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Effect of Turmeric Powder as a Dietary Supplement on Performance Indicators and Immune Responses in Broiler Chickens

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Abstract: This study investigated the effectiveness of Turmeric Powder (TP) as a dietary supplement on the performance and immune response of broiler chickens. A total of 288, 1 day old broiler chicks (Ross 308) were randomly assigned to eight groups with six replicates each. Turmeric powder was added to the basal diet at 10, 12, 14, 16, 18 and 20 g kg^{-1} feed and there were two control groups (positive and negative). The Body Weight (BW), Daily Feed Intake (DFI) and titers of antibodies specific for NDV, IBV and IBDV were measured weekly during the experiment. The relative weights of the lymphoid organs were measured in chickens at 21 and 42 days of age. The control groups performed significantly better than the treated chickens on all measurements during the experiment ($p \leq 0.05$). The chickens fed 20 g kg^{-1} of TP had significantly lower BWs after 42 days than the controls and those administered lower levels of TP (10 and 12 g kg^{-1} ($p \leq 0.05$)) and similar results were observed for Daily Weight Gain (DWG) after 42 days. Moreover, the DFI significantly decreased in chickens fed 18 and 20 g kg^{-1} of TP in the 0-21 and 0-42 days phases in comparison with the controls ($p \leq 0.05$). However, the other treated groups showed no significant differences in the Feed Conversion Ratio (FCR) ($p \geq 0.05$). The chickens fed TP did not significantly differ from the positive controls in terms of NDV or IBV-specific antibody titers in the post-vaccination periods ($p \geq 0.05$) except at the 3rd and 4th weeks for IBV. Additionally, at the 6th week, the chickens fed 14 and 16 g kg^{-1} of TP had significantly higher IBDV-specific antibody titers than the positive controls ($p \leq 0.05$). The TP had no significant ($p \geq 0.05$) effect on the relative weights of the thymus, bursa or spleen at 21 or 42 days of age. The additions of TP to the diet failed to significantly improve the performance indicators or the immune responses of broiler chickens.

Key words: Broiler, turmeric powder, performance, immune response, lymphoid organs

INTRODUCTION

Antibiotics are widely used in the poultry industry to promote growth and production and to treat many diseases (Dibner and Richards, 2005; Brenes and Roura, 2010). However, the health of the humans is affected because the addition of antibiotics at subtherapeutic doses in poultry feed may affect the response of the community to drugs.

Moreover, microbial resistance to many antibiotics is becoming increasingly evident (Yang *et al*., 2009). Therefore, the use of antibiotics as growth promoters in poultry and animal feed has been banned in the European Union since January 2006 (Wang *et al*., 1998). Toghyani *et al*. (2011) have described many studies in which bioactive plants have been used as additives in poultry feed to stimulate the appetite and feed intake with increased secretion of digestive enzymes. Additionally, as antimicrobial drugs, the additives may also activate the immune system.

Medicinal herbs and their extracts are used for poultry as feed additives or in drinking water. Turmeric (*Curcuma longa*) is an important medical plants. The rhizome of the turmeric plant is often used as a medicine or for human food either fresh or powdered (Jayaprakasha *et al*. 2005). Turmeric powder contains a large number of biologically active components such as curcumin, tetrahydrocurcumin, bismethoxycurcumin and dimethoxycurcumin. Curcumin is the most biologically active compound and represents 3-5% of turmeric curcuminoids (Osawa *et al*., 1995; Stankovic, 2004; Jayaprakasha *et al*., 2006; Lal, 2012). In recent years, turmeric powder has been used as a dietary supplement to improve the performance of poultry and to stimulate the immune system, in addition to exert antioxidant, antiviral, antibacterial, antifungal and anticoccidial effects (Iqbal *et al*., 2003; Garcea *et al*., 2005; Holt *et al*., 2005). However, the effectiveness of supplementing poultry feed with turmeric powder remains unclear. The research on the

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effects of the use of turmeric at different levels in poultry was recently reviewed (Khan *et al*., 2012; Eevuri and Putturu, 2013).

