Effect of ginger (Zingiber officinale Roscoe) and organic selenium on growth dynamics, blood melanodialdehyde and paraoxonase in broilers exposed to heat stress

Saufullah a, Naila Chanda b, Rifat Ullah Khana, Shabana Naz c, Munib Ahmad b and Sina Guld

aDepartment of Poultry Science, Faculty of Animal Husbandry & Veterinary Sciences, The University of Agriculture, Peshawar, Pakistan; bDepartment of Zoology, GC University, Faisalabad, Pakistan; cDepartment of Animal Health, Faculty of Animal Husbandry & Veterinary Sciences, The University of Agriculture, Peshawar, Pakistan; dAfghanistan Valued-chains, Kabul, Afghanistan

ABSTRACT

A total of 480 1-week-old chicks of about similar average weight, and size were divided into 6 groups. One group served as control, and was fed only basal diet, second group was fed ginger at the rate of 5 g/kg (T1), third group was given organic selenium (Se) at the rate of, 0.3 mg/kg diet (T2), fourth group was given organic Se at the rate of 0.4 mg/kg (T3), fifth group was fed with organic Se at the rate of 0.3 mg/kg + 5 g/kg ginger (T4), sixth group was given organic Se at the rate of 0.4 mg/kg + 5 g/kg ginger (T5). Mean feed intake was significantly (\( P < 0.05 \)) high in T3 and T5 while body weight was significantly (\( P < 0.05 \)) high in T3 compared to the control. Mean feed conversion ratio (FCR) was significantly (\( P < 0.05 \)) high in T2, T3 and T5 compared to the control. Dressing percentage was significantly (\( P < 0.05 \)) high in T4 and T5 compared to the control. Serum Antibody titre against Newcastle disease and paraoxonase (PON1) were significantly (\( P < 0.05 \)) high in the T4 and T5 groups compared to the control while melanodialdehyde (MDA) concentration was significantly (\( P < 0.05 \)) low in the same groups. Results of this study showed that ginger at the rate of 5 g/kg and Se at the rate of 0.4 mg/kg were more effective in improving the growth performance, immune response and antioxidant status in broiler chickens exposed to high ambient temperature.

Introduction

High ambient temperature causes major problems in the poultry industry in the form of high mortality, low feed intake and feed efficiency (Khan et al. 2012a; Chand et al. 2014). Metabolic rate and body temperature of birds are comparatively higher than that of mammals (Chand et al. 2018). During high environmental temperature, birds are susceptible to oxidative stress (Rehman et al. 2017). During heat stress, birds have limited physical resources to cope with the new challenge and birds need to redistribute the body reservoir of protein and energy at the cost of stunt growth (Khan et al. 2012a).

The body produces free radicals continuously for the need of normal physiological functions, but their excessive level may cause damage to the plasma membrane and organelles (Khan et al. 2011). Nutritional approaches are considered to lessen the undesirable effects of heat stress by maintaining feed intake, water and electrolyte balance or by the supplementation of antioxidant vitamins, essential oils, minerals and natural herbs (Khan et al. 2011; Rahman et al. 2014a; Majid et al. 2015; Abudabos et al. 2016; Chand et al. 2017). Supplementation of diets with natural antioxidants is a favourable strategy to decrease the lethal effects of heat stress in birds (Chand et al. 2016).

Selenium (Se) is an essential trace element. It upregulates the main components of the antioxidant defense mechanism of controlling its major Se-containing antioxidant enzymes and body’s glutathione pool. Glutathione-peroxidase (GSHPx) contains Se as an integral component. Dietary organic Se supplementation reduced lipid peroxidation products and improved the immune system (Cai et al. 2012).

Active constituents in the herbal plants are discovered as a source of antioxidants (Khan et al. 2012b; Raza et al. 2016). Ginger (Zingiber officinale) is best and commonly used spices. It is powerful appetizer and carminative (Rehman et al. 2018). It is known as a valuable medicine because of its action as anti-asthmatic and stimulant of the gastrointestinal tract (Zhang et al. 2009). Ginger supplementation has been reported to improve the actions of GSHPx and superoxide dismutase (SOD) and reduces melanodialdehyde (MDA) in broilers (Khan et al. 2012b). Ginger eliminates the lipid peroxidation in the cell via enhancing antioxidative action (Zhao et al. 2011). To the best of our knowledge, no study is available in the published literature on the effect combined effect of ginger and Se in broiler under heat stress. Therefore, the objective of this study was to evaluate the effect of ginger and Se on the production performance, immune status and antioxidant capacity of broiler exposed to heat stress.

