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The use of *Moringa oleifera* Extract in the Treatment and Control of Intestinal Coccidiosis in Weaned Rabbit

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Abstract

This study aimed to introduce some natural alternatives that can be used in the treatment and control of coccidiosis in weaned rabbits. *Moringa oleifera* (*M. oleifera*) was used for its immune enhancer effect and its content of antioxidant bioactive compounds. In the current investigation, sixty domestic male rabbits were divided into six groups with 10 rabbits in each. Group 1 (G1): noninfected and non-treated group; G2 was noninfected and supplemented with *M. oleifera* extract in drinking water at 1.5 g/L; G3 was infected and non-treated (control positive); G4 was supplemented with *M. oleifera* extract in drinking water (1.5 g/L) one week before the experimental infection till the end of the experiment; G5 was infected and treated by *M. oleifera* extract in drinking water (1.5 g/L) at the 5th-day post-inoculation till the end of the experiment; G6 was infected and treated with amprolium 20% (1.2 g/L) at the 5th-day post-inoculation for five successive days. Rabbits were infected by a suspension containing 10^4 sporulated oocysts of *Eimeria magna*, *E. media*, and *E. perforans*. G3 exhibited the typical symptoms of coccidiosis with a mortality rate of 30%, while clinical signs in G4, G5, and G6 were lesser than in G3 with a mortality rate of 0%. There was a significant increase in body weight and a significant decrease in oocyst count in G4, G5, and G6 compared with G3. In Addition, a significant decrease ($p>0.05$) in the liver enzyme (ALT), A/G ratio, serum cholesterol, and triglycerides, with a significant increase ($p>0.05$) in serum total protein activities in the treated groups (G4, G5, and G6) compared to the control positive group. Serum AST, creatinine, and urea did not report any changes among treatments, and they were within the normal range. While antioxidant activities in tissue showed a significant reduction in the malondialdehyde (MDA), a significant increase in SOD (superoxide dismutase), and GSH (glutathione reduced) activities in the treated groups compared to the control positive group. Histopathological changes of the intestine showed better profiles in the supplemented groups. Besides, histopathological changes in the intestine and the microscopical lesion score were significantly reduced in the challenged groups supplemented and treated with *M. oleifera* and amprolium. In conclusion, *M. oleifera* could be effective in controlling rabbit coccidiosis.

KEYWORDS

Eimeria oocysts, Coccidiostats, Antioxidants, Liver, Kidney functions, Lesion scores, Weaned rabbits

INTRODUCTION

Rabbits are small pseudo-ruminant animals that are raised for the production of wool, highly nutritive proteins, and low-fat contents, as well as for use in medical research (Al-Mathal, 2008; Hamid *et al.*, 2019). Coccidiosis is one of the most significant and widely spread parasitic diseases caused by protozoa of the genus *Eimeria* that affects rabbits (Okumu *et al.*, 2014; Yin *et al.*, 2016; Bachene *et al.*, 2019). It primarily affects young rabbits after weaning (Drouet-Viard *et al.*, 1997) and causes significant morbidity and mortality, as well as lower body weight gain (Renaux *et al.*, 2003). Two forms of coccidiosis are found, *Eimeria* stiedae, which invades the hepatobiliary epithelial cells and results in hepatic lesions (Hanada *et al.*, 2003), is the cause of the hepatic form of coccidiosis in rabbits. Ten other *Eimeria* species have also been found to develop in the epithelial cells of the intestinal tract (Flecknell, 2000), eight of which were discovered in Egypt (El-Shahawy and El-Ghoneimy, 2018). As multiple species of *Eimeria* parasitize the intestinal epithelium of rabbits, mixed infections are the most frequent (Elbarbary, 2015; El-Sayed *et al.*, 2020). Coccidiostats and coccidiocidal medications were added to the feed and water of rabbits because it is preferable to prevent coccidia infection before it occurs (Abd El-Ghany, 2020), but the potential emergence of drug-resistant parasite strains and the presence of antibiotic residues in meat prompted us to look for natural and secure substitutes for anticoccidial chemicals (Pakandl, 2009; Kowalska *et al.*, 2012). In addition to being safe and having an antibacterial effect, the plant *Moringa oleifera* is also rich in antioxidant bioactive compounds, such as vitamins, essential amino acids, polyphenols, flavonoids, and phenolic acids (Leone *et al.*, 2015), which may make it useful for treating coccidian infections (Naidoo *et al.*, 2008). Coccidiosis and oxidative stress are related because the parasite's invasion of the intestinal mucosa causes inflammation, which in turn causes an excess production of free radicals. (Cedric *et al.*, 2017). In addition to its growth-promoting effects, it was employed as a preventative and therapeutic agent in avian coccidiosis. This makes it effective as a substitute product for the control of coccidiosis (El Banna *et al.*,

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2016). In order to reduce intestinal coccidiosis in weaned rabbits, this study evaluated *M. oleifera* extract as a natural alternative to anticoccidial medications.

MATERIALS AND METHODS

Ethical approval

Animal care and study protocols were carried out in accordance with the ethical committees' guidelines at the Animal Health Research Institute in Dokki, Egypt.

Experimental design

Sixty domestic male rabbits were divided into six groups with 10 rabbits in each group, The first group of rabbits (G1) was the negative control group; non-infected and nontreated group; and the 2nd group (G2) was noninfected and supplemented by. *M. oleifera* extract in drinking water 1.5 g/L. (supplemented non-infected control group), the 3rd Group (G3): infected and non-treated (positive control group), the 4th Group (G4): supplemented by adding *M. oleifera* extract in drinking water (1.5 g/L) one week before infection till the end of the experiment (supplemented-infected), the 5th Group (G5): infected and treated by adding *M. oleifera* extract in drinking water (1.5 g/L) at the 5th day of inoculation till the end of the experiment(infected treated with *M. oleifera*), the 6th Group (G6): infected and treated with amprolium 20% (1.2 g/ L) at the 5th day of inoculation for five successive days. (Infected-treated with amprolium). Clinical signs and mortalities were observed from 0 days to 21 days of inoculation, feed intake, and body weight gain were weekly recorded throughout the study to calculate the Feed Conversion ratio (FCR) (total feed intake/body weight gain) according to Sainsbury 1984. Weighing was carried out before the morning feeding (at 8:00 h) (Belabbas *et al*., 2019). Fecal samples were collected from each group separately for calculation of oocysts per gram (OPG) starting from the 5th day of inoculation, blood samples were collected from slaughtered rabbits in each group (n=3) for evaluation of blood biochemical parameters and liver tissue samples for assessment of antioxidant activities. Duodenum, jejunum, and ileum were macroscopically examined, and lesions were recorded and then fixed in 10% formalin for histopathology. All parameters were compared among the six groups.

Animal feeding and housing

Sixty Domestic male newly weaned coccidian-free rabbits (4 weeks old weighing 700 -750 g) were obtained from good hygienic private rabbitry. Rabbits were reared in clean stainless steel cages (5 in each cage) at room temperature (20–25 °C) and light cycle (14 h light/ day) for two weeks for acclimatization before inoculation with sporulated *Eimeria* oocysts. Vigorous cleaning, disinfection, and daily fecal examination were carried out to ensure that rabbits are coccidia-free (Awade *et al*., 2019). Rabbits were provided with clean water and fed in dry pellets free from any medical additives.

