Research Article

In Vitro Anthelmintic Activity of Crude Extracts of Artemisia herba-alba and Punica granatum against Haemonchus contortus

Aliyi Hassen Ahmed, Mebrat Ejo, Teka Feyera, Dereje Regassa, Bahar Mummed, and Solomon Assefa Huluka

1Department of Biomedical Sciences, College of Veterinary Medicine and Animal Science, University of Gondar, Ethiopia
2Animal Science, School of Environmental and Rural Science, University of New England, Armidale, NSW 2351, Australia
3College of Veterinary Medicine, Haramaya University, Ethiopia
4Department of Pharmacology and Clinical Pharmacy, School of Pharmacy, Addis Ababa University, Ethiopia

Correspondence should be addressed to Solomon Assefa Huluka; solomon.assefa@aau.edu.et

Received 21 August 2019; Accepted 2 December 2019; Published 27 January 2020

1. Introduction

Gastrointestinal nematodes (GINs) remain a major threat to the health and welfare of small ruminants throughout the world [1]. GINs represent a major economic hurdle in ruminant systems through mortality, weight loss, and reduced milk and meat production [2, 3]. In Ethiopia, a total loss of US $81.8 million is reported annually due to helminth parasites [4].

Haemonchus contortus is an important abomasal helminth of small ruminants responsible for disease and major production losses worldwide [5]. Moreover, it is one of the major livestock parasites in tropical and temperate farming areas [6]. Compared to other nematodes, H. contortus is a highly pathogenic parasite of small ruminants and is capable of causing acute disease and high mortality in all classes of stock [7]. Heavy burdens of this blood-feeding parasite can cause severe anemia and rapid death in affected livestock [5]. It was reported to be one of the top ten constraints of sheep and goat production in East Africa [7].

GIN control has an important role to play in improving livestock production from a limited natural resource base and to improve animal health and welfare [8]. Synthetic anthelmintic agents are commonly employed to control
2. Materials and Methods

2.1. Collection of Plant Samples. Based on a preliminary interview conducted among livestock raisers of Midaga-Tola district, two plants (A. herba-alba and P. granatum) were selected. These plants were commonly used as anthelmintic agents in Ethiopian folkloric medicine. Therefore, fresh flower and aerial parts (stem and leaves) of A. herba-alba and peel and root parts of P. granatum were collected from their natural habitat around Midaga-Tola district, East Hararghe zone, 582 km away from Addis Ababa. Herbal identification of the collected plants was then made by a taxonomist at the herbarium of Plant Science Department, Haramaya University, where a voucher specimen (AH001/17 for A. herba-alba and AH002/17 P. granatum) were deposited for future references.

2.2. Plant Extract Preparation. The collected plant materials were cleaned, shade dried, mechanically ground, and coarsely powdered using a laboratory mortar and pestle. Then, the powdered specimens were subjected to a cold maceration technique using the methanol solvent system for 72 hr. For each sample, a total of 250 g of the coarsely powdered plant materials was separately soaked in the extraction solvent (1:10). The extraction process was facilitated using a mechanical shaker at 120 rpm. The same volume of solvent was used to remacerate the residue for another 72 hr, twice. Finally, the filtrates were recombined and concentrated on rotavapor (Buchi, Switzerland) at 40°C under reduced pressure. Moreover, the concentrated filtrate was freeze-dried in a lyophilizer to earn a dried extract.

The dried extract was weighed and provided a percent yield of 14.3% (w/w) and 12.5% (w/w) for the flower and aerial parts of A. herba-alba, respectively. Extract from the peel and root of P. granatum, on the other hand, yielded 13% (w/w) and 9.4% (w/w), respectively. The resulting extracts were transferred into well-labeled vials and kept in a refrigerator until required for use.

2.3. Phytochemical Screening. All extracts were screened for the presence and absence of different phytochemicals. Standard screening tests using conventional protocol, procedure, and reagents were conducted to identify the constituents as described in Trease and Evans [17] and Sofowora [18].

