*. (1994) showed that diets low in Zn lead to depressed appetite resulting in lowered feed intake and reduced weight gain.

Because of not enough investigations on effect of dopamine and zinc on broilers function, the present experiment was performed to describe the effect of these treatments on some physiological parameters, feed conversion ratio and abdominal fat of broiler chicks.

MATERIALS AND METHODS

Location of experiment: This study was conducted in Poultry Research Section of Animal Research Station belonged to Ferdowsi University of Mashad, located at Iran.

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Table 1: Composition of treatments in the broiler diet

Treatments	Ingredient (per kg of diet)
Zn_0D_0	Control
Zn_1D_0	40 mg kg^{-1} zinc sulfate
Zn_0D_1	50 mg kg^{-1} dopamine
Zn_1D_1	50 mg kg^{-1} dopamine and 40 mg kg^{-1} zinc sulfate
Zn_0D_2	100 mg kg^{-1} dopamine
Zn_1D_2	100 mg kg^{-1} dopamine and 40 mg kg^{-1} zinc sulfate

Chickens and diets: One hundred eighty 1-day-old Ross broiler males and females were used in this experiment. At the first day of trail, chicks were randomly distributed in 36 boxes at the same condition until day 15. After that, the treatments in low dosage were offered and from day 21 to 42 the main dose of them was administered. The ration used during the trail was regulated through NRC (1994) with 21.8% CP and 3150 kcal kg^{-1} ME. The level of feed intake was recorded daily and the chicks were weighed weekly.

Blood sampling: A volume of 5 mL blood sample was collected into an ethylenediminetetraacetic acid-coated tube from the brachial vein of each chick. The samples were centrifuged at 700 x g for 15 min at 20°C. Plasma was kept at -80°C until measurement. Enzymatic method by ELISA Reader was used to measure of GH concentration, 3-glyceride and cholesterol.

Experimental design and statistical analysis: The collected data were statistically analyzed using General Linear Models procedure (GLM) of SAS software (1995). A randomized complete block design was utilized with a 3×2×2 factorial arrangement of treatments with three levels of dopamine (0, 50 and 100 mg kg^{-1}) and two levels of zinc (0 and 40 mg kg^{-1}) in each sex (Table 1). The independent variables were treatment. All other variables, such as body weight, feed intake, feed conversion, GH concentration, 3-glyceride, cholesterol and Abdominal fat were considered as dependent variables.

RESULTS AND DISCUSSION

Dopamine and zinc had a significant effect on cholesterol concentration of plasma ($p<0.05$). However, no difference was found among the effect of treatments on 3-glyceride and abdominal fat. The interaction effects of sex×Zn, Zn×DA and sex×Zn×DA on cholesterol concentration of plasma were significant ($p<0.05$). This result shows that different levels of Zn in each sex and separate levels of DA have different responses (Table 2 and 3). The maximum concentration of cholesterol in plasma was observed in male chicks and related to diet contained Zn_1D_0 and the minimum was related to females administered Zn_0D_1. The least abdominal fat was observed

Table 2: ANOVA of effects of treatments on physiological parameters

Source of variation	Growth hormone (ng mL^{-1})	Cholesterol (mg 100 mL^{-1})	3-glyceride (mg 100 mL^{-1})	Abdominal fat (%)
Sex	4.218ns	239.686ns	7.823ns	0.450ns
Zn	0.649ns	1587.003*	127.379ns	0.046ns
DA	2.415ns	984.946*	352.300ns	0.147ns
Sex×Zn	2.445ns	1711.135**	46.931ns	0.056ns
Sex×DA	2.043ns	420.346ns	188.281ns	0.648ns
Zn×DA	3.000ns	1630.480**	114.218ns	0.019ns
Sex×Zn×DA	0.339ns	948.126*	375.585ns	0.420ns
Block	0.430ns	94.410ns	138.900ns	1.386ns
R-square	0.434	0.641	0.438	0.451

*Significant at $p<0.05$, **Significant at $p<0.01$, ns: Non significant

Table 3: The effects of DA and Zn supplementations on the physiological parameter (Mean±SEM)