Experimental infection of rabbits with isolated and identified E. magna, E. media, and E. perforans

Collection and concentration of oocysts

E. magna, *E. media*, and *E. perforans* used in artificial infection in this study were obtained by collecting fresh fecal samples from naturally infected rabbits, mixed with clean water then sieved to remove the coarse particles, transferred to centrifuge tubes and centrifuged at 1500 rpm for 3 minutes. The sediment was subjected to a concentration flotation technique. The supernatant containing *Eimeria* oocysts was washed with distilled water several times, and the cleaned oocysts were mixed in Petri dishes with 2.5% potassium dichromate solution in a thin layer (2ml depth) for sporulation (Coudert *et al*.,1995). Sporulated *Eimeria* oocysts were identified by a key provided by Eckert *et al*. (1995); Abdel-Baki and AL-Quraishy (2013) and Li *et al*. (2016), sporulated oocysts were stored in a refrigerator till being used. McMaster technique was used for counting oocysts (Ruiz *et al*., 2014; Gibbons *et al*., 2016).

The technique of experimental infection

Artificial infection was induced by oral inoculation of experimental rabbits with 2 ml of oocyst suspension containing 10^4 sporulated *Eimeria* oocysts using an Eppendorf pipette (Coudert *et al*., 1995).

Moringa oleifera and used dose

The commercial herbal product known as *Moringa oleifera* powder, which can be found at A.B CHEM pharmaceutical Row Materials, is made up of a variety of extracts. Anthraquinone (11.68±0.04), an alkaloid (3.17), steroids (3.21±0.00), terpenoids (4.84 0.05), cardiac glycoside (0.36±0.03), tannins (9.36±0.04), carotenoids (1.16±0.05), flavonoid (3.56±0.03), and saponins (1.46±0.03) are all present in each 100 It also contains nutrients like carbohydrate (57.01±0.01), protein (18.92±0.02), fats (2.74±0.03), fiber (9.31±0.02), and minerals like nitrogen (3.03 0.02), calcium (2.09±0.01), magnesium (0.48±0.00), potassium (1.62±0.02), phosphorous (0.44±0.01), zinc (0.005±0.00), iron (0.03±0.00), copper (0.01±0.00), and sulfur (0.85±0.0) (Onyekwere and Felix, 2014). Providing rabbits drink around 10% of their total weight in water (Okerman, 1994). As a result, by adding 1.5 g of M.O. extract to one liter of drinking water, the dose will be as prescribed: 150 mg/kg body weight (Lashari *et al*., 2021).

Biochemical analysis of serum

On the ninth day and three weeks PI, blood samples (n=3) were taken from each rabbit. The blood was then centrifuged for 15 minutes at 3000 rpm to extract the serum, which was then stored until analysis at -20 °C. An automatic clinical chemistry analyzer was utilized for serum biochemical analysis (Tang *et al*., 2017), which included liver enzymes [alanine aminotransferase (ALT) and aspartate aminotransferase (AST)], creatinine, urea, total protein and A/G, cholesterol, and triglyceride.

Evaluation of antioxidant parameters

According to the method proposed by Fodouop *et al*. (2015), the level of Malondialdehyde (MDA) was measured to determine the degree of peroxidation in the tissue. Oyedemi *et al*. (2010) method was used to measure reduced glutathione peroxidase (GSH) and superoxide dismutase (SOD) in tissue.

Efficacy of Moringa oleifera extract

Clinical signs, postmortem lesions, and mortality rate

To assess the effectiveness of M.O. extract, the primary clini-

cal symptoms, postmortem lesions, and mortality rates related to intestinal coccidiosis were compared across all groups. So, rabbits were observed twice daily, clinical signs (reduced growth performance, anorexia, lethargy, diarrhea, and rough coat), and mortality rate were noted from the time of inoculation until the end of the trial (21 days, PI). , White foci in the intestinal wall and an inflamed empty intestine were found during the postmortem inspection. .

Body Weight and Food Conversion Ratio

To determine the average body weights, rabbits in each group were weighed at the beginning of the experiment (0 days after supplementation with M.O extract). At the start of the experiment and the end of the experiment (at 21 days, P.I), the average BW was noted, and the FCR was determined. The difference between the value of body weight at the start of the experiment and the average body increase per rabbit in each group was calculated. (21-days, PI). By dividing the amount of feed ingested throughout the experiment days by the rabbits' body weight gain, the FCR was computed (Seddiek and Metwally, 2013; El-Ghoneimy and El-Shahawy, 2017).

Fecal oocyst counts.

Starting on the fifth post-infection day (PI) and continuing until the twenty-first (PI), feces samples were taken from the experimentally infected rabbits in order to detect and identify *Eimeria* oocysts. Every morning at 10 am, 10 fecal pellets from each group were collected and weighed (Eladla *et al*., 2020). The samples were rehydrated, sieved, then concentrated by employing the flotation procedure, and counted using McMaster method (Vadlejch *et al*., 2013). Seddiek and Metwally (2013) determined the oocyst reduction percentage as follows:

$$\text{Reduction \%} = \frac{\text{OPG of infected group} - \text{OPG of treated group}}{\text{OPG of infected group}} \text{X100}$$

Histopathology and lesion scoring

For histopathology, specimens from various intestinal regions were fixed in 10% buffered formalin. The fixed tissues were dehydrated, paraffin wax-infiltrated, and rinsed in flowing tap water overnight. The sections were deputized in three successive washes in xylol for five minutes before being rehydrated with five successive washes with alcohol in descending sequence of 100%, 95%, 80%, 70%, and 50% in deionized water. Serial paraffin slices (5 um thickness) were also obtained. After that, the histological sections underwent the standard Hematoxylin and Eosin (H and E) staining technique (Bancroft, and Gamble 2008). A light microscope was used to inspect each slide, and lesion comparisons between treatment groups were done. By noting the type, size, and frequency of the lesions at randomly chosen tissue sites, histopathological lesions were graded according to a set of criteria: marked (41-100% of tissue involved), moderate (21-40% of tissue involved), mild (11-20% of tissue involved), and minimal (0- 10% of tissue involved) (Ogolla *et al*., 2018). At different magnifications, certain intestinal lesions were assessed (Table 1).

Statistical analysis

One-way ANOVA tests were used to compare growth performance data, fecal oocyst counts, biochemical, antioxidant, and hematological parameter values expressed as Mean ± standard error (S.E) among the group. The Duncan test was used to determine whether there was a significant difference ($p<0.05$) between the control and experimental groups.

RESULTS

Effect of Moringa oleifera extract on clinical parameters

Rabbits in group (G1) and group (G2) did not exhibit any clinical abnormalities. While Rabbits in the positive control (G3) showed the typical signs of coccidiosis, such as depression, dullness, ruffled coat, loss of wall, reduction in feed intake, and offensive diarrhea on the seventh day and continued for three days, accompanied by progressive weakness and loss of weight, the diarrhea in the infected group that received supplements (G4) was mild and only persisted for one day, and the same was seen in the group that received amprolium treatment (G6). Also, diarrhea observed in the group infected then treated with *M. oleifera* (G5) was mild and continued only for two days then rabbits gain its normal behavior, thus the severity of clinical signs in G5, G4, and G6 was less than (G3), three individuals in G3 suffered from severe diarrhea, off food, dullness and convulsions followed by death, thus mortality rate in G3 was 30%. P.M. inspection showed bloat empty enflamed and hyperemic caecum and small intestine with numerous whitish nodules was seen along the wall of the small intestine, no mortalities recorded in all other groups, so the mortality rate was 0%. The supplemented noninfected group (G2) showed a significantly higher mean BW and BWG and better FCR than G1 which indicates the growth-promoting Effect of *Moringa oleifera* extract, G4, G5, G6 also showed a significantly higher BW and BWG and better FCR than the infected-untreated rabbits (G3) at day 21 PI (Table 2, Fig. 1).

Effect of Moringa oleifera extract treatment on fecal oocyst counts

No oocysts were detected in fecal samples of the rabbits in the negative control group (G1) and the supplemented noninfected group (G2), oocysts of *E. magna*, *E. media*, and *E. perforans* were detected in fecal samples of infected groups at the 5th-day post-infection, *E. perforans* oocyst was ellipsoid, with smooth thin colorless to light pink wall, micropyle very difficult to be de-

Table 1. Lesion scoring criteria used and intestinal lesions scored in the experimental efficacy trial.

