Agroforest Syst (2020) 94:1415–1432

<https://doi.org/10.1007/s10457-018-0295-6>

Potential contribution of plants bioactive in ruminant productive performance and their impact on gastrointestinal parasites elimination

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Received: 14 July 2018 / Accepted: 26 September 2018 / Published online: 8 October 2018

Springer Nature B.V. 2018

Abstract The worldwide emergence of anthelmintic resistance against gastrointestinal (GIT) parasites prompts investigation towards sustainable alternative approaches. Accordingly, several approaches have been endeavored to control GIT parasites and increase economic values of livestock production systems. Current scientific evidence implies that there is substantial capability to use the plant bioactive compounds to enhance animal’s health and promote their productivity. Despite the great efforts in man-agement, GIT parasites remain the main cause of mortality and weight gain–loss in ruminant industry. Recently, there is worldwide interest in exploiting plants bioactive and their secondary constituents as substitutes to anthelmintic treatment. However, we still necessitate to collect further data about their concentrations, sources, and composition, not only that but also understand their potential beneficial and

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detrimental impacts in livestock production. Simulta-neously, our review discusses the research efforts towards the development of plants bioactive and their impact on GIT parasites elimination in ruminants. A summarized background on their impacts on ruminant productivity and the future research ppossibilities in this area were also provided.

Keywords Plants Bioactive Gastrointestinal Parasites Ruminant

Introduction

The current livestock management operations and welfare integrity of food producing livestock in developing countries are facing many challenges to

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promote animal health and productions (Durmic and Blache [2012](#page15); Karki et al. [2018](#page16)). In line with these constraints, the virtuous animal production has been boosted to meets the societal demands for agricultural food products and reducing the impact of livestock industry on the surrounding environments (Bickell et al. [2010](#page15)). This notion entails less utilization of synthetic pharmaceuticals compounds, hormones, and in particular the routine use of infeed antibiotics (Piddock [2002](#page17)). The detrimental impact and conse-quences of using the synthetics chemicals pave the way for development of other alternative and natural options to manage animal production (Zain-Eldin et al. [2013](#page18); Zein-Eldin et al. [2014](#page18)). Currently, there is comprehensive curiosity in exploiting bioactive plants and their constituents, as alternatives to these chem-icals (Pent and Fike [2018](#page17)). While, bioactive plants and their metabolites have been exploited for centuries, we still require to congregate more data about their origins, concentrations, metabolism, absorption, and biological efficacy in order to determine their future benefit in improving animal health (Durmic and Blache [2012](#page15)). Presently, there is a significant prospec-tive to use the bioactive compounds (specifically tannin and saponin containing plants) to improve animal productivity, reproductive potency, meat qual-ity, and control of GIT parasites infestation (Rochfort et al. [2008](#page17)). Plants bioactive and their metabolites have been proved to be economical, efficient, easily available and safe to use with minimum side effect (Wijngaard et al. [2012](#page18); Ramı´rez-Rivera et al. [2010](#page17)). Currently, there have been a remarkable number of plants and their bioactive constituents with anthelmin-tic activity stated (Salem et al. [2017](#page17)). A web based search using the words ‘‘bioactive plants as anthel-mintic’’, yielded over 1000 citations. While, the herbs-based anthelmintic were the main treatment for the GIT nematodes prior to advancement in pharmaceu-ticals drugs (Sandoval-Castro et al. [2012](#page18)), their use are commonly restrained by the insufficient understanding of their authentic efficacy against specific parasites (Marie-Magdeleine et al. [2010](#page17)).

In this context, our review summarizes the research efforts towards the role of plant bioactive and their metabolites on selected animal functions and their impact on GIT parasites elimination in ruminants. We also provided a summarized background on their impacts on ruminant productivity, and outlined the future research possibilities in this area.

