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

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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 management, 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 detrimental impacts in livestock production. Simultaneously, 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; Karki et al. 2018). 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). This notion entails less utilization of synthetic pharmaceuticals compounds, hormones, and in particular the routine use of infeed antibiotics (Piddock 2002). The detrimental impact and consequences 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; Zein-Eldin et al. 2014). Currently, there is comprehensive curiosity in exploiting bioactive plants and their constituents, as alternatives to these chemicals (Pent and Fike 2018). 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). Presently, there is a significant prospective to use the bioactive compounds (specifically tannin and saponin containing plants) to improve animal productivity, reproductive potency, meat quality, and control of GIT parasites infestation (Rochfort et al. 2008). 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; Ramírez-Rivera et al. 2010). Currently, there have been a remarkable number of plants and their bioactive constituents with anthelmintic activity stated (Salem et al. 2017). A web based search using the words ''bioactive plants as anthelmintic'', yielded over 1000 citations. While, the herbs-based anthelmintic were the main treatment for the GIT nematodes prior to advancement in pharmaceuticals drugs (Sandoval-Castro et al. 2012), their use are commonly restrained by the insufficient understanding of their authentic efficacy against specific parasites (Marie-Magdeleine et al. 2010).

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; de Mendonca et al. 2014). 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, nutrition, and management protocols) (Tariq et al. 2008). GIT helminthiasis is a heterogeneous group of parasites 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). The most common GIT parasite species found in ruminants are listed in Fig. 1. 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*, *Oesophagostomun*, and *Cooperia* (Roeber et al. 2013). 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). Additionally, GIT Helminthiasis contribute to the prevalence of nutritional deficiencies, anaemia, eosinophilia, allergic manifestations and pneumonia in infected livestock (Tariq et al. 2009). Consecutively, animals have developed specific behavioral and physiological adaptations that neutralize 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 increasing ingestion of plants bioactive with anthelmintic potential (Villalba et al. 2014). Comprehensive understanding of that mechanism in infected host will help researchers to invent suitable and more eco-friendly management strategies to enhance livestock health and productivity.

