



RESEARCH ARTICLE

In Vivo Anticoccidial Activity Evaluation of Fennel Seed Essential Oil in Broiler Chicken

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ABSTRACT

Coccidiosis is a major parasitic disease infecting poultry across the globe. Coccidiostat and coccidiocidal drugs are being used frequently, but the issue needs modern medicine for effective control. Herbal products, especially essential oils, have compounds that have proven to be anticoccidial agents. For this purpose, a research experiment was conducted to evaluate the anticoccidial potential of the essential oil of *F. vulgare*. Broiler chicks of COBB 500 numbering two hundred and sixteen (216) were grouped into six random groups and were replicated thrice. Each group was replicated thrice, containing 12 chicks per replicate. These birds were subjected to oral infection of sporulated oocysts of *Eimeria* spp. on the 7th day of age excluding chicks of neutral control, which was a non-infected control. The feed for chicks in three groups contained fennel essential oil at 1, 2, and 3% concentrations. The remaining three groups consisted of a medicated group (treated with Toltrazuril), an infected but untreated group, and a healthy untreated control group. The study's parameters encompassed fecal scores, oocyst scores, oocyst counts per gram of feces, lesion scores, weight gain, feed intake, feed conversion ratio, mortality rates, organ weight ratios, blood profiles, and serum chemistry. The study's findings demonstrated the essential oil's anticoccidial properties. It was observed that fennel essential oil significantly outperformed the nonmedicated control groups ($P < 0.05$) in reducing lesion scores, fecal scores, and oocyst counts per gram when administered at a 3% concentration. Improvements in feed intake, FCR, and reduced mortalities were also observed. Blood and serum parameters remain statistically comparable ($P > 0.05$), showing no toxicity by the fennel oil. Results of this study show that fennel oil has potent anticoccidial effects, which can be used for further research to find out exact active ingredients

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INTRODUCTION

Eimeria is a genus of parasitic protozoa that causes an intestinal disease called coccidiosis in a large variety of animal species (Akram *et al.*, 2019; Zurisha *et al.*, 2021). Domestic fowl (*Gallus gallus domesticus*) is among the most threatened species of coccidiosis (Tuska and Yesica, 2025). Coccidiosis has been a nightmare at commercial poultry farms as high stocking density, increased humidity, and exposure to parasites are common at these farms (Moryani *et al.*, 2021; Qureshi, 2021). In the past, outbreaks of coccidiosis have caused havoc in the poultry industry (Moryani *et al.*, 2021). Preventive measures and

synthetic coccidiocidal (synthetic chemicals and ionophores) have helped farmers to avoid severe outbreaks of this disease (Hassanen *et al.*, 2020; Mohsin *et al.*, 2021).

Synthetic anticoccidials have been a popular and effective tool to control coccidiosis in commercial poultry flocks, but some issues are being experienced by practitioners and scientists, which put serious concerns about the future use of these drugs (Saeed and Alkheraije, 2023a). Antimicrobial drug resistance is among the major problems which are being faced by scientists currently (Uddin *et al.*, 2021). *Eimeria* is showing resistance to synthetic drugs (Vereecken *et al.*, 2021). Alternatively, vaccines have been developed, but vaccine failures and

high costs are minimizing the use of anticoccidial vaccines (Blake *et al.*, 2021). These scenarios demand a suitable alternative that may control this devastating disease.

Scientists have suggested multiple alternatives, including organic acids, vitamins, amino acids, and herbal products (Mirnawati *et al.*, 2022; Radwan *et al.*, 2022; Gul and Alsayeqh, 2023). Botanical preparations are prominent alternatives that are researched globally for the control of poultry coccidiosis (Saeed and Alkheraije, 2023a). Among plant products, essential oils are widely popular among researchers (Mirnawati *et al.*, 2022). Essential oil-based anticoccidial products like Orego-stim® products have been commercialized (Močár *et al.*, 2011). These findings suggest exploring other essential oils for optimal control of coccidiosis.