Moreover, the results of previous studies on the effectiveness of turmeric powder as a feed additive for poultry have been varied; some have found positive effects of turmeric on the performance and health of chickens whereas others have reported conflicting results. Thus, this study was designed to investigate the efficacy of turmeric powder as a dietary supplement on the immune response and on the overall performance characteristics of broiler chickens.

MATERIALS AND METHODS

Preparation of turmeric powder: The turmeric (*Curcuma longa*) rhizomes were purchased as dry roots which were ground into soft powder in an herbal shop in Riyadh City.

Birds and experimental design: Two hundred and eighty eight, 1 day old commercial broiler chicks (Ross 308) were purchased from a local hatchery (Al Wadi Poultry Farms Company, Saudi Arabia) for use in this study. The chicks were weighed on arrival and were randomly assigned (mixed sex and mean weight of 46±0.42 g) to 48 replicates of 6 birds each. The chickens were housed in electrically heated cages. Six replicates were used for each dietary group according to a completely randomized design. The dietary levels of Turmeric Powder (TP) were 10, 12, 14, 16, 18 and 20 g kg^{-1} added to the basal diet with positive (vaccinated birds fed basal diet without TP) and negative controls (unvaccinated birds fed a basal diet without TP). The experimental birds were fed a starter and a finisher diet from days 1-21 and 22-42, respectively (Table 1). Feed and water were provided *ad libitum* throughout the experiment. The temperature was set at 33°C for the 1st week, was gradually decreased until 25°C was reached at end of the 3rd week and then remained constant. The lights were on 24 h/day throughout the experiment.

Table 1: Composition of the basal diets (%)

	Basal diet	
Ingredients	Starter (1-21 days)	Finisher (22-42 days)
Metabolic Energy (ME) (Kcal kg^{-1})	2900.00	3000.00
Crude Protein (CP) (%)	21.50	18.50
Crude fat (%)	2.50	3.00
Calcium (%)	1.00	0.90
Available phosphorus (%)	0.42	0.40
Sodium (%)	0.15	0.15
Lysine (%)	1.20	1.00
Methionine (%)	0.50	0.45
Meth+cysteine (%)	0.85	0.80

The composition of vitamins and minerals in the premix (per kg of diet): vitamin A: 12,000 IU; vitamin D: 5,000 IU; vitamin E: 60 mg; vitamin C: 100 mg; vitamin K: 4 mg; vitamin B1: 3 mg; vitamin B2: 8 mg; vitamin B6: 5 mg; vitamin B12: 0.03 mg; niacin: 40 mg; folic acid: 2 mg; pantothenic acid: 15 mg; biotin: 0.2 mg; choline: 900 mg; cobalt: 0.5 mg; copper: 8 mg; iodine: 2 mg; iron: 35 mg; manganese: 90 mg; selenium: 0.2 mg and zinc: 70 mg

Vaccination of birds: The chickens were vaccinated with standard vaccines against Newcastle Disease Virus (NDV), Infectious Bronchitis Virus (IBV) and Infectious Bursal Disease Virus (IBDV). On day 5 and 28 of age, the birds were vaccinated against ND (for the HB1 strain and later for the LaSota strain) and IB (the H120 strain) and on day 14 of age, the birds were administered the IBD (D78) vaccine. The vaccines were administered to all groups except for the negative control group via a drop in the mouth and nostril roots.

Sampling of blood and separation of serum: For antibody titrations, 12 blood samples from each group were collected weekly (7, 14, 21, 28, 35 and 42 days of age) from wing veins using 3 mL syringes with 25 gauge needles. The blood samples remained for 2 h at room temperature. The samples were centrifuged at 2,000 g for 5 min at 4°C and the separated sera were stored in Eppendorf vials at -20°C until analysis.

Collection of lymphoid organs and titration of antibodies: At 21 and 42 days of age, five birds were randomly chosen, weighed and slaughtered from each dietary group. The lymphoid organs, including the Bursa, Thymus and spleen were removed and weighed for comparison with the live weight. Antibody production against the vaccinated viruses was measured with ELISA kits (IDEXX, The Netherlands) according to manufacturer's instructions.

Performance measurements: The mean Body Weight (BW) and Feed Intake (FI) were measured weekly for each replicate in the groups. The mortality per cage was recorded daily. Additionally, the mean Daily Weight Gain (DWG) and mean Feed Conversion Ratio (FRC = Feed intake/Weight gain) were calculated weekly for each group.

