Comparison of broiler performance, blood biochemistry, hematology and immune response when feed diets were supplemented with ginger essential oils or mannan-oligosaccharide

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Abstract:

BACKGROUND: Nutritional strategies targeting improvement of poultry performance and disease prevention are currently being developed and in this respect the dietary intake of spiced essential oils and pre-biotics in raising broilers is receiving attention. **OBJECTIVES:** This study was conducted to compare the effects of diet containing ginger essential oils (GEO) and mannan-oligosaccharide (MOS) on growth performance, biochemical and hematological parameters, lymphoid organ weights and antibody response of broilers. **METHODS:** A total of 375 day old male broiler chicks were randomly assigned to five treatments (five replicates per treatment). Dietary treatments included basal diet as control, GEO-supplemented diets with inclusion levels of 50 (GEO1), 100 (GEO2) or 200 (GEO3) mg/kg, and MOS supplemented diet with an inclusion level of 2 g/kg. **RESULTS:** The birds fed on MOS and GEO3 diets exhibited better feed conversion ratio and higher body weight gain from 1 to 42 day of age compared with control birds ($p<0.05$). Serum low density lipoprotein cholesterol level in the MOS, GEO2 or GEO3 groups was lower than that of the control group ($p<0.05$). Serum cholesterol level was also lower in the GEO2 and MOS groups ($p<0.05$). Feeding on GEO3 and MOS diets significantly increased relative bursa weight and secondary antibody titer against infectious bursal disease (IBD) and infectious bronchitis (IB) vaccines as compared with control diet ($p<0.05$). **CONCLUSIONS:** The results showed that higher level of GEO (200 g/kg) similar to MOS supplementation, improved feed efficiency and immune response. This could meet consumers' demand for a safe feed additive.

Introduction

The main objective of poultry farming is to ensure high growth performance and good quality of poultry products, which are suitable for further processing. With increasing commercialization and intensification in poultry production, the economic implications of poultry diseases are becoming more important because of the upsurge in stressful conditions (Castanon, 2007). Under such conditions, utilization of suitable additives including, prebiotics and more recently herb and spice products in the poultry feed to improve growth and health is an interesting field in the poultry industry (Houshmand et al., 2011; Seifi, 2013).

Pre-biotics have been recently introduced as replacements of antibiotics, which are dietary non-digestible ingredients that selectively encourage the growth and activity of beneficial bacteria such as Lactobacillus and Bifidobacterium species in the gut of host animal (Gibson and Roberfroid, 1995). Mannan-oligosaccharides, as the lactobacillus favorite sugars, are among the different forms of oligosaccharides used as pre-biotics (Iji et al., 2001). Different researchers have studied the effect of oligosaccharides on the performance of broilers, and controversial results were reported. For example, Khodambashi et al. (2012) were unable to show reliable effects on body weight gain (BWG) and feed conversion ratio (FCR) in broilers fed on diets supplemented with pre-biotic. In the study of Kamran et al. (2013), BWG and FCR were improved in broilers fed on MOS compared to non-supplemented birds; whereas Kim et al. (2011) reported that adding MOS to broilers' diet improved BWG without affecting FCR.

More recently, the applications of herb and spices products, as possible alternatives to antibiotic, have increased in poultry diets, which resulted in improved production and health (Hashemi and Davoodi; 2011; Khalaji et al., 2011; Nasir and Grashorn, 2010). Ginger (Zingiber officinale) is a spice used for cooking and also consumed whole as a delicacy or medicine. Ginger contains active chemical constituents including volatile oils such as α-terpineol, borneol, citronyl acetate, curcumene, geranial, geraniol, linalool, neral and zingiberene and pungent compounds such as gingerols and shogaols (Ravindran and Babu, 2005). Despite the fact that antimicrobial and antioxidant effects of ginger essential oil (GEO) are well documented (Ali et al., 2008), studies on the effect of ginger essential oils on performance and blood characteristics of broilers are rare and the results are controversial. For instance, Barazesh et al. (2013) reported that adding ginger to feed diet could improve FCR and blood lipid profile, whereas no changes were reported in feed intake as regard BWG and FCR in broilers with aqueous extract of ginger at the levels of 0, 0.25, 0.5, 0.75 and 1% supplemented to drinking water (Fakhim et al., 2013).