Materials and methods

Experimental design and birds husbandry

A total of 480 1-day-old broiler chickens were purchased from the local market in Peshawar and divided into 6 groups with 8...
replies. Cleaning and fumigation were performed before the arrival of the chicks. Wood shaving was used as litter for chicks. For the maintenance of better management, all the necessary materials (drinkers, feeders and bulbs) were provided to chicks.

Birds were fed starter, grower and finisher commercial corn-based basal diet with ad libitum access to fresh water, for 42 days (Table 1). Organic Se (SEL-PLEX, Alltech, selenium 1000 mg/kg) used in this experiment was yeast-bound. Ginger was obtained in the fresh form and dried in oven at 70°C for 3 days and then milled in a metal jar in the powder form and stored at room temperature. One group served as control, and were fed only basal diet, second group was fed ginger at the rate of 5 g/kg (T1), third group was given organic Se at the rate of 0.3 mg/kg diet (T2), fourth group was given organic Se at the rate of 0.4 mg/kg (T3), fifth group was fed with organic Se at the rate of 0.3 mg/kg + 5 g/kg ginger (T4), sixth group was given organic Se at the rate of 0.4 mg/kg + 5 g/kg ginger (T5). The temperature and humidity were determined at an interval of 6 h per day (Table 2).

Table 1. Basal composition of feed during the starter and finisher phase.

| Ingredients          | Starter   | Finisher  |
|----------------------|-----------|-----------|
| Corn                 | 53.21     | 60.75     |
| Soybean meal         | 37.92     | 25.00     |
| Corn gluten meal     | 2.00      | 7.10      |
| Corn oil             | 2.20      | 2.80      |
| Dicalcium phosphate  | 2.30      | 2.05      |
| Limestone            | 0.83      | 0.68      |
| Salt                 | 0.45      | 0.50      |
| VM Mix*              | 0.50      | 0.50      |
| DL-Methionine        | 0.20      | 0.10      |
| Lysine-HCl           | 0.22      | 0.37      |
| Threonine            | 0.11      | 0.10      |
| Choline chloride     | 0.05      | 0.05      |
| **Chemical composition** |          |           |
| ME, kcal/kg          | 3000      | 3150      |
| Crude protein, %     | 23.5      | 21.30     |
| Methionine, %        | 0.55      | 0.44      |
| Lysine, %            | 1.42      | 1.23      |
| Sulphur amino acids, % | 0.96    | 0.80      |
| Threonine, %         | 0.95      | 0.85      |
| Calcium, %           | 1.05      | 0.90      |
| Phosphorus, %        | 0.50      | 0.45      |

*Vitamin–mineral premix contains in the following per kg: vitamin A, 2,400,000 IU; vitamin D, 1,000,000 IU; vitamin E, 16,000 IU; vitamin K, 800 mg; vitamin B1, 600 mg; vitamin B2, 1600 mg; vitamin B6, 1000 mg; vitamin B12, 6 mg; niacin, 8000 mg; folic acid, 400 mg; pantothenic acid, 3000 mg; biotin 40 mg; antioxidant, 3000 mg; cobalt, 80 mg; copper, 2000 mg; iodine, 400; iron, 1200 mg; manganese, 18,000 mg; selenium, 60 mg; zinc, 14,000 mg.

Table 2. Ambient temperature and relative humidity during the experimental period.

| Period(days) | Maximum | Minimum | Average | Maximum |
|--------------|---------|---------|---------|---------|
| 0–21         | 38.4    | 32.3    | 36.0    | 39.6    |
|              | 84.9    | 65.3    | 73.5    | 88.7    |
| 22–42        | 31.5    | 36.5    | 40.2    | 32.6    |
|              | 68.4    | 77.3    | 88.7    | 65.3    |
| 0–42         | 37.0    | 37.0    | 37.0    | 37.0    |
|              | 75.4    | 75.4    | 75.4    | 75.4    |

AT, ambient temperature; RH, relative humidity.