Treatments	Growth hormone (ng mL^{-1})	Cholesterol (mg 100 mL^{-1})	3-glyceride (mg 100 mL^{-1})	Abdominal fat (%)
Male				
Zn_0D_0	6.53±0.78^{a}	129.30±4.10^{bcd}	117.00±10.60^{a}	0.83±0.03^{ab}
Zn_1D_0	6.27±0.84^{a}	158.20±8.40^{a}	100.50±19.60^{a}	1.17±0.20^{ab}
Zn_0D_1	6.90±1.20^{a}	115.90±0.80^{cd}	97.10±5.40^{a}	1.07±0.22^{ab}
Zn_1D_1	5.40±0.65^{a}	138.80±7.40^{abc}	81.30±8.00^{a}	0.50±0.21^{b}
Zn_0D_2	5.77±0.48^{a}	147.80±2.70^{ab}	94.20±4.10^{a}	0.63±0.12^{ab}
Zn_1D_2	6.17±1.84^{a}	119.70±7.30^{cd}	80.80±6.90^{a}	1.13±0.18^{ab}
Female				
Zn_0D_0	5.03±0.34^{a}	138.50±16.10^{abc}	105.30±14.50^{a}	1.10±0.25^{ab}
Zn_1D_0	5.55±0.25^{a}	124.20±2.10^{bcd}	89.40±15.70^{a}	1.63±0.50^{ab}
Zn_0D_1	7.27±1.27^{a}	105.30±3.80^{d}	94.80±13.70^{a}	2.00±1.17^{ab}
Zn_1D_1	7.70±1.41^{a}	132.80±4.40^{abcd}	102.30±3.90^{a}	3.17±2.23^{a}
Zn_0D_2	5.47±0.57^{a}	128.80±17.80^{bcd}	102.80±9.80^{a}	1.27±0.33^{ab}
Zn_1D_2	7.77±1.95^{a}	121.30±2.90^{bcd}	86.30±5.30^{a}	0.97±0.03^{ab}

Means within the same column without a common superscript differ ($p<0.05$)

in Zn_1D_1 treatment (males) which can be explained partly by lipolytic effect of catecholamines. These results are agreed with Catherine *et al*. (1984), Stiles *et al*. (1984), Buyse *et al*. (1990) and Rosebrough (1997). Some researches have shown that β-adrenergic complex such as DA can improve feed conversion ratio, decrease carcass fat, increase muscle weight and growth of chicks (Catherine *et al*., 1984; Colin, 1989; Adeola and Ball, 1992). Some medium composites (i.e., β-adrenergic receptors and cyclic adenosine mono phosphate) are necessary for activation of catecholamines (Goldberg and Haddox, 1977). β-adrenergic agonists inhibited the synthesize of fatty acids in chicks and stimulated lypolising of fat tissue (Catherine *et al*., 1984). Cincotta and Meier (1989) reported that administrations (injections and in feed) of bromocriptine, a DA agonist, reduced body fat stores, plasma total cholesterol and triglyceride concentrations in several rodent species. It was also shown that serum cholesterol levels significantly declined using DA (Ormiston *et al*., 2004).

The main and interaction effects of treatments on GH concentration of chickens were not significant (Table 2 and 3). These results are different with some previous studies that indicated administration of nor-epinephrine,

epinephrine, DA and β-agonists increase the range of secretory pulses of GH. Also, releasing some factors from hypothalamus that control the secretion of GH is affected by adrenergic compounds through α-adrenergic receptors (Chester, 1986; Buyse *et al*., 1990). The different result of present study may be due to not enough dosage of DA to affect GH concentration of plasma. However, Chang *et al*. (2003) found that DA had no effect on growth of broiler chicks at 6, 9 and 12 days of age. There is no demarcation between neurotransmitters and neuropeptides because they may coexist in the same neuron in different areas of the CNS and in mediobasal hypothalamus. So, both amine and amino acid neurotransmitters have roles in the control of GH release. In a series of studies, the increase in GH was shown to be induced by DA agonists (Muller, 1997).

As shown in the Table 4 and 5, the main effects of DA and Zn and interaction of sex×DA on feed conversion ratio from 35 to 42 days were significant ($p<0.05$). The minimum and maximum of feed conversion ratio was observed in male chicks used Zn_1D_2 and females administered Zn_1D_1, respectively. These results can be caused by decreasing and increasing of feed intake by males and females, respectively. DA may play a role in gut-brain axis regulation (Sun and Reiner, 2000) and within the intestinal mucosal cells, act locally as a regulator of intestinal function (Lucas-Teixeira *et al*., 2000). Disregulation of catecholamines has been associated with abnormal behaviours such as feed intake by the animal (Cheng *et al*., 2001).