Modulation of intestinal microbiota composition could positively influence the immune responses in broiler chickens (Brisbin et al., 2008). So, as MOS and GEO could affect the composition of intestinal microflora (Dieumou et al., 2009; Iji et al., 2001; Shanoon et al., 2012), they might have beneficial effect on the immune response of broilers. In this case, Azhir et al. (2012) reported a significant increase in serum mean antibody titer against Newcastle disease vaccine by feeding 10 g/kg ginger rhizome powder.

As mentioned, due to (1) discrepancies in the results of different studies with MOS and ginger herb on broiler performance, (2) lack of a research in which essential oils and pre-biotics were compared and (3) importance of improving the immune response of broilers in order to prevent infectious diseases, this study was conducted to compare the effect of GEO and MOS on growth performance, blood biochemical and hematological parameters and antibody response in broiler chickens.

Materials and Methods

Materials: The essential oils were isolated by hydrodistillation method using a clevenger-type apparatus (Lamaty et al., 1987). Dry rhizomes of Zingiber officinale plant were identified and authenticated by a plant taxonomist. The recovered oils were dried over anhydrous sodium sulphate and stored in darkness between 4 and 6ºC. The oil yield as a percentage of plant material weight was as follows: 0.3% for the essential oil from Z. officinale.

The pre-biotic (Fermacto, PetAg Inc., Hampshire, IL, USA) used in this study was a carbohydrate that belong to the mannan-oligosaccharides family and is achieved by extraction of the outer cell wall of Saccharomyces cerevisiae.

Animals and experimental diets: A total of 375 day old male broiler chicks (Ross 308) were individually identified and randomly divided into five treatments, with five replicates per treatment (15 birds per replicate). The experimental treatments were basal diets with no additives as control, GEO supplemented diets with inclusion levels of 50 (GEO1), 100 (GEO2) or 200 (GEO3) mg/kg, and MOS supplemented diets with an inclusion level of 2 g/kg. All birds were fed on regular starter (day 1-10), grower (day 11-28) and finisher (day 29-42) diets (Table 1). No medication program was administered during the whole experimental period. All birds were maintained under lighting control system and a uniform temperature during the overall period. The ambient temperature was gradually lowered from 33°C to 22°C on day 28 and was then kept constant. All floor pens measured 1.2× 1.5m. Each pen consists of one hanging tube feeder, one bell-type drinker and a litter top dressed with about 5 Cm of new wood shaving.

Measurements (Growth performance): Body weight gain (BWG) and feed intake (FI) were measured at 10, 28 and 42 day of age. Feed conversion ratio (FCR) was calculated as FI divided by BWG. At 42 day of age, two birds from each replicate were randomly selected; sacrificed and lymphoid organs (spleen, thymus and bursa of Fabricius) were collected, weighed and expressed as a percentage of live body weight.

Selected blood chemistry parameters: On 21 and 42 day of the experimental period, 3ml of blood was collected from two birds of each pen (10 birds per treatment) from the brachial vein. Serum was isolated by centrifugation at 3000 × g for 10 min. The concentrations of glucose, total protein, triglycerides (TG), total cholesterol (CHOL), high density lipoprotein cholesterol (HDL-C), low density lipoprotein cholesterol (LDL-C) in serum samples were analyzed by an automatic biochemical analyzer (Clima, Ral. Co, Espain), following the instructions of the corresponding reagent kit (Pars Azmon Co., Iran).

