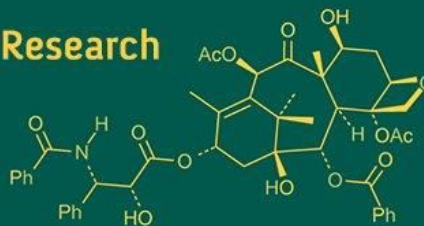
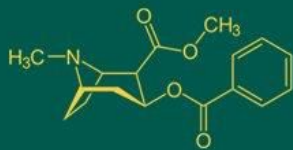


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Synergistic effects of phytochemicals and disinfectants in mitigating experimental coccidiosis in broiler chickens and its impact on growth performance and gut health

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Abstract

This study assessed the impact of various feed additives on *Eimeria* spp. colonization, intestinal health, and production performance in broiler chickens. A total of 270 chicks were divided into nine treatment groups, and key parameters such as lesion scoring, oocyst shedding, production performance, and microbiological counts were analyzed. The results demonstrated that certain feed additives significantly reduced *Eimeria* colonization, improved feed conversion ratios (FCR), and lowered bacterial loads. Notably, Group D (Respolite + Vet COC) exhibited the highest body weight (2.85 kg at day 42) and a significantly lower FCR (1.45) compared to Control A (1.72). Oocyst shedding was reduced by 78% in Group F (Respolite Plus + Vet COC) and by 72% in Group D, confirming their strong anticoccidial effects. Microbiological analysis revealed that *E. coli* counts were significantly lower in treated groups, with Group H (Coccihygeen Plus + Vet COC) showing the lowest bacterial load (3.1 log CFU/g vs. 6.4 log CFU/g in Control A). Pathological findings supported these results, as treatment groups exhibited milder intestinal lesions and reduced villous atrophy compared to control birds. The study concludes that phytochemical-based feed additives, particularly Respolite and Coccihygeen formulations, show strong potential as natural alternatives to conventional coccidiostats, enhancing both gut health and overall production performance in broiler chickens. These natural additives represent an intriguing option in view of growing concerns about antimicrobial resistance, the need to minimise or eradicate the use of antibiotic growth promoters, and the growing consumer demand for products free of chemicals and antibiotics.

Keywords: *Eimeria* colonization, feed additives, broiler chickens, intestinal health, growth performance

Introduction

The global human population is estimated to reach 9.6 billion by 2050. During this period, broiler chicken production is expected to grow by 121% to meet the increasing demand for animal protein (Mottet & Tempio, 2017) [19]. However, poultry health and nutrition face significant challenges, particularly due to the increased incidence of enteric diseases such as coccidiosis and necrotic enteritis, which impair nutrient absorption and digestion (Fathima *et al.*, 2022) [10]. These conditions result in poor feed conversion efficiency, higher mortality rates, and increased condemnation at processing plants. Ensuring food safety and security for the expanding human population requires effective control and prevention of enteric infections. Coccidiosis, caused by *Eimeria* spp., is a major parasitic disease affecting poultry, leading to significant economic losses due to reduced feed efficiency and increased mortality (Mathis *et al.*, 2024) [17]. The cellular immune response of chickens to *Eimeria* spp. invasion, which causes cecal coccidiosis, generates reactive oxidative species (ROS) (Ogwiji *et al.*, 2024) [22]. Coccidiosis is often considered a disease of poor management (Ali *et al.*, 2014; Bachaya *et al.*, 2015) [5, 7], with an estimated US\$ 20 million in annual economic losses recorded in India (Bera *et al.*, 2010) [8]. Antimicrobial growth promoters (AGPs) are subtherapeutic doses of antibiotics that have been widely used in animal production to enhance feed efficiency, growth performance, and intestinal health (Mehdi *et al.*, 2018) [18]. However, rising concerns about antimicrobial resistance and consumer demand for

antibiotic-free poultry products have led many countries to ban or restrict the use of AGPs. *Eimeria* parasites undergo intracellular development in the gut, directly impairing the intestinal mucosa and affecting overall bird health (Lee *et al.*, 2023) [16]. As an alternative, dietary supplementation with nucleotide-rich yeast extract at a 0.5% level has been shown to improve growth performance, including live body weight, weight gain, feed intake, and feed conversion ratio in broilers (Tembhurne, 2020) [28]. The recent shift toward reducing AGPs in poultry diets has increased the industry's focus on finding viable alternatives. In this context, phytogenic feed additives (PFAs) are being explored for their potential to enhance gut health and improve overall performance (Murugesan *et al.*, 2015) [20]. Considering these factors, the present study was conducted to evaluate the effects of different feed additives on *Eimeria* colonization, intestinal health, and production parameters in broiler chickens.

