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Effects of Turmeric Rhizome Powder and Oil Sources on Performance, Immune System and Bone Characteristics in Pre and Post Heat Stressed Broiler Chickens

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Authors' contributions

This work was carried out in collaboration between all authors. Author SJHV wrote the designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the paper. Authors AG and AY managed the literature searches and layout. All authors read and approved the final manuscript.

Original Research Article

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ABSTRACT

Aims: The objective of this study was to evaluate the effects of dietary Turmeric Rhizome powder (TRP) as a natural antioxidant and soybean (SO), canola oil (CO) and tallow (T) on performance, immune system, relative weight of organs and bone quality in 28d and post heat stressed broilers.
Study Design: The experiment was done in completely randomized design with 3×3 factorial arrangement.
Place and Duration of Study: Sample: Department of Animal Science, between July 2010 and September 2011.
Methodology: 792 day-old broilers were randomly allotted to a 3×3 factorial arrangement with three levels of TRP (0, 0.4 and 0.8%) and three oil sources of canola and soybean oil and tallow. Heat stress (33±1ºC) was applied from 10:30 to 15:30 of every day for all birds from 28-42d.

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Results: Diets did not affect feed consumption, production index (PI), protein efficiency ratio (PER) and energy efficiency ratio (EER) of birds at 28d and AHS. Higher BW and lower FCR were observed in broilers fed SO and CO as compared to those fed tallow in PHS. The heat stressed birds fed diet contained 8g/kg TRP have higher BW and lower FCR as compared to those fed 4g/kg TRP diet. The antibody production against SRBC, IgG and IgM were not affected by dietary treatments. The diaphysis diameters, thickness of lateral and medial walls and medullary canal diameter and abdominal fat were altered by dietary inclusion of TRP or oils in heat stressed chickens.
Conclusion: Inclusion of oils and supplementation of TRP to diet may affect performance, relative weight of abdominal fat and heart and bone characteristics of broilers reared under heat stress condition.

Keywords: Turmeric powder; oil sources; heat stress; performance and bone characteristics.

ABBREVIATIONS

SRBC: Sheep Red Blood Cell; IgM: Immunoglobulin M; IgG: Immunoglobulin G; PER: Protein Efficiency Ratio; EER: Energy Efficiency Ratio; Fas: Fatty Acids; TBARS: Thiobarbituric Acid Reactive Substance; SO: Soybean Oil; CO: Canola Oil; T: Tallow; TRP: Turmeric Powder; PI: Production Index.

1. INTRODUCTION

Dietary oils provide a large amount of calories in high-energy rations for fast growing broiler chickens. Oils are good source of energy for chickens reared in hot climate, because they have low heat increment and bulk. Oil diets supply nutrient required for broilers with minimum bulk [1]. Although, the unsaturated fatty acids especially n-3 fatty acids are better digested, but they are more susceptible to oxidation and thus the quality of meat is reduced [2]. Heat stress stimulates the metabolic oxidation capacity of skeletal muscle by increasing the release of corticosterone and catecholamines and initiates lipid peroxidation in cell membranes [3,4]. The acute heat stress has more negative impact than chronic heat stress. Chronic heat stress may decrease metabolic oxidation capacity due to a self-propagating scavenging system, though the system may not be fully activated [5]. Therefore, alternative strategies for enhancing tissue n-3 FAs content without affecting growth and product quality must be devised. The nature of dietary fats (degree of unsaturation) has been reported to influence the susceptibility to oxidation [6], which reflects the so-called thiobarbituric acid reactive substance (TBARS) value of broilers tissue [7]. Febel et al. [8] were reported that dietary oils including lard, linseed, sunflower and soybean oil did not affect the body weight and feed: gain of broiler chicks. Thus supplementation of some antioxidants such as vit E, C or some medicinal plants to broiler diets may improve the growth parameters, broiler products and meat quality. Turmeric powder (TRP) is a medicinal herb that may impact the nutrient metabolism in broiler chicks. The major component of TRP is curcumin that contributes in antioxidant defense system [9]. Inclusion of TRP to broiler diets may affect body weight and feed: gain in hot climate. A higher relative weight of breast and thigh meat and lower relative weight of abdominal fat was reported in birds fed diets contained TRP [10,11]. The lower abdominal fat was reported at higher levels of turmeric powder diets [12,13]. However the abdominal fat content was not affected by the concentrations of TRP in broiler diet [14]. Ashayerizadeh and coworkers [15] did not observe any impact of TRP on relative weight of heart, liver, gizzard, and abdominal fat. Diets contained high n-6 fatty acids improved the retention of calcium and phosphorous in bone of broiler chickens [16,17].