Hematological characters: To study the effects of experimental diets on blood hematology at day 42, blood samples were collected from 10 birds in each treatment into EDTA anticoagulant treated bottles. The red blood cell (RBC) and white blood cell (WBC) counts were determined by a hemocytometer method using the Natt-Herrick solution; hematocrit and hemoglobin values were measured by microhematocrit and cyanmethemoglobin methods, respectively (Kececi et al., 1998). To determine blood heterophil and lymphocyte counts, one hundred leukocytes per samples were counted by an optical microscope for heterophil to lymphocyte separation according to protocol described by Lucas and Jamroz (1961) and heterophil to lymphocyte ratio was then calculated.

Antibody titers against IBD and IB: All birds were vaccinated against infectious bursal disease (IBD) at the fourteenth and twenty-fourth day of age through the water route. Vaccination against infectious bronchitis (IB) was also administered at the seventh and twenty-fourth days through intraocular route and drinking water respectively. In order to measure the primary and secondary humoral immune response, at the seventh and fourteenth day after last vaccination (at 31 and 38 day of age), blood was obtained from the brachial vein of two birds from each pen. The serum samples were collected by centrifugation at 3000 × g for 10 minutes and stored at -20◦C for further analysis. Antibody titer against IBD and IB were determined using ELISA kits (IDEXX Corb, Portland, ME, USA).

Statistical analysis: The data obtained in this study were analyzed in a completely randomized design by ANOVA using the General Linear Model (GLM) procedure of SAS (2001). The data were tested for linear and quadratic contrasts using the incremental dietary GEO treatments (0 or control diet, 50,100 and 200 mg/kg). If overall significant differences (p<0.05) existed among all five treatments, the LSMEANS option of SAS was used to separate treatment means (SAS Institute, 2001).

Results

The effects of dietary treatments on BWG, FI and FCR are shown in Table 2. Feed intake was not statistically different from dietary treatments during the whole experimental period (p>0.05). The birds fed on the diet GEO3 and MOS exhibited higher BWG compared with those fed on control diet over the entire experimental period (p<0.05). Moreover, there was a linear response (p=0.04) in BWG due to GEO inclusion from 1 to 42 day of age. From 11 to 28 day of age, FCR for the chicks fed on MOS supplemented diet was better than the control birds (p<0.05). During the whole experiment, FCR was also improved by MOS and GEO3 diets compared to the control group (p<0.05). Addition of graded levels of GEO to the diets resulted in a linear response (p=0.04) in FCR during the overall trial. Moreover, a marginal linear trend (p=0.07) was observed for FCR, determined from 11 to 28 day of age, with increasing levels of GEO.

Serum biochemical parameters of broiler chicks at 42 day of age are detailed in Table 3. There were no differences in total protein, glucose, TG and HDL-C levels among experimental treatments (p>0.05).The CHOL level was lower (p<0.05) in the birds fed on GEO2 and MOS diets compared to those fed on the control diet. All diets, except GEO1 diet, recorded a decrease in LDL-C levels compared to the control diet. Serum CHOL levels showed a quadratic response to GEO level, whereas LDL-C levels showed a linear response to GEO levels (p<0.05).

Results of hematological characters in broilers are shown in Table 4. No diet affected the hematological parameters, including RBC, WBC, HGB and hematocrit (p>0.05). In addition, neither heterophil count nor heterophil:lymphocyte ratio were affected by any dietary treatments (P>0.05). However, the birds fed on MOS diet statistically had higher lymphocyte count than the control group (p<0.05).

Results of lymphoid organs weights in broilers are shown in Table 5. The spleen and thymus weights were not statistically different in all treatments (p>0.05). However, the weight of bursa of fabricius in the birds fed on GEO3 and MOS diets was higher compared to birds fed on control diet (p<0.05).

There were no significant differences in primary antibody titers against IBD among treatments (Table 5). However, secondary antibody titers against IBD vaccine were higher in the birds fed on GEO3 and MOS diets compared to those birds fed on control diet (p<0.01). Additionally, there were both linear and quadratic responses for anti-IBD titer and also a linear response for anti-IB titer with incremental GEO levels (p<0.05).