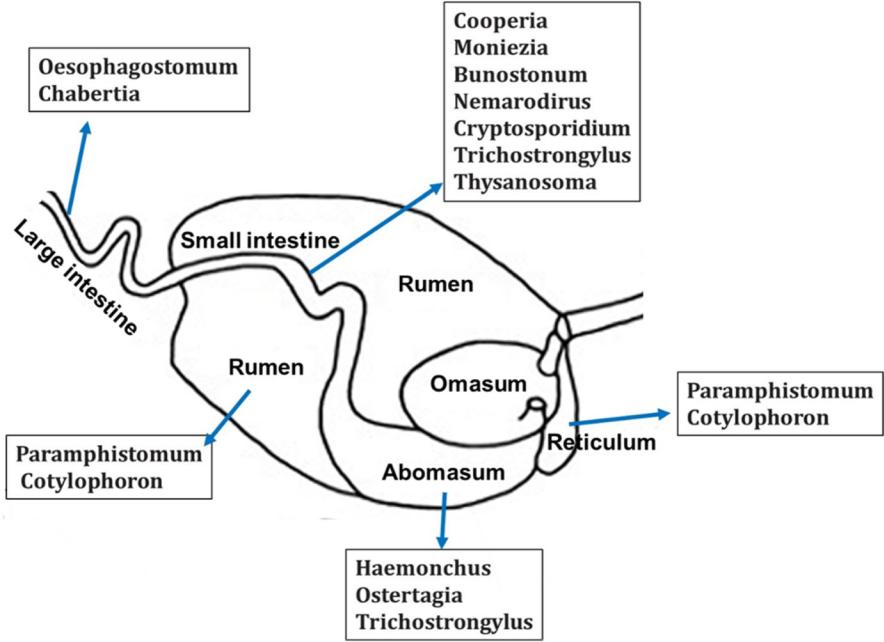
Gastrointestinal parasites in ruminant

GIT helminthiasis has been defined as one of the significant health, welfare and economic issues in livestock production system notably in the developing countries (Waller [1997](#page18); de Mendonca et al. [2014](#page15)). The primary risk factors of helminthiasis are generally relied to many factors including; host factors (Age and physiological status of the host), parasitic factors (different parasites epidemiology), and environmental factors (stocking rate, surrounding atmosphere, nutri-tion, and management protocols) (Tariq et al. [2008](#page18)). GIT helminthiasis is a heterogeneous group of para-sites with approximately 30,000 identified species. They are divided into phylum nemathelminthes (Roundworms: nematodes) and plathyhelminthes (flatworm: cestodes & trematodes). Approximately fifty percent of these species are considered marine parasites, twenty- five percent are free living, fifteen percent are animal parasites, and ten percent are plant parasites (Ghisalberti [2002](#page16)). The most common GIT parasite species found in ruminants are listed in Fig. [1](#page3). In this group of parasites, Haemonchus contortus represent the commonly prevalent nematode in small ruminant that cause severe damage to their hosts., followed by Strongyloides, Trichostrongylus, Oe-sophagostomun, and Cooperia (Roeber et al. [2013](#page17)). Most of these parasites are widespread in developing countries, and remains the main cause of increasing death rate, decreasing animal productivity (Zeineldin et al. [2018](#page18)). Additionally, GIT Helminthiasis con-tribute to the prevalence of nutritional deficiencies, anaemia, eosinophilia, allergic manifestations and pneumonia in infected livestock (Tariq et al. [2009](#page18)). Consecutively, animals have developed specific behavioral and physiological adaptations that neutral-ize this challenge and help in reduction the severity of parasitism. The infected animals at the pasture learn how to develop selective feeding behavior and self-medicate against GIT helminthiasis through increas-ing ingestion of plants bioactive with anthelmintic potential (Villalba et al. [2014](#page18)). Comprehensive under-standing of that mechanism in infected host will help researchers to invent suitable and more eco-friendly management strategies to enhance livestock health and productivity.

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Fig. 1 The most common gastrointestinal parasite species in small ruminants



Alternative methods to limit gastrointestinal parasitism in ruminant

The traditional strategies for GIT parasitism control relies on the repeated use of conventional chemical medicaments (Hoste et al. [2006](#page16)). The efficacies of chemical anthelmintic drugs against GIT parasitism have been reported with fluctuating accomplishment. The miss and overuse of these chemicals, increased prevalence of resistance in GIT populations, increased treatment cost and therefore increased economic impact of GIT parasites (Ga´rcia et al. [2016](#page16)). Gener-ally, the anthelmintic resistance is described as a heritable change in the ability of individual parasites to survive the prescribed therapeutic doses of an anthelmintic drug (Coles et al. [2006](#page15)). The current prosperous application of helminthiasis control strate-gies was planned to reduce anthelmintic resistance in nematode populations. There have been various literature reviews on anthelmintic resistance that have archived the accessible data on the different types of nematodes to which resistance has been distinguished, to which anthelmintic it had created and in what area it has been found (Taylor et al. [2002](#page18); Waller and Thamsborg [2004](#page18); Coles [2005](#page15); Coles et al. [2006](#page15); Torres-Acosta et al. [2012](#page18)). Responding to anthelmin-tic resistance crisis against the commonly used anthelmintic chemicals and the public health concern

regarding utilization of synthetic therapeutics in livestock management systems, many research studies are designed towards alternative and natural approaches for GIT parasites (Marie-Magdeleine et al. [2010](#page17); Oliveira et al. [2017](#page17)). These alternative strategies includes genetic resistance control, nutrition adjustment, biological control, vaccination, and pas-ture management techniques (Besier and Love [2003](#page15); Waller and Thamsborg [2004](#page18); Pisseri et al. [2013](#page17); Zeineldin et al. [2018](#page18)). While, these alternative strate-gies are eventual option in maintainable GIT helminthiasis control in cattle, until now there is no suitable option to for nematodes control in sheep (Coles [2005](#page15)). The challenge thusly is how to effi-ciently use a mix of these procedures to achieve the maximum anthelmintic control (Waller and Thams-borg [2004](#page18)). In the meantime, there is a consistent need to develop new and alternative approach for GIT parasites elimination in ruminant, and to interface their utilization with enhanced control methodologies (Taylor et al. [2002](#page18)).

Exploring the anthelmintic effects of plants bioactive in ruminants

The bioactive constituent generated by medicinal herbs to neutralize GIT nematodes are currently

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Table 1 Selected plants bioactive used for treatment of GIT nematodes in small ruminant

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| --- | --- | --- | --- | --- | --- |
| References | Host | Botanical name | Target parasite (s) | Route of administration | Comment (s) |
|  |  |  |  |  |  |
| Marie-Magdeleine | Small | Manihot | Haemonchus | In vitro assessment | These results suggest that the bioactive |
| et al. (2010) | ruminants | esculenta | contortus |  | component in Cassava leaves (terpenoids and |
|  |  |  |  |  | condensed tannin) are responsible for their |
|  |  |  |  |  | anthelmintic activities |
| Grade´ et al. (2008) | Sheep | Albizia | Mixed | Plant bark was packed into | This study indicates that the best dose of A. |
|  |  | anthelmintica | gastrointestinal | gel capsules and then | anthelmintica to control the mixed nematode |
|  |  |  | nematodes | given to the infected | infection was 58.7 mg/kg |
|  |  |  |  | sheep |  |



