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Effect of adding different levels of cumin (Cuminum cyminum) to diets on broiler performance

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Abstract:

The present study was conducted to explore the usage of different levels of cumin (Cuminum cyminum) in broiler nutrition. Sixty, (one-day-old) unsexed broiler chicks were randomly divided into four groups of similar mean weight, each with three replicates of five chicks. The control group T1 received a basal diet (fed ration without any supplements). For the other groups T2, T3 and T4, the basal diet was supplemented with 3, 6 and 9 g/kg cumin. The observed variables included growth performance, carcass parts and internal organ weights. Also, Growth performance parameters were measured 4 birds per treatment was slaughtered at the end of the trial to evaluate muscle characteristics. Results showed that Cumin did not affect the observed variables statistically. However, the best weight gain was observed in a 3g/kg Cumin group as compared to other treatments in 42 days of age. Similarly, the best feed conversion ratio was observed in a 3 g/kg Cumin group compared to 6 and 9 g/kg cumin while no statistical difference between was observed in T1 and T2 in 42 days of age. In addition to, numerically higher body weight, feed intake carcass, breast, thigh and wing weight observed in T2 compared to other treatments in in 42 days of age. Dietary cumin supplementation had not any adverse effects on growth performance, carcass weight, carcass parts weight and organ weights.

Keywords: Cumin, broiler, fed, performance, carcass weight.

INTRODUCTION:

Natural medicinal products made with herbs and spices have also been used as feed additives for poultry (Guo, 2004). Consequently, the natural herbal plants were used in the nutrition of poultry as feed additives due to their antioxidant (Allahghadri *et al.*, 2010), antimicrobial (Shalaby *et al.*, 2006), antifungal (Khosravi *et al.*, 2011), antipyretic (Ali *et al.*, 2010), antidiabetic (Sowbhagya, 2013) and similar effects.

Cumin was known as an aromatic plant, antioxidant (Lawrence, 1992; Srinivas, 1986). Cumin seeds help digestion, secretion of bile salts and digestive enzymes in the small intestine (Muthamma *et al.*, 2008 and Platel, 2000). Additionally, beneficial effects of bioactive plant substances in animal nutrition may include the stimulation of appetite and feed intake, the improvement in endogenous digestive enzyme secretion, absorption of nutrients and activation of immune response (Ertas *et al.*, 2005 and Steiner, 2009). Cuminum cyminum L. (cumin seeds) have a wide range of health advantages, such as their capacity to cure chronic diarrhoea, dyspepsia, and diabetes, as well as their neuroprotective, cardioprotective, chemopreventive, antiinflammatory, antioxidant, and digestive stimulant properties (Srinivasan, 2018).

Also,Cuminum cyminum. It has seen that analytical contents are moisture 11.9; protein 18.7; ether extraction 15.0; carbohydrates 36.6; mineral matter 5.8; calcium 1.08; phosphorus 0.49%; iron 31.0 mg/100 g; carotene calculated as vitamin A 870 I.U./100 gm and vitamin C 3.0 mg/100 g. (Mansoori et al., 2006). cumin seed powder (CSP), its essential oil (CEO) and meal (CSM) were used to improve meat, egg or breeding performances during the feeding of poultry (Mansoori *et al.*, 2006; Aami-Azghadi *et al.*, 2010; Ali *et al.*, 2011; 2012; Al-Anbari *et al.*, 2013; Singh *et al.*, 2015; Ali *et al.*, 2018; Alkattan, 2019). Additionally, there is evidence to suggest that consuming cumin seeds may improve hunger, taste perception, and intestinal digesting activity (Mnif and Aifa, 2015)

Nutritionally, inclusion the broiler diets with cumin seed meal induces an increase in the relative weight of the crop. An improvement in the absorption process as a result of increasing diet fibers was also noticed (Mansoori *et al.*, 2006). Other researchers proved to the high rates of final body weight when adding herbs and medicinal plants to diets (AL-Kassie et al., 2011; Khan, et al., 2012 and William and Losa, 2001). Therefore, the current study was designed to assess the effect of cumin levels on broiler performance.