Materials and Methods

Experimental Design

The present study was carried out in the Department of Veterinary Parasitology and Poultry Research and Training Centre, Nagpur Veterinary College, Nagpur. For the

experiment, day-old broiler chicks were procured and randomly divided into nine treatments, each treatment made of three replicate pens, and each pen was comprised of 10 chicks. All chicks were provided with similar management and environmental conditions and reared on floor pen with rice husk as bedding material. The birds of all the nine treatments were fed with standard commercial broiler ration without any coccidiostat in feed (pre-starter, starter & finisher ration). Proper vaccination, bio-security and sanitization were maintained in all the pens to prevent any infection during experimental period. All the experimental birds were kept under constant observation during the entire period of study. A total of 270, day old chicks of either sex were divided into nine treatments with each one duplicate pen. The cleaned and disinfected surfaces were contaminated with sporulated oocysts equivalent to $4.0 \times 10^5/\text{m}^2$. Then the floor was covered as usual with rice husk.

Methodology

Source of *Eimeria* spp. Oocyst

Eimeria oocysts were collected from natural outbreaks, speciated, and subjected to sporulation. The required dilution was made and used for the challenge study.

The groups of birds and dosages given to them were as follows:

Sr. No.	Experimental Groups	No. of Chicks	Treatment schedule
1	A (Control 1) Diet + Oocyst	30	Basal diet without any probiotic and no coccidiostat and challenged with <i>Eimeria</i> oocyst The cleaned surfaces will be contaminated with sporulated Oocysts equivalent to $4.0 \times 10^5/\text{m}^2$.
2	B (Control 2) Diet + Oocyst + Salinomycin	30	Basal diet without any probiotic with coccidiostat (Salinomycin 50g/100kg) and challenged with <i>Eimeria</i> oocyst The cleaned surfaces will be contaminated with sporulated Oocysts equivalent to $4.0 \times 10^5/\text{m}^2$.
3	C (Control 3) Diet + Oocyst + Vet COC (disinfection at 2%)	30	Basal diet without any probiotic with coccidiostat and challenged with <i>Eimeria</i> oocyst The cleaned surfaces will be contaminated with sporulated Oocysts equivalent to $4.0 \times 10^5/\text{m}^2$. Disinfection with 400 ml per square metre of Vet Coc 2% dilution. Bring the chicks not earlier than 24 hours after disinfection
4	D (Respolite) Diet + Oocyst + Respolite + Vet COC (disinfection at 2%)	30	Fed with ration as group A + Respolite supplemented in drinking water 20 ml/100 Litre water days 9-11, 16-18, 23-25, 30-32. The cleaned surfaces will be contaminated with sporulated oocysts equivalent to $4.0 \times 10^5/\text{m}^2$. Disinfection with 400 ml per square metre of Vet Coc 2% dilution. Bring the chicks not earlier than 24 hours after disinfection
5	F (Respolite plus) Diet + Oocyst + Respolite plus (respolite + aviator) + Vet COC (disinfection at 2%)	30	Fed with ration as group A + Respolite plus supplemented in drinking water 20 ml/100 Litre water days 9-11, 16-18, 23-25, 30-32. The cleaned surfaces will be contaminated with sporulated Oocysts equivalent to $4.0 \times 10^5/\text{m}^2$. Disinfection with 400 ml per square metre of Vet Coc 2% dilution. Bring the chicks not earlier than 24 hours after disinfection
6	G (Coccihygeen) Diet + Oocyst + Coccihygeen + Vet COC (disinfection at 2%)	30	Fed with ration as group A + (Coccihygeen 50g/100 kg) and challenged with <i>Eimeria</i> oocyst The cleaned surfaces will be contaminated with sporulated oocysts equivalent to $4.0 \times 10^5/\text{m}^2$. Disinfection with 400 ml per square metre of Vet Coc 2% dilution. Bring the chicks not earlier than 24 hours after disinfection.
7	H (Coccihygeen plus) Diet + Oocyst + Coccihygeen plus + Vet COC (disinfection at 2%)	30	Fed with ration as group A + (Coccihygeen Plus 50g/100 kg) and challenged with <i>Eimeria</i> oocyst The cleaned surfaces will be contaminated with sporulated Oocysts equivalent to $4.0 \times 10^5/\text{m}^2$. Disinfection with 400 ml per square metre of Vet Coc 2% dilution. Bring the chicks not earlier than 24 hours after disinfection.
8	I (Coccihygeen plus EU) Diet + Oocyst + Coccihygeen plus EU + Vet COC (disinfection at 2%)	30	Fed with ration as group A (Coccihygeen plus EU 50g/100 kg) and challenged with <i>Eimeria</i> oocyst. The cleaned surfaces will be contaminated with sporulated oocysts equivalent to $4.0 \times 10^5/\text{m}^2$. Disinfection with 400 ml per square metre of Vet Coc 2% dilution. Bring the chicks not earlier than 24 hours after disinfection!
9	J (Aviator) Diet + Oocyst + Aviator + Vet COC (disinfection at 2%)	30	Fed with ration as group A + Aviator supplemented in drinking water 20 ml/100 Litre water days 9-11, 16-18, 23-25, 30-32. The cleaned surfaces will be contaminated with sporulated Oocysts equivalent to $4.0 \times 10^5/\text{m}^2$. Disinfection with 400 ml per square metre of Vet Coc 2% dilution. Bring the chicks not earlier than 24 hours after disinfection