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| Galicia-Aguilar | Sheep | Havardia | Haemonchus | The plant was given to the |
| et al. (2012) |  | albicans | contortus | sheep during feeding |
|  |  |  |  | process |
| Fe´boli et al. (2016) | Sheep | Opuntia ficus- | 95% Haemonchus | In vitro assessment |
|  |  | indica | contortus and 5% |  |
|  |  |  | Trichostrongylus |  |
|  |  |  | sp. |  |
| van Zyl et al. (2017) | Sheep | Lespedeza | Mixed | The plan was given to the |
|  |  | cuneata | gastrointestinal | sheep during feeding |
|  |  |  | parasites | process |
| Mendonc¸a-Lima | Goats | Cratyliamollis | Mixed | The plant active ingredients |
| et al. (2016) |  | mollis | gastrointestinal | were administered orally |
|  |  |  | nematodes |  |
| Mehlhorn et al. | Sheep | Combination of | Mixed | The infected sheep treated |
| (2011) |  | Allium cepa | gastrointestinal | daily orally with the plant |
|  |  | and Cocos | nematodes | combination. In order to |
|  |  | nucifera |  | improve taste, 10 g of |
|  |  |  |  | milk powder were added |
|  |  |  |  | per treatment |
| Gaı´nza et al. (2015) | Sheep | Citrus sinensis | Haemonchus | In vitro assessment |
|  |  |  | contortus |  |
| Irum et al. (2015) | Sheep | Artemisia vestita | Haemonchus | In vitro and in vivo |
|  |  |  | contortus | assessment. The infected |
|  |  |  |  | sheep were orally treated |
|  |  |  |  | with single dose of |
|  |  |  |  | methanolic plant extract |

This study indicate that a short period of H. albicans intake reduced the H. contortus worm length and fecundity

The results demonstrated that O. ficus exhibits anthelmintic activity in vitro and could be used as alternative for gastrointestinal parasite control in sheep

The study proved that feeding of L. cuneata hay to infected sheep decreased the level of infection as measured by fecal egg count

This study proved that the extract of C. mollis has potential anthelmintic activity against gastrointestinal parasites in ruminant

The results of this study demonstrated that the treated animals exhibited a reduction in worm count when compared to untreated animals

The results suggested that these compounds are good candidates for nematode control

This study indicated that the investigated extracts showed significant activity against larvae and adult worms. The highest fecal egg count reduction for A. vestita was 87.2% at 100 mg/ kg on day 28 post-treatment

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Table 1 continued

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| References | Host | Botanical name | Target parasite (s) | Route of administration | Comment (s) |
|  |  |  |  |  |  |
| Tariq et al. (2009) | Sheep | Calotropis | Haemonchus | In vitro and in vivo | This study indicated that the Calotropis procera |
|  |  | procera | contortus, | assessment. The infected | flowers possess good anthelmintic activity |
|  |  |  | Trichostrongylus | sheep were orally treated | against nematodes yet it was lower than that |
|  |  |  | colubriformis, | with single dose of | exhibited by levamisole (97.8–100%) |
|  |  |  | Trichostrongylus | treatments |  |
|  |  |  | axei, Strongyloides |  |  |
|  |  |  | papillosus and |  |  |
|  |  |  | Trichuris ovis |  |  |



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| Jabbar et al. (2007) | Sheep | Chenopodium | Haemonchus | In vitro and in vivo |
|  |  | album and | contortus, | assessment. The infected |
|  |  | Caesalpinia | Trichostronglyus | sheep were orally treated |
|  |  | crista | spp., | with single dose of |
|  |  |  | Oesophagostomum | treatments |
|  |  |  | columbianum, and |  |
|  |  |  | Trichuris ovis |  |
| Tariq et al. (2009) | Sheep | Artemisia | Mixed | In vitro and in vivo |
|  |  | absinthium | gastrointestinal | assessment. The infected |
|  |  |  | nematodes | sheep were orally treated |
|  |  |  |  | with single dose of |
|  |  |  |  | treatments |
| Camurc¸a- | Sheep | Lippia sidoides | Trichostrongylus | Treatment by oral |
| Vasconcelos et al. |  |  | spp, and | administration during |
| (2008) |  |  | Haemonchus | 5 days of infection |
|  |  |  | contortus |  |
| Kanojiya et al. | Sheep | Ocimum sanctum | Mixed | In vitro and in vivo |
| (2015a) |  |  | gastrointestinal | assessment. The infected |
|  |  |  | Nematodes | sheep were orally treated |
|  |  |  |  | with single oral dose of |
|  |  |  |  | aqueous extract at a dose |
|  |  |  |  | of 5 g/animal by making |
|  |  |  |  | final volume of 5 ml with |
|  |  |  |  | water |

These data show that both Caesalpinia crista and Chenopodium album possess anthelmintic activity in vitro and in vivo. Both plants exhibited dose- and time-dependent anthelmintic effects by causing mortality of worms and inhibition of egg hatching

The oral administration of the extracts in sheep was associated with significant reduction in fecal egg count. Dosage had a significant influence on the anthelmintic efficacy of A. absinthium

Efficacy of 230 and 283 mg kg-1 on fecal egg count after treatment were ranged from 45 to 54%, respectively. Ivermectin was more efficient at controlling Trichostrongylus spp., while L. sidoides was more effective against H. contortus. However, results were not statistically different

In egg hatch assay, aqueous extract showed better anthelmintic effect in comparison with methanolic extract. In the larval paralysis test, both aqueous and methanolic extracts showed almost similar efficacy

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Table 1 continued

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| References | Host | Botanical name | Target parasite (s) | Route of administration | Comment (s) |  |
|  |  |  |  |  | This study showed that 1.35 and 5.4 mg ml-1 of |  |
| Macedo et al. (2010) | Goat | Eucalyptus | Haemonchus | In vitro assessment |  |
|  |  | staigeriana | contortus |  | Eucalyptus staigeriana essential oil inhibited |  |
|  |  |  |  |  | 99.27 and 99.20% H. contortus egg hatching |  |
|  |  |  |  |  | and larval development. The efficacy of the |  |
|  |  |  |  |  | plant essential oil against goat gastrointestinal |  |
|  |  |  |  |  | nematodes was 76.57% at 15th day after |  |
|  |  |  |  |  | treatment |  |



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Hernandez et al. Lambs Salix babylonica Mixed The plant extracts were

(2014) L. and gastrointestinal orally administered before

Leucaena nematode the 8:00 a.m feeding

leucocephala

L.