Grade/score	Grade description	Focal and multifocal lesions	Diffusely distributed lesions
		various *Eimeria* stages in lamina propria and enterocyte (X400 mag) (10 sites examined)	Desquamated Epithelium Enterocytes/ X400 (10 sites examined)
1	Minimal	<10% of tissue involved	<10% of the tissue is involved.
2	Mild	11-20% of the tissue involved.	11-20% of the tissue involved.
3	Moderate	Between 21 to 40% of tissue parts affected	Between 21 to 40% of tissue parts affected
4	Marked	Between 41 to 100% of tissue parts affected	Between 41 to 100% of tissue parts affected

tected, oocysts measurements were 15-27x11-17 µm with small residuum (3.6-4.8 µm) (Fig. 2A), *E. media* oocyst were ellipsoid in shape, with was smooth light pink wall having micropyle with a pyramidal-shaped protuberance, Oocysts measurements were 25-35x15-20 µm, residuum was 4.8-7.2 µm (Fig. 2B), *E. magna* oocysts were ovoid, truncated at the micropylar end with a marked collar like thickening around micropyle, with a smooth dark yellow wall. Oocysts measurements were 31-42x20-28 µm, with a large residuum (9.6-14.4 µm) (Fig. 2C).

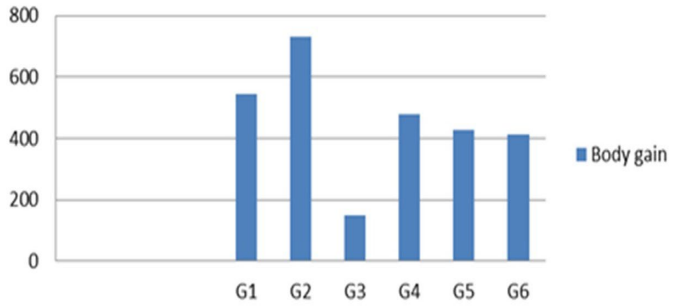

Fig. 1. The Effect of *Moringa oleifera* extract treatment on body weight gain (BWG).

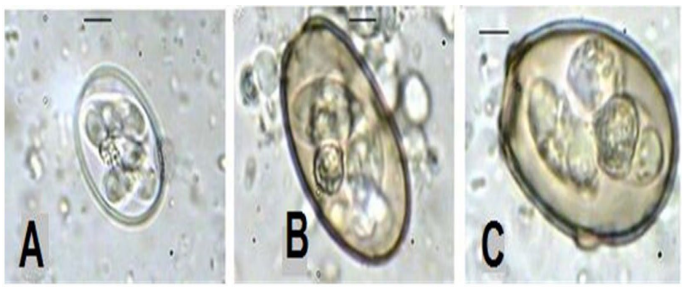

Fig. 2. Sporulated *E. perforans* (A), *E. media* (B), E magna. (C).

The mean oocyst per gram (OPG) value for G4 was significantly lower than that in G3, G5, and G6 at the 5th DPI while at the 7th DPI, OPG values for G4, G5, and G6 were significantly lower than that in G3, and continued in decrease till no oocyst were detected at 11th for G4 and G6 and few oocysts in G5, by the 13th DPI, while oocyst shedding in G3 continued, thus treated groups exhibited shorter excretion period of oocysts and significantly lower oocyst count than that in G3 (Table 3, Fig. 3).

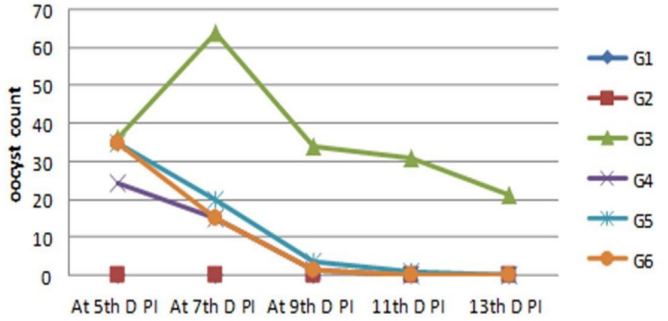

Fig. 3. The Effect of *Moringa oleifera* extract treatment on oocyst count/gram feces.

Effects of Moringa oleifera extract on Blood biochemical parameters

Table 4 shows the blood-based biochemical parameters of the experimental rabbits; the liver enzyme (ALT) was significantly lower ($p>0.05$) in the treated groups of rabbits (G4, G5, G6) than in the positive control group. (G3). However, , serum AST, creatinine, and urea did not show any differences between treatments and they were within the usual range. In comparison to the control positive group, there was a substantial increase ($p>0.05$) in serum total protein and a drop in the A/G ratio in the treated groups (G4, G5, and G6). The serum cholesterol and triglyceride levels in the treatment groups (G4, G5, G6) were significantly lower than those in the positive control group ($p<0.05$).

Antioxidant Indices

Malondialdehyde (MDA) was significantly lower in treated groups (G4, G5, G6) compared to the control positive group (G3), while SOD (superoxide dismutase) and GSH (glutathione reduced) activities were higher in treated groups (G4, G5, G6) compared to control positive group (G3) on the 9th and 21st days after

Table 2. The Effect of *Moringa oleifera* Extract treatment on body weight gain (BWG) and feed conversion rate (FCR).

Groups	7-day PI	14-day PI	21-day PI	Total body gain	FCR
G1	1081.67±2.89^{b}	1255±2.89^{b}	1385.00±2.89^{b}	545.00±2.89^{b}	3.61
G2	1185.00±2.89^{a}	1376±4.41^{a}	1571.67±4.41^{a}	731.67±7.26^{a}	2.77
G3	845.00±2.89^{e}	985±2.89^{e}	991.67±4.41^{f}	151.67±4.41^{f}	8.2
G4	1015.00±2.89^{c}	1145±2.89^{e}	1325.00±2.89^{e}	478.33±4.41^{e}	3.89
G5	995.00±2.89^{d}	1090±2.89^{d}	1235.00±2.89^{e}	428.33±1.67^{d}	4.07
G6	1018.33±1.67^{c}	1145±2.89^{e}	1283.33±3.33^{d}	413.33±6.01^{e}	4

Data are expressed as Means±SE. Values with different letters ($^{a, b, c, d}$) within the same column are significantly different at P value ≤ 0.05

Table 3. The Effect of *Moringa oleifera* extract on oocyst count/gram feces (x10^{3}) and Reduction % (OPG) in experimentally infected rabbits.

Groups	At 5th DPI	R%	At 7th DPI	R%	At 9th DPI	R%	11th D PI	R%	13th D PI	R%
G1	0.00±0.00^{c}	-	0.00±0.00^{d}	-	0.00±0.00^{e}	-	0.00±0.00^{d}	-	0.00±0.00^{b}	-
G2	0.00±0.00^{c}	-	0.00±0.00^{d}	-	0.00±0.00^{e}	-	0.00±0.00^{d}	-	0.00±0.00^{b}	-
G3	36.0±0.58^{a}	0	64.0±1.73^{a}	0	34.67±2.028^{a}	0	31.0±0.58^{a}	0	21.33±0.88^{a}	0
G4	24.3±0.88^{b}	33.30%	15.67±0.33	76.50%	1.46±1.33^{b}	95.78%	0.00^{c}±0.00	100%	0.00±0.00^{b}	100%
G5	35.0±0.58^{a}	0.03%	20.33±0.33^{b}	64.60%	3.40±.058^{c}	90%	0.80±0.058^{b}	98.40%	0.00±0.00^{b}	100%
G6	35.0±0.58^{a}	0.03%	15.0±1.15^{c}	75%	1.30±.058^{d}	96.20%	0.00±0.00^{c}	100%	0.00±0.00^{b}	100%

Data are expressed as Means±SE. Values with different letters ($^{a, b, c, d}$) within the same column are significantly different at P value ≤ 0.05

infection. The tissue antioxidant activity data from the rabbits are shown in Table 5.

