The effect of dietary sumac fruit powder (Rhus coriaria L.) on performance and blood antioxidant status of broiler chickens under continuous heat stress condition

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Abstract

The effects of different levels of 0.0 sumac fruit powder (Z-SFP), 0.25 (L-SFP), 0.50 (M-SFP) and 1% (H-SFP) along with 100 mg/kg alpha tocopherol acetate (VE) were investigated on performance and blood antioxidant status of broiler chickens under heat stress condition. L-SFP, M-SFP and VE birds showed higher body weight gain (BWG) than Z-SFP and H-SFP birds during the starter period (P<0.05). No significant differences were observed among the treatments for feed intake (FI) during the starter, grower and whole the experimental periods (P>0.05). Feed conversion ratio (FCR) of M-SFP and VE birds were lower than that of H-SFP birds during the starter period (P<0.05). Moreover, no significant differences were observed for FCR or BWG between the treatments during the grower and whole the experimental periods (P>0.05). The blood total antioxidant capacity (TAC), malondialdehyde (MDA) content and the activity of superoxide dismutase (SOD) and glutathione peroxidase (GPX) enzymes were not affected by dietary treatments at week 6 of age (P>0.05). It was concluded that although dietary SFP consumption can improve the performance of broiler chickens during the starter period under heat stress, it does not affect the performance during grower period or the blood antioxidant indices at week 6 of age.

Introduction

High environmental temperature decreases feed consumption, live weight and feed efficiency in broiler chickens (Debski et al., 2004). It is one of the most important stressors in the hot regions of the world (Altan et al., 2003; Wahab et al., 2010) resulting in the generation of enormous free radicals and other reactive oxygen species (ROS) to a level that overwhelms tissue antioxidant defense system and results in oxidative stress. The ravaging effects of oxidative free radicals are quenched by antioxidants (Akinwande and Adebule, 2003; Wahab et al., 2010). The magnitude of stress depends on the ability of the tissues to detoxify ROS by antioxidant defenses. Dietary manipulation is one of the usable methods for deletion or adjustment of high environmental temperature effects on performance in broilers (Debski et al., 2004). In this regard, antioxidant supplementation may provide beneficial effects against the stress-induced tissue damages (Wahab et al., 2010). Powerful defense mechanisms of enzymatic and non-enzymatic antioxidants must be developed in tissues against these free radicals to protect such damages effectively (Maini et al., 2007). For example, supplemental 30 mg zinc (ZnSO4 H2O) and 4.5 mg retinol/kg significantly have improved the live weight gain and feed efficiency in broiler chickens under heat stress condition (Kucuk et al., 2003). In response to the growing consumer demand, investigations on antioxidants from natural sources have been gained interest (Pokorny, 1991; Kosar et al., 2007). Natural antioxidants, as compared to synthetic products have the advantage that they are readily accepted by the consumers since they are considered to be safe and not a chemical (Steiner, 2009). In this regard, supplementation of non-enzymatic antioxidants such as dry powder of mint leaves (10 and 30 g/kg) during summer (Maini et al., 2007), turmeric rhizome powder (up to 0.75%) on blood antioxidant status with T3 induced ascites (Daneshyar et al., 2012) and turmeric rhizome powder (up to 0.75%) on body antioxidant status under normal temperature condition (Daneshyar et al., 2012) have been reported in broiler chickens.

Medicinal plants are receiving high attention as feed additives (Abdulkarimi et al., 2011) especially as the natural antioxidants. Sumac (Rhus Coriaria L.) is another medical plant that has antioxidant property. It is a small tree or shrub belongs to the Anacardiaceae family. Most of the plants in this family have essential oils (Steiner, 2009). Sumac grows in Mediterranean countries, North Africa, South Europe, Afghanistan and Iran. Hydrolysable tannin and remarkable quantities of flavonoids are the original components of sumac (Zalacain et al., 2003). Phenolic compounds are the secondary metabolites in plant materials (Kosar et al., 2007) that known to be responsible for antioxidant effect. Sumac has protective effects against the degradation of desoxyrribose and DNA (Giao et al., 2008; Kossah et al., 2011), and hepatic oxidative stress (Giao et al., 2010; Kossah et al., 2011). It seems that antioxidant effects of sumac exerted by flavonoided components and especially gallic acid (GA) (Chakraborty et al., 2009). Kosar et al. (2007) reported the amounts of 1.52, 4.14 and 4.13 percent galic acid for methanol extract, ethyl acetate extract and hydrolysed ethyl acetate extract of sumac respectively. Ferk et al. (2007) estimated the antioxidant effect of sumac 50 fold more than vitamins E and C. They also reported that daily consumption of 0.2 mg per kg body weight gallic acid (one of the major weight of sumac) for three days to male rats were showed protective effects on lymphocytes, brain, liver, colon and lung.