The purpose of this study was to evaluate the effect of dietary Turmeric Rhizome powder (TRP) as a natural antioxidant and soybean, canola oil and tallow on performance, immune system, relative organ weights and bone quality in pre and post heat stressed broiler chickens.

2. MATERIALS AND METHODS

Seven hundred ninety two day-old male Arian broiler chicks were randomized into thirty six experimental units and maintained on a commercial light schedule for 6 wks. The corn-soybean meal starter and grower basal diets (mash form) were formulated (NRC 1994) to meet or exceed the nutrient requirements of chicks from hatch to 6 wk as recommended by the Arian recommendation catalog (Table 1). Feed and water were provided ad libitum. The chicks were randomly allotted to a 3×3 factorial arrangement of three levels of turmeric rhizome powder (0, 0.4 and 0.8%) and three fat sources of canola, soybean oil and tallow with 4 replicates of 22 chicks each. Birds were maintained under recommended environmental temperature of Arian strain committee from day 1 to 28. Heat stress was applied for 5 hours daily (10:30 to 15:30) to all birds from 28-42d. The daily temperature was gradually (within 2h) increased from 21 to 33±1ºC and gradually (within 2h) decreased to 21±1ºC before and after heat stress time, respectively.

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

Ingredient	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 (TRP)	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
Vit. Premix[2]	0.25	0.25	0.25	0.25	0.25	0.25
Min. 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
Nutrient composition						
Metabolisable 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

[1]-soybean oil, canola oil and tallow are replaced the oil to provide nine starter or grower diets (3 TRP levels 3 oil sources). With minimum alteration in percentage of corn and soybean meal, all diets are isocaloric and isonitrogenous. [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, 1mg; Vit B2, 8mg; 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*

2.1 Data and Sample Collection

Chicks' weight and feed consumption were weekly recorded for each experimental unit. The feed: gain ratio was calculated (g feed intake: g weight gain). Daily mortality was recorded. The Energy efficiency ratio (EER; grams of weight gain ×100/total ME intake) and protein efficiency ratio (PER; grams of weight gain per gram of protein intake) and production index or European production index (PI; 100*[(body weight*livability)/ (FCR* rearing period (day))]) were calculated. Two samples of 2 ml of blood were obtained from the ulnar vein of two birds from each replicate pre (28d) and post heat stress (42d). These samples were used to provide the sera to study the antibody production against SRBC [18].

One bird from each pen in pre and post heat stress was selected, weighed, slaughtered, and the organs such as breast, thigh, gallbladder, spleen, bursa of fabricius, thymus, liver, heart and small intestine were weighed. The birds were killed as per the institutional standard procedure of of Animal Science of Ferdowsi University of Mashhad, Iran.

2.2 Bone Characteristics

The left tibia of slaughtered heat stressed birds was removed, labeled and immersed in boiling water (100ºC) for 15 min. After cooling to room temperature, the meat and fat around patella was removed by hand. The tibial length and bone weight were determined. The outside diameters of each bone were measured using a caliper at midpoint. After breaking, the thicknesses of the medial and lateral walls were measured at the midpoint. Medullary canal diameter was computed by subtracting the thicknesses of the medial and lateral walls from the diameter at the diaphysis.

To determine bone ash content, the tibia samples were oven-dried (Thelco Laboratory Oven, Thermo Electron Corporation, Pittsburgh, PA) at 101ºC for 24h. They were weighed to obtain a dry weight and ash in a muffle furnace (Series 550 Isotemp Muffle Furnace, Fisher Scientific, Pittsburgh, PA) at 550ºC for 12h. Remaining ash was weighed to determine total tibial ash. The percentage ash was determined relative to dry weight of the tibia [19]. The ash samples were digested with nitric acid and perchloric acid, then prepare for inject to atomic absorption spectrophotometer (Analyst 400, Perkin-Elmer, CT, USA) to measure the calcium concentration [20] or concentration of phosphorous by spectrophotometer.

2.3 Statistical Analysis

Data were analyzed as a 3×3 factorial (3 levels of turmeric powder involved 0, 0.4 and 0.8%of diet and 3 kinds of oil involved Soy, Canola and Tallow) by ANOVA using the GLM procedures of SAS [21]. The statistical differences between means were analyzed by Tukey's test ($P<0.05$). The percentage data were transformed using arcsine square root (x + 1) prior to statistical analysis.