Source of Anticoccidials

Respolite, Respolite Plus, Coccihygeen, Coccihygeen Plus,

Aviator, and Vet Coc were supplied by Saife Vetmed Pvt. Ltd, New Delhi.

Lesion Scoring and Sample Collection

Three birds from each replicate were sacrificed on the 28th and 42nd day of age. Intestines were observed, and lesion scoring was performed as per Johnson and Reid (1970) [15].

Oocyst Per Gram (OPG)/Oocyst Shedding

Fecal content from all groups was collected on days 14, 21, 28, 35, and 42. Oocyst count was performed using Stoll's method and expressed as OPG (Haug *et al.*, 2006) [14].

Weekly Performance

Weekly body weight and feed consumption were recorded, and cumulative feed conversion ratios (FCR) were calculated. Mortality was also recorded.

Microbiological Count

One gram of fecal material was collected aseptically from six birds per group at the time of sacrifice on the 42nd day. Enumeration of *E. coli* and *Clostridium* spp. per gram of feces was performed.

Statistical Analysis

Data were analyzed statistically using standard procedures.

Results

Pathology

Gross Pathology

Gross observations made on intestines in experimental broilers of different treatment groups (A-I) at Day 28 and Day 42 are presented in Fig. 1. At Day 28, the control group revealed ballooning of intestines along with hemorrhages in the caeca (lesion score 3). Other treatment groups exhibited mild ballooning of intestines. Milder lesions were noted in caeca of Groups C and G (lesion score 1). At Day 42, the intestine from the control group revealed enlargement and ballooning of caeca with hemorrhages (lesion score 2). Groups C, D, F, G, and H also showed mild enlargement and ballooning of caeca with hemorrhages (lesion score 2).

Histopathology

Histopathological analysis (Fig.2) revealed severe villous disruption, crypt necrosis, and inflammatory infiltration in the duodenum, jejunum, ileum, and cecum of the control group. Treated groups exhibited moderate to mild lesions. By Day 28, moderate lesions were observed in the duodenum of Groups C, F, G, and H, while Groups D and E displayed milder changes. By Day 42, lesion severity decreased across all treatment groups, with Group E showing the mildest changes in the cecum.

