A review of the effect of medicinal plant on helminthic infections

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Abstract

Nowadays, parasitic worm infection is one of the most critical global health problems. Worm infections cause severe detriments to the livestock industry and also it can cause irreparable damages to immunocompromised persons. Therefore, the present study aimed to review conducted research on the treatment of worm diseases using medicinal plants’ extract. In this systematic review, seven databases including 4 English (Scopus, PubMed, ScienceDirect, Google Scholar) and 3 Persian databases (Magiran, ISC, SID) were obtained between 2008 and 2020 to evaluate conducted studies related to the aim of the current review. Most of the studies focused on the Balanites aegyptiaca and Carica papaya plant. Water was the most common solvent (38.1%) and then it was methanol. The most studied parasite was Haemonchus contortus (35.5%), followed by Aacharidia galli (10.5%). Studies showed that plant extracts could reduce effect of worm infections in the host compared to synthetic drugs. Plant extracts can produce a medicine based on natural compounds and effective on worms with fewer side effects than synthetic drugs.

Introduction

One of the most critical health problems is parasitic worm infection that negatively affects third-world countries’ social, health, and economic conditions. Serious detriments have caused worm infections to the livestock industry with symptoms such as weight loss, decreased milk, meat, and wool production. Most importantly, these infections can also cause irreparable damages to immunocompromised individuals.² Today, various anthelmintics used to control worm infections have significant benefits in reducing worm load. However, these medicines’ efficiency has been decreased due to medicinal resistance.³-⁴ Because of the continuous use of anthelmintic. Interest in medicinal plants or their compounds in modern research against worm infection is increasing due to inaccessible and expensive synthetic drugs. Traditional medicines can be used as effective anti-worm treatment in many human and livestock populations because of easy access and appropriate effect. Within this framework, medicinal plants and herbal derivatives have been used as anti-worm treatments over the years by people.⁴ The appropriate anthelmintic should have an available range and clinical therapeutic ability, including being taken as a single dose, no toxicity in the host, and low cost. Currently, none of the synthetic drugs have such properties. Side effects of synthetic drugs include nausea, digestive disorders, and dizziness.⁶ According to the World Health Organization, 60% of developing countries still do not have anthelmintic medicines.⁷ In developing countries, people still depend on different herbal remedies to treat worm infections, and herbal medicines and traditional treatments are the sources of health care to treat various diseases such as intestinal worm infection in these areas.⁸ Thus, herbal remedies can provide an alternative to synthetic anthelmintic drugs and have fewer side effects and more efficacy than synthetic drugs; this indicates medicinal plant-based products to treat patients infected with worm infections.⁹ Due to the increasing trend of patients with immunodeficiency worldwide, it seems necessary to screen them for infection with Strongyloides stercoralis and produce new medicines to treat such patients.⁹ Several studies on worm models such as Pheritima posthuma,¹⁰ Acharidia galli¹¹ due to physiological and anatomical resemblance with human intestin-
al nematodes and treatment with medicinal plants have been done. Therefore, it seems necessary to use medicinal plants in the prevention and emergence of new therapeutic approaches due to worm infection treatment. The present study aimed to investigate the research conducted to treat worm disease using medicinal plant extracts.

**Material and Methods**

**Searching databases**
In this study, search for resources in 7 databases including 4 English databases (Scopus, PubMed, Science Direct, Google scholar) And 3 Persian databases (scientific information database or SID, Magiran, and ISC) through the years of 2018 - 2020 and in Persian and English, to review the studies about the purpose of the present study. The combination of the words “Herbal medicine,” “Extract,” “In vitro,” “In vivo,” and “Parasitic helminths” were used to search.

**Review and entry of studies**
Studies in which the effect of a plant extract or its derivatives on one or more parasitic worms was measured were selected. First, analyses were recorded in Mendele software version 7, and duplicate tasks were eliminated. Two independent authors then reviewed abstracts, and related articles were selected. The same two authors carefully read the selected studies, and the cases that met the inclusion criteria were added to the survey. Other studies were excluded from the study due to deficiencies in the required information, lack of access to the full text, non-compliance of methods with the results, and misinterpretation of the products. How studies were selected is shown in Figure 1.

**Data extraction and analysis**
Two independent authors extracted the required information from the selected articles and, if necessary, the difference between the two was resolved by the other author.

**Results**
Out of 3431 articles selected in the searching phase, 76 of them were eligible for inclusion in the study. The results of this review study showed that most studies were focused on *Balantites aegyptiacus* and *Carica papaya*. Water (38.1%) and then Methanol (36.8%) were the most used solvents in extraction. *Haemonchus contortus* (35.5%) and then *Aacharidia galli* (10.5%) were the most studied parasites. The extracted information is given in Table 1.

**Discussion**
Recently, special attention has been paid to modern therapies using herbs to treat various diseases like parasitic infections. Numerous studies have been performed on anthelmintic and anti-protozoal effects of different plant extracts *in vitro* and *in vivo* conditions.12-15 The present study examines the constant use of herbs, searching for new herbs, and their further production and effects and mechanisms of various extracts of herbs to replace with standard synthetic drugs.

**Using herbs is a treatment for Haemonchus contortus**
A gastrointestinal parasite that causes Haemonchosis disease. This parasite is found in the abomasum of goats and sheep. Economic losses resulting from Haemonchosis in tropical and subtropical areas often cause mortality and a reduction in livestock production and growth.16 A study by Sambodo et al. showed that the crude aqueous extract of *Biophytum petersianum* has proper anathematic properties against *Haemonchus contortus*. In this study, a 10% concentration of this plant’s aqueous extract in the 2-4 hours caused 100% death of worms. Also, in reviews using a scanning electron microscope (SEM), changes in the structure of worms like cuticle destruction, cervical protrusions loss, anterior part destruction, and posterior part shrinkage of the parasite in the 10% concentration of the aqueous extract of this plant were observed.17 Von Son - de Fernex et al. showed antiparasitic properties of the tropical plants *Cratylia argentea*, *C. argentea veranda*, *Arachis pintoi*, *Gliricidia sepium*, and *Yacapani* against *Haemonchus contortus*. In this study, a concentration of 1,200 µg/mL of these plants’ extract inhibited the molting and migration process of *Haemonchus contortus* larvae.18 Also, effects of the aqueous extract of *Annona* leaf was studied against *Haemonchus contortus* in eggs, larvae, and adult stages in vitro environment that showed a high concentration of *A. muricata* extract affected Egg Hatching Test (EHT) and larval motility assay test (LMT) by 84.91% and 89.08%, respectively, which was related to Phenolic compounds in the plant.19 A study of Castaneda Ramirez et al. examined *Acacia pennatula* vessels’ role in Larval Escheatment Inhibition Assay test (LEILA). In this study, it was found that the less the age of the larval stage of *Haemonchus contortus* (L3) is, the less concentration of *Acacia pennatula* extract is required to inhibit escheatment; so 100 µg/mL in the first week and 200 µg/mL in the fifth week were efficient.20 Using *Piper tuberculatum* and *Hura crepitans* extracts at EHT=9 affected Larval Development test (LD), *Lippia sidoides* had the best effect on EHT and LDT stage in inhibiting *Haemonchus contortus* larva growth.21

![Figure 1. Flow chart of selection of relevant publications](image-url)
### Table 1. Extracted data from studies.