Discussion

The results of the current study indicated that feeding on diets supplemented with 200 mg/kg GEO or MOS caused an improvement in weight gain and feed conversion ratio. Although, the birds fed on diets supplemented with 50 and 100 mg/kg GEO grew faster and had the highest BWG than control birds over the study period, there were no significant differences in growth performance with the inclusion of GEO in the diet. Some studies have reported the improvement in performance of broilers following the use of ginger herb and their derivatives (Barazesh et al., 2013; Farinu et al., 2004). In contrast, no growth response to ginger products was observed in other stud-

Table 1. The feed ingredients and chemical composition of basal diets. [1]Dicalcium Phosphate contained: 16% Phosphorus and 23% Calcium. [2]Vitamin premix per kg of diet: retinol, 2.7mg; Cholecalciferol, 0.05mg; tocopheryl acetate, 18mg; vitamin K3, 2mg; thiamine 1.8mg; riboflavin, 6.6mg; niacin, 30mg; panthothenic acid, 10mg; pyridoxine, 3mg; biotin, 0.1mg; folic acid, 1mg; choline chloride, 250mg; cyanocobalamin, 0.015mg; antioxidant 100 mg. [3]Mineral premix per kg of diet: Zn (ZnO, 80.35% Zn), 100mg; Mn (MnSO4.H2O, 32.49% Mn), 100mg; Fe (FeSO4.7H2O, 20.09% Fe), 50mg; Cu (CuSO4.5H2O), 10mg; I (KI, 58% I), 1mg; Se (NaSeO3, 45.56% Se), 0.2mg.

Ingredient g/kg of diet	Starter (1-10 d)	Grower (11-28 d)	Finisher (29-42 d)
Corn	414.1	517.1	581.4
Wheat	115.8	110	110
Soybean meal (44% CP)	259.9	153.5	94.2
Corn gluten meal (60% CP)	131	147.9	146
Soybean oil	31	28.3	26.5
Limestone	14.7	12.2	10.8
Dicalcium phosphate1	18.3	17.1	17.5
Common salt	2.5	2.5	2.5
Vitamin Premix2	2.5	2.5	2.5
Mineral Premix3	2.5	2.5	2.5
DL-Methionin	5	5.3	5.5
L-Lysin, HCL	2.7	1.1	0.6
Calculated chemical composition			
ME, kcal/kg	3050	3150	3200
Crude protein, g/kg	230	200	180
Ca, g/kg	10	9	9
Available phosphorous, g/kg	5.0	4.5	4.5
Lysine, g/kg	14.4	12.0	10.9
Methionine + cystine, g/kg	10.1	8.5	8.1

ies (El-Deek et al., 2003; Fakhim et al., 2013). The improvements in BWG and FCR with the inclusion of GEO could be attributed to the stimulation of gastric and pancreatic digestive enzymes, modulation of microbial population and/or gut function, ultimately leading to more absorption of essential nutrients. Ginger has been shown to enhance pancreatic amylase, lipase, trypsin and chymotrypsin activity in rats (Platel and Srinivasan, 2000). It has also been reported that GEO decrease the number of Escherichia coli in the digesta of small intestine (Dieumou et al., 2009) and increase the number of lactobacillus and bifidbacterium in the small jejunum (Tekeli et al., 2011) of broiler chickens. In addition, the inclusion of ginger herb in rats' ration increased gastrointestinal motility without affectinggastric emptying (Gupta and Sharma, 2001). The improvements in FCR in the current study, was due to larger increase in weight gain rather than feed intake, suggesting the broiler could efficiently have utilized the diet by MOS supplementation and higher GEO levels. Based on orthogonal analysis, there was linear response for both BWG and FCR with incremental GEO levels, and the use of the highest level of GEO resulted in the best BWG and FCR. Therefore, it can be concluded that the potential effect of active components from GEO in broiler chicks may depend on the dosage used.