Body Weight and Growth Performance

There were no significant differences ($p>0.05$) in body weight on Day 0. However, significant differences ($p<0.001$) were observed from Day 7 onwards. By Day 42, Group D had the highest body weight (2459.67 ± 2.60 g), followed by Groups G and F. Group I recorded the lowest body weight (2000.67 ± 1.20 g), indicating that Groups D, G, and E were effective in promoting weight gain.

Feed Consumption and Feed Conversion Ratio (FCR)

Feed intake varied among groups. The control group (Group A) exhibited the highest overall feed consumption. Despite consuming less feed, Groups E, G, and H achieved higher body weight, suggesting improved feed efficiency. Group E had the most favorable FCR values: 1.24, 1.46, and 1.36 during Weeks 1, 2, and 3, respectively. Group I showed the

poorest FCR (4.2) in Week 6.

Oocyst Shedding

Group A (Control) showed the highest oocyst counts ($45,833.33\pm4284.99$ oocysts/g) on Day 28, which declined to 1300.00 ± 196.64 by Day 42. Group B (Salinomycin) maintained zero oocyst count on most days. Group E showed high oocyst count initially ($74,166.67\pm3944.76$ on Day 28) but dropped significantly to 616.67 ± 90.98 by Day 42. Groups F and H also exhibited reduced oocyst shedding at later stages.

Microbial Load (CFU/mL)

Group A showed the highest bacterial load initially (2.98×10^7 CFU/mL), which increased to 1.11×10^8 CFU/mL. Among treatments, Group G (Coccyhygeen plus) had the highest final bacterial count (1.69×10^8 CFU/mL), while Groups B, E, and F had the lowest bacterial counts, indicating better bacterial control.

Discussion

The results demonstrate the impact of different treatments on mitigating the negative effects of coccidiosis and improving broiler performance. Gross and histopathological findings confirm that treated groups had fewer and milder intestinal lesions compared to the control, supporting the protective role of specific interventions. The moderate to mild histological changes in Groups D and E, especially by Day 42, reflect effective gut integrity restoration, in agreement with studies like Gieryńska *et al.* (2022) [11] and Tsiouris *et al.* (2021) [29]. Body weight gains in Groups D, G, and E suggest that bioactive compounds or herbal additives have a potential role in promoting growth, likely through improved feed utilization and antimicrobial activity. These results correspond with previous findings by Rivera-Mendez *et al.* (2017) [27], Habibi *et al.* (2016) [13], Ajaykumar *et al.* (2024) [1], and El-Ashram & Abdelhafez (2020) [9], who reported enhanced growth with herbal supplements such as ginger, cinnamon, thyme, and star anise. Although feed intake was highest in the control group, it did not translate into better body weight, unlike Groups E and G, which demonstrated improved FCR. The efficient feed conversion in these groups aligns with Valenzuela-Grijalva *et al.* (2017) [31], highlighting the influence of phytochemicals on production efficiency. However, similar to Vilién *et al.* (2024) [32], our results indicate that herbal additives, although promising, may not fully match the efficacy of synthetic coccidiostats in terms of final weight gain. Oocyst shedding patterns show the immediate efficacy of salinomycin and the delayed yet effective response of herbal treatments. This delayed response is possibly due to gradual immune modulation, as seen in studies by Alanazi *et al.* (2023) [3], indicating a time-dependent therapeutic effect of herbal additives like *Ficus religiosa*. The control of microbial load, particularly in Groups B, E, and F, points to antimicrobial potential of treatments. These results are consistent with findings by Ofima (2023) [21], El-Ashram & Abdelhafez (2020) [9], and support the idea that gut microbiota modulation contributes to better disease resistance and nutrient absorption. Additionally, the role of disinfectants in suppressing *E. tenella* sporulation (Rajendran & Fatima, 2023; You, 2014) [25, 33] further emphasizes the importance of integrated control strategies in coccidiosis management.