MATERIALS AND METHODS:

The current study was conducted in the field of animal science in the college of Agricultural engineering science at University of Sulaimani. A total 60 broiler chicks were used in this study. Chicks were obtained from the hatchery (Kosha), tasluja, Sulaimani. The birds were distributed into four experimental treatments with three replicates per treatment (5 birds per replicate) for 6 weeks. The birds were fed on four experimental diets. Birds were fed a starter diet from 1 to 7 days followed by grower diets from 8 to 21 days thereafter; finisher diets from 22 to 42 days of age Table 1. The Feed and water were supplied ad libitum. Cumin was obtained from local markets in Sulaimani city. Cumin was added to bird diets from the eight days to the end of the study as follows: First treatment was the control treatment (without any supplements). Then 3, 6 and 9 gm of cumin per kilogram feed were added to the second, third and fourth treatments respectively. Also, at 8 days of age all chickens were weighted and divided into experimental groups so that the average weight was the same in all groups. Diets were formulated to meet or excess requirements according to the National Research Council (NRC, 1994) for broilers at this age. Birds at age 7, 14, 21, 28, 35 and 42 days were weighed by a sensitive balance. At the age of 42 days, three birds were slaughtered from each treatment. The carcasses and the major parts (breast, wing and thigh) were weighed separately. In the end of this experiment all data were analyzed using XL Stat (XlSTAT, 2004). The significant differences between the means of traits were determined using Duncan's multiple range tests (Duncan, D. B.1955). Under the probability $P<0.05$.

Table (1): Compositions of the starter, grower and finisher diets (1-42days of age).

Feed Ingredients	**1-7 days of age**	8-21 days				**22-42 days of age**			
		T1 (control)	T2	T3	T4	T1 (control)	T2	T3	T4
protein conc.	6	5	5	5	5	5	5	5	5
Yellow corn	51.7	56.9	56.9	56.6	56.4	59.5	59.4	59.1	58.9
Soybean meal	29	24.8	24.5	24.5	24.4	22.2	22	22	21.9
Wheat	10	10	10	10	10	10	10	10	10
Sun flower seed oil	3	3	3	3	3	3	3	3	3
Salt	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
cumin	0	0	0.3	0.6	0.9	0	0.3	0.6	0.9
Total	100	100	100	100	100	100	100	100	100

Table (2): Composition of Protein concentrate

Nutrients	Inclusion %	Added Vitamins, minerals, trace elements and additives per kg:		
Crude protein	40.00	Vitamin A	220.00	I.U.
Crude fat	5.00	Vitamin D_3	60.00	I.U.
Crude fiber	2.00	Vitamin E	600	mg
Moisture	7.60	Vitamin B1	60	mg
Crude ash	28.30	Vitamin B2	140	mg
Calcium	5.60	Vitamin B6	80	mg
Phosphorus	2.60	Vitamin B12	700	mg
Phosphorus (avail.)	4.65	Vitamin H(Biotin)	2.00	mg
Lysine	3.85	Niacin	800	mg
Methionine	3.70	Vitamin BC (folic acid)	20	mg
Meth+cyst	4.10	Vitamin K_3	50	mg
Tryptophane	0.40	d-pantothenic acid	320	mg
Threonine	1.29	Choline chloride	5.00	mg
Metabolizable Energy	2150.00	Cu (from Copper Sulphate)	200	mg
Sodium	2.30	Mn(from Manganese oxide)	1.60	mg
CL	4.00	Zn (from zinc oxide)	1.20	mg
		Fe (from Iron Sulphate)	1.00	mg
		I (from calcium iodate)	20	mg
		Se (from sodium selenite)	5	mg
		Antioxidant	100	mg
		6-phytaseEC3.1.3.26 (46)	30.00	Fyt
		Salinomycine -Sodium	1.00	Mg