Foeniculum vulgare (Fennel) is a shrub of the *Apiaceae* family, that is known for its aromatic plants. Fennel is a common culinary item which is traditionally used as integral part of several savories and a traditional substance for the treatment of gastric and respiratory issues. Various fractions of the essential oil of *F. vulgare* have been proven to be anti-inflammatory, antimicrobial, and antiparasitic (Bava *et al.*, 2022). These activities make it a promising candidate for the control of coccidiosis in the chicken. The essential oil of fennel has more concentration of terpenes and aromatic compounds, which have potent gut protective, anti-inflammatory, and immunomodulatory activities (Rafieian *et al.*, 2024). Because of these reasons, this research was carried out for evaluation of potential of fennel oil against coccidiosis in chickens.

MATERIALS AND METHODS

Parasite Material: *Eimeria* species were isolated from the intestines of the chicken collected from the markets of Multan city, Pakistan. The species were identified microscopically as *Eimeria tenella*, *E. maxima*, *E. necatrix* and *E. mivati* (Kumar *et al.*, 2025). Intestinal and cecal material positive for the *Eimeria* species was collected, washed, and processed for sporulation, as described by Ryley *et al.* (1976). Sporulated samples were then adjusted for dose preparation.

Essential Oil: Fennel seeds were purchased, dried, and ground to a fine powder. Powder of fennel seeds was soaked in the water and hydro distillation was performed as described by Gavahian *et al.* (2012). Yield percent remained 3.1%. The essential oil was collected and stored in containers in the refrigerator (4°C).

Management of Birds: One-day-old, COBB-500 chicks (number 216) were purchased from a local hatchery. They were housed as per the COBB management guide. Floor management was done while the grouped chickens were fed with mesh feeds in the starter phase and then grown on the crumbs in the finisher phase. The composition of the feeds, along with the nutrient percentage, is given in Table 1.

Experimental Design: Birds were segregated into 6 groups, which were allotted alphabetical numbers from A to F. Each group contained 12 chicks in it and was replicated thrice. On the 7th day, all the members of groups A, B, C, D, and E were infected with the

sporulated oocysts of *Eimeria* and were given orally @ 6x10⁴ per chick. On the same day, groups A, B, and C were given essential oil of fennel 1, 2, and 3% in the feed. Group D was given standard medication (Toltrazuril @ 1mL/ L water), group E was not medicated and Group F was neither infected nor medicated to serve as controls. The initial weighing was done on the 7th day. The routine observation was done daily to observe feed intakes, mortalities, fecal scores, and oocyst scores. On the 7th day post-infection, final weights were taken, and the humane slaughtering of 3 birds from each bird was done to observe lesions on the ceca and intestine. On the 35th day, all the remaining birds were slaughtered, and weights of internal organ were recorded.

Table 1: Nutrient composition and Feed ingredients and of starter and finisher feeds of the broiler chicks

Elements	Composition of Starter Feed (%)	Composition of Finisher feed (%)
Corn	45.00	47.00
Rice grain	9.00	14.00
Rice polish	5.00	5.00
Soybean meal	17.00	15.00
Canola seed meal	18.00	10.00
Maize gluten 60%	2.00	3.00
Molasses	2.00	4.00
Di-calcium Phosphate	1.00	1.00
Vitamin supplement	0.70	0.7
DL methionine	0.15	0.15
L Lysine	0.15	0.15
Proximate analysis		
Metabolizable Energy (kilocalories/kilogram)	29 ×10 ³	3×10 ³
Percent Crude Protein	20	18
Percent Crude Fiber	04.9	04.5
Percent Ether Extract	3.01	4.0
Percent Calcium	1.02	0.80
Phosphorus available (%)	0.65	0.40

Parameters

Anticoccidial parameters: Anticoccidial activity of the fennel essential oil was estimated in the lesion, fecal, oocyst scores, and oocyst per gram of feces. Feces of the birds were collected to observe morphology of oocysts for identification, fecal conditions and oocyst per gram, as described by Youn *et al.* (1993). Fecal scoring was performed on a scale of 0 to 4.