| Plant name                                      | Solvent         | Parasite name          | In vivo / in vitro | Results                                                                 | Reference |
|------------------------------------------------|-----------------|------------------------|--------------------|--------------------------------------------------------------------------|-----------|
| Annona squamosa (L.)                                           | water           | Nematodes in goats     | In vivo            | Revealed no reductions on day 10 post-infection in animals treated with herbal extracts. | [50]      |
| Myrotheca africana (Kerri)                                   | Hydroalcoholic  | Haemonchus contortus   | In vivo            | 80% of Hydroalcoholic extracts of M. Africana exhibited larvicidal activity. The LC50 was 217.77 microgram per milliliter. The lethal dose (LD50) of the plant extract was beyond 200mg/kg of body weight. | [51]      |
| Mitragyna inermis (Willd.) Karre                           | Powder of leaves| Haemonchus contortus   | In vivo            | The powder of M. inermis leaves (> 80%) significantly reduced (p < 0.01) fecal egg counts in the three breeds of lambs. | [52]      |
| Myristica esmerinata/unbd./Zing Hu                      | Methanol        | Haemotoma posthuma     | In vivo            | Peak activity was exhibited by the methanolic extract at a concentration of 50ug/ml. | [53]      |
| Ferula asafoetida (H.Karst.) Allium sativum L.            | Hydroalcoholic  | Strongyloides spp.     | In vivo            | Hydroalcoholic extract of F. asafoetida at a concentration of 150, 100, and 50 mg/mL, killed 99% of the larva, and A. sativum extract at the concentrations of 50 and 10 mg/mL killed 95% of larvae (p< 0.05). | [54]      |
| C. papaya L.                                                | Water, ethyl acetate| Phenoma posthuma     | In vitro           | Apigenin extract gave the highest extractive yield of 31.8%. It is followed by the ethyl acetate extract at 17.2%. | [55]      |
| Sida Senegalensis (ADC) pichon                              | Aqueous decoction (AD) | Heteropneustes heterax | In vitro          | HED's oxidative and larvicidal activity is more interesting than that of AD with an EC50 = 55.60% and an IC50 of 190 µg/mL. | [56]      |
| Osygranthaus acaus (Schult.) Karre                          | Water           | Haemonchus contortus   | In vitro            | The crude aqueous extract, looks more pointed. Morphometry study of H. Contortus indicates that it has a significant difference for body length, body width, cervical papilla, and spiral length in the male. | [57]      |
| Cynoglosus citratus (DC), Stapf.                           | Water, methanol | Haemonchus spp.        | In vitro            | Both extracts were active against Haemonchus spp. and Trichostongyus spp. Larvae. | [58]      |
| Saponins from Medicago spp.                                 | Methanol        | Strongyloides spp.     | In vitro            | With 1.72 mg/mL ET50 and 1.39 mg/mL ET50, a saponin from M. Polyneurpha culminaris Anguina was the most active. | [59]      |
| ginger (Z. officinalis)                                     | Ethanol         | Proteus of hydatid cyst| In vitro           | There was no significant difference between the three concentrations of 200, 150, and 100 mg/ml. (P=0.05). | [60]      |
| Uchiloobs ohneae (Laxt)                                     | Ether            | Ezonla lepida (Acacina) | In vitro           | Significant antioxidant activity was established by the ethanolic and aqueous extracts. Inhibition of alpha-amylase by ethanolic and aqueous extracts was significant with the IC50 value of 36.63 and 73.94 µg/mL, respectively, compared to standard acarbose. | [61]      |
| Areca catechu L.                                            | Water           | Ascaridia galli        | Both               | The extract damaged the morphology of A. Galli in vivo. The average eggs per gram decreased from 1485±386.62 to 0±0.00 during 14 days of treatment of 79 mg/mL of extract. | [62]      |
| Balantos argenticus (L.) Debite                           | Methanol        | Trichomonas canis     | In vitro            | The main changes induced by treatment with the tested extract were wrinkled cuticular surface and deformed sessile papilla. | [63]      |
| Abblozam garamen (C.ESered)/ C.A.Sir. Physstlococidasson C.AH. Verminous amynadacta Del. | Hydroalcoholic | Ovine GIT nematodes | In vitro           | All three plant crude extracts were inhibited egg hatching significantly (p<0.05) as compared with the negative control but the inhibition among them was not significantly different in the effect. | [64]      |
| Cassia spp.                                                 | Ethanol         | Haemonchus contortus   | In vitro            | The movement of H. Contortus larvae was significantly inhibited after exposure to Among the species of Cassia, the C. Sunthrosia (at 200 mg/µl) showed the highest (p < 0.05) inhibition level on the larve. | [65]      |
| Corindra unisess (L.), Konztre                              | Ethanol         | Haemonchus contortus   | In vitro            | Both A. Lebueck and C. Siemas exhibited 90% and 95% mortality at 4 & 8 mg/ml after 8 hours of treatment. | [66]      |
| Abblozam lebech (L) Benth Babadiy fatamou Borb Dongotam phatamom Por at DC. Mitragyna inermis (Wild), Konztre | Methanol        | Haemonchus contortus   | In vitro            | At the highest concentration (2400 µg/ml), all adult worms were motionless after 24 h of exposure, while at the lowest concentration (<150 µg/ml), this occurred after 48 h of exposure. M. Inermis and C. Giliusino extracts were more effective than B. Foranguina extracts (p < 0.05). | [67]      |
| Syzygium aromaticum (close)                                 | Water           | Hymenoloeiphilun      | In vitro            | The extracted oil’s lethal and therapeutic doses were also calculated as 0.05 and 0.25 mg/ml. | [68]      |
Table 1. Continue from previous page.

| Plant name                              | Solvent                        | Parasite name              | In vivo / In vitro | Results                                                                 | Reference |
|-----------------------------------------|--------------------------------|----------------------------|--------------------|--------------------------------------------------------------------------|-----------|
| Scrophularia marramifera (spoon)         | water                          | Rhytonchus poincianei      | In vitro           | The extracted oil’s lethal and therapeutic doses were also calculated    | [70]      |
| Cinara papyri                            | methanol                       | Indian earworners          | In vitro           | The result indicated that the Papyri seeds lead to paralysis of         | [70]      |
| Laurencia flexiflora (Val)               | ether chloroform               | Earthworm                  | In vitro           | The ethanolic extract was found to produce the highest degree of        | [91]      |
| Ocimum sanctum L.                        | ethanal                         | Ascandinia galli           | In vitro           | The results were LC50 of Ocimum sanctum L. Leaves ethanol extract      | [81]      |
| tobacco (Nicotiana tabacum)              | water                          | Ascaridia galli            | In vitro           | Scanning electron microscope of tobacco infected treated nematodes     | [82]      |
| Cymbopogon citratus (DC.) Stapf          | essential oils (CCEO) nanoemulsion (CCEO) | Haemonchus contortus | In vitro / In vivo | In the egg hatching test, croc and croc (1.25 mg/ml) inhibitedellar    | [83]      |
| Hypoestes for Silkii (Ind)               | n-hexane methanol chloroform   | Trichuris suis             | In vitro           | The n-hexane extract has a percentage of inhibition of egg hatching    | [84]      |
| Santolinia camara (L)                   | methanol mertanex methyl acetate methanol benzene | Ondasconisasis          | In vitro           | The extract inhibited egg hatching with high efficiency at concentrations| [85]      |
| Terminalia Catappa (Linn)                | ether methyl acetate methanol water Dichloromethane hydroalcoholic | Haemonchus contortus      | In vitro           | The dichloromethane extract displayed the highest egg hatch inhibition percentage of 98.84% at 1.25mg/ml, and also showed 100% larval reduction at a concentration of 12.5mg/ml after 1 days and 98.9% at the least concentration of 0.25 mg/ml. While the methanol extract showed the lowest inhibition of 95.77% at the same concentration. | [86]      |
| Caudarum foxta L.                        | Water methanol                 | Gastrointestinal nematodes | In vitro           | Revealed ED50 for egg batch was 6.394 indicates a high degree of       | [89]      |
| Ascaridia indica (Abu.)                 | chloroform benzene methyl acetate is butanol | Haemonchus contortus      | In vitro           | There was no significant difference statistically (P>0.05) in FED50 (   | [91]      |
| Ocimum gramineum L.                      | acetone                        | Haemonchus placei          | In vitro           | The best fit LC50 values, found to be significantly different           | [91]      |
| Cymbopogon citratus (DC.) Stapf          | essential oil (CCEO)           | Pseudocercocystis          | In vitro           | Although CCEO at the doses of 50, and 100 µL/g exhibited no similar effect in the in vitro analysis, but at the dose of 20 µL/mL and an exposure time of 5 min, approximately 100% of cysts | [92]      |
| Terminalia bellirica                     | benzene                        | Sterina cerni              | In vitro           | T. Bellirica, T. Chebula and T. Catappa showed a decline in the viability of the worms at higher doses of 5 and 10 mg/kg after 4 h of incubation, whereas dec (dihydrarkanam) worms were active at all the doses up to 8 h and further after 3 h followed by ntt reduction assas. | [89]      |
| Terminalia chebula                       | Chloroform Metanol Aceitine    | Haemonchus contortus       | In vitro           | Subfraction (SF), SF 1, and 2 of the chloroform fraction showed better ovicidal activity whereas SF 3, 4, 5, 22 and 27 showed the best larvicidal activity. The larvae that were used for testing the larvicidal activity, were found to be drastically unlike after half an hour of incubation with the extract and were progressively dead in a dose-dependent manner. | [94]      |
| Murraya koenigii (L.) Speng.             | methanol benzene chloroform is butanol water | Haemonchus contortus      | In vitro           | The LMI assays, the aqueous extract of M. Snegophilus showed a significant (p<0.05) inhibition of larval migration in a concentration-dependent manner. The highest concentration used (2000 μg/mL) showed 57.37% inhibition. | [95]      |

