# Effects of turmeric rhizome powder and source of oil in diet on blood metabolites, immune system and antioxidant status in heat stressed broiler chickens

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**Abstract** This study was conducted to determine the effect of dietary turmeric rhizome powder (TRP) as a natural antioxidant, and soybean oil, canola oil and tallow on lipid metabolism, blood metabolites, immune system, and antioxidant status of broiler chickens before (BHS, 28 d) and after exposure to heat stress (AHS, 42 d). Seven hundred and ninety two d-old male Arian broilers were randomly allotted to a 3×3 factorial arrangement with three levels of TRP (0, 0.4 and 0.8 g/kg) and three oil sources (canola, soybean and tallow). Each diet was fed to four replicates of 22 birds each. Heat stress (33ºC±1) was applied from 28-42 d of age. Canola oil diet decreased blood cholesterol in BHS and AHS birds. Birds fed 8 g/kg TRP diet had lower blood cholesterol in BHS and lower cholesterol and LDL in AHS. Serum concentration of HDL increased when the birds were fed TRP diets. Lower enzyme activity of creatine kinase (CK) and alkaline phosphatase (ALP) in BHS and CK, alanine aminotransferase (ALT), aspartate aminotransferase (AST), and ALP in AHS were observed in birds fed 8 g/kg TRP diets. The enzymatic activity was not affected by the type of oil, with the exception of heat stressed birds on canola oil diet having lower AST and ALP activities. Diets containing either of the oil sources and TRP did not affect the activity of LDH, and lipase, or the antibody titer against the Newcastle disease. The diets containing TRP increased the enzyme activity of GPx and SOD, and decreased blood TBARS index. Type of oil did not affect the antioxidant parameters in BHS. The canola diet caused a higher GPx activity in AHS, and tallow resulted in lower TBARS concentration. It was concluded that supplementation of canola oil and TRP might decrease blood cholesterol and LDH activity, and that TRP might improve the antioxidant status in broilers.

**Keywords**: turmeric powder, oil, heat stress, blood metabolite, antioxidant status, broiler chickens

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## Introduction

High environmental temperature and diets containing unsaturated fatty acids (USFAs) may enhance oxidative reactions in the animal body (Miret et al., 2003; Mujahid et al., 2007). The bis-allylic hydrogens of the methylene group present in USFAs react with free radicals and cause oxidative reactions (Hogg and Kalyanaraman, 1999), which initiate a chain-reaction known as lipid peroxidation (Roch et al., 2000). On the other hand, heat stress stimulates the metabolic oxidative capacity of the skeletal muscles by increasing the release of corticosterone and catecholamines and initiating lipid peroxidation in cell membranes (Sahin et al., 2001; Mujahid et al., 2007). Chronic heat stress may decrease metabolic oxidative capacity through a self-propagating scavenging system (Azad et al., 2010). Therefore, alternative strategies for n-3 fatty acid (FA)-enhanced products, without affecting the growth and product quality of chickens reared under heat stress condition or in hot climate, need to be considered. Natural antioxidant components such as vitamins E (α-tocopherol), C and A (provitamin A, β-caroten) (Roussan et al., 2008; Vakili et al., 2010; Rymer and Givens, 2010), and zinc (Sahin and Kucuk, 2003) and selenium (Malayoglu et al., 2009) or some medicinal plants may improve the performance and product quality of heat stressed broilers fed PUFAs or n-3 PUFAs (Fellenberg and Speisky, 2006).

Some reports have been published about the protect-

ive effects of medicinal herbs such as thymol, rosemary and turmeric rhizome against oxidative reactions (Hars et al., 2000; Williams et al., 2004). Although synthetic antioxidants were generally used in the past, their use has decreased due to undesirable effects on animal products and on animal or human health (Aruoma et al., 1999). Turmeric is a medicinal herb that inhibits many oxidative reactions. The bioactive compounds of turmeric are curcumin, demethoxycurcumin, bisdemethoxycurcumin, and tetrahydrocurcuminoids (Wuthi-udomler et al., 2000). Curcumin is the major component of turmeric, which has beneficial effects on many biological processes such as enhancing the antioxidant defense system (Chattopadhyay et al., 2004) or preventing lipid peroxidation (Sreejayan et al., 1997). Curcumin is a strong scavenger of the superoxide radical, a free radical that initiates potentially harmful oxidative processes such as lipid peroxidation (Rao and Rao, 1996). However, the antioxidant mechanism of curcumin is not yet well understood (Masuda et al., 2001). Supplementation of turmeric to broiler diets improved the performance parameters, immune system and antioxidant status of broiler chickens (Emadi and Kermanshahi, 2006; 2007). The purpose of this study was to determine the effect of dietary turmeric rhizome powder as a natural antioxidant, and soybean oil, canola oil and tallow as the oil sources, on lipid metabolism, blood metabolites, immune system, and antioxidant status of broiler chickens both before and after exposure to heat stress.