Histopathology and lesion scores

All the intestinal coats of the small and large intestines were normal in G1 (Figs. 4 A and B). The intestinal villi and their lining enterocytes were normal and contained numerous goblet cells mainly in their glands in G2 (Fig. 4C). Sometimes intestinal villi appeared broad and contained goblet cells in their lining epithelia beside mucosal lymphocytic infiltrates and hyperemic blood vessels in sub mucosa in G2 (Fig. 4D). The intestinal villi were broad and fused with partial separation and desquamation of upper villous portion together with edema and hemorrhages in sub mucosa due to intense Coccidian developmental stage in G3 (Fig. 4E). Hemorrhagic exudate mixed with mucosa inside the intestinal lumen with numerous coccidian developmental stages within hyperplastic villous enterocytes and intestinal crypts in G3 (Fig. 4F). The intestinal villi showed partial desquamation of their apical portions, proliferate enterocytes with a few coccidian developmental stages inside enterocytes and lamina together with intense sub mucosal leukocytic infiltrates mainly lymphocytes and eosinophils in G4 (Fig. 4G). More mucous inside the lumen in G4 (Fig. 4H). The intestinal villi were elongated and contained moderate stages of coccidian intestinal within their hyperplastic villous enterocytes beside edema and hemorrhage in the submucosa in G5 (Fig. 4I). Hyperplasia of villous epithelia in the form of finger-like projection with loss of inter villous spaces, hemorrhages in the tips of villi, and intense coccidian intestinal stages within the mucosa and submucosa in G5 (Fig. 4J). The intestinal

Table 4. Effect of supplementation of Moringa Oliefera on serum parameters of rabbits infected with Intestinal coccidiosis.

	ALT (U/L)	AST (U/L)	Creatinine (mg/dl)	Urea (mg/dl)	Cholesterol (mg/dl)	Triglyceride (mg/dl)	Total protein (g/dl)	A/G
9 days PI								
G1	16.0±1.15^{de}	32±2.30^{bc}	0.63±0.14^{ab}	26.33±1.76^{ab}	67.0±1.15^{c}	119.0±1.73^{e}	5.91±0.00^{a}	1.08±0.00^{d}
G2	14.66±1.45^{e}	30±1.73^{ac}	0.70±0.11^{ab}	25.33±1.76^{ab}	67.0±1.15^{c}	100.0±2.88f	5.89±0.02^{a}	1.28±0.01^{b}
G3	32.0±0.57^{a}	38±1.73^{a}	1.0±0.11^{a}	32.0±4.58^{a}	100.0±2.88^{a}	216.0±1.73^{a}	4.43±0.14^{c}	1.46±0.01^{a}
G4	20.0±1.73^{cd}	36±1.15^{ab}	0.43±0.17^{b}	26.33±1.45^{ab}	72.33±1.4^{c}	146.66±1.20^{d}	4.90±0.02^{b}	1.22±0.01^{c}
G5	22.0±1.15^{bc}	35±1.52^{abc}	0.51±0.19^{ab}	30.0±1.73^{ab}	71.0±1.15^{c}	173.66±1.45^{b}	4.90±0.02^{b}	1.28±0.01^{b}
G6	25.0±1.52^{b}	31±1.45^{bc}	0.48±0.17^{ab}	29.33±1.20^{ab}	70.33±2.02^{c}	157.33±1.45^{c}	4.73±0.14^{b}	1.29±0.01^{b}
21 days PI								
G1	16.0±1.73^{bc}	30.66±1.45^{b}	0.5±0.11^{a}	23.66±1.45^{b}	70.0±2.30^{b}	115.0±1.73^{d}	4.56±0.35^{c}	1.29±0.01^{a}
G2	15.0±1.15^{c}	34.33±1.45^{b}	0.73±0.14^{a}	23.0±1.15^{b}	55.33±1.45^{c}	95.33±0.88^{e}	6.0±0.02^{a}	1.23±0.01^{c}
G3	22.0±1.52^{a}	40.0±1.73^{a}	0.80±o.11^{a}	30.33±1.20^{a}	93.33±2.02^{a}	150.33±2.02^{a}	6.53±0.14^{a}	1.25±0.01^{ab}
G4	18.0±1.73^{abc}	34.0±1.73^{b}	0.73±o.18^{a}	24.0±1.73^{b}	66.66±1.20^{b}	129.66±2.02^{c}	6.50±0.11^{a}	1.11±0.01^{d}
G5	21.33±1.45^{a}	33.33±1.20^{b}	0.80±0.20^{a}	26.0±1.73^{ab}	70.33±1.45^{b}	138.33±1.45^{b}	6.03±0.14^{a}	1.14±0.01^{d}
G6	20.33±1.67^{ab}	32.0±1.73^{b}	1.0±0.17^{a}	25.0±1.52^{b}	65±1.15^{b}	141.66±0.88^{b}	5.20±0.11^{b}	1.20±0.01^{c}

Data are expressed as Mean±S.E. values within the same column carrying different superscripts is significantly differ at (p>0.05). PI= post-infection.

Table 5. Effect of *Moringa olifera* on antioxidant activity of rabbits infected with intestinal coccidiosis.

	9 days post infection			21 days post infection		
	MDA (nmol/g).	SOD (U/g)	GSH (mmol/g)	MDA (nmol/g)	SOD (U/g)	GSH (mmol/g)
G1	59.5±1.44^{d}	157.33±0.8^{a}	1.93±0.01^{b}	56.33±1.45^{c}	152±1.73^{b}	1.90±0.01^{b}
G2	48.8±1.48^{e}	161.0±1.73^{a}	2.07±0.01^{a}	42.33±1.45^{d}	164.0±1.15^{a}	2.09±0.06^{a}
G3	77.6±1.45^{a}	98.0±1.15^{d}	1.10±0.01^{e}	68.33±0.88^{a}	121.0±1.15^{e}	1.56±0.01^{ed}
G4	65.0±1.52^{c}	116.33±1.4^{b}	1.83±0.01^{c}	60.0±1.15^{bc}	139.33±1.45^{c}	1.63±0.02^{d}
G5	68.3±1.45^{bc}	84.66±1.45^{e}	0.96±0.01^{f}	62.0±1.73^{b}	131.66±1.76^{d}	1.49±0.01^{e}
G6	70.0±1.15^{b}	103.66±1.4^{c}	1.19±0.01^{d}	63.0±1.52^{b}	129.33±1.45^{d}	1.75±0.01^{c}

Data are expressed as Means±SE. Values with different letters ($^{a, b, c, d}$) within the same column are significantly different at P value ≤ 0.05

Table 6. Mean intestinal microscopic lesion scores quantifying the effects of the anticoccidials on coccidial lesions.

Groups	Epithelial desquamation	*Eimeria* stages in intestinal tissue and lumen
Negative control (G1)	1.33±0.33^{a}	0.00±0.00^{c}
Supplemented non-infected control group (G2)	1.00±0.00^{a}	0.00±0.00^{c}
Infected group (G3)	4.0 4±0.00^{a}	4.00±0.00^{a}
Infected treated (G4)	1.67±0.67^{bc}	1.67±.33^{b}
Supplemented-infected-treated (G5)	1.44±0.44^{c}	1.00±0.00^{b}
Infected- treated Amprolium (G6)	1.67±0.67^{bc}	1.67±0.33^{b}
P value	0.00	<0.001

Aggregated mean lesion scores of three rabbits per treatment group. Values without similar superscripts in a column are significantly different at 0.05

villi showed mild development stages of coccidian intestinal with hyperplastic goblet cells, and little mucus exudate in G6 (Fig.4K). Sometimes, broad intestinal tips with hyperplastic intestinal crypts containing a few stages of coccidian were evident in G6 (Fig. 4L). Mean lesion scores are presented in Table 6.