Continue to the next page.
| Plant name                        | Solvent       | Parasite name            | In vivo/in vitro | Results                                                                                           | Reference |
|----------------------------------|---------------|--------------------------|------------------|---------------------------------------------------------------------------------------------------|-----------|
| Asteraceae                       | water         | Haemonchus contortus     | in vitro         | In EHT, LC50 values of HC and reference were 4.93 and 1.84 ppm, respectively. In AMA, 100% mortality of H. Contortus was observed after 6 hr of treatment with HC (100 mg mL⁻¹) whereas two positive control groups could not kill all worms after this exposure time. These results indicated the anthelmintic potential of HC. | [36]      |
| Annona muricata L.               |               |                          |                  | Annona muricata extract was 84.91% on EHT and 89.08% on LMT effective.                           | [19]      |
| Arachis pintoi C.                |               |                          |                  | -                                                                                                 |           |
| Annona muricata                   |               | Caenorhabditis elegans   | in vitro         | The present study results indicated that the aqeous and chloroform extracts of leaves of Tridax procumbens linn show significant dose-dependent anthelmintic activity on the Indian earthworms. The anthelmintic activity was selective to the model organism C. elegans. The anthelmintic activity was evaluated in the in vitro and in vivo models. | [98]      |
| Citrus aurantiifolia (Christm.) Swingle | n-hexane    | Phoritina posthuma       | in vitro         | The anthelmintic activity was selective to the model organism C. elegans. The anthelmintic activity was evaluated in the in vitro and in vivo models. | [100]     |
| Nauclea diderrichii (De Wild.) Merr. | Methanol     | Embelia ribes            | in vitro         | The anthelmintic activity was selective to the model organism C. elegans. The anthelmintic activity was evaluated in the in vitro and in vivo models. | [101]     |
| Zanthoxylum rhetsa                | methanol      | Eubosia loxos (Ammonoida) | in vitro         | The anthelmintic activity was selective to the model organism C. elegans. The anthelmintic activity was evaluated in the in vitro and in vivo models. | [102]     |
| Cinnamomum verum J.Presl          | Methanol      | Helichrysum sp           | in vitro         | The anthelmintic activity was selective to the model organism C. elegans. The anthelmintic activity was evaluated in the in vitro and in vivo models. | [103]     |
| Aloe ferox                        | Methanol      | Strobilomelos suaveolens | in vitro         | The anthelmintic activity was selective to the model organism C. elegans. The anthelmintic activity was evaluated in the in vitro and in vivo models. | [104]     |
| Papaya capensis                   | Methanol      | Poasaphotheurans censi   | in vitro         | The anthelmintic activity was selective to the model organism C. elegans. The anthelmintic activity was evaluated in the in vitro and in vivo models. | [105]     |
| Capsicum annuum L.               | Methanol      | Pherithma posthuma       | in vitro         | The anthelmintic activity was selective to the model organism C. elegans. The anthelmintic activity was evaluated in the in vitro and in vivo models. | [106]     |
| Rosmarinus officinalis L.         | Methanol      | Pherithma posthuma       | in vitro         | The anthelmintic activity was selective to the model organism C. elegans. The anthelmintic activity was evaluated in the in vitro and in vivo models. | [107]     |
| Cinnamomum zeylanicum             | Methanol      | Pherithma posthuma       | in vitro         | The anthelmintic activity was selective to the model organism C. elegans. The anthelmintic activity was evaluated in the in vitro and in vivo models. | [108]     |
| Citrus unshiuifolia (Christg.) Osbeck | Methanol     | Pherithma posthuma       | in vitro         | The anthelmintic activity was selective to the model organism C. elegans. The anthelmintic activity was evaluated in the in vitro and in vivo models. | [109]     |
| Carica papaya L.                  | Methanol      | Pherithma posthuma       | in vitro         | The anthelmintic activity was selective to the model organism C. elegans. The anthelmintic activity was evaluated in the in vitro and in vivo models. | [110]     |
| Tabebuia avellanedae Miers        | Methanol      | Pherithma posthuma       | in vitro         | The anthelmintic activity was selective to the model organism C. elegans. The anthelmintic activity was evaluated in the in vitro and in vivo models. | [111]     |
| Avicennia marina L.               | Methanol      | Pherithma posthuma       | in vitro         | The anthelmintic activity was selective to the model organism C. elegans. The anthelmintic activity was evaluated in the in vitro and in vivo models. | [112]     |
| Annona muricata                   | Methanol      | Pherithma posthuma       | in vitro         | The anthelmintic activity was selective to the model organism C. elegans. The anthelmintic activity was evaluated in the in vitro and in vivo models. | [113]     |
| Review                           |               |                          |                  | The present study results indicated that the aqeous and chloroform extracts of leaves of Tridax procumbens linn show significant dose-dependent anthelmintic activity on the Indian earthworms. The anthelmintic activity was selective to the model organism C. elegans. The anthelmintic activity was evaluated in the in vitro and in vivo models. | [99]      |
| Plant name                        | Solvent       | Parasite name            | In vivo/in vitro | Results                                                                                           | Reference |
|----------------------------------|---------------|--------------------------|------------------|---------------------------------------------------------------------------------------------------|-----------|
| Brugmansia suaveolens             | Ethanol       | Haemonchus contortus     | in vitro         | Larval mortality assays were carried out on the aqeous plant extracts at concentrations of 2.5 mg/mL, 5 mg/mL, and 12.5 mg/mL. Thiacetamide was used as a positive control. Extracts of all plant species demonstrated larval mortality abilities that were concentration and time-dependent. | [97]      |
| Haemonchus (CV)                   | n-hexane      | Caenorhabditis elegans   | in vitro         | The complete extract exhibited significant anthelmintic activity against the model organism C. elegans. The anthelmintic activity was evaluated in the in vitro and in vivo models. | [98]      |
| Discocora Mexicana Fruits         | Ethanol       | Phoritina posthuma       | in vitro         | The animal was given a dose of 0.04 mg/mL dose and it was found to be a low dose which has a long time for the paralysis conditions. 0.1 mg/mL dose had a perfect time for paralysis compared to low and high doses. | [100]     |
| Zanthoxylum rhothenia             | Methanol      | Eubosia loxos (Ammonoida) | in vitro         | The extracts exhibited significant anthelmintic activity as evidenced by a decrease in paralysis death time in the treatment groups when compared to the standard. | [101]     |
| Embelia ribes                     | Water         | Ascocotyla galli         | in vitro         | Methanolic extract of Embelia ribes showed a better inhibitory effect (61.27%) on the embryo nation of eggs of Ascocotyla gilli than its aqeous extract (54.24%). Inhibitory effect of 77.66±1.85%. | [102]     |
| Monoporia indica                 | methanol      | Haemonchus placeri      | in vitro         | The anthelmintic activity was selective to the model organism C. elegans. The anthelmintic activity was evaluated in the in vitro and in vivo models. | [103]     |
| Acanthopanax pallidiflorus (Greciphellaceae) | Ethanol  | Eubosia loxos (Ammonoida) | in vitro         | All the extracts were found to be exhibited dose-dependent anthelmintic activity. The decreasing order of extracts activity was ethyl acetate, ethanol, dichloromethane, and petroleum ether extracts. | [104]     |
| Citrus unshiuifolia (Christg.) Osbeck | Methanol     | Phoritina posthuma       | in vitro         | Ethanol extracts of the leaves of the C. Papaya responsible for the death of P. Cento and H. Contortus especially at the higher concentration (10%) compared to the standard reference of Piperazine citrate. | [105]     |
| Carica papaya L.                  | Methanol      | Pherithma posthuma       | in vitro         | Ethanol extracts of the leaves of the C. Papaya responsible for the death of P. Cento and H. Contortus especially at the higher concentration (10%) compared to the standard reference of Piperazine citrate. | [106]     |
| Tabebuia avellanedae Miers        | Methanol      | Pherithma posthuma       | in vitro         | Ethanol extracts of the leaves of the C. Papaya responsible for the death of P. Cento and H. Contortus especially at the higher concentration (10%) compared to the standard reference of Piperazine citrate. | [107]     |
| Annona muricata                   | Methanol      | Pherithma posthuma       | in vitro         | Ethanol extracts of the leaves of the C. Papaya responsible for the death of P. Cento and H. Contortus especially at the higher concentration (10%) compared to the standard reference of Piperazine citrate. | [108]     |
| Plant name | Solvent | Parasite name | In vivo | In vitro | Results | Reference |
|------------|---------|---------------|---------|----------|---------|-----------|
| Annona muricata L. | water  | Haemonchus contortus | Both | | 50 and 100 μg/mL of acacia oearumulua leaf extract obstructed worm motility. | [20] |
| Piper tabulatum | Ethyl acetate | Haemonchus contortus | Both | | Lipoic acid had the best effect on EHT and LTD stages on Haemonchus contortus growth. | [21] |
| Lippia sidoides Carapa guianensis | ethanol Water Methanol | Haemonchus contortus | Both | | Acquose extract of Lippia sidoides caused 100% growth inhibition in larvae. | [22] |
| Rumex abyssinicus Schimperiana | methanol | Haemonchus contortus | Both | | The most significant decrease in the number of eggs in the feces was in the group treated with the methanolic extract of Rumex abyssinicus. | [24] |
| Ondexyz coccidica | Acetone water | Haemonchus contortus | Both | | Changes such as muscle cell breakdown, intestinal cell lysis, changes in hystodermia, and abnormal chromatin density of epithelial cells were observed. Wounds and lesions also appeared on the surface of the worms. | [25] |
| Clinicidae sp. | acetonitrile | Cooperia punctata | Both | | After treatment with 70% ethanol, 7 days after injection, in TEM and SEM examination of eggs of the worm. Changes and fructation in the eggshell of Cooperia punctata was observed. | [27] |
| Leucaena leucocephala | Distilled water | Cooperia punctata | Both | | Treatment with TRH fractions of Leucaena leucocephala, EHT was 59.09-<265. | [28] |
| Chenopodium ambrosioides | methanol Distilled water | Thioscarasavus | Both | | Hexane extracts of Chenopodium ambrosioides reduce inflammation in the lungs and liver of Thioscarasavus infected rats in vivo and aqueous extract of Nhizosiniva had the best effect in vitro. | [30] |
| Pycnanthus angolensis Nuttavent | Dichloromethane | Ancylostoma caninum | Both | | 150 μg/mL. Chenopodium ambrosioides essential oil caused 100%. | [29] |
| Chenopodium ambrosioides L. | methanol | Trichosrotaphy | Both | | In this study, the methanolic extract caused severe damage to the larvae. | [35] |
| Uliva | Distilled water | Trichosrotaphy Calabrica | Both | | In this study, 75μg/mL of LAE reduced worm growth by 52%. | [36] |
| Benincasa Acanthin (CPT) | NR | Angiostrongylus Cantonensis | Both | | Combination of Albendazole and Tanshinone II-A reduced neartis in Angiostrongylus cantonensis infected mice. | [38] |
| Carmin and giner | methanol | Ascariis galli | Both | | Lethal dose 100μg/mL of both curcumin and ginger extract was up to 88 % less than aspirin/gall. | [11] |
| Balantidium saggitaris | methanol | Thioscarasavus | Both | | Treatment with 120 μg/mL methanolic extract of BAE made the cuticle surface wrinkled and the worm surface porous. | [39] |
| Balantidium saggitaris | methanol | Trichosrotaphy | Both | | 1000 μg/mL methenolic extract of Balantidium saggitarins in 5 days caused a reduction in worm migration and larvae cytolysis in rats. | [40] |
| Cyanodon dactylon | methanol | Phascolosoma diminuta | Both | | 48 μg/mL of Cyanodon dactyli in 112-465 hours caused worm paralysis. Also in rat treatment with 800μg/mL in 5 days caused 17.4% decrease in the number of eggs in the feces. | [47] |
| Alpinia sp. | ethanol | Fasciolopsis buski | Both | | Treatment with 30 μg/mL extract of flavonoids in 31.41-<8.18 hour caused worm paralysis but in 3.94-<23 hour caused death in Fasciolopsis buski. | [48] |
| Ustilago cajon | Methanol Ethyl acetate Hexane | Fasciolopsis Hepatica | Both | | According to this study, the lethal dose of the 5 studied extracts significantly had a lethal effect on the worm. | [30] |
| Soybean | NR | Fasciolopsis Hepatica | Both | | Soybean extract reduced liver damage due to Fasciolopsis gigantia and reduced caspase 3 in liver cells. | [31] |
| Allisc | NR | Schizostoma mansoni | Both | | 10 μg/mL of Acicin caused changes in surface tubercles and spines of the worm. | [54] |
| Menisa zolobu Hadi | Sodium chloride | Schizostoma mansoni | Both | | M50 caused ultra morphological changes on Schizostoma mansoni and tegumental distortion. | [55] |
| Cluromidendron umbellatum Pair | water | Schizostoma mansoni | Both | | Treatment with 180 μg/mL aqueous leaf extract caused 100% death in Cluromidendron umbellatum pair. | [50] |
| Oxyxus nodulus | methanol | Paragonimiasis microstomum | Both | | 100 μg/mL Methanolic extract of Bambusa nodulosa in 22.17-<4.98 minutes caused death in Paragonimiasis esculentum. | [51] |
| Balantidium saggitaris | methanol | Paragonimiasis microstomum | Both | | 300 μg/mL Methanolic extract of the fruit of Balantidium saggitarins caused severe damage to the worm tegument. | [33] |
A study of *Haemonchus contortus* larva EHT and LDT using a hydroalcoholic extract of *Senna Occidentalis* leaf, the aerial part of *Rumex abyssinicus*, *Leonotis ocymifolia*, *Albizia schimperiana*, and *Leucas martincensis* stem bark showed that the aqueous extract of *Leonotis Ocymifolia* caused 100% growth of larvae. The best concentration of ED50 for EHT of aqueous and hydroalcoholic extract of *Leucas Martinicensis* was 0.09 mg/mL. In a study, anthelmintic activities of an extract combination of *Indica azadirachta* leaf, *Nicotiana tabacum* (N.), *Calotropis procera* (C.) flower, and *Trachyspermum Ammi* seed were examined in EHT and Adult Motility Test (AMT) of *Haemonchus Contortus* worm. Accordingly, by increasing the compound concentration, the amount of EHT decreased. At a concentration of 50 mg/mL, only 1% of worms hatched; whereas, at a concentration of 0.02 mg/mL, approximately 70% of the worms hatched. Within 6 hours, from 3.125 mg/mL to high, all worms died. A study used the methanolic and aqueous extract of *Prunella vulgaris* to examine its anthelmintic properties against *Haemonchus contortus*. In this study, crude methanolic extract with LC50 (Lethal concentration of 50) equivalent to 2.48 mg/mL was used which showed more inhibitory effects on EHT than a crude aqueous extract with LC50 equal to 3.36 mg/mL. Also, the group treated with methanolic extract of *Prunella vulgaris* had the highest decrease in the number of eggs in the feces. Brunet et al. studied the role of *Onobrychis vicifolia* (Saintfoin) extract in larva stage B L3 of *Haemonchus contortus* worm using morphological changes. Larval envelope structure at a concentration of 1200 mg/mL of *Sainfoin* extract using a Transmission Electron Microscope (TEM) shows changes such as muscle cell breakdown, intestinal cells breakdown, hypodermic changes, abnormal chromatin density of the nucleus of epithelial cells, and wounds and lesions created on the surface of the worm.