## Materials and methods

A total of 792 day-old male Arian broiler chicks were randomly allotted into thirty six floor pens (1.0 m × 2.4 m). Feed (three times per day) and water were available at all times. Birds were maintained on a photoscedule of 23L:1D. The corn-soybean meal starter and grower basal diets (mash form) were formulated to meet the nutrient requirements of chicks from hatching to 6 wk of age (Arian broiler Catalogue; Table 1). The chicks were randomly allotted to a 3×3 factorial arrangement of three levels of turmeric rhizome powder (0, 4 and 8 g/kg) and 3 sources of oil, canola oil, soybean oil and tallow, with 4 replicates of 22 chicks each. Birds were maintained under recommended environmental temperature from day 1 to 28. Heat stress was applied for 5 hours (10:30 to 15:30 hrs) each day from 28-42 d age. To apply the heat stress condition, the daily temperature was increased gradually (within 2 h; 8:30-10:30) from 21 to 33± $1^0$C , maintained for 5 h, and then decreased gradually (within 2 h; 15:30-17:30) to 21±$1^0$C. The relative humidity was 45-55% throughout the experiment.

### *Blood Parameters*

Blood samples were taken from two birds in each replicate before applying heat stress (at 28 d, BHS) and after applying heat stress (at 42 d, AHS), and processed as

**Table 1.** Composition of starter(0-21d) and grower (21-42d) diets fed to broiler chickens*

| Ingredients | Starter diets | | | Grower diets | | |
|---|---|---|---|---|---|---|
| | 0% TRP** | 0.4% TRP | 0.8%TRP | 0% TRP | 0.4% TRP | 0.8%TRP |
| Corn | 56.59 | 56.41 | 56.21 | 61.58 | 61.49 | 61.40 |
| Soybean meal | 36.61 | 36.57 | 36.43 | 30.99 | 30.92 | 30.80 |
| Turmeric powder | 0.00 | 0.40 | 0.80 | 0.00 | 0.40 | 0.80 |
| Oyster shell | 1.58 | 1.50 | 1.44 | 1.59 | 1.53 | 1.41 |
| Oil[1] | 2.50 | 2.50 | 2.50 | 3.00 | 3.00 | 3.00 |
| Dicalcium phosphate (DCP) | 1.51 | 1.45 | 1.43 | 1.59 | 1.44 | 1.42 |
| Salt | 0.52 | 0.46 | 0.42 | 0.55 | 0.50 | 0.40 |
| Vitamin premix[2] | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| Mineral premix[2] | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| DL-Methionine | 0.16 | 0.17 | 0.19 | 0.16 | 0.17 | 0.19 |
| L-Lysine | 0.03 | 0.04 | 0.08 | 0.04 | 0.05 | 0.09 |
| Chemical composition | | | | | | |
| Metabolizable energy (kcal/kg) | 2990 | 2985 | 2972 | 3080 | 3070 | 3062 |
| Crude protein % | 21.51 | 21.48 | 21.45 | 19.35 | 19.33 | 19.25 |
| Lysine (%) | 1.23 | 1.23 | 1.23 | 1.08 | 1.07 | 1.06 |
| Met +Cys (%) | 0.89 | 0.88 | 0.88 | 0.85 | 0.85 | 0.84 |
| Calcium (%) | 1.01 | 1.00 | 0.98 | 0.98 | 0.98 | 0.98 |
| Available phosphorous (%) | 0.45 | 0.45 | 0.44 | 0.44 | 0.43 | 0.43 |

*Soybean oil, canola oil and tallow replaced to oil, with minimum alteration in percentage of corn and soybean meal.