2.4. Biological Assay

2.4.1. Collection of Parasites. Adult parasites of H. contortus were collected from the abomasum of a sheep obtained from Haramaya municipal abattoir. The abomasum was collected immediately after slaughtering and transported to Veterinary Parasitology laboratory of Haramaya University. In the laboratory, abomasum was washed by running water and worms were then isolated by incising the greater curvature of the abomasum and the parasites were kept in phosphate buffer saline (PBS) until the in vitro evaluation was started. The female worms were then ground using a mortar and pestle to liberate the eggs.

2.4.2. Adult Motility Assay (AMA). A total of about 368 adult H. contortus parasites were used to assess the anthelmintic effect of extracts against mature H. contortus worms on adult motility assay (AMA), according to the technique described by Sharma et al. [19]. Each plant extract was tested on different concentrations (10, 5, 2.5, and 1.25 mg/mL) prepared in PBS.

The assay was conducted in six groups. Group I and Group II received crude methanol extract from the aerial and flower parts of A. herba-alba, respectively. Group III was treated with crude methanol extract of P. granatum peel part while Group IV received the methanol extract of P. granatum root part. Group V and V1 received 0.25 mg/mL of albendazole (positive control) and PBS (negative control), respectively.

Inhibition of motility was taken as an indication of worm mortality/paralysis. To assess the motility inhibition effect of the extracts, the observations were taken at regular time intervals until the 7th hour after treatment. Worms not showing any motility were taken out and placed in lukewarm PBS for 10 minutes and, in case of revival in motility, the observed worms were counted as alive; otherwise, they were counted as dead.

2.4.3. Egg Hatch Inhibition Assay (EHIA). The ability of the extracts to inhibit egg hatching was conducted according to the procedure described by Coles et al. [20]. Eggs were washed thrice with distilled water and adjusted to a concentration of 100-200 eggs/mL using the McMaster technique [21]. The suspension was centrifuged for 5 minutes at 1500 rpm and the supernatant was discarded. Approximately, 100 eggs in 200 μL of distilled water were pipetted into each well of a 48-well microtiter plate. To each of the test wells, 200 μL of each plant extract at concentrations of 0.1, 0.25, 0.5, and 1 mg/mL was added to a final volume of 400 μL per well. Similarly, 200 μL of albendazole (99.8% pure standard reference) at a concentration of 0.25 mg/mL was
used as a positive control, while distilled water (200 μL) was used as a negative control. The experiment was conducted in duplicates for each concentration and replicated three times. In this assay, all plates were incubated at 37 °C for 48 hr. A drop of Lugol’s iodine solution was added to each well to stop further hatching, and all the unhatched eggs and L1 larvae in each well were counted under a dissecting microscope. Finally, percent inhibition of egg hatching was calculated:

$$\text{Percent inhibition} = 100 \left( 1 - \frac{P_{\text{test}}}{P_{\text{control}}} \right)$$

where $P_{\text{test}}$ = number of eggs hatched in EHIA.

2.4.4. Data Analysis. Data were organized, edited, and analyzed using SPSS Version 20. Results generated from both assays were analyzed with one-way ANOVA followed by Tukey’s HSD multiple comparison. $p$ value of less than 0.05 was considered statistically significant.

3. Results

3.1. Phytochemical Screening. The preliminary phytochemical screening of the plant materials revealed the presence of alkaloids, saponins, flavonoids, tannins, glycosides, and phenols in all of the tested extracts (Table 1). Moreover, the strong presence of alkaloids, tannins, flavonoids, glycosides, and phenols were detected from the root crude extract of $P$. granatum.

3.2. Adult Motility Test. The present study indicated that all concentrations of methanolic flower and aerial part extracts of $A$. herba-alba as well as the highest concentration of methanolic peel extract of $P$. granatum produced a relatively comparable anthelmintic activity with the conventional anthelmintic agent, albendazole (Figure 1). The anthelmintic activity of plant extracts increased with time. Accordingly, after 7 hr exposure of adult $H$. contortus to the highest concentration (10 mg/mL) of extracts, both plants produced a significant ($p < 0.05$) mortality of adult $H$. contortus. Albendazole, on the other hand, killed all parasites within 5 hr at a concentration of 0.25 mg/mL (Table 2).

3.3. Egg Hatching Inhibition Assay. Both $A$. herba-alba (flower and aerial extract) and $P$. granatum (peel and root extract) induced a significant egg hatching inhibition effect in a concentration-dependent manner. Flower and aerial part methanolic extract of $A$. herba-alba exhibited a 98.67% and 88.3% inhibition, respectively, at 1 mg/mL concentration.