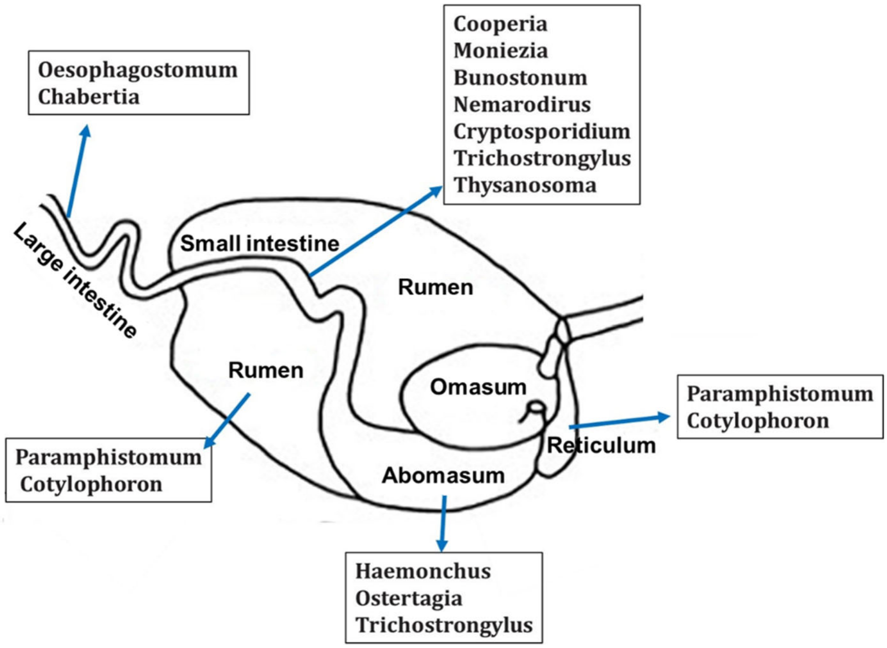

Fig. 1 The most common gastrointestinal parasite species in small ruminants

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). 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 (Gárcia et al. 2016). Generally, 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). The current prosperous application of helminthiasis control strategies 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; Waller and Thamsborg 2004; Coles 2005; Coles et al. 2006; Torres-Acosta et al. 2012). Responding to anthelmintic 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; Oliveira et al. 2017). These alternative strategies includes genetic resistance control, nutrition adjustment, biological control, vaccination, and pasture management techniques (Besier and Love 2003; Waller and Thamsborg 2004; Pisseri et al. 2013; Zeineldin et al. 2018). While, these alternative strategies 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). The challenge thusly is how to efficiently use a mix of these procedures to achieve the maximum anthelmintic control (Waller and Thamsborg 2004). 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).

Exploring the anthelmintic effects of plants bioactive in ruminants

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

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

References	Host	Botanical name	Target parasite (s)	Route of administration	Comment (s)
Marie-Magdeleine et al. (2010)	Small ruminants	*Manihot esculenta*	*Haemonchus contortus*	In vitro assessment	These results suggest that the bioactive component in Cassava leaves (terpenoids and condensed tannin) are responsible for their anthelmintic activities
Gradé et al. (2008)	Sheep	*Albizia anthelmintica*	Mixed gastrointestinal nematodes	Plant bark was packed into gel capsules and then given to the infected sheep	This study indicates that the best dose of *A. anthelmintica* to control the mixed nematode infection was 58.7 mg/kg
Galicia-Aguilar et al. (2012)	Sheep	*Havardia albicans*	*Haemonchus contortus*	The plant was given to the sheep during feeding process	This study indicate that a short period of *H. albicans* intake reduced the *H. contortus* worm length and fecundity
Féboli et al. (2016)	Sheep	*Opuntia ficus-indica*	95% *Haemonchus contortus* and 5% *Trichostrongylus* sp.	In vitro assessment	The results demonstrated that *O. ficus* exhibits anthelmintic activity in vitro and could be used as alternative for gastrointestinal parasite control in sheep
van Zyl et al. (2017)	Sheep	*Lespedeza cuneata*	Mixed gastrointestinal parasites	The plan was given to the sheep during feeding process	The study proved that feeding of *L. cuneata* hay to infected sheep decreased the level of infection as measured by fecal egg count
Mendonça-Lima et al. (2016)	Goats	*Cratyliamollis mollis*	Mixed gastrointestinal nematodes	The plant active ingredients were administered orally	This study proved that the extract of *C. mollis* has potential anthelmintic activity against gastrointestinal parasites in ruminant
Mehlhorn et al. (2011)	Sheep	Combination *of Allium cepa* and *Cocos nucifera*	Mixed gastrointestinal nematodes	The infected sheep treated daily orally with the plant combination. In order to improve taste, 10 g of milk powder were added per treatment	The results of this study demonstrated that the treated animals exhibited a reduction in worm count when compared to untreated animals
Gaínza et al. (2015)	Sheep	*Citrus sinensis*	*Haemonchus contortus*	In vitro assessment	The results suggested that these compounds are good candidates for nematode control
Irum et al. (2015)	Sheep	*Artemisia vestita*	*Haemonchus contortus*	In vitro and in vivo assessment. The infected sheep were orally treated with single dose of methanolic plant extract	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