DISCUSSION

Coccidiosis is one of the widely distributed parasitic diseases that affect rabbits, especially weaned rabbits (Drouet-Viard *et al*., 1997). Recently, most efforts were directed toward replacing anti-coccidian drugs with natural extractions which stimulate the immune system, improving performance and the bacteriostatic or bactericidal activities to avoid drug resistance problems (Castaneda and Gonzalez, 2015). *M. oleifera* extract was used in this study for being rich in many bioactive therapeutic compounds such as essential amino acids, vitamins, flavonoids, and polyphenols (Leone *et al*., 2015), our results showed that supplemented group with *M. oleifera* had the highest body gain and better food conversion ratio which indicate its growth-promoting effect. This result agreed with Frederick (2010), El Banna *et al*. (2016); Mohammed *et al*. (2019) who reported that *M. oleifera* leaves meal (MOLM) supplementation improved litter weight. Besides, Raza (2021) and Osunkeye *et al*. (2022) declared that M.O. was rich in protein, mineral contents, and carbohydrates fasting the growth in broiler birds,. In addition, *M. oleifera* leaves meal improved the dry matter (DM), and crude protein (CP) digestibility of rabbits as reported by Nuhu (2010). Also supplemented infected groups G4 and G5 showed significantly higher BW and BWG and better FCR than the infected-untreated rabbits (G3). This could be attributed to the high levels of vitamins and amino acids in *M. oleifera* leaves which improved the recovery from the disease condition and increased feed intake and feed conversion rate (El Banna *et al*., 2016). While there was weight loss; and a decrease in weight gain in the infected untreated group. This result agreed with Vereecken *et al*. (2012), this could be attributed to the damaging effect of the *Eimeria* species on the epithelial lining of the intes-

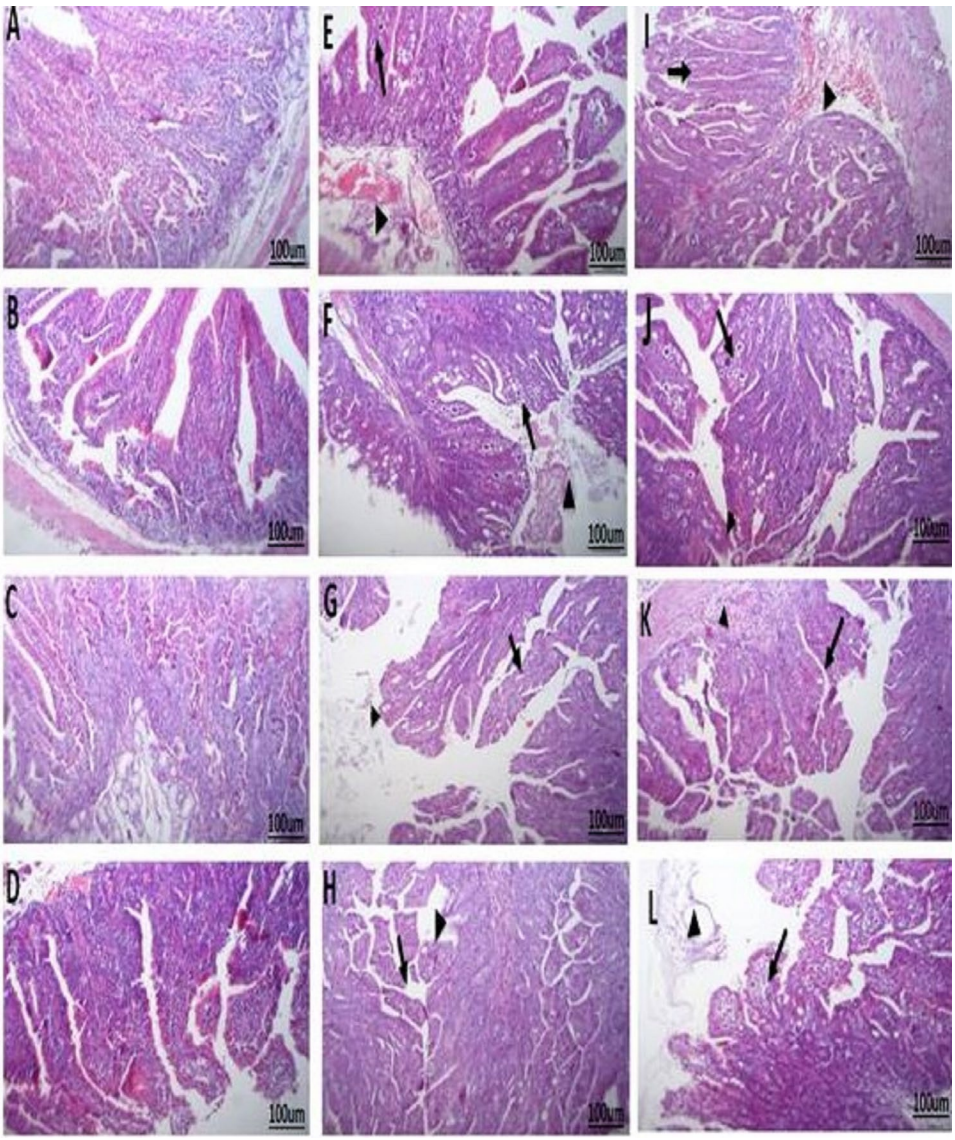

Fig. 4. Photomicrograph of sections from the intestine of rabbit at 7 days post-infection with *Eimeria* species stained with H&E (X400). (A) Histological picture of the intestine shows normal picture in G1 (Control group); (B) Normal intestinal mucosa and sub mucosa in G1 (Control group); (C) Proliferative intestinal glands and metaplasia to goblet cells in sub mucosal glands in G2 (supplemented non-infected control group); (D) Broad intestinal villi with hyperplastic intestinal crypts and goblet cells in G2 (supplemented non-infected control group); (E) Destruction of THE upper portion of villi and cococcidial stages in mucosa (arrow) beside hyperemia and edema in sub mucosa (arrow head) in G3 (infected group); (F) Hemorrhagic exudate inside the lumen (arrow head) and intense coccidial stages with hyperplastic villous enterocytes (arrow) in G3 (infected group););(G) A few coccidial stages (arrow) and hyperplastic goblets cells (arrow head) with intact villous epithelia in G4 (supplemented-infected-treated); (H) Hyperplastic glands continue a few coccidial stages (arrow) with proliferative intestinal crypt (arrow head) in G4 (supplemented-infected-treated);(I) Intact villous mucosa continuing moderate cocidial stages (arrow) and hemorrhage in sub mucosa (arrow head) in G5 (infected-treated); (J) Destruction of the upper portion of villi and coccidial stages in mucosa (arrow) beside hyperemia and edema in sub mucosa (arrow head)in G5 (infected- treated). (K) Partial desquamation of villous enterocytes, a few coccidial stages within enterocytes (arrow) and inflammatory cells infiltrates in submucosa (arrow head) in G6 (infected-treated with Amprolium); (L) A few coccidial stages within mucosa and intestinal glands (arrow) inside the lumen.

tinal mucosa which impairs the absorption of nutrients and water from the intestine.

The supplemental infected groups G4 and G5 had considerably lower oocyst counts than the untreated group G3, infection duration was short, and these findings suggest *M. oleifera* anticoccidial activity. This finding agreed with those of El Banna *et al*. (2016), Abu El Ezz *et al*. (2020), who found that moringa and thyme oils both had an anti-coccidial effect in rabbits, and Mgbojikwe *et al*. (2021), who stated that *M. oleifera* has great potential for use in the treatment and control of bird coccidiosis. Additionally, Meskerem and Boonkaewwan (2013) verified that Moringa stenopetala protects chickens from E. tenella infection.