As mentioned, the antioxidant property of sumac has been reported already. So we hypothesized that it could positively affect the performance, and malondialdehyde (MDA as an indicator of lipid peroxidation), and superoxide dismutase (SOD) and glutathione peroxidase (GPX) activities in blood of broiler chickens under continuous heat stress condition.

Endogenous antioxidant enzymes such as SOD...
and GPX play vital role in scavenging oxidative radicals (Spurlock and Savage, 1993) and are considered as the indicators for body antioxidant status.

Materials and methods

A total of two hundred and fifty one-day-old male broiler chicks (Ross 308) were obtained from a commercial hatchery. All the birds were weighed on arrival and randomly divided between 25 pens (with 10 birds each) and each five were assigned to one of the experimental treatments. All the birds were fed the same starter (from day one to day 21 of age) and grower (from day 22 to day 42 day of age) diets in mash form but received the different levels of 0.0 sumac fruit powder (Z-SFP), 0.25 (L-SFP), 0.50 (M-SFP) and 1 percent sumac fruit powder (H-SFP) or 100 mg/kg alpha tocopherol acetate (VE) (Table 1). The different levels of SFP were replaced by sand in the basal diet. Fresh SFP (with total phenols of 34.57 mg/gr) was provided from a local market, grounded and used in the diets. Feed and water were provided ad libitum consumption.

To induce heat stress, the room temperature was set at 32±1°C throughout the whole experimental period. Birds were exposed to 23 h light and 1 h darkness during the experiment.

Body weight gain (BWG), feed intake (FI) and feed conversion ratio (FCR) were determined for the starter, grower and whole the experimental periods. At the end of the experiment (week 6), five birds per treatment were randomly selected and slaughtered. At slaughter, two series of blood samples were collected in anticoagulant tubes (EDTA). The blood samples were immediately transferred to laboratory, then one series of blood samples was centrifuged at 5000 rpm for 5 min and their plasma separated and stored at -20°C along with other series of blood samples for the later analyses.

Plasma TAC was determined using Randox total antioxidant capacity test kit (Randox Laboratories Ltd., Crumlin, UK), blood SOD activity by Ransod spectrophotometric kit (Ransod, Randox Laboratories Ltd.), blood GPX activity by Ransel spectrophotometric kit (Ransel, Randox Laboratories Ltd.) and plasma MDA concentration by MDA reaction with thiobarbituric acid followed by extraction with butanol (Kolahi et al., 2011). The colorimetric method and Folin-Ciocalteau reagent were used for determination of total phenols (McDonald et al., 2001). Firstly one gram SFP was crushed in 10 mL of (80%) methanol in a pestle and mortar. The extract was filtered and centrifuged at 5000 rpm for 5 min and the supernatant was collected. Then 0.5 mL of extract was mixed with Folin- Ciocalteau reagent (1:10 v/v) and Na2CO3 (1 mol). After 15 min, this solution was used for determination of total phenols using a spectrophotometer (single beam scanning UV/Visible spectrophotometer, M 501, Unicosh CO., Shanghai, China) at absorbance of 765 nm. Gallic acid was used as the standard.

The data were analyzed based on a completely randomized design using the GLM procedure of SAS (2002). Duncan’s multiple range test was used to separate the means when treatment means were significant (P≤0.05). The experimental protocols were reviewed and approved by the Animal Care Committee of the Urmia University.

Table 1. Composition of experimental diets.

| Ingredients, % | Starter, 0-21 d | Finisher, 22-42 d |
|----------------|----------------|------------------|
| Maize          | 31.08          | 31.98            |
| Wheat          | 20.00          | 25.00            |
| Soybean meal   | 39.68          | 33.92            |
| Soybean oil    | 3.50           | 3.95             |
| Dicalcium phosphate | 2.10 | 2.15         |
| Limestone      | 1.10           | 0.86             |
| Lysine         | 0.29           | 0.22             |
| DL-methionine  | 0.38           | 0.08             |
| Vitamin-mineral mix° | 0.50 | 0.50       |
| Sodium chloride| 0.37           | 0.54             |
| Sand #         | 1.00           | 1.00             |
| Total          | 100            | 100              |

Calculated analysis

| Dry matter, % | 85.16          | 85.43            |
| Metabolisable energy, Kcal/g | 2.85          | 2.95             |
| Crude protein, % | 22.01        | 20.00            |
| Fat, %         | 5.36           | 5.89             |
| Fibre, %       | 3.94           | 3.68             |
| Calcium, %     | 1.00           | 0.90             |
| Available phosphorus, % | 0.45      | 0.45             |
| Calcium/phosphorus | 2.22        | 2.00             |
| Chloride, %    | 0.33           | 0.30             |
| Sodium, %      | 0.16           | 0.15             |
| Methionine, %  | 0.70           | 0.58             |
| Lysine, %      | 1.43           | 1.24             |
| Arginine, %    | 1.54           | 1.38             |
| Methionine + cysteine, % | 1.07 | 0.73       |
| Tryptophan, %  | 0.29           | 0.26             |
| Tyrosine , %   | 0.98           | 0.89             |
| Threonine , %  | 0.85           | 0.77             |