### Table 1: Phytochemical constituents of investigated plant extracts.

| Extracts | Phytochemicals |
|----------|----------------|
|          | Alkaloid | Saponin | Tannins | Flavonoids | Glycosides | Sterols | Phenol |
| $A$. herba-alba | | | | | | | |
| Flower part | +++ | ++ | +++ | ++ | + | - | +++ |
| Aerial part | ++ | ++ | + | ++ | ++ | - | ++ |
| $P$. granatum | | | | | | | |
| Peel part | ++ | ++ | + | ++ | +++ | - | ++ |
| Root part | +++ | + | +++ | +++ | +++ | - | +++ |

Key: +++ = strongly detected, ++ = moderately detected, + = slightly detected, and - = absent.

![Figure 1: Relative nematocidal efficacy of graded concentration of crude extracts of $A$. herba-alba and $P$. granatum. AHAF: $A$. herba-alba flower part, AHAA: $A$. herba-alba aerial part, PGP: $P$. granatum peel part, PGR: $P$. granatum root part, Alb: albendazole, PBS: phosphate buffer saline.](image-url)
Table 2: *In vitro* nematocidal effect of crude extracts of different parts of *A. herba-alba* and *P. granatum* against *H. contortus*.

| Treatment                  | Concentration (mg/mL) | 1 hr  | 2 hr  | 3 hr  | 4 hr  | 5 hr  | 6 hr  | 7 hr  |
|----------------------------|-----------------------|-------|-------|-------|-------|-------|-------|-------|
| *A. herba alba* flower     | 10                    | 4.00 ± 0.58<sup>def</sup> | 5.00 ± 0.88<sup>def</sup> | 6.33 ± 0.88<sup>efa</sup> | 7.67 ± 0.67<sup>efa</sup> | 8.67 ± 0.67<sup>efa</sup> | 9.33 ± 0.33<sup>efa</sup> | 10.00 ± 0.00<sup>efa</sup> |
|                           | 5                     | 3.00 ± 0.58  | 4.67 ± 0.33  | 6.00 ± 0.33  | 7.33 ± 0.67  | 8.33 ± 0.33  | 9.33 ± 0.33  | 10.00 ± 0.00  |
|                           | 2.5                   | 2.33 ± 0.33  | 3.67 ± 0.33  | 5.33 ± 0.33  | 6.67 ± 0.33  | 8.00 ± 0.00  | 9.67 ± 0.33  | 10.00 ± 0.00  |
|                           | 1.25                  | 1.33 ± 0.33<sup>cde</sup> | 3.33 ± 0.33<sup>cde</sup> | 5.33 ± 0.33<sup>cde</sup> | 6.67 ± 0.33<sup>cde</sup> | 8.33 ± 0.33<sup>cde</sup> | 9.67 ± 0.33<sup>cde</sup> | 10.00 ± 0.00<sup>cde</sup> |
| *A. herba alba* aerial part| 10                    | 4.00 ± 0.58<sup>de</sup> | 5.67 ± 0.33<sup>de</sup> | 6.67 ± 0.33<sup>ef</sup> | 7.67 ± 0.33<sup>ef</sup> | 8.67 ± 0.33<sup>ef</sup> | 9.67 ± 0.33<sup>ef</sup> | 10.00 ± 0.00<sup>ef</sup> |
|                           | 5                     | 2.00 ± 0.58  | 3.33 ± 0.33  | 4.67 ± 0.33  | 6.00 ± 0.58  | 7.33 ± 0.33  | 9.00 ± 0.00  | 10.00 ± 0.00  |
|                           | 2.5                   | 1.67 ± 0.33  | 3.33 ± 0.33  | 4.67 ± 0.33  | 6.33 ± 0.67  | 8.33 ± 0.33  | 9.33 ± 0.33  | 10.00 ± 0.00  |