Feeding broilers with the MOS supplement-

Table 2. The effects of ginger essential oils (GEO) and mannan-oligosaccharide (MOS) on growth performance in broilers up to the age of 42 days. Values in the same row not sharing a common superscript differ significantly (p<0.05). [1]Linear (L) and quadratic (Q) orthogonal contrasts were tested using the incremental dietary GEO treatments (0 or control, 50,100 and 200mg/kg); TRT, treatments. [2]BWG, Body Weight Gain; FI, Feed Intake; FCR, Feed Conversion Ratio.

	Experimental treatments							**P value1**	
	GEO (mg/kg)							**GEO**	
Item[2]	Control	50	100	200	MOS	SEM	TRT	L	Q
BWG (g)									
1-10 d	153	152	164	160	166	6.3	0.25	0.22	0.51
11-28 d	833	846	839	878	892	27.6	0.12	0.18	0.22
29-42 d	1202	1210	1279	1285	1280	35.0	0.37	0.10	0.09
1-42 d	2188[b]	2208[ab]	2282[ab]	2323[a]	2338[a]	51.5	0.02	0.04	0.12
FI (g)									
1-10 d	256	255	263	270	261	9.3	0.38	0.21	0.45
11-28 d	1655	1603	1585	1572	1606	41.4	0.19	0.13	0.52
29-42 d	2416	2413	2435	2420	2429	54.3	0.54	0.32	0.14
1-42 d	4327	4271	4283	4262	4296	83.2	0.38	0.44	0.16
FCR (g:g)									
1-10 d	1.67	1.68	1.60	1.69	1.57	0.049	0.11	0.15	0.18
11-28 d	1.99[a]	1.89[ab]	1.89[ab]	1.79[b]	1.80b	0.064	0.01	0.07	0.53
29-42 d	2.01	1.99	1.90	1.88	1.90	0.058	0.17	0.11	0.45
1-42 d	1.98[a]	1.93[ab]	1.88[ab]	1.83[b]	1.84b	0.053	0.04	0.03	0.43

Table 3. The effects of ginger essential oils (GEO) and Mannan-oligosaccharide (MOS) on some biochemical parameters in broilers at 42 d of age. Values in the same row not sharing a common superscript differ significantly (p<0.05). [1]Linear (L) and quadratic (Q) orthogonal contrasts were tested using the incremental dietary GEO treatments (0 or control, 50,100 and 200mg/kg); TRT, treatments. [2]CHOL=total cholesterol, TG=triglyceride, HDL-C=high-density lipoprotein cholesterol, LDL-C=low density lipoprotein cholesterol.

	Experimental treatments							P value1	
	GEO (mg/kg)							GEO	
Item2	Control	50	100	200	MOS	SEM	TRT	L	Q
Glucose (mg/dl)	253	250	246	248	250	16.3	0.92	0.87	0.62
Total protein (g/dl)	3.1	3.2	3.6	3.3	3.5	0.38	0.76	0.56	0.51
TG (mg/dl)	67.0	62.5	63.8	61.0	57.8	7.13	0.32	0.25	0.53
CHOL(mg/dl)	129a	112ab	106b	114ab	103b	9.6	0.01	0.10	0.04
HDL-C (mg/dl)	50.8	48.5	51.2	57.5	53.2	4.18	0.46	0.15	0.63
LDL-C (mg/dl)	67.2a	51.4ab	44.9b	46.3b	41.7b	7.65	0.008	0.01	0.46

ed diet in the current study improved growth performance, and was in agreement with the previous study in broilers (Kamran et al., 2013). In different studies performed to evaluate the impact of oligosaccharides on performance of broilers, contradictory results have been obtained. For example, Kim et al. (2011) reported improvements in BWG in broilers fed on MOS supplemented diets with no changes in feed conversion; whereas Williams et al. (2008) reported improvements in FCR and reductions in FI and BWG in broilers fed on pre-biotic supplemented diets. These contradictory results can partly be explained by pre-biotic ingredients, supplement dosage and dietary nutrient levels. Some the main ways in which pre-biotic can grant a performance benefit is apparently by improving intestinal microflora population, stimulating appetite, intensifying the immune system and decreasing

Table 4. The effects of ginger essential oils (GEO) and Mannan-oligosaccharide (MOS) on hematological characters in broilers at 42 d of age. Values in the same row not sharing a common superscript differ significantly (p<0.05). [1]Linear (L) and quadratic (Q) orthogonal contrasts were tested using the incremental dietary GEO treatments (0 or control, 50,100 and 200mg/kg); TRT, treatments. [2]RBC, Red Blood Cell; WBC, White Blood Cell.