°Supplied per kilogram of diet: vitamin A, 9000 IU; vitamin D3, 2000 IU; vitamin E, 18 IU; vitamin B12, 0.15 mg; riboflavin, 6.5 mg; calcium pantothenate, 10 mg; niacin, 30 mg; choline, 500 mg; biotin, 0.1 mg; thiamine, 1.8 mg; pyridoxin, 3 mg; folic acid, 1 mg; vitamin Kc, 2 mg; antioxidant (Ethoxyquin), 100 mg; zinc, 50 mg; manganese oxide, 100 mg; copper, 10 mg; Fe, 50 mg; I, 1 mg; Se, 0.2 mg. #Different levels of sumac fruit powder or vitamin E were replaced by sand in the diets.

Results

Performance

The effect of dietary SFP on BWG, FI and FCR during the starter, grower and whole the experimental periods is shown in Table 2. BWG of L-SFP, M-SFP and VE birds were higher than those of Z-SFP and H-SFP birds during the starter period (P<0.05). Moreover there was no significant differences between the treatments for BWG during the grower or whole the experimental periods (P>0.05). No significant differences were observed between the treatments for FI during the starter, grower and whole the experimental periods (P>0.05). Meanwhile during the starter period, FCR of M-SFP and VE birds were lower than that of H-SFP ones (P<0.05) but there was no significant difference between the FCR of other
treatments (P > 0.05). For grower period, no significant differences were observed between the treatments for FCR (P > 0.05). Although there was no significant difference between the treatments for FCR during the whole experimental period, a strong trend was observed (P = 0.08). Moreover, compared with the control, SFP consumption improved the BWG and FCR during the starter period (P < 0.05).

**Blood parameters**

At week 6 of age, none of the blood TAC content and the activity of SOD and GPX were affected by dietary treatments (P > 0.05) (Table 3). Although no significant difference was denoted for blood MDA content among the treatments at week 6 of age (P > 0.05), a high trend was detected (P = 0.09).

### Discussion

High ambient temperature negatively influence the performance of broilers (Sahin et al., 2002) through decreasing the feed intake and consequently nutrient intake, live weight gain and feed efficiency (Donkoh, 1989). In recent study, dietary supplementation of 0.5 percent SFP or 100 mg/kg alpha tocopherol acetate improved the performance of broiler chickens during the starter period. The positive effect of vitamin E has been well established in broiler chickens. For example, dietary supplementation of 250 mg/kg (Sahin et al., 2010) or 100 mg/kg of α-tocopherol (Hossinl-Mansoub et al., 2010) have increased the performance and reduced the negative effects of heat stress in broiler chickens. This is the first report regarding the dietary SFP effect on performance and blood antioxidant status in broiler chickens under heat stress condition. Although we did not assess the body or blood antioxidant indices at day 21 of age, the improved BWG of M-SFP fed birds during the starter period possibly is related to their higher body antioxidant capacity due to sumac consumption.

Although feeding 0.5 SFP improved the performance during the starter period but supplementation of higher level (1%) did not affect the performance. Lack of higher SFP effect on performance may be due to its tannic acid content. Tannins not only reduce the digestibility of dietary ingredients through the formation of complexes with the substrates or their related enzymes, but also disturb the transport mechanisms involved in absorption of simple molecules (Mansoori et al., 2007). As a conse-

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### Table 2. Average feed intake, body weight gain and feed conversion ratio of broiler chickens fed different levels of sumac fruit powder or 100 U/kg alpha tocopherol from day 1 to day 42 of age.

| Treatment | Starter | Grower | Total |
|-----------|---------|--------|-------|
| Feed intake |         |        |       |
| Z-SFP, g   | 988.32  | 2715.82| 3707.20|
| L-SFP, g   | 1083.89 | 2962.95| 4046.80|
| M-SFP, g   | 1007.10 | 2830.60| 3837.70|
| H-SFP, g   | 1005.65 | 2882.63| 3888.20|
| VE         | 1056.99 | 2819.06| 3876.10|
| Pooled SEM | 13.54   | 32.15  | 41.16  |
| P-value    | 0.11    | 0.16   | 0.11   |