Gether *et al*. (2001) reported that Zn^{2+} acts as a potent non-competetive inhibitor of DA uptake mediated by DA transporter. Zn^{2+} binding site is responsible for allosteric modulation of D2 dopamine receptor (Liu *et al*., 2006). The effect of Zn on chick weight, livability and humoral or cellular immunity was not significant in the study of Kidd *et al.* (1992). The level of Zn in the diet did not significantly influence broiler growth performance during the entire 7 week of the study of Bartlett and Smith (2003). However, Zn levels were apparently not low enough to affect feed intake or weight gain in that study. In the study of Chang *et al*. (2003), after peritoneal injection of DA to the chicks at day 6, there were no significant differences in body weight gain, feed consumption and feed conversion between 7 to 15 days. Also, Feeding diets supplemented with various levels of DA during 7 to 15 days had no significant effects on the weights of visceral organs, intestinal density, small intestinal and cecal weights and small intestinal and cecal lengths adjusted for feed-deprived body weight. These different results show that the effectiveness of DA depends on various levels of that and period of administration.

Table 4: ANOVA of effects of treatments on feed conversion ratio

Source of variance	Days 21 to 28	28 to 35	35 to 42	42 to 49
Sex	0.0005ns	0.2607*	0.0000ns	0.3180
Zn	0.0108ns	0.0069ns	0.2204*	0.0020ns
DA	0.0002ns	0.0963ns	0.2315*	0.1620ns
Sex×Zn	0.0043ns	0.0000ns	0.1657ns	0.0130ns
Sex×DA	0.0004ns	0.1016ns	0.1764*	0.1480ns
Zn×DA	0.1158ns	0.0452ns	0.1015ns	0.0520ns
Sex×Zn×DA	0.0055ns	0.1023ns	0.1537ns	0.0520ns
Block	0.0021ns	0.0923ns	0.0291ns	0.0980ns
R-square	0.8719	0.8083	0.6700	0.7520

* Significant at $p<0.05$, ns: Non significant

Table 5: The effects of DA and Zn supplementations on the feed conversion ratio (Mean±SEM)

Treatments	Days 21 to 28	28 to 35	35 to 42	42 to 49
Male				
Zn_0D_0	1.83 ± 0.06^{a}	2.28 ± 0.40^{ab}	2.32 ± 0.10^{ab}	2.18 ± 0.15^{b}
Zn_1D_0	1.83 ± 0.10^{a}	1.86 ± 0.10^{b}	1.94 ± 0.11^{bcde}	2.28 ± 0.35^{b}
Zn_0D_1	1.82 ± 0.05^{a}	1.98 ± 0.08^{b}	1.77 ± 0.03^{de}	2.62 ± 0.13^{ab}
Zn_1D_1	1.84 ± 0.09^{a}	1.95 ± 0.18^{b}	1.82 ± 0.17^{cde}	2.40 ± 0.09^{b}
Zn_0D_2	1.94 ± 0.07^{a}	2.09 ± 0.18^{ab}	2.09 ± 0.16^{abcd}	2.63 ± 0.25^{ab}
Zn_1D_2	1.95 ± 0.17^{a}	1.85 ± 0.06^{b}	1.68 ± 0.17^{e}	2.28 ± 0.23^{b}
Female				
Zn_0D_0	1.96 ± 0.09^{a}	2.17 ± 0.17^{ab}	2.32 ± 0.05^{ab}	2.72 ± 0.15^{ab}
Zn_1D_0	1.88 ± 0.06^{a}	2.14 ± 0.11^{ab}	2.41 ± 0.15^{a}	2.55 ± 0.05^{ab}
Zn_0D_1	1.95 ± 0.13^{a}	2.22 ± 0.21^{ab}	2.42 ± 0.11^{a}	2.54 ± 0.06^{ab}
Zn_1D_1	2.01 ± 0.04^{a}	2.76 ± 0.40^{a}	2.06 ± 0.15^{abcde}	2.64 ± 0.03^{ab}
Zn_0D_2	2.03 ± 0.08^{a}	2.58 ± 0.09^{ab}	2.19 ± 0.14^{abc}	2.83 ± 0.05^{ab}
Zn_1D_2	1.92 ± 0.09^{a}	2.39 ± 0.33^{ab}	2.05 ± 0.03^{abcde}	3.13 ± 0.36^{a}

Means within the same column without a common superscript differ ($p<0.05$)

CONCLUSION

Administration of DA to broiler chicks decrease carcass fat and improve carcass quality. The use of 100 mg DA with 40 mg Zn per kg of diet improves performance of male chicks. However, the effects of these treatments are different on males and females. Whereas, Zn supplementation can improve immune system and under heat stress condition the immunity of chicks may decrease, so more studies on the effect of different levels of Zn in various physiological conditions of chicks are necessary.

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