A review on the use of herbs and spices as alternative compounds to manage helminthosis in small ruminants

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Abstract

Gastrointestinal parasites (worms) in sheep and goats are common in all world regions. Parasite burdens have undermined survival of producers and are a limiting factor for farm profitability. Additionally, rampant worm resistance to commercially available anthelmintics adds complexity to parasite management plans and researchers have been looking for alternative compounds with effective anthelmintic properties. Also, organic sheep and goat producers have indicated the need of alternative parasite management practices including plant compounds. Anecdotal reports about anthelmintic alternative compounds (including diatomaceous earth) and plant compounds abound and researchers have tested many of them. This review intents to examine reports of plants used to control helminths in sheep and goats.

Key Words: worms; natural anthelmintics; small ruminants; sheep; goat.

Implications

Helminthosis (worm burdens) in small ruminants is a problem within itself in all agro-climatic zones of the world (Macedo et al., 2010). In addition, anthelmintic resistance (AR) is a global problem that threatens the welfare of sheep and goats and represents a challenge in eroding the productivity of small ruminants, thus affecting the survival of the sheep and goat farms (Jabbar et al. (2006). AR is identified when a previously used commercially available anthelmintic ceases to kill an exposed worm population at the recommended therapeutic dosage. In the United States (USA), all major groups of the commercially available anthelmintics have been reported to have experienced variable degrees of resistance when used to protect small ruminants, and in some cases multi-class resistance to these drugs has been reported.

Introduction

Efforts to reduce production losses caused by gastrointestinal nematode parasitism in small ruminants (sheep and goats) have led to the investigation, development and implementation of a number of alternative control methods to complement or replace commercially available anthelmintics. This review will attempt to focus on the use of herbs and spices (including plant parts) considered *"natural alternative compounds"* to reduce gastrointestinal parasitism in sheep and goats. Herbs, leaves and spices have been an essential factor in health preservation all over the world and in many cultures (Peter, 2004). Depending on the use, for external or internal applications, the extraction of the active ingredients varies. The definitions of *¨herbs¨* are abundant. Generally, herbs are plants valued for their medicinal, aromatic, coloring and flavor enhancing properties. Hence, herbs are grown and harvested for such unique properties. The link between humans and herbs is documented from 4,000 years ago in Egypt. In addition in this review, results from several experiments using, garlic, eucalyptus, pumpkin seeds, papaya seeds, etc., to control worms will be appraised.

Alternative Natural Dewormers

Bearing in mind that the list of reports on the use of the so called *"alternative natural"* dewormers is overwhelming, suggestions are proposed in order to evaluate the informative value and more importantly, use of the natural materials to enhance survival of parasitized sheep and goats, including the use of *diatomaceous earth* as an alternative anthelmintic. Diatomaceous earth (DE) is a powdered, fossilized, geological siliceous deposit, rich in unicellular marine or fresh water diatoms, which damages the invertebrate cuticle (arthropods and nematodes), increasing permeability and causing death by dehydration (McLean et al., 2005). DE with less than 7% composition of crystalline silica is generally recognized as a safe feed additive in Canada and the USA (Bennett et al., 2011, Köster, H, 2013). DE is used to control many invertebrate pests, including grain storage invertebrate pests and as an alternative anthelmintic product fed to domestic animals (poultry, sheep and cattle) for gastro-intestinal parasite control, although the small number of efficacy studies show mixed results (Fernandez et al., 1998 and McLean et al., 2005, Bennett et al., 2011). Bernard (2009) reported that DE did not express an anthelmintic effect as expressed by eggs per gram of feces when naturally infected goats (*Haemonchus contortus, Eimeria* and *Thichostrongylus spp.)* were fed DE at 50, 100 and 150 µg/kg body weight.