Brocon-5 Special W (WAFI- HOLLAND)

Table (3): composition of Cumin seed

Nutritional value per 100 g			
Energy	1,567 kJ (375 kcal)	Vitamins	Quantity
Carbohydrates	44.24 g	Vitamin A equiv. beta-Carotene	64 µg 762 µg
Sugars	2.25 g	Vitamin A	1270 IU
Dietary fibre	10.5 g	Thiamine (B1)	0.628 mg
Fat	22.27 g	Riboflavin (B2)	0.327 mg
Saturated	1.535 g	Niacin (B3)	4.579 mg
Monounsaturated	14.04 g	Vitamin B6	0.435 mg
Polyunsaturated	3.279 g	Folate (B9)	10 µg
Protein	17.81 g	Vitamin B12	0 µg
Minerals	Quantity	Choline	24.7 mg

Calcium	931 mg	Vitamin C	7.7 mg
Iron	66.36 mg	Vitamin D	0 µg
Magnesium	931 mg	Vitamin D	0 IU
Manganese	3.333 mg	Vitamin E	3.33 mg
Phosphorus	499 mg	Vitamin K	5.4 µg
Potassium	1788 mg	Other constituents	Quantity
Sodium	168 mg	Water	8.06 g
Zinc	4.8 mg		
"Cumin Seed". National Nutrient Database, United States Department of Agriculture. 2017. Retrieved 24 February 2018.			
Units µg = micrograms • mg = milligrams IU = International units			

RESULTS AND DISCUSSION:

Body weight:

Table 4 shows the results of the statistical analysis of the effect of adding three ratios of cumin to broiler chickens' diet on live body weight between experimental treatments. When, broilers receiving 3 g/kg cumin exhibited numerically higher final body weight at 42 days of age. The improvement observed at the moderate inclusion level may be attributed to the bioactive compounds present in cumin, particularly essential oils such as cumin aldehyde, terpenes, and flavonoids, which are known to stimulate digestive secretions and improve nutrient utilization. Most of cumin's properties have been related to its bioactive ingredients, which include phenols, flavonoids, and terpenes (Mughal, 2022). Although, in the 14, 21, 28, 35 and 42 days of age there are no significant differences between the four experimental factors. These results are in accordance with those by (Orhan and Gökhan 2020), who reported that the addition of different doses of CSP to quail diets as growth stimulants did not affect final BW (P>0.05). While, these results adversely with (Galib, 2010) who reported that chicks fed diet supplemented with 1%Cuminum cyminum had significantly (p<0.05) higher weight compared to other treatment groups. The lack of additional improvement at the higher inclusion levels (6 and 9 g/kg) suggests that cumin may exert its beneficial effects only within an optimal dosage range. Excessive inclusion of aromatic herbs can reduce feed palatability due to their strong flavor and odor, potentially limiting nutrient utilization. Moreover, high concentrations of bioactive compounds may not provide additive physiological benefits and may even interfere with digestive processes (Windisch *et al.*, 2008).

Table (4): Effect of different levels of cumin on body weight (g) (Means ±SE) of broiler.

Treatments *	Body weight (gm.)					
	Age (day)					
	7	14	21	28	35	42
T1(control)	129.667±1.667[a]	305.000±9.452[a]	558.667±15.191[a]	883.000±19.655[a]	1204.500±25.643[a]	1508.000±21.733[a]

T2	131.333±1.453[a]	310.000±5.568[a]	556.333±14.903[a]	880.667±45.907[a]	1182.389±50.381[a]	1631.667±41.491[a]
T3	131.667±0.882[a]	319.000±9.849[a]	570.667±29.311[a]	886.667±39.502[a]	1240.111±45.230[a]	1498.000±34.395[a]
T4	132.333±1.856[a]	306.667±9.528[a]	545.000±10.017[a]	862.000±19.502[a]	1227.917±64.712[a]	1480.583±95.106[a]