** TRP: Turmeric rhizome powder

[2]Supplied the following per kilogram of diet: Vit A, 25000 IU; Vit D, 5000 IU; Vit E, 12.5 IU; Vit K, 2.5 IU; Vit B1, 1 mg; Vit B2, 8 mg; Vit B6, 3 mg; Vit B12, 0.015 mg; Folic acid, 0.025 mg; nicotinic acid, 17.5 mg; calcium pantothenate, 12.5 mg; Fe, 80 mg; Cu, 10 mg; Mn, 80 mg; Se, 0.15 mg; I, 0.35 mg.

serum or plasma. The concentration of blood lipid (ml/dL), total protein (mg/dl) and blood enzyme activity (in U/L) of lactate dehydrogenase (LDH), creatine kinase (CK), aspartate aminotransferase (AST), alanine aminotransferase (ALT), alkaline phosphatase (ALP), and lipase were determined by autoanalyzer instrument (BioSystems autoanalyzer A15 Costa Brava 30, 08030 Barcelona, Spain) with biosystem kit.

### *Immune system*

For studying the antibody response, birds were vaccinated against live Newcastle disease vaccine (Lasota strain) in drinking water at 8 and 24 d of age. Two blood samples (2 mL each) were obtained from the wing vein of two birds from each replicate before and after heat stress application. Antibody titer was measured in the serum using the heamagglutination method (Wegmann and Smithies, 1966). Serum (2.5 ml) containing antibody was serially diluted into a 96-well plate. If antibodies during the incubation period were sufficient, hemagglutination would be inhibited completely. Antibody titers were reported as $\log_2$ of the reciprocal of the last serum dilution showing hemagglutination inhibition.

### *Antioxidant parameters*

Activities of glutathione peroxidase (GPx) and superoxide dismutase (SOD) were measured in 2 mL whole blood, washed and centrifuged (2500 rpm for 10 min) three times with 0.9% NaCl. The washed centrifuged erythrocytes volume was made up to 2.0 mL with cold redistilled water. Then, the lysate was prepared based on the instruction in the kits manual RANSEL and RANSOD (RANDOX Kits, Crumlin Co, UK) to determine the activity of GPx and SOD, respectively. The absorbance was read spectrophotometrically (CECIL instruments LTD, Aquarius, Cambridge, England) at 340 and 505 nm for GPx and SOD, respectively.

Plasma MDA concentration was measured in accordance with Yoshioka et al. (1979) by spectrophotometer at 520 nm, and expressed as nmol/mL TBARS (Thiobarbituric acid reaction substances) index.

### *Statistical Analysis*

Data were analyzed in a 3×3 factorial manner by ANOVA using the GLM procedures of the SAS and mean separation was performed by the Tukey's test ($P<0.05$). The percentage data were transformed using arcsine square root (x + 1) prior to statistical analysis.

## Results and Discussion

Lower cholesterol level was measured in birds fed canola oil both before and after exposing them to heat stress (Table 2). Serum triglyceride, HDL and LDL concentrations were not affected by the type of fats either before or after heat stress. Canola oil is a rich source of n-3 PUFAs. Most of SFAs are hypercholesterolemic while USFAs are hypocholesterolemic (Kris-Etherton and Yu, 1997). It has been shown that stearic acid has a unique effect on blood cholesterol; it may play a neutral effect or independent cholesterol lowering effects (Kris-Etherton 1993; Yu et al., 1995). The n-3 PUFAs have more hypocholesterolemic effects on blood lipids as compared to other fatty acids (Prasad, 2000). Therefore, decreased cholesterol level in birds fed canola oil may be due to higher levels of n-3 PUFAs compare to birds fed the tallow diet. This is in agreement with studies reporting cholesterol-lowering effects for n-3 PUFAs (Prasad, 2000; Chashnidel et al., 2010, Hosseini-Vashan et al., 2011). Birds fed 8 g/kg TRP diet had decreased blood

**Table 2**. Effect of turmeric rhizome powder (TRP) and oil source on blood lipids and total protein before and after heat stress application in broiler chickens[1].

