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Dose Coriander (*Coriandrum sativum*) Seed Can Improve Broilers Welfare?

Research Article

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ABSTRACT

At present experiment the effects of coriander (*Coriandrum sativum*) seed powder on performance, humoral immunity, intestine morphology, litter quality, and footpad grade of broilers was studied. Four hundred male broiler chicks (Ross-308) were used in a completely randomized design with five treatments and four replicates at the age of 42 days. The experimental diets included: basal diet (negative control), basal diet + Lincomycin at 0.5% per kg diet (positive control), and basal diets containing 1, 2 and 3% coriander seed powder. There was no significant difference among the birds´ growth performance traits during 22-42 d of age, and also during the whole period of the experiment (1-42 days). Also, there was no difference among the birds´ livability and production efficiency index during 1-42 days of age ($P>0.05$). The birds fed with different levels of coriander had higher villus height ($P<0.05$). Coriander had no effect on moisture or pH of broilers´ litter, however, the inclusion of coriander in the broilers diet increased score 0 and score 1 parallel to a decrease in score 4 litter ($P<0.05$). Inclusion of coriander at the levels of 2% or 3% decreased the incidence of footpad dermatitis at score 2 or score 3 on d 42. Thus, using coriander seed powder at the levels of 1%, 2%, or 3% during 1 to 42 days of age improved renal biomarkers, villus height, litter quality, and footpad grade of broiler chickens.

KEY WORDS broilers, coriander seed, immunity, litter quality, performance.

INTRODUCTION

Today, it is well-known that herbal products are interesting to poultry nutritionist due to their safety and promoting effects on the health state and performance of the birds beside improvement of digestibility, antimicrobial activities, anti-inflammatory and antioxidant effects, and reduction of environmental pollution (Shehata *et al.* 2022). Coriander (*Coriandrum sativum*) is a plant that relates to *Apiaceae* family. This plant is native to the eastern Mediterranean region and is mainly cultivated in the temperate regions that surround the Mediterranean Basin, as well in Eastern Europe, China, India, and Thailand (Machado *et al.* 2023).Previous researchers revealed that coriander seeds improved growth performance, immune responses, and antioxidative status of animals (Bahrekazemi *et al.* 2020; Ashry *et al.* 2022). Coriander ´s main effective substances are linalool (67.6%), camphor (4.4%), α-pinene (7.1%), and terpinene gamma (Hamodi *et al.* 2010). Coriander seed has different essential amino acids such as glutamine, asparagine, and arginine, and various minerals such as calcium, phosphorus, potassium (Khamisabadi *et al.* 2022). Coriander can promote the appetite, digestion process, feed efficiency, and also growth performance of broiler chickens (Khubeiz and Shirif, 2020; Gurram *et al.* 2022). Khubeiz *et al.* (2024) reported that using coriander seed improved gut morphology in different parts of intestine that promoted growth performance of the broilers.

Sholiha *et al*. (2023) reported that using nano-emulsion of coriander essential oil in drinking water improved villus morphology that can increase absorption of nutrients. Footpad dermatitis in broilers causes to weak performance, and it happens by poor litter quality. An improvement on intestinal health can reduce severity of wet litter due to usage of herbal feed additives. Therefore, the target of the study was to evaluate the effects of coriander (*Coriandrum sativum*) seed powder on growth performance, humoral immunity, intestinal morphology, litter quality, and footpad grade in broilers.

MATERIALS AND METHODS

Ethical statement

All the birds´ procedures and ethics considerations were done according to the Guide of the Care and Use of Agricultural Animals in Research and Teaching (FASS, 2010).

