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Evaluation of aqueous coriander (*Coriandrum sativum*) seed extract as a natural anthelmintic against *Haemonchus contortus* in naturally infected goats

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ABSTRACT

Gastrointestinal nematode infections, particularly those caused by *Haemonchus contortus*, remain a major constraint to goat production worldwide. The present study evaluated the dose-dependent anthelmintic efficacy of an aqueous seed extract of *Coriandrum sativum* in naturally infected goats and its effect on haematological, biochemical, and antioxidant parameters of the host. Thirty naturally infected goats (18–30 months old) with faecal egg counts (EPG) exceeding 1000 were randomly allocated to five groups (n = 6). Group C served as the untreated negative control, Group PC received closantel (10 mg/kg body weight, orally) as the positive control, and Groups CS-50, CS-250, and CS-500 received aqueous *C. sativum* seed extract at doses of 50, 250, and 500 mg/kg body weight, respectively. Blood and faecal samples were collected on days 0, 7, 14, 21, and 28 post-treatments. Highest faecal egg count reduction percentage was observed in the CS-500 group (40.38%) on day 28, whereas closantel achieved a complete faecal egg count reduction (100%). CS-500 also showed improvements in haemoglobin concentration, packed cell volume, total erythrocyte count, serum total protein, and albumin levels compared with those in the untreated goats. Antioxidant markers, showed statistically significant increasing trend in the treated animals. The findings demonstrated a dose-dependent anthelmintic effect of aqueous *C. sativum* seed extract against naturally acquired *H. contortus* infection, with the 500 mg/kg dose producing the greatest response among the tested doses. Although its efficacy was lower than that of closantel, the extract showed no adverse effects and may serve as a promising complementary phytotherapeutic option for the integrated management of gastrointestinal nematodes in goats.

Keywords: Antioxidant status, *Coriandrum sativum,* Faecal egg count reduction test, Goat, *Haemonchus contortus*

Gastrointestinal nematode (GIN) infections are an important health constraint affecting small ruminant production worldwide, causing substantial economic losses through reduced growth, poor feed conversion efficiency, decreased reproductive performance, lower milk production, anaemia, and increased mortality (Rahman *et al.* 2017). Among the gastrointestinal nematodes infecting goats, *Haemonchus contortus* is an important pathogenic species because of its haematophagous nature, which results in severe blood loss, anaemia, hypoproteinaemia, and death in heavy infections (Kaur *et al.* 2025). The warm and humid climatic conditions prevailing in tropical and subtropical regions favour the survival and transmission of infective larvae, making *H. contortus* a persistent challenge to sustainable goat production (Ramakant *et al.* 2024a). Traditionally, the control of gastrointestinal nematodes has relied on the extensive use of synthetic anthelmintic drugs (Good *et al.* 2012). However, indiscriminate repeated use of these compounds has resulted in widespread development of anthelmintic resistance, reducing the efficacy of commonly used drugs and posing a serious threat to livestock production systems (Ratanapob *et al.* 2022, Negash *et al.* 2023). Moreover, concerns regarding drug residues in animal products, environmental contamination, treatment costs, and consumer preferences for residue-free

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livestock products have stimulated interest in alternative parasite control strategies. Consequently, integrated parasite management approaches that incorporate phytotherapeutic agents have garnered significant attention as sustainable alternatives to conventional chemotherapy (Maqbool *et al.* 2017).

Medicinal plants are an important source of biologically active compounds with diverse pharmacological activities, including antiparasitic, antioxidant, anti-inflammatory, antimicrobial, and immunomodulatory properties (Mahima *et al.* 2012). These compounds may interfere with parasite metabolism, impair neuromuscular function, disrupt cuticular integrity, inhibit egg hatching and larval development, or induce oxidative stress within the parasite, thereby reducing its survival and fecundity (Athanasiadou *et al*. 2007, Dhama *et al.* 2013). *Coriandrum sativum* L. (Apiaceae), commonly known as coriander, is an aromatic medicinal herb extensively cultivated in Asia, Europe, and the Mediterranean region. In addition to its widespread culinary use, coriander has long been employed in traditional medicine for the treatment of digestive disorders, microbial infections, inflammation, diabetes, and parasitic diseases. The seeds are rich in biologically active constituents, including linalool, γ-terpinene, α-pinene, camphor, flavonoids, phenolic acids, coumarins, tocopherols, and other antioxidant compounds, which contribute to their diverse pharmacological activities (Laribi et al. 2015; Sobhani et al. 2022). Previous experimental studies have demonstrated that crude extracts of *C. sativum* possess *in vitro* and *in vivo* anthelmintic activities against *H. contortus* (Ramakant *et al.* 2024b; Eguale *et al.* 2007). However, information regarding the therapeutic efficacy of aqueous seed extract in naturally infected goats, together with its influence on haematological, biochemical, and antioxidant responses under field conditions, remains limited.