| Main effects | Before heat stress | | | | | After heat stress | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Cholesterol (ml/dl) | HDL (ml/dl) | LDL (ml/dl) | Triglyceride (ml/dl) | Total protein (mg/dl) | Cholesterol (ml/dl) | HDL (ml/dl) | LDL (ml/dl) | Triglyceride (ml/dl) | Total protein (mg/dl) |
| Oil | | | | | | | | | | |
| Soybean | 113.89$^{ab}$ | 78.78 | 38.33 | 75.89 | 3.47 | 123.11$^{ab}$ | 74.56 | 42.78 | 74.44 | 3.60 |
| Canola | 106.89$^{b}$ | 77.33 | 39.67 | 78.78 | 3.53 | 113.78b | 74.11 | 45.11 | 74.33 | 3.54 |
| Tallow | 122.78$^{a}$ | 71.67 | 45.00 | 76.11 | 3.48 | 126.78a | 68.67 | 45.33 | 77.00 | 3.76 |
| TRP % | | | | | | | | | | |
| 0.0 | 122.44$^{a}$ | 71.89$^{b}$ | 43.56 | 75.11 | 3.51 | 131.00$^{a}$ | 69.57 | 48.56$^{a}$ | 76.22 | 3.58 |
| 0.4 | 113.43$^{ab}$ | 74.91$^{ab}$ | 41.33 | 77.00 | 3.50 | 116.44$^{b}$ | 70.11 | 44.56$^{ab}$ | 74.89 | 3.64 |
| 0.8 | 107.67$^{b}$ | 81.00$^{a}$ | 38.11 | 78.67 | 3.47 | 116.22$^{b}$ | 77.67 | 40.11$^{a}$ | 74.67 | 3.69 |
| SEM | 4.098 | 3.384 | 2.228 | 3.958 | 0.112 | 3.038 | 3.231 | 2.912 | 3.464 | 0.0949 |
| Source of variation | P-Value | | | | | | | | | |
| Oil | 0.0417 | 0.3147 | 0.1213 | 0.849 | 0.9042 | 0.0204 | 0.3770 | 0.7919 | 0.8288 | 0.2896 |
| TP | 0.0489 | 0.0423 | 0.2649 | 0.819 | 0.9585 | 0.0037 | 0.1688 | 0.0509 | 0.9429 | 0.7534 |
| Oil*TP | 0.9811 | 0.8474 | 0.9480 | 0.627 | 0.8296 | 0.3185 | 0.7416 | 0.6878 | 0.2987 | 0.0826 |

[a,b] Means within a column with common superscript (s) are not different ($P > 0.05$).

cholesterol before or after heat stress. Concentrations of LDL in BHS, and triglyceride in BHS and AHS birds were not affected by TRP; however, heat stressed birds fed 8 g/kg TRP had lower LDL. The birds fed TRP had significantly higher blood HDL as compared to the control at 28 days. On day 42, blood HDL concentration was non-significantly higher (P>0.05) in birds fed the TRP diets. Curcumin decreases blood cholesterol by increasing cholesterol 7α-hydroxylase (CYP7A1) synthesis as a rate limiting enzyme in the biosynthesis of bile acid from cholesterol (Kim and Kim, 2003). Hypercholesterolemia increases the risk of cardiovascular disease and atherogensis. Kim and Kim (2003) reported that rats fed curcumin had lower atherogenic index. Therefore, TRP supplementation of diets containing n-3 PUFAs (canola oil) could decrease cardiac disorders in birds and improve the meat quality for consumers and indirectly influence human health.