Performance parameters: The performance of the birds was estimated by the weight gain, feed conversion ratio (FCR), feed intake, percent mortalities, and organ weights as described by Abbas *et al.* (2019).

Blood Parameters: Packed Cell values (PCV), hemoglobin, Red blood cell counts (RBC), and white blood cells were counted using Natt and Herrick (1952) technique.

Serum Chemistry: Urea, creatinine, serum glutamic oxaloacetate transaminases (SGOT), and serum glutamic pyruvic transaminases (SGPT) were estimated to evaluate the toxicities following spectrometric techniques adopted by Abbas *et al.* (2019).

Statistical Analysis: Analysis of variance was performed, and means were compared by Tukey test. The significance level of 5% was observed to mention statistical differences. Minitab® statistical software was used for statistical analysis.

RESULTS

Anticoccidial Effects: Fennel essential oil showed excellent anticoccidial activities and reduced lesions, fecal oocyst output, OPG, and the scores of feces ($P < 0.05$) when compared to group E. The results show that the fennel essential oil showed the best effects at 3% concentration (Tables 2, 3).

Table 2: Effect of different concentrations of the fennel oil on oocyst per gram and lesion scores in broiler chicks

Groups	Lesion Scores	Oocyst per gram (x1000)
A	3.33±0.33 ^a	27.57±0.74 ^b
B	2.67±0.33 ^{ab}	22.19±0.57 ^c
C	1.67±0.33 ^{abc}	18.21±1.26 ^d
D	1.00±0.57 ^{bc}	18.36±0.65 ^{cd}
E	3.33±0.33 ^a	34.53±1.05 ^a
F	0.00±0.00 ^c	0.00±0.00 ^e

A: 1% fennel oil-treated group; B: 2% fennel oil-treated group; C: 3% fennel oil-treated group; D: Toltrazuril (standard medicine) treated group; E: infected non-medicated group; F: no-infected non-medicated group. Similar superscripts within a column show a non-significant interaction ($P > 0.05$).

Table 3: Effect of different concentrations of the fennel oil on the oocyst and fecal scores of the chicks

Groups	Oocyst scores (Days)			Fecal Scores (Days)		
	4	5	6	4	5	6
A	3.33±0.33 ^a	2.15±0.85 ^b	3.87±0.51 ^c	3.57±0.33 ^{ab}	3.67±0.33 ^{ab}	3.14±0.33 ^{ab}
B	2.67±0.33 ^{ab}	1.76±0.81 ^b	2.81±0.50 ^{bc}	2.45±0.33 ^{bc}	2.67±0.33 ^{bc}	2.17±0.33 ^{bc}
C	1.67±0.33 ^{abc}	1.33±0.74 ^b	1.53±0.51 ^{bc}	1.63±0.33 ^c	1.67±0.33 ^c	1.34±0.33 ^c
D	1.00±0.57 ^{bc}	1.17±0.50 ^b	1.22±0.51 ^{3b}	1.31±0.33 ^{cd}	1.33±0.33 ^{cd}	1.29±0.33 ^{cd}
E	3.33±0.33 ^a	3.33±0.33 ^{3a}	3.23±0.64 ^{5a}	4.21±0.33 ^a	4.33±0.33 ^a	4.77±0.33 ^a
F	0.00±0.00 ^c	0.00±0.00 ^c	0.00±0.00 ^d	0±0.00 ^d	0±0.00 ^d	0±0.00 ^d

A: 1% fennel oil-treated group; B: 2% fennel oil-treated group; C: 3% fennel oil-treated group; D: Toltrazuril (standard medicine) treated group; E: infected non-medicated group; F: no-infected non-medicated group. Similar superscripts within a column show a non-significant interaction ($P > 0.05$).

Effects on Performance: Weight gains, feed intake, and feed conversion ratio were significantly improved by the addition of essential oil, and mortalities were decreased (Fig. 1, Table 4).