**Performance traits**

Weighed amount, of feed was provided, to the broilers two times a day and leftover feed was weighed the following morning. At the start, all the chicks were weighed. Weight gain on a weekly basis was determined by deducting weight at day one from body weight at day seven of each week. Overall, weight gain was calculated, from weekly body weight gain. Feed conversion ratio (FCR) on a weekly basis was calculated on the basis of feed intake and weight gain. Two chicks, per replicate were randomly selected, weighed, and slaughtered, at the age of 42 days. Feet, head, and visceral organs, were detached and weighed again for the determination of the dressing percentage.

**Blood collection**

At the end of the experiment, blood (5 ml) was collected from two birds per replicate by cutting the jugular vein and centrifuged at 3000 rpm for 10 min. The serum was stored –20°C until analysis.

**Determination of MDA**

MDA was determined by the procedure, of Chand et al. (2016) using a spectrophotometer. Briefly, the serum sample of about 200 µl was mixed with 20% citric acid (pH 3.5), 0.81% sodium dodecyl sulphate and heated gradually at 94.9°C for 1 h. Then the mixture of pyridine and butanol was added, mixed and centrifuged at 400 rpm, for 10 min. The supernatants were collected and measured at 352 nm in a spectrophotometer (IRMECO Model U2020).

**Paraoxonase (PON1)**

PON1 enzyme was determined by the method described by Rehman et al. (2017) using spectrophotometer (IRMECO Model U2020). Briefly, 10 µl serum, 350 µl of the reagent (Tris–base buffer 0.1 M, pH 8.0) and calcium chloride (2 mmol) and 3 µl of paraoxason were mixed and measured spectrophotometrically at 503 nm.

**Antibody titre against Newcastle disease (ND)**

Antibody against ND was determined by the method described by Khan et al. (2014b) through hemagglutination-inhibition test.

**Statistical analysis**

Data was statistically analysed through analysis of variance (ANOVA) using the method described by Steel and Torrie (1997) through Statistical package (STATISTIC-2010).

**Results**

Mean feed intake of broiler supplemented with ginger and Se under heat-stressed condition is given in Table 3. During the second week and fourth, feed intake was significantly
The results of this study revealed that supplementation of Se and ginger under heat stress is given in Table 6. Mean dressing percentage, ND titre, MDA and PON1 in broiler chicks, fed with different levels of organic selenium and ginger supplementation under heat stress.

Mean within the same column, with different superscripts, differ significantly (P < 0.05).

Discussion

Most of the studies have documented the effect of Se and ginger singly. This is the first study, which investigated the comparative effect of single and combined effect of ginger and Se. The results of this study revealed that supplementation of (P < 0.05) high in the treated groups compared to the control. Feed intake was significantly (P < 0.05) high in broilers fed with combination of Se and ginger. During fifth week, significantly (P < 0.05) high feed intake was found in T1 and T3 compared to during sixth week and overall mean basis.

The effect of supplementation of ginger and Se on the body weight is given in Table 4. During second and sixth weeks, mean body weight was significantly (P < 0.05) high in the treated groups compared to the control. During third week, except T2, significantly (P < 0.05) high body weight was found in the treated groups compared to the control group. In the fourth week, significantly (P < 0.05) high body weight was recorded in T2, T3, and T5 compared to the control. Significantly (P < 0.05) high body weight was observed in T2, T3 and T5 compared to the control. Overall, significantly (P < 0.05) high body weight was observed in T3.

Mean FCR of control and treated groups of broiler under heat-stressed condition.

Table 3. Mean feed intake (g) of broiler supplemented with ginger and selenium under heat-stressed condition.

Table 4. Mean body weight gain in broiler chicks fed with different levels of organic selenium and ginger supplementation under natural heat stress.

Table 5. Mean FCR, in broiler chicks fed with different levels of organic selenium and ginger supplementation under heat stress.