Overall, the result of this study showed that the oral administration of extracts has improved the egg and worm count reductions in lamb feces

Singh et al. (2015) Sheep and Butea Haemonchus In vitro and in vivo

goats monosperma contortus assessment. The infected

animals were orally

treated with single dose of

treatments

Aggarwal et al. Sheep and Calotropis Gastrothylax indicus In vitro assessment

(2016) goats procera,

Azadirachta

indica, and

Punica

granatum

The plant extract showed complete mortality of the adult H. contortus worms at the concentrations of 100 mg/ml at the time exposure of 6 h and with the concentration of 50 mg/ml at the post exposure of 8 h. These cidal effects may be due to presence of high phenolic, flavonoids and tannin content

The result of this study showed that all the three plants can be potential sources for novel anthelmintic

El-Far et al. (2014) Ewe Nigella Sativa Mixed The mixed extract were

and Zingiber gastrointestinal supplemented with basal

Officinale nematode diet in a dose of 3 g/

animal/day

Salem et al. (2017) Sheep and Salix babylonica Mixed The plant bioactive was

goats gastrointestinal orally administered

nematode weekly before the

morning feeding to each

animal for 60 days

Singh et al. (2016) Sheep and Zanthoxylum Haemonchus In vitro assessment

goats armatum contortus

Fecal examination was revealed that the mean numbers of eggs per gram were significantly decreased till the last readings and in comparison, with the control group

This study showed that the weekly administration of plant extract at 20 ml per animal can be used to treat gastrointestinal of small ruminants in organic and traditional farming systems

In vitro experimental trial revealed complete mortality of H. contortus worms at the concentration of 100 mg/ml at the time exposure of 8 h. At 50 mg/ml concentration the mortality at 6 and 8 h were 45.45 ± 4.55 and 63.64 ± 4.54% respectively

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Table 1 continued

References Host Botanical name Target parasite (s) Route of administration Comment (s)



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Kanojiya et al. Sheep Allium sativum Mixed In vitro and in vivo

(2015b) gastrointestinal assessment. The infected

nematode animals were orally

treated with a single oral

dose of aqueous extract at

5 g/animal

The results of this study showed that the aqueous extract had a better efficacy in egg hatch assay and larval development test. A significant amount of 57% fecal egg count reduction was observed in in vivo trail using the aqueous extract on day 21 post-treatment, although in initial stages it showed 30% and 83% effectiveness on days 7 and 14 post-treatment, respectively

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| Gregory et al. (2015) | Sheep | Banana plant | Haemonchus | The infected sheep were |
|  |  | leaves (Musa | contortus and | offered 400 g of dried |
|  |  | spp.) | Trichostrongylus | ground banana plant |
|  |  |  | colubriformis | leaves |
| Saha and Rahman | Sheep | Neem leaves and | Mixed | The infected sheep were |
| (2015) |  | Pineapple | gastrointestinal | treated with neem leaves |
|  |  | leaves | nematodiasis | and pineapple leaves |
|  |  |  |  | (10% water extract of |
|  |  |  |  | leaves@ 100 ml/sheep) |

The results confirmed that the dried ground banana plant leaves possess anthelmintic activity

This study showed a significant (p \ 0.01) reduction of egg count in all treated groups

Hasan et al. (2015) Black Bengal Garlic Mixed The infected goats of were

goat gastrointestinal fed with normal feeds

nematodiasis plus either 25 ml or 50 ml

of 10% water solution of

garlic twice per day,

respectively for 60 days

The study suggests that 10% water solution of garlic is a useful supplementation to decrease egg count and improving the general health condition of goat

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Eguale et al. (2007) Sheep Hedera helix Haemonchus In vitro assessment.

contortus Aqueous extract of H.

helix was also evaluated

for in vivo anthelmintic

activity at dose of 1.13

and 2.25 g/kg in infected

sheep. The plant extract,

dissolved in distilled

water, and was drenched

using a stomach tube

Morais-Costa et al. Sheep Piptadenia Haemonchus The plant bioactive was

(2016) viridiflora contortus orally administered to

lambs at the dose of

283 mg/kg bw

The results of this study showed a dose dependent worm count reduction in the sheep treated with H. helix. Increasing the dose of H. helix improved the efficacy against the male than the female parasites

Piptadenia viridiflora extracts had low condensed tannin content and exhibited high anthelminthic efficacy and significantly reduced fecal egg count

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Table 1 continued

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| References | Host | Botanical name | Target parasite (s) | Route of administration | Comment (s) |
|  |  |  |  |  |  |
| Khan et al. (2016) | Sheep | Iris kashmiriana | Haemonchus | In vitro and in vivo | This study showed that the aqueous extracts |
|  |  | Linn | contortus | assessment. Infected | exhibited greater anthelmintic activity under |
|  |  |  |  | sheep were treated with | both in vitro and in vivo conditions than |
|  |  |  |  | single dose of crude | methanolic extract and this could be due to the |
|  |  |  |  | methanolic or aqueous | presence of water soluble active ingredients in |
|  |  |  |  | extract@ 1.0 g kg-1 body | I. kashmiriana |
|  |  |  |  | weight |  |