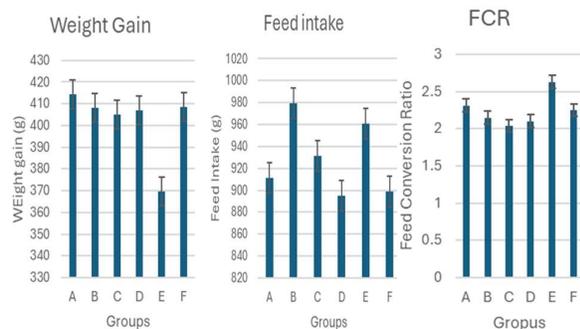


Fig. 1: Effect of different concentrations of the fennel oil on the weight gain, feed intake, and feed conversion ratio (FCR) of the chicks. A: 1% fennel oil treated group; B: 2% fennel oil treated group; C: 3% fennel oil treated group; D: Toltrazuril (standard medicine) treated group; E: infected non-medicated group; F: no-infected non-medicated group.

Serum profile: Serum chemistry of the chicks was done and the effects of fennel essential oil on the SGPT, SGOT, serum urea, and creatinine were observed. There were no statistical differences across the groups, which showed that the essential oil of fennel had no effects on these parameters (Table 5)

Effects on Blood Parameters: Blood parameters (RBC, WBC, PCV, and hemoglobin) were not affected by the addition of fennel oil in the feed of the chicks. The results are presented in Table 6.

Table 4: Effect of different concentrations of the fennel oil on the Lesion scores and oocyst per gram of the chicks

Groups	Birds died on various days post-infection				Total Birds died	Mortality (%)
	4 th	5 th	6 th	7 th		
A	0	0	1	1	2	16.67
B	1	0	0	0	1	8.33
C	0	0	0	0	0	0.00
D	0	0	0	0	0	0
E	1	1	1	1	4	33.33
F	0	0	0	0	0	0

A: 1% fennel oil treated group; B: 2% fennel oil treated group; C: 3% fennel oil treated group; D: Toltrazuril (standard medicine) treated group; E: infected non-medicated group; F: no-infected non-medicated group.

Table 5: Effect of different concentrations of the fennel oil on the serum glutamic pyruvic aminotransferase (SGPT), serum glutamic oxaloacetate aminotransferase (SGOT), lactate dehydrogenase (LDH), urea and creatinine on broiler chicks

Groups	SGPT (IU/L)	SGOT (IU/L)	LDH (IU/L)	Urea (mmol/L)	Creatinine (mg/dL)
A	11.41±0.04 ^b	177.17±1.55 ^c	484.24±5.25 ^c	5.45±0.45 ^d	0.17±0.01 ^b
B	12.68±0.29 ^a	272.53±1.98 ^a	647.04±6.85 ^b	15.99±0.40 ^b	0.22±0.01 ^{ab}
C	11.30±0.26 ^b	255.62±3.88 ^b	640.27±7.23 ^b	14.80±0.23 ^b	0.23±0.02 ^{ab}
D	12.44±0.24 ^{ab}	176.07±1.33 ^c	472.54±5.44 ^c	10.36±0.64 ^c	0.26±0.02 ^a
E	11.30±0.27 ^b	263.21±1.23 ^b	886.87±8.33 ^a	21.18±0.63 ^a	0.21±0.03 ^{ab}
F	13.11±0.29 ^a	183.70±2.38 ^c	464.67±3.40 ^c	9.68±0.82 ^c	0.17±0.02 ^b

A: 1% fennel oil-treated group; B: 2% fennel oil-treated group; C: 3% fennel oil-treated group; D: Toltrazuril (standard medicine) treated group; E: infected non-medicated group; F: no-infected non-medicated group. Similar superscripts within a column show a non-significant interaction ($P > 0.05$).