Therefore, the present study was undertaken to evaluate the dose-dependent anthelmintic efficacy of an aqueous seed extract of *Coriandrum sativum* against naturally acquired *Haemonchus contortus* infection in goats and to investigate its effects on faecal egg count reduction, haematological indices, serum biochemical parameters, and antioxidant status.

MATERIALS AND METHODS

Ethical approval: The experimental protocol was reviewed and approved by the Institutional Animal Ethics Committee (IAEC), College of Veterinary and Animal Sciences, Sardar Vallabhbhai Patel University of Agriculture and Technology (SVPUAT), Meerut, India (Approval No. IAEC/SVPUAT/2022/125, dated 03 December 2022).

Experimental animals: Thirty apparently healthy, naturally infected Barbari goats, irrespective of sex, aged between 18 and 30 months (body weight 15-30 kg) and maintained under semi-intensive management at the Instructional Livestock Farm Complex-II, SVPUAT, Meerut, were included in this study. All goats were maintained under identical feeding and management conditions during the study. The animals were provided seasonal green fodder, dry roughage, a concentrate mixture, and clean drinking water ad libitum.

Inclusion criteria: Animals were included in the study if they were naturally infected with gastrointestinal strongyle nematodes, exhibited faecal egg counts (EPG) greater than 1000 eggs per gram, were clinically stable and suitable for experimental treatment, and showed PCR confirmation of *H. contortus* infection.

Exclusion criteria: Animals showing severe concurrent systemic illness, pregnancy, recent anthelmintic treatment (<8 weeks), or infections other than gastrointestinal strongyle nematodes requiring immediate therapeutic intervention were excluded from the study.

Molecular confirmation of H. contortus: Genomic DNA was extracted from strongyle eggs recovered from fecal samples using the QIAamp DNA Mini Kit (Qiagen, Germany) according to manufacturer's instructions with minor modifications. PCR amplification targeted the internal transcribed spacer-2 (ITS-2) region of the ribosomal DNA using species-specific primers (Ramakant *et al.* 2025). Each 25 µL PCR reaction contained 12.5 µL PCR Master Mix, 1 µL each of forward and reverse primers (10 pmol), 3 µL genomic DNA, and 7.5 µL nuclease-free water. PCR amplification was performed under the following cycling conditions: initial denaturation at 95°C for 5 min; 35 cycles of denaturation at 94°C for 30 s, annealing at 58°C for 30 s, extension at 72°C for 45 s, and final extension at 72°C for 10 min. Amplified products were resolved on a 1.5% agarose gel, stained with ethidium bromide, and visualised using a Gel Documentation System. Amplification of the expected 265 bp fragment confirmed the presence of *Haemonchus contortus*.

Preparation of aqueous extract of Coriandrum sativum seeds: Authenticated *C. sativum* seeds were shade-dried and ground into a fine powder. One hundred grams of powdered seeds were soaked in one litre of distilled water and heated in a water bath at 100°C for 30 min. The mixture was filtered through a sterile muslin cloth and subsequently through a Whatman No. 1 filter paper. The filtrate was concentrated under reduced pressure using a rotary evaporator at 42.6°C and dried in a hot-air oven maintained at 40°C to obtain a dry extract. The extraction yield was calculated as follows:

$$\text{Extraction yield (\%)} = (\text{Weight of dried extract} / \text{Weight of seed powder}) \times 100$$

The dried extract (E) had an extraction yield of 8.25%. The extract was stored in sterile airtight amber glass containers at 4°C until use and was freshly reconstituted in distilled water immediately before administration. The required dose was prepared individually according to the body weight of each animal to ensure accurate dosing of the animals.

Experimental design: Thirty goats were randomly allocated to five equal groups (n = 6 per group):

Group C (Negative Control): Untreated infected goats.
Group PC (Positive Control): Closantel (10 mg/kg body weight) was administered orally as a single dose.
Group CS-50: aqueous *C. sativum* E at 50 mg/kg body weight orally as a single dose.
Group CS-250: 250 mg/kg body weight E orally as a single dose.
Group CS-500: 500 E mg/kg body weight orally as a single dose.

The extract was administered as a single oral dose mixed with approximately 10–15 g of honey immediately before administration to improve palatability. The selected doses were based on the dose range previously reported by Eguale et al. (2007), enabling comparison with earlier studies while evaluating the dose-response relationship under natural field infection conditions. Although Eguale et al. (2007) also evaluated a higher dose (0.9 g/kg), the present study focused on doses considered practically applicable under field conditions and selected to assess the minimum effective therapeutic level.