**The use of herbs for *Cooperia punctate***

This parasite is 5-9 mm long. In all species of this parasite, the head part is dilated and has transverse lines. Thick spicules, often with a wing-like dilation, are in the midline. The female parasite has a long tail, and its genital area is covered. The parasite lives in the small intestine of cows. Von Son-de Fermex et al. using the isolated component of *Gliricidia sepium* against *Cooperia punctata* worms showed that this extract inhibits the growth and egg hatching of *Cooperia punctata* worm (Half maximal effective concentration or EC50 equivalent to 0.024 0.082 mg/mL). Examining worm eggs with SEM and TEM revealed changes and fractures in parasite eggshell through treatment with H-chromene-2-one 2 component. Also, the use of components derived from the aqueous extract of *Leucaena leucocephala* to conduct EHT and worm egg damages showed that the percentage of egg hatching inhibition in the LICIF3 segment is equal to 90;49±2;85, which was higher than other components. Also, studying parasite eggs after treatment with LICIF3 Fraction using SEM revealed the eggshell’s disintegration and a formation of depressions and tears on the eggs’ surface. Also, changes in electron density and thickening of the layer of worm eggs were observed by TEM.

**The use of herbs for *Toxocara canis***

*Toxocara canis* is a nematode that causes Toxocariasis disease in humans, which is caused by infection formed after consumption of *Toxocara canis* eggs in soils contaminated with dog feces. Children are more susceptible to this infection due to glutony (Pica). In a study, antiparasitic effects of *Pycnantha angolensis*, *Chenopodium ambrosioides*, and *Nutridinex* extracts against *Toxocara canis* larva were evaluated. The results showed that the hexane extract of *Chenopodium ambrosioides* is more effective than other extracts in vivo environment and reduces inflammatory reactions caused by *Toxocara Canis* larva infection.