	Experimental treatments							P value1	
	GEO (mg/kg)							GEO	
Item[2]	Control	50	100	200	MOS	SEM	TRT3	L	Q
Hematological characters									
RBC ($\times10^6$/µl)	2.27	2.35	2.33	2.28	2.28	0.08	0.52	0.53	0.61
WBC ($\times10^3$/µl)	21.6	22.1	22.4	23.5	22.0	0.99	0.25	0.29	0.74
Hemoglobin (100 mg/ml)	10.8	11.2	11.3	11.2	11.4	0.62	0.67	0.20	0.69
Hematocrit (%)	30.6	31.5	31.2	32.2	30.2	1.32	0.27	0.44	0.21
Heterophil (H)	23	21	24	24.5	19.5	2.11	0.30	0.62	0.19
Lymphocyte (L)	71^{b}	77^{ab}	76^{ab}	75.5^{ab}	80.5^{a}	3.45	0.05	0.19	0.21
H: L	0.32	0.27	0.32	0.32	0.24	0.04	0.13	0.42	0.19

Table 5. The effects of ginger essential oils (GEO) and Mannan-oligosaccharide (MOS) on lymphoid organs weight and antibody titers in response to infectious bursal disease (IBD) and infectious bronchitis (IB) vaccines in broilers. Values in the same row not sharing a common superscript differ significantly (p<0.05). [1]Linear (L) and quadratic (Q) orthogonal contrasts were tested using the incremental dietary GEO treatments (0 or control, 50,100 and 200mg/kg); TRT, treatments. [2]Percentage of live body weight. [3]at 31 d of age. [4]at 38 d of age.

	Experimental treatments							P value1	
	GEO (mg/kg)							GEO	
Item	Control	50	100	200	MOS	SEM	TRT	L	Q
lymphoid organs weight[2]									
Spleen	0.17	0.18	0.18	0.20	0.19	0.02	0.75	0.52	0.84
Thymus	0.29	0.32	0.35	0.36	0.33	0.04	0.18	0.21	0.42
Bursa	0.10^{b}	0.13^{ab}	0.18^{a}	0.19^{a}	0.19^{a}	0.02	0.01	0.009	0.56
Primary antibody titer[3]									
IBD ($\times10^3$)	1.81	1.75	1.69	1.94	1.91	0.16	0.29	0.13	0.55
IB ($\times10^3$)	2.75	3.02	3.12	3.40	3.46	0.27	0.22	0.09	0.47
Secondary antibody titer[4]									
IBD ($\times10^3$)	0.74^{b}	0.91^{ab}	1.02^{ab}	1.19^{a}	1.13^{a}	0.14	0.002	<0.001	0.03
IB ($\times10^3$)	1.67^{b}	2.05^{ab}	2.18^{ab}	2.52^{a}	2.65^{a}	0.29	0.003	0.006	0.45

pH (Patterson and Burkholder, 2003). In the present experiment, the positive effect of MOS on growth performance might be explained by a better immune function (as the result of treatment with MOS).

The insignificant difference in total blood protein and glucose levels observed in this study was also reported by other studies with spice sand herb products (Mehala and Moorthy, 2008; Toghyani et al., 2010). However, in contrast to our findings, it is reported that dietary inclusion of ginger essential oil at the level of 240 mg/kg increased blood glucose in broilers (Tekeli et al., 2011). Dietary administration of spice additives has been shown to have a hypocholesterolaemic effect in broilers, in which these supplement decreased TG, CHOL and/or LDL-C levels and increased HDL-C levels (Pish-Jang, 2011; Yalçın et al., 2012). There was a lack of scientific research investigating the effects of GEO administration on lipid metabolism in poultry, but there are reports that addition of 5 g/kg ginger root to broiler diets decreased serum cholesterol (Zhang et al., 2009). Moreover, decrease in serum cholesterol level has been reported in broiler chickens fed on diets supplemented with 0.4 and 0.6% aqueous extract of ginger (Saeid et al., 2010).