Broiler chickens, experimental diets, and house management

Four hundreds of broiler chicks (male, Ross 308) were weighted on arrival moment (42.05±0.46), then allocated to 20 litter pens (1 m×2 m^2) in a completely randomized design with five treatments, 4 replicates, and 20 chicks per pen. Coriander (*Coriandrum sativum*) seed was prepared, air dried, grounded and its chemical composition was studied considering the methods of AOAC (1990). It had 94.40% dry matter, 12.75% crude protein, 3.27% calcium, 0.28% total phosphorus. The diets included: 1- basal diet (control), 2- basal diet + 0.5% dietary antibiotic (Lincomycin, positive control), 3- diet contained 1 percent coriander powder, 4- diet contained 2 percent coriander powder, 5- diet contained 3 percent coriander powder. All treatments were iso-caloric and iso-nitrogenous (Tables 1 and 2). The temperature of the experimental house was kept at 32 ± 1 °C during the first seven days of the experiment, then gradually reduced 3 °C weekly. The relative humidity of the house was about 55-65% during the study. The study lasted 6 weeks. The lighting schedule considered as 23 h light: 1 h dark. Vaccination of the birds was done via drinking water according to a local veterinarian.

Growth performance

Body weight (BW), body weight gain (BWG), feed intake (FI), and feed conversion ratio (FCR) was considered as growth performance parameters, and recorded as weekly. The birds' access to feed was restricted for six hours before weighting the broilers to lower the effect of intestinal feed residuals on body weight gain of the birds. The birds´ livability percentage was calculated by dividing the number of live broilers at d 42 to the numbers of animals at the start of the study.

The production efficiency factor (PEF) was calculated as:

PEF= [live ability (%) × live weight (kg)] / [age (d) × FCR] × 100 (Al-Dawood and Al-Atiyat, 2022).

Humoral immunity

In order to evaluate the humoral immunity, 10 days following Newcastle disease (ND) vaccination (on 11, 21, or 37 d), blood samples of two broilers each replicate was collected into blood tubes, centrifuged at 3000 rpm for 10 minutes, then the serum samples were separated. The response against ND was assessed regards to Hemagglutination Inhibition (HI) antibody titration (Hongzhuan *et al*. 2020).

Hepatic and renal biomarkers

At d 42, the blood sample of three birds in each replicate were taken from their wing vein into laboratory tubes. After coagulation, the samples were centrifuged at 3,500 rpm for 15 min to separate their serum (Al-Ruwad *et al*. 2024). The calorimetric activity ALT or AST, uric acid, and creatinine levels was assessed by using a spectrophotometer and commercial kits (Elsherbeni *et al*. 2024).

Carcass characteristics

At 42 day, after six hours fasting, three birds from each experimental unit slaughtered and the carcass yield were calculated as the carcass weight (without the head, feet, neck, and viscera) relative to the live weight of the broilers. Also, the breast and thigh + drumstick (leg) yields were calculated as the organs´ relative weight to eviscerated carcass weight. The percentages of the internal organs such as abdominal fat, liver, pancreas, bursa of Fabricius were calculated as the percentage of live weight (Ahmat *et al*. 2021).

Intestinal morphology

At d 42, three birds with body weight near to the related experimental unit were slaughtered by cervical dislocation, and then jejunum samples were separated immediately. The samples were rinsed by using normal saline, and then 3 cm segments from the center of jejunum were separated for studying the jejunum morphological parameters according to Hajati *et al*. (2015).

Litter quality

In order to evaluate the litter quality (as a welfare index), the litter score method, moisture and pH of litter was recorded according to Brink *et al*. (2022). Briefly, the litter scoring system was as: score 0= dry litter, score 1= dry litter, but not move with foot, score 2= leaves imprint of foot, score 3= sticks to boots or make a ball when compacted, score 4= sticks to boots.