Faecal examination and faecal egg count reduction test (FECRT): Approximately 20–30 g of faecal material was collected directly from the rectum of each goat before treatment (day 0) and on days 7, 14, 21, and 28 post-treatment. Qualitative examination was performed using floatation and sedimentation techniques (Soulsby, 1982). Quantitative egg counts were determined using the Modified McMaster technique (Coles *et al.* 1992), and faecal egg counts were expressed as eggs per gram (EPG) of faeces. Anthelmintic efficacy was evaluated using Faecal Egg Count Reduction Test (FECRT), as per the recommendations of World Association for the Advancement of Veterinary Parasitology (WAAVP).

$$\text{FECRT (\%)} = [(\text{Pre-treatment EPG} - \text{Post-treatment EPG}) / \text{Pre-treatment EPG}] \times 100$$

Negative FECRT values indicate an increase in egg count after treatment, suggesting inadequate therapeutic efficacy rather than an adverse treatment effect. Confidence intervals for the FECRT could not be calculated because the study was originally designed to compare treatment responses rather than to estimate population efficacy according to WAAVP statistical recommendations. This limitation has been acknowledged in the discussion section.

Haematological, biochemical, and antioxidant analyses: Blood samples were collected from the jugular vein on days 0, 7, 14, 21, and 28 after treatment. Haematological parameters, including haemoglobin (Hb), packed cell volume (PCV), total erythrocyte count (TEC), total leukocyte count (TLC), and differential leukocyte counts, were determined using an automated veterinary haematology analyser. Serum biochemical analyses included AST, ALT, blood urea nitrogen, creatinine, total protein, albumin, globulin, and albumin-to-globulin ratio, using an automated biochemical analyser. Antioxidant parameters, including catalase (Aebi, 1984), superoxide dismutase (SOD) (Marklund and Marklund, 1974), and Total Antioxidant Capacity (Benzie and Strain, 1999), were determined using standard published methods.

Statistical analysis: Data were analysed using IBM SPSS Statistics version 20.0. Continuous variables are presented as mean ± standard error (SE). Data collected repeatedly from the same animals over time were analysed using repeated-measures analysis of variance (ANOVA) to evaluate the effects of treatment, time, and treatment × time interaction. When significant differences were detected, Tukey's multiple comparison test was used for post hoc comparisons. Statistical significance was set at $P < 0.05$.

Sample size consideration: The sample size (n = 6 animals per group) was selected based on previous comparable *in vivo* studies evaluating herbal anthelmintics against *Haemonchus contortus* (Eguale *et al.* 2007). Although no formal a priori power analysis was performed, the sample size was considered adequate for this exploratory study.

RESULTS AND DISCUSSION

Molecular confirmation of H. contortus: PCR amplification of DNA extracted from strongyle eggs produced the expected 265 bp amplicon specific for *H. contortus*, confirming that the natural infection (Fig. 1).

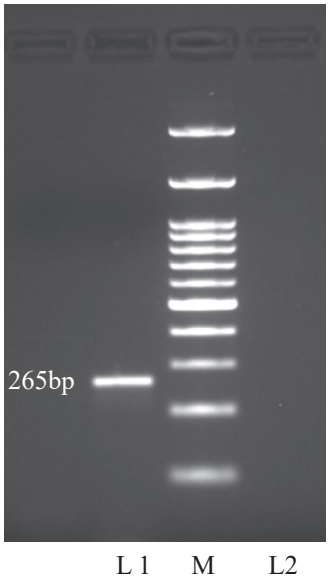

Fig. 1. PCR amplification of the ITS-2 region of the ribosomal DNA gene specific to *Haemonchus contortus* (265 bp).
Lane M: 100 bp DNA ladder (molecular weight marker); Lane L1: Positive sample showing a distinct band at 265 bp; Lane L2: Negative control showing no amplification

Anthelmintic efficacy of aqueous Coriandrum sativum seed extract: The mean fecal egg counts (EPG) of goats before and after treatment are presented in Table 1, while the fecal egg count reduction percentages (FECRT) are shown in Table 2.