Table 6: Effect of different concentrations of the fennel oil on the Packed cell volume (PCV%), hemoglobin, erythrocyte counts, and leukocyte count of chicks

Groups	PCV (%)	Haemoglobin (g/L)	Erythrocyte Count ($\times 10^9/uL$)	Leukocyte count ($10^3/uL$)
A	27.29±1.27 ^a	12.90±0.48 ^a	3.95±0.17 ^a	24.63±1.06 ^b
B	28.04±0.57 ^a	11.63±0.84 ^a	3.38±0.19 ^{ab}	24.65±0.65 ^b
C	28.70±0.91 ^a	12.83±1.18 ^a	3.66±0.10 ^{ab}	22.02±1.20 ^b
D	27.48±0.64 ^a	11.26±0.63 ^{ab}	2.90±0.17 ^b	22.53±0.59 ^b
E	19.48±0.23 ^b	11.58±0.90 ^a	1.94±0.04 ^c	33.53±0.29 ^a
F	27.53±0.51 ^a	7.72±0.52 ^b	3.56±0.22 ^{ab}	21.66±1.28 ^b

A: 1% fennel oil-treated group; B: 2% fennel oil-treated group; C: 3% fennel oil-treated group; D: Toltrazuril (standard medicine) treated group; E: infected non-medicated group; F: no-infected non-medicated group. Similar superscripts within a column show a non-significant interaction ($P > 0.05$).

DISCUSSION

In this research, anticoccidial properties of the essential oil of *Foeniculum vulgare* (Fennel) seed were evaluated against coccidiosis in broiler chicks. The essential oil was given in three dose levels i.e., 1, 2, and 3%. The essential oil was proven effective in controlling the lesions produced by coccidiosis, and results showed that fennel essential oil had potent effects on the performance of the chicks. Multiple researchers have worked on the effect of plants and plant-extracted products and stated that the plants were effective in controlling the signs of coccidiosis (Lee *et al.*, 2020; Sidiropoulou *et al.*, 2020; Chang *et al.*, 2021; Moryani *et al.*, 2021; Nahed *et al.*, 2022).

We have proven such types of results in our study conducted for the evaluation of the anticoccidial effects of the essential oil of *Amomum subulatum*, except that there

were no alterations in the red blood cells and packed cell volume of the chicken with the therapeutic doses of the essential oil (Saeed *et al.*, 2023). Raza *et al.* (2022) also had similar results, and they proved the anticoccidial effects of *Citrus sinensis* in the broiler chicken in an experiment. Our study had similar results with the study conducted by Abbas *et al.* (2019), which showed that *Trachyspermum ammi* effectively controlled the signs of coccidiosis and improved the performance of the chicks in the research.

The anticoccidial efficiency of fennel may be attributed to its active compounds. Active compounds of the fennel essential oil belong to terpenes and terpenoids (Tariq *et al.*, 2019). Terpenes and terpenoids are frequently present in several essential oils. They have multiple direct and indirect mechanisms that lead to the control of coccidiosis. The terpenes and terpenoids can penetrate the cell walls of merozoites and destroy their energy production mechanism (Menezes and Tasca, 2023). They arrest several enzymes that are related to the cell cycle of *Eimeria*, stopping its multiplication (Saeed and Alkheraije, 2023b). Along with it, research reports that the terpenes and derivatives can control coccidiosis by disrupting the formation of gametes, hence stopping the multiplication (Aziz-Aliabadi *et al.*, 2026). Besides these direct activities, the essential oils have proven antioxidant substances and help reduce signs of coccidiosis by reducing oxidative damage (Mustafa *et al.*, 2025). Schizogony and immune activities stopping the schizogony cause massive destruction of the cells. This damaging process leads to the production of free radicals, which rapidly interact with the nearby cells, increasing the damage (Mohsin *et al.*, 2021). The control of coccidiosis chiefly depends on the control of oxidative stress produced by free radicals during the invasion of immune cells into the gut. Terpenes and terpenoids have proven efficacy in capturing the free radicals and control the inflammatory damage inside the gut.

This research states that fennel had no toxic effect on the serum profile during the trial period. Long-term effects cannot be concluded from this study.

Conclusions: This study states that fennel essential oil has anticoccidial properties and can improve the performance of the birds and help control the mortalities caused by coccidiosis. The study suggests further research to evaluate the individual effects of the components of the essential oil of fennel to explore the exact mechanism of action and discover the effective compound and pharmacological interaction of various components of essential oil belonging to different chemical groups.