Table 1 Feed ingredients and chemical composition of starter (1-21 d) diets

Ingredients of diets (g/kg)	Treatments[1]				
	T1	T2	T3	T4	T5
Corn	60.30	60.30	60.40	59.05	57.25
Soybean meal (44%)	31.95	31.95	30.56	30.26	30.26
Concentrate[2]	5.0	5.0	5.0	5.0	5.00
Di calcium phosphate	1.40	1.40	1.25	1.60	2.00
Salt (NaCl)	0.10	0.10	0.29	0.29	0.29
Vegetable oil	1.0	1.0	1.30	1.60	2.00
Coriander powder	-	-	1.0	2.0	3.00
Methionine	0.25	0.25	0.20	0.20	0.20
Chemical compositions of diets					
ME (Kcal/kg)	2900	2900	2900	2900	2900
CP (%)	21.04	21.04	21.01	21.03	21.00
Ca (%)	1.00	1.00	1.00	1.00	1.00
Available P (%)	0.49	0.49	0.48	0.50	0.50
Lysine (%)	1.40	1.40	1.38	1.38	1.38
Methionine (%)	0.68	0.68	0.68	0.67	0.67
Methionine + cystine (%)	1.03	1.03	1.03	1.02	1.02
Chemical analysis					
DM (%)	98.43	98.81	98.65	98.27	98.32
CP (%)	20.93	20.84	20.88	20.90	21.05
EE (%)	3.65	3.53	3.50	3.45	3.51
CF (%)	3.10	3.15	3.05	3.20	3.17

[1] T1: basal diet; T2: basal diet + 0.5% dietary antibiotic (Licodan contained 8.8 g Lincomycin HCL/kg; T3: diet contained 1 percent Coriander; T4: diet contained 2 percent Coriander and T5: diet contained 3 percent Coriander.
[2] Each kg of concentrate contained: Cp: 25%; Lysine: 2.50%; Methionine: 2.20%; Met + Cys: 2.5%; Thr: 0.82%; Ca: 2.50%; P: 1.60%; Na: 2.0%; vitamin A: 220000 IU; vitamin D_3: 100000 IU; vitamin E: 2500 IU; vitamin K_3: 6 mg; Thiamine: 6 mg; Riboflavin: 160 mg; Pantothenic acid: 300 mg; Pyridoxine: 1200 mg; Folic acid: 80 mg; Cobalamin: 0.32 mg; Biotin: 3 mg; Mn: 2.4 g; Zn: 20 g; Fe: 0.8 g; Cu: 0.32 g; I_2: 25 mg; Se: 6 mg and Choline chloride: 120 g.
ME: metabolizable energy; CP: crude protein; DM: dry matter; EE: ether extract and CF: crude fiber.

Table 2 Feed ingredients and chemical composition of starter (22-42 d) diets

Ingredients of diets (g/kg)	Treatments[1]				
	T1	T2	T3	T4	T5
Corn	63.29	63.29	62.14	60.75	59.70
Soybean meal (44%)	28.00	28.00	28.00	28.00	28.00
Concentrate[2]	5.00	5.00	5.00	5.00	5.00
Di calcium phosphate	0.85	0.85	0.85	0.85	0.85
Oystershell	0.90	0.90	0.85	0.75	0.70
Salt (NaCl)	0.16	0.16	0.16	0.16	0.16
Vegetable oil	1.80	1.80	2.00	2.50	2.60
Coriander powder	-	-	1.00	2.00	3.00
Chemical compositions of diets					
ME (Kcal/kg)	3000	3000	3000	3000	3000
CP (%)	20.00	20.00	20.02	20.02	20.01
Ca (%)	0.86	0.86	0.84	0.83	0.83
Available P (%)	0.43	0.43	0.42	0.41	0.41
Lysine (%)	1.10	1.10	1.05	1.05	1.05
Methionine (%)	0.46	0.46	0.46	0.46	0.46
Met + Cys (%)	0.80	0.80	0.80	0.80	0.80
Chemical analysis					
DM (%)	98.01	98.66	98.74	98.15	98.90
CP (%)	19.90	19.85	19.81	19.96	19.89
EE (%)	3.85	3.81	3.92	3.95	3.88
CF (%)	4.15	4.12	4.21	4.19	4.17