3. RESULTS AND DISCUSSION

The effect of turmeric rhizome powder (TRP) and oil sources (canola, soybean oil and tallow) on performance parameters of pre and post heat stressed broiler chickens are shown in Table 2. Feed consumption did not affected by the inclusion of oil and TRP in diets. Higher body weight (BW) and lower feed: gain (FCR) observed in broilers fed soybean and canola oil as compared to those fed tallow pre heat stress (PHS). Heat stressed broilers fed different oil diets were similar in performance. There were not an interaction among oil and TRP on BW and FCR of heat stressed broilers. Several researchers reported similar observations with respect to performances among birds fed different types of fat [8,22,23]. Soybean and canola oil diets improved the BW and FCR of birds as compared to those fed tallow in pre heat stress. This may due to higher digestible unsaturated fatty acids than saturated fatty acids [24]. No improved performance of heat stressed birds fed unsaturated fatty acids may due to the role of unsaturated bonds and high temperature in stimulating of oxidation reaction [3]. TRP diets improved the BW and FCR after heat stress (AHS) with the exception of those fed diets contained canola oil and TRP. The heat stressed broilers fed diet contained 8g/kg TRP had higher body weight and lower FCR as compared to those fed 4g/kg TRP diet. The improved performance (BW and FCR) of heat stressed broilers that fed TRP diets may be due to reduce oxidative reaction, oxidative stress and free radical. Similar findings in broilers fed different kind of oils (sunflower, flaxseed and fish oil) were reported. These findings were approved by Suvanated et al. in broilers fed TRP diets [25]. Therefore inclusion of unsaturated oil sources with supplementation of TRP could improve the performance of broilers pre heat stress. Adding of unsaturated oil sources in high ambient temperature due to high susceptibility to oxidation may reduce the performance of broilers and need to add some antioxidant components.

The production index (PI), protein efficiency ratio (PER) and energy efficiency ratio (EER) did not reveal significant alteration among birds fed different diets at PHS and AHS conditions (Table 3). However some researchers believed that unsaturated fatty acids have higher digestion coefficient [26]. Although unsaturated fatty acids improved performance and EER, PER and PI of broilers, but broilers fed these oils did not show better indices and this may be due to the higher rate of oxidative reactions in heat stressed birds. Birds fed canola and soybean oils with high levels of TRP provide better PI as compared to other groups in the PHS condition. This may be due to higher digestibility of unsaturated oils in birds reared at the optimum environmental temperature.

The antibody production against SRBC, IgG and IgM of broilers in PHS and AHS conditions are shown in Table 4. The antibody production against SRBC, IgG and IgM were not altered in birds fed oils and/or TRP diets in pre and post heat stress conditions. An improvement in antibody production response to SRBC observed in broilers fed omega-3 fatty acids and antioxidant components such as vit E and D and zinc [27]. Omega-3 polyunsaturated fatty acids (PUFA) rather than other PUFAs are associated to the alteration of immune and inflammatory response [28]. These modulations depends on different factors, such as the nature of fatty acids added to diet, the concentration of fatty acids, the duration of supplementation with dietary lipids, or differences among animal species fed dietary lipids [29]. The environmental condition involved the ambient temperature, environment mist, broiler density and methods of preparation of diets may also affect the response of birds. Although some previous researches reported that omega-3 PUFAs improved the immune system and antibody production titer in serum of broilers [27,30], but omega-3 PUFAs may not be the cause of improvement in the immune system of birds exposed to high ambient temperature, because both of them stimulate the oxidative stress [3,31].

Table 2. Effect of turmeric rhizome powder (TRP) and oil sources (canola, soybean oil and tallow) on performance parameters of pre and post heat stressed broiler chickens

Main effect		Pre-heat stress			Throughout heat stress		
		Feed intake (g)	Body weight (g)	Feed: gain (g:g)	Feed intake (g)	Body weight (g)	Feed: gain (g:g)
Oil							
	Soybean	1606	1127a	1.424b	2046	943	2.170
	Canola	1619	1119ab	1.436b	2041	951	2.096
	Tallow	1632	1102b	1.483a	2083	986	2.113
TRP %							
	0.0	1611	1118	1.440	2054	984ab	2.087b
	0.4	1640	1114	1.468	2011	918b	2.190a
	0.8	1606	1116	1.435	2088	994a	2.101ab
SEM		181.28	52.45	0.0087	389.05	97.86	0.0223
Source of variation		---		P-Value	---		
Oil		0.7598	0.0342	0.0296	0.7866	0.1103	0.1705
TP		0.5881	0.9716	0.3131	0.4611	0.0320	0.0485
Oil*TP		0.7938	0.0435	0.0943	0.5223	0.7911	0.1251

[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 22 chicks per pen

Table 3. Effect of turmeric rhizome powder (TRP) and oil sources (canola, soybean oil and tallow) on production index (PI), energy (EER) and protein efficiency ratio(PER) of pre and post heat stressed broiler chickens