|                           | 1.25                  | 1.33 ± 0.33<sup>cde</sup> | 2.67 ± 0.33<sup>cde</sup> | 4.00 ± 0.58<sup>cde</sup> | 5.00 ± 0.58<sup>cde</sup> | 7.00 ± 0.58<sup>cde</sup> | 8.67 ± 0.33<sup>cde</sup> | 10.00 ± 0.00<sup>cde</sup> |
| *P. granatum* peel part    | 10                    | 4.33 ± 0.33<sup>cde</sup> | 5.67 ± 0.33<sup>cde</sup> | 6.67 ± 0.33<sup>cde</sup> | 7.67 ± 0.33<sup>cde</sup> | 8.67 ± 0.33<sup>cde</sup> | 9.67 ± 0.33<sup>cde</sup> | 10.00 ± 0.00<sup>cde</sup> |
|                           | 5                     | 2.00 ± 0.58  | 3.00 ± 0.58  | 4.00 ± 0.58  | 5.00 ± 0.58  | 6.00 ± 0.58  | 7.67 ± 0.33  | 9.00 ± 0.58  |
|                           | 2.5                   | 1.33 ± 0.33  | 2.00 ± 0.58  | 3.67 ± 0.88  | 4.67 ± 0.9   | 6.00 ± 0.58  | 7.33 ± 0.33  | 8.67 ± 0.33  |
|                           | 1.25                  | 0.33 ± 0.33<sup>cde</sup> | 1.00 ± 0.58<sup>cde</sup> | 2.00 ± 0.58<sup>cde</sup> | 4.00 ± 0.58<sup>cde</sup> | 5.00 ± 0.58<sup>cde</sup> | 6.67 ± 0.33<sup>cde</sup> | 7.67 ± 0.33<sup>cde</sup> |
| *P. granatum* root part    | 10                    | 3.00 ± 0.58<sup>cde</sup> | 4.00 ± 0.58<sup>cde</sup> | 5.00 ± 0.58<sup>cde</sup> | 6.00 ± 0.58<sup>cde</sup> | 7.00 ± 0.58<sup>cde</sup> | 8.00 ± 0.58<sup>cde</sup> | 9.00 ± 0.58<sup>cde</sup> |
|                           | 5                     | 1.00 ± 0.58  | 2.00 ± 0.58  | 3.00 ± 0.58  | 4.33 ± 0.67  | 5.33 ± 0.67  | 6.33 ± 0.67  | 7.33 ± 0.67  |
|                           | 2.5                   | 0.33 ± 0.33  | 1.33 ± 0.33  | 2.67 ± 0.33  | 3.67 ± 0.33  | 5.00 ± 0.00  | 6.33 ± 0.33  | 7.33 ± 0.33  |
|                           | 1.25                  | 0.00 ± 0.00<sup>cde</sup> | 1.00 ± 0.58<sup>cde</sup> | 2.00 ± 0.58<sup>cde</sup> | 3.67 ± 0.68<sup>cde</sup> | 4.67 ± 0.68<sup>cde</sup> | 6.00 ± 0.58<sup>cde</sup> | 7.00 ± 0.58<sup>cde</sup> |
| Albenazole                | 0.25                  | 4.00 ± 0.58<sup>cde</sup> | 5.67 ± 0.33<sup>cde</sup> | 8.33 ± 0.33<sup>cde</sup> | 9.67 ± 0.00<sup>cde</sup> | 10.00 ± 0.00<sup>cde</sup> | 10.00 ± 0.00<sup>cde</sup> | 10.00 ± 0.00<sup>cde</sup> |
| PBS                       | 0.00 ± 0.00          | 0.00 ± 0.00<sup>cde</sup> | 0.00 ± 0.00<sup>cde</sup> | 0.00 ± 0.00<sup>cde</sup> | 0.00 ± 0.00<sup>cde</sup> | 0.00 ± 0.00<sup>cde</sup> | 0.00 ± 0.00<sup>cde</sup> | 0.00 ± 0.00<sup>cde</sup> |
Furthermore, the egg hatch inhibitory efficacy profile of *P. granatum* extracts, as percentage of eggs unhatched at the end of the observation period, is as follows; 49.33 and 46.33% at concentration 0.1 mg/mL, 60.67 and 54.33 at 0.25 mg/mL, 72.67 and 68.33 at 0.5 mg/L, and 94.63 and 90.33 at 1 mg/mL concentration of peel and root crude extracts, respectively (Figure 2).