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Iqbal et al. (2006) Sheep Nicotiana Mixed species of In vitro and in vivo

tabacum L. gastrointestinal assessment. The infected

nematodes sheep were received

including single doses of plant

(Haemonchus extract at two different

contortus, dose of 1.0 and 3.0 g/kg

Trichostrongylus

colubriformis,

Trichostrongylus

axei,

Oesophagostomum

columbianum,

Strongyloides

papillosus and

Trichuris ovis)

This study showed that the aqueous and methanol extracts of Nicotiana tabacum exhibit dose dependent anthelmintic activity both in vitro and in vivo, thus justifying its use in the traditional medicine system

Kanojiya et al. Sheep Eucalyptus Mixed In vitro and in vivo

(2015c) globulus gastrointestinal assessment. Infected

nematodes sheep were treated with

single oral dose of

aqueous extract at 5 g/

animal

Cala et al. (2012) Sheep Melia azedarach Mixed In vitro assessment

L. and Trichilia gastrointestinal

claussenii C. nematodes

Saidou et al. (2015) Sheep Cassia Haemonchus In vitro assessment

obtusifolia and contortus

Piliostigma

reticulatum

This study concluded that the leaves of E. globulus possess good level of anthelminthic efficacy through significant and prolonged reduction of fecal egg count

Comparing the extracts of the species from the Meliaceae family in this study, T. claussenii showed greater anti-parasite potential in vitro than M. azedarach

This study showed that, all concentrations of two extracts caused a significant inhibition of eggs hatching and larval development of H. contortus compared to the control group

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Table 1 continued

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| --- | --- | --- | --- | --- | --- |
| References | Host | Botanical name | Target parasite (s) | Route of administration | Comment (s) |
|  |  |  |  |  |  |
| Akkari et al. (2014) | Sheep | Artemisia | Haemonchus | In vitro assessment | The result of this study showed that the plant |
|  |  | campestris | contortus |  | extract completely inhibited egg hatching at a |
|  |  |  |  |  | concentration close to 2 mg/ml. The ethanolic |
|  |  |  |  |  | extract showed better in vitro activity against |
|  |  |  |  |  | adult parasites than the aqueous extract in |
|  |  |  |  |  | terms of the paralysis and/or death of the |
|  |  |  |  |  | worms at different hours post treatment |



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| Iqbal et al. (2010) | Sheep | Azadirachta | Mixed | Seeds of A. indica were |  |
|  |  | indica | gastrointestinal | administered as crude |  |
|  |  |  | nematodes | powder or crude aqueous |  |
|  |  |  |  | or and crude methanolic |  |
|  |  |  |  | extracts at the doses of 1 |  |
|  |  |  |  | and 3 g/kg of body weight |  |
|  |  |  |  | to naturally infected sheep |  |
| Ahmed et al. (2014) | Sheep | Ananas comosus, | Mixed | These were applied as an |  |
|  |  | Aloe ferox, | gastrointestinal | oral dose (100 mg kg-1 |  |
|  |  | Allium sativum, | nematodes | BW), one dose per week |  |
|  |  | Lespedeza |  | per sheep for 42 days |  |
|  |  | cuneata and |  | (Phase 1). |  |
|  |  | Warburgia |  | From day 42, sheep were |  |
|  |  | salutaris |  |  |
|  |  |  | orally dosed for 3 |  |
|  |  |  |  |  |
|  |  |  |  | consecutive days with the |  |
|  |  |  |  | same treatments in the |  |
|  |  |  |  | same groups (Phase 2) |  |

The result of this study showed that the lower dose has no anthelmintic effect but were found effective at 3 g/kg and the maximum anthelmintic effect was observed at the 15 days post-treatment with both crude powder and crude methanolic extracts

The result of this study revealed that, Ananas comosus and L. cuneata treatments had the highest efficacies of 58% and 61%, respectively, in Phase 1; and 77% and 81%, respectively, in Phase 2. Continuous treatment with these plants could further reduce nematode parasites and improve host health

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Cedillo et al. (2015) Lambs Sauce lloron Mixed The sheep were fed a total

gastrointestinal mixed ration (Control), or

nematodes and Control plus plant extract

Moniezia spp. extract using 20 (SB), 40

(SB) and 60 (SB) ml/

lamb/day for 45 days

Tadesse et al. (2009) Sheep and Maesa Haemonchus In vitro assessment

goats lanceolata and contortus

Plectranthus

punctatus

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The aqueous extract of SB could be more effective against nematodes at 20 and at 40 ml/ lamb/day for Moniezia spp. The use of the SB extract could represent a promising alternative to synthetic anthelmintics for the treatment of gastrointestinal nematodes and Moniezia spp. in small ruminants from organic and conventional production systems

All extracts have shown dose dependent inhibition of larval development with variable results. All extracts of plants tested have shown complete inhibition of egg hatching at or below 1 mg/ml

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Table 1 continued

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| References | Host | Botanical name | Target parasite (s) | Route of administration | Comment (s) |
|  |  |  |  |  |  |
| Kozan et al. (2016) | Sheep | Pelargonium | Haemonchus | In vitro assessment | The extracts exerted significant anthelmintic |
|  |  | endlicherianum | contortus |  | activity on three life cycle stages of |
|  |  |  |  |  | Haemonchus contortus when compared to the |
|  |  |  |  |  | negative control group |



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Matthews et al. Goat and pumpkin seeds Mixed Infected animals were