[1] T1: basal diet; T2: basal diet + 0.5% dietary antibiotic (Licodan contained 8.8 g Lincomycin HCL/kg; T3: diet contained 1 percent Coriander; T4: diet contained 2 percent Coriander and T5: diet contained 3 percent Coriander.
[2] Each kg of concentrate contained: Cp: 25%; Lysine: 2.50%; Methionine: 2.20%; Met + Cys: 2.5%; Thr: 0.82%; Ca: 2.50%; P: 1.60%; Na: 2.0%; vitamin A: 220000 IU; vitamin D_3: 100000 IU; vitamin E: 2500 IU; vitamin K_3: 6 mg; Thiamine: 6 mg; Riboflavin: 160 mg; Pantothenic acid: 300 mg; Pyridoxine: 1200 mg; Folic acid: 80 mg; Cobalamin: 0.32 mg; Biotin: 3 mg; Mn: 2.4 g; Zn: 20 g; Fe: 0.8 g; Cu: 0.32 g; I_2: 25 mg; Se: 6 mg and Choline chloride: 120 g.
ME: metabolizable energy; CP: crude protein; DM: dry matter; EE: ether extract and CF: crude fiber.

To measure the pH of the litter, five samples was collected, pooled, oven-dried at 65 °C to calculate the dry matter. The pH of litter was studied by sampling of litter from three points each experimental unit. Then, added to a hundred ml of distilled water. After 30 minutes, the pH of the litter samples was measured by a portable pH meter.

Footpad grade

The severity of FPD (as a welfare index) was measured at 42 days of age using the footpad scoring method according to Eichner *et al*. (2007). Four scores was considered (score 0, 1, 2, or 3) for different severity of lesions, as score 3 related to food pad lesion higher than 50 % of planta surface.

Statistical model and analysis

At present study, completely randomized design was considered. The data of the present study analyzed by using generalized linear model procedure of SAS software (SAS, 2004). The differences among treatments were studied by Duncan's multiple range test. Probability values at $P \leq 0.05$ were considered as significant.

RESULTS AND DISCUSSION

The effects of different experimental diet on body weight gain, feed intake, and feed conversion ratio during different periods of the broilers´ rearing is shown in Table 3. Dietary treatments had no effect on body weight gain and feed conversion ratio of broiler chickens during 1-21 d of age, however, the birds fed with 2 or 3 percent coriander seed powder had higher feed intake than the control group (P<0.05). There was no significant different among the birds´ growth performance traits during 22-42 d of age, and also during the whole period of the experiment (1-42 d). Also, there was no difference among the birds´ livability and production efficiency index during 1-42 d of age (P>0.05).

The effects of the experimental diets on anti-body titers against Newcastle disease is shown in Table 4. There was no significant difference among humoral immunity responses of the broiler chickens on 11, 21, or 37 d of age.

The effects of the experimental diets on the hepatic and renal biomarkers of broiler chickens are shown in Table 5. Different dietary treatments had no significant effect on ALT or AST level in broilers´ serum. Feeding coriander at 2 or 3 percent decreased uric acid level in broilers´ serum compared to the control group (P<0.05). Also, the birds fed with different levels of coriander seed powder had lower levels of creatinine (P<0.05).

The effects of the experimental treatments on carcass characteristics is shown in Table 6. The different experimental treatments had no significant effect on carcass yield, breast, thigh + drumstick, abdominal fat, liver, pancreas, or bursa fabricius percentage of broilers on day 42 (P>0.05).

The effects of different levels of coriander on jejunum morphology of broiler chickens are shown in Table 7. Results showed that dietary treatments had no significant influence on muscle layer thickness, villus width, crypt depth, and villus height/crypt depth ratio on d 42 (P>0.05). The birds fed with different levels of coriander had higher villus height compared to control group (P<0.05).

The effects of the experimental diets on litter quality of broilers´ house on d 42 are shown in Table 8. Different levels of coriander had no effect on moisture or pH of broilers´ litter, however, inclusion of coriander in broilers diet increased score 0 (dry litter) and score 1 (dry litter, but not move with foot) parallel to decreased score 4 litter (sticks to boots once the cap).

Effects of the experimental diets on footpad grade of broilers chickens on d 42 are shown in Table 9. Inclusion of coriander at the levels of 2 or 3 percent decreased the incidence of footpad dermatitis at score 2 (25-50% footpad lesions), or score 3 (more than 50% lesions) on d 42.