Values are mean ± SEM. All superscripts indicate significance at $p < 0.05$, compared to untreated (PBS), compared to albendazole, and compared to the lowest concentration of methanolic extract of *A. herba-alba* flower, and compared to the lowest concentration of methanolic extracts of *A. herba-alba* aerial part, compared to the lowest concentration of methanolic extract of *P. granatum* peel part, and compared to the lowest concentration of methanolic extract of *P. granatum* root.

4. Discussion

The emergence of resistant strains, the presence of anthelmintic drug residues in animal products, and synthetic drugs’ toxicity have led to a rebirth of interest in the use of natural products [22]. Plant materials tested for their in vitro anthelmintic activity in the present study have been identified by local livestock raisers. In vitro techniques such as the AMA and EHIA are preferred to in vivo methods due to their low cost, simplicity, and rapid turnover [23]. Moreover, for in vitro studies, *H. contortus* is proved to be a good test worm because of its longer survival in PBS. This abomasal helminth has recently been used for in vitro studies by other workers [23, 24].

In the current in vitro study, 10 mg/mL concentration of methanol peel extract of *P. granatum* produced a statistically significant anthelmintic activity that is comparable with the conventional anthelmintic agent, albendazole. This finding is additionally in line with the clinical study that confirmed the efficacy of the plant against nematodes in calves [25] and superior to an in vitro study that reported a moderate level of anthelmintic activity from the rind of *P. granatum* [26]. Moreover, similar to a study done by Prakash et al. [27] on the alcoholic extract of *P. granatum*, our study showed a significant anthelmintic activity of the plant as revealed by a concentration-dependent inhibition of transformation of eggs to the larva of *H. contortus*.

Some previous works similarly indicated that *P. granatum* has a marked effect on cestode and nematodes [28] as well as protozoan infections [29]. Moreover, our study substantiated a previous report on the traditional application of *P. granatum* plant, in which various parts of the plant can be used as a traditional anthelmintic agent [30, 31].

The plant, *A. herba-alba*, is mainly used as an anthelmintic agent in traditional practice [10]. Concordant with this, in EHIA of the present study, flower part methanol extract of *A. herba-alba* induced a significant egg hatching inhibition of 98.67%, at 1 mg/mL concentration. This is in line with a study done by Boonmasawai et al. [11] in which shoot parts are used as an anthelmintic in *H. contortus* infestation of sheep as the result of its santonin. The result exhibited by the plant in AMA, moreover, is in agreement with a previously reported activity of a plant in the same genus, *A. absinthium*, which significantly affected motility and viability of *H. contortus*, in vitro [32]. Furthermore, the genus is a rich source of sesquiterpene lactones and flavonoids that might have anthelmintic activity with low risk of mammalian toxicity [33].

The exhibited anthelmintic effect of the two plants might be attributed to the existing secondary metabolites. Joshi et al. [34] assimilated that tannins may exert anthelmintic activity by reducing hatching, blocking its development to the infective larval stage and decrease in adults’ motility. Besides, tannins have been shown to interfere with coupled oxidative phosphorylation and block ATP synthesis in *H.
contortus [35]. Wang et al. [36] has confirmed the anthelmintic efficacy of plant-based alkaloids. The environmental stimuli on the host lead to the release of enzymes by larvae, which degrade the egg membrane [37]. The action of alkaloids in these two plants might be linked to the inhibition of these enzymes' activity.

Once a plant has proven its efficiency in vitro, further in vivo testing will be necessary to confirm the obtained results and evaluate risks, side effects, and future applicability [38]. Therefore, in vivo anthelmintic evaluation of these plants is imperative prior to their clinical use.

5. Conclusion

The in vitro anthelmintic activity of tested plants is characterized by a decrease in hatching and reduced motility of the larvae and adult stage of H. contortus. Accordingly, they have the potential to contribute in controlling gastrointestinal parasites of ruminants. Therefore, fractionation of the crude extracts and isolation of compounds to further evaluate the anthelmintic efficacy of these plants involving other parasite developmental stages are warranted.

Acknowledgments

The authors are grateful to the University of Gondar and Haramaya University for providing financial support and laboratory facilities, respectively.