Table 1 continued

References	Host	Botanical name	Target parasite (s)	Route of administration	Comment (s)
Tariq et al. (2009)	Sheep	*Calotropis procera*	*Haemonchus contortus, Trichostrongylus colubriformis*, *Trichostrongylus axei*, *Strongyloides papillosus* and *Trichuris ovis*	In vitro and in vivo assessment. The infected sheep were orally treated with single dose of treatments	This study indicated that the *Calotropis procera* flowers possess good anthelmintic activity against nematodes yet it was lower than that exhibited by levamisole (97.8–100%)
Jabbar et al. (2007)	Sheep	*Chenopodium album* and *Caesalpinia crista*	Haemonchus contortus, *Trichostronglyus* spp., *Oesophagostomum columbianum,* and *Trichuris ovis*	In vitro and in vivo assessment. The infected sheep were orally treated with single dose of treatments	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
Tariq et al. (2009)	Sheep	*Artemisia absinthium*	Mixed gastrointestinal nematodes	In vitro and in vivo assessment. The infected sheep were orally treated with single dose of treatments	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*
Camurça-Vasconcelos et al. (2008)	Sheep	*Lippia sidoides*	*Trichostrongylus* spp, and *Haemonchus contortus*	Treatment by oral administration during 5 days of infection	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
Kanojiya et al. (2015a)	Sheep	*Ocimum sanctum*	Mixed gastrointestinal Nematodes	In vitro and in vivo assessment. The infected 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	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

Table 1 continued

References	Host	Botanical name	Target parasite (s)	Route of administration	Comment (s)
Macedo et al. (2010)	Goat	*Eucalyptus staigeriana*	*Haemonchus contortus*	In vitro assessment	This study showed that 1.35 and 5.4 mg ml^{-1} of *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
Hernandez et al. (2014)	Lambs	*Salix babylonica* L. and *Leucaena leucocephala* L.	Mixed gastrointestinal nematode	The plant extracts were orally administered before the 8:00 a.m feeding	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 goats	*Butea monosperma*	*Haemonchus contortus*	In vitro and in vivo assessment. The infected animals were orally treated with single dose of treatments	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
Aggarwal et al. (2016)	Sheep and goats	*Calotropis procera, Azadirachta indica,* and *Punica granatum*	*Gastrothylax indicus*	In vitro assessment	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* and *Zingiber Officinale*	Mixed gastrointestinal nematode	The mixed extract were supplemented with basal diet in a dose of 3 g/animal/day	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
Salem et al. (2017)	Sheep and goats	*Salix babylonica*	Mixed gastrointestinal nematode	The plant bioactive was orally administered weekly before the morning feeding to each animal for 60 days	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
Singh et al. (2016)	Sheep and goats	*Zanthoxylum armatum*	*Haemonchus contortus*	In vitro assessment	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

Table 1 continued

References	Host	Botanical name	Target parasite (s)	Route of administration	Comment (s)
Kanojiya et al. (2015b)	Sheep	*Allium sativum*	Mixed gastrointestinal nematode	In vitro and in vivo assessment. The infected 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
Gregory et al. (2015)	Sheep	Banana plant leaves (*Musa* spp.)	*Haemonchus contortus* and *Trichostrongylus colubriformis*	The infected sheep were offered 400 g of dried ground banana plant leaves	The results confirmed that the dried ground banana plant leaves possess anthelmintic activity
Saha and Rahman (2015)	Sheep	*Neem leaves* and *Pineapple leaves*	Mixed gastrointestinal nematodiasis	The infected sheep were treated with neem leaves and pineapple leaves (10% water extract of leaves@ 100 ml/sheep)	This study showed a significant ($p < 0.01$) reduction of egg count in all treated groups
Hasan et al. (2015)	Black Bengal goat	*Garlic*	Mixed gastrointestinal nematodiasis	The infected goats of were fed with normal feeds 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
Eguale et al. (2007)	Sheep	*Hedera helix*	*Haemonchus contortus*	In vitro assessment. 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	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
Morais-Costa et al. (2016)	Sheep	*Piptadenia viridiflora*	*Haemonchus contortus*	The plant bioactive was orally administered to lambs at the dose of 283 mg/kg bw	*Piptadenia viridiflora* extracts had low condensed tannin content and exhibited high anthelminthic efficacy and significantly reduced fecal egg count