**The use of herbs for *Ancylostoma caninum***

*Ancylostoma caninum* is a hookworm that mainly causes diseases in dogs’ small intestine. This worm infection shows a wide range of symptoms in dogs. Other hosts include carnivores such as wolves, foxes, and cats, and also a small number of diseases have been reported in humans. In a study by Monteiro et al., the role of ethanolic extract and essential oil of *Chenopodium ambrosioides* L. in controlling *Ancylostoma caninum* worms is discussed. *Chenopodium ambrosioides* essential oil was effective in a concentration of 140 μL/mL against larva L3 and reduces the number of eggs per each gram of feces the aim of this study was quantitate the yield the chemical composition of the essential oil of *C. ambrosioides* and they found that as well as the in vitro effect of the ethanolic extract and the essential oil in L3 of *Ancylostoma spp* and the in vivo effect(s) of the essential oil in dogs. The effects of the ethanol extract and essential oil on *Ancylostoma spp* were observed in vitro by exposing larvae to the extract at concentrations ranging from 0.005 g mL-1 to 0.2 g mL-1 and to essential oil at concentrations of 50, 100, 150 μL mL-1.

**The use of herbs for *Trichostrongylus spp***

*Trichostrongylus spp* is a species of nematodes distributed among herbivorous animals worldwide. At least 10 species of *Trichostrongylus* are associated with human infections. The infection occurs through consuming infectious larvae in vegetables and contaminated water. Today, anthelmintic resistance is expanding worldwide; therefore, manufacturing non-synthetic drugs seems necessary. Kozan et al. investigated the anthelmintic role of *Vicia pannonica* against *Trichostrongylus* parasites. In this study, aqueous, ethanolic, chloroformed, Estonian, and hexane extracts of *Vicia pannonica var. purpurascens* had a 100% effect on larval movements in 10th minute and all mentioned extracts damaged the larval sheath in this study they cover in vivo and in vitro tests that have been developed for the detection of nematode resistant to the main anthelmintic groups, but each suffer to some degree from reliability reproducibility, sensitivity and ease of interpretation. Aqueous extracts of *Pithecobium dulce* and *Lysiloma acapulcensis* had lethal effects on *Trichostrongylus clabriformis* eggs at concentrations of 250 and 500 μg/mL. Also, *Pithecobium dulce* has lower larvacidal effects than aqueous extracts of *Lysiloma acapulcensis* and *Levamisole*.56

**The use of herbs for *Angiostrongylus***

*Angiostrongylus* is a nematode parasite that can cause diseases in humans’ gastrointestinal tract and central nervous system. *Angiostrongylus cantonensis*, called rat lungworm, causes eosinophilic meningitis disease commonly found in Southern East Asia and the Pacific Islands. In one study, the effects of TSII-A (Tanshionone IIA) and *Cryptotanshinone* (CPT) with Albendazole on ocular nerve inflammation caused by *Angiostrongylus cantonensis* infection were evaluated in mice. The results showed the suitability of Albendazole in combination with TSI-E in the treatment of the optic nerve inflammation caused by *Angiostrongylus cantonensis*.38

**The use of herbs for *Onchocerca ochengi***

*Onchocerca ochengi* is a bovine Filariasis parasite found in
West Africa as Cameroon. It is closely related to a human parasite called *Onchocerca volvulus*. Studies by Ndjouka *et al.* showed antiparasitic activities of aqueous extracts of *Annona senegalensis* and *Euphorbia hirtan* and ethanolic extracts of *Parquetina nigrescens*, *Khaya senegalensis*, and *Anogeissus leio-carpus* with an LC50 concentration in a range of 0.08-0.55 mg/mL for *Onchocerca ochengi* worm. Based on this study, *Euphorbia hirta*, *Annona senegalensis*, *Khaya senegalensis*, and *Anogeissus leio-carpus* extracts can be suitable alternatives for worm infections.  

**The use of herbs for *Ascaridia galli***  
*Ascaridia galli* is one of the *Ascaridia* genus nematodes that live in poultry intestines and sometimes causes accidental closure of the intestine and Ascariasis in poultry. In a study by Bazh and El-Bahy, a concentration of 100 mg/mL of ginger (*Zingiber officinale*) and turmeric (*Curcuma longa*) in 48 hours in an in vitro environment causes the death of *Ascaridia galli* worms in an in vivo environment, there was lower mortality. Also, in all concentrations, ginger caused more mortality than turmeric.  

**Herbs’ anthelmintic effect for *Toxocara vitulorum***  
*Toxocara vitulorum* is the largest parasite, and its female species is up to 30 cm long. This parasite that lives in the intestine of cattle and buffalo calves, its spread is currently global, and often comes from tropical and subtropical areas, is one of the most important parasites of newborn calves. In one study, using the methanolic extract of *Balanites aegyptiaca* fruit at a concentration of 240 mg/mL showed 100% inhibitory activity on *Toxocara vitu-lorum* egg growth.  

**The use of herbs in *Trichinella spiralis***  
An adult *Trichinella spiralis* is 4-6 cm long with a thick posterior end. Its anterior end suddenly narrows and forms as a thin and long wire embedded in the mucosa. *Trichinella spiralis* is the most important cause of human infections. A study by Shalaby *et al.* showed that within five days, the methanolic extract of *Balanites aegyptiaca* with a concentration of 1000 mg/mL per kg of body weight in Rat reduced migration and death of larvae for 61.7% and 81.7% respectively.  

**The use of herbs for *Hymenolepis diminuta***  
*Hymenolepis diminuta* that is also known as Tap worm rat is the cause of Hymenolepiasis. Unlike *Hymenolepis nana*, this worm uses insects as mediator hosts for transmitting to infect humans. Also, in a study by Yadav and Nath, the *Cynodon dactyl- lon* extract had anthelminthic properties. A concentration of 40 mg/mL of the *Cynodon dactylon* extract caused paralysis and death of worms at hours 4/12 ± 0.55 and 5.16±0.32, respectively. Also, the treatment of rats by a dose of 800 mg/mL/kg for five days caused a reduction of 77.64% and 79.00% in the number of eggs per gram of feces and the worm load, respectively, after the treatment with *Cynodon dactylon*.  

**The use of herbs for worms of the *Fasciolidae* family***  
These worms are large leaf-shaped flukes. The cone-shaped anterior end and the anterior balloon are located at the end of the cone. The abdomen balloon is at the level of the so-called shoulders of the fluke. There are three main genera, including *Fasciola*, *Fascioloides*, and *Fasciolopsis*, in this family that often cause severe damage to their host’s liver and intestines. The ethanolic extract of *Alpinia nigra* in a 20 mg/mL concentration at hour 2.14±0.48 caused worm paralysis; While at hour 3.94 ± 0.23 caused the death of *Fasciolopsis buski* worms. In the control group, worms’ physical activities continued until hour 21.05±0.22. A study on *Fasciola hepatica* worm showed that the extract of *Lantana camara*, *Cajanus cajan*, and *Piper auritum* at a 50 mg/mL concentration caused 100% death worms. Whereas extracts of *Bocconia frutescens* and *Artemisia Mexicanana* plants at a 125 mg/mL concentration caused 100% death of worms.  

Research by Roy and Swargiary discussed about the role of *Fasciolopsis buski* in changing enzymes at *Alpinia nigra* tegument. Accordingly, by the effect of *Alpinia nigra* extract, the overall activity of Acid phosphatase (ATPase), Adenosine triphosphatase (ATPase), and Alkaline phosphatase (AlkPase) enzymes decreased because these enzymes have an important role in parasite survival by digesting and absorbing the nutrients. Using Soybean extract reduces liver lesions because of the presence of *Fasciola gigantica* and the amount of 3-cell caspase of the liver, and on the other hand, caused induced apoptosis in the parasite DNA.  

**The use of herbs for the *Schistosomatidae* family’s***  
This family is located in the gastrointestinal tract and bladder’s blood vessels. Schistosomiasis is an acute and chronic disease caused by blood trematodes of the genus *Schistosoma*. About 206 million people need preventive treatments to reduce the infection and prevent death from schistosomiasis. In one study, different concentrations of Allicin caused morphological changes in *Schistosoma mansoni* in a way that a concentration of 10 mg/mL led to changes in small bumps and a reduction in the surface of the worm and at higher concentrations increased damaging the tegument including vesicles and ulcers. A study by Matos-Rocha *et al.* discussed the role of Mentha x villosa Huds Essential Oil (MVEO) against *Schistosoma mansoni* worms. MVEO at a concentration of 500 µg/mL caused the death of all worms within 24 hours, and examining it by SEM showed bubble-like lesions formed around the body of the worm and erosion in small bumps in some areas of the abdomen. Also, by studying using TEM, changes were observed in integument and vesiculation in the syncytial matrix region. Using the *Clorodendrum umbellatum* extract in mice infected with *Schistosoma mansoni* significantly reduced the number of eggs excreted from mice; In a way that the amount of excreted eggs in treated mice with a concentration of 80 mg/kg and 160 mg/kg decreased by a rate of 75.48% and 85.14%, respectively.  