Statistical analyses: The data were analyzed using the general linear model procedure of SAS (2000) (SAS Institute Inc.9.1.3.2003). Analysis of variance was used according to a Completely Randomized Design (CRD) and for the means for measurements that showed significant differences, the Duncan test was used to assess significant differences among the experimental groups at the probability level of $p \leq 0.05$.

RESULTS AND DISCUSSION

Performance indicators: The performance parameters of broiler chickens which included Body Weight (BW), Daily Weight Gain (DWG), Daily Feed Intake (DFI) and Feed Conversion Ratio (FCR) were not significantly increased with the addition of turmeric powder compared with the control groups (positive and negative) as shown in Table 2 and 3 ($p \geq 0.05$). At 21 and 42 days of age, the BW, DWG and DFI in the positive and negative control groups were significantly higher than in groups receiving other dietary treatments ($p \leq 0.01$). The chickens fed 20 g kg^{-1} of turmeric powder had significantly lower BWs (2287.13 g/chick), DWGs (53.35 g/chick) and DFIs (88.35 g/chick) than the chicks of the same age in the controls groups ($p \leq 0.05$).

Although, no significant ($p \leq 0.05$) differences in the FCRs were found between the treated and the control groups, the FCR was higher in all treated groups than in the control groups throughout the experimental period (0-42 days of age). The diet containing turmeric powder was observed to have a negative effect: decreasing the growth rate and feed consumption in the birds. The turmeric powder might have reduced consumption of the supplemented diets because of an adverse effect on the palatability of the feed and thus the DFI of the treated groups was significantly lower than that of the control groups ($p \leq 0.05$).

Table 2: Effect of Turmeric Powder (TP) on Body Weight (BW) and Daily Weight Gain (DWG) of broiler chickens

TP	Body Weight (BW)			Daily Weight Gain (DWG)		
(g kg^{-1})	7 days	21 days	42 days	0-21	22-42	0-42
10	155.61	708.47^{b}	2383.21^{b}	31.53^{b}	79.75^{b}	55.64^{b}
12	155.58	706.85^{b}	2375.28^{b}	31.46^{b}	79.45^{b}	55.45^{b}
14	154.50	705.03^{b}	2361.42^{bc}	31.37^{b}	78.87^{bc}	55.12^{bc}
16	154.33	704.47^{b}	2344.28^{bc}	31.34^{b}	78.09^{bc}	54.72^{bc}
18	153.58	700.89^{b}	2333.54^{bc}	31.17^{b}	77.75^{bc}	54.46^{bc}
20	152.86	681.08^{c}	2287.13^{c}	30.22^{c}	76.48^{c}	53.35^{c}
0-C^{+}	156.56	735.58^{a}	2483.22^{a}	32.82^{a}	83.22^{a}	58.02^{a}
0-C^{-}	156.31	729.27^{a}	2464.70^{a}	32.52^{a}	82.64^{a}	57.58^{a}
SEM	2.48	10.34	26.30	0.49	1.20	0.63
p-values	0.96	0.02	0.01	0.02	0.03	0.01

TP (g/kg): Levels of turmeric powder added to the diet; SEM = Standard Error of Means for treatment effect. $^{a-c}$Values with different superscript letters in the same column differ significantly ($p \leq 0.05$)

Table 3: Effect of Turmeric Powder (TP) on Daily Feed Intake (DFI) and Feed Conversion Ratio (FCR) of broiler chickens

TP	Daily Feed Intake (DFI)			Feed Conversion Ratio (FCR)		
(g kg^{-1})	0-21	22-42	0-42	0-21	22-42	0-42
10	44.51^{b}	146.84^{b}	93.62^{b}	1.42	1.84	1.68
12	44.19^{b}	144.20^{b}	93.70^{b}	1.41	1.82	1.69
14	43.29^{b}	141.24^{c}	92.68^{b}	1.38	1.80	1.68
16	43.05^{b}	141.07^{c}	92.22^{b}	1.38	1.81	1.69
18	42.76^{c}	140.68^{c}	90.63^{c}	1.37	1.81	1.67
20	41.27^{c}	140.26^{c}	88.35^{c}	1.37	1.84	1.66
0-C^{+}	46.77^{a}	152.82^{a}	95.80^{a}	1.43	1.84	1.65
0-C^{-}	46.21^{a}	150.21^{a}	94.95^{a}	1.42	1.82	1.65
SEM	0.69	0.98	1.21	0.03	0.03	0.03
p-values	0.01	0.01	0.02	0.72	0.92	0.93