Table 6. Mean Dressing percentage, ND titre, MDA and PON1 in broiler chicks, fed with different levels of organic selenium and ginger supplementation under heat stress.
different levels of organic Se and ginger improved feed intake, in all the supplemented, groups under heat-stressed broilers. The lower feed intake in the control group may be due to the decreased metabolic rate and altered metabolism that lead to lower feed consumption and ineffective digestion. Se has been known for proper utilization of protein, lipids and carbohydrates, although there are conflicting reports published in the literature on feed intake, weight gain and feed efficiency under high ambient temperature as reviewed by Habibian et al. (2015). The differences could be due to dose, duration and organic or inorganic form of Se. The high feed intake, body weight and FCR in the ginger supplemented group may be due to the fact that ginger increases the palatability (Khan et al. 2012b). Ginger supplementation also increases the secretion, of gastrointestinal, enzymes like lipase, maltase, and disaccharidase, (Zhang, et al. 2009).

In this study, serum MDA concentration decreased while PON1 concentration improved in the treated groups. Best results were found in birds fed with ginger and Se. During high heat temperature, mitochondrial respiratory chain activity increases resulting in high level MDA in the serum (Khan et al. 2014a). MDA is the indicator of oxidative stress and is the end product of polyunsaturated fatty acid peroxidation (Rehman et al. 2018). High level of MDA is the result of higher lipid peroxidation (Abudabos et al. 2018). Heat stress increases the production of free radicals and reduces the concentration of antioxidants (Chand et al. 2016). Studies have also documented that serum MDA level decreased with dietary supplementation of Se in broiler chickens (Habibian et al. 2015). It has been suggested that Se is a part of several antioxidant enzymes thereby suppressing the production of free radicals and inhibits lipid peroxidation (Khan 2011). Second, in Se deficiency, the absorption of vitamin E is suppressed, leading to the reduced antioxidant activities in the body (Habibian et al. 2015). According to Ghaffari et al. (2011), antioxidative activity of paraoxonase enzyme in the serum was improved when diet was supplemented with Se and vitamin E. Findings, of our results, are in line with, the results of Zhang et al. (2009) who recorded better activities of antioxidant enzymes and decreased level of MDA content when birds were given Ginger (5 g per kg).

In this study, the level of antibody titre increased in chickens supplemented with ginger and Se. Heat stress is known for reduced immune response in chickens (Khan et al. 2011). The higher immune response may be due to the increased weight of the lymphoid organs, enhanced phagocytic activity and higher production of antibodies (Khan et al. 2012a). Se is critical for the proper functions of the immune organ and its deficiency may lead to decreased phagocytic activities and lower production of interleukin and T-helper cells (Habibian et al. 2015). The supplementation of Se in broiler diet has improved the immune response in chickens by supporting the immune organs, production of antibodies and phagocytic activities of the cells.

From the results of this study, it was concluded that combined supplementation of ginger and Se had no synergistic effect on the performance of broiler chickens, however, the antioxidant capacity and immune response were improved when ginger and Se were used in combined form.

Disclosure statement

No potential conflict of interest was reported by the authors.

References

Abudabos AM, Alyemni AH, Dafalla YM, Khan RU. 2016. The effect of phyto-genic feed additives to substitute in-feed antibiotics on growth traits and blood biochemical parameters in broiler chicks challenged with Salmonella typhimurium. Environ Sci Pollut Res. 23:24151–24157.

Abudabos AM, Alyemni AH, Dafalla YM, Khan RU. 2018. The effect of phyto-genics on growth traits, blood biochemical and intestinal histology in broiler chickens exposed to Clostridium perfringens challenge. J Appl Anim Res. 46:691–695.

Cai SJ, Wu CX, Gong LM, Song T, Wu H, Zhang LY. 2012. Effects of nano-se-lenium on performance, meat quality, immune function, oxidation resistance, and tissue selenium content in broilers. Poultry Sci. 91(10):2532–2539.

Chand N, Muhammad S, Khan RU, Alhidyari IA, Rahman Zia ur. 2016. Ameliorative effect of synthetic γ-aminobutyric acid (GABA) on performance traits, antioxidant status and immune response in broiler exposed to cyclic heat stress. Environ Sci Pollut Res. 23:23930–23935.

Chand N, Naz S, Khan A, Khan S, Khan RU. 2014. Performance traits and immune response of broiler chicks treated with zinc and ascorbic acid supplementa-tion during cyclic heat stress. Int J Biometeorol. 58:2153–2157.