**Herbs’ use for the *Paramphistomatidae* family’s***  
The adult *Paramphistomum* worm often exists in the ruminant pre-stomachs. Although, there is a species found in the intestines of ruminants, pigs, and dogs, which sometimes causes intestinal inflammation with edema, bleeding, and wounds. In one study, the methanolic extract of *Bombax malabaricus* at a concentration of 100 mg/mL at minutes 22.17±0.48 caused the death of *Paramphistomum explanandum* worms, and at minutes 18.50±0.62 caused worm paralysis. The *Balantias aegyptiaca* (BAE) fruit extract at a 200 µg/mL concentration caused severe damage to the *Paramphistomum microbothrium* tegument and the deformation of both suckers of the worm.  

**Conclusions***  
Nearly all the plants in this review showed promising anthelmintic effects, mainly in vitro studies also plant medicines are thought to be good sources for the development of effective
anthelmintic agents. This work as well mentioned that there is a lack of studies on the effect of chemical constituents isolated from plants against helminth infections. Therefore, it is necessary to look for further effective anthelmintic drugs with minimum side effects.

References

1. Daumerie D, Savioli L. Working to overcome the global impact of neglected tropical diseases: first WHO report on neglected tropical diseases, vol. 1. Geneva: World Health Organization; 2010.
2. Perry BD. Investing in animal health research to alleviate poverty. ILRI (aka ILCA and ILRAD); 2002.
3. Bull K, Cook A, Hopper NA, et al. Effects of the novel anthelmintic emodepside on the locomotion, egg-laying behaviour and development of Caenorhabditis elegans. Int J Parasitol 2007;37:627-36.
4. Cheraghipour K, Moridnia A, Sharifi M, et al. The effect of medicinal plant extracts on helminthes: A systematic review. J Isfahan Med Sch 2019;37:462-74.
5. Satyavati GV. Use of plant drugs in Indian traditional systems of medicine an their relevance to primary health care. New Delhi, India: Indian Council of Medical Reserch; 1985.
6. Liu LX, Weller PF. An update on antiparasitic drugs. N Engl J Med 1996;334:1178-84.
7. Qi Z. WHO Traditional Medicine Strategy. 2014-2023. Geneva: World Health Organisation; 2013.
8. Roy B. Anthelmintic activity of Artemisia maritima against Hymenolepis diminuta (Cestoda), an in vitro and in vivo study. Parasitol Res 2016;115:1275-85.
9. Keiser PB, Nutman TB. Strongyloides stercoralis in the immunocompromised population. Clin Microbiol Rev 2004;17:208-17.
10. Bhardwaj LK, Anand L, Chandrul KK, Patil KS. In-vitro anthelmintic activity of Ficus benghalensis Linn leaves extracts. Asian J Pharm Clin Res 2012;5:118-20.
11. Bazh EKA, El-Bahy NM. In vitro and in vivo screening of plant extracts. Asian J Pharm Clin Res 2013;6:3679-86.
12. Roy B. Anthelmintic activity of Artemisia maritima against Artyfechinostomum suffrayef, a zoonotic parasite in northeast India. Riv Parasitol 2003;64:143-8.
13. Faridnia R, Kalani H, Fakhar M, Akhtari J. Investigating in vitro anti-leishmanial effects of silibinin and silymarin on Leishmania major. Ann Parasitol Res 2018;6:29-35.
14. Eskandarian AA, Jafari H, Asghari G, et al. In vitro antileishmanial activity of Falcaria vulgaris fractions on Leishmania major. Jundishapur J Nat Pharm Prod 2017;12:e63754.
15. Mirzaei F, Bafghi AF, Mohaghegh MA, et al. In vitro anti-leishmanial activity of Satureja hortensis and Artemisia dracunculus extracts on Leishmania major promastigotes. J Parasit Dis 2016;40:1571-4.
16. Machen RV, Crockro F, Craig T, Fuchs TW. A Haemonchus contortus management plan for sheep and goats in Texas. Texas FARMER Collect 1998.
17. Sambodo F, Prastowo J, Kurniasih K, Indarjulianto S. In vitro potential anthelmintic activity of Biophyllum petersianum on Haemonchus contortus. Vet World 2018;11:1.
18. von Son-de Fernex E, Alonso-Díaz MA, Valles-de la Mora B, Capetillo-Leal CM. In vitro anthelmintic activity of five tropical legumes on the exsheathment and motility of Haemonchus contortus infective larvae. Exp Parasitol 2012;131:413-8.
19. Ferreira LE, Castro PMN, Chagas ACS, et al. In vitro anthelmintic activity of aqueous leaf extract of Annona muricata L.(Annonaceae) against Haemonchus contortus from sheep. Exp Parasitol 2013;134:327-32.
20. Castaño-Cañete-Ramírez GS, Mathieu C, Vilarem G, et al. Age of Haemonchus contortus third stage infective larvae is a factor influencing the in vitro assessment of anthelmintic properties of tannin containing plant extracts. Vet Parasitol 2017;243:130-4.
21. Carvalho CO, Chagas AC, Cotinguiba F, et al. The anthelmintic effect of plant extracts on Haemonchus contortus and Strongyloides venezuelensis. Vet Parasitol 2012;183:260-8.
22. Eguale T, Tadesse D, Giday M. In vitro anthelmintic activity of crude extracts of five medicinal plants against egg-hatching and larval development of Haemonchus contortus. J Ethnopharmacol 2011;137:108-13.
23. Zaman MA, Iqbal Z, Khan MN, Muhammad G. Anthelmintic activity of a herbal formulation against gastrointestinal nematodes of sheep. Pak Vet J 2012;32:117-21.
24. Lone BA, ChishtiMZ, Bhat FA, et al. Anthelmintic activities of aqueous and methanol extracts of Prunella vulgaris L. Nat Prod Chem Res 2017;5:2.
25. Brunet S, Fourquaux I, Hoste H. Ultrastructural changes in the third-stage, infective larvae of ruminant nematodes treated with sainfoin (Onobrychis vicifolia) extract. Parasitol Int 2011;60:419-24.
26. Stromberg BE, et al. Cooperia punctata: effect on cattle productivity? Vet Parasitol 2012;183:284-91.
27. von Son-de Fernex E, Alonso-Díaz MÁ, Valles-de la Mora B, et al. Anthelmintic effect of 2H-chromen-2-one isolated from Gliricidia sepium against Cooperia punctata. Exp Parasitol 2017;178:1-6.
28. von Son-de Fernex E, Alonso-Díaz MÁ, Mendoza-de Givis P, Valles-de la Mora B, et al. Elucidation of Leucaena leucocephala anthelmintic-like phytochemicals and the ultrastructural damage generated to eggs of Cooperia spp. Vet Parasitol 2015;214:89-95.
29. Despommier D. Toxocariasis: clinical aspects, epidemiology, medical ecology, and molecular aspects. Clin Microbiol Rev 2003;16:265-72.
30. Reis M, Trinca A, Ferreira MJU, Monsalve-Puello AR, Grácio MAA. Toxocara canis: potential activity of natural products influencing the in vitro assessment of anthelmintic properties of tannin containing plant extracts. Vet Parasitol 2012;134:299-303.
vitro activity of *Pithecellobium dulce* and *Lysiloma acapulcensis* on exogenous development stages of sheep gastrointestinal strongyles. Ital J Anim Sci 2014;13:3104.

37. Thiengo SC, de Oliveira Simões R, Fernandez MA, Júnior AM. Angiostrongylus cantonensis and rat lungworm disease in Brazil. Hawai’i J Med Public Heal 2013;72:18.

38. Feng F, Feng Y, Liu Z, et al. Effects of Albenza combined with TSII-A (a Chinese herb compound) on optic neuritis caused by Angiostrongylus cantonensis in BALB/c mice. Parasit Vectors 2015;8:1-8.

39. Doyle SR, Armoo S, Renz A, et al. Discrimination between Onchocerca volvulus and O. ochengi filarial larvae in Simulium damnosum (sl.) and their distribution throughout central Ghana using a versatile high-resolution speciation assay. Parasit Vectors 2016;9:536.

40. Ndjonka D, Agyare C, Lüersen K, et al. In vitro activity of Triclabendazole. Menoufia Med J. 2014;27:93.

41. Lalchhandama K. On the structure of Ascaridia galli, the roundworm of domestic fowl. Sci Vis 2010;10:20-30.

42. Ahmed R, Wani ZA, Allaie IM, et al. *Toxocara vitulorum* in a testicular nematode infection in at-risk population groups. WHO Guideline: Preventive chemotherapy to control soil-transmitted helminth infections in at-risk population groups. Trans R Soc Med 2011;104:397-402.