[*]: Means with different superscript within factor differ significantly (p<0.05).
***T1=control, T2, T3 and T4 Adding 3, 6 and 9gm cumin powder /kg feed respectively.**

Weight gain:

Table 5 explains effect of different levels of cumin on weight gain of broiler. In T2 (diet supplemented with 0.3% Cumin) had significantly higher than T1, T3 and T4 at 42 days of ages in body weight gain. May be due to, the antioxidant activity of cumin may reduce oxidative stress and support metabolic efficiency, thereby promoting growth. Cumin seeds help digestion, secretion of bile salts and digestive enzymes in the small intestine (Muthamma *et al.*, 2008 and Platel, 2000). Also, this results similar with (Galid, 2010) declares that chicks fed diet supplemented with 1%Cuminum cyminum had significantly (p<0.05) higher body weight gains compared to other treatment groups and control group. This improvement may be attributed to the biological functions of cumin that are essential for growth (Cowieson et al., 2003; Ghazalah et al., 2005).

While, there were not significant differences between treatments at ages 14, 21, 28 and 35 days, in addition to there were not significant differences between T1, T3 and T4 at 42 days of ages in body weight gain. Supporting our study (Orhan and Gökhan 2020), reported that the weekly BWG, FI, and FCR were not statistically significant as addition of different doses of CSP to quail diets.

Table (5): Effect of different levels of cumin on weight gain (g) (Means ±SE) of broiler.

Treatments *	Weight gain (g)				
	Age (day)				
	14	21	28	35	42
T1(control)	175.333±8.293[a]	253.667±13.836[a]	324.333±4.807[a]	321.500±26.679[a]	303.500±17.197[b]
T2	178.667±6.119[a]	246.333±9.615[a]	324.333±32.769[a]	301.722±11.651[a]	449.278±50.014[a]
T3	187.333±9.493[a]	251.667±21.341[a]	316.000±22.030[a]	353.444±20.273[a]	257.889±17.095[b]
T4	174.333±7.881[a]	238.333±2.186[a]	317.000±9.504[a]	365.917±47.881[a]	252.667±49.512[b]

[*]: Means with different superscript within factor differ significantly (p<0.05).
***T1=control, T2, T3 and T4 Adding 3, 6 and 9gm cumin powder /kg feed respectively**.

Feed intake:

Table 6 displays the effect of different levels of cumin on feed intake of broiler. Although, at 28 and 42 days T2 numerically showed the highest feed intake as compared to other treatments, may be attributed to the aromatic compounds present in cumin seeds, such as cumin aldehyde and essential oils, which can stimulate appetite and improve digestive activity. (Muthamma *et al.* 2008) who found that cumin promotes the secretion of bile salts and digestive enzymes, improving digestive activity.

Meanwhile, there were not significant differences between treatments (T1. T2, T3 and T4) at 14, 21, 28, 35 and 42 days of age. These result identical with (Ahmed A.Dawood and Ahmed A. Alou AL- Douri, 2014) found no significant (P>0.05) differences among treatments

that received different levels of cumin in feed consumption. While, these results reverse with (Galid, 2010), who found that positive effects of cumin supplementation on broiler feed intake in 1.5% cumin to diet compared to 0.5, 1 % cumin and control. Dietary cumin supplementation did not significantly influence feed intake throughout the experimental period. This finding indicates that cumin inclusion at the tested levels did not adversely affect feed acceptance by broilers.

Table (6): Effect of different levels of cumin on feed intake (g) (Means ±SE) of broiler.