Table 1: Average weekly body weight (gm) of chicks from different treatment groups

Treatment	Body Weight						
	0 th day	7 th day	14 th day	21 st day	28 th day	35 th day	42 nd day
A	40.83±0.60	160.33±0.88	354.17±0.44	603.67±0.88	987.67±0.88	1655.00±1.53	2210±1.15
B	41.50±0.29	180.67±2.33	359.67±0.88	608.83±0.60	950.50±1.32	1640.33±1.45	2309.33±1.20
C	41.00±0.58	165.60±0.31	362.33±1.45	709.67±0.88	1121.00±2.08	1723.83±1.69	2289.33±2.33
D	41.17±0.73	171.80±0.42	386.00±0.58	670.67±0.33	1231.67±2.40	1832.67±1.20	2459.67±2.60
E	41.00±0.76	162.30±0.72	360.33±1.45	735.33±1.45	1301.33±1.86	1701.00±1.53	2259.00±2.08
F	40.83±0.44	170.17±1.30	374.33±1.45	679.67±1.45	1212.33±1.45	1808.67±1.20	2301.00±1.53
G	40.83±0.60	180.33±0.88	364.33±0.33	765.00±0.58	1229.00±1.15	1984.33±0.33	2350.33±1.45
H	41.50±0.29	168.73±0.37	350.33±1.45	686.67±1.45	1158.67±0.88	1780.33±3.18	2221.00±0.58
I	41.00±0.58	166.60±0.31	385.83±0.44	746.33±1.45	1283.00±1.15	1763.33±0.67	2000.67±1.20
SEM	0.16	1.22	2.32	9.84	20.60	17.84	22.48
P-Value	0.993 (NS)	0.000 (<i>p</i> <0.001)	0.000 (<i>p</i> <0.001)	0.000 (<i>p</i> <0.001)	0.000 (<i>p</i> <0.001)	0.000 (<i>p</i> <0.001)	0.000 (<i>p</i> <0.001)

Values indicate mean±S.E. Mean values with common alphabets as superscripts do not differ significantly (*p*<0.001)

Table 2: Average weekly feed consumption (gm) of chicks from different treatment groups

Groups	1 st week	2 nd week	3 rd week	4 th week	5 th week	6 th week
A	175.16	420	635	875	1035	1150
B	150	314	520	657	866	907
C	165.88	368	640	891	1049	1137
D	150	348	531	840	850	1106
E	150	290	513	738	831	1024
F	161	322	531	791	934	937
G	160	303	506	804	949	996
H	150	310	525	781	923	977
I	162	328	513	747	881	993

Table 3: Average weekly FCR of chicks from different treatment groups

Groups	1 st week	2 nd week	3 rd week	4 th week	5 th week	6 th week
A	1.44	2.18	2.54	2.27	1.54	2.07
B	1.07	1.74	2.09	1.92	1.25	1.35
C	1.32	1.87	1.83	2.17	1.73	2.01
D	1.14	1.63	1.86	1.49	1.41	1.76
E	1.24	1.46	1.36	1.3	2.07	1.82
F	1.24	1.57	1.73	1.48	1.56	1.9
G	1.15	1.64	1.26	1.73	1.25	2.72
H	1.17	1.65	1.55	1.65	1.48	2.22
I	1.28	1.49	1.32	1.39	1.83	4.2

Table 4: Average Oocysts (x10²) per gram of feces of chicks from different treatment groups

Treatment	Oocyst count					
	7 th day	14 th day	21 st day	28 th day	35 th day	42 nd day
A	0±0	166.67±33.33	5650.00±0331.41	45833.33±4284.99	8283.33±319.81	1300.00±196.64
B	0±0	0.00±0.00	0950.00±117.62	0.00±0.00	0.00±0.00	0.00±0.00
C	0±0	250±56.27	3433.33±297.40	400.00±85.63	316.67±60.09	250.00±42.82
D	0±0	266.67±66.67	3433.33±348.97	250.00±61.91	166.67±33.33	83.33±30.73
E	0±0	0.00±0.00	2150.00±223.23	74166.67±3944.76	1366.67±105.41	616.67±90.98
F	0±0	266.67±66.67	3600.00±250.33	0.00±0.00	33.33±21.08	33.33±21.08
G	0±0	250.00±61.91	6166.67±340.26	400.00±63.25	183.33±60.09	166.67±33.33
H	0±0	266.67±80.28	8850.00±212.52	033.33±21.08	83.33±30.73	66.67±21.08
I	0±0	483.33±65.40	6533.33±278.89	450.00±61.91	83.33±30.73	50.00±22.36
SEM	0.00	23.88	316.50	3265.28	318.21	54.20
P-Value		0.000 (<i>p</i> <0.001)	0.000 (<i>p</i> <0.001)	0.000 (<i>p</i> <0.001)	0.000 (<i>p</i> <0.001)	0.000 (<i>p</i> <0.001)