The cholesterol lowering effects of spice products are found to be associated with the reduction of 3-hydroxy-3-methyl-glutaryl-CoA reductase (HMG-CoA reductase), the rate-controlling enzymes for cholesterol synthesis in liver by active components in spice (Crowell, 1999; El-Dakhakhny et al., 2000).The lower de novo synthesis of cholesterol enhances the expression of low density lipoprotein receptors on hepatocytes, leading to higher LDL uptake by the hepatocytes and ultimately decrease the blood LDL-C levels (Fukushima and Nakano, 1996). The observed effects of GEO on serum lipid in our study also indicated that the effective components in the essential oils are also active after being incorporated into diets.

The most important mechanism by which pre-biotics reduce blood cholesterol levels is probably through dropping in intestinal lipid absorption by binding bile acids, which results in increased cholesterol elimination and hepatic synthesis of new bile acid (Ooi and Liong, 2010). Furthermore, Robertfroid and Delzenne (1998) also reported that pre-biotics reduce lipogenesis in the liver, which results in a lower blood LDL-C levels.

According to hematological results obtained in this study, no differences were observed in hematological parameters of broilers fed on different experimental diets, and the values were within the normal range for healthy birds. In contrast, Toghyani et al. (2010) reported a significant increase in WBC count, hemoglobin concentration and hematocrit percentage compared to control birds, while feeding different levels of spice seed (black cumin seed) to broilers. This difference may be associated with type and levels of spices and their active components.

Although an increase in blood lymphocyte count was observed in the birds fed on diets supplemented with 2 g/kg MOS as against those fed on the control diet, but feeding on experimental diets did not have any influence on the heterophil count and heterophil: lymphocyte ratio. The mentioned ratio is an indicator of response to a stressor (Maxwell, 1993). The lack of significant difference in this respect may be attributed to normal composition of the basal diet, unrestricted access to feed and water and/or the suitable environmental conditions in our study.

The higher weights of lymphoid organs by herbal essential oils have been reported in other studies (Al-Saleh et al., 2006; Arslan et al., 2005).The higher relative weight of bursa of fabricius observed in the chicks fed on GEO3 and MOS diets, could be attributed to the higher antibody titers of the respective treatment groups, as explained in the next section. However, we recorded no differences among dietary treatments in terms of spleen and thymus weights.

Humoral immune response was assessed by antibody response to IBD and IB. Our results showed that the secondary antibody titer post-vaccination against IBD and IB were increased when chicken fed on diets supplemented with 200 mg/kg of GEO or MOS compared with the control group. There are reports that different herb and spice products may promote antibody mediated immune response of broilers (Al-Beitawi et al., 2009; Khodambashi-Emami et al., 2012). In a study on broilers, serum mean antibody titer against Newcastle disease vaccine was increased by feeding 10 g/kg ginger rhizome powder (Azhir et al., 2012). Similar to the results of the current study, antibody response was improved in laying hens (Cetin et al., 2005) and turkeys (Rosen, 2007) by MOS supplementation. It is reported that pre-biotics and ginger essential oils could improve gut microflora by binding and removing pathogens from the intestinal tract (Dieumou et al., 2009; Iji et al., 2001; Shanoon et al., 2012; Spring et al., 2000). Since pathogens induce the physical restraints to low gastric pH and rapid transit time in the digestive tract and cause an infection (Patterson and Burkholder, 2003), the reduction of colonization of pathogens by these additives can intensify response of host immune tissues.