During 1-21 d of age the birds which consumed diet contained 2 or 3 percent Coriander consumed more feed than the birds fed with basal diet. In agreement with this result, some researchers stated that higher feed intake of the birds can be due to the essential oils and their main component as linalool content of Coriander (Gurram and Venkateshwarlu, 2022) which improves the digestive enzymes activity, parallel to improvement of diet palatability (Khubeiz and Shirif, 2020). Coriander is considered as medicinal plant that has medicinal and nutritional attributes. The active substances of coriander have exhibited antibacterial, antioxidant, free radical, anti-diabetic, anti-cancer and antimutagenic activities (Chahal *et al*. 2017). Coriander had antispasmodic properties and it was useful for treatment of loss of appetite, and upper abdominal discomforts (Sahib *et al*. 2013). Using of coriander seed powder in broilers diet was recommended as an antibiotic alternative to promote growth performance of the birds (Gurram and Venkateshwarlu, 2022). However, there was no significant different among the birds´ growth performance traits such as body weight gain, and feed conversion ratio during the whole period of the experiment. In contrast, Ahmad *et al*. reported that using coriander seed powder in broilers´ diet improved their weight gain. Also, it was reported that using 2% coriander seed in broilers' diets enhanced their growth performance without any negative effects on their blood metabolites (Barad *et al*. 2016). The discrepancy in results may be due to differences in the level of effective substances, basal diet composition, or health state of the birds.

Table 3 Effect of the experimental diets on the growth performance of broiler chickens

Item	Treatments					SEM	P-value
	T1	T2	T3	T4	T5		
1-21 d							
BWG (g/bird)	29.62	30.66	29.10	31.98	31.06	0.435	0.238
FI (g/bird)	45.04^{c}	45.22^{bc}	47.62^{ab}	49.11^{a}	48.68^{a}	0.506	0.006
FCR (g/g)	1.52	1.48	1.65	1.54	1.57	0.021	0.087
22-42 d							
BWG (g/bird)	84.65	87.41	80.08	85.30	86.50	1.017	0.176
FI (g/bird)	156.22	157.83	151.56	157.96	156.11	1.392	0.640
FCR (g/g)	1.85	1.80	1.89	1.85	1.80	0.016	0.415
1-42 d							
BWG (g/bird)	55.07	57.10	52.12	56.70	56.35	0.673	0.108
FI (g/bird)	98.50	99.56	97.04	101.66	100.17	0.618	0.496
FCR (g/g)	1.79	1.74	1.86	1.79	1.78	0.017	0.270
PEF	277.7	296.8	271.3	285.4	282.0	8.600	0. 100
Livability (%)	92.85	95.20	95.00	95.20	94.02	0.980	0.130

T1: basal diet; T2: basal diet + 0.5 % dietary antibiotic (Licodan contained 8.8 g Lincomycin HCL/kg. T3: diet contained 1 percent Coriander; T4: diet contained 2 percent Coriander and T5: diet contained 3 percent Coriander.
BWG: body weight gain; FI: feed intake; FCR: feed conversion ratio and PEF: production efficiency factor.
The means within the same row with at least one common letter, do not have significant difference (P>0.05).
SEM: standard error of the means.

Table 4 Effects of the experimental treatments on anti-body titers against Newcastle disease (primary, secondary, and third responses) in broiler chickens

Treatments	D 11	D 21	D 37
T1	3.00	1.00	3.67
T2	3.67	1.33	3.47
T3	3.33	1.33	3.00
T4	4.25	2.00	3.33
T5	2.33	1.67	3.26
SEM	0.143	0.143	0.175
P-values	0.213	0.213	0.935

T1: basal diet; T2: basal diet + 0.5 % dietary antibiotic (Licodan contained 8.8 g Lincomycin HCL/kg. T3: diet contained 1 percent Coriander; T4: diet contained 2 percent Coriander and T5: diet contained 3 percent Coriander.
The means within the same row with at least one common letter, do not have significant difference (P>0.05).
SEM: standard error of the means.