(2016) sheep and ginger gastrointestinal supplemented with plant

nematodes bioactive mixed into feed

daily at a rate of 5 g/kg

body weight for 21 days,

28, 35, and 42 in different

experiment

In these studies, pumpkin and ginger treatments administered were not effective in reducing fecal egg count in meat goat kids or lambs

Azrul et al. (2016) Goat Sesbania Mixed Leaves were provided This study showed that S. grandiflora reduced

grandiflora gastrointestinal ad libitum and the nematode eggs after 14 days feeding

parasites supplemented with

manufacturing

concentrate for 14 days

Ferreira et al. (2016) Sheep Thymus vulgaris Haemonchus In vitro and in vivo

L. contortus assessment Treatment

consisted of the oral

administration of T.

vulgaris essential oil at

doses of 300, 150, and

75 mg/kg body weight on

days 0, 6, and 12

The result of this study showed that, both the essential oil and thymol, which accounts for 50.22% of the oil composition, were effective against the three main stages of H. contortus. The oil and thymol were able to inhibit egg hatching by 96.4–100%, larval development by 90.8–100%, and larval motility by 97–100%

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investigated and received a great attention in the field of anthelmintic medication (Athanasiadou and Kyri-azakis [2004](#page15); Wolstenholme et al. [2004](#page18)). The utiliza-tion of plants bioactive for their GIT helminthiasis counteractive action has its origin in ethnoveterinary traditional medicine. While, the anti-parasitic activi-ties of plants bioactive and their metabolites has been generally based on episodic perception, there is as of now an expanding number of controlled experiments that aim to evaluate, quantify and validate such plant activities in a scientific manner (Marie-Magdeleine et al. [2010](#page17)).

Throughout many years of researches, large num-ber of plants bioactive with anthelmintic activities in ruminant has been scientifically approved in veteri-nary practice, either through administering plant extracts to the diseased animal or consuming the whole plant through feeding (Athanasiadou et al. [2007](#page15); Faria et al. [2016](#page15)). Table [1](#page4) lists a selected example of these plants bioactive. Most of these studies have spotlighted on small ruminant under grazing conditions, in which animals were ingested freshly collected plants without further processing. For instance, Havardia albicans and Lespedeza cuneate were given to the sheep during feeding process as alternative for gastrointestinal parasite control (Galicia-Aguilar et al. [2012](#page16); Fe´boli et al. [2016](#page16)). Notwithstanding, each year, the list of new plants with nematocidal in vitro and in vivo properties against known helminths is updated as new natural choices for supplanting (at any rate mostly) the utilization of synthetics chemicals. However these tremendous number of plants that have nematocidal activity, the majority of the bioactive constituents that responsible for this anthelmintic activity remain uncharacterized (Ghisalberti [2002](#page16)). Exploring the in vivo and in vitro anthelmintic effect of the available plants bioactive and their secondary metabolites have been the subject of recent review (Zeineldin et al. [2018](#page18)). The extent of described plants bioactivity shifts enormously and sometimes it is hard to evaluate the level of action since the compound that responsible for activity might be unidentified and the plant utilized as a part of the trials may have an unspecified amount of the bioactive constituents. The presumed bioactivity falls into an extensive variety of compound classes including; phenolics (tannins), lipids (fatty acids),

alkaloids and terpenes (essential oils, saponins and glycosoylated triterpenes). It has been noticed that the synergistic impacts between the plant bioactive con-stituents especially lipids and essential oils is imper-ative for their natural biological activities and their nematocidal properties (Ghisalberti [2002](#page16)). Similarly, recent studies focused on identifying the secondary metabolites that responsible for plants activity against GIT parasitism have identified a contributing role of the plants bioactive components including condensed tannins, catechins, polyphenolics, steroids, and flavo-noids (Oliveira et al. [2009](#page17)).

Tannins-containing plants are the commonly used plants bioactive, and their impacts on parasitic infes-tation have been the first to be explored among the known plants bioactive. Interdisciplinary groups of researchers (Paolini et al. [2003](#page17); Barrau et al. [2005](#page15); Alonso-Dı´az et al. [2008](#page15); Vargas-Magan˜a et al. [2014](#page18); Hoste et al. [2015](#page16)) have studied the role of plants containing condensed tannins in control of GIT helminthiasis particularly Haemonchus contortus. The condensed tannins biological mechanisms of action to eliminate parasites can vary from plant to another. Two main different mechanism of action have been suggested (van Zyl et al. [2017](#page18)). Firstly, tannins-containing plants could act indirectly, by enhancing the reaction of the host to parasites. In view of their protein-restricting capacity, tannins can prevent breakage of proteins in the rumen and increase amino acid absorption by the small intestine, which thus enhance host homeostasis and modulate host immune response against different parasites (Min et al. [2003](#page17)). Few studies have addressed this indirect mechanism by estimating particularly local or general parameters related to host immunity, but the outcomes remain to a great extent uncertain (Athanasiadou et al. [2005](#page15); Niezen et al. [2002](#page17); Tzamaloukas et al. [2005](#page18); Hoste et al. [2006](#page16)). Secondly, the direct mechanism, in which, the tannin containing plants showed different anthel-mintic potentials in themselves and influence several key biological processes of the parasites. This mech-anism is bolstered by results from multiple in vitro tests and, importantly, from in vivo assays in small ruminant in which the short-term experimental design did not allow the development and expression of effective host immune reactions (Paolini et al. [2003](#page17); Athanasiadou et al. [2001](#page15)).