Authors contribution: ZS and AA conducted the research and wrote the paper. XW, LW, MS actively participated in designing and supervising the experiment, and reviewed the manuscript. All authors finally read and approved the manuscript.

Conflict of interest: The authors declare no conflict of interest.

Ethical statement: All the experiments were conducted as per the ethical guidelines of the World Association for

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REFERENCES

- Abbas A, Abbas RZ, Khan MK *et al.*, 2019. Anticoccidial effects of *Trachyspermum ammi* (Ajwain) in broiler chickens. *Pakistan Veterinary Journal* 39(2):301-304.
- Akram MZ, Zaman MA, Jalal H *et al.*, 2019. Prevalence of gastrointestinal parasites of captive birds in Punjab, Pakistan. *Pakistan Veterinary Journal* 39(1):132-134.
- Aziz-Aliabadi F, Noruzi H and Imari ZK, 2026. A review of the control of coccidiosis in poultry using natural additives, focusing on gut health and immunity. *Advances in Agriculture* 2026(1):9936396.
- Bava R, Castagna F, Palma E *et al.*, 2022. Phytochemical profile of *Foeniculum vulgare* subsp. *piperitum* essential oils and evaluation of acaricidal efficacy against *Varroa destructor* in *Apis mellifera* by in vitro and semi-field fumigation tests. *Veterinary Sciences* 9(12):684.
- Blake DP, Marugan-Hernandez V and Tomley FM, 2021. Spotlight on avian pathology: *Eimeria* and the disease coccidiosis No. 50. 209-213. Taylor & Francis.
- Chang LY, Di KQ, Xu J *et al.*, 2021. Effect of natural garlic essential oil on chickens with artificially infected *Eimeria tenella*. *Veterinary Parasitology* 300:109614.
- Gavahian M, Farahnaky A, Javidnia K *et al.*, 2012. Comparison of ohmic-assisted hydrodistillation with traditional hydrodistillation for the extraction of essential oils from *Thymus vulgaris* L. *Innovative Food Science & Emerging Technologies* 14:85-91.
- Gul ST and Alsayeqh AF, 2023. Probiotics improve physiological parameters and meat production in broiler chicks. *International Journal of Veterinary Science* 12(2):182-191.
- Hassanen EAA, Anter RGA, El-Neshwy WM *et al.*, 2020. Prevalence and Phylogenetic Analysis of *Eimeria* Species in Sheep and Goats in Sharkia Governorate, Egypt. *Pakistan Veterinary Journal* 40(4): 437-442.
- Kumar S, Kumar P, Rakesh RL *et al.*, 2025. Diagnostic methods of parasitic diseases of poultry, handbook of poultry parasites. Bentham Science Publishers. pp:150-178
- Lee J-W, Kim D-H, Kim Y-B *et al.*, 2020. Dietary encapsulated essential oils improve production performance of coccidiosis-vaccine-challenged broiler chickens. *Animals* 10(3):481.
- Mirawati GC, Djulardi A and Makmur M, 2022. Broiler Response to the Utilization of Fermented Palm Oil Sludge with *Phanerochaete chrysosporium* and *Neurospora crassa*. *International Journal of Veterinary Science* 11(2):201-206.
- Močar K, Štofan D, Angelovičová M *et al.*, 2011. The application of probiotics, essential oils and their combination in the poultry production. *Scientific Papers: Animal Science & Biotechnologies/Lucrari Stiintifice: Zootehnie si Biotehnologii* 44(1):71-75
- Mohsin M, Abbas RZ, Yin G *et al.*, 2021. Probiotics as therapeutic, antioxidant and immunomodulatory agents against poultry coccidiosis. *World's Poultry Science Journal* 77(2):331-345.
- Moryani AA, Rajput N, Naeem M *et al.*, 2021. Screening of the herbs and evaluation of their combined effects on the health and immunity of coccidiosis challenged broiler chickens. *Pakistan Veterinary Journal* 41(2):228-234.
- Mustafa S, Abbas RZ, Saeed Z *et al.*, 2025. Use of metallic nanoparticles against *eimeria*—the coccidiosis-causing agents: A Comprehensive Review. *Biological Trace Element Research* 203(6):3412-3431.
- Nahed A, Abd El-Hack ME, Albaqami NM *et al.*, 2022. Phytochemical control of poultry coccidiosis: a review. *Poultry Science* 101(1):101542.
- Natt MP and Herrick CA, 1952. A new blood diluent for counting the erythrocytes and leucocytes of the chicken. *Poultry Science* 31(4):735-738.
- Qureshi NA, 2021. In vitro anticoccidial, antioxidant activities and biochemical screening of methanolic and aqueous leaves extracts of selected plants. *Pakistan Veterinary Journal* 41(1):57-63.
- Radwan IA-H, Moustafa MMM, Abdel-Wahab SH *et al.*, 2022. Effect of essential oils on biological criteria of gram-negative bacterial pathogens isolated from diseased broiler chickens. *International Journal of Veterinary Science* 11(1):59-67.