The anticoccidial activity of *M. oleifera* extract as a treatment agent could be due to its antioxidant properties as antioxidant compounds are known to have a cellular protective action against oxidative stress produced by *Eimeria* infections by altering the degree of intestinal lipid peroxidation (Allen *et al*., 1998).

Concerning biochemical analysis, the current findings revealed that serum liver enzyme level (ALT) in infected rabbits with intestinal coccidiosis treated with M.O. (G4, G5) was significantly decreased than control positive (G3) at the 9th-day post-infection. On the other hand, there were no significant changes ($p<0.05$) in AST, creatinine, and urea levels between all groups, these findings agree with Wisniak and Potential (1994); Adaszynska-Skwirzynska *et al*. (2021); Gad *et al*. (2021) this result may be attributable to the protective effect of liver cells from damage by M.O. and improvement of liver function, Kumar (2012) and Nazir *et al*. (2020) reported that (Funiculus Valgare) decrease ALT, AST, and ALP (alkaline phosphatase) levels in the serum of rabbits, this finding agrees with Saeed *et al*.(2019) who noticed that prebiotic supplementation did not have any adverse effect on liver and kidney functions in rabbits infected with intestinal coccidiosis, Cedric *et al*. (2018); Mona and Aya (2013) recorded that M.O. was safe and improved renal function also has cholesterol-lowering action.

Our results showed that there was a significant decrease in the serum cholesterol in the treated groups (G4, G5, G6) compared to the infected non-treated group, while the negative group supplemented with M.O. showed a decrease in the cholesterol level compared to the negative control group. Triglyceride also showed a significant decrease in G4, G5, and G6 than the positive control, while G2 showed a much decrease than G1. This finding agrees with Jain *et al*. (2010), Reddy *et al*. (2012), Mona and Aya (2013) who reported that M.O. has a hypo cholesterol effect.

Regarding total serum protein and A/G ratio, our results revealed that there was a significant decrease ($p>0.05$) in the total protein and a significant increase in the A/G ratio in the infected nontreated group compared to treated groups. Likely, Seddiek and Metwally (2013) and Mondal *et al*. (2011) reported that a decrease in serum total protein in coccidia infection in broiler chicken might be due to the acute stress which leads to cortisol secretion and catabolism of protein.

The current study investigates that supplementation of M.O. extract to rabbits infected with intestinal coccidiosis has an antioxidant effect by decreasing MDA levels and increasing SOD, and GSH levels in the tissue in comparison with the control positive group (G3), this may be because of phenolic compounds in M.O. extract. Paliwal *et al*. (2014), Barbarestani *et al*. (2020); Tharwat *et al*. (2021) noticed that essential oils could increase the oxidative stability of chicken tissues. Cedric *et al*. (2018) mentioned that the increase of MDA levels in serum and organs induced by infection was due to increased membrane peroxidation leading to damage of the tissue and failure of antioxidant defense mechanism to prevent the formation of excessive free radicals. Idris *et al*. (2017) confirmed that antioxidants can help in reducing the damage to the intestinal tissue during the invasion of the parasite by decreasing the cytotoxic effect caused by the reactive oxygen species. Sreelatha and Padma (2009) and Shad and Xiang (2019) recorded that M.O. has antioxidant and antibacterial effects. Paliwal *et al*. (2011), estimated that Moringa has 46 types of antioxidants. Also, Alhotan and Abudabos (2019) noticed that the antioxidant effect of an herbal plant is linked directly with the anticoccidial effect.

In terms of histology and lesion scores, our research on the ninth PI day revealed that the challenged treatment groups displayed fewer inflammatory and degenerative alterations as well as fewer stages of coccidial development than the control positive. The amprolium-treated group G6 showed the greatest improvement in the inflammatory alterations and reduction in the coccidial developmental phases, followed by G4 and G5. These findings corroborated those of El Banna *et al*. (2016), who found that the lamina propria of rabbits fed with *M. oleifera* was infiltrated with inflammatory cells, primarily macrophages and lymphocytes, and that the intestine of the rabbits appeared to be free of *Eimeria*. Abd El-Dayem *et al*. (2021) reported that the large intestine appeared free from coccidial stages with noticeable degenerative changes in crypts and glandular epithelium and the absence of inflammatory or hemorrhagic complicating changes of avian coccidiosis treated with amprolium, which is similar to the findings of the current study. The reduction in lesion ratings as compared to both the amprolium-treated group and the infected non-treated group is consistent with the findings reported by El Banna *et al*. (2016). On the other hand, Ogolla *et al*. (2018) found no statistically significant difference ($p>0.05$) in the gross and microscopic lesion scores of rabbits treated with amprolium and trimethoprim-sulfamethoxazole and those of the infected-untreated control group.

CONCLUSION

M. oleifera could be used as a prophylactic and treatment for coccidiosis in rabbits when added to water or food as a natural alternative for chemical drugs enhancing quick recovery, decreasing oocyst count, and shedding period. Thus, decreasing body weight loss and increasing body gain, as it is proven to be a good immune enhancer preventing coccidial stages development and propagation in the epithelial cells lining the alimentary tract in addition to its growth-promoting effect providing that rabbits are reared under good hygienic condition preventing repeated infection.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

REFERENCES

Abdel-Baki, A.S., Al-Quraishy, S., 2013. Prevalence of Coccidia (*Eimeria* spp.) Infection in Domestic Rabbits, *Oryctolagus cuniculus*, in Riyadh, Saudi Arabia. Pakistan J. Zool. 45, 1329-1333.

Abd El-dayem, G.H., Abd elmaged, R.R., Rasheed, N., 2021. The potential efficacy of aloe vergel and yucca schidigera extract on growth performance, intestinal lesions, and inflammatory response in broiler chickens challenged with coccidian. Assiut Vet. Med. J. 67, 21-36.

Abd El-Ghany, W.A., 2020. Coccidiosis; A Parasitic Disease of Significant. World Vet. J. 10, 499-507

Abu El Ezz, N.M.T., Aboelsoued, D., Hassan, S.E., Abdel Mageedm K.N., El Metenawy, T.M., 2020. The therapeutic effect of *Moringa olifera* and thymus vulgaris oils against hepatic coccidiosis in experimentally infected rabbits. Trop. Biomed. 37, 1018-1028.

Adaszynska-Skwirzynska, M., Szczerbinska, D., Zych S., 2021. The use of lavender essential oil as an additive to drinking water for broiler chickens and its in vitro reaction with enrofloxacin. Animals 11, 1535.

Awade, M., Youssef, M., Alakabawy, L., 2019. Immunization of V-line rabbits against intestinal coccidiosis by using attenuated *Eimeria* oocysts. Benha Vet. Med. J. 36, 314-324.

Alhotan, R.A., Abudabos, A., 2019. Anti-coccidial and antioxidant effect of plants derived polyphenol in broilers exposed to induced coccidiosis. Environ. Sci. Pollut. Res. Int. 26, 14194-14199..

Allen, P.C., Danforth, H.D., Augustine, P.C., 1998. Dietary modulation of avian coccidiosis. Inter. J. Parasitol. 28, 1131–1140.