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| Table 2 Selected plants bioactive that impacts animal health | | |  |
|  |  |  |  |
| References | Botanical name | Common name | Action |
|  |  |  |  |
| Tanner et al. | Cinnamomium | Cinnamon | Destabilize plant protein foams |
| ([1995](#page18)) | spp. |  |  |
| Stoldt et al. | Trifolium | Red clover | Increase final live and carcass weight |
| ([2016](#page18)) | pratense |  |  |
| Stoldt et al. | Cichorium | Chicory | Increase final live and carcass weight |
| ([2016](#page18)) | intybus |  |  |
| Zhang et al. | Glycyrrhiza | Liquorice | Improve antioxidant capacity of meat |
| ([2015](#page18)) | uralensis |  |  |
| Fu et al. |  |  |  |
| ([2013](#page16)) |  |  |  |
| Stoldt et al. | Fagopyrum | Buckwheat | Increased Plasma glucose, b-hydroxybutyrate, and albumin |
| ([2016](#page18)) | esculentum |  | level, indicating a possible metabolic effect on energy |
|  |  |  | metabolism |
| Abou-Elkhair | Piper Nigrum | Black Pepper | Enhanced the performance and health status |
| et al. ([2014](#page14)) |  |  |  |
| Abou-Elkhair | Curcuma Longa | Turmeric Powder | Enhanced the performance and health status |
| et al. ([2014](#page14)) |  |  |  |
| Abou-Elkhair | Coriandrum | Coriander Seeds | Enhanced the performance and health status |
| et al. ([2014](#page14)) | Sativum |  |  |
| Ramı´rez- | Lotus | Birdsfoot trefoil | Increased ovulation rate and resulting in increased multiple |
| Restrepo | corniculatus |  | births |
| et al. ([2004](#page17)) |  |  |  |
| Reis ([1978](#page17)) | Leucaena | White leadtree | Effective in stopping the growth of wool and allowing |
|  | leucocephala |  | subsequent manual removal of the fleece |
| Wang et al. | Portulaca | Pigweed | Can promote the extent of fermentation and effectively |
| ([2013](#page18)) | oleracea |  | inhibit methane production |
| Wang et al. | Triticum | Wheat straw | Has the potential to improve feed efficiency and carcass |
| ([2017](#page18)) |  |  | quality |
| Mandal et al. | Acacia | Okra, Abelmosk, Ambrette | May improve the concentrations of beneficial fatty acid in |
| ([2014](#page17)) | concinna pods | seeds, Annual hibiscus, Bamia | meat without any adverse effect on digestibility and growth |
|  |  | Moschata | performance |
| Raju et al. | Quercus | Oak | Beneficial in augmenting nutrient utilization, increase growth |
| ([2015](#page17)) | semecarpifolia |  | performance and improve feed efficiency |
| Gobindram | Citrus medica | Citron | Increase feed intake, performance, feeding behavior |
| et al. ([2017](#page16)) |  |  |  |
| Choubey et al. | Woodfordia | Flame Bush | Improve nutrient utilization and has antioxidant effect |
| ([2016](#page15)) | fruticosa |  |  |
| Choubey et al. | Solanum nigrum | European black nightshade | Improve nutrient utilization and has antioxidant effect |
| ([2016](#page15)) |  |  |  |
| Choubey et al. | Trigonella | Fenugreek | Improve nutrient utilization and has antioxidant effect |
| ([2016](#page15)) | foenum- |  |  |
|  | graecum |  |  |
| Choubey et al. | Ceratonia | Carob | Increase feed intake, improve animal performance, feeding |
| ([2016](#page15)) | siliqua |  | behavior, and reduced blood cholesterol |
| Mamaghani | Zingiber | Ginger | Have stimulant effect on reticulorumen motility |
| et al. ([2013](#page17)) | officinale |  |  |
| Valdes et al. | Salix | Babylon willow | Increased feed intake, nutrient digestibility and daily gain |
| ([2015](#page18)) | babylonica |  |  |
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Effect of bioactive plants on behavior, production and performance of ruminant

Generally, the plants bioactive have been approved to play a crucial role in increasing animal productivity, as well as in modification the animal behaviors (Table [2](#page12)). The impact of bioactive compound on different physio-logical parameter in the host may be reversible or irreversible, acute or chronic, preventative, and or curative. Approximately, 80,000 plants bioactive are acknowledged for their importance in improving animal health and productivity worldwide (Bernhoft [2010](#page15)). More recently, relationship between plant secondary metabolites and animal health has been the main point of scientific researchers to identify the specific plant components that have beneficial effect on animal production (Bickell et al. [2010](#page15); Stanner et al. [2004](#page18)). More than 200,000 bioactive component are documented as plant secondary metabolites, with various categories including tannins, flavonoids, alkaloids, saponins, cyano-genic glycosides, non-protein amino acids, terpens, and glycosinolates (Hart et al. [2008](#page16)). Considering the vari-ation in the different structure and function of GIT between animal species, numerous investigations have exhibited that ingestion of plant secondary metabolites diminished feed conversion proficiency and impaired nutrient utilization (Reed [1995](#page17); Stienezen et al. [1996](#page18)). While, others have revealed enhanced absorbability and feed effectiveness with bioactive compound use in food producing animals (Hussain and Cheeke [1995](#page16)).

Effect of bioactive plants on animal reproduction

Bioactive plants may have beneficial outcomes in improving animal reproductive performance. The plant secondary metabolites can encourage expression of male conceptive practices, including mating and court-ship behavior (Patel et al. [2011](#page17)), increase production of sex steroids and increase sperm count (Gauthaman and Ganesan [2008](#page16)). Additionally, high intake of plants bioactive that contains high amount of vitamin E connects with decrease prevalence of retained placenta and mastitis in ruminant (Celi and Gabai [2015](#page15)).