All treatment groups exhibited reductions in fecal egg counts compared with the untreated control group. The closantel group showed complete efficacy, achieving 100%

Table 1. Impact on EPG in goats administered an aqueous extract of *Coriandrum sativum* seeds and closantel across different groups on various days before and after treatment

Days	C	PC	CS-50	CS-250	CS-500
0	1083.33±16.67	1300.00±73.60	1862.50±238.11	1695.83±107.90	1983.33±178.96
07	1108.33±16.67	62.50±10.70	1770.83±227.98	1541.67±98.04	1691.67±152.02
14	1133.33±16.67	0.00±0.00	1900.00±250.04	1345.83±85.49	1437.50±125.95
21	1175.00±19.36	0.00±0.00	1925.00±242.98	1554.17±98.41	1300.00±112.18
28	1233.33±16.67	0.00±0.00	2104.17±266.73	1812.50±117.57	1191.67±106.98
Mean± SE	1146.67^{b}±17.21	272.50^{a}±16.86	1912.50^{d}±245.17	1590.00^{c}±101.48	1520.83^{c}±135.22

$^{a, b, c, d}$ Mean bearing values with different superscripts in a row demonstrated a significant statistical difference at P<0.001.

Table 2. Effects on FECRT (%) in goats receiving treatment with an aqueous extract of *Coriandrum sativum* seeds and closantel across different groups on various pre- and post-treatment days

Days	PC	CS-50	CS-250	CS-500
07	95.29±0.66	4.98±0.20	9.07±0.49	14.70±0.38
14	100.00±0.00	-2.00±0.16	20.63±0.31	27.46±0.33
21	100.00±0.00	-3.45±0.20	8.34±0.24	34.36±0.30
28	100.00±0.00	-13.04±0.36	-6.85±0.28	40.38±0.14
Mean± SE	98.82^{d}±0.16	-3.38^{a}±0.23	7.80±0.33	29.23^{c}±0.29

$^{a, b, c, d}$ Mean bearing with various superscripts in a row demonstrated a statistical difference at P<0.001

FECRT by Day 28. Among the extract-treated groups, the response was dose dependent. The CS-500 group exhibited greatest reduction in fecal egg counts, with a FECRT of 40.38% on Day 28, followed by CS-250 and CS-50 groups. Negative FECRT values observed on some sampling days reflected increases in fecal egg counts relative to pretreatment values and indicated inadequate therapeutic efficacy rather than adverse effects of treatment. Although the aqueous extract reduced parasite egg shedding, its efficacy remained substantially lower than that of closantel under the conditions of the present study.

Haematological parameters: The effects of aqueous *C. sativum* seed extract on haematological parameters are presented in Table 3. Goats treated with closantel showed significant improvements ($P < 0.05$) in haemoglobin concentration (Hb), packed cell volume (PCV), and total erythrocyte count (TEC) during the 28-day observation period compared with untreated controls. Similar improvements were observed in the CS-500 group, although the magnitude of response was lower than that recorded in the positive control. The CS-500 group showed progressive increases in Hb, PCV, and TEC from Day 0 to Day 28. Eosinophil counts decreased following treatment in both the closantel-treated and extract-treated groups, with the greatest reduction observed in the positive control. Total leukocyte count, neutrophil percentage, lymphocyte percentage, monocyte percentage, and basophil percentage showed minor fluctuations and did not differ significantly among treatment groups ($P > 0.05$).

Serum biochemical parameters: Changes in serum biochemical parameters following treatment are presented in Table 4. No significant differences ($P > 0.05$) were observed among treatment groups for serum AST and ALT activities throughout the experimental period. Similarly, serum creatinine concentrations remained within the normal physiological range in all groups. Blood urea nitrogen (BUN) showed significant differences ($P < 0.05$) among treatment groups, with comparatively lower mean values observed in the CS-500 group than in the untreated control. Total serum protein (TSP), albumin, and albumin-to-globulin (A:G) ratio increased significantly ($P < 0.05$) in the closantel-treated group and CS-500 group. Serum globulin concentrations did not differ significantly among treatment groups ($P > 0.05$).

Antioxidant enzyme activity: The effects of aqueous *C. sativum* seed extract on antioxidant biomarkers are summarized in Table 5. Catalase (CAT), superoxide dismutase (SOD), and ferric reducing antioxidant power (FRAP) values showed increasing trends between Day 0 and Day 28 in the positive control, CS-250, and CS-500 groups. However, these increases were not statistically significant ($P > 0.05$). The untreated control group showed either stable or slightly decreased antioxidant enzyme activities during the experimental period.