'Treatments .*	feed intake (g)				
	Age (day)				
	14	21	28	35	42
T1(control)	244.000±10.583 [a]	371.000±18.037 [a]	524.000±18.475 [a]	624.000±18.592 [a]	593.917±4.094[a]
T2	250.333±2.906[a]	360.333±10.477 [a]	535.667±45.718 [a]	602.917±38.985 [a]	615.917±31.497 [a]
T3	259.000±7.371[a]	369.667±17.525 [a]	511.333±26.340 [a]	569.803±42.259 [a]	561.889±10.078 [a]
T4	244.000±10.066 [a]	349.333±11.667 [a]	489.333±23.333 [a]	569.053±39.737 [a]	580.250±54.308 [a]

⁎: Means with different superscript within factor differ significantly (p<0.05).
***T1=control, T2, T3 and T4 Adding 3, 6 and 9gm cumin powder /kg feed respectively.**

Feed conversion ratio:

The effects of supplementation ration with cumin on Feed conversion ratio at (14^{th} - 42^{nd}) day-old chicks were presented in Table 7. There were not significant differences between (T1, T2, T3 and T4) in feed conversion ratio at 14, 21, 28 and 35 days of age. Also, T1, T3 and T4 were not significant differences in FCR at 42 days of age. The lack of significant differences in FCR reflects the similar feed intake and body weight gain recorded among treatments, as feed conversion ratio is determined by the relationship between these two parameters (Leeson and Summers, 2005). While, feed conversion ratio was significantly improved in birds fed 3 g/kg cumin at 42 days of age compared with the higher supplementation levels. Improved feed efficiency may be related to the antimicrobial and digestive properties of cumin. (Srinivasan., 2005) reviewed the role of spices, including cumin, in enhancing digestion and nutrient utilization through their bioactive compounds.

Table (7): Effect of different levels of cumin on feed conversion ratio (FCR) (Means ±SE) of broiler.

Treatments *	Feed conversion ratio (FCR)				
	Age (day)				
	14	21	28	35	42
T1(control)	1.392±0.011[a]	1.464±0.011[a]	1.615±0.035[a]	1.895±0.128[a]	1.969±0.109[ab]
T2	1.404±0.041[a]	1.464±0.015[a]	1.661±0.081[a]	1.885±0.077[a]	1.409±0.186[b]
T3	1.386±0.030[a]	1.480±0.069[a]	1.625±0.069[a]	1.625±0.169[a]	2.198±0.147[a]
T4	1.401±0.031[a]	1.465±0.041[a]	1.543±0.047[a]	1.739±0.128[a]	2.408±0.301[a]

⁎: Means with different superscript within factor differ significantly (p<0.05).
***T1=control, T2, T3 and T4 Adding 3, 6 and 9gm cumin powder /kg feed respectively.**

Carcass weight and carcass cuts:

Carcass weight, breast weight, thigh weight and wing weights are presented in Table 8. there were no significant differences between treatments in carcass weight, breast weight, thigh weight and wing weight. These results similar

with (Golian *et al.*, 2010) who reported that relative weight of carcass, legs, breast, liver, heart, gallbladder and gastrointestinal tract were not influenced by Fermacto, Cumin Seed Meal CSM and Cumin Seed CS (P>0.05) at day 28 and 42.

Although the differences were not significant. In the same time, numerically higher carcass, breast, thigh and wing weight observed in T2 compared to other treatments may be associated with the digestive-stimulatory effects of cumin bioactive compounds, including essential oils and cuminaldehyde, which have been shown to enhance digestive processes and nutrient utilization (Platel and Srinivasan, 2000; Srinivasan, 2005).

Table (8): Effect of different levels of cumin on Carcass, breast, thigh and wing weights (g) (Means ±SE) of broiler chicks at 42 days of age.

Treatments *	Carcass weight and Carcass cuts weights (gm.) at 42 days of age			
	Carcass weight	Breast weight	Thigh weight	Wing weight
T1(control)	1076.250±108.135[a]	378.750±33.996[a]	330.000±46.143[a]	142.500±15.877[a]
T2	1345.000±145.057[a]	473.750±62.629[a]	427.500±44.651[a]	160.000±16.202[a]
T3	1203.333±94.634[a]	403.333±37.988[a]	375.000±36.286[a]	145.000±10.206[a]
T4	1152.500±63.031[a]	375.000±29.083[a]	365.000±28.795[a]	145.000±8.416[a]

⁎: Means with different superscript within factor differ significantly (p<0.05).
***T1=control, T2, T3 and T4 Adding 3, 6 and 9gm cumin powder /kg feed respectively**.