TP (g/kg): Levels of turmeric powder added to the diet; SEM = Standard Error of Means for treatment effect; $^{a-c}$Values with different superscript letters in the same column differ significantly ($p \leq 0.05$)

The results of the present study agreed with those of Namagirilakshmi (2005) and Emadi and Kermanshahi (2006) who found that broiler chickens fed turmeric (2.5, 5.0, 7.5 and 10 g kg^{-1}) did not significantly gain weight compared with those not fed turmeric ($p \leq 0.05$). Additionally, Durrani *et al.* (2006) found that adding 0.5% turmeric to broiler diets lowered average DFIs and FCRs in both the starter and finisher periods. Moreover, other studies have shown that the growth indicators of broilers did not change significantly with turmeric powder as a dietary additive at the following levels: 3.3, 6.6 and 10 g kg^{-1} of feed (Nouzarian *et al.*, 2011), at 0.5 g kg^{-1} of feed (Akbarian *et al.*, 2012) or at 4 or 8 g kg^{-1} of the diet (Hosseini-Vashan *et al.*, 2012).

However, Al-Sultan (2003) and Kumar *et al.* (2005) found that the inclusion of 0.5 or 1% turmeric powder significantly increased body weight gain and the FCR in broilers compared with controls ($p<0.05$). In a similar study, Abd Al-Jaleel (2012) found that a lower level of turmeric powder (0.5 g kg^{-1}) significantly increased the BW gain and the FCR compared with higher levels (1.0 and 1.5 g kg^{-1}) ($p<0.05$). Additionally, Al-Kassie *et al.* (2011) reported that performance increased in chickens with diets supplemented with 0.75 or 1.0% turmeric powder compared with controls.

Our results were in agreement with several previous studies and were in disagreement with others and this discrepancy was probably due to the turmeric plant source, the chicken strain, the diet composition or the environmental conditions under which the experiment was conducted.

Immune responsiveness: Highly significant differences were observed between the unvaccinated chickens (negative control) and the vaccinated chickens at 2, 5 and 6 weeks postvaccination ($p \leq 0.05$). However, the different levels of turmeric powder did not have any significant effects on the titers of antibodies specific for NDV compared with the positive control as shown in Table 4.

The antibody titer showed significant differences between the positive control and the other dietary groups at the 3rd and 4rth weeks ($p \leq 0.05$) except in the group that received 20 g kg^{-1}, turmeric for which the positive control was lower than for the other treatments. Additionally, highly significant differences in antibody titers to IBV were observed between all groups treated

Table 4: Effect of Turmeric Powder (TP) on Newcastle Disease Virus (NDV) specific antibody titer in broiler chickens

TP	Weeks					
(g kg^{-1})	1	2	3	4	5	6
10	3.64	3.18^{a}	2.28	2.02	2.90^{a}	3.25^{a}
12	3.61	3.14^{a}	2.38	2.17	2.66^{a}	3.33^{a}
14	3.55	3.07^{a}	2.33	2.27	3.13^{a}	3.28^{a}
16	3.65	3.21^{a}	2.47	2.13	2.98^{a}	3.50^{a}
18	3.64	3.11^{a}	2.30	2.21	2.97^{a}	3.39^{a}
20	3.65	3.08^{a}	2.40	2.19	3.07^{a}	3.41^{a}
0-C^{+}	3.45	3.03^{a}	2.45	2.34	3.15^{a}	3.44^{a}
0-C^{-}	3.55	2.76^{b}	2.36	1.95	1.36^{b}	1.13^{b}
SEM	0.05	0.06	0.05	0.11	0.10	0.10
p-values	0.10	0.01	0.17	0.30	0.01	0.01

TP (g/kg): Levels of turmeric powder added to the diet; SEM = Standard Error of Means for treatment effect; ^{a,b}Values with different superscript letters in the same column differ significantly ($p \leq 0.05$)