Diets containing different types of oils did not affect the activity of LDH, CK, ALP, AST, ALT and lipase of birds either before or after heat stress, except in the heat-stressed birds fed canola oil which had lower ALP and AST compared to the control (Table 3). Increased levels of serum ALT, AST and LDH are used as indicators of the liver damage (Ozaki et al., 1995). High ambient temperature disturbs the liver and heart functions. Lower activity of ALP in birds fed canola oil and 8 g/kg TRP indicates decreased adverse effects of HS on the liver and better metabolism in skeletal muscles. There are reports showing no changes in the activity of ALT and AST in rats fed curcumin (Kim and Kim, 2003; Bassavaraj et al., 2011). No changes in the activity of lipase and LDH in BHS and AHS were observed in TRP groups. The TRP diets decreased the activity of ALP, CK in BHS and AHS, and that of ALT and AST in heat stressed birds. The lower activity of transaminase may be due to improved liver function of birds fed canola oil and 8 g TRP/kg diets. It has been reported that curcumin decreased the activity of ALT, AST and LDH in iron injected rats (Reddy and Lokesh, 1996). The ALP activity decreased in chicks fed 8 g TRP /kg compared to the control birds. Birds fed diet that contained both TRP and canola oil or soybean oil had lower enzyme activity under high ambient temperature. These suggest that the addition of TRP and canola oil alone or in combination may decrease the adverse effects of heat stress.

### *Immune system*

The titer of antibody production against ND was not affected by the type of oil or TRP concentration in the either before or after heat stress (Table 4), supporting other published data (Emadi and Kermanshahi, 2007; Sugiharto et al., 2011). This may be due to an interaction between USFAs and high ambient temperature; TBARS were increased in birds fed unsaturated FAs. Thus supplementation of TRP may neutralize the side effects of unsaturated oil diets under heat stress. These findings suggest that the addition of TRP to diets containing unsaturated FAs may be useful for health of the birds under heat stress.

### *Antioxidant system*

The TRP diets increased the activities of GPx and SOD in BHS and AHS birds (Table 4). The activities of GPx and SOD in BHS and AHS were not affected by the type of oils with the exception of heat- stressed birds fed diets containing canola oil, which were higher than those fed the soybean diet. Oxidative stress in birds results in

**Table 3**. Effect of turmeric rhizome powder (TRP) and oil sources on enzyme activity(U/L) of before and after heat stressed broiler chickens[1].

| Main effects | Before heat stress | | | | | | After heat stress | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | LDH[2] | CK | AST | ALT | ALP | Lipase | LDH | CK | AST | ALT | ALP | Lipase |
| Oil | | | | | | | | | | | | |
| Soybean | 796 | 2079 | 177.67 | 11.72 | 1248 | 843 | 829 | 6245 | 215.39$^{a}$ | 21.48 | 1970$^{ab}$ | 959 |
| Canola | 674 | 2775 | 168.94 | 11.61 | 1396 | 715 | 858 | 6530 | 196.49$^{b}$ | 21.46 | 1920$^{b}$ | 838 |
| Tallow | 910 | 2900 | 180.20 | 12.26 | 1355 | 910 | 903 | 6438 | 206.81$^{ab}$ | 21.69 | 2089$^{a}$ | 1018 |
| TRP | | | | | | | | | | | | |
| 0.0 | 896 | 2990$^{a}$ | 183.06 | 12.46 | 1515$^{a}$ | 925 | 939 | 7255$^{a}$ | 229.94$^{a}$ | 23.25$^{a}$ | 2162$^{a}$ | 1047 |
| 0.4 | 790 | 2791$^{ab}$ | 177.91 | 12.04 | 1311$^{ab}$ | 754 | 841 | 6066$^{b}$ | 196.03$^{b}$ | 21.22$^{b}$ | 1983$^{b}$ | 927 |
| 0.8 | 695 | 2603$^{b}$ | 165.84 | 11.1 | 1172$^{b}$ | 789 | 811 | 5893$^{b}$ | 192.72$^{b}$ | 20.18$^{b}$ | 1834$^{b}$ | 839 |
| SEM | 66.55 | 46.616 | 4.055 | 0.338 | 49.071 | 61.814 | 57.139 | 210.92 | 6.193 | 0.383 | 62.87 | 56.062 |
| Source of variation | P-Value | | | | | | | | | | | |
| Oil | 0.0679 | 0.0535 | 0.1393 | 0.3607 | 0.2476 | 0.1044 | 0.6562 | 0.6242 | 0.0462 | 0.8970 | 0.0420 | 0.0947 |
| TP | 0.1308 | 0.0001 | 0.0567 | 0.0549 | 0.0026 | 0.1468 | 0.2825 | 0.0002 | 0.0003 | 0.0001 | 0.0003 | 0.0495 |
| Oil*TP | 0.9021 | 0.4138 | 0.9790 | 0.8102 | 0.8603 | 0.8851 | 0.6520 | 0.5026 | 0.7379 | 0.9858 | 0.9061 | 0.3098 |

[a,b] Values within a column with no common superscript are significantly different (P <0.05).