Anthelmintic efficacy: The reduction in faecal egg counts observed following treatment with *C. sativum* extract suggested that the plant possesses moderate in vivo anthelmintic activity against *H. contortus*. The highest efficacy was recorded in the CS-500 group, indicating a dose-dependent response. Nevertheless, the extract did not achieve the level of efficacy produced by closantel, which resulted in the complete elimination of egg shedding by day 28. These observations are consistent with previous reports demonstrating the anthelmintic properties of *C. sativum* against *H. contortus* in sheep and goats (Eguale *et al.* 2007, Ahmed *et al.* 2019). The anthelmintic activity

Table 3. Hematological (Mean± SE) data in goats treated with an aqueous extract of *C. sativum* seeds and closantel in several groups at various intervals before and after treatment

Parameters	Days	C	PC	CS-50	CS-250	CS-500
Hb (g/dl)	0	8.38±0.21	8.47±0.10	8.60±0.23	8.93±0.13	9.12±0.19
	7	8.20±0.16	8.87±0.10	8.50±0.23	9.03±0.13	9.28±0.17
	14	8.10±0.14	9.37±0.10	8.33±0.22	9.23±0.13	9.40±0.18
	21	8.03±0.16	10.37±0.09	8.20±0.18	8.83±0.13	9.52±0.17
	28	8.00±0.16	10.82±0.11	8.13±0.11	8.63±0.13	9.42±0.14
	Mean±SEM	8.14±0.17^{a}	9.58±0.10^{c}	8.35±0.19^{a}	8.93±0.13^{b}	9.35±0.17^{c}
PCV (%)	0	26.50±0.92	26.67±0.49	27.50±1.02	28.83±0.79	28.50±0.89
	7	26.17±0.70	28.00±0.58	27.17±0.79	29.33±0.80	30.00±0.86
	14	25.67±0.61	29.67±0.49	26.33±0.76	30.33±0.95	30.50±0.92
	21	24.83±0.79	31.50±0.43	25.50±0.56	27.33±0.61	31.00±0.97
	28	24.67±0.80	33.50±0.43	24.50±0.76	26.67±0.76	30.50±0.85
	Mean±SEM	25.57±0.76^{a}	29.87±0.48^{c}	26.20±0.78^{a}	28.50±0.78^{b}	30.10±0.90^{c}
TEC ($\times 10^{6}$/µl)	0	8.72±0.21	8.30±0.17	8.40±0.18	8.73±0.13	8.92±0.18
	7	8.48±0.11	8.70±0.17	8.25±0.17	8.83±0.13	9.05±0.18
	14	8.38±0.14	9.20±0.17	8.15±0.13	9.03±0.13	9.13±0.17
	21	8.23±0.22	10.20±0.17	8.05±0.04	8.63±0.13	9.25±0.15
	28	8.10±0.19	10.73±0.17	7.95±0.06	8.43±0.13	9.13±0.14
	Mean±SEM	8.38±0.17^{a}	9.43±0.17^{d}	8.16±0.12^{a}	8.73±0.13^{b}	9.10±0.16^{c}
TLC ($\times 10^{3}$/ µl)	0	10.63±0.11	10.42±0.11	10.37±0.09	10.50±0.12	10.30±0.07
	7	10.58±0.10	10.82±0.11	10.25±0.09	10.58±0.11	10.40±0.07
	14	10.52±0.10	10.82±0.11	10.22±0.07	10.78±0.11	10.50±0.07
	21	10.48±0.07	11.00±0.10	10.13±0.06	10.47±0.12	10.60±0.07
	28	10.47±0.06	11.10±0.10	10.06±0.03	10.37±0.11	10.53±0.05
	Mean±SEM	10.54±0.09^{b}	10.83±0.11^{c}	10.21±0.07^{a}	10.54±0.11^{b}	10.47±0.07^{b}
Neutrophils (%)	0	38.00±0.73	38.67±0.61	39.83±0.60	39.67±0.42	40.83±0.75
	7	38.17±0.79	38.17±0.60	39.33±0.49	39.33±0.42	40.50±0.72
	14	37.67±0.71	37.33±0.56	38.67±0.49	39.33±0.42	39.83±0.54
	21	37.33±0.80	37.33±0.56	37.67±0.42	38.50±0.22	39.50±0.34
	28	36.83±0.70	38.00±0.58	37.17±0.31	38.17±0.31	39.17±0.31
	Mean±SEM	37.60±0.75^{a}	37.90±0.58^{a}	38.53±0.46^{ab}	39.00±0.36^{bc}	39.97±0.53^{c}
Lymphocytes (%)	0	47.83±1.08	49.17±0.70	49.17±0.54	48.17±0.70	46.83±0.65
	7	48.33±1.17	50.17±0.70	49.67±0.33	48.83±0.60	47.67±0.71
	14	50.83±1.85	51.50±0.43	50.00±0.37	49.33±0.33	48.50±0.43
	21	51.00±1.88	53.33±0.49	50.50±0.43	49.83±0.31	49.17±0.40
	28	51.33±1.84	54.00±0.52	50.67±0.33	50.00±0.45	49.33±0.49
	Mean±SEM	49.86±1.56^{b}	51.63±0.57^{c}	50.00±0.40^{b}	49.23±0.48^{ab}	48.30±0.54^{a}
Eosinophils (%)	0	5.83±0.31	7.17±0.40	6.00±0.26	7.17±0.40	7.50±0.34
	7	6.17±0.31	6.67±0.33	6.17±0.40	6.83±0.31	7.00±0.26
	14	6.50±0.22	6.17±0.31	6.50±0.34	6.33±0.21	6.67±0.21
	21	6.67±0.33	4.33±0.21	6.83±0.54	6.67±0.33	6.33±0.33
	28	6.83±0.31	3.00±0.26	7.17±0.48	6.83±0.40	6.50±0.43
	Mean±SEM	6.40±0.30^{b}	5.47±0.30^{a}	6.53±0.40^{b}	6.77±0.33^{b}	6.80±0.31^{b}