43. Shalaby HA, El Namaky AH, Khalil FA, Kandil OM. Efficacy of methanolic extract of Balanites aegyptiaca fruits on Toxocara vitulorum. Vet Parasitol 2012;183:86-392.

44. Mitreva M, Jasmer DP. Biology and genome of Trichinella spiralis. 2006. In: WormBook: The Online Review of C. elegans Biology [Internet]. Pasadena (CA): WormBook; 2005-2018.

45. Shalaby MA, Moghazy FM, Shalaby HA, Nasr SM. Effect of methanolic extract of Balanites aegyptiaca fruits on enteral and parenteral stages of *Trichinella spiralis* in rats. Parasitol Res 2010;107:17-25.

46. Sheiman IM, Shkutin MF, Terenina NB, Gustafsson MKS. A behavioral study of the beetle *Tenebrio molitor* infected with cysticercoids of the rat tapeworm *Hymenolepis diminuta*. Naturwissenschaften 2006;93:305-8.

47. Yadav AK, Nath P. Anthelmintic effects and toxicity of *Cynodon dactylon* (L.) Pers. in rodent models. J Complement Med Res 2013;7:407-13.

48. Olson PD, Cribb TH, Tkach VV, et al. Phylogeny and classification of the Digenea (Platyhelminthes: Trematoda). Int J Parasitol 2003;33:733-55.

49. Swargiary A, Roy B. In vitro anthelmintic efficacy of *Alpinia nigra* and its bioactive compound, atractaglin against Fasciolopsis buski. J Pharm Pharm Sci 2015;7:30-35.

50. Alvarez-Mercado JM, Ibarra-Velarde F, Alonso-Díaz MA, et al. In vitro anthelmintic effect of fifteen tropical plant extracts on excysted flakes of *Fasciola hepatica*. BMC Vet Res 2015;11:45.

51. Roy B, Swargiary A. Anthelmintic efficacy of ethanolic shoot extract of *Alpinia nigra* on tegumental enzymes of *Fasciolopsis buski*, a giant intestinal parasite. J Parasit Dis 2009;33:48-53.

52. Nassef NE, El-Kersh WM, El Sobky MM, et al. In-vitro and in-vivo Assessment of the Effect of Soybean Extract on Fasciola gigantica Infection in Comparison with Triclabendazole. Menoufia Med J. 2014;27:93.

53. Savioli L, Albonico M, Daumerie D, et al. Review of the 2017 WHO Guideline: Preventive chemotherapy to control soil-transmitted helminth infections in at-risk population groups. An opportunity lost in translation. PLoS Negl Trop Dis 2018;12:e0006296.

54. Lima CM, Freitas FI, Morais LC, et al. Ultrastructural study on the morphological changes to male worms of *Schistosoma mansoni* after in vitro exposure to allicin. Rev Soc Bras Med Trop 2011;44:327-30.

55. Matos-Rocha TJ, Cavalcanti MG, Veras DL, et al. Ultrastructural changes in *Schistosoma mansoni* male worms after in vitro incubation with the essential oil of Mentha *villo*losa Huds. Rev Inst Med Trop Sao Paulo 2016;58:4.

56. Jatsa HB, Sock TM, Thuente LA, Kamtochoue P. Evaluation of the in vitro activity of different concentrations of *Ceratodendron umbellatum* Poir against *Schistosoma mansoni* infection in mice. Afr J Tradit Complement Altern Med 2009;6:216-21.

57. Hossain E, Chandra G, Nandy AP, et al. Anthelmintic effect of a methanol extract of *Dregea volubilis* on *Paramphistomum explanatum*. Parasitol Res 2012;110:809-14.

58. Hossain E, Chandra G, Nandy AP, et al. Anthelmintic effect of a methanol extract of *Bombax malabaricum* leaves on *Paramphistomum explanatum*. Parasitol Res 2012;110:1097-102.

59. Shalaby H, Soad N, Farag T. Tegumental effects of methanolic extract of *Balanties aegyptiaca* fruits on adult *Paramphistomum microbothrium* (Fisch. hoeder 1001) under laboratory conditions. Iran J Parasitol 2016;11:396.

60. Dixit AK, Das G, Dixit P, Sharma RL. Efficacy of herbal extracts and closantel against fenbendazole-resistant *Haemonchus contortus*. J Helminthol 2019;93:529-32.

61. Basha H, et al. In vitro anthelmintic efficacy of the 80% hydro-alcohol extract of *Myrsine africana* (kecheo) leaf on hookworm larvae. J Public Heal Dis Prev 2018;1:106.

62. Alowanao GG, Azando EVBB, Adenilé AD, et al. Evaluation of the in vivo anthelmintic properties of *Mitragyna inermis* (Willd.) as a livestock dewormer against parasitic hematophagous worm *Haemonchus contortus* infections in different breeds of lambs. Trop Anim Health Prod 2020;52:309-19.

63. Joshi UP, Wagh RD, Phabharaki Joshi U, Dayaram Wagh R. In vitro anthelmintic activity of *Maytenus Emarginata* stem bark on indian adult earthworm. In Vitro 2019;12:3.

64. Tavassoli M, Jalilzadeh-Amin G, Fard VRB, Esfandiarpour R. The in vitro effect of *Ferula asafoetida* and *Allium sativum* by extracts on Strongylus spp. Ann Parasitol 2018;64:59-63.

65. Muunda M, Musabire JB, Nassali G, et al. Combined effects of *Carica papaya* seeds with *Albendazole* on adult philterra posthuma. East Africa Sci 2020;2:89-91.

66. Belemiliga MB, Traoré A, Belemmba L, et al. Ovivalid and larvical activities of *Saba senegalensis* (A. DC) Pichon (Apocynaceae) extracts and fractions on heligmosomoides barkeri (Nematoda, Heligmosomatidae). J Pharm Res Int 2019;31:1-13.

67. Widiarso BP, Kurniasih K, Lüersen K, et al. A versatile high-resolution speciation assay. Parasit Vectors 2016;9:536.

68. Tawosso ML, Kini G, Adenilé AD, et al. Combined effects of the in vivo anthelmintic properties of *Mitragyna inermis* (Willd.) as a livestock dewormer against parasitic hematophagous worm *Haemonchus contortus* infections in different breeds of lambs. Trop Anim Health Prod 2020;52:309-19.

69. Tawosso ML, Kini G, Adenilé AD, et al. Combined effects of the in vivo anthelmintic properties of *Mitragyna inermis* (Willd.) as a livestock dewormer against parasitic hematophagous worm *Haemonchus contortus* infections in different breeds of lambs. Trop Anim Health Prod 2020;52:309-19.

70. Muunda M, Musabire JB, Nassali G, et al. Combined effects of *Carica papaya* seeds with *Albendazole* on adult philterra posthuma. East Africa Sci 2020;2:89-91.

71. Belemiliga MB, Traoré A, Belemmba L, et al. Ovivalid and larvical activities of *Saba senegalensis* (A. DC) Pichon (Apocynaceae) extracts and fractions on heligmosomoides barkeri (Nematoda, Heligmosomatidae). J Pharm Res Int 2019;31:1-13.

72. Widiarso BP, Kurniasih K, Prastowo J, Nurcahyo W. The in vitro effect of *Ferula asafoetida* and *Allium sativum* by extracts on Strongylus spp. Ann Parasitol 2018;64:59-63.

73. Muunda M, Musabire JB, Nassali G, et al. Combined effects of *Carica papaya* seeds with *Albendazole* on adult philterra posthuma. East Africa Sci 2020;2:89-91.

74. Belemiliga MB, Traoré A, Belemmba L, et al. Ovivalid and larvical activities of *Saba senegalensis* (A. DC) Pichon (Apocynaceae) extracts and fractions on heligmosomoides barkeri (Nematoda, Heligmosomatidae). J Pharm Res Int 2019;31:1-13.
70. Houshmand E, Kamalifar HS, Elmi H. In vitro scolicidal effect of ginger (Zingiber officinale Roscoe) ethanolic extract against protoscoleces of hydatid cyst. Iran J Vet Med 2019;13:87-99.

71. Goswami S, Singh RP. In vitro assessment of anthelmintic and alpha-amylase inhibition of schleicheria oleosa (Lour.) oken leaf extracts. Asian J Pharm Clin Res 2018;11:487-91.

72. Mubarakah WW, Nurcahyo W, Prastowo J, Kurniasih K. In vitro and in vivo catechu crude aqueous extract as an anthelmintic against Ascaris galli in chickens. Vet World 2019;12:877.