Table 5 Effect of the different diets on the hepatic and renal biomarkers of broilers

Item	Treatments					SEM	P-value
	T1	T2	T3	T4	T5		
ALT (U/L)	17.1	15.4	17.5	16.1	16.6	1.102	0.1417
AST (U/L)	201.5	190.4	186.1	197.3	192.5	7.712	0.1512
Uric acid (mg/dL)	5.21^{a}	4.83^{a}	3.98^{a}	2.87^{b}	2.91^{b}	0.527	0.0053
Creatinine	0.671^{a}	0.523^{ab}	0.402^{b}	0.382^{bc}	0.349^{c}	0.071	0.0084

T1: basal diet; T2: basal diet + 0.5 % dietary antibiotic (Licodan contained 8.8 g Lincomycin HCL/kg. T3: diet contained 1 percent Coriander; T4: diet contained 2 percent Coriander and T5: diet contained 3 percent Coriander.
ALT: alanine transaminase and AST: aspartate transaminase.
The means within the same row with at least one common letter, do not have significant difference (P>0.05).
SEM: standard error of the means.

Table 6 Effects of the experimental treatments on carcass characteristics (%) of broiler chickens

Treatments	Carcass	Breast	Thigh + drumstick	Abdominal fat	Liver	Pancreas	Bursa of Fabricius
T1	75.40	46.05	26.55	2.17	2.90	0.31	0.13
T2	74.91	46.27	26.20	2.06	2.89	0.37	0.11
T3	74.68	45.60	25.48	2.75	2.93	0.35	0.16
T4	74.08	44.99	27.08	2.17	2.84	0.31	0.16
T5	75.51	45.89	25.80	2.69	2.98	0.38	0.23
SEM	0.002	0.003	0.002	0.002	0.001	0.001	0.001
P-values	1.931	0.428	1.892	0.619	0.233	2.710	1.987

T1: basal diet; T2: basal diet + 0.5 % dietary antibiotic (Licodan contained 8.8 g Lincomycin HCL/kg. T3: diet contained 1 percent Coriander; T4: diet contained 2 percent Coriander and T5: diet contained 3 percent Coriander.
The means within the same row with at least one common letter, do not have significant difference (P>0.05).
SEM: standard error of the means.

Table 7 Effects of the experimental treatments on jejunum morphology of broiler chickens

Treatments[1]	Muscle layer thickness (µ)	Villus height (µ)	Villus width (µ)	Crypt depth (µ)	Villus height/ crypt depth
T1	200.92	891.93^{c}	101.59	135.67	6.628
T2	203.62	963.41^{a}	104.32	143.24	6.855
T3	197.23	947.97^{b}	110.24	137.94	6.958
T4	206.33	971.05^{a}	124.47	138.63	7.004
T5	198.49	933.49^{b}	107.49	140.59	6.710
SEM	6.380	10.76	8.38	10.36	0.226
P-values	0.986	0.688	0.484	0.200	0.746

T1: basal diet; T2: basal diet + 0.5 % dietary antibiotic (Licodan contained 8.8 g Lincomycin HCL/kg. T3: diet contained 1 percent Coriander; T4: diet contained 2 percent Coriander and T5: diet contained 3 percent Coriander.
The means within the same row with at least one common letter, do not have significant difference (P>0.05).
SEM: standard error of the means.

Table 8 Effects of the experimental treatments on litter quality of broilers´ house

Treatments	Moisture (%)	pH	Score 0	Score 1	Score 2	Score 3	Score 4
T1	41.30	9.05	5.00^{b}	20.08^{b}	24.16	36.6^{a}	14.16^{a}
T2	37.83	8.76	10.88^{a}	29.16^{a}	29.16	25.8^{b}	5.00^{b}
T3	39.43	8.97	10. 6^{a}	23.30^{ab}	27.80	33.3^{ab}	5.0^{b}
T4	37.45	8.68	11.20^{a}	29.00^{a}	24.30	30.0^{ab}	5.50^{b}
T5	36.00	8.47	10.00^{a}	30.00^{a}	25.00	30.0^{ab}	5.00^{b}
SEM	0.833	0.089	0.687	1.00	0.883	1.212	1.010
P-values	0.592	0.408	0.0121	0.0226	0.241	0.0171	0.0236

T1: basal diet; T2: basal diet + 0.5 % dietary antibiotic (Licodan contained 8.8 g Lincomycin HCL/kg. T3: diet contained 1 percent Coriander; T4: diet contained 2 percent Coriander and T5: diet contained 3 percent Coriander.
The means within the same row with at least one common letter, do not have significant difference (P>0.05).
SEM: standard error of the means.