[2]LDH: Lactate dehydrogenase, CK: Creatine kinase, AST: Aspartate aminotransferase, ALT: Alanine aminotransferase, ALP: Alkaline phosphatase.

Table 4. Effect of turmeric rhizome powder (TRP) and oil sources on blood antioxidant enzyme activity(U/L) and TBARS index (nmol/ml) and ND titer of before and after heat stressed broiler chickens[1].

| Main Effects | Pre-heat stress | | | | Post-heat stress | | | |
|---|---|---|---|---|---|---|---|---|
| | GPx[2] (U/L) | SOD (U/L) | TBARS (nmol/ml) | ND Titer | GPx (U/L) | SOD (U/L) | TBARS (nmol/ml) | ND titer |
| Oil | | | | | | | | |
| Soybean | 167.15 | 177.72 | 0.599[a] | 6.22 | 225.33[b] | 171.00 | 0.605[a] | 5.89 |
| Canola | 164.52 | 172.62 | 0.650[a] | 5.78 | 246.40[a] | 165.41 | 0.578[a] | 5.67 |
| Tallow | 172.26 | 173.41 | 0.527[b] | 5.89 | 240.80[ab] | 175.20 | 0.517[b] | 5.78 |
| TRP | | | | | | | | |
| 0.0 | 149.34[b] | 167.30[b] | 0.734[a] | 5.67 | 222.59[b] | 156.03[b] | 0.650[a] | 5.44 |
| 0.4 | 170.20[a] | 173.78[ab] | 0.610[b] | 5.75 | 235.56[b] | 175.23[a] | 0.556[b] | 5.67 |
| 0.8 | 184.39[a] | 182.57[a] | 0.532[b] | 6.56 | 254.38[a] | 180.35[a] | 0.504[b] | 6.22 |
| SEM | 4.368 | 3.004 | 0.0198 | 0.333 | 4.969 | 3.802 | 0.0259 | 0.287 |
| Source of variation | P-Value | | | | | | | |
| Oil | 0.4451 | 0.4543 | 0.0192 | 0.6256 | 0.0162 | 0.2076 | 0.0248 | 0.8618 |
| TP | 0.0052 | 0.0001 | 0.0001 | 0.1220 | 0.0005 | 0.0003 | 0.0001 | 0.1712 |
| Oil*TP | 0.8285 | 0.0093 | 0.5523 | 0.8643 | 0.1634 | 0.9758 | 0.6760 | 0.9889 |

a,bValues within a column with no common superscript are significantly different (P <0.05).

[2]GPx: Glutathione peroxidase, SOD: Superoxide dismutase, TBARS: Tiobarbituric acid reaction score.

an increase in oxidized glutathione (GSSG), the ratio of oxidized to reduced glutathione (GSSG/GSH) in tissue, and in plasma lipid peroxides (Bottje et al., 1998). Decreased activity of major enzymatic antioxidants in birds fed unsaturated fatty acids, especially n-6 FAs may be due to higher susceptibility of PUFAs to oxidation in high ambient temperature. There is an interaction between TRP and oil source, as heat stressed birds fed the diet supplemented with canola oil and TRP had higher GPx activity. The phenolic compounds of TRP may contribute to antioxidant defense system. The degree of antioxidant capacity is in order of: curcumin > demethoxycurcumin > bisdemethoxycurcumin. A group of these components must be present for strong antioxidants activity (Miquel et al., 2002). The TBARS index increased when canola oil or soybean oil was included I the diet compared to the tallow diet. The TRP diet also decreased plasma TBARS index both in BHS and AHS periods. These findings suggest that diets contained highly unsaturated fatty acids may be more susceptible to oxidative reaction in high ambient temperature. Thus supplementation of diet with unsaturated oils without antioxidant components may cause a series of oxidative reactions in tissues, which may decrease the meat quality in birds reared under heat stress. An increase in oxidative reaction may cause oxygen-deficiency in birds and increase the chance of pulmonary and cardiac disorders. On the other hand, increased oxidative reaction in broiler reduces the stability and quality of meat. It also affects the meat flavor and taste (Rymer and Givans2005; Fellenberg and Speisky, 2006). Therefore, it is recommended to decrease oxidative reaction especially at high ambient temperature by dietary supplementation of natural antioxidant such as turmeric. It is suggested that addition of TRP to diets containing unsaturated fatty acids, especially N-3 PUFAs, might improve the liver and heart functions and stability of meat in heat stressed broiler chickens and indirectly improve the human health.