Effect of bioactive plants on growth performance of animals

Plants bioactive represents an essential part in animal feeding and affect significantly growth performance

and healthy status of animals. Plants bioactive demon-strated a significance contribution in the feeding of grazing animals especially in area where few or no choices are accessible (Mahala et al. [2007](#page16)). Small ruminant used trees forages as a source of energy, vitamins, protein, and minerals. For instance, supple-mentation of Leucaena leucoephala to small ruminant gave higher convergences of rumen metabolites, which normally enhanced rumen capacity and absorbability (Bonsi et al. [1995](#page15)). Most of the plant extracts are used to enhance growth performance and improve nutrient digestibility in food producing animals because of their beneficial impacts on ruminal microorganisms activity and amino acid flow to the GIT (Jime´nez-Peralta et al. [2011](#page16)). The plants bioac-tive and their constituents influence not only animal growth but also body structure and carcass composi-tion. For example, natural plants bioactive, that consists of betaine (naturally occurring amino acid derivative) and conjugated linoleic acid can enhance the fat to lean content and has substantial implications on consumer acceptance (Sillence [2004](#page18)).

Effect of bioactive plants on wool and skin quality

Plants bioactive can be utilized to heal skin wounds and mitigate skin bothering or aggravation, or to treat general skin disorders such as dermatosis, eczema, warts, and abscesses (Dilika et al. [2000](#page15)). For example, sheep grazing on lotus containing tannins exhibited increased in wool production (Patra and Saxena [2011](#page17)).

Effect of bioactive plants on immunity, stress and pain

Bioactive plants and their biological constituent have been demonstrated to boost and improve host function, with impacts extending from anti-inflammatory (Neto et al. [2005](#page17)), to enhancing and modulation of humoral and cellular immunity (More and Pai [2011](#page17)). For instance, ruminant grazing on plant rich in bioactive constituent showed elevated in immune response with lower level of lymphocyte, monocyte and eosinophil (Tzamaloukas et al. [2006](#page18); Mahgoub et al. [2008](#page16)). Moreover, plant secondary components have showed a great effect on the host psychological and physio-logical response (Stafford et al. [2008](#page18)). For instance, feeding Lavender oil (Lavendula augustifolia) to the small ruminant resulted in diminish anxiety-like

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behavior (Hawken et al. [2012](#page16)). While, other plants bioactive (Passiflora incarnate, chamomile, Matri-caria recutita, and Papaver somniferum) were used traditionally to calm horses and donkeys (Cruz-Vega et al. [2009](#page15)).

Further consideration when using the plant bioactive

However the existing knowledge on anthelmintic effect, and the beneficial effect of plants bioactive in improving host productivity, the in-field toxicity and environmental risk should be assessed before intro-duction of any new feed as alternative to the current used strategies (Hoste et al. [2006](#page16)). Additionally, the variations between the gut anatomical structures and GIT different prevailing conditions could play a crucial role in the response of GIT parasites to plants bioactive (Hoste et al. [2006](#page16)). The host physiological adaptations to plants bioactive constituent could change the amount of bioactive components needed to interact with the parasites (Silanikove [2000](#page18)). There are additionally a few variables which should be considered while surveying the effect of bioactive plants in livestock producing system. For example, the ethnoveterinary medicines are usually produced either from the entire plant, or from part of the plant. The field application of plants bioactive are often lack standardization, because they have been used in livestock through trial-and-error, instead of valid scientific approach. Therefore, isolation and distin-guishing of the plants bioactive biological compounds is critical (Provenza and Villalba [2010](#page17)). Another important factor that should be considered is the palatability of bioactive plants (Rogosic et al. [2008](#page17)). Generally, plants bioactive are considered unpalat-able, which in turn reduced animal consuming ability (Beauchemin and McGinn [2006](#page15)). Further factors, for example, administration time (the time it takes to achieve the advantageous effect), persistence, adapta-tion, and interactions with host should be likewise considered. It is important to conduct a long term and controlled experimental studies with repeated appli-cations of the plants bioactive to allow adequate time and amounts for the bioactive effect to develop, but also to give the host the chance to adapt the plants bioactive components. Finally, the future use of bioactive plants needs to consider the different

environmental issues such as agronomy of the plant, accessibility of natural resources, preservation of resources and ecological sustainability. Utilization of bioactive plants in livestock production systems must be well-founded and linked to farm economics, to clearly demonstrate the improvement percent in animal health without affecting total farm productivity (Durmic and Blache [2012](#page15)).

Concluding remarks

This review article aimed to cite the widely used plants bioactive for treatment of most common GIT parasites in ruminants and to document scientist’s interest in utilizing natural option as alternatives to the synthetics chemicals in the livestock production industry. Sev-eral research studies in ruminants to date have investigated the use of specific classes of plants bioactive for nematocides treatment, suggesting that this could be a fertile area for future research. Despite that, assessing the potential anthelmintic effect of plant bioactive lack the chemical analysis of plant constituents. Considering the previously mentioned issues, this review suggests that plants bioactive may certainly be valuable for livestock health, while in the meantime, highlights the need for further in-depth and controlled in vivo studies to validate and assess the plants bioactivity. Isolating plant bioactive com-pounds is vital to understand the bioactive components and their mechanism of action to achieve maximum efficacy of the plants and reduced their potential toxicity. Exploiting plants bioactive in livestock management system may offer practical, inexpensive, environmentally safe, and sustainable alternatives to synthetic chemicals, however more research is required before such compounds can be suggested in commercial livestock production systems.

Compliance with ethical standards

Conflict of interest The authors declare no conflict of interest.

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