Chand N, Naz S, Maris H, Khan RU, Khan S, Qureshi MS. 2017. Effect of betaine supplementation on the performance and immune response of heat stressed broilers. Pak J Zool. 49:1857–1862.

Chand N, Naz S, Rehman Z, Khan RU. 2018. Blood biochemical profile of four fast-growing broiler strains under high ambient temperature. Appl Biol Chem. 61:273–279.

Ghaffari T, Nouri M, Irannejad E, Rashidi MR. 2011. Effect of vitamin E and selenium supplement on paraoxonase-1 activity, oxidized low density lipopro-tein and antioxidant defense in diabetic rats. BiomPacls. 1(2):121–128.

Habibian M, Sadeghi G, Ghazi S, Moenei MM. 2015. Selenium as a feed supple-ment for heat-stressed poultry: a review. Biol Trace Elem Res. 165 (2):183–193.

Khan RU. 2011. Antioxidants and poultry semen quality. World Poultry Sci J. 67(2):297–308.

Khan RU, Naz S, Dharma K. 2014a. Chromium: pharmacological applications in heat stressed poultry. Intern J Pharmacol. 10:213–317.

Khan RU, Naz S, Nikousefat Z, Tufarelli V, Javdani M, Qureshi MS, Laudavio D. 2012a. Potential applications of ginger (Zingiber officinale) in poultry diet. World Poultry Sci J. 68(2):245–252.

Khan RU, Naz S, Nikousefat Z, Tufarelli V, Javdani M, Rana N, Laudavio D. 2011. Effect of vitamin E in heat-stressed poultry. World Poultry Sci J. 67(3):469–478.

Khan RU, Rehman ZU, Javed I, Muhammad F. 2014b. Effect of vitamins, protein level and probiotics on immune response of molted male broiler breeders. J Anim Physiol Anim Nutr. 98(4):620–627.

Khan RU, Rehman ZU, Nikousefat Z, Javdani M, Tufarelli V, Dario C, Selvaggi M, Laudavio D. 2012b. Immunomodulating effects of vitamin E in broilers. World Poultry Sci J. 68(1):31–40.

Majid A, Qureshi MS, Khan RU. 2015. In vivo adverse effects of alpha-toco-pherol on the semen quality of male bucks. J Anim Physiol Anim Nutr. 99:841–846.

Rahman H, Qureshi MS, Khan RU 2014a. Influence of dietary zinc on semen traits and seminal plasma antioxidant enzymes and trace minerals of Beestal bucks. Reprod Domest Anim. 48(6):1004–1007.

Raza T, Chand N, Khan RU, Shahid MS, Abudabos AM. 2016. Improving the fatty acid profile in egg yolk through the use of hempseed (Cannabis sativa), ginger (Zingiber officinale), and turmeric (Curcuma longa) in the diet of Hy-line White Leghorns. Arch. Anim. Breed. 68:183–190.

Rehman ZU, Chand N, Khan RU. 2017. The effect of vitamin E, L-carnitine and ginger on production traits, immune response and antioxidant status in two broiler strains exposed to chronic heat stress. Environ Sci Poll Res. 24:26851–26857.

Rehman ZU, Chand N, Khan RU, Naz S, Alhidary IA. 2018. Serum biochemical profile of two broilers strains supplemented with vitamin E, raw ginger
(Zingiber officinale) and L-carnitine under high ambient temperatures. South Afr. J. Anim. Sci. 48:935–942.
Steel RGD, Torrie JH, Diekey DA. 1997. Principles and procedures of statistics: a biometrical approach. New York, NY: Mc Graw HillBook.
Zhang GF, Yang ZB, Wang Y, Yang WR, Jiang SZ, Gai GS. 2009. Effects of ginger root (Zingiber officinale) processed to different particle sizes on growth performance, antioxidant status, and serum metabolites of broiler chickens. Poultry Sci. 88(10):2159–2166.
Zhao X, Yang ZB, Yang WR, Wang Y, Jiang SZ, Zhang GG. 2011. Effects of ginger root (Zingiber officinale) on laying performance and antioxidant status of laying hens and on dietary oxidation stability. Poultry Sci. 90(8):1720–1727.