$^{a, b, c}$ Mean bearing with various superscripts in a row demonstrated a statistical difference at P<0.05

Table 4. Biochemical (Mean± SE) values in goats administered an aqueous extract of *C. sativum* seeds and closantel across different groups on various days before and after treatment

Parameters	Days	C	PC	CS-50	CS-250	CS-500
AST (U/L)	0	57.97± 1.51	55.97±1.20	57.00±1.37	55.65±1.25	56.13±0.74
	7	58.27± 1.46	54.93±1.01	54.77±2.20	54.62±1.43	55.22±1.42
	14	60.13±1.60	54.80±0.85	54.95±0.97	54.37±0.70	55.47±0.94
	21	53.45±3.90	56.20±1.45	47.45±0.46	55.87±1.15	54.85±1.41
	28	53.67±1.18	54.58±1.48	55.18±1.64	53.58±1.35	54.43±0.85
	Mean±SEM	56.70±1.93	55.30±1.20	53.87±1.33	54.81±1.18	55.22±1.07
ALT (U/L)	0	17.93±1.19	18.05±1.15	18.30±1.29	17.43±1.52	20.50±1.68
	7	18.05±1.20	19.67±1.22	20.62±1.47	20.85±0.97	20.13±0.70
	14	19.08±1.38	20.08±1.22	18.13±1.10	17.95±1.34	20.12±1.00
	21	18.17±0.84	18.42±1.83	19.23±1.43	19.48±1.49	17.00±1.51
	28	18.00±1.24	14.70±1.96	18.60±1.02	20.73±1.38	16.62±0.65
	Mean±SEM	18.25±1.17	18.18±1.48	18.98±1.26	18.29±1.34	18.87±1.11
BUN (mg/dl)	0	24.13±1.50	21.85±0.96	21.28±1.43	21.57±0.99	20.07±0.84
	7	23.96±1.54	21.10±1.64	21.56±0.51	20.43±0.85	20.63±0.96
	14	23.92±0.95	24.27±0.67	21.23±0.92	22.65±0.45	21.12±0.94
	21	20.46±1.09	18.38±0.81	20.89±0.89	20.67±1.17	20.44±1.05
	28	21.89±1.27	21.57±1.22	21.77±1.03	20.59±1.19	18.22±1.19
	Mean±SEM	$22.87±1.27^{b}$	$21.43±1.06^{ab}$	$21.35±0.96^{ab}$	$21.18±0.93^{ab}$	$20.10±1.00^{a}$
Creatinine (mg/dl)	0	1.48±0.03	1.54±0.05	1.54±0.09	1.58±0.06	1.45±0.10
	7	1.49±0.02	1.52±0.03	1.59±0.10	1.55±0.05	1.58±0.07
	14	1.45±0.03	1.61±0.03	1.70±0.04	1.56±0.05	1.58±0.06
	21	1.51±0.06	1.56±0.04	1.58±0.05	1.47±0.08	1.48±0.06
	28	1.54±0.04	1.37±0.09	1.60±0.03	1.50±0.03	1.37±0.05
	Mean±SEM	$1.49±0.04^{a}$	$1.52±0.05^{ab}$	$1.60±0.06^{b}$	$1.53±0.05^{ab}$	$1.49±0.07^{a}$
TSP (gm/dl)	0	5.65±0.23	5.47±0.08	5.37±0.14	5.63±0.11	5.43±0.06
	7	5.57±0.22	5.48±0.12	5.35±0.11	5.40±0.05	5.53±0.07
	14	5.30±0.10	5.63±0.14	5.37±0.09	5.47±0.09	5.67±0.05
	21	5.22±0.09	5.67±0.07	5.32±0.07	5.48±0.12	5.72±0.05
	28	5.17±0.08	6.00±0.12	5.27±0.09	5.47±0.11	5.78±0.03
	Mean±SEM	$5.38±0.14^{a}$	$5.65±0.11^{b}$	$5.34±0.10^{a}$	$5.49±0.10^{ab}$	$5.63±0.05^{b}$
Albumin (gm/dl)	0	3.48±0.14	3.18±0.09	3.15±0.08	3.33±0.10	3.23±0.07
	7	3.42±0.14	3.22±0.10	3.12±0.07	3.12±0.05	3.35±0.07
	14	3.05±0.06	3.48±0.14	3.27±0.10	3.18±0.05	3.52±0.03
	21	3.03±0.08	3.58±0.05	3.08±0.05	3.22±0.09	3.58±0.07
	28	3.02±0.06	3.88±0.14	3.07±0.06	3.23±0.08	3.67±0.02
	Mean±SEM	$3.20±0.10^{a}$	$3.47±0.10^{b}$	$3.14±0.07^{a}$	$3.22±0.07^{a}$	$3.47±0.05^{b}$
Globulin (gm/dl)	0	2.17±0.11	2.30±0.09	2.22±0.11	2.27±0.05	2.20±0.06
	7	2.18±0.12	2.27±0.07	2.23±0.09	2.28±0.05	2.18±0.05
	14	2.25±0.07	2.15±0.07	2.10±0.09	2.28±0.08	2.15±0.07
	21	2.20±0.09	2.15±0.08	2.23±0.06	2.27±0.09	2.13±0.04
	28	2.13±0.05	2.08±0.07	2.20±0.06	2.25±0.06	2.12±0.03
	Mean±SEM	2.19±0.09	2.19±0.08	2.20±0.08	2.27±0.07	2.16±0.05
A:G ratio	0	1.62±0.06	1.39±0.09	1.44±0.09	1.48±0.06	1.48±0.06
	7	1.60±0.07	1.48±0.07	1.41±0.06	1.37±0.05	1.54±0.06
	14	1.36±0.04	1.63±0.09	1.57±0.09	1.40±0.06	1.65±0.06
	21	1.39±0.08	1.68±0.07	1.39±0.04	1.43±0.08	1.69±0.06
	28	1.42±0.04	1.88±0.10	1.40±0.04	1.44±0.05	1.73±0.03
	Mean±SEM	$1.48±0.06^{a}$	$1.61±0.08^{b}$	$1.44±0.06^{a}$	$1.42±0.06^{a}$	$1.62±0.05^{b}$