Table 1 continued

References	Host	Botanical name	Target parasite (s)	Route of administration	Comment (s)
Khan et al. (2016)	Sheep	*Iris kashmiriana Linn*	*Haemonchus contortus*	In vitro and in vivo assessment. Infected sheep were treated with single dose of crude methanolic or aqueous extract@ 1.0 g kg^{-1} body weight	This study showed that the aqueous extracts exhibited greater anthelmintic activity under both in vitro and in vivo conditions than methanolic extract and this could be due to the presence of water soluble active ingredients in *I. kashmiriana*
Iqbal et al. (2006)	Sheep	*Nicotiana tabacum* L.	Mixed species of gastrointestinal nematodes including (*Haemonchus contortus, Trichostrongylus colubriformis, Trichostrongylus axei, Oesophagostomum columbianum, Strongyloides papillosus* and *Trichuris ovis*)	In vitro and in vivo assessment. The infected sheep were received single doses of plant extract at two different dose of 1.0 and 3.0 g/kg	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. (2015c)	Sheep	*Eucalyptus globulus*	Mixed gastrointestinal nematodes	In vitro and in vivo assessment. Infected sheep were treated with single oral dose of aqueous extract at 5 g/animal	This study concluded that the leaves of *E. globulus* possess good level of anthelminthic efficacy through significant and prolonged reduction of fecal egg count
Cala et al. (2012)	Sheep	*Melia azedarach* L. and *Trichilia claussenii* C.	Mixed gastrointestinal nematodes	In vitro assessment	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*
Saidou et al. (2015)	Sheep	*Cassia obtusifolia* and *Piliostigma reticulatum*	*Haemonchus contortus*	In vitro assessment	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

Table 1 continued

References	Host	Botanical name	Target parasite (s)	Route of administration	Comment (s)
Akkari et al. (2014)	Sheep	*Artemisia campestris*	*Haemonchus contortus*	In vitro assessment	The result of this study showed that the plant 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
Iqbal et al. (2010)	Sheep	Azadirachta indica	Mixed gastrointestinal nematodes	Seeds of *A. indica* were administered as crude 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	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
Ahmed et al. (2014)	Sheep	*Ananas comosus, Aloe ferox, Allium sativum, Lespedeza cuneata* and *Warburgia salutaris*	Mixed gastrointestinal nematodes	These were applied as an oral dose (100 mg kg^{-1} BW), one dose per week per sheep for 42 days (Phase 1). From day 42, sheep were orally dosed for 3 consecutive days with the same treatments in the same groups (Phase 2)	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
Cedillo et al. (2015)	Lambs	*Sauce lloron*	Mixed gastrointestinal nematodes and *Moniezia* spp.	The sheep were fed a total mixed ration (Control), or Control plus plant extract extract using 20 (SB), 40 (SB) and 60 (SB) ml/lamb/day for 45 days	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
Tadesse et al. (2009)	Sheep and goats	*Maesa lanceolata* and *Plectranthus punctatus*	*Haemonchus contortus*	In vitro assessment	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

Table 1 continued

References	Host	Botanical name	Target parasite (s)	Route of administration	Comment (s)
Kozan et al. (2016)	Sheep	*Pelargonium endlicherianum*	*Haemonchus contortus*	In vitro assessment	The extracts exerted significant anthelmintic activity on three life cycle stages of *Haemonchus contortus* when compared to the negative control group
Matthews et al. (2016)	Goat and sheep	*pumpkin seeds* and *ginger*	Mixed gastrointestinal nematodes	Infected animals were supplemented with plant 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 grandiflora*	Mixed gastrointestinal parasites	Leaves were provided ad libitum and supplemented with manufacturing concentrate for 14 days	This study showed that *S. grandiflora* reduced the nematode eggs after 14 days feeding
Ferreira et al. (2016)	Sheep	*Thymus vulgaris* L.	*Haemonchus contortus*	In vitro and in vivo assessment Treatment consisted of the oral administration of *T. vulgar*is 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%

investigated and received a great attention in the field of anthelmintic medication (Athanasiadou and Kyriazakis 2004; Wolstenholme et al. 2004). The utilization of plants bioactive for their GIT helminthiasis counteractive action has its origin in ethnoveterinary traditional medicine. While, the anti-parasitic activities 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).