Table 5: Effect of Turmeric Powder (TP) on Infectious Bronchitis Virus (IBV) specific antibody titer in broiler chickens

TP	Weeks					
(g kg^{-1})	1	2	3	4	5	6
10	3.11	2.56	2.42^{a}	2.00^{a}	2.09^{a}	2.19^{a}
12	3.17	2.57	2.48^{a}	2.04^{a}	2.06^{a}	2.15^{a}
14	3.11	2.50	2.29^{a}	1.95^{a}	2.01^{a}	2.23^{a}
16	3.19	2.54	2.48^{a}	1.89^{a}	2.00^{a}	2.08^{a}
18	3.09	2.58	2.42^{a}	1.80^{a}	2.00^{a}	2.15^{a}
20	3.10	2.44	1.78^{b}	1.70^{b}	2.04^{a}	2.09^{a}
0-C^{+}	3.08	2.32	1.77^{b}	1.70^{b}	1.96^{a}	2.21^{a}
0-C^{-}	3.05	2.49	1.50^{c}	1.36^{c}	0.95^{b}	0.78^{b}
SEM	0.05	0.07	0.06	0.05	0.05	0.05
p-values	0.60	0.28	0.01	0.01	0.01	0.01

TP (g/kg): Levels of turmeric powder added to the diet; SEM = Standard Error of Means for treatment effect; $^{a-c}$Values with different superscript letters in the same column differ significantly ($p \leq 0.05$)

Table 6: Effect of Turmeric Powder (TP) on Infectious Bursal Disease Virus (IBDV) specific antibody titer in broiler chickens

TP	Weeks					
(g/kg)	1	2	3	4	5	6
10	3.31	2.34	1.55	1.80^{a}	1.86^{a}	2.03^{c}
12	3.25	2.42	1.71	1.76^{a}	1.81^{a}	2.12^{c}
14	3.29	2.45	1.74	1.81^{a}	2.01^{a}	3.04^{a}
16	3.11	2.36	1.78	1.87^{a}	2.02^{a}	3.26^{a}
18	3.27	2.26	1.64	1.74^{a}	1.81^{a}	2.08^{c}
20	3.21	2.34	1.65	1.76^{a}	1.92^{a}	2.03^{c}
0-C^{+}	3.12	2.19	1.70	1.79^{a}	1.99^{a}	2.54^{b}
0-C^{-}	3.16	2.27	1.77	1.45^{b}	1.29^{b}	0.69^{d}
SEM	0.07	0.09	0.10	0.09	0.12	0.12
p-values	0.34	0.42	0.78	0.05	0.01	0.01

TP (g/kg): Levels of turmeric powder added to the diet; SEM = Standard Error of Means for treatment effect; $^{a-d}$Values with different superscript letters in the same column differ significantly ($p \leq 0.05$)

with turmeric powder and the negative control groups at weeks 3, 4, 5 and 6 ($p \leq 0.05$). However, no significant differences between the chickens that were fed turmeric powder and the positive control group were found at the 5th and 6th weeks ($p \leq 0.05$) as presented in Table 5.

Additionally, the antibody titers to IBDV, shown in Table 6, were not significantly different between the chickens fed turmeric powder and the positive control chickens on the 4th and 5th weeks ($p \leq 0.05$). However, at

Table 7: Effect of turmeric powder on the relative weight of lymphoid organs of broiler chickens at 21 day of age

TP	Organs (%)		
(g kg^{-1})	Thymus	Bursa	Spleen
10	0.35	0.22	0.07
12	0.39	0.20	0.06
14	0.42	0.18	0.09
16	0.42	0.25	0.09
18	0.39	0.25	0.08
20	0.40	0.21	0.07
0-C^{+}	0.37	0.19	0.08
0-C^{-}	0.40	0.19	0.07
SEM	0.03	0.02	0.01
p-values	0.61	0.13	0.16

Table 8: Effect of turmeric powder on the relative weight of lymphoid organs of broiler chickens at 42 day of age