[a, b, c] Mean bearings values with distinct superscripts in a row demonstrated a statistical difference at $P<0.05$

Table 5. Catalase, SOD, and FRAP (Mean ± SE) values in goats administered an aqueous extract of *C. sativum* seeds and closantel across different groups on various days before and after treatment

Parameters	Days	C	PC	CS-50	CS-250	CS-500
Catalase (µM/min/ g Hb)	0	47.38±3.57	35.53±3.28	45.26±6.66	43.15±4.14	36.38±4.28
	28	41.03±3.90	46.95±3.57	40.61±4.49	46.53±6.07	42.30±3.63
	Mean ±SEM	44.21±3.74	41.24±3.43	42.94±5.58	44.84 ± 5.11	39.34±3.96
SOD (U/g Hb)	0	3066.67±688.32	2000.00±647.04	3033.33±912.75	2133.33±345.12	2166.67±307.32
	28	2300.00±690.41	2433.33±340.26	2466.67±266.67	2266.67±341.24	2400.00±338.62
	Mean ±SEM	2683.34±689.37	2216.67±493.65	2750.00±589.71	2200.00±343.18	2283.34±322.97
FRAP (µmol/l)	0	114.29±27.23	77.89±8.19	142.86±21.46	79.93±10.83	118.03±7.25
	28	105.44±19.28	168.03±24.39	134.35±21.08	114.63±9.22	174.83±25.24
	Mean ±SEM	109.87±23.26	122.96±16.29	138.61±21.27	97.28±10.03	146.43±16.25

[a, b] Mean bearing with differing superscripts in a row demonstrated a statistical difference at P<0.05

of *C. sativum* is likely attributable to the combined action of several bioactive phytochemicals, including linalool, flavonoids, phenolic compounds, terpenoids, and tannins (Laribi *et al.* 2015). These constituents have been reported to interfere with parasite metabolism, disrupt cuticular integrity, inhibit neuromuscular function, reduce egg production, and impair larval development (Adak and Kumar, 2022). Polyphenolic compounds might have also induced oxidative damage in parasites, leading to reduced survival and fecundity. As the present study employed a crude aqueous extract rather than purified compounds, the observed activity reflects the synergistic action of multiple phytochemicals rather than a single active constituent. The lower efficacy of the extract compared with closantel may be explained by several factors, including lower concentrations of active metabolites in the aqueous extract, limited gastrointestinal bioavailability, variation in phytochemical composition, and the use of naturally infected animals with heterogeneous parasite burdens. Unlike controlled experimental infections, naturally infected goats are exposed to repeated parasite challenges and varying nutritional and immunological conditions, which may influence treatment responses (Risa *et al.* 2024).