- Rafieian F, Amani R, Rezaei A *et al.*, 2024. Exploring fennel (*Foeniculum vulgare*): Composition, functional properties, potential health benefits, and safety. *Critical Reviews in Food Science and Nutrition* 64(20):6924-6941.
- Raza QS, Saleemi MK, Gul S *et al.*, 2022. Role of essential oils/volatile oils in poultry production—A review on present, past and future contemplations. *Agrobiological Records* 7:40-56.
- Ryley JF, Meade R, Hazelhurst J *et al.*, 1976. Methods in coccidiosis research: separation of oocysts from faeces. *Parasitology* 73(3):311-326.
- Saeed Z, Abbas RZ, Khan MK *et al.*, 2023. Anticoccidial activities of essential oil of *Amomum subulatum* in broiler chicks. *Pakistan Journal of Agricultural Sciences* 60(2):377-384.
- Saeed Z and Alkheraije KA, 2023b. Botanicals: A promising approach for controlling cecal coccidiosis in poultry. *Frontiers in Veterinary Science* 10:1157633.
- Sidiropoulou E, Skoufos I, Marugan-Hernandez V *et al.*, 2020. In vitro anticoccidial study of oregano and garlic essential oils and effects on growth performance, fecal oocyst output, and intestinal microbiota in vivo. *Frontiers in Veterinary Science* 7:420.
- Tariq S, Wani S, Rasool W *et al.*, 2019. A comprehensive review of the antibacterial, antifungal and antiviral potential of essential oils and their chemical constituents against drug-resistant microbial pathogens. *Microbial pathogenesis* 134:103580.
- Tuska A and Yesica R, 2025. Identification, prevalence estimation, and mapping of coccidiosis in Broiler Chickens (*Gallus domesticus*) across varying elevations in Malang Regency and Batu City Heri Irawan I, Filza Hannani Vawzia Hanifa I, Shelly Kusumarini RI, Habib Syaiful. *Journal of Basic Medical Veterinary* 14(2):148-162.
- Uddin TM, Chakraborty AJ, Khusro A *et al.*, 2021. Antibiotic resistance in microbes: History, mechanisms, therapeutic strategies and future prospects. *Journal of Infection and Public Health* 14(12):1750-1766.
- Vereecken M, Dehaeck B, Rathinam T *et al.*, 2021. Restoration of the sensitivity of *Eimeria acervulina* to anticoccidial drugs in the chicken following use of a live coccidiosis vaccine. *Veterinary Parasitology* 292:109416.
- Youn HJ, Kang YB and Jang DH, 1993. Effects of γ -irradiation from cobalt-60 on pathogenicity of *Eimeria tenella*. *Korean Journal of Veterinary Research* 33(4):649-655.
- Zurisha R, Abbas RZ, Abbas A *et al.*, 2021. In vitro and in vivo anticoccidial effects of butyric acid and its impact on blood and serum chemistry of broiler chickens. *Kafkas Üniversitesi Veteriner Fakültesi Dergisi* 27(5): 583-588.