Values indicate mean±S.E. Mean values with common alphabets as superscripts do not differ significantly. *p*≤0.001.

Table 5: *E. coli* count of caecal content of broilers in different groups at 42nd day of age (n=6)

Group	CFU/ML	CFU/ML
A (Control 1)	2.98 × 10 ⁷	1.11 × 10 ⁸
B (Salinomycin)	5.1 × 10 ⁶	3 × 10 ⁷
C (Control 3)	1.74 × 10 ⁷	6.1 × 10 ⁷
D (Respolite)	1.08 × 10 ⁷	9.1 × 10 ⁷
E (Respolite plus)	5.3 × 10 ⁶	3.1 × 10 ⁷
F (coccyhygeen)	4.6 × 10 ⁶	2.4 × 10 ⁷
G (coccyhygeen plus)	2.81 × 10 ⁷	1.69 × 10 ⁸
H (coccyhygeen EU)	9.7 × 10 ⁶	7.3 × 10 ⁷
I (Aviator)	1.14 × 10 ⁷	9.3 × 10 ⁷

Conclusion

The findings suggest that different treatments significantly influenced gut health, body weight, feed efficiency, and oocyst shedding in broilers affected by coccidiosis. Group D exhibited the best overall weight gain, while Group E demonstrated the best feed conversion efficiency and

reduced oocyst shedding over time. Group B showed the strongest anticoccidial effects, with nearly complete suppression of oocyst shedding. In terms of microbial balance, Groups B, E, and F controlled bacterial load effectively, which may contribute to improved gut health. The results highlight that strategic supplementation with anticoccidial and growth-promoting agents can mitigate the effects of coccidiosis, improve growth performance, and enhance feed efficiency in broilers.

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Disclosure Statement

No potential conflict of interest was reported by the author(s).