Throughout many years of researches, large number of plants bioactive with anthelmintic activities in ruminant has been scientifically approved in veterinary practice, either through administering plant extracts to the diseased animal or consuming the whole plant through feeding (Athanasiadou et al. 2007; Faria et al. 2016). Table 1 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; Féboli et al. 2016). 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). 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). 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 constituents especially lipids and essential oils is imperative for their natural biological activities and their nematocidal properties (Ghisalberti 2002). 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 flavonoids (Oliveira et al. 2009).

Tannins-containing plants are the commonly used plants bioactive, and their impacts on parasitic infestation have been the first to be explored among the known plants bioactive. Interdisciplinary groups of researchers (Paolini et al. 2003; Barrau et al. 2005; Alonso-Díaz et al. 2008; Vargas-Magaña et al. 2014; Hoste et al. 2015) 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). 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). 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; Niezen et al. 2002; Tzamaloukas et al. 2005; Hoste et al. 2006). Secondly, the direct mechanism, in which, the tannin containing plants showed different anthelmintic potentials in themselves and influence several key biological processes of the parasites. This mechanism 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; Athanasiadou et al. 2001).

Table 2 Selected plants bioactive that impacts animal health

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

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). The impact of bioactive compound on different physiological 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). 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; Stanner et al. 2004). More than 200,000 bioactive component are documented as plant secondary metabolites, with various categories including tannins, flavonoids, alkaloids, saponins, cyanogenic glycosides, non-protein amino acids, terpens, and glycosinolates (Hart et al. 2008). Considering the variation 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; Stienezen et al. 1996). While, others have revealed enhanced absorbability and feed effectiveness with bioactive compound use in food producing animals (Hussain and Cheeke 1995).

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 courtship behavior (Patel et al. 2011), increase production of sex steroids and increase sperm count (Gauthaman and Ganesan 2008). 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).

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 demonstrated a significance contribution in the feeding of grazing animals especially in area where few or no choices are accessible (Mahala et al. 2007). Small ruminant used trees forages as a source of energy, vitamins, protein, and minerals. For instance, supplementation of Leucaena leucoephala to small ruminant gave higher convergences of rumen metabolites, which normally enhanced rumen capacity and absorbability (Bonsi et al. 1995). 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 (Jiménez-Peralta et al. 2011). The plants bioactive and their constituents influence not only animal growth but also body structure and carcass composition. 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).

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). For example, sheep grazing on lotus containing tannins exhibited increased in wool production (Patra and Saxena 2011).

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), to enhancing and modulation of humoral and cellular immunity (More and Pai 2011). 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; Mahgoub et al. 2008). Moreover, plant secondary components have showed a great effect on the host psychological and physiological response (Stafford et al. 2008). For instance, feeding Lavender oil (*Lavendula augustifolia*) to the small ruminant resulted in diminish anxiety-like behavior (Hawken et al. 2012). While, other plants bioactive (*Passiflora incarnate, chamomile, Matricaria recutita, and Papaver somniferum*) were used traditionally to calm horses and donkeys (Cruz-Vega et al. 2009).

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 introduction of any new feed as alternative to the current used strategies (Hoste et al. 2006). 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). The host physiological adaptations to plants bioactive constituent could change the amount of bioactive components needed to interact with the parasites (Silanikove 2000). 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 distinguishing of the plants bioactive biological compounds is critical (Provenza and Villalba 2010). Another important factor that should be considered is the palatability of bioactive plants (Rogosic et al. 2008). Generally, plants bioactive are considered unpalatable, which in turn reduced animal consuming ability (Beauchemin and McGinn 2006). Further factors, for example, administration time (the time it takes to achieve the advantageous effect), persistence, adaptation, and interactions with host should be likewise considered. It is important to conduct a long term and controlled experimental studies with repeated applications 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).

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. Several 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 compounds 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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