Historical Perspective

Among many systems of herbal medicine, the most important is the Ayurvedic system which originated in China and India (Peter, 2004). Ayurveda is one of the oldest documented health care systems consisting of theoretical and practical clinical applications (Jain, 2006). One of the earlier reports in the USA on the use of plants with anthelmintic properties was published in 1781. The author (Kissam, 1771) expressed that the plant known as cow-itch (*Phaseolus zuratensiss iliquahirsuta)* could be used as a vermifuge to treat children with worms instead of preparations of mercury, aloes, rhubarb, jalap (a dried tuberous root from *Ipomoea purga*syn. *Exogoniumpurga,* a plant in the morning-glory family*),* steel, tin, Sulphur [*sic*] (sulfur)…"and others too tedious to mention". The author indicated that the hairy substance growing outside the pods was mixed with molasses or syrup and given to children and adults for 3 consecutive days at the rate of one teaspoon for children and double for adults.

Current practices: Condensed tannins as an alternative anthelmintic for sheep and goats

One of the documented alternative treatments in the USA are *condensed tannins* (CT) in sericea lespedeza (*Lespedeza cuneata)* and other plants. CT have shown an effective control of worms in sheep and goats (Coffey et al, 2007). At the end of this review, recommendations are proposed to develop a dialogue with other disciplines in order to help animal scientists in identifying effective natural dewormers to minimize parasite burden in sheep and goats.

Tannins are natural polyphenols. Biosynthetically CT are formed by the successive condensation of the single building blocks, with a degree of polymerization between two and greater than fifty blocks being reached. The coupling pattern of the catechin units in CT can vary considerably (Khanbabaee and van Ree, 2001). In some herbs, spices and forages (mostly leguminous plants), tannins are considered secondary compounds and in

general, herbivores avoid plants with excess tannin content. However, it has been reported by many investigators that CT have beneficial effects relative to parasitized sheep or goats eating plants with CT because CT aid in the management of Gastro Intestinal Nematodes (GIN) infestations (Min and Hart, 2003; Coffey, 2007; Lisbonbee et al., 2009; Novobilský et al., 2001; Juhnke et al., 2012). In the USA, several plants containing CT are of interest to sheep and goat producers, such as: Sericea lespedeza (*Sericea cuneata*), birdsfoot trefoil (*Lotus corniculatus*), chicory (*Cichori umintybus*) and sainfoin (*Onobrychis viciifolia*). In other regions in the world plants of the genera *Acacia, Schinopsis, Leucaena, Salix* have shown to have anthelmintic activities (Minho et al., 2008; Beserra de Oliveira et al., 2011; Mupeyo et al., 2011). Chicory (*Cichorium intybus L.*), a perennial herb of the Asteraceae family, has a long history and utilization in many parts of the world. It is relatively new as a forage crop. Recently, forage chicory is being studied for its bioactive compounds, such as tannins or sesquiterpene lactones, which can reduce nematode infection in animals. However, feeding high tannin containing feedstuffs have not always reduced parasite burdens. For example, studies conducted at our Small Ruminant Farm with goats eating high tannin cracked grain sorghum showed that the rations did not affect Fecal Egg Count (FEC) or Pack Cell Volume (PCV) of the treated goats (Whitley et al., 2009). Also, Max et al., (2007) reported a slight FEC reduction (only 19%) in sheep and goats fed up to 170 g/animal/day of acacia leaf meal (*Acacia polycantha*) compared to control groups. Use of plans containing CT as alternative anthelmintic has multiple research trials backing up claims of efficacy and has encouraged producers to the use of lespedeza as a component of integrated parasite management plans.

Other tested "herbal dewormers" and natural anthelmintic compounds

At least two commercial herbal dewormers have been tested in research trials. Burke at al. (2009a) did not find any indication, after a 112 day trial of a commercially available herbal dewormer controlled GIN in goats.

Yoder (2011) tested **plumbagin** in sheep and reported that treated sheep and control sheep did not show a difference on parasite burden as expressed by PCV and FEC. Plumbagin is a compound found in several herbal mixtures, but mostly in venus flytrap, *Dionaea muscipula* (carnivora, plumbagin).