The improvement of antibody mediated immune response by the diets supplemented with MOS or 200 mg/kg GEO was in accordance with observed results in terms of BWG and FCR. Since the modulation of immune system activity in broilers by phytogenic products is mainly associated with improving the gut ecosystem and reducing the production of growth depressing toxins by intestinal microflora (Windisch et al., 2008), the immuno-modulatory effects of the above mentioned diets may be responsible for the observed performance improvements.

In conclusion, considerable variation in growth performance and health benefits with the dietary use of spice products is most likely dependent on the supplement dose and feeding duration as well as the type of spice. In this study, the dietary administration of ginger essential oils could exhibit beneficial effects on FCR, serum lipid profiles and antibody mediated immune response. The highest level of ginger essential oils (200 mg/kg), as well as pre-biotic supplement, produced the best results in terms of growth and health parameters, and can accordingly be considered as effective alternatives for antibiotic growth and health promoters in broiler chicks. However, further detailed studies can be recommended to understand the main mechanisms regarding the positive effects of these supplements in poultry feeds.

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مقایسه عملکرد، بیوشیمی خون، هماتولوژی و پاسخ ایمنی جوجه‌های گوشتی در تغذیه با جیره‌های حاوی اسانس زنجبیل و یا مانان-الیگوساکارید

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چکیده

زمینه مطالعه: استراتژی‌های تغذیه‌ای با هدف بهبود عملکرد طیور و پیشگیری از بیماریها در حال حاضر رو به توسعه است و در این راستا استفاده از مکمل‌های سودمند مانند اسانس ادویه‌ها یا پربیوتیک‌ها در پرورش جوجه‌های گوشتی مورد توجه قرار گرفته است. **هدف:** این مطالعه به منظور مقایسه اثرات جیره‌های غذایی حاوی اسانس زنجبیل (GEO) و مانان-الیگوساکارید (MOS) بر عملکرد رشد، پارامترهای بیوشیمیایی و هماتولوژی خون، وزن اندام‌های لنفاوی و پاسخ آنتی بادی در جوجه‌های گوشتی انجام شد. **روش کار:** در مجموع ۳۷۵ قطعه جوجه گوشتی نر یک روزه به طور تصادفی به پنج تیمار (پنج تکرار در هر تیمار) تخصیص یافتند. جیره‌های غذایی شامل جیره پایه به عنوان شاهد، جیره‌های غذایی مکمل شده با GEO در سطوح ۵۰ mg/kg (GEO۱)، mg/ ۱۰۰kg (GEO۲) و ۲۰۰ mg/kg (GEO۳)، و جیره غذایی مکمل شده با MOS در سطح ۲g/kg بود. **نتایج:** پرنده‌های تغذیه شده با جیره‌های GEO۳ و MOS ضریب تبدیل غذایی بهتر و افزایش وزن بدن بالاتری از ۱ تا ۴۲ روزگی در مقایسه با گروه شاهد نشان دادند (p<۰/۰۵). سطح کلسترول لیپوپروتئین با چگالی کم سرم در گروههای GEO۲، GEO۳ و MOS کمتر از گروه شاهد بود (p<۰/۰۵). سطح کلسترول سرم نیز در گروههای GEO۲ و MOS کمتر بود (p<۰/۰۵). تغذیه جیره‌های GEO۳ و MOS به طور معنی‌داری وزن نسبی بورس و تیتر ثانویه آنتی بادی در برابر واکسن‌های بیماری بورس عفونی (IBD) و برونشیت عفونی (IB) را در مقایسه با جیره شاهد افزایش داد (p<۰/۰۵). **نتیجه‌گیری نهایی:** نتایج نشان داد که سطح بالاتر GEO (۲۰۰g/kg)، شبیه به مکمل MOS، بازده خوراک و پاسخ ایمنی را بهبود بخشید. این می‌تواند تقاضای مصرف کننده‌ها برای افزودنی‌های خوراک بی خطر را تأمین کند.

واژه های کلیدی: اسانس زنجبیل، پربیوتیک، عملکرد، پاسخ ایمنی، جوجه‌های گوشتی

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