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Ethical Approval

IAEC approved the proposal no. NVC/IAEC/21/2021

References

1. Ajaykumar R, Harishankar K, Shri Rangasami SR, Saravanakumar V, Yazhini G, Rajanbabu V, *et al.* Growth performance, quantitative analysis, and economics of broiler chickens as influenced by herbal dietary additives as alternative growth boosters. *Indian Journal of Animal Research*. 2024;58(7):1139-1147. <https://doi.org/10.18805/IJAR.B-5326>
2. Akhtar M, Tariq AF, Awais MM, Iqbal Z, Muhammad F, Shahid M, *et al.* Studies on wheat bran Arabinoxylan for its immunostimulatory and protective effects against avian coccidiosis. *Carbohydrate Polymers*. 2012;90:333-339.
3. Alanazi HH, Elsbali AM, Alanazi MK, El Azab EF. Medicinal herbs: Promising immunomodulators for the treatment of infectious diseases. *Molecules*. 2023;28:8045.
4. Al-Ghamdi ES. Use of ginger and cinnamon oils mixture as a natural alternative to antibiotics in quail feed. *Rendiconti Fisici dell'Accademia dei Lincei*. 2022;33:843-849. <https://doi.org/10.1007/s12210-022-01106-4>
5. Ali H, Naqvi F, Tariq N. Prevalence of coccidiosis and its association with risk factors in poultry of Quetta, Pakistan. *Asian Journal of Applied Sciences*. 2014;2:554-558.
6. Aviagen. Ross 308 AP: Ross Broiler Management Handbook; 1118-AVNR-032. Aviagen Group, Huntsville, AL, USA; 2018:80-105.
7. Bachaya HA, Abbas RZ, Raza MA, Iqbal Z, Rehman TU, Baber W, *et al.* Existence of coccidiosis and associated risk factors in broiler chickens in Southern Punjab, Pakistan. *Pakistan Veterinary Journal*. 2015;35:81-84.
8. Bera AK, Bhattacharya D, Pan D, Dhara A, Kumar S, Das S. Evaluation of economic losses due to coccidiosis in the poultry industry in India. *Agricultural Economics Research Review*. 2010;23:91-96.
9. El-Ashram S, Abdelhafez GA. Effects of phytogenic supplementation on productive performance of broiler chickens. *Journal of Applied Poultry Research*. 2020;29(4):852-862. <https://doi.org/10.1016/j.japr.2020.07.005>
10. Fathima S, Al Hakeem WG, Shanmugasundaram R, Selvaraj RK. Necrotic enteritis in broiler chickens: A review on the pathogen, pathogenesis, and prevention. *Microorganisms*. 2022;10(10):1958. <https://doi.org/10.3390/microorganisms10101958>
11. Gieryńska M, Szulc-Dąbrowska L, Struzik J, Mielcarska MB, Gregorczyk-Zboroch KP. Integrity of the intestinal barrier: The involvement of epithelial cells and microbiota—A mutual relationship. *Animals*. 2022;12(2):145. <https://doi.org/10.3390/ani12020145>
12. Graham D, Petrone-Garcia VM, Hernandez-Velasco X, Coles ME, Juarez-Estrada MA, Latorre JD, *et al.* Assessing the effects of a mixed *Eimeria* spp. challenge on performance, intestinal integrity, and the gut microbiome of broiler chickens. *Frontiers in Veterinary Science*. 2023;10:1224647. <https://doi.org/10.3389/fvets.2023.1224647>
13. Habibi H, Firouzi S, Nili H, Razavi M, Asadi SL, Daneshi S. Anticoccidial effects of herbal extracts on *Eimeria tenella* infection in broiler chickens: *in vitro* and *in vivo* study. *Journal of Parasitic Diseases*. 2016;40:401-407.
14. Haug A, Williams R, Larsen S. Counting coccidial oocysts in chicken faeces: A comparative study of a standard McMaster technique and a new rapid method. *Veterinary Parasitology*. 2006;136(3-4):233-242. <https://doi.org/10.1016/j.vetpar.2005.11.024>
15. Johnson J, Reid WM. Anticoccidial drugs: Lesion scoring techniques in battery and floor-pen experiments with chickens. *Experimental Parasitology*. 1970;28(1):30-36. [https://doi.org/10.1016/0014-4894\(70\)90063-9](https://doi.org/10.1016/0014-4894(70)90063-9)
16. Lee Y, Park I, Lillehoj HS. Oral administration of chicken NK-lysin or recombinant chicken IL-7 improves vaccine efficacy of *Eimeria tenella* elongation factor-1 α (EF-1 α) against coccidiosis in commercial broiler chickens. *Poultry Science*. 2023;102:102611. <https://doi.org/10.1016/j.psj.2023.102611>
17. Mathis GF, Lumpkins B, Cervantes HM, Fitz-Coy SH, Jenkins MC, Jones MK, *et al.* Coccidiosis in poultry: Disease mechanisms, control strategies, and future directions. *Poultry Science*. 2024;104:663. <https://doi.org/10.1016/j.psj.2024.104663>
18. Mehdi Y, Létourneau-Montminy MP, Gaucher ML, Chorfi Y, Suresh G, Rouissi T, *et al.* Use of antibiotics in broiler production: Global impacts and alternatives. *Animal Nutrition*. 2018;4(2):170-178.
19. Mottet A, Tempio G. Global poultry production: Current state and future outlook and challenges. *World Poultry Science Journal*. 2017;73:245-256. <https://doi.org/10.1017/S0043933917000071>
20. Murugesan GR, Syed B, Halder S, Pender C. Phytogenic feed additives as an alternative to antibiotic growth promoters in broiler chickens. *Frontiers in Veterinary Science*. 2015;2:21. <https://doi.org/10.3389/fvets.2015.00021>
21. Ofima SJ. Fecal microbial evaluation of *Gallus domesticus* supplemented with *Allium cepa*. 2023. <https://doi.org/10.13140/RG.2.2.35883.62245>
22. Ogwiji M, Jatau ID, Natala AJ, Mohany M, Al-Rejaie SS, Zhu M. Effect of prebiotic, probiotic, and synbiotic products on oxidative status, performance, and parasitological parameters of broiler chickens induced with cecal coccidiosis. *Journal of Applied Poultry Research*. 2024;33(4):100472. <https://doi.org/10.1016/j.japr.2024.100472>
23. Pajić M, Aleksić N, Vejnović B, Polaček V, Novakov N, Ostojić-Andrić D, *et al.* Influence of anticoccidials on oxidative stress, production performance and faecal oocyst counts in broiler chickens infected with *Eimeria* species. *Kafkas Üniversitesi Veteriner Fakültesi Dergisi*. 2019;25(3):379-385.
24. Qaid M, Al-Mufarrej S, Azzam M, Al-Garadi MA. Anticoccidial effectivity of a traditional medicinal plant, *Cinnamomum verum*, in broiler chickens infected with *Eimeria tenella*. *Poultry Science*. 2020;100:Article 101071. <https://doi.org/10.1016/j.psj.2020.11.071>