73. Shahaby H, El Namaky A, Kandil O, Hassan N. In vitro assessment of Balanites aegyptiaca fruit methanolic extract on the adult Toxocara canis. Iran J Parasitol 2018;13:643.

74. Tsehayneh B, Melaku A. In vitro egg hatchability inhibition effect of Albizia gummifera, Phytolacca dodecandra, and Vernonia amygdalina against natural infection of ovine GIT nematodes. J Med Bot 2019;3:5-7.

75. Walyuni S, Sunarso S, Prasetyoyono BWHE, Satrija F. Anthelmintic effect of Cymbopogon citratus essential oil and its nanoemulsion on sheep gastrointestinal nematodes. Electron Braz J Vet Parasitol 2019;28:522-7.

76. Zaheer S, Hussain A, Khalil A, et al. In vitro anthelmintic activity-guided fractionation and GC-MS analysis of extracts from Embelia schimperi fruits. In J Appl Res Nat Products 2018. Available from: https://www.researchgate.net/publication/325287233_Anthelmintic_activity-guided_fractionation_and_GC-MS_analysis_of_extracts_from_Embelia_schimperi_fruits

77. Alowanou GG, Olounladé PA, Akouèdegni GC, et al. In vitro anthelmintic activity of ethanolic extracts of Camellia sinensis L. and Albizia lebbeck L. against Haemonchus contortus. Punjab Univ J Zool 2019;34:41-45.

78. Alowanou GG, Olounladé PA, Akouèdegni GC, et al. In vitro anthelmintic effects of Bridelia ferruginea, Combretum glutinosum, and Mitragyna inermis leaf extracts on Haemonchus contortus, an abomasal nematode of small ruminants. Parasitol Res 2019;118:1215-23.

79. Hmoodal-Khalidy K. Molecular diagnosis of hymenolepis-nananae experimentally infected swiss mice and study the effect of the hot aqueous extract of syzygiumaromaticum (clove) on the worms. J Res Lepid 2020;51:147-57.

80. Giradkar PN, Lkhande VK. Worm Infestation and child health care: anthelmintic pellets of papaya. J Pharmaceut Adv Res 2018;1:101-10.

81. Philip R, Krishnasamy K, Abraham E. Evaluation of in vitro anthelmintic activity of extracts of jasminum sessiliflorum. Int J Res Pharm Sci 2019;10:2542-44.

82. Kharisma VL, Koedsarto S, Supriandono K, et al. Anthelmintic activity ethanol extract of Ocimum sanctum Linn leaves against Ascaridia galli in vitro. J Parasite Sci 2018;2:21-8.

83. Lalruatfela B, Lalthanpuii PB, Lalnunfela C, Lalchhandama K. Nematocidal effects of tobacco infusion (tuibur) against intestinal helminth parasites of chicken. J Environ Biol 2019;2020;41:840-4.

84. Freitas Macedo IT, Beserra de Oliveira LM, Pinheiro André WP, et al. Anthelmintic effect of Cymbopogon citratus essential oil and its nanoemulsion on sheep gastrointestinal nematodes. Efeto anti-helmíntico do óleo essencial de Cymbopogon citratus e sua nanoemulsão sobre nematóides gastrintestinais de ovinos. Electron Braz J Vet Parasitol 2019;28:522-7.

85. D’Ambola M, et al. In vitro anthelmintic efficacy of Hypoestes forskaölii (Vahl) Br (Acanthaceae) extracts on gastrointestinal nematodes of sheep. Vet Sci 2018;5:89.

86. Ahmed AIH, Ejo M, Feyera T, et al. In vitro anthelmintic activity of crude extracts of Artemisia herba-alba and Punica granatum against Haemonchus contortus. J Parasitol Res 2020;2020:4950196.

87. Ngwewondo A, et al. Filaricidal properties of Lantana camara and Tamarindus indica extracts, and Lantadene A from L. camara against Onchocerca ochengi and Loa loa. PLoS Negl Trop Dis 2018;12:e0006565.

88. Olukotun AB, Bello IA, Oyewale OA. Phytochemical and anthelmintic activity of Terminalia catappa (Linn) leaves. J Appl Sci Environ Manag 2018;22:1343.

89. Nath S, Pal S, Sanyal PK, et al. Anthelmintic activity of curcuma longa essential extract against benzimidazole resistant gastrointestinal nematodes in goats. Int J Livestock Res 2019;9:117-22.

90. Hamad KK. Assessment of Azadirachta indica seed kernel extracts to restrict the rampanty of antinematicidal-resistant Haemonchus contortus in ovine. Zanco J Pure Appl Sci 2018;30:29-43.

91. Aderibigbe SA, Idowu SO. Anthelmintic activity of Ocimum gratissimum and Cymbopogon citratus leaf extracts against Haemonchus placei adult worm. J Pharm Bioresour Sci 2018;1:53-4.

92. Mahmoudvand H, Pakravan M, Aflatoonian MR, et al. Efficacy and safety of Curcuma longa essential oil to inactivate hydatid cyst protoscoleces. BMC Complement Altern Med 2019;19:187.

93. Behera DR, Bhatnagar S. Assessment of macrofilaricidal activity of leaf extracts of Terminalia sp. against bovine filarial parasite Setaria cervi. J Infect Public Health 2018;11:643-7.

94. Sujith S, Priya MN, Deepa CK, Usha PTA. Characterization of the Anthelmintic Activity of Murraya koeingii (Linn.). Pharmacogn J 2018;10:s100-3.

95. Zangueu CB, Olounlade AP, Osokomack M, et al. In vitro effects of aqueous extract from Maytens senegalensis (Lam.) Exell stem bark on egg hatching, larval migration and adult worms of Haemonchus contortus. BMC Vet Res 2018;14:147.

96. Zaman MA, Qamar W, Yousaf S, et al. In vitro Experiments Revealed the Anthelmintic Potential of Herbal Complex against Haemonchus contortus. Pakistan Vet J 2019:128.

97. Chitura T, Shiba MR, Afful DB, et al. In vitro anthelmintic activity of seven medicinal plants used to control livestock internal parasites in chief Albert Luthuli municipality, South Africa. Livestock Res Rural Dev 2019;31:14.

98. Chaudhari MK, Chaudhari RD, Girase PR, et al. Anthelmintic activity of Tridax procumbens Linn leaves on indian earthworms. Res J Pharm Technol 2018;11:5373-5.

99. Tessima EN, Neubert RHI, Tanemossa SAF, et al. Anthelmintic activity-guided fractionation and GC-MS analysis of extracts from Embelia schimperi fruits. In J Appl Res Nat Products 2018. Available from: https://www.researchgate.net/publication/325287233_Anthelmintic_activity-guided_fractionation_and_GC-MS_analysis_of_extracts_from_Embelia_schimperi_fruits

100. Naraparaju NA, Lokesh C, Sojan WA, et al. Phytochemical examination of plant and preforming anthelmintic activity of ethanolic extract of Dioscorea mexicana fruits on pherithima posthuma and bioassy on frog rectum abdominal muscle. Int J Res Eng Sci Manag 2018;2018;1:53-4.

101. Mallya R, Malim F, Malik A, Bhiture M. Evaluation of Anthelmintic Potential of Leaves and Fruits of Zanthoxylum rhetsa. Pharmacogn J 2019;11:475-8.
102. Sen D, Agnihotri RK, Sharma D, Moudgil AD. In-Vitro Assays on Mangifera indica and Embelia ribes against Ascaridia galli of poultry. Himachal J Agric Res 2018;44:117-24.

103. Aderibigbe SA, Oyeniran OS, Idowu SO. Anthelmintic activity of Nauclea diderrichii leaf extracts and fractions against adult haemonchus placei. Niger J Pharm. Res 2020;16:81-6.

104. Singh G, et al. Investigation of in vitro anthelmintic activity of Caesalpinia pulcherrima leaves. Plant Arch 2019;19:4527-30.

105. Jadhav A, Patil S, Inamdar S. A study on in vitro anthelmintic activity of ethanolic extracts of leaves Citrus aurantifolia swingle against Pheritima posthuma. Int J Pharm Sci Med 2018;3:1-8.

106. Islam R, Zahra SFT, Sumon SMI, et al. Evaluation of anthelmintic activity of ethanolic extracts of Carica papaya leaves using Paramphistomum cervi and Haemonchus contortus. African J Pharm Pharmacol 2019;13:146-50.

107. Barone CD, et al. Anthelmintic efficacy of cranberry vine extracts on ovine Haemonchus contortus. Vet Parasitol 2018;253:122-9.

108. Lalchhandama K. Anthelmintic activity of millettia pachycarpa root bark extract on an intestinal roundworm, Ascaridia galli. Pharmacogn J 2019;11:1428-33.