Haematological responses: Improvement in haemoglobin concentration, packed cell volume, and total erythrocyte count following treatment indicated recovery from anaemia associated with *H. contortus* infection. Adult *H. contortus* are blood-feeding nematodes that attach to the abomasal mucosa, causing continuous blood loss and depletion of iron and plasma proteins. Consequently, infected animals frequently develop anaemia and reduced erythrocyte indices, which have been widely reported in goats naturally infected with gastrointestinal nematodes (Ashfaque *et al.* 2016, Moudgil *et al.* 2017, Sarkar *et al.* 2024, Sunder *et al.* 2025). The decline in eosinophil counts after treatment further supported the reduction in the parasite burden. Eosinophilia is a characteristic host response to helminth infections and reflects the activation of the immune system against parasitic antigens (Balic *et al.* 2000). The gradual normalisation of eosinophil numbers observed in the treated animals is consistent with reduced antigenic stimulation following parasite control (Shin *et al.* 2009). Similar haematological improvements following successful anthelmintic treatment have been documented in previous studies on naturally infected goats (Shrimali *et al.* 2016).

Biochemical responses: Serum biochemical analysis indicated that the administration of *C. sativum* extract did not adversely affect hepatic or renal function. AST and ALT activities remained within physiological limits throughout the study, suggesting the absence of hepatocellular injury. Similarly, serum creatinine concentrations showed no clinically relevant alterations, indicating preserved renal function. The significant improvements in total serum protein, albumin concentration, and albumin-to-globulin ratio observed after treatment probably reflected the recovery of protein metabolism following the reduction of gastrointestinal parasitism. The restoration of these parameters after treatment suggests improved gastrointestinal integrity and nutritional status. Similar observations have been reported in goats and sheep following successful treatment of gastrointestinal nematode infections in goats and sheep (Ashfaque *et al.* 2016, Bandhaiya *et al.* 2019).

Antioxidant responses: Catalase, superoxide dismutase, and ferric reducing antioxidant power showed increasing trends in the treated groups, particularly in goats receiving closantel and higher doses of *C. sativum* extract. However, these increases were not statistically significant, indicating that the antioxidant effects should be interpreted with caution. This modest improvement may be related to the antioxidant constituents naturally present in coriander seeds, including phenolic acids, flavonoids, tocopherols, carotenoids, and linalool, which have previously been shown to scavenge reactive oxygen species and enhance endogenous antioxidant defense systems (Ramadan and Morsel, 2004, Samojlik *et al.* 2010). In addition, the reduction of parasite burden may decrease oxidative stress by limiting inflammation and tissue damage. Because the observed changes did not reach statistical significance,

further studies with larger sample sizes are required to clarify the antioxidant potential of *C. sativum* in infected goats.

This study had several limitations. First, phytochemical characterisation of the aqueous extract was not performed; therefore, the concentrations of individual bioactive constituents responsible for the observed activity could not be determined. Second, a formal sample size calculation was not performed before the initiation of the experiment. Third, 95% confidence intervals for FECRT were not calculated, and additional clinical indicators such as the FAMACHA score, body weight change, body condition score, and feed intake were not evaluated. Finally, the study duration was limited to 28 days, and long-term reinfection or repeated dosing was not assessed. Future investigations incorporating phytochemical profiling (e.g. HPLC or GC-MS), pharmacokinetic studies, optimised dosing regimens, larger animal populations, and longer follow-up periods will provide a more comprehensive evaluation of the therapeutic potential of *C. sativum*.

The growing prevalence of anthelmintic resistance necessitates the development of sustainable parasite control strategies that reduce dependence on synthetic drugs. Although the efficacy of *C. sativum* extract was inferior to that of closantel, its moderate anthelmintic activity, along with improvements in haematological and biochemical parameters, suggested that it may be valuable as a complementary component of integrated parasite management rather than as a replacement for conventional anthelmintics. Its use may be particularly relevant in organic or low-input production systems, where phytotherapeutic approaches are encouraged.

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