Garlic, papaya seeds and **pumpkin** seeds have been used in trials with sheep and goats and have not been found to enhance PCV or reduce FEC in the treated sheep and/or goats (Burke et al., 2009b; Gooden 2012, Escobar et.al., unpublished data). However, Strickland et al. (2009) reported 64.4% reduction in FEC in sheep using garlic and 65.5% reduction in FEC when pumpkin seeds were fed.

Diehl (2004) published an extensive report of 60 plants from the Ivory Coast that have shown larvicidal activity against *H. contortus.* Several parts of plants were extracted with 90% ethanol and 25.6% of the extracts showed a high anthelmintic activity. Only 12 species showed proven activity against *H. contortus* (caused 95% to 100% larvae mortality in-vitro).

Oil and seed paste of ***Chenopodium*** spp. (epazote, wormseed, erva de Santa María) has been used to treat worm infections in animals and humans for centuries, however the margin of safety is very narrow (Jabbar et al., (2007). *Chenopodium* may cause adverse reaction and even death to the treated animals (Cornell University, 2013).

Jain (2006) mentioned that the powder of ***Embelia ribes*** Burm.f. (Familty Myrsinaceae) is the drug of choice for worms, *i.e.*,tapeworms, in the Ayurvedic system. Chaudhary (2012) reported up to 96% anthelmintic activity of an *E. ribes* seeds extract (10 to 200 μg/mL) by micro-well plat assay using levamisole and ivermectin as reference. The *Embelia* seeds were extracted with 95% ethanol by using soxhlet extractor. Phytochemical screening of the extract indicated the presence of tannins and glycoside. Other names for *Embelia ribes* Burm.f. , are: Van Vidanka, false black pepper, and Devnagari.

From the Mediterranean area, ***capitatus*** (family Lamiaceae) is used traditionally as a spice and grown in most part of the world. Also known as Spanish oregano. Aqueous and ethanolic extracts of ***Thymus*** leaves and stems were compared to albendazole on effects on in-vitro hatching of *Haemonchus contortus* eggs (Boubaker-Elandalousi et al., 2013). Both *Thymus* extracts inhibited eggs hatching in concentrations of 2mg/ml. The ethanolic extract contained thymol (71.22%) and camphor (17.18%) and showed higher ($P<0.05$) in-vitro activity against adult worms than the aqueous extract. The anthelmintic activity was defined as paralysis or death of the worms after several hours post-treatment. Other plants containing similar compounds are ***Lysiloma*** spp., and ***Acacia*** spp. Other relevant alternative plants are included in Table 1.

The essential oil (EsO) of ***Eucalyptus staigeriana*** leaves, predominantly limonene and citral, effectively inhibited egg hatching and larval development of *H. contortus* (99.3% and 98.7%, respectively), Macedo et al., 2010. Furthermore, in a fecal egg count reduction test, goats treated with a single dose of 500 mg/kg EsO exhibited a fecal egg count reduction of up to 77% after 8 and 15 days of a single dose treatment.

Aquino et al. (2013) used EsO to study anthelmintic activity in sheep, but added one other process. To prevent oxidation of the unstable oils and preserve their anthelmintic properties an encapsulation process was applied to allow the alternative oils release in targeted organs. Aquino at al. (2013) used chitosan as the encapsulating agent because its biocompatibility, biodegradability and abundance. The encapsulated *Eucalyptus oils* show efficacy against abomasal nematodes (83.75%) in sheep dosed with 365 mg/kg.