Main effect		Pre-heat stress			Post heat stress		
		PI	EER	PER	PI	EER	PER
Oil							
	Soybean	2.803	18.486	2.760	2.470	13.180	2.108
	Canola	2.786	18.488	2.731	2.433	13.639	2.159
	Tallow	2.630	18.043	2.693	2.549	14.351	2.242
TRP %							
	0.0	2.774	18.318	2.734	2.605	13.868	2.160
	0.4	2.693	18.085	2.679	2.323	13.176	2.106
	0.8	2.750	18.613	2.772	2.525	14.126	2.243
SEM		0.0482	1.4872	0.0356	0.0891	2.872	0.0603
Source of variation		---	P-Value	---			
Oil		0.1220	0.5937	0.6893	0.6287	0.2513	0.4091
TP		0.4557	0.5746	0.4915	0.0750	0.3781	0.3972
Oil*TP		0.0476	0.2184	0.1909	0.5375	0.7699	0.7267

[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 22 chicks per pen

Table 4. Effect of turmeric rhizome powder (TRP) and oil sources (canola, soybean oil and tallow) on antibody production against SRBC, IgG and IgM of pre and post heat stressed broiler chickens

Main effect		Pre-heat stress			Post heat stress		
		SRBC	IgG	IgM	SRBC	IgG	IgM
Oil							
	Soybean	7.11	2.11	5.00	6.89	4.56	2.33
	Canola	7.11	1.78	5.33	6.79	4.89	1.90
	Tallow	6.44	1.88	4.56	6.84	4.44	2.40
TRP %							
	0.0	6.89	2.11	4.78	6.67	4.56	2.11
	0.4	7.11	2.11	5.00	7.00	4.55	2.45
	0.8	6.67	1.56	5.11	7.00	4.78	2.22
SEM		2.22	0.984	1.148	1.815	1.037	0.847
Source of variation		---------------------------------------P-Value ---------------------------------------					
Oil		0.5594	0.5564	0.3260	0.9899	0.6359	0.6547
TP		0.8205	0.4562	0.8001	0.8337	0.8679	0.5987
Oil*TP		0.6843	0.7124	0.6268	0.9439	0.9846	0.7456

Values within a column with no superscript are not significantly different (P <0.05)

Table 5. Effect of turmeric rhizome powder (TRP) and oil sources (canola, soybean oil and tallow) on percentage of organs in carcass of pre and post heat stressed broiler chickens

Main effect	Pre-heat stress						Post heat stress					
	Fat%	Heart%	Bursa%	Spleen%	Liver%	Gall bladder%	Fat%	Heart%	Bursa%	Spleen%	Liver%	Gall bladder%
Oil												
Soybean	0.849	0.859	0.470	0.387	1.673	0.354	0.858ab	0.802ab	0.268	0.339	1.545	0.296
Canola	0.761	0.848	0.383	0.364	1.685	0.343	0.767b	0.786b	0.290	0.358	1.500	0.344
Tallow	0.893	0.830	0.398	0.335	1.562	0.341	1.048a	0.895a	0.308	0.362	1.577	0.278
TRP %												
0.0	0.871	0.825	0.433	0.365	1.608	0.374	0.902	0.900a	0.264	0.364	1.576	0.299
0.4	0.853	0.830	0.413	0.367	1.661	0.320	0.914	0.788b	0.306	0.354	1.479	0.290
0.8	0.872	0.880	0.405	0.355	1.651	0.344	0.858	0.794ab	0.294	0.340	1.576	0.330
SEM	0.0005	0.00002	0.00008	0.00003	0.0002	0.00007	0.0006	0.0001	0.00008	0.00003	0.0004	0.0001
Source of variation	---P-Value ---											
Oil	0.3512	0.3587	0.0530	0.0821	0.1041	0.9223	0.0332	0.0341	0.5656	0.5418	0.6892	0.3367
TP	0.4903	0.0875	0.7169	0.8413	0.6563	0.2889	0.8525	0.0231	0.4982	0.5310	0.4879	0.6611
Oil*TP	0.7410	0.0489	0.4864	0.4153	0.5218	0.1445	0.1421	0.0014	0.5372	0.1822	0.4884	0.7946

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

Table 6. Effect of turmeric rhizome powder (TRP) and oil sources (canola, soybean oil and tallow) on bone characteristics of pre and post heat stressed broiler chickens