TP	Organs (%)		
(g kg^{-1})	Thymus	Bursa	Spleen
10	0.48	0.10	0.08
12	0.44	0.10	0.08
14	0.44	0.10	0.08
16	0.48	0.10	0.08
18	0.47	0.10	0.07
20	0.42	0.12	0.11
0-C^{+}	0.40	0.09	0.07
0-C^{-}	0.44	0.12	0.11
SEM	0.02	0.01	0.01
p-values	0.18	0.51	0.06

TP (g/kg): Levels of turmeric powder added to the diet; SEM = Standard Error of Means for treatment effect

the 6th week, the groups fed 14 and 16 g kg^{-1} turmeric powder had higher titers of antibodies than the positive control and those in the other treatment groups ($p \leq 0.05$) whereas the chickens fed 10, 12, 18 and 20 g kg^{-1} turmeric powder had lower antibody titers to IBDV than the positive control group. However, highly significant differences ($p \leq 0.05$) were observed between all groups and the negative controls at 4, 5 and 6 weeks (post vaccination).

Used as feed additives, the different levels of turmeric powder did not have any significant effects on the relative weights of the lymphoid organs (thymus, bursa and spleen) of the birds compared with the control groups at 21 and 42 days of age ($p \leq 0.05$) (Table 7 and 8).

Turmeric plant root powder has an important role in stimulating the immune system and turmeric is a potent immunomodulatory agent that modulates the activation of T-cells, B-cells, macrophages, neutrophils, natural killer cells and dendritic cells. Therefore, our expectation in this research was to find an elevation of antibody titer production and consequently better immune responses but the treatments had no significant effects on antibody production ($p \leq 0.05$) except on IBDV-specific antibody titers at 14 and 16 g kg^{-1} of turmeric powder at the 6th week as described previously. Additionally, the

relative weights of lymphoid organs were not affected by the dietary levels of turmeric powder measured at 21 and 42 days of age. However, these results are consistent with the results of Nouzarian *et al.* (2011) who reported that 3.3, 6.6 and 10 g kg^{-1} of turmeric powder in the feed did not increase antibody production in broiler chickens administered Newcastle Disease (ND) or Avian Influenza Disease (AID) vaccines. Sadeghi *et al.* (2012) also found that the addition of 5 g L^{-1} of turmeric powder to the drinking water of male broilers did not increase the antibody titer to NDV or the relative weights of the bursa and spleen.

Many studies have shown that turmeric powder enhances the immune response in broiler chickens. For example, Kermanshahi and Emadi (2007) found that the serum immunoglobulins of chickens were affected by the inclusion of turmeric powder in the diet and that the amount of serum IgA and IgM at 21 days of age and of IgG at 21 and 42 days of age significantly increased in birds fed different levels of turmeric. Furthermore, turmeric powder increased the antibody titer against the reovirus disease vaccine in broilers fed 1.0 g kg^{-1} turmeric powder as a dietary supplement according to Kumari *et al.* (2007). Al-Sultan (2003) found that the inclusion 0.5 or 1% turmeric powder in broiler feed increased the weights of the bursa, thymus, spleen and increased the numbers of red and white blood cells as well. However, the addition of 0.25% turmeric did not significantly affect the immunological organs. Another study by Madbouly *et al.* (2011) showed that the titer of antibodies specific for the Newcastle Disease Virus (NDV) and Marek's Disease Virus (MDV) increased in chickens fed diets that contained 1% turmeric as a feed additive. Additionally, recent research by Arshami *et al.* (2013) found that the titers of humoral immunity indicators such as IgG and IgM, increased in the sera of Hy-line hens treated with 15 and 25 g kg^{-1} turmeric powder.

The concentration of curcumin may vary in turmeric powder depending on the plant type with the percentage estimated to be between 1.06 and 5.70% in four 'commercially available' turmeric samples, according to Jayaprakasha *et al.* (2002). Hence, the differences between our results for the immune response and those of the other studies that we described above might be due to the concentration of curcumin in the turmeric powder. The environmental conditions of the experiment, the types of vaccines and the method of vaccine application might also have influenced the results.

CONCLUSION

The results of the current study show that an increase in turmeric powder in the basal diet adversely affected the performance of chickens. The turmeric powder had no significant effects on the immune response to the NDV, IBV or IBDV vaccines and the relative weights of the lymphoid organs of the chickens were also not affected.

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