Table 9 Effects of the experimental treatments on footpad grade of broilers chickens

Treatments	Score 0	Score 1	Score 2	Score 3
T1	35.62	32.08	26.95^{a}	5.35^{a}
T2	39.29	32.96	25.47^{a}	2.28^{b}
T3	38.37	33.14	25.92^{a}	2.57^{b}
T4	42.80	36.04	18.71^{b}	2.45^{b}
T5	39.30	39.60	18.5^{b}	2.60^{b}
SEM	1.096	1.076	0.647	0.290
P-values	0.087	0.630	0.0004	0.0031

T1: basal diet; T2: basal diet + 0.5 % dietary antibiotic (Licodan contained 8.8 g Lincomycin HCL/kg. T3: diet contained 1 percent Coriander; T4: diet contained 2 percent Coriander and T5: diet contained 3 percent Coriander.
The means within the same row with at least one common letter, do not have significant difference (P>0.05).
SEM: standard error of the means.

Broilers fed diet contained 2 or 3 percent coriander had higher livability or production efficiency index, numerically. This can be due to anti-microbial and antioxidant effects of the coriander reported by several researchers (Kačániová *et al*. 2020; Lin *et al*. 2022).

Immune system consists of cells and molecules responsible for immunity of the body. Different diseases such as infectious diseases occur because of inadequate number of immune cells or disruption in their functions. The most common target of the body immune system is promoting body health state while facing with pathogenic microorganisms (Dillasamola *et al*. 2019). It is well known that the effective substances of the herbs have the potential to promote blood circulation, weaken pathogenic microorganisms, and develop the immune responses of the birds (Ali *et al*. 2019; Haq *et al*. 2020).

However, this study showed that there was no significant difference among humoral immunity state of the broilers 10 days after each vaccination. So, it seems that the level of the effective substances of coriander in present study was not enough to promote the humoral immunity response of the broiler chickens.

The liver is an organ which is important in the metabolism of different substances in the body (Bodea *et al*. 2020). According to a previous research, AST or ALT levels studied as important hepatic biomarkers to evaluate the influence of unconventional ingredients or new dietary supplements on broiler chickens´ health state (Al-Khalaifah *et al*. 2020). any toxicological study. In agreement with present study, Al-Khalaifah *et al*. (2020) reported no significant differences in ALT or AST levels of broilers that fed on diets containing herbal ingredient as leek leaf extract.

Also, it was reported that feeding diets containing garlic extract (Noman *et al*. 2015) or onion extract (An *et al*. 2015) had no significant effect on AST and ALT levels. The levels of uric acid and creatinine as renal biomarkers were reduced in birds fed coriander seed powder. It seems that improvement of the kidney function can be due to the antioxidant properties of herbal flavonoids and tannin content. These results are in agreement with the findings of some researchers who reported that the hepato and nephroprotective effects of Artemisia were mainly related to the antioxidant attributes of flavonoids and phenolic acids (Dhibi *et al*. 2016; Saoudi *et al*. 2017). At present study, Coriander powder did not have negative effect on liver or kidney functions that might be due to active substances such as linalool, linoleic acid, vitamin C, terpenoids, or mineral content of Coriander, which can keep the physiological functions of the organs (Said *et al*. 2023).

At present experiment, different experimental treatments had no effect on carcass traits of the broilers on d 42. Parallel to these results, Naeemasa *et al*. (2015) have found that using phytogenic substances had no significant effect on the carcass yield of broilers. However, in contrast to present study, Omar *et al*. (2016) reported that antioxidants and phenolic materials of phytogenic materials promoted the breast yield of broilers about 1.2%. Also, Naeemasa *et al*. (2015) and Hady *et al*. (2016) reported that using coriander powder or extract had positive effect on heart, liver, and gizzard weights. Also, Khubeiz and Shirif (2020) reported that using coriander seed powder in broilers´ diet improved the proventriculus weight. The differences among results of the researchers can be related to level of herbal effective substance, different formula of basal diets, birds' strain or age of slaughter.