Al-Mathal, I.M., 2008. Hepatic coccidiosis of domestic rabbit Oryctolagus

cunicuyus dodesticus L. Sauddi Arabia. World J. Zool. 3, 3-0-35.
Bachene, M. S., Temim, S., Ainbaziz, H., Bachene, A., 2019. Prevalence of rabbit coccidia in Medea Province, Algeria. World's Veterinary Journal 9, 123-128.
Bancroft, J., Gamble, A., 2008. Theory and Practice of Histological Techniques, 6th ed.; Churchill-Livingstone: Edinburgh, UK; London, UK; Melbourne, Australia; New York, NY, USA.
Barbarestani, S.Y., Jazi, V., Mohebodini, H., Ashayerizadeh, A., Shabani, A., Toghyani, M., 2020. Effect of dietary Lavender essential oils on growth performance, intestinal function, and antioxidant status of broiler chickens. Livest. Sci. 233, 103958.
Belabbas, R., Luz García, M., Ainbaziz, H., Benali, N., Berbar, A., Boumahdi, Z., Argente M. J., 2019. Growth performances, carcass traits, meat quality, and blood metabolic parameters in rabbits of local Algerian population and synthetic line. Vet. World 12, 55–62.
Castaneda, R.E., Gonzalez, E,D., 2015. Control of Avian coccidiosis: Furture and present Natural alternatives. BioMed. Res. Int. 2015, 43610.
Cedric, Y.V.K., Payne, N.A.C., Nadia, N., Kollins, K.E., 2017. In vivo anticoccidial activities of Psidium guajava methanol extract. Eur. J. Med. Plants 21, 1-12.
Cedric, Y.V.K., Payne, N.A.C., Nadia, N., Kodjio, E., Kollins, L., Megwi, J.R., Kuiate., Mbida, M., 2018. Assessment of anticoccidial and Antioxidant Efficacy of Methanolic Extract of Pentaclethra macrophylla on Rabbits.Res. J. Vet. Sci. 11, 1-10.
Coudert, P., Licois, D., Drouet-Viard, F., 1995. *Eimeria* species and strains of rabbit, in J. Eckert, R. Braun, M.W. Shirley, P. Coudert (Eds.), COST. 89/820. Biotechnology: Guidelines on Techniques in Coccidiosis Research, Office for Official Publications of the European Communities, Luxembourg, pp. 52–73.
Drouet-Viard, F., Coudert, P., Licois, D., Boivin, M., 1997. Vaccination against *Eimeria magna* coccidiosis using spray dispersion of precocious line oocysts in the nest box. Vet. Parasitol. 70, 61-66.
Eckert, J., Taylor, M., Catchpole, J., Licois., D., Coudert P., Bucklar H., 1995. *Eimeria* species and strains of rabbit, in J. Eckert, R. Braun, M.W. Shirley, P. Coudert (Eds.), COST. 89/820. Biotechnology: Guidelines on Techniques in Coccidiosis Research, Office for Official Publications of the European Communities, Luxembourg, pp. 113-116.
El Banna, H.A., Atef, M., Ghazal, N., 2016. Anti-coccidial Activity of *Moringa oleifera* Plant Animal and Veterinary Sciences 4, 19-25.
Elbarbary, N.B., 2015. Advanced studies on *Eimeria* species of rabbits. Ph.D. Thesis, Department of Parasitology Faculty of Veterinary Medicine, Kafrelsheikh University.
Eladla, A.H., Mahgoubb, H.A., El-Shafeic, R.A., Al-Kappanyd, Y.M., 2020. Comparative effects of Herba Cox®, a commercial herbal extract, on rabbits (*Oryctolagus cuniculus*) experimentally infected with *Eimeria* stiedae Comparative Immunology, Microbiol. Infect. Dis. 68, 101378.
El-Sayed, N., Metwally, M.M.M., Ras, R., 2020. Prevalence and morphological identification of *Eimeria* spp. in the domestic rabbit (*Oryctolagus cuniculus*) in Sharkia province, Egypt. EVMPSJ 16, 114-130.
El-Ghoneimy, A., El-Shahawy, I., 2017. Evaluation of amprolium and toltrazuril efficacy in controlling natural intestinal rabbit coccidiosis. Iran J. Vet. Res. 18, 164–169
El-Shahawy, I., El-Ghoneimy, A., 2018. An Epidemiological Study on Endoparasites of Domestic Rabbits (*Oryctolagus cuniculus*) in Egypt with Special Reference to Their Health Impact. Sains Malaysiana 47, 9–18.
Flecknell, P., 2000. Manual of Rabbit Medicine and Surgery. Looker, Upton, Pole, Dorset, UK., pp. 43-45.
Fodouop, S.P.C., Gatsing, B.T., Tangue, R.S., Tagne, S.D., Tala, J., Tchoumboue, J., Kuiate, J.R., 2015. Effect of *Salmonella* typhimurium infection on the rat cell oxidation and in vivo antioxidant activity of Vitellaria paradoxa and Ludwigia abyssinica aqueous extract. Asian Pac. J. Trop. Dis. 5, 38-46.
Frederick, N., 2010. Effect of Moringa leaf meal (MOLM) nutrient digestibility, growth, carcass, and blood indices of weaner rabbits, B. SC. (HONS) AGRIC. (CAPE COAST).
Gad, H.A., Roberts, A., Hamzi, S.H., Touiss, I., Altyar, A.E., Kensara, O.A, Ashour, M.L., Jojoba, O., 2021. An updated comprehensive review on chemistry, pharmaceutical uses, and toxicity. Polymers 13, 1711.
Gibbons, P., Love, D., Craig, T., Budke, C., 2016. Efficacy of treatment of elevated coccidial oocyst counts in goats using amprolium versus ponazuril. Vet. Parasitol. 218, 1–4.
Hamid, P.H., Prastow, S., Kristianingrum, P.Y., 2019. Intestinal and hepatic coccidiosis among rabbits in Yogyakarta, Indonesia., Vet. World 12, 1256- 1260.
Hanada, S., Umemota, Y., Omata, Y., Koyama, T., Nishiyama, K., Kobayashi, Y., Furuoka, H., Matsui, T., Maeda, R., Saito, A., 2003. *Eimeria* stiedae Merozoites 49-KDa soluble antigen induces protection against infection. J. Parasitol. 89, 613-617.
Idris, M., Abbas, R.Z., Masood, S., Rehman, T., Farooq, U., Babar, W., 2017. The potential of antioxidant-rich essential oils against avian coccidiosis. Worlds Poult. Sci. J. 73, 89-104.
Jain, P.S., Patil, N., Haswani, M., Girase, S., Suran, S.J., 2010. Hypolipidemic activity of *Moringa oleifera* Lam., *Moringaceae*, on the high-fat diet, induced hyperlipidemia in albino rats. Brazilian Journal of Pharmacognosy 20, 969-973.
Kowalska, D., Bielanski, P., Nosel, P., Kowal, J., 2012. Natural alternatives to coccidiostats in rabbit nutrition. Annals of Animal Science 12, 561-574.
Kumar, A.A., 2012. review on hepatoprotective herbal drugs. Int. J. Res. Pharm.Chem., 2, 96-102.
Lashari, M.H., Tasleem, M.W., Rajpoot, S.R., Afzal, F., Shari M., Ahmad, M., 2021. Effect of *Moringa oleifera* Leaf Extract on Ethogram of Rabbit Does Annals of R.S.C.B. 25, 1130–1141.
Leone, A., Spada, A., Battezzati, A., Schiraldi, A., Aristil, J., Bertoli, S., 2015. Cultivation, genetics, ethnopharmacology, phytochemistry, and pharmacology of *Moringa oleifera* leave an overview. International Journal of Molecular Science 16, 12791-12835.
Li, H., Shen, M., Hou, Z., Yin, X., 2016. Morphology and Molecular Identification of the *Eimeria* spp. in Domestic Rabbits.Pakistan J. Zool.48, pp. 289-291.
Meskerem, A., Boonkaewwan, C., 2013. Protective Effects of Moringa stenopetala leaf supplemented Diets on *Eimeria tenella* Infected Broiler Chickens in Debre Zeit, Central, Ethiopia. Kasetsart J. (Nat. Sci.) 47, 398 – 406.
Mgbojikwe, A.C., Vihi, S.K., Olanihan, A.O., Okeke-Agulu, K.I., OKPARA, J.O., 2021. The evaluation of the anticoccidial properties of aqueous leaf extract of *Moringa oleifera*. Food Environ. Saf. 4, 371-379.
Mohammed, A.A., Iyeghe-Erakpotobor, G.T., Zahraddeen, D., Barje, P.P., Samuel, F.U., 2019. Growth and reproductive performance of rabbits fed *Moringa oleifera* leaf meal-based diet supplemented with garlic, ginger, or black pepper. J. Anim. Prod. Res. 31, 74-87.
Mona, H., Aya, A.A., 2013. Original articles effect of *Moringa oleifera* on serum lipids and kidney function of hyperlipidemic rats. J. Appl. Sci. Res. 15378127.
Mondal, D.K.S., Chattopadhyay, S., Batabyal, A.K., Bhattacharya, D., 2011. Plasma biochemical indices at various stages of infection with a field isolate of *Eimeria tenella* in broiler chicken. Vet. World 4, 404-409.
Naidoo, V., Mc Gaw, L.J., Bisschop, S.P.R., Duncan, N.J.N., Eloff., N., 2008. The value of plant extracts with antioxidant activity in attenuating coccidiosis in broiler chickens. J. Vet. Parasitol.. 153, 214-219.
Nazir, T., Shakir. L., Rahman, Z.U., Najam. K., Choudhary, A., Saeed. N, Rasheed H.U., Nazir, A., Aslam, S., Khanum, A.B., 2020. Hepatoprotective Activity of Foeniculum Vulgre Against Paracetamol Induced Hepatotoxicity in Rabbit. J. Appl. Pharm. 12, 1-6.
Nuhu, F., 2010. Effect of Moringa leaf meal (MOLM) on nutrient digestibility, growth, carcass and blood indices of weaner rabbits. Master thesis submitted to the School of graduate studies, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana.
Okumu, P.O., Gathumbi, P.K., Karanja, D.N., Mande, J.D., Wanyoike, M.M., Gachuiri, C.K., Kiarie, N., Mwanza, R.N., Borter, D.K., 2014. Prevalence, pathology, and risk factors for coccidiosis in domestic rabbits (*Oryctolagus cuniculus*) in selected regions in Kenya. Vet. Quart. 34, 205-210.
Ogolla, K.O, Okumu, P.O., Gathumbi, P.K., Waruiru, R.M., 2018. Effects of Anticoccidial Drugs on Gross and Histopathological Lesions Caused by Experimental Rabbit Coccidiosis. SOJ Vet. Sci. 4, 1-10.
Okerman, L., 1994. Diseases of domestic rabbits, Second Edition 1, Black well scientific publications. Oxford, UK.
Onyekwere, N.N., Felix, N.I., 2014. Phytochemical, Proximate and Mineral Composition of Leaf Extracts of *Moringa oleifera* Lam. from Nsukka, South-Eastern Nigeria. IOSR J. Pharm. Biol. Sci. 9, 99-103.
Oyedemi, S.O., Bradley, G., Afolayan, A.J., 2010. In-vitro and in–vivo antioxidant activities of aqueous extract of *Strychnos henningsii* Gilg. Afr. J. Pharm. Pharmacol. 4, 70-78.
Osunkeye, O.J., Akinduro, V.O., Adedire, A.O., Adewumi, A.A., Aluko, O.P., Omole, A.J., Oyedokun, A.J., 2022. Effect of *Moringa oleifera* Leave Meal on Digestibility and Haematological Parameters, and Health Status of Doe Rabbits. J. Appl. Sci. Environ. Manage. 26, 1075-1080.
Paliwal, R., Sharma, V., Prachita., A., 2011 . A Review on Horse Radish Tree (*Moringa oleifera*): A Multipurpose Tree with High Economic and Commercial ImportanceAsian J. Biotechnol. 3, 3017-3028.
Pakandl, M., 2009. Coccidia of rabbit: a review Folia Parasitologica 56, 153–166.
Raza, A., 2021. The ameliorative activity of *Moringa oleifera* on blood pa-