Liver, heart and gizzard weights:

Table 9 show the Effect of different levels of cumin on liver, gizzard and heart weights (g) (Means ±SE) of broiler chicks at 42 days of age. There was no significant difference between treatments in liver weight, gizzard weight and heart weight. These findings indicate that dietary cumin supplementation did not induce pathological enlargement or adverse effects on major internal organs. Similar observations were reported by (Golian et al., 2010) who found no significant effects of cumin supplementation on liver, heart, or gastrointestinal tract weights in broiler chickens.

Table (9): Effect of different levels of cumin on liver, gizzard and heart weights (g) (Means ±SE) of broiler chicks at 42 days of age.

Treatments *	Organ weights (gm.) at 42 days of age		
	Liver weight	Gizzard weight	Heart weight
T1(control)	30.000±2.041[a]	20.000±0.000[a]	7.500±1.443[a]
T2	35.000±2.887[a]	22.500±2.500[a]	6.250±1.250[a]
T3	40.000±2.041[a]	20.000±2.041[a]	8.333±1.179[a]
T4	42.500±8.292[a]	18.750±1.250[a]	8.750±1.250[a]

⁎: Means with different superscript within factor differ significantly (p<0.05).
***T1=control, T2, T3 and T4 Adding 3, 6 and 9gm cumin powder /kg feed respectively**.

CONCLUSION:

Considering the results obtained in the current study it could be concluded that dietary inclusion of cumin may not improve broiler performance and carcass parameter, but has the improve weight gain and feed conversion ratio at 42 days of age when a ratio of supplementary cumin at level 3g/kg diet. And also, numerically higher body weight, feed intake carcass, breast, thigh and wing weight observed in T2 compared to other treatments in the same.

RECOMMENDATIONS:

1. Supplementing broiler diets with **3 g cumin powder/kg feed** is recommended, as it improved body weight gain and feed conversion ratio at 42 days of age.

2. Higher levels of cumin supplementation (**6 and 9 g/kg feed**) are not recommended because they did not provide additional productive benefits.
3. Further studies are needed to determine the optimum level of cumin supplementation in broiler diets. In addition to, Future research should investigate the effects of cumin on immune response, blood biochemical traits, antioxidant status, and gut health.

Data Availability:

The data used to support the results of this study has been included in the article.

Conflict of Interest:

The authors declare that they have no conflicts of interest.

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References:

1. Aami-Azghadi, M., Golian, A., Kermanshahi, H., & Sedghi, M. (2010). Comparison of dietary supplementation with cumin essential oil and prebiotic fermacto on humoral immune response, blood metabolites and performance of broiler chickens. Global Veterinaria, 4(4), 380–387.
2. Ahmed, A. A., & Al-Douri, A. A. (2014). Effect of adding cumin (Cuminum cyminum) seeds to the diet on productive performance of broiler chickens (Ross 308). Al-Furat Journal of Agricultural Sciences, 6(3), 85–92.
3. Al-Anbari, E. H., Abbas, A. A., Al-Samarai, F. R., Al-Shamire, J. S., & Al-Zaidi, F. H. (2013). Effect of using cumin oil (Cuminum cyminum) as feed additives on profile analysis and growth curve of broiler. GJBB, 2(3), 326–330.
4. Al-Kassie, G. A. M., Mohseen, A. M., & Abd-Al-Jaleel, R. A. (2011). Modification of productive performance and physiological aspects of broilers on the addition of a mixture of cumin and turmeric to the diet. ROAVS, 1(1), 31–34.
5. Ali, H. A. M., Hussein, A. S., Al-Shamire, J. S. H., & Hamodi, S. J. (2018). Effect of interaction between dietary two levels of cumin (Cuminum cyminum) and ginger (Zingiber officinale) on Japanese quail performance. Euphrates Journal of Agriculture Science, 10(3), 11–19.
6. Ali, M. N., Hassan, M. S., Abd El-Ghany, F. A., & Awadein, N. B. (2012). Using natural antioxidants with or without sulphate to improve productive and reproductive performance of two local strains at late egg production period. International Journal of Poultry Science, 11(4), 269–282.
7. Ali, M. N., Moustafa, K. E. K. M. E., Shabaan, M., Radwan, A. M., & Sayed, M. A. (2011). Effect of using Cuminum cyminum L., citric acid and sodium sulphate for improving the utilization of low protein low energy broiler diets. International Journal of Poultry Science, 10, 514–522.
8. Ali, M. N., Qota, E. M. A., & Hassan, R. A. (2010). Recovery from adverse effects of heat stress on slow-growing chicks using natural antioxidants without or with sulphate. International Journal of Poultry Science, 9(2), 109–117.
9. Allahghadri, T., Rasooli, I., Owlia, P., Nadooshan, M. J., Ghazanfari, T., Taghizadeh, M., & Astaneh, S. D. A. (2010). Antimicrobial property, antioxidant capacity, and cytotoxicity of essential oil from cumin produced in Iran. Journal of Food Science, 75(2), H54–H61.

10. Alkattan, M. M. (2019). Effects of cumin seeds in some physiological characteristics of quail. Journal of Physics: Conference Series, 1294(6), 062084.
11. Cowieson, A. J., Acamovic, T., & Bedford, M. R. (2003). Supplementation of diets containing pea meal with exogenous enzymes: Effect on weight gain, feed conversion, nutrient digestibility and gross morphology of the gastrointestinal tract of growing broiler chicks. British Poultry Science, 44, 427–437.
12. Dalkiliç, B., & Güler, T. (2009). The effects of clove extract supplementation on performance and digestibility of nutrients in broilers. F.Ü. Sağ. Bil. Vet. Derg., 23, 161–166.
13. Duncan, D. B. (1955). Multiple range and multiple F tests. Biometrics, 11, 1–42.
14. Ertas, O. N., Güler, T., Çiftçi, M., Dalkılıç, B., & Simsek, Ü. G. (2005). The effect of an essential oil mix derived from oregano, clove and anise on broiler performance. International Journal of Poultry Science, 4(11), 879–884.
15. Galib, A. M. Al-Kassi. (2010). Effect of feeding cumin (Cuminum cyminum) on the performance and some blood traits of broiler chicks. Pakistan Journal of Nutrition, 9(1), 72–75.
16. Ghazalah, A. A., Abd El-Gawad, A. H., Soliman, M. S., & Youssef, W. A. (2005). Effect of enzyme preparation on performance of broilers fed corn-soybean meal-based diets. Egyptian Poultry Science, 25, 295–316.
17. Golian, A., Aami-Azghadi, M., & Sedghi, M. (2010). The comparison of supplemental cumin seed and cumin seed meal with prebiotic fermacto on blood metabolites and performance of broiler chickens. Journal of Animal and Veterinary Advances, 9(19), 2546–2551.
18. Guo, F. C. (2004). Mushroom and herb polysaccharides as alternatives for growth promoters in poultry. Ph.D. Thesis, Wageningen University, Wageningen, The Netherlands.
19. Khan, S. H., Ansari, J., Haq, A. U., & Abbas, G. (2012). Black cumin seeds as phytogenic product in broiler diets and its effects on performance, blood constituents, immunity and caecal microbial population. Italian Journal of Animal Science, 11, 438–444.
20. Khosravi, A. R., Shokri, H., & Minooeianhaghighi, M. (2011). Inhibition of aflatoxin production and growth of Aspergillus parasiticus by Cuminum cyminum, Ziziphora clinopodioides, and Nigella sativa essential oils. Foodborne Pathogens and Disease, 8(12), 1275–1280.
21. Lawrence, B. M. (1992). Progress in essential oils. Perfumer and Flavorist, 17(4), 42–44.
22. Leeson, S., & Summers, J. D. (2005). Commercial Poultry Nutrition (3rd ed.). University Books, Guelph, Ontario, Canada.
23. Mansoori, B., Mehrdad, M., & Mohammad-Mehdi, K. S. (2006). Cumin seed meal with enzyme and polyethylene glycol as an alternative wheat bran in broiler diets. Journal of the Science of Food and Agriculture, 86(15), 2621–2627.
24. Mnif, S., & Aifa, S. (2015). Cumin (Cuminum cyminum L.) from traditional uses to potential biomedical applications. Chemistry & Biodiversity, 12, 733–742.
25. Mughal, S. S. (2022). A review on potential antioxidant effects of cumin (Cuminum cyminum), phytochemical profile and its uses. Authorea Preprints.
26. Muthamma, M. K. S., Dholakia, H., Kaul, T. P., & Vishveshwaraiah, P. (2008). Enhancement of digestive enzymatic activity by cumin (Cuminum cyminum L.) and role of spent cumin as a bionutrient. Food Chemistry, 110, 678–683.
27. National Research Council (NRC). (1994). Nutrient Requirements of Poultry (9th rev. ed.). National Academy Press, Washington, DC.
28. Orhan Çetinkaya, & Gökhan Filik. (2020). Dietary cumin (Cuminum cyminum) seed powder supplementation had no adverse effects on growth performance and carcass traits of Japanese quail, Coturnix coturnix japonica. Journal of Poultry Research, 17(1), 15–21.
29. Platel, K. (2000). Stimulatory influence of select spices on bile secretion in rats. Nutrition Research, 20, 1493–1503.