References

[1] G. Stepek, J. M. Behnke, D. J. Buttle, and I. R. Duce, "Natural plant cysteine proteinases as anthelmintics?,” Trends in Parasitology, vol. 20, no. 7, pp. 322–327, 2004.
[2] C. M. Diaz-Lira, T. N. Barry, W. Pomroy, E. L. McWilliam, and N. Lopez-Villalobos, "Willow (Salix spp.) fodder blocks for growth and sustainable management of internal parasites in grazing lambs," Animal Feed Science and Technology, vol. 141, no. 1-2, pp. 61–81, 2008.
[3] J. D. Githiori, J. Hoglund, P. J. Waller, and R. L. Baker, “The anthelmintic efficacy of the plant, Albizia anthelmintica, against the nematode parasites Haemonchus contortus of sheep and Heligmosomoides polygyrus of mice,” Veterinary Parasitology, vol. 116, no. 1, pp. 23–34, 2003.
[4] H. Hoste, F. Jackson, S. Athanasiadou, T. Stig Milan, and H. O. Simone, “The effects of tannin-rich plants on parasitic nematodes in ruminants,” Trends in Parasitology, vol. 22, no. 6, pp. 253–261, 2006.
[5] D. L. Emery, P. W. Hunt, and L. F. Le Jambre, "Haemonchus contortus: the then and now, and where to from here?," International Journal for Parasitology, vol. 46, no. 12, pp. 755–769, 2016.
[6] B. D. Perry, T. F. Randolph, J. J. McDermott, K. R. Sones, and P. K. Thornton, Investing in Animal Health Research to Alleviate Poverty, ILRI (International Livestock Research Institute), Nairobi, Kenya, 2002.
[7] B. Demelash, J. Yilma, and C. Hassen, “Ovine helminthiosis, a major health constraint to productivity of sheep in Ethiopia,” Animal Health Research Reviews, vol. 7, no. ½, pp. 107–118, 2006.
[8] J. Charlier, S. M. Thamsborg, D. J. Bartley et al., “Mind the gaps in research on the control of gastrointestinal nematodes of farmed ruminants and pigs,” Transboundary and Emerging Diseases, vol. 65, no. 1, pp. 217–234, 2018.
[9] M. B. Molento, F. Fortes, D. Pondelek et al., “Challenges of nematode control in ruminants: focus on Latin America,” Veterinary Parasitology, vol. 180, no. 1-2, pp. 126–132, 2011.
[10] J. F. J. Torres-Acosta, M. Molento, and P. M. Gives, “Research and implementation of novel approaches for the control of nematode parasites in Latin America and the Caribbean: is there sufficient incentive for a greater extension effort?,” Veterinary Parasitology, vol. 186, no. 1-2, pp. 132–142, 2012.
[11] S. Boonmasawai, S. Sungpradit, C. Jirapatharastate, L. Piasai, and C. Nakthong, "Effects of alcoholic extract from pomegranate (Punica granatum L.) peels on gastrointestinal nematode egg counts in doe," Journal of Applied Animal Science, vol. 6, pp. 27–37, 2013.
[12] B. Abu-Irmailehand and F. Afifi, "Herbal medicine in Jordan with special emphasis on commonly used herbs," Journal of Ethnopharmacology, vol. 89, no. 2-3, pp. 193–197, 2003.
[13] U. E. Idris, S. E. Adam, and G. Tartour, “The anthelmintic efficacy of Artemisia herba-alba against Haemonchus contortus infection in goats,” National Institute of Animal Health Quarterly, vol. 22, no. 3, pp. 138–143, 1982.

Abbreviations

AMA: Adult motility assay
ATP: Adenosine triphosphate
EHIA: Egg hatch inhibition assay
GINs: Gastrointestinal nematodes
PBS: Phosphate buffer saline.

Data Availability

Upon reasonable request, the supporting dataset are available from the corresponding author. Moreover, the dried specimens of tested plants and their voucher numbers are deposited in the herbarium of Haramaya University.

Ethical Approval

This research work was approved by the research and ethics committee of Haramaya University, Ethiopia.

Conflicts of Interest

The authors declare that they do not face any conflicts of interest in this article.