rameters of commercial broiler – Mini Review. Academic letters, Article 2709.

Reddy, V., Ahmed, F., Urooj, A., 2012. Inhibition of 3-Hydroxy-3-Methylglutaryl Coenzyme A (HMG Co-A) Reductase in Liver Microsomes by *Moringa oleifera* L. Polyphenols. IJPSR 3, 2510-2516.

Renaux, S., Quéré, P., Buzoni-Gatel, D., Sewald, B., Le Vern, Y., Coudert, P., Drouet-Viard, F., 2003. Dynamics and responsiveness of T-lymphocytes in secondary lymphoid organs of rabbits developing immunity to *Eimeria* intestinalis. Veterinary Parasitology 110, 181-195.

Ruiz, A., Muñoz, M. C., Molina, J. M., Hermosilla, C., Andrada, M., Lara, P., Taubert, A., 2014. Immunization with *Eimeria* ninakohlyakimovae-live attenuated oocysts protects goat kids from clinical coccidiosis. Veterinary Parasitology 199, 8–17.

Saeed, A.E., Shawky, M. Aboelhadid, El-Sayed, M.A., Shymaa A.H., Lilian, N.M., Eman, M.F., Usama, K.M., Asmaa, A., 2019. Prophylactic and Therapeutic Efficacy of Prebiotic Supplementation against Intestinal Coccidiosis in Rabbits. Animals J. 9, 965.

Sainsbury, D., 1984. System of management in "Poultry health and management". Ch.9 P. 102. In "Poultry health and management". 2nd Ed By Sainsbury. Granada Publishing Ltd., 8 Grafton Street, Landon WIX 3 LA.

Seddiek, S.A., Metwally, A.M., 2013. Anticoccidial activity of black cumin (*Nigella sative*) in rabbits, Assiut Vet. Med. J. 59, 85–96.

Shad, M., Xiang, S. P., 2019. Application of Moringa (*Moringa oleifera*) as Natural Feed Supplement in Poultry Diets. Animals J. 9, 431.

Sreelatha, S., Padma, P. R., 2009. Antioxidant activity and total phenolic content of *Moringa oleifera* leaves in two stages of maturity. Plant Foods Human Nutri. 64, 303-311.

Tang, S. G., Sieo, C., Ramasamy, K., Saad, W.Z., Wong, H.K., Ho, Y.W., 2017. performance, biochemical and hematological responses, and relative organ weights of laying hens fed diets supplemented with prebiotic, probiotic, and symbiotic. BMC Vet. Res.13, 248.

Tharwat, I., Islam. S, Ali, O., Kamal, M., Shimaa, A.A., Aziza, M.H., Nikolay, K., Walid, H., Ahmed, A. E., 2021. Impact of Fennel Essential Oil as an Antibiotic Alternative in Rabbit Diet on Antioxidant Enzymes Levels, Growth Performance, and Meat Quality. Antioxid. J. 10, 1797.

Wisniak, J., Potential., P., 1994. Uses of jojoba oil and meal-Areview. Ind. Crops Prod. 3, 43-68.

Vadlejch, J., Petrtyl, M., Lukešova, D., Čadkova, Z., Kudrnačova, M., Jankovska, I., Langrova, I., 2013. The concentration McMaster technique is suitable for the quantification of coccidia oocysts in bird droppings, Pak. Vet. J. 33, 291–295.

Vereecken, M., Lavazza A., De Gussem K., Chiari M., Tittarelli C., Zuffellato A., Maertens L. 2012. The activity of diclazuril against coccidiosis in growing rabbits: experimental and field experiences. World Rabbit Sci. 20, 223–230.

Yin, G., Goraya, M. U., Huang, J., Suo, X., Huang, Z., Liu, X., 2016. Survey of coccidial infection of rabbits in Sichuan Province, Southwest China. Springer Plus 5, 870.