Table 1- Potential of alternative natural anthelmintics used in small ruminants

Species	Alternative dewormer	Parasite	Test conducted	Results	Reference
Sheep	Jujube (Bark, crude methanolic extract) - *Ziziphus nummularia.*	*H. contortus*	In-vitro: adult motility assay, egg hatch, larval development In-vivo:	Effective 84.7 % Fecal Egg Count Reduction (FECR)	Bachaya, et.al, 2009.
Sheep	*Acacia nilolitica*-pods with seeds - crude methanolic extract	*H. contortus*	In-vitro: adult motility assay, egg hatch, larval development In-vivo	Effective 78.5 % FECR	Bachaya, et.al, 2009.
Sheep	*Chenopodium album*	*H. contortus*	In-vitro: adult motility assay egg hatch, In-vivo, reduced FEC	Effective, LC_{50}= 0.449 mg/mL 93.9% reduction	Jabbar et al, 2007
Sheep	*Caesalpinia crista*	*H. contortus*	In-vitro: adult motility assay egg hatch In-vivo, reduced FEC	Effective, LC_{50}= 0.134 mg/mL 82.2% reduction	Jabbar et al, 2007
Sheep	Wormwood - *Artemisia absinthium*	*H. contortus*	In-vitro: adult motility assay In-vivo, reduced FEC	Effective 80 to 83% reduction	Tariq et al, 2009
Sheep	Banana leaves	*H. contortus*	In-vitro: adult motility assay In-vivo, reduced FEC	Reduced 97% larval development Reduced 58%	Oliveira et al, 2010

Conclusion

The list of anecdotal reports on the use of alternative anthelmintics for use in sheep and goats is overwhelming; however, the methods for analysis are ingenious but not standardized. Diehl (2004), Jain (2006), Bachayaetal. (2009), Boubaker-Elandalousi et al. (2013), Macedo et al. (2010), Aquino et al. (2013) and Tariq et al. (2009) have listed extraction procedures, encapsulation methods and in-vitro procedures to measure worm egg hatching rate and worm larval mortality when the eggs and larvae are exposed to the plant extracts. It seems that the compounds tested may reduce larval activity in-vitro but when tested in- vivo the results from treated animals are not different than results from the control subjects. One critical aspect of testing natural dewormers is the difficulty of treatment materials administration to experimental units, including the challenge to overcome the goats' ability to select feed components (sorting). One challenge, which is very common, is the proper identification of the plants and the geographical origin. Therefore, the scientific name, the variety plus the exact place were the herbs, vegetative material or spices were collected should be included in the reports. For example, pumpkin's scientific name is *Cucurbita pepo*; still there are at least 5 varieties commercially cultivated in the USA. Another example: *Thymus capitatus* grows in many parts of the world; exceptionally, Boubaker-Elandalousi et al. (2013) properly identified the part of the world where the tested material came from "…*Tunisian arid zone*…".Another underlying situation exist when researchers need to decide between running an in-vitro trial or an in-vivo trial. Both complement each other providing information to better understand the results in the field and specially to make recommendations. Once more there is the need of collaborative studies and the contribution of parasitologists, chemists, botanists and animal scientists in order to identify alternative compounds to control worms in sheep and goats. Scientists and producers need to take into account that incorporating the use of alternative natural anthelmintics will not result in the 90% to 98% efficacy expected from conventional anthelmintics. For example, Strickland et al. (2009) reported 64.4% reduction in FEC in sheep using garlic and 65.5% reduction in FEC when pumpkin seeds were fed; and, Aquino et al. (2013) reported 85.75% efficacy using encapsulated *Eucalyptus* oils. Nevertheless, the inclusion of alternative natural anthelmintics in an integrated parasite control system permits to slow down the worm infections in small ruminants. Preferably, research aimed to find how and why some natural compounds are active as anthelmintics should be the next task, taking advantage of available rapid analytical and precise equipment. It is conceivable, however, that by the time the mode of action of the natural anthelmintic is known, the worms would had developed a degree of resistance to the compound of interest. Another research emphasis must be the methods to determine quality consistency of the anthelmintic compound in production batches to ensure an effective treatment dosage.

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