25. Rajendran RM, Fatima SN. Effect of phenolic disinfectant on sporulation inhibition of *Eimeria tenella* for prevention of coccidiosis. Journal of Applied Biology & Biotechnology. 2023;11(6):228-232. <https://doi.org/10.7324/JABB.2023.135101>
26. Ramezani F, Shekarabi SPH, Mehrgan MS, Foroudi F, Islami HR. Supplementation of Siberian sturgeon (*Acipenser baerii*) diet with barberry (*Berberis vulgaris*) fruit extract: Growth performance, hemato-biochemical parameters, digestive enzyme activity, and growth-related gene expression. Aquaculture. 2021;540:736750.
27. Rivera-Méndez C, Plascencia A, Torrentera N, Zinn RA. Effect of level and source of supplemental tannin on growth performance of steers during the late finishing phase. Journal of Applied Animal Research. 2017;45(1):199-203. <https://doi.org/10.1080/09712119.2016.1141771>
28. Tembhurne PB, Borkar SD, Bonde SW, Kadam MM, Khose KK, Patil DV, *et al.* Effects of graded level of nucleotide-rich yeast extract supplementation in diets on growth performance and economics of broilers. Journal of Entomology and Zoology Studies. 2020;8(4):1335-1338.
29. Tsiouris V, Giannenas I, Bonos E, Papadopoulos E, Stylianaki I, Sidiropoulou E, *et al.* Efficacy of a dietary polyherbal formula on the performance and gut health in broiler chicks after experimental infection with *Eimeria* spp. Pathogens. 2021;10:524.
30. Ullah MI, Akhtar M, Awais MM, Anwar MI, Khaliq K. Evaluation of immunostimulatory and immunotherapeutic effects of tropical mushroom (*Lentinus edodes*) against eimeriasis in chicken. Tropical Animal Health and Production. 2018;50:97-104.
31. Valenzuela-Grijalva NV, Pinelli-Saavedra A, Muhlia-Almazán A, Domínguez-Díaz D, González-Ríos H. Dietary inclusion effects of phytochemicals as growth promoters in animal production. Journal of Animal Science and Technology. 2017;59(1):1-17. <https://doi.org/10.1186/s40781-017-0133-9>
32. Vilienė V, Murawska D, Gesek M, Matusevičius P, Miknienė Z, Nutautaitė M. Evaluation of herbal anticoccidials on growth performance in experimentally infected broiler chickens. Agriculture. 2024;14(12):2261. <https://doi.org/10.3390/agriculture14122261>
33. You MJ. Suppression of *Eimeria tenella* sporulation by disinfectants. Korean Journal of Parasitology. 2014;52(4):435-438. <https://doi.org/10.3347/kjp.2014.52.4.435>