## Conclusion

It was concluded that the addition of canola oil to broiler diets may decrease cholesterol level and the activity of ALT, ALP and GPx. The blood HDL and glutathione peroxidase activities improved in birds fed with the canola diet. The TRP diets reduced cholesterol, LDL and dehydrogenase activity. The activities of GPx and SOD and blood HDL level were improved in birds fed TRP. TRP reduced the concentration of malondialdehyde. Therefore, supplementation of TRP and canola oil might improve the metabolite parameters and decrease oxidative reactions in birds reared under high ambient temperature.

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# اثر پودر زردچوبه و منبع چربی بر متابولیت‌های خونی، سامانه ایمنی، و وضعیت ضداکسیدانی جوجه‌های گوشتی در تنش گرمایی

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**چکیده** در این آزمایش، تأثیر افزودن پودر زردچوبه بعنوان ضداکسیدان طبیعی، و روغن‌های کانولا، سویا و پیه حیوانی بر غلظت لیپیدهای خونی، متابولیت‌های خونی، سامانه ایمنی و وضعیت ضداکسیدانی جوجه‌های گوشتی قبل و بعد از تنش گرمایی بررسی شد. تعداد ۷۹۲ جوجه یکروزه سویه آرین در ۹ تیمار، ۴ تکرار و ۲۲ جوجه در هر تکرار توزیع شدند. این آزمایش به‌صورت فاکتوریل ۳×۳ در قالب طرح کاملاً تصادفی با سه نوع چربی (سویا، کانولا و پیه حیوانی)، و سه سطح پودر زردچوبه (۰، ۰/۴ و ۰/۸درصد) انجام شد. در دوره تنش گرمایی (۴۲-۲۹ روزگی) روزانه به مدت ۵ ساعت دمای ۱ ±۳۳ درجه سانتی گراد و رطوبت نسبی حداقل ۵۰ درصد اعمال شد. در جوجه‌های تغذیه شده با روغن کانولا غلظت کلسترول در شرائط قبل و بعد از تنش گرمایی کاهش یافت. غلظت کلسترول خون در جوجه‌های تغذیه شده با ۸ گرم در کیلوگرم پودر زردچوبه (TRP) قبل از تنش و غلظت کلسترول و LDL بعد از تنش گرمایی بطور معنی‌داری کاهش یافت. زردچوبه میزان HDL-C خون را افزایش داد (P<۰/۰۵) درجوجه های تغذیه شده با ۸گرم TRP، میزان فعالیت کراتین کیناز و آلکالین فسفاتاز قبل از تنش و کراتی کیناز، آلانین آمینوترانسفراز، آسپارتات آمینوترانسفراز و آلکالین فسفاتاز در شرایط بعد از تنش گرمایی بطور معنی داری کاهش یافت. فعالیت آنزیم‌های خونی تحت تأثیر منبع روغنی قرار نگرفت بجز فعالیت ALP, AST که در جوجه‌های تغذیه شده با روغن کانولا حداقل شد. منبع روغن و سطح پودر زردچوبه بر میزان فعالیت LDH و لیپاز و تیتر پادتن نیوکاسل اثری نداشت. افزودن پودر زردچوبه به جیره باعث افزایش میزان فعالیت SOD، و GPx و کاهش شاخص TBARSگردید. جوجه‌های تغذیه شده با روغن کانولا، دارای سطح بالاتر فعالیت آنزیم GPx و چربی حیوانی باعث کاهش TBARS گردید. بنابراین مکمل نمودن روغن کانولا و پودر زردچوبه احتمالا باعث کاهش کلسترول وفعالیت آنزیم‌های کبدی و بهبود وضعیت ضداکسیدانی جوجه‌های گوشتی تحت تنش می شود.