Authors’ Contributions

Aliyi Hassen Ahmed, Mebrat Ejo, and Teka Feyera conceived the study. Plant materials were collected by Aliyi Hassen Ahmed. All experiments were designed by Dereje Regassa, Bahar Mummed, and Aliyi Hassen. Aliyi Hassen Ahmed carried out all the experiments. Data analysis was carried out by Mebrat Ejo, Teka Feyera, Solomon Assefa Huluka, Dereje Regassa, and Bahar Mummed. The manuscript was prepared by Solomon Assefa Huluka and Teka Feyera. All authors read and approved the final manuscript.
M. R. Amin, M. Mostofa, M. E. Hoque, and M. A. Sayed, “In vitro anthelmintic efficacy of some indigenous medicinal plants against gastrointestinal nematodes of cattle,” Journal of the Bangladesh Agricultural University, vol. 7, no. 1, pp. 57–61, 2009.

A. Shabbir, M. Shahzad, and Y. Arfat, “Berberis lycium Royle: a review of its traditional uses, phytochemistry and pharmacology,” African Journal of Pharmacy and Pharmacology, vol. 6, no. 31, pp. 2346–2353, 2012.

T. Mekonen, M. Giday, and E. Kelbessa, “Ethnobotanical study of homegardens in the region of Ethiopia to assess use, species diversity and management practices,” Journal of Ethnobiology and Ethnomedicine, vol. 11, no. 1, p. 64, 2015.

G. E. Trease and W. C. Evans, Pharmacognosy, Bailliere Tindall, London, UK, 13th edition, 1989.

A. Sofowora, Medicinal Plants and Traditional Medicine in Africa, Spectrum Books Ltd, Ibadan, Nigeria, 1993.

L. D. Sharma, H. S. Bahga, and P. S. Srivastava, “In vitro anthelmintic screening of indigenous medicinal plants against Haemonchus contortus (Rudolphi, 1803) Cobbold, 1898 of sheep and goats,” Indian Journal of Animal Research, vol. 5, pp. 33–38, 1971.

G. C. Coles, C. Bauer, F. H. M. Borgsteede et al., “World Association for the Advancement of Veterinary Parasitology (W.A.A.V.P.) methods for the detection of anthelmintic resistance in nematodes of veterinary importance,” Veterinary Parasitology, vol. 44, no. 1-2, pp. 35–44, 1992.

F. J. Soulsby, Helminth; Arthropods and Protozoa of Domesticated Animals, Bailliere Tindall, London, UK, 7th edition, 1982.

A. Asase, A. A. Oteng-Yeboah, G. T. Odamtten, and M. S. Simmonds, “Ethnobotanical study of some Ghanaian antimalarial plants,” Journal of Ethnopharmacology, vol. 99, no. 2, pp. 273–279, 2005.

X. De Jesús-Martínez, A. Olmedo-Juárez, J. Olivares-Pérez et al., “In vitro anthelmintic activity of methanolic extract from Caesalpinia coriaria J. Wild fruits against Haemonchus contortus eggs and infective larvae,” BioMed Research International, vol. 2018, Article ID 7375693, 6 pages, 2018.

S. Zenebe, T. Feyera, and S. Assefa, “In vitro anthelmintic activity of crude extracts of aerial parts of Cissus quadrangularis L. and leaves of Schinus molle L. against Haemonchus contortus,” BioMed Research International, vol. 2017, Article ID 1905987, 6 pages, 2017.

M. S. Akhtar, Z. Iqbal, M. N. Khan, and M. Lateef, “Anthelmintic activity of medicinal plants with particular reference to their use in animals in the Indo-Pakistan subcontinent,” Small Ruminant Research, vol. 38, no. 2, pp. 99–107, 2000.

V. K. Dixit and K. C. Varma, “Anthelmintic properties of essential oils from rhizomes of Hedychium coronarium Koe nig and Hedychium spicatum Koenig,” Indian Journal of Pharmacology, vol. 37, pp. 143-144, 1975.

V. Prakash, K. C. Singhal, and R. R. Gupta, “Anthelmintic activity of Punica granatum and Artemisia silversiana,” Indian Journal of Pharmacology, vol. 12, p. 62, 1980.

F. Abdel-Ghaffar, M. Semmler, K. A. Al-Rasheid et al., “The effects of different plant extracts on intestinal cestodes and on nematodes,” Parasitology Research, vol. 108, no. 4, pp. 979–984, 2011.