Main effect		Diaphysis diameter, mm	Thickness of lateral wall, mm	Thickness of medial wall, mm	Medullary canal diameter, mm	DM (%)	Ash (%)	Ca (%)	P (%)
Oil									
	Soybean	11.89a	1.692b	2.034a	8.164	67.39	43.56	25.49	7.54
	Canola	11.74ab	2.194a	1.825b	7.721	64.82	42.12	24.22	7.05
	Tallow	11.29b	1.808b	1.779b	7.703	65.99	43.65	24.80	7.13
TRP %									
	0.0	11.45b	1.783b	2.259a	7.408b	66.26	43.84	25.46	7.51
	0.4	11.38b	1.820b	1.646b	7.914ab	64.98	42.37	24.45	7.35
	0.8	12.09a	2.089a	1.736b	8.265a	66.96	43.12	24.60	6.86
SEM		3.557	0.505	0.783	3.039	30.068	9.786	2.898	0.547
Source of variation		---P-Value ---							
Oil		0.0505	0.0001	0.00008	0.0857	0.5255	0.4145	0.5751	0.2255
TP		0.0118	0.0046	0.0013	0.0029	0.6737	0.5198	0.6647	0.0973
Oil*TP		0.2008	0.0003	0.0001	0.0266	0.0320	0.8155	0.3205	0.3795

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

The TRP and oil sources did not affect the relative organ weights in pre and post heat stressed birds with the exception of abdominal fat and heart in heat stressed birds (Table 5 above). The relative weight of lymphoid organs including bursa, spleen, and liver did not significantly alter. These are in agreement with finding of Rashidi et al. [27]. Birds fed diets contained soybean and canola oils had lower abdominal fat as compared to those fed tallow. These findings are in agreement with other researches [24,30,32]. Lower Liver fatty acid (FA) synthetase activity and hepatic lipogenesis reported in hens fed unsaturated FAs as compared to those saturated FAs. The lower concentration of postprandial plasma triglyceride that indicating the rate of dietary lipid clearance from bloodstream to tissues also observed in birds fed unsaturated FAs as compared to those fed saturated FAs. TRP diets did not significantly affect relative abdominal fat weight. The same results were observed by Sugiharto et al. [14]. Lower relative weight of abdominal fat in broiler fed TRP was reported by other researchers [10,13,15]. Lipid oxidation in meat, particularly in products with relative high content of unsaturated FAs, is considered one of the most important factors reducing the nutritional value and quality of meat [33,34]. Therefore inclusion of unsaturated FAs especially omega-3 FAs and antioxidant components may improve the meat quality of broilers. Oil sources and TRP diets did not significantly affect relative heart weight in pre heat stressed birds; however TRP and canola oil diets reduced relative heart weight of heat stressed broilers. Polyunsaturated fatty acids especially omega-3 FAs improve the heart function and bloodstream, therefore these FAs may provide to reduce the ascites. In addition the enhancement of meat with omega-3 FAs improves the meat quality of broiler for human nutrition and health [35].

The diaphysis diameters, the thickness of lateral and medial walls and medullary canal diameter were altered by the inclusion of TRP or oils in diets of heat stressed chickens, but the percentage of DM, Ash, Ca and P were not affected (Table 6 above). The manipulation of bone characteristics may be due to the role of PUFAs and antioxidant feature of turmeric. Birds fed canola oil diet had higher diaphysis diameters, the thickness of lateral and medullary canal diameter as compared to those fed canola oil or tallow diets. These findings approved the reports that found a better bone quality in birds fed omega-3 fatty acids [17,36]. Vitamin C is one of the major components in antioxidant defense system and bone metabolism and mineralization. Therefore supplementation of turmeric powder to broiler diets and contribution of that at antioxidant defense system, the requirement of antioxidant components such as vitamin C was reduced. Thus improving the quality of bone may due to role of vit C in bone metabolism and mineralization. The diets contained higher n-3 fatty acids improved the retention of calcium and phosphorous of bone in broilers [16,17]. Supplementation of antioxidant components to broiler diets improved the bone quality [36]. Therefore supplementation of TRP and omega-3 PUFA oil sources may improve the bone mineralization and bone quality of heat stressed broilers.

4. CONCLUSION

Inclusion of oils and supplementation of TRP to diets improved the performance of broilers pre heat stress, but unsaturated oil sources could not improve the performance of heat stressed broilers. The unsaturated oil sources and TRP diets reduce the heart and abdominal fat of heat stressed broilers and improved the meat quality. The bone quality of birds fed omega-3 unsaturated FAs (Canola oil) and TRP diets were improved. Therefore, to obtain the better performance and lower bone disorders, the author recommend to add vegetable oils especially canola oil with turmeric rhizome powder to broiler diet chickens.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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