### Orthogonal contrast

| Z-SFP vs S | 0.18   | 0.88  | 0.73  |
|------------|--------|-------|-------|

### Table 3. Blood activity of superoxide dismutase and glutathione peroxidase enzymes and total antioxidant capacity, and malondialdehyde of the different levels of sumac fruit powder fed broiler chickens at day 42 of age under continuous heat stress condition.

| Treatment | SOD, u/gHb | GPX, u/gHb | TAC, mmol/L | MDA, nm/mL |
|-----------|------------|------------|-------------|------------|
| Z-SFP     | 1407.6     | 40.99      | 0.75        | 2.77       |
| L-SFP     | 1405.2     | 38.54      | 0.73        | 2.46       |
| M-SFP     | 1646.0     | 46.18      | 0.75        | 1.40       |
| H-SFP     | 1604.3     | 40.22      | 0.81        | 2.20       |
| VE        | 1610.4     | 49.71      | 0.85        | 2.15       |
| Pooled SEM | 46.59    | 1.50       | 0.04        | 0.17       |
| P-value   | 0.44       | 0.12       | 0.86        | 0.09       |

### Orthogonal contrast

| Z-SFP vs S | 0.68 | 0.18 | 0.78 | 0.65 |

SOD, superoxide dismutase; GPX, glutathione peroxidase; TAC, total antioxidant capacity; MDA, malondialdehyde; Z-SFP, 0.0% sumac fruit powder level; L-SFP, 0.25% sumac fruit powder level; M-SFP, 0.5% sumac fruit powder level; H-SFP, 1% sumac fruit powder level; VE, 100 U/kg alpha tocopherol acetate diet.
quence, the growth performance of the birds decline (Mansoori et al., 2007). Growth depressing effect of tannic acid has been distinguished in rats (Glick and Joslyn, 1970) and chickens (Kubena et al., 2001). Even in wean-
ing pigs, Lee et al. (2010) observed a reduced average daily gain and feed efficiency by con-
sumption of up to 500 mg tannic acid in the diet. During the grower period, BWG of H-SFP fed birds was numerically higher than that of M-SFP birds. This phenomenon shows the compensatory growth of these birds due to completed enzymatic actions. The age related increases in the amounts of gastrointestinal enzymes have been reported in broiler chick-
ens already. For example, two fold increase of the lipase level in the intestinal contents have been reported by Nitsan et al. (1991) up to 21 days of age. Green and Kellog (1987) indicated doubled level of bile salts in intestinal contents during a 44 d period.

According to our results during the starter period, we expected better performance for SFP fed birds during the grower and whole experimental periods. But as shown, there were no significant differences between the treatments for performance that is consistent with the non-significant results of blood indices especially blood TAC and MDA content. In the same way, consumption of 1.35 mL sumac extract in 500 mL of drinking water (0.02 g/kg per animal) for 3 days did not change the activity of GPX and SOD in H2O2, and anti-benzopyrene-7,8-dihydro-diol-9,10-
epoxide induced DNA damage rats (Chakraborty et al., 2009). In disagreement with our results, Jassabi and Azirun (2010) fed sumac (300 mg/kg body weight) once a day for 14 days to microcystin treated Bab/C mice and observed attenuated microcystin induced reduction activities of GPX and SOD, and GSH content and even diminished MDA and lipid hydroperoxide contents in both the plasma and kidney homogenates. In the other experiment, sumac extract has decreased the oxidized purines and pyrimidines in induced DNA dam-
gaged rats (Chakraborty et al., 2009). This conflict may be due to more intense oxidative stress in our experiment because of contin-
uous heat stress during the whole experimental period. Our results for blood indices and performance show that dietary sumac supplemen-
tation could improve the performance under mild heat stress, since the experiment temper-
ature was 32°C, which is 2, 4 and 6 degrees warmer than the needs of broiler chickens dur-
ing week 1, 2 and 3 of age, respectively. After the starter period, exposing the birds to this temperature (32°C) induced intensive heat stress and increases the body peroxides pro-
duction (2.77 nm/mL blood MDA for control birds). Hence, despite the numerically better FCR (P=0.08) and blood MDA content (P=0.09) of M-SFP of H-SFP birds at the end of the experiment, dietary sumac supplemen-
tation changed none of the performance or the blood antioxidant indices. This phenomenon indicates that SFP can be effective to attenuate the mild oxidative stresses, such as mild heat stress of our experiment during starter period, but not preventing the negative effects of intensive heat stress in broiler chickens.

Conclusions

Consequently, dietary supplementation of 0.5% SFP can be effective to attenuate the neg-
a tive effects of mild heat stress on broiler chickens and improve the performance during the first 21 days of age. Higher SFP level (1%) did not affect the performance during the starter period due to having more tannin. Moreover, dietary SFP could not obvi ate the deleterious effects of intensive heat stress (32°C) during the grower or whole the experi-
mental periods.

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