30. Platel, K., & Srinivasan, K. (2000). Influence of dietary spices and their active principles on pancreatic digestive enzymes in albino rats. Nahrung/Food, 44(1), 42–46.
31. Shalaby, M. E., Ismail, A. A., Derbalah, A. S., & Eid, Y. Z. (2006). Antifungal activities of some plant extracts against some mould fungi and their toxicological effect on Japanese quail (Coturnix coturnix).
32. Singh, H. O., Singh, H. N., Singh, V. P., & Kumar, A. (2015). Microbiological stability of aerobically packaged quail meat (bone-in) pickle at room temperature (30 ± 2°C). Journal of Livestock Science, 6, 16–22.
33. Sowbhagya, H. B. (2013). Chemistry, technology, and nutraceutical functions of cumin (Cuminum cyminum L.): An overview. Critical Reviews in Food Science and Nutrition, 53(1), 1–10.
34. Srinivas, S. R. (1986). Atlas of Essential Oils. New York: Bronx.
35. Srinivasan, K. (2005). Spices as influencers of body metabolism: An overview of three decades of research. Food Research International, 38(1), 77–86.
36. Srinivasan, K. (2018). Cumin (Cuminum cyminum) and black cumin (Nigella sativa) seeds: Traditional uses, chemical constituents, and nutraceutical effects. Food Quality and Safety, 2(1), 1–16.
37. Steiner, T. (Ed.). (2009). Phytogenics in Animal Nutrition: Natural Concepts to Optimize Gut Health and Performance. Nottingham University Press, Nottingham, United Kingdom.
38. William, P., & Losa, R. (2001). The use of essential oils and their compounds in poultry nutrition. World Poultry, 17, 14–15.
39. Windisch, W., Schedle, K., Plitzner, C., & Kroismayr, A. (2008). Use of phytogenic products as feed additives for swine and poultry. Journal of Animal Science, 86(Suppl. 14), E140–E148.
40. XLSTAT. (2004). XLSTAT-Pro User's Manual. Addinsoft, Paris, France.