It is well known that short villi and deep crypts decrease the absorption of nutrients and has negative effect on the performance of broilers. However, according to Ghazanfari *et al*. (2015) higher villus height can promote digestion and absorption process of the intestine because of larger absorptive surface area besides the higher expression of brush border enzymes and nutrient transport systems. At present study, the broilers fed coriander had higher villus height compared to the control group.

Some researches reported that the level of amylase enzyme in broiler´s intestine increased after adding coriander oil to the birds´ diet. Dietary amylase had positive effect on the length of villi. In agreement with present study, Ghazanfari *et al*. (2015) have found that using dietary coriander oil increased villus height in the small intestine of broilers. Coriander seeds contained several bioactive substances such as monounsaturated fatty acids, petroselinic, linolenic acids, β-carotene, flavonoids, and phenolic substances which cause its functional properties and can modulate the gastrointestinal environment in broilers (Khubeiz *et al*. 2024). Khubeiz *et al*. (2024) reported that using of coriander seed powder at 1.5% or 3.5% improved the villus heights of the duodenum, jejunum or ileum. The main component of coriander oil is linalool which increases the broilers´ villus height, and may promote the activity of digestive enzymes which leads to change of the intestine morphology.

The level of litter moisture is an important welfare index in poultry rearing house management, and it affects the severity of injuries in poultry carcasses. According to Qiu and Guo (2010), litter moisture influences the evaporation of ammonia gas. Higher levels of ammonia and the birds excreta increases the pH of litter, which normally ranges between 7.0 and 8.5 (Rehbeger, 2002). Traldi *et al*. (2007) reported that litter pH values above 7.0, combined with high moisture, can promote growth of detrimental bacteria and raise the production of ammonia. At this study, using coriander in broiler chickens´ diet decreased pH or moisture level in litter, numerically. Beside, coriander seed powder increased score 0 (dry litter), and score 1 (dry litter), however, it reduced score 4 litter (sticks to boots). So, it seems that coriander seed powder had lowering effect on the pH or moisture level of the broilers´ house litter which lead to improve litter quality.

Footpad dermatitis is a common indicator considered as leg health state in broilers. The other names of footpad dermatitis are pododermatitis, hyperkeratosis or footpad lesions. Footpad dermatitis is along with inflammation and pain on the plantar surface (Kittelsen *et al*. 2024). Severe lesions of foot pad are along with pain which has negative effect on the broilers´ welfare and growth performance (Hunter *et al*. 2017). Several factors have effect on foot pad health state such as type and moisture of litter, diet composition, genotype, sex, age, stock density, method of ventilation, rearing house condition, lighting schedule, ammonia arising from litter (Swiatkiewicz *et al*. 2017; Kittelsen *et al*. 2024). Using coriander at the levels of 2 or 3 percent improved foot pad health of the birds that can be due to lower litter pH and moisture. It was determined that the diet composition of the birds is a critical factor affecting water intake, litter quality, and foot pad grade in poultry house (Collett, 2012). In agreement with present study, Hinz *et al*. (2019) reported that adding 0.2% fermented herbal extract enriched charcoal which contained organic acids (acetic and lactic acids) improved foot pad health of the broiler chickens. It seems that improving foot pad health is directly related to litter quality of the broilers, so Coriander powder has the potential to promote the litter quality in broilers house.

CONCLUSION

In conclusion, coriander seed powder had positive effect on the broiler ´ appetite during 1-21 d of age. Also, using coriander seed powder at the levels of 1, 2, or 3 percent during 1 to 42 d of age improved renal biomarkers, villus height, litter quality, and foot pad grade of broiler chickens. Thus, coriander can be considered as a feed ingredient that has positive effect on broilers welfare.

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